Nutritional Properties of Recreationally Caught Marine Fishes

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Introduction

This paper discusses the nutritional properties of various species of fish caught by marine anglers. Most of the species mentioned are strictly marine, although a few are anadromous. Actually, most recreationally caught fish are ones which also are caught and marketed by commercial fishermen; there is, of course, no difference in the nutritional properties whether the fish are caught by either means.

The terms oil and fat can be used interchangeably; here, we use the term oil. The oil content of fishes varies to a greater extent (from 0.3 to 15 percent or more) than any other component in fish flesh or even in meats. The moisture content of fish tends to vary inversely with the oil content, and the sum of the two items usually approximates 80 percent.

The protein content of fish usually ranges from 18 to 20 percent, but may be as low as 13 percent or as high as 26 percent for a few species. The ash content of fish flesh is about 1.25 percent, falling occasionally to 1 percent or a little less, or sometimes rising to 1.5 percent. If some fine bones or parts of bones have not been eliminated, as in some canned fish, the ash content may appear to be much higher.

Fish have been classified into five categories based on the relative percentages of protein and oil in the flesh (Stansby, 1962). These range from category A, low oil-high protein, to category E, low oil-low protein (Table 1).

For low calorie diets (as for weight reduction), species of fish in category A are especially desirable because they have a low calorie content (low oil—lower than most meats), but as high a protein content as other flesh foods. Category B corresponds to fish having composition comparable to meat (excepting, of course, the levels of the omega 3 and 6 fatty acids as discussed later in this paper). Fish in category D are especially valuable for individuals requiring high protein content since the protein in these species is at higher levels than in other flesh foods. Many, if not most of the species sought by marine anglers are in the desirable categories A, B, or D.

While there may be, on the average, considerable differences in nutritive value from one species of fish to another, there may be also a large difference in nutritional properties of fish of the same species when the fish are taken from different waters or at different seasons of the year. This is due in part to changing food availability or feeding patterns, changes due to spawning conditions and migrations, and other factors.

Fish Composition Compared With Other Flesh Foods

Protein

The amount of protein in fish flesh (usually about 18-20 percent for most species) is ordinarily about the same as that of the flesh of meat and poultry. Occasionally the amount of protein in fish flesh may be as high as 22 percent or a little more. On the other hand, there are a very few species of fish where the protein content is as low as 14 percent, and even more rarely, slightly less. Thus, the protein content is relatively constant in fish, and the variation between the lowest and highest protein content is never more than two times. The quality of the protein of fish, as measured by its amino acid content, is almost identical to that of the

Table 1.—Types of fish and representative species (Stansby, 1962)

Category	Type of fish	Species	Moisture	Protein	Oil	Ash
A	Low oil-high protein (<5%) (15-20%)	Pacific cod, *Gadus macrocephalus*	81.5%	17.9%	0.6%	1.6 %
B	Medium oil-high protein (5-15%) (15-20%)	Mackerel, *Scomber scombrus*	67.5%	18 %	13 %	1.5 %
C	High oil-low protein (>15%) (<15%)	Lake trout, *Salvelinus namaycush siscowet*	52.5%	11.3%	36.0%	0.53%
D	Low oil-very high protein (<5%) (>20%)	Skipjack tuna, *Katsuwonus pelamis*[1]	72.4%	26.2%	0.7%	1.5 %
E	Low oil-low protein (<5%) (<15%)	Butter clam, *Saxidomus nuttall*	83.0%	13.3%	1.3%	1.9 %

[1]Light meat only.

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protein in other flesh foods such as meat and poultry.

Fish Oils

The oil content of fish, unlike the protein content, is, on average, considerably less than that of meat. Furthermore, the oil content of fish flesh varies a great deal from one species to another, or even between samples of a given species. The average oil content among most fish is usually between 1 and 13 percent (Stansby, 1986), a thirteenfold variation. On the other hand if we consider the variation from fish to fish instead of on average values for the different species, then a huge variation of from about 0.3 to 65 percent can occur. This is a variation of about 200 times. There is no comparable variation in fat content for the flesh of meat or poultry, where variations are seldom more than eightfold.

Most species of fish—even those considered to have a higher range of oil content—are on the average lower in fat than most meat samples. If one is attempting to select a fish of a given oil content, one also has to take into account both the species of fish and often either season of the year when the fish was caught or sometimes also the geographical area where the fish was taken. These variations in fat content of fish of the same species relate to 1) the spawning season, whereby as the season advances the oil content may build up to several times as high as it was at the beginning and then drop sometimes rapidly to a low level after spawning, or 2) to the fact that the oil content of fish depends in part upon the kind and amount of feed available to it, and the feed in the water often varies extensively from one geographical area to another. This latter factor results in a much wider variation in fat content of fish than is the case with domestic animals where the type of feed is more nearly constant.

