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SODIUM AND POTASSIUM IN THE EDIBLE PORTIONS OF 34 SPECIES OF FISH

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ABSTRACT

THE 34 SPECIES OF FRESH-WATER AND SALT-WATER FISH ANALYZED IN THE PRESENT STUDY ARE EXCELLENT FOODS FOR INCLUSION IN DIETS THAT REQUIRE A LOW CONTENT OF SODIUM. IN NONE OF THE SPECIES--NOT EVEN IN THE SALT-WATER FISH--DID THE CONTENT OF SODIUM EXCEED THE MAXIMUM AMOUNT (100 MILLIGRAMS PER 100 GRAMS OF MEAT) SPECIFIED BY FOOD AUTHORITIES FOR LOW-SODIUM DIETS.

THE RATIO OF THE CONTENT OF SODIUM TO THAT OF POTASSIUM WAS QUITE SIMILAR IN BOTH THE FRESH-WATER AND THE SALT-WATER FISH, BEING APPROXIMATELY ONE PART BY WEIGHT OF SODIUM TO FIVE PARTS BY WEIGHT OF POTASSIUM.

INTRODUCTION

Doctors, in treating such disorders as inadequate protein digestion and congestive heart failure with its attendant edema, are placing increased emphasis on rigid control of the sodium content of the patient's diet (Proudfit and Robinson 1955). Although the normal intake of salt averages several grams a day, this amount often must be reduced to as little as one-half gram during medical treatment. This requirement can be met by using unsalted foods and by avoiding those that have a high natural content of sodium.

As the function of sodium in the development of pathological condition becomes better known, a more exact knowledge of the amounts present in the various foods assumes increasing significance. The values for many animal and vegetable products have been determined (Bills, McDonald, Nedermeier, and Schwartz 1949), but information available on fish is very limited (National Research Council 1954). Although data definitely are needed on fresh-water fish, the lack of data on salt-water fish is particularly unfortunate, for many persons undoubtedly have reasoned that since the marine species live in a salty habitat, they must contain a large quantity of salt and, hence, of sodium.

The objective of the work reported here was to determine the content of sodium in as wide a variety as possible of the principal species of fresh-water and salt-water fish. Potassium values were included for comparative purposes because considerable attention now is being directed to the sodium-potassium balance.

COLLECTION AND PREPARATION OF SPECIMENS

The specimens used in this study included 26 salt-water species from the Atlantic and the Pacific oceans, and 8 fresh-water species from lakes and rivers. The specimens can be listed conveniently under the following groupings:

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(a) Ten species of fish from the Pacific Ocean were purchased in Seattle markets during January and February 1957. Six iced whole fish of each species were obtained in fair condition. These fish were out of the water not more than 1 week. One composite sample was prepared from the light meat of the six fish in each series. Each sample of light meat was ground in a Hobart grinder, vacuum packed in $\frac{1}{2}$-pound cans, and stored at 0° C. until analyzed.

