Short communication

Direct demonstration of the presence of zinc in the acetone-extractable red pigment from Parma ham

Jun-ichi Wakamatsu [a, *], Toshiaki Ito [b], Takanori Nishimura [a], Akihito Hattori [a]

[a] Division of Bioresources and Product Science, Research Faculty of Agriculture, Hokkaido University, Sapporo 060-8589, Japan

[b] Electron Microscope Laboratory, Research Faculty of Agriculture, Hokkaido University, Sapporo 060-8589, Japan

* Corresponding Author

Jun-ichi Wakamatsu

Meat Science Laboratory, Division of Bioresources and Product Science
Research Faculty of Agriculture, Hokkaido University
N-9, W-9, Kita-ku, Sapporo 060-8589, JAPAN
(tel) +81-11-706-2547 (fax) +81-11-706-2547
(e-mail) jwaka@anim.agr.hokudai.ac.jp

Abstract

We studied the presence of zinc in the red pigment extracted from Parma ham by scanning electron microscopy/energy dispersive X-ray microanalysis. The large peak of about 8.6 KeV and the small peaks at about 1.1 KeV and 9.5 KeV were derived from K□, L□1 and K□ X-ray of zinc, respectively. Thus, the results suggested that zinc existed in the red pigment extracted from Parma ham. In contrast, the K_{α} X-ray peak of iron (6.4 KeV) was not detected and the K_{α} X-ray peak of magnesium (1.3 KeV) was hardly detected. These results revealed that the red pigment contained not iron but zinc. In addition to the results of mass analysis in previous studies, the red pigment was demonstrated to be zinc protoporphyrin IX.

Keywords: Parma ham; zinc; zinc protoporphyrin IX; scanning electron microscopy/energy dispersive X-ray microanalysis

1. Introduction

Parma ham, Italian traditional dry-cured ham, is manufactured without the addition of a curing agent such as nitrite or nitrate and the colour is not brought about by nitrosylmyoglobin. Wakamatsu, Nishimura and Hattori (2004) reported that the fluorescent red pigment extracted with 75% acetone from Parma ham was identified as zinc protoporphyrin IX by its fluorescent property and chromatographic behaviour and by results of electrical ion spray mass (ESI-MS) analysis.

It has also been shown in model systems that anaerobic conditions are suitable for the formation of zinc protoporphyrin IX and that endogenous enzymes as well as microorganisms may be involved in the formation of zinc protoporphyrin IX (Wakamatsu, Okui, Ikeda, Nishimura, & Hattori, 2004). The distribution of zinc protoporphyrin IX in Parma ham was shown by using autofluorescence (Wakamatsu, Odagiri, Nishimura, & Hattori, 2006). Adamsen, Møller, Laursen, Olsen & Skibsted (2006) found by fluorescent analysis that the red pigment was present not only in Parma ham but also in Iberian ham but that the pigment content in meat products cured with nitrite was very low. The content of zinc protoporphyrin IX increases throughout the processing and maturation of Parma ham (Adamsen, Møller, Parolari, Gabba & Skibsted, 2006). Møller, Adamsen, Catharino, Skibsted, & Eberlin (2007) recently showed by ESI-MS and TOF-MS analysis that zinc protoporphyrin IX was present not only in Parma ham but also in Iberian ham.

62 Although these results obtained by mass spectrum analysis are consistent
63 with zinc protoporphyrin IX, the presence of zinc in the red pigment has not been
64 demonstrated directly (Wakamatsu, Nishimura and Hattori, 2004; Møller,
65 Adamsen, Catharino, Skibsted, & Eberlin, 2007). In this study, we demonstrated
66 the presence of zinc in the red pigment extracted and purified from Parma ham by
67 scanning electron microscopy/energy dispersive X-ray microanalysis (SEM-EDX).

2. Materials and methods

2.1. Materials and chemicals

Parma ham was purchased from f.lli Galloni s.p.a. (Italy). Acetone was purchased from Kanto Chemical Co., Inc. (Tokyo, Japan).

