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Mineral Spectrum in different body parts of five species of tuna consumed in Sri Lanka

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Abstract

The mineral spectrum of five species of tuna namely; skipjack (Balaya, *Katsuwonus pelamis*) ,Yellow fin tuna (Kellawalla, *Thunnus albacares*), Bullet tuna(Ragoduwa, *Auxis rochei*), Frigate tuna (Alagoduwa, *Auxis thazard*) and kawakawa (Attawalla, *Euthynnus affinis*) were detected in skin, red muscle, white muscle, head muscle and belly flap using an Atomic Absorption Spectrophotometer (GBC 932 plus). Both macro and micro elements were detected in all tunas studied. Accordingly from the recorded minerals K was the most abundant macro element as its mean concentration among the tunas studied ranged from 246.94±62.27 to 293.84±77.78mg/100g and the highest K level among the different body parts, was recorded in the skin ($p<0.05$). The second most abundant macro element was Na and its mean concentration among all tunas varied from 135.19 ±41.04to 155.47±38.92mg/100g.The ratio between Na:K was 1:2 to 1:3. Skin was five times (103.36±67.43- 512.72±88.23mg/100g) as rich in Ca as

other body parts (9.84±2.43 - 19.32±14.47 mg/100g) in tunas studied except yellow fin tuna ($p<0.05$). Mg concentration varied from 52.95±11.68 mg/100g to79.66±15.02mg/100g in all tunas studied and highest values were recorded in the skin samples except for skipjack tuna.. Fe was the most abundant micro element (2.52±1.78 -3.29±1.88 mg/100g) followed by Zn (1.03 ±0.53mg/100g -1.70±0.88mg/100g). Red muscles of all tunas were significantly rich in Fe than the other body parts. The recorded mean values for Mn were always less than 0.2 mg/100g. Cu, Ni and Cr were the other trace elements studied and those were recorded occasionally in trace amounts, and were well below the permissible limits.

Key Words: Tuna, macro elements, micro elements

Introduction

Fish and seafood play a significant role in human nutrition and health. They are rich sources of nutrients. They provide a good balance of proteins, lipids, vitamins, and minerals and have a relatively low caloric value than other muscle foods. (Edirisinghe *et al*, 2000). At least 25 mineral elements occur in foods, sometimes in minute amounts, and may find their way into our bodies. About 16 of these are known to be essential to life and must be present in the diet. (Fox *et al,*1995).

Fish and shellfish, like other living organisms, contain most of the naturally occurring elements. The greater proportion of their body consists of carbon, hydrogen, nitrogen, oxygen, and sulfur. In addition six macro elements, i.e. calcium, magnesium, phosphorus, sodium, potassium and chlorine and several trace elements occur in the body in much lower concentrations (mg or μg per kg). The concentration of

minerals in fish and fishery products is influenced by a number of factors such as season biological differences (species, size, age, sex, and sexual maturity), food sources, environment (water chemistry, salinity, temperature and contaminants) and the method of food processing. Most aquatic organisms accumulate and retain minerals from the environment; however, their incorporation is highly selective. Accordingly the present study was carried out to determine the mineral spectrum in different body parts of five species of tuna.

Materials and Methods

Five species of tuna namely; skipjack (Balaya, *Katsuwonus pelamis*),Yellow fin tuna (Kellawalla, *Thunnus albacares*), Bullet tuna(Ragoduwa, *Auxis rochei*), Frigate tuna (Alagoduwa, *Auxis thazard*) and kawakawa (Attawalla, *Euthynnus affinis*) were brought from Pitipana, Negombo fish landing site from July 2006 to April 2008 and samples ($n \geq 6$) of skin, red muscle, white muscle, head muscle and belly flap were taken and oven dried at 105°C for about 5 hours and 1g from each sample was taken to obtain ash by using the muffle furnace at 550°C. Then each sample was assayed after dissolving in 5N HCl and was analyzed with an Atomic Absorption Spectrophotometer (GBC 932 plus).The concentration of each element was calculated according to their absorbancies.

