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Differential Scanning Calorimetry of Fish and Shellfish Meat

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Thermal properties of five fish and shellfish meat proteins were studied using the differential scanning calorimetry (DSC). As a result, the main three endothermic peaks were shown for both fish and shellifish meats. The first, second and third peaks corresponded to myosin, sarcoplasmic proteins/or actomyosin complex and actin. The transition temperature (Tm) of fish and shellfish actin was lower than those of mammals. Saury and scallop meat showed a small endothermic peak within the temperature range of 36–39°C which corresponded by transition temperature of myosin tail and defined as low temperature endothermic peak (LTEP).

INTRODUCTION

Functional and textural characteristics of meats depend on their proteins mainly on myofibrils. This dependence is more important for fish muscle than mammalian muscle because of its low collagen content[1]. The information of the thermal behaviour of fish meat proteins would be useful and beneficial to the food processing industry. Several chemical techniques have been applied to study the properties and behaviour of fish meat proteins during heating. However, classical methods to measure protein denaturation provide only partial information on this phenomenon, and the extraction and purification process might affect the native state of the proteins. Differential scanning calorimetry (DSC) provides a direct and simple method to study the thermal transition of muscle protein without chemical or mechanical destruction[2].

DSC can be used to study individual proteins in mixed systems such as meat, provided that the various proteins are denatured in different temperature ranges, yielding distinguishable peaks. Also muscle has a complex protein structure and several changes occur during heating which can be monitored by DSC. DSC is based on the principle that whenever a material undergoes a physical or chemical change heat is either liberated or absorbed. Since heating is one of the most important steps in the processing of foods of muscular origin, many studies have

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been published on the thermal behaviours such as coagulation, gelation and denaturation of meat, fish meat and their component proteins[3]. This study was conducted to detect the thermal transition temperatures for denaturation of some fish and shellfish meat proteins.

EXPERIMENTAL

Frozen block blue marlin *Makaira mazara* and frozen whole saury *Cololabis saira* were obtained from Misaki, Kanagawa Prefecture and Shiogama, Miyagi Prefecture, Japan, respectively. Fresh skipjack *Katsuwonus pelamis*, scallop *Patinopecten yessoensis*, and prawn *Penaeus japonicus* were purchased from local fishmongers, Tokyo, Japan.

Differential scanning calorimetry (DSC) of fish and shellfish meats were performed on a Perkin-Elmer, Model DSC-7 (Perkin-Elmer Corp.) over 30–90°C range at heating rate of 5°C/min. Nitrogen was used as the purge gas. Sample weight ranged from 13 to 15 mg and the samples were hermetically sealed in aluminum pans to avoid moisture loss during heating. An empty pan was used as the reference. The base line and transition temperature (Tm) were identified by the method of Parsons and Patterson[4]. The determination of each sample was repeated three times.

RESULTS AND DISCUSSION

The DSC thermograms of investigated fish and shellfish meats are shown in Fig. 1. All the meats had main three characteristic endothermic peaks in DSC thermogram within the temperature range of 30–90°C. It is apparent that fish meats have the same DSC profile as higher vertebrate meats, being composed of myosin, sarcoplasmic proteins and actin[5]. The main difference is that major actin transition in fish meats occurs about 8–10°C below that of the others. Similar profiles have been reported with other fish species[3, 6–9]. The main components of the first transition in the DSC thermogram for fish and shellfish meats are ascribed to myosin in various other fish species[3, 10, 11, 12]. The second transition peak is due to the denaturation of the sarcoplasmic proteins and actomyosin complex[12, 13]. The third transition peak is due to actin denaturation[3, 5]. Since there is a small amount of connective tissue in fish muscles[1], the endothermic transition might be assigned to the denaturation of myofibrillar and sarcoplasmic proteins.