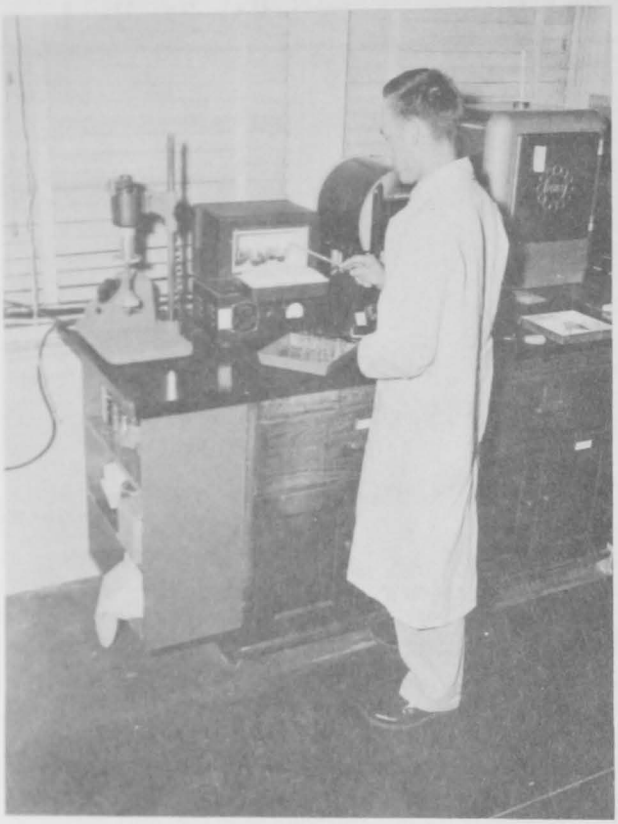

FIG. 1 - ASHING A SAMPLE OF FISH BY MEANS OF ELECTRIC FURNACE.

(b) Prepared samples of eight species of fish were received from the Bureau's Fishery Technological Laboratory at College Park, Md., April 19, 1957. Each sample was composed of one to six fish and was received composited and frozen in a sealed $\frac{1}{2}$-pound can. The composites were prepared as in (a).

(c) Prepared samples of frozen fillets from five species of fish were received from the Bureau's Fishery Technological Laboratory at East Boston, Mass., April 18, 1957. All of the fillets, except those of ocean perch, had been cut within 24 hours of capture. Iced ocean perch fillets in good condition were from fish obtained from a trawler within 1 week of capture. None of the fillets had been brine-dipped. The samples were prepared as in (a).

(d) Four species of fish were received from different sources. Sixteen frozen steaks taken from 10 different halibut were obtained from a Seattle fish dealer. A composite sample was prepared as in (a). Six albacore tuna were received frozen from the Bureau's exploratory fishing vessel John N. Cobb. Composites of the light and the dark meat were prepared as in (a). Six yellowtail rockfish also were obtained frozen from the John N. Cobb. Each rockfish was prepared individually by the method used in (a) on the day they were received. Twelve pink salmon were obtained from a Ketchikan, Alaska, cannery during July and August 1956. All of the specimens came from Burroughs Bay. They were taken in gill nets and had not been out of water more than 24 hours. The fish were dipped in boiling water, skinned, and eviscerated. Seven different samples then were prepared from the various parts of each fish by the method used in (a). The data in table 1 give only the value on the pink meat, as data on the other parts of the salmon will be reported later. The values shown here are averages obtained in individual analyses of the 12 fish.

(e) Six iced whole fish of four different species were received in good condition on April 29, 1957. They were taken from the Mississippi River below Clinton, Iowa. Samples were prepared as in (a).

(f) Four other species of fish either frozen or iced whole were received in good condition. Six whitefish from Red Lake, Minn., and three mullet (suckers) from Lake Erie, Mich., were prepared as in (a). Sixteen lake herring from Lake Superior, 16 sheepshead from the Mississippi River at Clinton, Iowa, and 48 sheepshead from Lake Winnebago, Wis., were prepared as individual samples as in (a).

EXPERIMENTAL PROCEDURE

The analyses, both for sodium and potassium, were made with a direct-reading flame photometer. The procedure employed was adapted from one used by the National Canners Association (1956). Details of the analyses were as follows:

1. Partially thaw a can of frozen sample in lukewarm water for 30 minutes, and then open can.

2. Transfer a 10-gram portion of the sample to a porcelain evaporating dish.

3. Divide the sample into fine particles by cutting it with a shears; remove any particles of bone, scale, or skin that may be present.