Results and Discussion

Table 1 Concentrations of Macro elements in different body parts of five species of tuna (mg/100g), Mean±SD

Element	Body part	Yellow fin tuna	Skipjack	Kawakawa	Frigate tuna	Bullet tuna
Na	Skin	184.77±12.62	142.17±3.68	152.92±31.65	198.38±22.44	122.50±20.65
	White muscles	97.30±14.22	116.57±5.48	121.54±20.76	111.37±18.57	92.75±12.07
	Red muscles	108.21±21.69	127.30±6.02	118.54±7.69	117.04±11.66	132.07±13.55
	Head muscles	178.95±18.54	172.07±2.96	155.67±26.01	177.71±29.69	203.49±9.14
	Bellyflap	135.82±9.37	128.55±3.74	156.46±11.11	172.85±21.81	125.12±7.16
	Mean±SD	141.01±39.90	137.33±21.44	141.02±19.23	155.47±38.92	135.19±41.04
K	Skin	362.64±104.78	369.36±152.26	421.61±110.63	326.24±96.79	363.97±71.53
	White muscles	170.59±87.96	256.69±75.72	304.73±16.29	178.17±57.12	227.06±40.94
	Red muscles	311.08±59.02	253.89±97.69	179.24±28.52	294.81±37.39	221.71±30.50
	Head muscles	271.92±67.66	273.11±82.65	208.87±9.15	201.98±5.05	242.90±1.76
	Bellyflap	352.99±38.95	311.10±12.26	256.48±87.43	233.52±42.19	360.64±60.51
	Mean±SD	293.84±77.78	292.83±48.48	274.19±95.21	246.94±62.27	283.25±72.59
Ca	Skin	14.33±7.56	103.36±67.43	393.05±265.56	284.07±170.49	512.72±88.23
	White muscles	11.29±9.98	12.79±3.38	10.41±8.89	11.13±8.52	11.48±8.18
	Red muscles	6.84±9.98	27.81±18.59	14.30±9.27	15.63±9.46	21.97±32.79
	Head muscles	12.26±3.21	20.17±7.43	40.89±4.39	7.29±1.30	22.53±24.35
	Bellyflap	8.96±5.62	15.74±9.54	11.69±4.89	23.11±7.74	16.41±0.36
	Mean±SD	10.74±2.91	35.97±38.09	94.07±167.60	68.25±120.79	117.02±221.25
Mg	Skin	110.32±15.70	42.91±13.10	106.09±8.96	94.50±5.55	105.88±40.57
	White muscles	68.95±31.16	70.70±7.63	56.37±12.85	61.97±20.90	69.58±6.12
	Red muscles	67.40±31.16	57.57±12.96	54.89±8.36	33.23±4.85	71.63±14.51
	Head muscles	67.84±10.33	42.77±15.52	61.93±15.33	47.09±7.04	78.45±1.91
	Bellyflap	71.04±20.31	50.80±13.55	73.56±10.08	55.43±13.77	72.77±10.12
	Mean±SD	77.11±18.62	52.95±11.68	70.57±21.17	58.44±22.84	79.66±15.02

The mean Na and K concentrations among the tunas investigated varied from 135.19 ±41.04to 155.47±38.92mg/100g and 246.94±62.27 to 293.84±77.78mg/100g respectively among the five species of tunas studied (Table 1). According to table 1 K concentration was always high in skin than other body parts studied ($p<0.05$). Compared to Na concentration, the concentration of K was significantly high in all the samples. Though the recorded ratio between Na:K was 1:3 or 1:4 in fish species (Ruiter, 1995) , in the present research it was 1:2 or 1:3.

