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MINERALS AND TRACE ELEMENTS IN FILLETS OF NINE FRESHWATER FISHES FROM NORWAY

By

KÅRE JULSHAMN, OLE RINGDAL and JORUN HAUGSNES

Institute of Nutrition
Directorate of Fisheries
N-5013 Bergen, Norway

ABSTRACT

The fillets from nine different freshwater fishes were analysed by atomic absorption spectrometry for their contents of the minerals: sodium, potassium, magnesium, calcium and phosphorus, and the trace elements: iron, zinc, copper, manganese, selenium, arsenic, mercury and cadmium. The element concentrations based on wet weight and the percentage covering of the Recommended Daily Intakes (RDI) in a portion of 200 g fillet are given for the essential elements. The percentage of the Tolerable Weekly Intake (TWI) in a corresponding meal size is given for mercury and cadmium.

Relative to the percentage covering of the RDI-values, the fish fillets were rich sources of phosphorus and selenium. The potassium content were about three times higher than the sodium content and covered up to 40% of the RDI-value in a meal portion of fish fillet. For the other elements the fillets were poor dietary sources, especially for calcium and manganese, for which a portion of 200 g covered only 1–5% of the RDI-values.

Arsenic and cadmium concentrations were low and represented no dietary hazard. The mercury content of the fish fillets ranged between 0.1 and 0.8 mg/kg. These relatively high concentrations give certain restrictions on the dietary intake, and this concerns particularly the burbot and arctic char analysed in the present study.

INTRODUCTION

Fish products are known to be good sources of many elements (JULSHAMN and RINGDAL, 1983), and contents in several marine fish species are well documented (EISLER, 1981). Freshwater fish species, however, are often neglected as a source of these nutrients and little information is available on the mineral and essential trace element composition of these fishes. Freshwater

species are frequently used as indicators of heavy metal pollution (SANDLUND et al., 1981), and thus there are more data available on contents of such elements as mercury and cadmium.

In Norway, the fish consumed are mainly of marine origin, but freshwater fish are also of some importance as a good source in some inland districts. Household and sports fishing are of value in these districts and are not included in the official statistics of fish consumption. This paper reports analyses of several minerals and trace elements in fish species caught in lakes in Eastern Norway.

MATERIALS AND METHODS

The fish samples were obtained from different lakes in Eastern Norway and transported frozen to the institute (Table 1).

The fillets were prepared, cut into small pieces and mixed for sampling. The samples were freeze-dried to constant weight, homogenized and stored in tightly closed bottles until analysis. No effort was made to obtain representative samples with regard to age, sex, time of year etc.

All samples were digested in a mixture of concentrated nitric and perchloric acid (suprapure 9:1) as described by JULSHAMN et al. (1982), and the elements were then analysed by atomic absorption spectrophotometry (AAS). Sodium and potassium were measured in the emission mode and calcium, magnesium, iron, zinc, copper and manganese by flame absorption as described by JULSHAMN et al. (1978). Phosphorus, selenium, arsenic and cadmium were measured by graphite furnace AAS (LIN and JULSHAMN, 1984; JULSHAMN et al., 1982) and mercury was analysed by cold vapour AAS as described by EGAAS and JULSHAMN (1978). The accuracy of the element analyses was tested in an intercalibration study arranged by ICES (BERMAN, 1984) as well as by analysing standard reference material from the National Bureau of Standards, and all methods were found satisfactory with regard to both tests.

RESULTS AND DISCUSSION

Sodium, potassium, magnesium, calcium and *phosphorus* contents are summarized in Table 2. The sodium concentrations were slightly above 1 g/kg except in burbot with a concentration of 2.3 g/kg. These values are high compared with values reported in the Finnish food composition tables, which gives sodium concentrations in some of the same fish species of approximately 0.5 g/kg (VARO, 1984). The concentration levels of sodium found in this study cover 6–20 % of the Recommended Daily Intakes (RDI) when calculated from a meal size of 200 g fillet.

Table 1. Names, numbers and mean weight of the fish samples and composition of the fillets.

Species (art)	Number of fish	Mean weight (kg)	Dry matter[1]	Protein (N×6.25)	Fat g/kg	Ash g/kg
Vendace, Coregonus albula (lagesild)	30	0.09	251	200	39	12
Powan, Coregonus lavaretus (sik)	8	0.25	212	180	12	12
Roach, Rutilus rutilus (mort)	14	0.05	200	170	13	12
Brown Trout, Salmo trutta (bekk-ørret)	8	0.19	219	180	20	11
Arctic Char, Salvelinus alpinus (røye)	10	0.19	199	170	13	11
Burbot, Lota lota (lake)	6	0.57	170	190	5	11
Ide, Idus idus (vederbuk)	5	0.70	201	190	6	12
Bream, Abramis brama (brasme)	2	1.07	213	190	8	12
Northern Pike, Esox lucius (gjedde)	3	1.01	210	180	3	11

[1] Contents in g/kg.