The type or composition of oil in fishes is also different than that in meat. The type of fat is usually a function of the particular fatty acids combined together as triglycerides or phospholipids. Most animal fats (as well as vegetable oils) contain fatty acids of chain lengths of 16-18 carbons atoms (predominantly 16 and 18). Each fatty acid in animal fats usually contains from 0 to 4 (usually from 0 to 2) double bonds.

Fish oils, on the other hand, while containing most of the same fatty acids in meat fats, also contain substantial quantities of longer chain length (C20 and C22) fatty acids. Furthermore, fish oils contain considerable amounts of fatty acids with 5 and 6 double bonds making them highly polyunsaturated. In fatty acids from meat, the polyunsaturation is largely made up from fatty acids with 2 double bonds, and although trace or very small quantities with 3 or 4 double bonds may occur, there never are any with 5 or 6 double bonds.

Of perhaps even greater importance from a nutritional standpoint is the fact that the arrangement of the double bonds in the long-chain fatty acids of fish oils is generally quite different from that in the fatty acids of meat fats. In fats other than marine oils, any long chain (over C18) polyunsaturate that may be present has its first double bond at the sixth carbon atom from the methyl end. When the fatty acids are numbered from the methyl end, the position of the double bond is designated as the omega position. Thus all long-chain polyunsaturates of oils or fats of flesh foods other than those from fish, are called omega-6 (N-6) fatty acids. With fish oils, however, most of the long-chain polyunsaturated fatty acids have their first double bond starting at the third carbon atom and are therefore designated as omega-3 (N-3) fatty acids. As will be seen in a subsequent section the omega-3 fatty acids can possess desirable nutritional properties not present in the omega-6 variety.

Other Components

The principal component of fish is moisture (water) which usually amounts to 65-80 percent, but which does not contribute to nutritional value. As mentioned, water content tends to vary inversely with oil content. Several other components, present in relatively small quantities, can have important nutritional value. All flesh foods contain inorganic material, which, when proximate composition of the food is determined, are lumped together and termed "ash content". These are determined by heating the food to such a high temperature that all organic material is volatilized along with the moisture. The remaining inorganic materials occur after the heating in the form of oxides of the metallic cations of the inorganic substances.

Ordinarily the "ash" amounts to about 1.2 percent or just a little more in flesh foods. The ash mostly comes from such compounds as sodium and potassium salts. Some nutritionally important elements, such as calcium also occur. In fish, the amount of calcium often exceeds that occurring in other flesh foods. This is particularly the case where fish bone remains in canned fish; then the calcium content can be especially high. Other inorganic components occurring in very small quantities are known as trace elements. Fish contains considerably higher quantities of the trace element iodine, which is also important nutritionally.

All flesh foods contain vitamins, particularly the various B complex vitamins such as thiamine, riboflavin, and vitamin B_{12}. The amounts of these vitamins are similar in the various flesh foods including fish. Vitamins A and D occur to a fairly high level in the fat of fish. These amounts are higher in fatty fish than in leaner ones, or in the fat of other flesh foods. Vitamin A occurs in the form of carotene in many vegetables, such as carrots, to a much higher level than the vitamin A in fish, however.

Fatty Acid Stability During Fish Storage

Because fish oil fatty acids contain 5 and 6 double bonds compared with mostly 2 or 3 in those of other flesh foods or oils, the fish oil fatty acids oxidize and deteriorate more rapidly than is the case with the oils or fats in other foods. The only way to eliminate all such oxidation is to keep the fish or its oil away from all air. Ordinarily this is usually not possible, but any protective barrier which reduces penetration of oxygen from the air into the fish (such as wrapping in moisture-proof paper) reduces on the speed of oxidation.

The oils from fish of different species vary in their content of the long-chain polyunsaturated fatty acids, and thus oils from some species are much more vulnerable to oxidation than those from others. Unfortunately we have very little information on the content of the fatty acids most highly susceptible to oxidation in fish of different species. Until research provides such data we should treat all fish or fish oils in a way to minimize their contact with oxygen.

