Differential Scanning Calorimetry of Several Jellyfish Mesogloea

Takeshi Nagai,*1,† Moritsugu Hamada,*1 Norihisa Kai,*1 Yasuhiro Tanoue,*1 and Fumio Nagayama*2

*1Department of Food Science and Technology, National Fisheries University, Nagata-honmachi, Shimonoseki, Yamaguchi 759-65, Japan
*2Akita Junior College, Shimokitade, Akita 010, Japan

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Thermal properties of several jellyfish mesogloea were studied using the differential scanning calorimeter. As a result, the three endothermic peaks were shown for many jellyfish. The first, second, and third peak corresponded to myosin, sarcoplasmic proteins and/or collagen, and actin. Each transition temperature (Tm) in jellyfish were lower than those in mammals. Although the three endothermic peaks were shown for hydrozoan jellyfish, the highest Tm were lower than the lowest one for the other jellyfish. Only two peaks were shown for cubic jellyfish. It was suggested that the first and second peak corresponded to sarcoplasmic protein and/or collagen and actin.

Moreover, it did not related between the water temperature in the sampling occasion and the denaturation temperature of each protein in jellyfish.

Key words: differential scanning calorimetry, jellyfish, mesogloea, transition temperature, protein

Differential scanning calorimetry (DSC) is a useful technique to determine the thermodynamic data of food materials under some conditions to reflect commercial processing. Therefore, DSC has been used to determine the protein denaturation temperature and energy. Previous studies have reported the three transition stages in typical muscle proteins such as myosin and its subunits, sarcoplasmic proteins and collagen, and actin.1-3) These transition temperatures were 54-58, 65-67, and 71-83°. In fish, it is known that the stability of these proteins correlates with their environmental and body temperature. Moreover, myosins from cold-water fish denature easier than those of warm-water fish under the same conditions.4-6) There are many investigations using DSC in fish1-3,7-10) and animal muscle,11-15) but few have been in marine invertebrates.16,17) There are many more studies for jellyfish.18,19)

Some jellyfish are used in Chinese food owing to their unique textures. They are marketed as salted jellyfish. So far, there are a few rheological studies with respect to salted jellyfish during cooking. These jellyfish were used for this work in which some are used for food such as edible jellyfish and hydrozoan jellyfish, others are not used for food. As a result of the investigation of the physico-chemical properties in jellyfish mesogloea, the development of unused resources will advance and these jellyfish will be eaten as food in the future. The objective of this study was to examine the thermal properties of several jellyfish as measured by DSC.

Materials and Methods

Materials

Cubic jellyfish Carybdea rastoni, hydrozoan jellyfish Aequorea coerulescens, and moon jellyfish Aurelia aurita were caught in Hibiki Nada, Shimonoseki City, Yamaguchi Prefecture. Rhizostomous jellyfish Rhopilema asamushi were caught in Brisbane Bay, Australia. Edible jellyfish Stomolophus meleagris were caught in Senzaki Bay, Nagato City, Yamaguchi Prefecture. They were stored at -85° until used.

Differential Scanning Calorimetry

Differential scanning calorimetry (DSC) analysis was performed on a Seiko Instruments Inc DSC 100 under ambient pressure. A heating rate of 2°/min over the range 0-100°C was selected. Sample weights were accurately measured at 50 mg and the sample was placed in hermetically sealed aluminium pans. The pans were treated with the boiling water before use to avoid oxidation during measurement. Distilled water (50 mg) was used as a reference. The DSC thermograms were normalized from three replicates.

Results and Discussion

In Table 1, the temperature of the water in the sampling occasion are shown. The water temperature in the sampling occasion ranged from 26.0 to 26.6°. There was little difference in these values.