Table 2. Sodium, Potassium, Magnesium, Calcium and Phosphorus concentrations in the fillet of nine different freshwater fishes and percentage of the Recommended Daily Intake (RDI) in a portion of 200 g fillet.

SPECIES	Sodium		Potassium		Magnesium		Calcium		Phosphorus	
	g/kg	%RDI[1]	g/kg	%RDI[1]	g/kg	%RDI[1]	g/kg	%RDI[1]	g/kg	%RDI[1]
Vendance	1.60	10–29	3.80	14–41	0.281	16	0.114	3	2.37	59
Powan	1.01	6–18	4.20	15–45	0.288	16	0.169	4	2.56	64
Roach	1.02	6–19	3.21	11–34	0.281	16	0.520	13	1.84	46
Brown Trout	0.80	5–15	3.74	13–40	0.259	15	0.095	2	2.46	62
Arctic Char	1.00	6–18	3.90	14–42	0.253	14	0.054	1	1.99	50
Burbot	2.30	14–42	2.67	9-28	0.189	11	0.078	2	1.61	40
Ide	1.23	7–22	3.93	14–42	0.240	14	0.147	4	2.39	60
Bream	1.32	8–24	3.55	13–38	0.234	13	0.193	5	1.91	48
Northern Pike	0.94	6–17	4.12	15–44	0.309	18	0.212	5	2.45	61

[1] Calculated from the U.S. values and intervals of RDI (Nutrition Abstracts and Reviews, 1983).

The potassium contents ranged from 3 to 4 g/kg in nearly all fishes, in agreement with the values found in the same species caught in Finnish lakes (VARO, 1984; NUURTAMO et al., 1980). The potassium contents are approximately three times higher than the sodium content, except for burbot. This is remarkably high since most foods of animal origin have a sodium/potassium ratio of approximately one (Statens Ernæringsråd, 1984). The content of potassium in these freshwater fishes covered approximately 13–40% of the RDI in one meal of 200 g fillet. This is twice the RDI covering of sodium, and is thus desirable from a nutritional point of view (Statens Ernæringsråd, 1984).

The magnesium concentrations ranged from 0.2 to 0.3 g/kg, in agreement with earlier reports (VARO, 1984; NUURTAMO et al., 1980). On a suggested meal size of 200 g, this would supply only 15% of the RDI-values of magnesium.

The calcium concentrations ranged from 0.05 to 0.2 g/kg with the exception of roach which had a content of 0.52 g/kg in the fillet. These values were low compared with the reported Finnish values of 0.3 to 4 g/kg (VARO, 1984; NUURTAMO et al., 1980). Based on our values, the covering of the RDI-value of calcium was 2–5% in a meal size of 200 g, and therefore fillets of freshwater fishes are poor sources of calcium.

The phosphorus concentrations ranged from 1.6 to 2.6 g/kg corresponding to reported values from these species (VARO, 1984; NUURTAMO et al., 1980). The phosphorus content in a portion of 200 g fillet would cover between 40 and 60% of the RDI-value. Fillets of freshwater fish therefore may be a rich source of this element.

Iron, zinc, copper, manganese and *selenium* contents are summarized in Table 3. With the exception of vendace and bream, the iron concentration in the fillets varied between 2 and 8 mg/kg, corresponding well with earlier values reported by VARO (1984) and NUURTAMO et al. (1980). Only vendace and bream with approx. 15 mg/kg contained enough iron in the fillet to cover more than 25% of the RDI-value in a portion of 200 g.

The zinc contents, again with the exception of the vendace (18 mg/kg), ranged from 4 to 10 mg/kg. VARO (1984) and NUURTAMO et al. (1980) gave somewhat higher zinc concentrations in the fillet, but they also found a significantly higher value for zinc in the vendace compared with the other species. The RDI-values in a portion of 200 g fillet were covered only to 5–14%, except for vendace which covered 24% of the RDI-value.

The copper concentrations ranged from 0.6 to 1.9 mg/kg in the fish fillets covering between 5 and 20% of the RDI-values in a 200 g portion. These values were higher than those reported earlier, which gave concentrations between 0.3 and 0.9 mg/kg in some of the same species (VARO; 1984, NUURTAMO et al., 1980).

The manganese concentrations in the fillets were all below 0.5 mg/kg, in agreement with the levels generally found in such foods (OHMANG, 1980). The content in a meal size of 200 g covered only 1 to 4% of the RDI-value. Freshwater fish fillets are thus very poor sources of manganese.

Selenium concentrations in the fillets ranged from 0.1 to 0.3 mg/kg, which agrees with earlier reported values of 0.2–0.3 mg/kg in some of the same species caught in Finland (VARO, 1984; NUURTAMO et al., 1980). The fillets

Table 3. Iron, Zinc, Copper, Manganese and Selenium concentrations in the fillet of nine different freshwater fishes and percentage of the Recommended Daily Intake (RDI) in a portion of 200 g fillet.

