Chemical Composition and Microflora of Channel Catfish (*Ictalurus punctatus*) Roe and Swim Bladder

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Proximate analysis determined that channel catfish (*Ictalurus punctatus*) roe was 64.5% moisture, 2.4% ash, 24.6% protein, and 8.0% fat and swim bladder was 74.6% moisture, 0.2% ash, 13.8% protein, and 0.7% fat. The major vitamin of catfish roe was vitamin A. The cholesterol content in catfish roe was 639 mg/100 g. The major fatty acids were oleic, palmitic, stearic, linoleic, and docosahexaenoic acids in roe and palmitic, oleic, and linoleic acids in swim bladder. Major amino acids in roe were glutamic and aspartic acids and alanine and leucine. In isinglass from swim bladder, major amino acids were proline, glutamic acid, alanine, and aspartic acid. The predominant minerals in catfish roe were P, K, Ca, Na, and Mg. *Plesiomonas shigelloides* and *Escherichia vulnaris* were the two dominant species of the six identified microorganisms of catfish roe. Typical microbial counts of roe ranged from TPC of 10^4 to 10^5 CFU/g.

INTRODUCTION

Demand for catfish (*Ictalurus punctatus*) has grown dramatically in recent years due to year-round availability, consistent quality, and health benefits attributed to eating catfish. In 1992, 206 million kg (457 million lb) was produced in the United States (*The Catfish Journal*, 1993). As the catfish industry has grown, the amount of byproducts has increased, thereby creating a need to develop effective uses, preferably as high-value products for human consumption.

Traditional applications of catfish processing have concentrated on production of catfish fillets, and most catfish producers utilized byproducts by converting them into fish meal. Producers have usually realized a profit of $0.02/kg for catfish offal. This amount just covers the cost of transporting the waste materials to rendering plants (Hoke, 1993).

A large part of these byproducts could be better utilized. In previous research, catfish mince recovered from frames was shown to be a feasible use in commercially valued food products (Liu *et al.*, 1992). A profit might also be realized with other additional catfish byproducts such as roe and swim bladder.

Roe from some fish, such as mullet, salmon, cod, herring, and pollack, has been salted, seasoned, boiled, and/or broiled and has been commercially marketed as a food (Lu *et al.*, 1979; Chiou *et al.*, 1989). The swim bladder has been used to make isinglass for use as a clarification agent in the wine and beer industries (Qadri *et al.*, 1969).

Chemical and nutritional information concerning byproducts is needed before their use as food products. The chemical composition of raw roe of 18 fish species (Iwasaki and Harada, 1985) and salted roe of mullet (*Mugil cephalus* Linnaeus), Baltic herring (*Clupea harengus*), and rainbow trout (*Salmo gairdneri*) (Lu *et al.*, 1979; Kaitaranta *et al.*, 1980) has been reported. The United States Department of Agriculture (USDA, 1987) has been consulted for finfish roe composition of mixed species. Chiou *et al.* (1989) compared extractive components between raw and salted Alaska pollack roe. Some studies on the swim bladder lipids of marine fish species (Phleger *et al.*, 1978) and amino acids of isinglass of marine fish swim bladder have been conducted (Beveridge and Lucas, 1944; Qadri *et al.*, 1969).

However, although emphasis on utilization of catfish byproducts for human consumption has increased, no compositional information on catfish roe and swim bladder is available. The purpose of this research was to examine the chemical composition and microflora of catfish roe and swim bladder in terms of possible use as food or food components.

MATERIALS AND METHODS

Materials. Roe and swim bladder from about 2 kg of catfish (*I. punctatus*) were obtained from a local catfish processing plant. Once removed, roe and swim bladder were rinsed with water and then stored at -20 °C until analyzed.

Isinglass Preparation. Swim bladders were washed with water to remove contaminants, then soaked in a 0.5% hydrogen peroxide solution, and stored at 6 ± 1 °C for 5 days. At this stage the swim bladders were considered to be converted to isinglass and were placed on a net in a drying oven at 40 °C for 12 h. The dried isinglass was stored at −20 °C until used.

Chemical Analysis. All experiments were performed in duplicate with at least three replicated samples.

Proximate composition was determined by AOAC (1990) methods (930.15, moisture; 920.39, lipid; 988.05, protein; 942.05, ash). All values were calculated on a percent wet weight basis.

Samples for mineral analysis (except for phosphorus) were prepared and analyzed according to the procedure of Gordon and Roberts (1977) using an atomic absorption spectrophotometer (Model IL357, Instrumentation Laboratory Inc., Wilmington, MA). Total phosphorus content was determined according to AOAC (1990) procedures and a procedure from Clesceri *et al.* (1989).

For the fatty acid profile, lipid was first extracted. The fatty acids were converted according to AOAC (1990) methods (24.006 and 28.056) and then separated using a gas chromatograph (Model 5890 Series 1, Hewlett-Packard Corp., Palo Alto, CA) equipped with a flame ionization detector. Separations were conducted with a DB 23 capillary column (30 m × 0.25 mm; J&W Scientific, Folsom, CA). Helium was used as the carrier gas at a flow rate of 1.0 mL/min with split ratio 100:1. Column temperature was programmed at 150 °C for 8 min, raised to 200 °C at 3 °C/min and held at 200 °C for 15 min. Detector temperature was 260

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°C and injector temperature was 250 °C. One microliter of the FAME preparation was injected by an autoinjector (Hewlett-Packard 7673). FAMEs were tentatively identified by comparison of their retention times with those of standards (PUFA 1, menhaden oil, and rapeseed oil, Supelco, Inc., Bellefonte, PA). Relative quantities were calculated from peak area divided by total area of the sample and were expressed as area percent of the total amount of fatty acids in each sample.

