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Nutritional evaluation in five species of tuna

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Abstract

Proximate composition was determined in different body parts (skin,white muscle, red muscle, head muscle and belly flap) of five species of tuna; *Katsuwonus pelamis* (skipjack, balaya,) , *Thunnus albacares* (yellow fin tuna, kellawalla), *Auxis rochei* (Bullet, tuna, ragoduwa), *Auxis thazard* (frigate tuna, alagoduwa) and *Euthynnus affinis* (kawakawa, attawalla,) obtained from the Negombo fish landing site. Fatty acid profiles were also analyzed in the skin, red and white muscle of the five species. No significant differences between the tuna species were observed with respect to protein, total fat, and moisture contents. The ash content in Frigate tuna and Kawakawa were significantly higher than the other species. The muscle tissue in all the species was rich in protein (20-25%) and low in fat (<2%). The skin of all the species recorded high protein (27-32%) and lipid (6-8%) levels. The moisture content was low in the skin compared to the other tissues. All five species of tuna studied here recorded less SFA (11-33%) and more PUFA (50-74%) in the muscle tissues. The MUFA content in muscle tissue ranged from 8-25% and all the species contained both EPA (eicosapentaenoic acid, C20:5n-3) (2-19.7%) and DHA (docosahexaenoic acid, C22:6n-3) (4-42%) in varying amounts.

Key words: Tuna, proximate composition, n-3 fatty acids, n-6 fatty acids, EPA, DHA

Introduction

Nutrition has been cited as one of the primary reasons why consumers are attracted to seafood (Gall *et al*, 1983). They also provide a good balance of proteins, lipids, vitamins and minerals (Edirisinghe *et al*, 2000). Edible fish muscle normally contains about 18% protein, 1-2% ash and the balance 80% of the wet weight of muscle is made up of lipid and water (Ackman, 1995).
Like most animal foods, seafood proteins have excellent nutritive value. Fish protein contains all the essential amino acids and it is highly digestible. (Jhaveri *et al*, 1984). In terms of nutritive value, fish protein ranks above

casein (Haard 1995; Snook, 1984). Fish is the chief source of animal protein in the cereal-based diet of Sri Lankans (Nathanael *et al*, 1997).

Lipids have been considered as a key energy source for growth metabolism, visceral organs and muscle functions. But now, marine lipids are receiving increasing attention as a source of C20 and C22 carbon omega 3 polyenoil fatty acids which have profound implications for health and disease (Uauy-dagach and Valenzuela, 1992).

The unique feature that differentiates lipids of marine species from those of land animals is the presence of long chain PUFA, namely eicosapentaenoic acid (EPA C20:5 ω-3), docosahexaenoic acid (DHA C22:6 ω-3) and to a lesser extent, docosapentaenoic acid (DPA C22:5 ω-3) (Shahidi, 1998), which are important in the prevention and treatment of cardiovascular diseases, hypertension, arthritis, other inflammatory and autoimmune disorders, and cancers (Jones, 2002).

Anatomical position of the flesh sampled is an important factor because nutrients are not distributed evenly in all the body parts of the fish. Lipid content has been found to vary from 2% to almost 30% depending on the area of the body being sampled (Porter, 1992). Red or blood meat has been found to contain more fat and less protein than white meat (Geiger. and Borgstrom, 1962). The major portion of minerals in the fish body is distributed in skeletal tissues. Generally most of the bones and other skeletal tissues of fish are removed prior to consumption.

Tunas are among the largest, most specialized and commercially important of all fishes. Belonging to the genus Thunnus of the family Scombridae, they are found in temperate and tropical oceans around the world and account for a major proportion of the world fishery products (Lee *et al*, 2005).

In the present study, moisture, ash, total fat, and protein contents of five species of tunas namely; *Katsuwonus pelamis* (skipjack, balaya,) , *Thunnus albacares* (yellow fin tuna, kellawalla), *Auxis rochei* (Bullet, tuna, ragoduwa), *Auxis thazard* (frigate tuna, alagoduwa) and *Euthynnus affinis* (kawakawa, attawalla,) were determined in different body parts (skin, red muscle, white muscle, head muscle and belly flap) and the fatty acid profiles of the skin, red muscle and white muscle of these five species of tuna were also determined.

Sample size and the average size (Fork length) of the fish are given in table 1.

