Proximate and Protein Compositions of Requiem Shark Muscle

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Proximate and protein compositions of the ordinary muscle of requiem shark *Triakis scyllia* were examined. The proximate composition of the dorsal muscle was: moisture 76.0%, crude protein 24.9%, crude fat 2.7%, and crude ash 1.3%. The protein content corrected for urea (5.4 mgN/g) and for non-protein nitrogenous compounds (11.2 mgN/g) was 21.5% and 17.5%, respectively.

The protein compositions of the dorsal and ventral muscle remained unchanged essentially through *pre*-, *in*-, and *post-rigor* stages: In the dorsal part, sarcoplasmic 22.1-25.9% (av. 24.5%), myofibrillar 60.1-66.8% (63.2%), alkali-soluble 4.1-5.5% (4.7%), and stroma fraction 6.5-8.9% (7.6%). In the ventral part, corresponding data were 20.4-26.1% (24.2%), 58.4-67.2% (63.5%), 2.9-9.2% (6.1%), and 3.8-8.2% (6.1%), respectively. The protein composition of each muscle did not show any significant changes after a 2-week frozen storage at -20°C.

Marine elasmobranchs osmoregulate the blood and other body fluids in conformity to the environment, by means of nitrogenous compounds such as urea and trimethylamine oxide.¹⁻⁴⁾ The urea levels up to 460 mM have so far been determined in their body fluids.¹⁾ After their death, urea is gradually decomposed into ammonia, lowering the meat quality.⁵⁾

Since urea is a protein denaturant, proteins of an elasmobranch are supposed to be urea-resistant, or be protected from denaturation by some mechanism(s). In fact, the hemoglobins of the elasmobranch fishes such as *Raja eglanteria*, *Torpedo nobiliana*, etc., were found to be more urea resistant than human hemoglobin.⁶⁾ No corresponding studies have been carried out on muscle proteins of elasmobranchs.

The present series of study was started under the above situations, and this paper deals with the proximate and protein compositions of the muscle of requiem shark.

Materials and Methods

Materials

Live specimens of the requiem shark, "do-chizame" *Triakis scyllia* (4.6 kg in average body weight) were supplied from the Enoshima Aquarium. After decapitation, dorsal and ventral parts of the ordinary muscle were carefully excised and

analyzed for proximate and protein compositions as described below. In addition, the blood serum prepared as usual and the liver were assayed for urea. The dorsal muscle of sea bass *Lateolabrax japonicus* (0.9 kg in body weight) was analyzed for protein composition for comparison.

Analytical Methods

Urea was determined enzymatically by the method of GUTMANN and BERGMAYER.⁷⁾ Proximate composition was determined as usual on the dorsal muscle from requiem shark. Protein composition was assayed by the method reported previously,⁸⁾ on the muscles of shark and sea bass in *pre*-, *in*-, and *post-rigor* stages. A portion of the muscle of each fish was stored at -20°C for 2 weeks, and similarly analyzed.

Results and Discussion

Urea

Urea concentrations of requiem shark were 194 mM in dorsal muscle, 195 mM in blood serum, and 175 mM in liver. A range from 200 to 460 mM has so far been reported for the tissues of some marine elasmobranchs such as *Raja stabuliformis*,¹⁾ *Norcine brasiliensis*,¹⁾ and *Squalus acanthias*.⁹⁾

Proximate Composition

The proximate composition of shark dorsal muscle was moisture 76.0%, crude protein 24.9%,

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crude fat 2.7%, and crude ash 1.3%, the total being 104.9%. When corrected for urea nitrogen (5.4 mg/g, as calculated from the above datum) and for non-protein nitrogen (11.2 mg/g, as described below), the protein contents of 21.5 and 17.5% were obtained, respectively. The proximate compositions thus corrected resemble those of sluggish teleostean fishes such as cod and plaice featuring in a low fat content.¹⁰⁾

The urea nitrogen to non-protein nitrogen ratio was calculated to be 48%. The values of 47–60% have so far been reported for various marine elasmobranchs.¹¹⁾

Protein Composition

The protein compositions of both shark muscles in various stages are shown in Table 1. Non-protein nitrogen contents of the dorsal and ventral muscles were 11.2 and 12.3 mgN/g, respectively, on an average. These values are considerably higher than that of sea bass muscle, 2.9 mgN/g (refer to Table 2). The differences can reasonably be accounted for by those of urea.