The Ca concentration varied over a wide range among different body parts (9.84±2.43 - 512.72±88.23mg/100g) and among species (10.74±2.91, yellow fin tuna-17.02±221.25 mg/100g, bullet tuna) ($p<0.05$). Causeseret (1962) also found high Ca levels in the skin. Accordingly, the highest concentration of Ca ($p < 0.05$) was recorded in the skin samples except for Yellow fin tuna. Therefore except Yellow fin tuna, Ca concentration in skin samples of tunas studied ranged from 103.36±67.43- 512.72±88.23mg/100g. Though the skin contained more Ca, the other body parts contained less than 100 mg/100g.(9.84±2.43 mg/100g, Yellow fin tuna; red muscle – 19.32±14.47mg/100g Skip jack; red muscle) (Table 1).

The mean Mg concentration varied in a relatively narrow range (52.95±11.68 mg/100g to79.66±15.02 mg/100g) compared to other elements. The highest Mg was recorded in the Skin samples (94.5± 5.55, Frigate tuna - 110.32 ±15.70 mg/100g, yellow fin tuna) among the body parts studied, except for Skipjack tuna. In skip jack Mg concentration in skin was 42.91±13.10 mg/100g and was significantly lower than the other body parts studied (42.77± 15.52 (head muscles) - 70.70 ±7.63 mg/100g, white muscles).

Table 2 Concentrations of Micro elements in different body parts of five species of tuna (mg/100g)

Element	Body part	Yellow fin tuna	Skipjack	Kawakawa	Frigate tuna	Bullet tuna
Fe	Skin	2.32±0.31	2.47±0.83	3.04±0.28	2.98±0.28	3.06±0.45
	White muscles	1.06±0.14	1.52±0.31	2.99±0.29	1.45±0.29	1.32±0.04
	Red muscles	5.59±0.58	6.15±2.44	5.97±2.94	6.26±2.94	5.02±1.75
	Head muscles	1.68±0.31	4.21±1.34	2.55±0.59	2.19±0.59	2.22±0.80
	Bellyflap	1.93±1.82	2.10±0.30	1.74±0.24	1.72±0.24	3.48±0.93
	Mean±SD	2.52±1.78	3.29±1.88	3.26±1.61	2.92±1.95	3.02±1.39
Zn	Skin	1.94±0.81	2.96±1.00	0.62±1.72	3.98±1.72	0.95±0.75
	White muscles	0.68±0.08	0.84±0.16	0.73±0.07	0.65±0.07	0.87±0.27
	Red muscles	1.05±0.16	0.96±0.12	1.21±0.16	0.94±0.16	1.18±0.37
	Head muscles	0.75±0.15	2.15±0.36	2.01±0.50	1.14±0.50	1.07±0.64
	Bellyflap	0.75±0.14	1.60±0.16	1.38±0.54	1.09±0.54	1.38±0.09
	Mean±SD	1.03±0.53	1.70±0.88	1.19±0.56	1.56±1.37	1.09±0.20
Mn	Skin	0.08±0.03	0.06±0.01	0.11±0.07	0.18±0.07	0.09±0.07
	White muscles	0.04±0.01	0.03±0.003	0.05±0.002	0.02±0.002	0.03±0.003
	Red muscles	0.06±0.01	0.19±0.03	0.09±0.01	0.05±0.01	0.05±0.01
	Head muscles	0.05±0.01	0.04±0.01	0.04±0.002	0.03±0.002	0.04±0.01
	Bellyflap	0.03±0.01	0.04±0.01	0.03±0.01	0.05±0.01	0.04±0.01
	Mean±SD	0.05±0.02	0.07±0.07	0.06±0.04	0.07±0.06	0.05±0.03
Cu	Skin	0.48±0.61	0.14±0.29	0.02±0.17	0.14±0.17	1.20±0.46
	White	0.05±0.03	0.14±0.13	0.003±0.10	0.04±0.10	0.66±0.37
	Red	0.29±0.13	0	0.24±0.13	0.06±0.13	0.34±0.20
	Head	0.002±0.01	0.99±2.13	0.02±0.12	0.05±0.12	0
	Belly flap	0	0.67±0.34	0.09±0.11	0.07±0.11	0.14±0.23
	Mean±SD	0.16±0.21	0.39±0.42	0.08±0.10	0.07±0.04	0.47±0.48

