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POTENTIAL PHARMACEUTICAL USES OF THE BURBOT (Lota lota, Linnaeus)

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Introduction

The burbot is a very common but rarely seen freshwater fish. It is found throughout the Great Lakes and in deepwater lakes in Alaska, Canada, and much of the northern half of the United States. It is also found in corresponding latitudes of the Eurasian continent and is an important food fish in some areas.

In the Great Lakes region, the burbot is also known as the lawyer, ling, eelpout and freshwater cod. It is, in fact, a relative of the cod and it, too, has a large liver rich in vitamins A and D. In the 1930s burbot were harvested in Minnesota and other Great Lakes states for extraction of the liver oil. The liver, which makes up 8.5 percent of total weight, is considered a delicacy in Scandinavia but is seldom eaten in this country. Although a market for the flesh of the burbot as a food item is growing here, the liver is no longer processed for oil. Given the high waste in processing burbot, it would appear important to again utilize the liver and its oil.

The fresh burbot flesh is considered to be very tasty, although it may darken with time when frozen (1). Burbot fillets are being sold for food today in Chicago, Minneapolis, and other midwestern areas. It is estimated that from one to two million pounds of burbot could be processed from Minnesota lakes alone during the months of December, January, and February (2). Production could be considerably greater if collected from the freshwater lakes of other northern states and Canada.

Background

Fat content of fish is of current concern because organic contaminents concentrate in fatty issue. The fat content of burbot is low (3). By contrast, Lake Superior burbot (whole fish) contain 5 percent fat whereas lake trout (whole fish) contain 20 percent fat (4). The polychlorinated biphenyl (PCB) content in Lake Superior burbot flesh ranges from 0.5 ± 0.5 parts per million (ppm) to 1.4 ± 0.4 ppm. DDE content ranges from 0.2 ± 0.2 ppm to 0.7 ± 0.3 ppm (5). The present U.S. Food and Drug Administration tolerance levels for PCB and DDE in fish (edible portion) are 2.0 ppm and 5.0 ppm, respectively.

The liver of the burbot has been used as an animal food and occasionally as food for man (6). In the 1930s degalled burbot livers were extracted for their oil which was taken orally as a vitamin A and D supplement similar to cod liver oil. The oil was also used in the preparation of an ointment to promote wound healing. In northern Minnesota during that time, 3,000 pounds of liver were extracted for oil each day for approximately six weeks prior to lake freezing (October 1 to November 15).

The burbot liver is approximately 25 percent oil, of which each gram contains about 4,500 units of vitamin A and 600 units of vitamin D. The United States Recommended Daily Allowances (USRDA) of vitamins A and D for adults and children more than four years old are 5,000 units and 400 units, respectively (8). By contrast, cod liver oil contains 850 units of vitamin A and 600 units of vitamin D per gram. Shark liver oil is reported to contain more than 300,000 units of vitamin A per gram.

It is estimated that 100,000 pounds of burbot liver will yield 25,000 pounds of oil or 12,000,000 doses of vitamin A (1,000 units each). One health food store may use 120,000 dosages of vitamin A (10,000 units each) per year. Based on these estimates, 25,000 pounds of burbot oil would satisfy the annual vitamin A market of 10 health food stores. For each 1,000 units increase in yield of vitamin A per gram of oil, 10 additional health food store needs could be satisfied. The wholesale cost for cod liver oil is approximately 80¢ per pound (9), and that pound may retail for $4. One-hundred soft gelatin capsules of natural vitamin A (10,000 units) and vitamin D (400 units) may retail for $2.15.

The principal steps in the manufacture of cod liver oil are the following (10):

I. Separation of Impurities - generally at 170°F (77°C) in the absence of air and then centrifuged at 7,000 revolutions per minute (rpm) to obtain the oil

II. Drying - in vacuum to remove the residual water from the oil

III. Winterization - cool to 32°F (0°C) to enable stearins (saturated fatty acids) to be removed by filtration and to result in a polyunsaturated, enriched oil

IV. Deodorization - a steaming process to remove volatile aldehyde and ketone impurities

V. Standardization - principally for quality assurance and to determine the vitamin A and D content

VI. Storage - well filled, airtight containers that are protected from light and stored in a cool place; antioxidents such as dodecyl gallate may be added

Higher oil and vitamin yields are reported for degalled fish livers extracted by alkali digestion and a rapid steam-injection centrifuge process (11). The amounts of oil rancidity, bitterness, vitamin content, color (yellow to orange-brown), fish odor and taste are affected by the degree of exposure to light, air, high temperature, and fish debris. In the 1930s, degalled, fresh burbot livers stored on ice were extracted for 30 minutes with steam. Frozen livers were not used because of a resulting oil emulsion. Saturated fats were then removed by filtration from the chilled oil.