4. Tare two porcelain crucibles, and weigh a 4-gram sample into each one.

5. Using an electric hot plate, carefully char the samples.

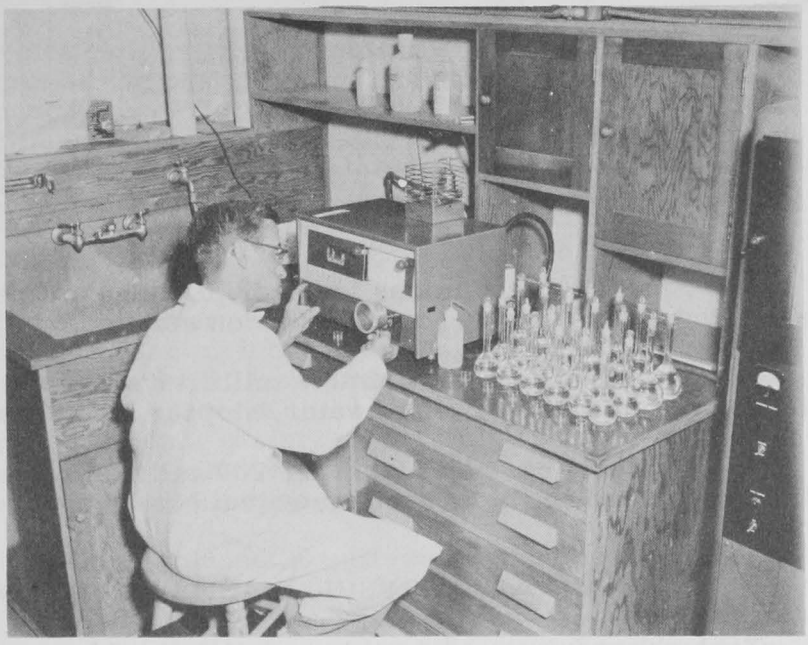

FIG. 2 - USING FLAME PHOTOMETER TO DETERMINE NATURAL CONTENT OF SODIUM AND POTASSIUM IN FISH.

6. Transfer the crucibles to an electric furnace at 550° C.; heat for 4 hours or for as long as 24 hours if the ash remains dark.

Table 1 - Analyses of Salt-Water Fish

Series Designation 1/	Common Name	Scientific Name	Place of Capture	No. of Fish in Sample	Ash	Sodium		Potassium	
					%	Mg./100 g.	4-oz. Portion	Mg./100 g	4-oz. Portion
d	Albacore tuna	Germo alalunga	Washington coast	6	1.18	34	39	293	334
c	Pollock	Pollachius virens	Fippines Ledge	1	1.15	48	55	350	399
b	Spanish mackerel (Atlantic)	Scomberomorus maculatus	Atlantic coast	3	0.92	48	55	236	269
d	Halibut	Hippoglossus stenolepis	Alaska coast	10	1.50	53	60	379	432
b	Shad	Alosa sapidissima	Chesapeake area	5	1.27	54	62	330	376
c	Yellowtail flounder	Limanda ferruginea	Fippines Ledge	6	1.21	56	64	366	417
b	Sea trout	Cynoscion regalis	Atlantic coast	2	1.07	59	67	317	361
c	Haddock	Melanogrammus aeglefinus	Fippines Ledge	1	1.09	61	70	304	347
a	Ling cod	Ophiodon elongatus	Washington coast	6	1.23	62	71	352	401
d (i)	Yellowtail rockfish	Sebastodes flavidus	Washington coast	6	1.20	50	57	358	408
b	Porgy (or scup)	Stenotomus chrysops	Atlantic coast	4	1.17	63	72	287	327
c	Whiting	Merluccius bilinearis	Fippines Ledge	6	1.01	65	74	274	312
b	Whiting	Merluccius bilinearis	Atlantic coast	3	1.11	82	93	302	344
a	Red rockfish	Sebastodes ruberrimus	Washington coast	6	1.28	66	75	413	471
a	Black rockfish	Sebastodes melanops	Washington coast	6	1.28	66	75	432	492
b	Sea bass (Atlantic)	Centropristes striatus	Atlantic coast	5	0.99	68	78	256	292
b	Red snapper	Lutianus blackfordi	Atlantic coast	1	1.21	70	80	323	368
a	Orange rockfish	Sebastodes pinniger	Washington coast	6	1.26	71	81	347	396
d (i)	Pink salmon	Oncorhynchus gorbuscha	Burroughs Bay, Alaska	12	1.15	76	87	290	331
a	True cod	Gadus macrocephalus	Washington coast	6	1.22	76	87	372	424
a	Ocean perch (Pacific)	Sebastodes alutus	Washington coast	6	1.03	79	90	324	369
c	Ocean perch (Atlantic)	Sebastes marinus	Atlantic coast	8	1.12	79	90	269	307
b	Mullet	Mugil cephalus	Atlantic coast	5	1.13	81	93	292	333
a	Starry flounder	Platichthys stellatus	Washington coast	6	1.14	85	97	285	325
a	Spanish mackerel (Pacific)	Scomberomorus maculatus	California coast	6	1.12	89	101	292	333
a	English sole	Parophrys vetulus	Vancouver Island	6	1.21	91	104	330	376
a	Petrale sole	Eopsetta jordani	Vancouver Island	6	1.12	96	109	268	306
	Average				1.16	68	78	320	365