2.2. Extraction and purification of Parma ham pigment

The extraction and purification of the pigment were carried out according to the method described by Wakamatsu, Nishimura & Hattori (2004). Minced Parma ham was homogenized in distilled water. After centrifugation, the supernatant was filtered through a filter paper. Three vol. of cold acetone was added to the filtrate and kept on ice for 15 min. After centrifugation, the supernatant was diluted 1:1 with distilled water. The mixture was applied to a disposable C18 column, Sep-Pak® Vac C18 Cartridge (12 cc/ 2g; Waters Co., MA U.S.A.) prewashed with methanol and distilled water. The column was washed with 37.5% acetone, and then the red pigment preparation was eluted with 75% acetone.

2.3. Elemental analysis by scanning electron microscopy/energy dispersive X-ray microanalysis (SEM-EDX)

Elemental analysis of the red pigment preparation was performed by scanning electron microscopy/energy dispersive X-ray microanalysis (SEM-EDX). The red pigment preparation from Parma ham was dried up using a centrifugal evaporator (CVE-2000, Tokyo Rikakiki Co., Ltd., Tokyo, Japan) and was fixed on an aluminium stub using carbon tape. The sample was coated with carbon and was analyzed with a scanning electron microscope (S-800, Hitachi Ltd., Tokyo, Japan) equipped with an energy dispersive X-ray micro-analyzer (EMAX-2000, Horiba Ltd., Kyoto, Japan). The sample was observed with an accelerating voltage of 20 KeV and a spectral resolution of 10 KeV per channel during 100 sec.

3. Results and discussion

We examined the presence of zinc in the red pigment preparation from Parma ham by using SEM-EDX analysis. SEM-EDX analysis makes it possible to carry out elemental analysis of a selected infinitesimal area under SEM observation. The spectrophotometric and fluorescent behaviours of the red pigment preparation were the same as those previously reported (Wakamatsu, Nishimura and Hattori, 2004; Møller, Adamsen, Catharino, Skibsted, & Eberlin, 2007) (data not shown). An SEM image of the red pigment preparation and the fluorescent X-ray spectrum of the square area are shown in Fig. 1. SEM-EDX analysis of the square area in the SEM image was carried out (Fig. 1A). Zinc has several energy values of fluorescent X-ray, and the main energy values are 8.630 KeV of K_{α}, 9.570 KeV of K_{β}, 1.012 KeV of $L_{\alpha 1}$ and 1.034 KeV of $L_{\beta 2}$. Large peaks were observed at about 2.3, 3.3 and 8.6 KeV in the fluorescent X-ray spectrum of the red pigment (Fig. 1B). The peak of about 8.6 KeV seems to be derived from K_{α} X-ray of zinc. Furthermore, the small peaks at about 1.1 KeV and 9.5 KeV seem to be derived from $L_{\alpha 1}$ and K_{β} X-ray of zinc, respectively. Thus, the results suggested that zinc existed in the red pigment extracted from Parma ham. In contrast, the K_{α} X-ray peak of iron (6.4 KeV) was not detected and the K_{α} X-ray peak of magnesium (1.3 KeV) was hardly detected. This means that the red pigment was neither an iron nor magnesium complex. The peaks at about 3.3 KeV and about 2.3 KeV seem to be derived from K_{α} X-rays of potassium and sulphate, respectively. Both are thought to be contaminations from Parma ham. Accordingly, our results

indicated that the red pigment shown as metalloporphyrin spectrophotometrically was a zinc-porphyrin complex.

Although the red pigment purified from Parma ham is nearly identical to zinc protoporphyrin IX presupposing the presence of zinc in previous studies using mass spectral analysis (Wakamatsu, Nishimura and Hattori, 2004; Møller, Adamsen, Catharino, Skibsted, & Eberlin, 2007), the presence of zinc in the red pigment has not been demonstrated directly. In this study, the presence of zinc demonstrated that zinc protoporphyrin IX (Fig. 2) exists in traditional dry-cured hams such as Parma ham and Iberian ham without addition of nitrite or nitrate.

4. Conclusions

SEM-EDX analysis revealed that the red pigment of Parma ham purified by solid-phase extraction contained not iron but zinc. The results of this study together with the results of mass spectral analysis in previous studies show that the red pigment is Zn protoporphyrin IX.