Evaluations of Burbot Liver Oil

Degalled, fresh and frozen burbot livers were obtained from the Lake of the Woods, Minnesota, during December 1978 and January 1979. Fresh livers were prepared and extracted for the oil within 24 hours of receipt at the College of Pharmacy, University of Minnesota.

A series of extractions, as can be seen in Table 1, was made using fresh and frozen livers in whole form and cut in one-inch square pieces.

TABLE I. BURBOT LIVER OIL EXTRACTIONS*

Extraction†	Liver Preparation (Type, Size)	% Oil Content
1	Fresh, Whole	6.0
2	Fresh, Whole	10.0
3	Fresh, Pieces	3.0
4	Fresh, Pieces	9.0
5	Frozen, Whole	27.2‡
6	Frozen, Pieces	33.5‡
7	Frozen, Homogenized	15.1‡
8	Frozen, Whole	0.5
9	Frozen, Pieces	11.1
10	Frozen, Whole	5.0
11	Frozen, Pieces	20.0
12	Fresh, Pieces	9.0
13	Fresh, Pieces	9.0
14	Frozen, Pieces	6.0
15	Frozen, Pieces	16.0
16	Fresh, Pieces	12.0
17	Fresh, Pieces	15.0
18	Frozen, Pieces	13.0
19	Frozen, Pieces	21.0

*The technical assistance of Ms. Joanna J. Staba is acknowledged with appreciation.

†Extractions 1 & 3 at 115°C for 30 minutes; Extractions 2, 4, 8, and 9 at 80°C for 30 minutes; Extractions 5 - 7 and 10 - 19 at 80°C for 60 minutes

‡Includes oil obtained by solvent extraction: Extraction 5, 12.2 percent; Extraction 6, 8 percent and Extraction 7, 7.1 percent.

Approximately one pound of burbot livers (500 g) was extracted for oil in a stainless steel beaker placed in either an autoclave set for dry heat sterilization (115° ± 3°C) or in a steam bath (80° ± 3°C).

After 30 minutes of heat extraction the oil was poured from either fresh, whole livers (Extractions 1 and 2) or fresh liver pieces (Extractions 3 and 4). Efforts to mechanically squeeze additional oil from the cooked livers placed in muslin were not successful. The yield of oil after 30 minutes of heat extraction was only 3 to 10 percent.

After 60 minutes of steam extraction, frozen whole liver or liver pieces yielded 15 or 25.5 percent of oil, respectively (Extractions 5 and 6). In Extraction 7, under the same conditions, a homogenized liver preparation entrapped the oil and resulted in an 8 percent oil yield. The oil was removed from the three cooked liver preparations by centrifugation at approximately 2,000 rpm for 3 minutes. An additional amount of oil (7 to 12.2 percent) was obtained by mixing an organic solvent (petroleum ether, B.P. 30 - 60°C) with the centrifuged, cooked liver preparation. The solvent was removed from the oil by heating the mixture on a steam bath.

After 30 or 60 minutes of steam extractions, frozen whole liver or liver pieces yielded 0.5 to 20.0 percent (Extractions 8 through 11). The oil yield after 30 minutes of heat extraction was considerably lower than that obtained after 60 minutes. The extracted livers were homogenized and centrifuged to obtain additional oil.

After 60 minutes of steam extraction, fresh and frozen liver pieces yielded 25.5 percent (Extraction 6), 10.5 percent (Extraction 11), and 9.0, 9.0, 16.0, 12.0, 15.0, 13.0, and 21.0 percent oil (Extractions 12, 13, and 15 - 19, respectively). Extractions 12 to 19 were not centrifuged to obtain additional oil, and in Extractions 16 to 19 the liver pieces were stirred every 15 minutes.

The average oil yield obtained after steam extraction of liver pieces for 60 minutes was 14.5 ± 2.2 percent. An estimated 5 to 10 percent greater yield could be obtained by centrifugation or solvent extraction. A minimal oil yield of 10.5 percent and a maximum of 33.5 percent was obtained from frozen liver pieces. All burbot oil preparations froze at 4°C and were yellow in color.

In extractions performed by another laboratory using a rapid steam-injection centrifuge process, fresh, degalled livers from the same batch gave a yield of approximately 40 percent of an orange-colored oil (11). In all studies, no significant emulsion problems were experienced with either fresh or frozen liver preparations although emulsion problems have been observed in the past when frozen livers were extracted (7).

Vitamin and Organic Chemical Residue Content

The oil obtained from Extraction 15 was analyzed for vitamin A (12) and vitamin D (13). The vitamin content was 1,190 units/gram of vitamin A and 379 units/gram of vitamin D (14). Samples of the same oil contained a residue content of 2.1 ppm PCBs as Aroclor 1254 and 0.6 ppm DDE (15). The tolerance level for PCBs in milk (fat basis) is 1.5 ppm and the action level for DDE in eggs is 1.5 ppm.