Materials and Methods

Fresh fish samples purchased from Pitipana, Negombo fish landing site were packed in ice and transported to the laboratory from July 2006 to April 2008. Samples of skin, belly flap, red, white and head muscles were separated to determine moisture, ash, total fat, and protein contents in each species respectively. Moisture content was determined by oven drying at 105 °C and the ash content of each sample was determined by using the muffle furnace at 550°C. Total fat and protein contents were determined by Majonnier method and Kjeldhal method respectively (Kirk and Sawyer, 1991). Then oils were extracted from the Bligh and Dyer method and the Fatty Acid Methyl Esters (FAMEs) were prepared by sodium methoxide method. The methyl esters of each fatty acid were then analyzed by Gas chromatography (Agilent, 4890 D, Innowax,) (Temperature; injector 270°C and detector 250°C, the oven was first maintained at 170°C and then programmed to225°C at the rate of 1°C/minute) The chromatographic peaks were then identified by comparison of the retention time with cod liver oil as standard and GLC 411 as internal standard. Percentages of each fatty acid was calculated as a percentage of FAMEs. Statistical differences between species and within species were determined at 5% level using One-Way variance of analysis (ANOVA) Minitab version 14.

Results and Discussion

From table 1 it is observed that the highest constituent in all the samples was moisture. The average moisture content did not vary significantly between the tuna species. The skin contained significantly ($p<0.05$) less moisture (58-60%) compared to the other body parts which contained between 69- 74%. Edirisinghe *et al* (2000) had reported higher values (69-80%) for of moisture content of some marine fish. Jayasinghe (1996) reported values for fresh water species in the range of 60-84%.

No significant differences in the average protein content were observed between the species. But the protein content of the skin was significantly higher ($p<0.05$) than the other body parts in all the tuna species (Table 1) and ranged from 27-32%. The protein content in the red muscle, white muscle and head muscle were 20-25%, 20-23% and 20-25% respectively. There were no significant differences in the protein contents among red, white and head muscles. According to Sidwell (1981) the belly flap recorded significantly low amount of protein (16-17%) than the other body parts. Most fin fish muscle contains about 18-22% protein and the average for 540 analyses made was 18.5±3.6%. In the present study protein values recorded for the tuna species are higher than this average. Suzuki (1981) has reported that within species, white flesh has more protein than dark flesh. In the present study no significant difference in protein content was evident in the white and red muscle of tuna.

Kawakawa and Frigate tuna recorded significantly higher ($p<0.05$) amount of ash compared to the other species (Table 1). These two species also recorded significantly much higher contents of ash in their skins than the other tissues studied. In most fish the average ash content in the edible muscle portion has been found to range between 0.5 to 1.8% of wet weight (Sidwell, 1981). In the present study the ash content in muscle and belly flap varied between 0.4 to 1.2%, which is similar to the values reported by Sidwell (1981) for the edible muscle portion.

There was no significant difference in total fat content among the different species of tuna (Table 1). The percentage of total fat in the skin of all tunas was significantly higher ($p<0.05$) than in the other body parts. In the skin total fat varied from 6-9% and in the other body parts it was less than 2%. The total fat content in the red muscle, white muscle, head muscle and belly flap ranged from 1-1.3%, 0.6-0.9%, 0.7-1.5% and 0.9-1.3% respectively. There is considerable variation in the distribution of fat in different tissues. The belly flap of Salmon has been reported to contain 30-50% fat (Ackman, 1995). The Indian oil Sardine (*Sadinella longiceps*) has been reported to have 27% or more lipid in the skin and only 6% in the muscles (Nair *et al*,1979). In the capelin (*Mallotus villosus*) the highest amount of fat (35%) was found in the belly flap, followed by the skin (25%). In the mackerel the Skin contained most fat followed by the white muscle. In all tunas investigated here the skin recorded the highest amount of fat compared to the other tissues.

Table 1. Proximate Composition in the different body parts of five species of tuna (n>20, mean ± SD)

