NOAA TECHNICAL MEMORANDUM NMFS-SEFC-83

SELENIUM LEVELS IN YELLOWFIN TUNA (THUNNUS ALBACARES) AND SHARKS FROM THE CAROLINAS

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U.S. DEPARTMENT OF COMMERCE
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ABSTRACT

A limited survey of locally available finfishes was undertaken to satisfy requirements for a source of selenoproteins for an ongoing selenium (Se) chemical form research project. Included in these requirements was the availability of a source tissue which contained a Se concentration in excess of 5 µg/g. Potential species were chosen on the basis of values reported in the literature for Se in selected tissues. The Se content was determined for several species of shark and yellowfin tuna (Thunnus albacares). The shark species observed to contain the highest liver Se concentrations were sandbar shark (Carcharhinus plumbeus) (15.2 µg/g), blacktip shark (Carcharhinus limbatus) (4.4 µg/g) and great hammerhead shark (Sphyrna mokarran) (3.0 µg/g). Yellowfin tuna samples from North Carolina also contained high liver Se concentrations, 9.7 µg/g. However, samples of yellowfin tuna caught off the coast of South Carolina contained a mean liver Se concentration of only 0.48 µg/g. Both sandbar shark and yellowfin tuna met the initial criteria as source tissue for the Se chemical form project.

INTRODUCTION

The selenium (Se) content of many species of commercially available fish has been reported in the past. Levels of Se in muscle tissue for most species are usually well below the 1 μg/g level on a wet weight basis (Hall et al. 1978). Selenium levels are generally higher in liver tissues. In the NMFS survey of trace elements in the fishery resource (Hall et al. 1978), species such as albacore (Thunnus alalunga), bigeye (Thunnus obesus) and yellowfin tuna (Thunnus albacares), and great hammerhead shark (Sphyrna mokarran) were occasionally observed to contain liver Se levels in excess of 10 μg/g. No species were found with muscle Se levels above 2 μg/g.

As one phase of our current Se chemical form research[1/] (Braddon 1981), several species of shark and yellowfin tuna (sampled from two areas) were surveyed for Se content. Requirements for that study dictated that we find fish which contained elevated tissue Se levels in excess of 5 μg/g, a soluble Se fraction derived from that tissue which contained greater than 50% of the original Se and greater than 25% of the soluble Se in a seleno-protein or seleno-peptide form. Analysis of data reported in the literature had led to the belief that shark or tuna liver would yield a conveniently high Se concentration. Therefore, we undertook the collection and chemical analyses of fresh shark and tuna livers from locally available species. Also included in the analyses were two yellowfin tuna livers obtained from North Carolina.

1/ Braddon, S.A. and C.R. Sumpter. Manuscript in preparation. The Isolation and Purification of a Unique Selenoprotein from Yellowfin Tuna (Thunnus albacares) Liver.

MATERIALS AND METHODS

Sample collection: Fresh liver and muscle samples of shark and tuna were collected during the weigh-in for several local fishing tournaments held in Charleston, South Carolina. Additional yellowfin tuna livers were obtained from boats fishing out of Oregon Inlet and Morehead City, North Carolina. The samples were bagged in plastic and kept on ice prior to freezing. Samples of shortfin mako (Isurus oxyrinchus) and blue shark (Prionace glauca) were collected and frozen immediately during an extensive cruise off the southeastern coast of the United States.[2/]

Selenium Analysis: Se analysis was performed by a selenium hydride generation atomic absorption method using a Varian Model 5 atomic absorption spectrophotometer[1,3/]. A certified atomic absorption standard for Se (Fisher Scientific, Inc.) was used to verify a detection limit of 30 ng and to obtain a standard curve.

Mercury Analysis: Mercury (Hg) concentration was determined by a standard cold vapor technique following digestion and oxidation using a Coleman mercury analyzer (MAS 50) (Hatch and Ott 1968, Uthe et al. 1970, Uthe 1971). Johnson-Matthey Spec-pure $HgCl_2$ was used to obtain a standard curve and a detection limit of 50 ng.