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7. Weigh the ash.

8. Add 10 to 15 milliliters of nitric acid solution (1 volume of concentrated nitric acid to 9 volumes of distilled water) to each crucible, and break up any particles with a stirring rod.

9. Using funnels and filter papers, filter the contents of the crucibles into 100-milliliter volumetric flasks.

10. Wash the residue on the filter papers three times with distilled water, dilute the contents of the flasks to volume, stopper, and shake thoroughly.

Table 2 - Analyses of Fresh-Water Fish

Series Designation 1/	Common Name	Scientific Name	Place of Capture	No. of Fish in Sample	Ash	Sodium		Potassium	
					%	Mg./100 g.	4-oz. Portion	Mg./100 g.	4-oz. Portion
f (i)	Lake herring (Lake Huron)	Leucichthys artedi	Lake Huron, Mich.	16	1.07	38	43	280	319
f (i)	Lake herring (Lake Superior)	Leucichthys artedi	Lake Superior, Minn.	16	1.26	56	64	358	408
e	Buffalofish	Ictiobus species	Mississippi River, Iowa	6	1.02	50	57	292	333
e	Carp	Cyprinus carpio	Mississippi River, Iowa	6	1.01	51	58	285	325
e	Yellow pike	Stizostedion vitreum	Mississippi River, Iowa	6	1.20	52	59	324	369
f	Mullet (suckers)	Catostomidae species	Lake Huron, Mich.	3	1.19	52	59	344	392
f	White fish	Coregonus clupeaformis	Red Lake, Minn.	6	1.11	53	60	317	361
f (i)	Sheepshead (river)	Aplodinotus grunniens	Clinton, Iowa	16	1.06	59	67	301	343
f (i)	Sheepshead (lake)	Aplodinotus grunniens	Lake Winnebago, Wis.	48	1.05	84	96	278	317
e	Yellow perch	Perca flavescens	Mississippi River, Iowa	6	0.92	67	76	238	271
Average					1.09	56	64	282	321

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11. Analyze the solutions for sodium, using a direct-reading flame photometer calibrated against a standard sodium-ion solution.

12. From each flask, pipette 5 milliliters of solution into a 200-milliliter flask, dilute to volume with distilled water, stopper, and shake thoroughly.

13. Analyze the solutions in the 200-milliliter flasks for potassium by means of a direct-reading flame photometer calibrated against a standard potassium-ion solution.

RESULTS AND DISCUSSION

Tables 1 and 2 give data obtained with the 26 species of salt-water fish and the 8 species of fresh-water fish. The tables are arranged in order of increasing sodium content, since that is the important constituent.