As shown in Table 1, the protein nitrogen level as well as protein composition of shark muscle did not differ widely between both muscles, and among the *pre*-, *in*-, *post-rigor*, and frozen sam-

Table 1. Protein compositions of dorsal and ventral muscles from *pre*-, *in*-, *post-rigor*, and frozen requiem shark samples

Sample	Part of muscle	Non-protein nitrogen	mgN/g muscle			
			Protein nitrogen			
			Sarcoplasmic	Myofibrillar	Alkali-soluble	Stroma
<i>Pre-rigor</i>	Dorsal	11.1	5.8 (22.1)* ¹	17.5 (66.8)	1.2 (4.6)	1.7 (6.5)
	Ventral	13.1	5.5 (20.4)	17.5 (65.0)	1.7 (6.3)	2.2 (8.2)
<i>In-rigor</i>	Dorsal	11.2	6.9 (25.5)	16.3 (60.1)	1.5 (5.5)	2.4 (8.9)
	Ventral	12.6	6.5 (26.0)	14.6 (58.4)	2.3 (9.2)	1.6 (6.4)
<i>Post-rigor</i>	Dorsal	11.1	6.3 (25.9)	15.2 (62.6)	1.0 (4.1)	1.8 (7.4)
	Ventral	11.4	6.2 (26.1)	16.0 (67.2)	0.7 (2.9)	0.9 (3.8)
Frozen* ²	Dorsal	11.5	7.0 (25.5)	15.6 (56.7)	1.8 (6.5)	3.1 (11.3)
	Ventral	12.0	5.9 (23.8)	16.8 (67.7)	0.7 (2.8)	1.4 (5.6)

*¹ Numbers in parenthesis represent percentage distribution.

*² Kept frozen at -20°C for 2 weeks.

Table 2. Protein compositions of dorsal muscle from *pre*-, *in*-, *post-rigor*, and frozen sea bass samples

Sample	Non-protein nitrogen	mgN/g muscle			
		Protein nitrogen			
		Sarcoplasmic	Myofibrillar	Alkali-soluble	Stroma
<i>Pre-rigor</i>	3.0	7.0 (26.7)* ¹	14.4 (55.0)	3.7 (14.1)	1.1 (4.2)
<i>In-rigor</i>	3.0	7.2 (28.0)	16.7 (65.0)	1.0 (3.9)	0.8 (3.4)
<i>Post-rigor</i>	2.6	6.5 (24.8)	17.5 (66.8)	1.3 (5.0)	0.9 (3.4)
Frozen* ²	3.2	7.3 (26.0)	18.8 (66.9)	1.0 (3.6)	1.0 (3.6)

*¹ Numbers in parenthesis represent percentage distribution.

*² Kept frozen at -20°C for 2 weeks.

Fig. 1. Changes in protein composition of the ordinary muscles from requiem shark, sea bass, and sardine.⁸⁾ A, *pre-rigor*; B, *in-rigor*; and C, *post-rigor* stage; and D, after a 2-week frozen storage at -20°C . Symbols in the figure are; sarcoplasmic Δ , myofibrillar $\circ$, alkali-soluble $\bullet$, and stroma protein fraction $\square$.

ples. The protein nitrogen level (23.8–27.5 mgN/g) was comparable to that of sea bass, 25.7–28.1 mgN/g (Table 2).

The protein composition of shark dorsal muscle in the three *rigor* stages was sarcoplasmic 22.1–25.9% (av. 24.5%), myofibrillar 60.1–66.8% (63.2%), alkali-soluble 4.1–5.5% (4.7%) and stroma 6.5–8.9% (7.6%). The protein composition of the ventral part was 20.4–26.1% (av. 24.2%), 58.4–67.2% (63.5%), 2.9–9.2% (6.1%), and 3.8–8.2% (6.1%), respectively. Both muscles of the shark exhibited similar protein compositions after the frozen storage, as shown in Table 1.

The sarcoplasmic protein content (20.4–26.1%) was roughly comparable to that of sea bass (24.8–28.0%) and other sluggish teleosts (18–31%),¹²⁾ but much lower than that of sardine (34.7–39.4%).⁸⁾ It is noteworthy that the stroma content of requiem shark muscle (3.8–11.3%) is comparable to those of other elasmobranchs (7–12%),^{12,13)} and clearly higher than those of sea bass (3.1–4.2%) and other teleosts (2–4%).^{12,14)}

Changes in the protein composition of both shark muscles through *rigor* stages and after the frozen storage are illustrated in Fig. 1 for detailed comparison. The corresponding data for sea bass and sardine dorsal muscle⁸⁾ are also included in the figure. In requiem shark dorsal muscle, myofibrillar protein accounted for 66.8% of the total in *pre-rigor*, and then decreased to 60.1% in *in-rigor* stage, with some concomitant increase of sarcoplasmic and alkali-soluble fractions. The dorsal muscle, when kept frozen, showed the lowest myofibrillar (56.7%) and the highest

stroma level (11.3%). The ventral muscle showed the lowest myofibrillar level in *in-rigor* stage, but the highest after the frozen storage.

In contrast to those data for requiem shark muscles, sea bass muscle showed the lowest myofibrillar and the highest alkali-soluble levels in *pre-rigor* stage, no significant changes occurring among *in-rigor*, *post-rigor*, and frozen samples. As seen in Fig. 1, the myofibrillar protein level of sardine muscle is fairly constant through all these samples.⁸⁾

Further investigations are now in progress to characterize elasmobranch muscle proteins.

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