2/ These samples were collected by a joint team of NMFS scientists and the crew of a Polish high-seas trawler, the Wieczno.

3/ Reference to trade names in this publication does not imply endorsement of commercial products by NMFS.

RESULTS AND DISCUSSION

Data presented in Table 1 are reported in micrograms Se or Hg per gram wet weight of the tissue analyzed. The analyses were performed in duplicate, and the data used for determination of standard error (SE) are the means of the duplicate determinations for each sample. The value n refers to the number of individual samples analyzed for each species and tissue.

Comparison of the liver Se levels with those for the limited selection of muscle samples analyzed (Table 1) showed them to be consistently higher for each of the species examined. The muscle values, which range from 0.12 to 0.28 μg Se/g tissue, are in accord with those reported previously for marine fish (Glover 1979, Luten et al. 1980, Hall et al. 1978). Although these muscle values (Table 1) are lower than those reported by Hall et al. (1978) for yellowfin tuna caught off both Hawaii and California, the difference may reflect local environmental and dietary differences.

The highest Se content for shark livers was observed in two sandbar sharks (Carcharhinus plumbeus); the individual concentrations were 22.5 and 7.9 μg Se/g tissue (Table 1). The first of these two animals appeared to be in an emaciated condition at the weigh-in, possibly due to recent parturition. This condition of reduced total body weight (as adjudged by expected weight for length) may have contributed artificially to the elevated Se level of the liver. Both blacktip (Carcharhinus limbatus) and great hammerhead shark livers had elevated Se levels as compared to the

average value obtained from the remaining shark livers analyzed. The values determined for blacktip and great hammerhead livers were 4.4 and 3.0 μg Se/g respectively, well above the mean value of 0.54 μg Se/g liver observed for the remaining shark species analyzed. A correlation could not be drawn between characteristic habits of a specific shark species and the observed Se levels in its tissues. The measured concentrations of Se are consistent with those reported by Hall et al. (1978) for these species.

Analysis for Se content of yellowfin tuna livers revealed an interesting difference between the two groups sampled (Table 1). Livers obtained from fish caught off the North Carolina coast had considerably higher Se levels (9.67 ± 2.39 μg/g) than those obtained from fish caught off the South Carolina coast (0.48 ± 0.03 μg/g). It should be pointed out that the elevated liver Se levels of the North Carolina yellowfin tuna correlate well with the data reported by Hall et al. (1978) on 21 yellowfin tuna caught off California and Hawaii, which had liver Se levels of 10-20 μg/g. A genetic predisposition to Se accumulation is not a likely explanation for the differences in the two tuna groups since different stocks of yellowfin tuna are not known to exist off the coast of the Carolinas. However, it is possible that the continuous consumption of a diet greatly different in Se content could account for the observed Se accumulation pattern. Such a dietary component has not been identified.

Evidence presented in a study of freshwater fish in Canada supports the hypothesis that a substantial dietary difference may influence uptake of Se by two different populations of the same

species. Speyer et al. (1980) reported a comparative study conducted on two northwestern Quebec lakes; the levels of Se were determined for northern pike (Esox lucius), superficial sediments, and water obtained from the two lakes. The data revealed a close correlation between the elevated Se level in the superficial sediment of one lake bottom and elevated Se muscle levels of pike resident to the lake. The mean sediment Se concentrations reported were 7.2 and 0.5 mg/kg for the two lakes whereas the mean Se levels in muscle tissues of resident pike were 2.0 and 0.2 mg/kg for the same two lakes respectively. It is important to note that the Se concentration in the water of both lakes was at or below the reported detection limit of 0.1 μg Se/l. From these data one concludes that the elevated Se muscle levels may be attributed to a food source linked to the lake sediments, rather than to uptake from the water. It is also interesting that the Se tissue concentrations did not vary with fish size, indicating that Se was accumulated in a homeostatic manner dependent upon environmental conditions, rather than by a cumulative deposition.