Fe was the most abundant micro element (2.52±1.78 -3.29±1.88 mg/100g) and it significantly varied among the body parts ($p<0.05$) recording the highest amounts in the red muscles. Lall (1995) has reported that the Iron in tunas ranged from 2.7 -80.0 mg/kg (0. 27 -8 mg/100g) and Causeseret (1962) showed that dark muscles is almost

twice as rich in Fe as white muscles. Present observations also showed that red muscle was twice as rich in Fe as other body parts (Table 2). Fe concentration in red muscles varied from 5.02 ±1.75 to 6.26±2.94mg/100g and in the other body parts studied it varied from 1.06±0.14 (Yellow fin tuna, White) to 4.21±1.34mg/100g (Skip jack tuna, head).

The average zinc content of marine and fresh water fish is approximately 8 mg/kg (0.80mg/100g) (Lall.1995). But present mean values for Zn were relatively high compared to it (1.03 ±0.53mg/100g -1.70±0.88mg/100g). The concentration of Zn also varied significantly among the body parts studied ($p<0.05$). Among the different body parts studied, Zn concentration ranged from 0.62±0.87mg/100g (Kawakawa, skin) to 3.98±1.72mg/100g (Frigate tuna, skin). Except for Kawakawa and Bullet tuna the highest Zn was recorded in skin samples (Table 2).

Recorded Mn concentration was always less than 0.2mg/100g (0.02±0.002 -0.19±0.03 mg/100g) (Table 2) and it significantly varied among the body parts ($p<0.05$). Fish from the Arabian Gulf (El-Faer *et al*, 1992) and New Zealand (0.14µg/g) (Lee and Vlieg, 1991) also contained only traces of Mn. In the present study the highest Mn concentration was detected in red muscle of skipjack tuna (0.19 ±0.03mg/100g) followed by the skin of Frigate tuna (0.18±0.07mg/100g). Except skip jack, skin of other four tunas contained more Mn compared to other body parts studied.

The mean Cu concentration among the tuna studied ranged from 0.73±0.39 (Frigate tuna) to 4.68±4.76µg /100g (Bullet tuna) (Table 3). And the presence of Cu within the different body parts investigated varied significantly (0-11.95± 4.59µg /100g bullet tuna, skin) (Table 3) ($p<0.05$).The permissible limit established by WHO (World Health Organization) in 1989 and maximum limit for fish by FAO (Food and Agriculture Organization) were 30 and 10-100µg/g respectively (Mokhtar *et al*, 2009).Accordingly the detected values (Table 3) for Cu was well below the permissible limit for Cu.

Chromium and Nickel were not detected in every sample (Table 3). According to the table 3, detected mean values of Cr and Ni ranged from zero to 0.25±0.49 µg/100g (Frigate tuna) and 0 to 0.05±0.12µg/100g respectively. Among the body parts both Cr and Ni significantly varied ($p<0.05$). The highest amounts of Cr and Ni were detected in the skin of Frigate tuna (1.12±0.45 and 0.27±0.0038 µg/100g respectively). The established maximum permissible limit of Cr by WHO and for fish by FAO was 50 and 1 μg/g respectively. According to WHO the maximum permissible limit of Ni was 0.5-1.0 μg/g (Mokhtar *et al*, 2009). Hence in the present study Ni and Cr in fish tissues studied were well below the permissible limits for human consumption as indicated by WHO and FAO.

Conclusions

These five species of tunas were rich in minerals, both macro and micro element, as they contained Na, K, Mg, Ca, Fe, Mn,Zn, Ni, Cu, and Cr. The highest amount of Fe was recorded in red flesh. Skin contained the highest amounts of K, Ca, Mg, Zn and Mn among the body parts investigated. And the detected heavy metals (Cu, Ni and Cr) were well below the permissible limits for human consumption as indicated by WHO and FAO.

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