The percentage of ash in the samples ranged from 0.92 to 1.50, with most of the values falling between 1.00 and 1.25. The high value of 1.50 was for a halibut sample, which gave a black ash even after prolonged heating.

The data show that, frequently, the content of sodium varied inversely with that of potassium, but this inverse relationship was not general enough to be considered a rule. As might be expected, the fresh-water fish were somewhat lower in both sodium and potassium contents than were the salt-water varieties. The ratio of the content of sodium to that of potassium, however, was quite similar in both kinds of fish, being 0.213 for salt-water fish and 0.199 for fresh-water fish--or roughly one part by weight of sodium to five parts by weight of potassium.

Large differences were noted in sodium values for similar species from various geographical areas. The sodium content of whiting from the Atlantic Ocean, for example, was much higher than was that of whiting from the Pacific Ocean (82 milligrams per 100 grams of fish versus 65 milligrams per 100 grams of fish). Similar large differences were noted with Lake Superior and Lake Huron lake herring (56 versus 38), with lake and river sheepshead (84 versus 59), and with salt-water and fresh-water mullet (81 versus 52).

Albacore tuna and Lake Huron lake herring had the lowest content of sodium, with 34 and 38 milligrams per 100 grams of fish, respectively. The low value for halibut (53) was surprising in view of its high percentage of ash (1.50).

The sodium contents of the individual species of salt-water fish ranged from 34 to 96 milligrams per 100 grams of fish and averaged 68 milligrams. That for the individual species of fresh-water fish ranged from 38 to 84 milligrams per 100 grams of fish and averaged 56 milligrams. Together, the salt-water and the fresh-water varieties averaged 64 milligrams of sodium per 100 grams of fish.

Although the salt-water fish averaged higher in sodium content than did the fresh-water varieties, the higher values for even the salt-water ones were very favorable in respect to the values approved by dietetic experts, who have found that a food to be acceptable in a low-sodium diet should contain less than 100 milligrams of sodium per 100 grams of food and, preferably, less than 60 milligrams.

None of the individual species--either of salt-water or fresh-water fish--were found to contain as much sodium as the permitted maximum. All of the species of fish reported here can be included therefore in menus for those whose sodium intake must be reduced to a minimum. Since these fish markedly vary in flavor and texture, they make possible a greater variety in diets restricted as to the content of sodium.

SUMMARY

Much concern is being shown by doctors as to the amounts of sodium naturally present in foods, since they now are placing increasing emphasis on low-sodium diets in the alleviation of certain disorders. Inasmuch as little has been known about the sodium content of fish, the objective of the work reported here was to determine the content of sodium in as wide a variety as possible of the principal species. In addition, potassium values were included because attention now also is being directed to the sodium-potassium balance.

The specimens used in this study included 26 salt-water species from the Atlantic and Pacific oceans, and 8 fresh-water species from lakes and rivers. The samples were homogenized by use of a grinder, were ashed, and the ash was analyzed quantitatively for sodium and potassium by means of a direct-reading flame photometer.

The ratio of the content of sodium to that of potassium was 0.213 for salt-water fish and 0.199 for fresh-water fish--or approximately one part by weight of sodium to five parts by weight of potassium for both salt-water and fresh-water fish.

Large differences were noted in the sodium values for similar species from various geographical areas.

Albacore tuna and Lake Huron lake herring had the lowest content of sodium of the 34 species analyzed.

The sodium contents of the individual species of salt-water fish ranged from 34 to 96 milligrams per 100 grams of fish and averaged 68 milligrams. That for the individual species of fresh-water fish ranged from 38 to 84 milligrams per 100 grams of fish and averaged 56 milligrams. Even the highest of the individual values for the salt-water fish lie within the limit approved by the dietetic experts, who have found that a low-sodium diet should contain less than 100 milligrams per 100 grams of food. The species of fish reported here, owing to their great diversity of flavor and texture, thus may serve as an excellent food for those restricted to monotonous low-salt diets.

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