An analysis of liver residue for use as plant fertilizer was also made as shown in Table II. The heat and solvent extracted liver residues from Extraction 6 (Dried Fish Liver Sample - A) and Extraction 7 (Dried Fish Liver Sample - B) were dried for 48 hours at approximately 150°F (65°C) in an air circulating oven. The two samples were analyzed for plant fertilizer use (Laboratory I and II) and Sample A was analyzed as if it were a soil sample (Laboratory III). The results for these laboratories are reported in Table II. Lawns sometimes receive a 6-4-3 (N-P-K) fertilizer application. Burbot liver residue was found to have a 6-2-1 content and could be strengthened in phosphorus and potash for use as fertilizer.

TABLE II. LIVER RESIDUE ANALYSIS

Laboratory	Sample	Total Nitrogen	Total Phosphorus	Potash (Potassium)	Composition Inorganic	Organic	Moisture
I	A	5.39	1.29	0.22	4.02	95.98	-
	B	6.09	1.39	0.22	4.68	95.32	-
II	A	5.5	1.8	0.8	4.5	93.0	2.5
	B	6.2	1.9	0.9	4.1	29.9	3.0
III	A	Nitrate 3 (50-120) Ammonium 30+ (8)	27+ (5-15)	150+ (40-80)	Calcium 6 (80+)	-	-

*Laboratories I and II analyzed the liver residue for fertilizer use. The data reported are expressed in percentages.

+Laboratory III analyzed liver residue as if it were a soil sample. The data are reported in parts-per-million, and those in parenthesis represent normal soil values. The pH of Sample A was 5.1 (5.5-7.0), and it contained a high amount of soluble salts, 265, as compared to the normal range for soil (30-80).

Conclusion

From the above it can be seen that oil extraction techniques used in the past can be duplicated today to provide a yield of approximately 25 percent. Using the most modern methods of extraction, that yield could be increased to approximatley 40 percent, but extraction of burbot livers cannot deliver the 50 to 70 percent yield commonly derived from cod and shark liver. Thus, it would appear that a fishery for the burbot could not be maintained for oil alone.

While it has also been shown that a demand exists for burbot flesh, there are additional uses to which this underutilized fish could be put. Possible additional food uses could include preparation of a liver pâté and caviar. It is also possible that the liver residue left from extraction might contain useful amounts of vitamin B-12, essential amino acids, and proteins. It is interesing to note in this regard that during the past decade, natural vitamins and food supplements have made strong inroads on synthetic products and today account for 25 percent of the market. It has also been suggested that burbot skin be processed to prepare a glue or gelatin-type product or even tanned as a type of leather.

Through maximum utilization of the fish and its by-products, it appears that a viable burbot fishery could be maintained.

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References

1. *Personal Communication.* Burt Smith, Smith Brothers Fisheries, Inc., 100 N. Franklin Street, Port Washington, WI 53074

2. *Personal Communication.* Floyd Hennagir, Commercial Fisheries Coordinator, Minnesota Department of Natural Resources, St. Paul, MN.

3. Stansby, M.E. 1973. Polyunsaturates and fat in fish flesh. *J. Am. Dietetic Assoc.* 64:625-630.

4. International Joint Commission. 1977. Waters of Lake Huron and Lake Superior. Vol. III, Part B, pp. 378-380.

5. Veith, G.D., Kuehl, D.W., Puglishi, F.A., Glass, G.E., and Eaton, J.G. 1977. Residues of PCB's and DDT in the western Lake Superior ecosystem. *Archiv. Environ. Contam. and Toxicol.* 5:487-499.

6. ________________. 1932. Health from the lakes. *The Fisherman* (March). Reprinted 1978, 30(7):14 & 17.

7. *Personal Communication.* Ted Rowell, Sr., Rowell Laboratories, Baudette, MN.

8. U.S. Food and Drug Administration. 1973. New regulations on vitamins and minerals. *Drug Bulletin* (December), Washington, D.C.

9. *Personal Communication.* Louis E. Kovacs, Vitamins, Inc., 200 East Randolph Drive, Chicago, IL

10. Trease, G.E., and Evans, W.C. 1978. Pharmacognosy. Pages 630-634, 11th ed. New York Bailliere Tindall, London-Macmillian Publ. Co.

11. *Personal Communication.* Mark Howard, World Sea Food, Inc., 18416 - 18th Ave., N.E., Bothell, WA

12. United States Pharmacopeia. 1975. Vitamin A spectrophotometric assay. Vol. XIX, p. 632.

13. Official Methods Analysis. 1975. Vitamin D bioassay. 12th ed., p. 851, with modifications. AOAC, Washington, D.C.

14. *Personal Communication.* Robert E. Christensen, Raltech Scientific Services, Inc., P.O. Box 7545, Madison, WI

15. *Personal Communication.* Ray Mattson, Minnesota Department of Agriculture, 510 State Office Bldg., St. Paul, MN