DSC measurements for several jellyfish were performed.
Table 1. Data on the temperature of the water in the sampling occasion

<table>
<thead>
<tr>
<th>species</th>
<th>temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>edible jellyfish</td>
<td>26.2</td>
</tr>
<tr>
<td>hydrozoan jellyfish</td>
<td>26.4</td>
</tr>
<tr>
<td>moon jellyfish</td>
<td>26.6</td>
</tr>
<tr>
<td>rhizostomous jellyfish</td>
<td>26.0</td>
</tr>
<tr>
<td>cubic jellyfish</td>
<td>26.5</td>
</tr>
</tbody>
</table>

Fig. 1. DSC thermograms of several jellyfish mesogloea. (a) cubic jellyfish, (b) rhizostomous jellyfish, (c) moon jellyfish, (d) hydrozoan jellyfish, (e) edible jellyfish.

To determine the denaturation temperature of the tissue components, the mesogloea was quickly cut, weighed, and sealed in hermetical aluminium pan.

The DSC thermograms of several jellyfish mesogloea are shown in Fig. 1. As a result, the DSC curve for cubic jellyfish showed two endothermic peaks. The first transition temperature was at 53.9 °C, and the second one was at 59.2 °C. However, the other species gave different thermograms. The DSC curve for other jellyfish exhibited three endothermic peaks. The transition temperature (Tm) values for edible jellyfish were at 44.4, 52.4, and 56.4 °C. Tm for hydrozoan jellyfish were at 30.4, 39.3, and 44.0 °C. Tm for moon jellyfish were at 46.0, 51.5, and 64.0 °C. Tm for rhizostomous jellyfish were at 44.8, 55.6, and 64.1 °C. As compared with the Tm among these jellyfish, the peak range in the lowest Tm was approximately similar among three jellyfish (edible jellyfish, moon jellyfish, and rhizostomous jellyfish). But for hydrozoan jellyfish, the peak area for the lowest was fairly different from other jellyfish. The peak area in the highest Tm for this jellyfish was smaller than that in the lowest of other jellyfish. These Tm values in the five jellyfish were summarized in Table 2.

In general, the DSC thermograms have three endothermic peaks in mammal and fish muscle tissues. Martens et al. reported that the denaturation temperatures of myosin, collagen, and actin were at about 40–60, 56–62, and 66–73 °C. Wright et al. reported that those of myosin, sarcoplasmic proteins, and actin were at 60, 67, and 80 °C. Stabursvik and Martens reported that those of myosin, connective tissue, collagen, sarcoplasmic proteins, and myosin, and actin were at 58, 65, and 77 °C. Moreover, Kijowski et al. reported that those of myosin, sarcoplasmic proteins, and actin were at 60, 70, and 80 °C.

On the other hand, Davies et al. studied about the myosin thermal stability in fish muscle. As a result, the Tm in cod were at 41.9 °C and the one in snapper were at 51.9 °C. With increasing pH and ionic strength, the snapper myosin transition decreased to that of cod myosin. Ogawa et al. reported the thermal stability of myosin in 10 species of fish. As a result, the denaturation process differed from species to species of fish. Some fish gave three endothermic peaks, others gave two. Furthermore, Mochizuki et al. reported that the Tm of raw “ika” mantle meat showed three major endothermic peaks at 50, 57, and 74 °C, and the first and second peaks corresponded with the denaturation of myosin and collagen, and third peak was that of actin.

The data from our investigation indicated that these jellyfish mesogloea had three major structural proteins. Excepting hydrozoan jellyfish, the first peak showed the denaturation temperature of myosin (44.0–46.0 °C), second peak corresponded that of sarcoplasmic proteins and/or collagen (51.5–55.6 °C), and third peak showed that of actin (56.4–64.1 °C). Although the three endothermic peaks were shown, it is not clear whether each endothermic peak corresponds to the major structural protein peak in hydrozoan jellyfish mesogloea. Moreover, there was no relation between the water temperature in the sampling occasion and the denaturation temperature of each protein. This work should be useful to understand the physico-chemical properties in jellyfish mesogloea.

Further work is planned to isolate the muscle constituent proteins and to examine the thermal properties.

References

2) E. Stabursvik and H. Martens: Thermal denaturation of proteins in...