Ordinarily, fish oils oxidize relatively slowly when they are in the raw flesh of fish which are kept cold, such as by being held in ice. Once the fish are cooked, however, oxidation, with development of obnoxious rancid flavors, can be quite rapid. Frozen fish, unless glazed by dipping in water while frozen to form an ice coating, will oxidize appreciably with both formation of rancid flavors and eventually the loss of some of the long-chain omega-3 fatty acids after prolonged storage. These changes occur more rapidly when the fat of a given species of fish contains more of these long-chain polyunsaturated fatty acids. For example, pink salmon (which has very high amounts of such vulnerable fatty acids) after freezing and storage can become rancid after only a few weeks in storage. Some other salmon species such as king salmon, with less of these polyunsaturates, can be kept for many months after freezing without developing objectionable flavors if wrapped in moisture or vapor-proof wrappers. If they are given an ice glaze before wrapping they may remain palatable for more than a year.

When fish are cooked, the use of high temperatures during the cooking process will also favor oxidation of the fish oils to produce undesirable flavors and loss of the valuable omega-3 fatty acids. Use of relatively low temperatures such as boiling in water or even by baking or broiling gives much less such chance for oxidation than by frying.

Some Aspects of Fat in Fish and Nutritional Value

Low Fat Fish for Weight Reduction

Fish can play two special roles in the diet when used more frequently. For overweight individuals who want to reduce, use of the least oily species of fish can considerably reduce the calories consumed while providing high-quality protein and other nutritional components. A number of species of fish contain well under 1 percent fat which is in marked contrast to lean meats or other flesh foods where there is seldom less than 10 percent fat.

Marine fishes with less than 1 percent fat include haddock, cod, and pollock. (Most all shellfishes and crustaceans also contain only about 1 percent oil.) Use of such species drastically reduces one's fat intake compared with the consumption of flesh foods other than fish. Furthermore, there are many species of fish which have a fat content of from 1 to about 3.5 percent. These include, for example, most flatfishes (i.e., flounder, sole, and halibut), as well as ocean perch, Pacific ocean perch, mullet, and many others. Fresh (i.e., uncanned) tuna or tuna canned in brine (rather than oil) also has a very low fat content. Thus, for those seeking weight reduction, catching and eating fishes of very low fat content can provide a nutritious food with far fewer calories than meat.

Fish as a Source of Omega-3 Fatty Acids

As mentioned, fish are unique among all foods in having an abundant supply of long-chain omega-3 fatty acids in their oil. Much recent research indicates that consumption of such fatty acids has a beneficial effect in lessening the risk of heart attack and, in some cases, perhaps other medical conditions (Lands and Bimbo, 1983; Lands, 1986, Stansby, 1985). Dozens of research papers have been published in the past several years on this subject (e.g., see Simopoulos et al., 1986).

For individuals who want to increase their intake of long-chain omega-3 fatty acids, the best way at present is to consume species of fish having a moderately high fish oil content (about 5-10 percent). Such species have no more oil than occurs in even the leanest varieties of meat (which of course contains no omega-3 fatty acids). Such marine species of fish would include, for example, salmon (all species), herring, sardines, sablefish, mackerel, and many others. Other species of fish with lower fat content would furnish smaller, but still important, amounts of omega-3 fatty acids.

One problem in seeking species of fish having adequate amounts of omega-3 fatty acids is the lack of reliable data on the omega-3 fatty acid content (Stansby, 1981). A number of tables giving such values have been published recently but they are all based upon data involving inadequate sample sizes. Recently published values for omega-3 fatty acids in oil from different species of fish are therefore apt to be quite erroneous. It is better (and easier) to use the overall fat content of fish as an approximate index of omega-3 fatty acids. As pointed out by Stansby (1986), the availability of omega-3 fatty acids in fish is, to a large extent, a function of the oil content of the fish. While there is a small (but indeterminate under the present lack of knowledge) variation in the omega-3 fatty acid content, there is a very large variation in fat content.

Composition of Recreationally Caught Marine Fishes

As noted, the composition and nutritive value of marine fish is the same, whether caught commercially or recreationally. Table 2 shows the proximate compositions of selected species of fish which are taken in various parts of the country by recreational fishermen.

In choosing species for inclusion in Table 2, preference was usually given to species especially sought by marine recreational fishermen. Some species are strictly marine, but some are anadromous, returning to freshwater to spawn.

Information on what are considered desirable sport fishes was found in some tabulations on the catches of recreational fishermen. For example, in the publication Marine Recreational Fishery Statistics Survey, Atlantic and Gulf Coast, 1985 (NMFS 1986), Table 34, "Fish species sought out by fishermen" lists bluefish as most sought by marine anglers in the north and middle Atlantic areas; spotted seatrout is listed first in the south Atlantic and Gulf areas. Since composition data for each of these species were available they were included in Table 2.