Fish Type		Skipjack tuna	Yellow fin tuna	Frigate tuna	Bullet tuna	Kawakawa
Number of Samples		29	26	28	22	27
Fork Length		49.50± 1.8	52.00±2.1	47.20± 1.6	45.00± 1.7	25.50 ± 2.3
Moisture %	Skin	59.60±1.61	58.13±3.43	58.19±1.87	58.65±2.39	58.19±1.87
	Red	71.60±1.05	70.83±0.70	71.39±1.45	70.68±1.15	72.77±1.45
	White	72.05±1.20	72.44±1.41	73.00±1.14	71.06±1.03	73.41±1.42
	Head	71.83±1.38	71.93±0.71	73.41±2.80	69.86±2.74	73.73±1.42
	Belly flap	71.97±0.78	70.53±0.76	71.67±1.49	68.60±1.89	71.02±0.77
Protein content %	Skin	28.31± 0.53	27.12± 0.5	31.67±0.38	32.67±0.42	30.06±0.42
	Red	24.53± 0.24	20.22± 0.19	25.35± 0.21	21.95±0.31	21.42±0.40
	White	23.79±0.38	21.42±0.25	23.92±0.43	23.37±0.41	20.73±0.29
	Head	20.48±0.85	20.98±0.34	24.83±0.41	25.6±0.26	20.7±0.39
	Belly flap	16.04±0.24	16.94±0.67	19.74±0.18	17.47±0.23	16.85±0.42
Total fat %	Skin	7.45±1.34	8.87±1.23	8.92±1.03	6.71±1.23	6.31±1.12
	Red muscle	0.98±0.23	1.01±0.23	1.08±0.77	0.99±0.23	1.26±0.43
	White Muscle	0.77±0.23	0.88±0.25	0.75±0.12	0.68±0.54	0.60±0.14
	Head	0.72±0.17	0.98±0.13	1.54±0.13	1.21±0.12	0.67±0.32
	Belly flap	1.34±0.42	0.90±0.16	0.99±0.12	0.88±0.37	1.26±0.21
Ash %	Skin	1.33±0.98	1.03±0.45	3.21±2.27	0.98±0.63	6.06±0.98
	Red muscle	1.09±0.22	0.92±0.21	0.73±0.12	1.19±0.17	0.90±0.36
	White Muscle	1.02±0.10	1.12±0.15	0.79±0.35	0.71±0.40	1.03±0.04
	Head	0.88±0.07	1.00±0.06	0.40±0.28	0.69±0.70	0.65±0.46
	Belly flap	0.58±0.12	0.67±0.38	1.03±0.59	0.78±0.34	0.92±0.59

In all the tuna species studied here the skin recorded the highest amounts of protein, total fat and ash (only in 2 species), compared to the other body parts. Therefore if the skin is not consumed valuable nutrients may be lost with it. In the smaller species of tuna such as Bullet tuna (Ragoduwa), Frigate tuna (Alagoduwa) and Kawakawa (Attawalla) the skin is not as tough as in Yellow fin tuna, and may be consumed with the flesh.

Fatty acid profiles of the skin and muscle for the five species of tuna are given in table 2. In the present study significant differences ($p<0.05$) between the total saturated fatty acids and unsaturated fatty acids were observed within the species. Total saturated fatty acids (SFA) in the muscle tissue (red and white muscle) of the tunas were low and varied between 11% (skipjack, white muscle) to 33% (skipjack, red muscle). Total polyunsaturated fatty acids (PUFA) in the muscle tissues of all species of tuna were high and ranged between 50% (frigate tuna, red muscle) to 74% (kawakawa, red muscle). Total monounsaturated fatty acids in the muscle tissues of tunas were also low and varied between 8% (skipjack tuna, red muscle) and 25% (yellow fin tuna, white muscle).

Table 2. Percentage of saturated fatty acids (SFA), MUFA (Monounsaturated Fatty acids) and PUFA (Poly unsaturated fatty acids) in five species of tuna. (Mean± SD)

Fish Type	Body part	SFA	MUFA	PUFA
Skipjack	Skin	23.47±0.90	24.57±1.61	51.27±1.40
	White	10.92±1.44	21.05±1.41	68.05±1.99
	Red	33.11±2.57	7.52±1.14	59.36±1.89
Kawakawa	Skin	18.18±1.01	36.53±2.53	45.02±1.93
	White	26.64±1.62	10.71±1.21	61.92±1.88
	Red	13.91±1.98	11.85±0.78	73.94±2.83
Yellow fin tuna	Skin	33.77±1.63	11.61±1.01	53.33±2.19
	White	12.30±1.52	14.11±0.93	72.36±2.56
	Red	22.74±1.46	21.11±0.94	55.85±1.78
Bullet tuna	Skin	13.65±1.46	10.67±1.09	75.69±3.32
	White	17.58±1.63	25.44±1.07	56.01±1.95
	Red	21.31±1.35	11.40±0.75	64.06±2.09
Frigate tuna	Skin	26.35±2.52	34.93±1.43	38.73±1.62
	White	24.92±1.80	22.02±1.07	53.05±2.13
	Red	21.33±1.46	20.81±1.15	49.91±1.78

Total SFA, MUFA, and PUFA levels in herring (*Clupea harrengus)* from USA were found to be 26%, 47% and 27% respectively (Ackman, 1995). In fresh water carp (*Cyprinus carpio)* from Turkey the corresponding values were 36%, 32% and 32% (Donmez, 2009) respectively. Tunas in this study were characterized by high levels of PUFA, while in herring higher concentrations of MUFA were found. Carp was characterized by sightly higher concentrations of SFA over MUFA and PUFA. In little tuna (*Euthunnus alletteratus)* from the Mediterranean similar results to the tunas in this study were reported, as the major fatty acid class was PUFA followed by SFA and MUFA (Selmi *et al,* 2008)