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159 Figure legends

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161

162 Fig. 1. SEM image (A) and SEM-EDX X-ray spectrum (B) of the red pigment
163 preparation from Parma ham. SEM-EDX analysis of the square area of the SEM
164 image was carried out. The sample was observed with an accelerating voltage of
165 20 KeV and a spectral resolution of 10 KeV per channel during 100 sec.

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167 Fig. 2. Structure of zinc protoporphyrin IX.

Figure 1

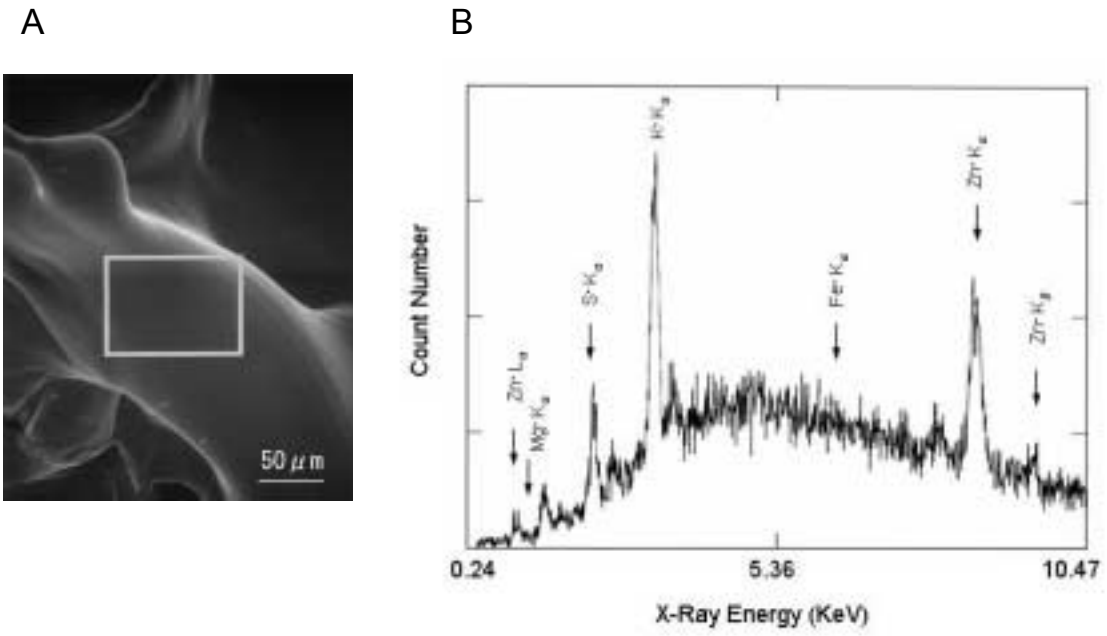

Fig. 1. SEM image (A) and SEM-EDX X-ray spectrum (B) of the red pigment preparation from Parma ham. SEM-EDX analysis of the square area of the SEM image was carried out. The sample was observed with an accelerating voltage of 20 KeV and a spectral resolution of 10 KeV per channel during 100 sec.

Figure 2

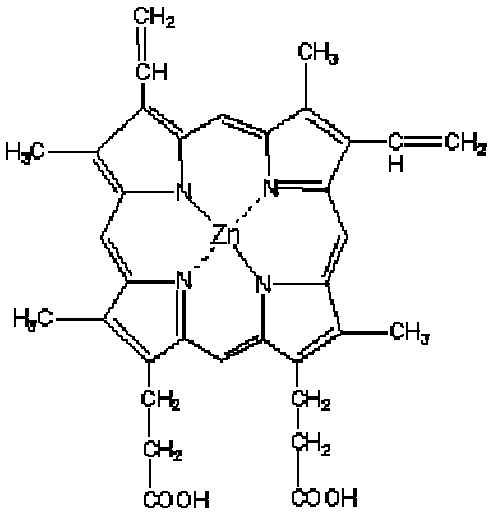

Fig. 2 Structure of zinc protoporphyrin IX