There is no trend apparent or implied in the information in Table 2. High-oil and low-oil content species of fish are listed, as are fish with protein content varying from 17 to 22 percent (17 percent is a low value and 22 percent is a high value).

Table 2.—Proximate composition of 25 species of fish taken by marine anglers.

Common name	Scientific name	Where[1] caught	Moisture	Protein	Oil (range)	Oil (avg.)	Ash	Data source
Albacore (light meat)	*Thunnus alalunga*	P	66.4	25.9	0.5-18	8.1	1.25	Unpubl.[2]
Striped bass	*Morone saxatilis*	A, P[3]	77	19	n.d.[4]	2.8	1.1	Atwater (1892)
Bluefish	*Pomatomus saltatrix*	A	72	20	0.6-20	7	1.1	Gooch et al. (1987)
Atlantic cod	*Gadus morhua*	A	81.4	17.4	0.1-0.6	0.30	1.25	Atwater (1892)
Pacific cod	*Gadus macrocephalus*	P	81.4	18.0	0.5-0.8	0.63	1.20	Unpubl.[2]
Spiny dogfish	*Squalus acanthias*	A, P	71.1	15.4	5-20	13.2	1.20	Unpubl.[2]
Red drum	*Sciaenops ocellatus*	A	79	19	0.6-1.1	0.9	1.0	Gooch et al. (1987)
Haddock	*Melanogrammus aeglefinnus*	A	81.7	17.2	n.d.[4]	0.25	1.23	Atwater (1892)
Pacific halibut	*Hippoglossus stenolepis*	P	80	18.5	n.d.[4]	0.8	1.1	Unpubl.[2]
King mackerel	*Scomberomorus cavalla*	A	76	21	0.8-3.0	1.7	1.4	Gooch et at. (1987)
Pollock	*Pollachius virens*	A	80.3	18.6	n.d.[4]	0.6	1.16	Unpubl.[2]
Walleye (Alaska) pollock	*Theragra chalcogramma*	P	81.2	16.7	0.2-2.0	0.8	1.4	Unpubl.[2]
Longspine porgy	*Stenotomus caprinus*	A	80	18	1.3-1.6	1.5	1.0	Gooch et al. (1987)
Rockfishes	*Sebastes* spp.	P	78	19	0.6-4.1	1.5	1.2	Thurston (1961)
Coho salmon	*Oncorhynchus kisutch*	P[3]	69	21	5.2-12.5	8.3	1.2	Karrick and Thurston (1964)
Sockeye salmon	*Oncorhynchus nerka*	P[3]	68	22	5.1-10.6	8.9	1.1	Thurston and Newman (1962)
White seabass	*Cynoscion nobilis*	P	80.5	17.4	n.d.[4]	0.8	1.1	Unpubl.[2]
Spotted seatrout	*Cynoscion nebulosus*	A	77	19	1.6-3.7	2.6	1.1	Gooch et al. (1987)
Tiger shark	*Galeocerdo cuvieri*	A	80	19.2	0.6-0.7	0.6	1.2	Gooch et al. (1987)
Spot	*Leiostomus xanthurus*	A	75	18	4-7	6.0	1.1	Gooch et al. (1987)
Swordfish	*Xiphias gladius*	A, P	76	19.9	n.d.[4]	3.7	1.3	Gooch et al. (1987)
Steelhead (rainbow) trout	*Salmo gairdneri*	P[3]	68	21.2	6-16	9.5	1.3	Unpubl.[2]
Bluefin Tuna (light meat)	*Thunnus thynnus*	A, P	70.3	24.2	2-7	5.7	1.3	Unpubl.[2]
Yellowfin tuna	*Thunnus albacares*	P	70.3	24.6	0.5-4	1.3	1.6	Unpubl.[2]
Weakfish	*Cynoscion regalis*	A	78	19	1.0-2.6	1.7	1.1	Gooch et al. (1987)

[1]A = Atlantic and/or Gulf waters, P = Pacific.
[2]Unpublished data from files of Utilization Research Division, NMFS Northwest and Alaska Fisheries Center, Seattle, Wash.
[3]Also is anadromous and may be taken by freshwater anglers.
[4]Too few data to show ranges or based on data from very few samples.

There are a very large number of species of recreational fish not included in Table 2 for it is beyond the scope of this report to list many dozens of species. Those included cover species caught in the Atlantic and Pacific Oceans and several anadromous species taken in fresh waters. The values can be considered as typical for recreationally caught marine fishes.

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