Table 3. PUFA/SFA ratio for five species of tuna

Fish Type	SFA%			PUFA%			PUFA/SFA/ratio		
	White	Red	Skin	White	Red	Skin	White	Red	Skin
Skip jack	10.92	33.11	23.47	68.05	59.36	51.27	6.23	1.79	2.18
Kawakawa	26.64	13.91	18.18	61.92	73.94	45.02	2.32	5.32	2.47
Yellow fin tuna	12.3	22.74	33.77	72.36	55.85	53.33	5.88	2.46	1.58
Bullet tuna	17.58	21.31	13.65	56.01	64.06	75.69	3.19	3.01	5.55
Frigate tuna	24.92	21.33	26.35	53.05	49.91	38.72	2.13	2.34	1.46

The total SFA, MUFA and PUFA in the skin of the tunas varied between 13.65 - 33.77%, 10.67 - 36.53% and 38.75 to 75.69% respectively. The ratio of PUFA/SFA for white and red muscle of the five species of tuna is given in table 3. A minimum value for PUFA/SFA ratio recommended by nutritionists is 0.45. From table 3 it is seen that for the tuna species investigated here. PUFA/SFA ratio varied between 1.79 and 6.23, which was well above the recommended minimum value.

Table 4. Ratio of n6/n3 fatty acids for five species of tuna

Species	Total n-6 Fatty acids			Total n-3 Fatty acids			n6/n3 ratio		
	White	Red	Skin	White	Red	Skin	White	Red	Skin
Skip jack	15.47	15.31	18.87	57.45	60.51	45.42	0.27	0.25	0.42
Kawaka wa	21.27	37.97	26.38	53.20	40.11	31.09	0.40	0.95	0.85
Yellow fin tuna	20.77	1.30	16.7	61.09	44.77	48.19	0.34	0.03	0.35
Bullet tuna	21.73	41.46	18.31	48.38	35.29	56.51	0.45	1.17	0.32
Frigate tuna	36.46	26.70	46.51	25.60	40.19	12.08	1.42	0.66	3.85

The n6/n3 fatty acid ratio for white and red muscle of the five species of tuna is given in table 4. Nutritionists believe that the desirable n6/n3 fatty acid ratio should be 5 at a maximum. The n6/n3 ratios in both white and red muscle of the five species of tuna investigated here were found to be between 0.03 and 1.42 which was well below the recommended maximum value of 5.

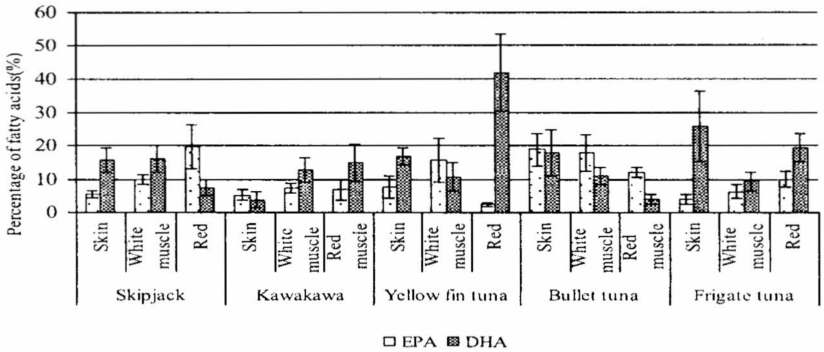

Figure I. EPA and DHA in skin, red and white flesh of five species of

Figure 1 shows the distribution of EPA (eicosapentaenoic acid, C20:5n-3) and DHA (docosahexaenoic acid, C22:6n-3) which are considered as beneficial fatty acids in health care, especially coronary heart diseases. The highest DHA value (42%) and the lowest EPA value (2.4%) were recorded in the red muscle of yellow fin tuna. The highest EPA and value (19.73%) was recorded in the red muscle of skipjack tuna. The sum of EPA and DHA in the muscle tissue of the tunas ranged from 16% (frigate tuna, white muscle) to 44% (yellow fin tuna, red muscle). Therefore these tuna species can be considered as good source of these fatty acids. Reena *et al* (1994) report that the Indian fish they evaluated were excellent source of EPA and DHA as the major constituent of PUFA were these two fatty acids.Although the muscle tissue of the tuna species contain low levels of fat (2%) they have desirable fatty acid profiles which can contribute to good health.

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