A Cause and Mechanism of Blue Discoloration of Canned Crab Meat—IV. Spectrophotometric Study of Blue Meat

Norio INOUE* and Terushige MOTOHIRO*

(Received April 27, 1970)

In the inspection of canned crab meat, the colour has up to now only been assessed organoleptically, whereas any systematic study of discoloration, in this case the development of a blue colour, requires an objective assessment. It has already been shown that crab haemocyanin can yield a dark greenish colour when it is heated with hydrogen sulphide,¹⁾ and it seemed possible to us that there might be a similarity in reflectance spectrum between the compound so formed and the blue meat of unacceptable canned crab.

The present paper describes spectrophotometric observations on blue and normal meats of canned crab and the reaction between crab haemocyanin and hydrogen sulphide.

Materials and Methods

A batch of raw king crab, *Paralithodes camtschatica*, caught in the Bristol Water in the summer fishing season was divided into two groups in a floating cannery. A group consisting of 5 crabs was packed in 25 parchment-lined 1/2 lb flat cans lacquered with zinc oxide at the inside surface (C-enameled) following the usual method. A second group consisting of 5 crabs was used for preparing haemocyanin solution as described in a previous paper.²⁾ Blue and normal meats were separated from the canned crabs as described in a previous paper.³⁾ A haemocyanin-sulphide complex was prepared as follows; the haemocyanin solution (2 ml) in a test tube was heated with 2 ml of hydrogen sulphide solution (44 mg%) for 15 min. at 100°C and cooled, and the coagulated material was ground in a mortar. As a control sample, the haemocyanin solution without hydrogen sulphide was heated for 15 min. at 100°C.

Red pigment in the epidermis was picked out by hand from the meat of the canned crab. Meat samples were then placed on filter paper, and any excess of water was removed. Three g were then inserted in a glass cell (diameter 2.0 cm), and the reflectance was measured within the range of wavelength 400 to 700 m μ . The blue meat was mixed with the normal meat in various proportions ranging 0–100% to make 3 g in total weight.

* Laboratory of Marine Food Technology, Faculty of Fisheries, Hokkaido University, Hakodate.
(猪上徳雄・元広輝重: 北海道大学水産学部食品製造学教室)

The haemocyanin-sulphide complex was mixed with the heat-coagulated haemocyanin prepared as described above. The percentage reflectances of the mixtures were measured at 550 $m\mu$. The colour intensity was calculated from the following equation.

Colour intensity = Percentage reflectance of normal meat at 550 $m\mu$ minus percentage reflectance of blue meat at 550 $m\mu$

or Colour intensity = Percentage reflectance of heat-coagulated haemocyanin at 550 $m\mu$ minus percentage reflectance of haemocyanin-sulphide complex at 550 $m\mu$

A Hitachi Perkin-Elmer 139 spectrophotometer fitted with diffuse reflectance apparatus was employed.

Results and Discussion

Reflectance spectra of blue and normal meats are illustrated in Fig. 1. A maximum reflectance was observed at 550–570 $m\mu$ in the sample of blue meat, but not in the sample of normal within the range studied. If the colour intensity of a blue meat sample was slight, the maximum reflectance at 550 $m\mu$ was not obvious, but the percentage reflectance decreased as the meat became more deeply coloured. A maximum reflectance was also found at 530–550 $m\mu$ in the sample of haemocyanin-sulphide complex, but not in the heat-coagulated haemocyanin (Fig. 2). Red pigment from the epidermis showed a minimum reflectance at 480–490 $m\mu$ (Fig. 3). The results in Fig. 1 and Fig. 2 indicated that the

Fig. 1. Reflectance spectra of the normal meat (A), slightly coloured blue meat (B) and strongly coloured blue meat (C) in canned king crab.

Fig. 2. Reflectance spectra of the heat-coagulated haemocyanin and haemocyanin-sulphide complex. Broken line --- heat-coagulated haemocyanin; continuous line — haemocyanin-sulphide complex.

Fig. 3. Reflectance spectrum of the red pigment of epidermis.

blue meat and the haemocyanin-sulphide complex yielded slight differences in the wavelengths of maximum reflectance. However, where the red epidermal pigment was added to the haemocyanin-sulphide complex, minimum and maximum reflectances were found at 480 $m\mu$ and 550–570 $m\mu$ respectively, closely resembling those of the blue meat (Fig. 4). Since the blue meat contained considerable amounts of the red pigment, the wavelength of the maximum reflectance of the blue meat seems to be longer than that of the haemocyanin-sulphide complex alone.

As shown in Fig. 1, the percentage reflectance of blue meat is decreased by an increase in the intensity of pigmentation. A linear relationship was found between the logarithm of blue meat content in normal meat and the colour intensity (Fig. 5). For meat to qualify as desirable, the colour intensity must be less than 10%, at which level it cannot be distinguished from normal. In the case of haemocyanin-sulphide complex, a linear

Fig. 4. Reflectance spectra of blue meat and haemocyanin-sulphide complex mixed with red pigment of epidermis. Broken line --- haemocyanin-sulphide complex mixed with red pigment in epidermis; continuous line — blue meat.

Fig. 5. Relationship between the blue meat content in normal meat and the colour intensity.

Fig. 6. Relationship between the haemocyanin-sulphide complex content in heat-coagulated haemocyanin and the colour intensity.

relationship was also found between the logarithm of haemocyanin-sulphide complex content in heat-coagulated haemocyanin and the colour intensity (Fig. 6). The relationship in Fig. 5 can be represented by the equation

$$y = 2.0e^{0.138x}$$

where y is the blue meat content of the sample and x the colour intensity. The relationship for Fig. 6 is

$$y = 2.1e^{0.138x}$$

where y is the content of haemocyanin-sulphide complex in the heat-coagulated haemocyanin and x again the colour intensity. There is a similarity between both equations which suggests that the colour intensity is related to the copper content combined with sulphide, and the analysis of percentage reflectance of the blue meat offers good possibilities for colour assessment of the blueing.

Summary

The reflectance spectra of blue meat and haemocyanin-sulphide complex showed maxima at 550–570 $m\mu$ and 530–550 $m\mu$ respectively. A decrease of the percentage reflectance is related to an increase of blueing. A linear relationship was found between the colour intensity and the content of copper combined with sulphide.

Acknowledgements

The authors are indebted to Prof. E. Tanikawa and Prof. K. Kobayashi of the Hokkaido University, Faculty of Fisheries, for valuable advice, and to Dr. R. M. Love of the Torry Research Station, Aberdeen, Scotland, for keen interest in these studies.

References

- 1) N. INOUE and T. MOTOHIRO: This Bull., **36**, 695–697 (1970).
- 2) N. INOUE and T. MOTOHIRO: *ibid.*, **36**, 692–694 (1970).
- 3) N. INOUE and T. MOTOHIRO: *ibid.*, **36**, 588–591 (1970).