SPECIES	Iron		Zinc		Copper		Manganese		Selenium	
	mg/kg	%RDI[1]	mg/kg	% RDI[1]	mg/kg	% RDI[1]	mg/kg	% RDI[1]	mg/kg	%RDI[1]
Vendace ...	13.2	26	18.0	24	1.75	12–18	0.37	2–3	0.18	18– 72
Powan	4.6	9	5.5	7	0.84	6– 8	0.31	1–3	0.09	9– 36
Roach	7.7	15	10.5	14	1.87	12–19	0.44	2–4	0.12	12–48
Brown Trout	4.1	8	7.0	9	1.74	12–17	<0.30	1–2	0.18	18– 72
Arctic Char	4.3	9	5.1	7	0.98	7–10	<0.30	1–2	0.27	27–108
Burbot	2.6	5	6.1	8	0.84	6– 8	<0.30	1–2	0.14	14– 56
Ide	7.7	15	4.1	5	0.99	7–10	<0.30	1–2	0.09	9– 36
Bream	16.4	33	4.1	5	0.84	6– 8	0.47	2–4	0.28	28–112
Nothern Pike	1.8	4	5.2	7	0.62	4– 6	0.46	2–4	0.19	19– 76

[1] Calculated from the U.S. values and intervals of RDI (Nutrition Abstracts and Reviews, 1983).

Table 4. Arsenic, Mercury and Cadmium concentrations in the fillet of nine different freshwater fishes and percentage of the Tolerable Weekly Intake (TWI) and portion of 200 g fillet.

SPECIES	Arsenic	Mercury		Cadmium	
	mg/kg	mg/kg	% TWI[1]	mg/kg	% TWI[1]
Vendace	0.050	0.14	9	0.020	0.8–1.0
Powan	0.020	0.16	11	0.010	0.4–0.5
Roach	0.015	0.17	11	0.022	0.9–1.1
Brown Trout	0.017	0.09	6	0.019	0.8–1.0
Arctic Char	0.022	0.46	31	0.007	0.3–0.4
Burbot	0.054	0.78	52	0.012	0.5–0.6
Ide	0.020	0.33	22	0.009	0.4–0.5
Bream	0.019	0.19	13	0.025	1.0–1.3
Northern Pike	0.024	0.26	17	0.007	0.3–0.4

[1] Calculated from the WHO/FAO's limits of Tolerable Weekly Intake (WHO, 1973).

would cover 10 to 100% of the RDI-values for selenium, which is estimated to 50–200 µg per day. There is a lack of information on the effect of food processing, as well as on the bioavailability and biological functions of selenium, and this led to such an inaccurate recommendation. Nevertheless, freshwater fish fillets are a rich source of selenium.

Arsenic, mercury and *cadmium* contents are summarized in Table 4. The arsenic concentrations in the fillets ranged from 0.02 to 0.05 mg/kg, agreeing with the findings of NUURTAMO et al. (1980) who reported a mean value of 0.04 mg/kg in the fillet of fresh water fishes, but who also reported contents up to 0.30 mg/kg in the same species from the sea (brackish water). The organic compounds of arsenic found in marine fish are, however, absorbed and excreted without any toxic effects (FREEMAN et al., 1979). The arsenic contents in fish are therefore not discussed with regard to Tolerable Weekly Intake which was intentionally set up for inorganic arsenic compounds.

The mercury contents in the fillets varied between 0.1 and 0.8 mg/kg. These values are, however, difficult to compare with previous reported values, because of possible correlations between age of the fish and mercury content in the muscle (SANDLUND et al., 1981). The varying degree of pollution in inland lakes increases the difficulties in the evaluation of «normal» mercury levels in these fishes. The high levels found for mercury in burbot were also reported in previous studies (VARO, 1984; NUURTAMO et al., 1980). A portion of 200 g of fish fillet would give between 6 and 50% of the Tolerable Weekly Intake (TWI) of mercury. According to these TWI-limits, burbot should be restricted to two meals and arctic char to three meals weekly. The other fish species

could be used frequently in a normal diet provided they are not caught in extensivly polluted lakes.

The cadmium contents in the fillets were in the range of 0.007 to 0.025 mg/kg. These values are somewhat higher than those reported from Finland (0.004–0.010 mg/kg) (VARO, 1984; NUURTAMO et al., 1980). The content in 200 g fillet gave not more than about 1% of the Tolerable Weekly Intake, thus freshwater fish are of no concern regarding the cadmium content.

Among the essential elements, the fillets of the freshwater fishes were rich sources of phosphorus and selenium. The potassium contents were also quite high particularly relative to sodium, and the fillets may therefore represent a good source of this element. For the other elements analysed, and especially for calcium and manganese, the fillets represented poor dietary sources. Only mercury could give a limitation in the dietary use of the fish fillets investigated, but as mercury polluted lakes are registered all over Scandinavia, this should be noted.

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