However, in shellfish meat actin transition temperature was almost similar to higher vertebrate meats. Akahane *et al.*[3] reported higher heat stability of shellfish actin than fish. They showed that the pure actin of scallop adductor muscle had heat stability higher than 77°C. Furthermore, Mochizuki *et al.*[14] reported that the Tm of raw cuttle fish and squid mantle meat showed also three major endothermic peaks at 50°, 58° and 78°C, and the first and second peaks corresponded with the denaturation of myosin and collagen, and the third was the actin. The data from out study (Fig. 1) indicate that two major Tm for myosin and sarcoplasmic proteins are approximately similar in both fish and shellfish meats. Saury and

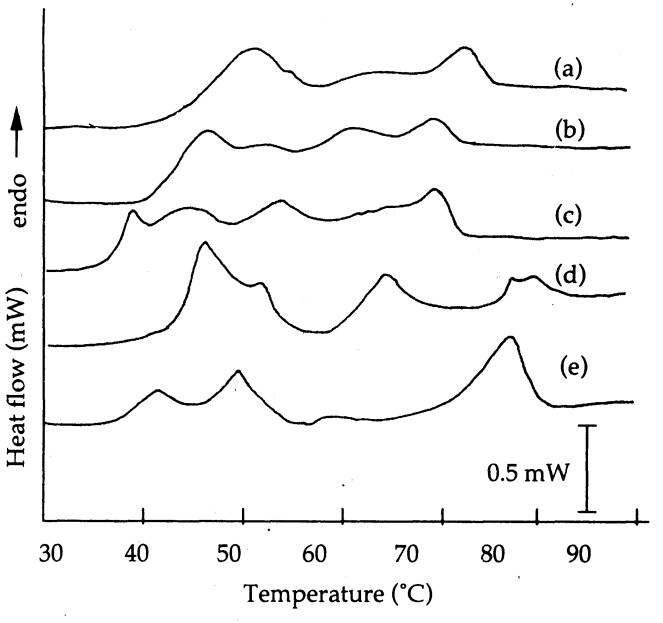

Fig. 1. DSC thermograms of fish and shellfish meats: (a) blue marlin, (b): skipjack, (c) saury, (d) prawn, (d) scallop. Scanning rate: 5°C/min.

scallop meats showed a small endothermic peak within the temperature range of 36–39°C. This small peak observed in some animal habitat at relatively low temperature is defined as low temperature endothermic peak (LTEP). The LTEP of sharks is considered to be caused by the heat denaturation of myofibrillar proteins[12]. Hastings *et al.*[8] suggested that the LTEP of cod protein around 35°C might correspond to the first transition of myosin and collagen. However, other investigators concluded that this LTEP over the temperature range of 36–39°C corresponds to the Tm of their respective myosin tail[3, 10, 15].

The Tm values of the five fish and shellfish meats were summarized in Table-1. The Tm values for blue marlin and skipjack meats are closely related to each other, these could be the reason that both fish are tuna group. Their Tm values for myosin between 47 to 50, 62 to 63 for sarcoplasmic proteins/or actomyosin complex and 70 to 73 for actin. Similar results were also observed in black marlin by Lo *et al.*[10] In saury meat, all three Tm were a little bit lower than that of blue marlin and skipjack meats. On the other hand two shellfish showed similar Tm values. This work would be useful to understand the physico-chemical properties of fish and shellfish proteins.

TABLE-1
THREE MAJOR DSC ENDOTHERMIC PEAK MAXIMA OF FISH AND SHELLFISH MEATS

Sample name	Transition temperature (°C)		
Blue marlin	50.4 ± 0.2	63.9 ± 0.4	73.3 ± 0.5
Skipjack	47.2 ± 0.1	62.3 ± 0.2	69.8 ± 0.3
Saury	44.9 ± 0.2	54.4 ± 0.2	70.1 ± 0.3
Prawn	47.6 ± 0.3	65.1 ± 0.1	80.2 ± 0.2
Scallop	49.7 ± 0.3	60.5 ± 0.1	77.9 ± 0.1

*Mean ± standard deviation for three replicates.

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