Another explanation for the apparent population difference observed in our results on yellowfin tuna is the influence of an abnormal concentration of water-borne Se. Such a condition could arise from a localized source of pollution in the coastal waters. This idea finds some support in the work of Hodson et al. (1980) who have studied rainbow trout (Salmo gairdneri) under controlled conditions of Se exposure. The trout, when exposed to elevated concentrations of water-borne Se (53 μg/l vs 0.4 μg/l for control), accumulated Se in their livers at a level five fold greater than

control fish. The reported carcass (muscle, bone, skin) levels for this study were two fold greater in treated than in control fish. The authors suggest that trout regulate their tissue Se levels through uptake and retention at low waterborne concentrations, and uptake and excretion at high waterborne concentrations. The results suggest that the fish were not able to maintain Se homeostasis at a waterborne Se level of 0.4 μg/l, that used for the control group. As a result, the control fish exhibited artificially low Se carcass levels as compared to the treated group which was exposed to a moderate waterborne Se concentration of 53 μg/l. Their results also suggest that a strong relationship exists between waterborne Se levels and the organs involved in excretion. Thus, liver Se levels should be elevated upon exposure to high concentrations of waterborne Se.

Liver tissue collected from both sandbar shark, and yellowfin tuna from North Carolina contained sufficiently elevated Se levels to meet the needs of the Se chemical form research project. Tuna liver was selected as source tissue in preference to the shark liver. This was due to the high oil content (> 50% total weight) of the shark liver, the presence of which was considered to be a detriment to column chromatographic procedures used in that project.

Mercury analyses were performed incidently on both yellowfin tuna liver and muscle samples. The mean values were 0.22 μg Hg/g for liver and 0.18 μg Hg/g for muscle (Table 1). These values

correspond very closely to the values of 0.2-0.3 μg Hg/g for liver and 0.1-0.2 μg Hg/g for muscle reported by Hall et al. (1978) for the same species.

In conclusion, the Se levels in several species of shark and two sample groups of yellowfin tuna have been determined. As predicted from the results of other studies, several of these species contained elevated levels of Se in their liver tissue. The observed Se concentrations for liver and muscle from both shark and tuna were generally found to be consistent with those levels reported by other investigators. Mercury values for yellowfin tuna tissues were also found to be consistent with those previously reported. An apparent trend toward different levels of Se liver accumulation in yellowfin tuna from two separate geographical areas warrants further investigation.

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TABLE 1. Selenium and Mercury Levels in Several Species of Shark and in Yellowfin Tuna.

Species	Tissue	n	Se(μg/g)± SE	Hg(μg/g) ± SE
SHARK:				
Blacktip, *Carcharhinus limbatus*	liver	2	4.45 ± 1.35	
Great Hammerhead, *Sphyrna mokarran*	liver	2	3.00 ± 1.30	
Tiger, *Galeocerdo cuvieri*	liver	1	0.70	
Sandtiger, *Odontaspis taurus*	liver	1	0.50	
Sandbar[1], *Carcharhinus plumbeus*	liver	1	22.5	
	liver	5	7.90	
Shortfin Mako, *Isurus oxyrinchus*	liver	5	0.78 ± 0.06	
	liver	5	0.45 ± 0.09	
	muscle	5	0.20 ± 0.03	
Blue, *Prionace glauca*	liver	6	0.96 ± 0.03	
	liver	5	0.55 ± 0.10	
	muscle	7	0.12 ± 0.05	
TUNA				
Yellowfin, *Thunnus albacares*	liver	11	0.48 ± 0.03	0.22 ± 0.03
	liver[2]	2	9.67 ± 2.39	
	muscle	2	0.28 ± 0.06	0.18 ± 0.08

1 The two sandbar shark had total body weights of 48 and 59 kg respectively with liver weights of 2.3 kg and 5.4 kg while their lengths were identical. The shark that contained the higher Se liver level of 22.5 μg/g was in an emaciated state as evidence by outward appearance in addition to the observed reduced body and liver weights.

2 Samples obtained in North Carolina.