For amino acid analysis, samples of roe and isinglass from swim bladder were submitted to the Woodson-Tenant Laboratories, Inc. (Memphis, TN). These laboratories analyzed all amino acids except tryptophan according to AOAC (1990) Method 975.44 using an amino acid analyzer. Tryptophan was analyzed by AOAC (1990) Method 988.15 using reversed-phase HPLC chromatography equipped with a UV detector.

Fat-soluble vitamin (vitamins A, D, and E) content was determined according to AOAC (1990) Method 979.24 using a high-performance liquid chromatograph (Waters, Milford, MA) equipped with a UV detector (Perkin-Elmer LC-75). Two Waters M6000A pumps and a solvent programmer were used for separation. The solvent was delivered at a flow rate of 2 mL/min gradient from 90% methanol–10% water to 100% methanol for 3 min. An Ultrasphere ODS C_{18} column (4.6 × 250 mm) (Beckman Inc., Palo Alto, CA) was used. Fat-soluble vitamins eluted from the column were detected at 254 nm with 0.01 AUFS and identified by comparing their retention times with those of standards (Sigma Chemical Co., St. Louis, MO). Vitamin C content was determined according to the method of Strohecker and Henning (1966).

Cholesterol content was determined according to AOAC (1990) Method 976.26 using a gas chromatograph (Hewlett-Packard 5890 Series I) equipped with a FID detector and autoinjector. An SPB1 capillary column (30 m × 2.5 mm, Supelco) was used. Injector temperature and detector temperature were 325 °C, and column temperature was 285 °C. Cholesterol was identified by comparing the retention times with a that of a standard, and cholestane (Sigma) was used as an internal standard. Quantities were calculated from peak heights of cholesterol and cholestane.

Microbiology. Total bacterial counts in fresh catfish roe were enumerated following the procedures of Messer *et al.* (1984) and Bactometer Microbial Monitoring System (bioMerieux-Vitek, Hazelwood, MO).

Microflora in catfish roe were identified using the Vitek Identification System (bioMerieux-Vitek). Bacteria were isolated by the rinse bag method (American Public Health Association, 1992) of shaking vigorously in sterile physiological saline (0.9% sodium chloride) (Baxter Healthcare Corp., Deerfield, IL) at a 1:1 sample weight/diluent for 60 s. Catfish roe was aseptically removed, dilutions were made, and 0.1 mL of rinsate was spread plated on plate count agar (Difco Laboratories, Detroit, MI). Selected microorganisms from total plate count agar were streaked on blood agar to provide pure cultures. Then a suspension of cells at a specific optical density was inoculated onto Vitek identification cards and incubated at 35 °C until identified. The Vitek identification cards are specific for various microorganism classifications. The cards are composed of 30 miniature wells of biochemicals. During incubation, the microbe metabolism causes color changes of the biochemicals. Extensive computer software is implemented to monitor the rate of color changes and assign a biocode to the set of color reactions. The computer then identifies the organisms on the basis of this biocode.

RESULTS AND DISCUSSION

Proximate analysis determined that channel catfish roe was 64.5% moisture, 2.4% ash, 24.6% protein, and 8.0% fat (Table 1), which was similar to roe of mixed fish species (USDA, 1987). However, the moisture content of catfish roe was lower than that of Alaska pollack roe as reported by Chiou *et al.* (1989). The lipid content of catfish roe was lower than that of mullet roe (Lu *et al.*, 1979), but eggs from middle-age females in carp, *Gadid* sp., and flounder contained the highest level of lipid (Kjorsvik *et al.*, 1990). The lipid content of roe of catfish could also differ with the age of the fish. Proximate analysis in swim bladder of catfish was 74.6% moisture, 0.2% ash, 13.8% protein, and 0.7% fat. Swim bladder of catfish was higher in moisture than that of marine fishes (Qadri *et al.*, 1969). Ash and fat contents of catfish swim bladder were similar to those of marine fishes (Qadri *et al.*, 1969).

Table 1. Proximate Composition (Percent) of Catfish Roe and Swim Bladder

	roe[a]	swim bladder[b]
moisture	64.53 ± 2.39[c]	74.60 ± 0.45
ash	2.39 ± 0.22	0.18 ± 0.02
protein	24.64 ± 1.48	13.83 ± 0.61
crude fat	8.03 ± 0.61	0.73 ± 0.16

[a] Four replicated samples. [b] Three replicated samples. [c] Mean ± standard deviation.

Table 2. Fatty Acid Composition (Percent of Total Fatty Acids) of Catfish Roe and Swim Bladder

fatty acid	roe[a]	swim bladder[b]
saturated		
C14:0	0.84 ± 0.06[c]	1.63 ± 0.13
C16:0	16.28 ± 0.71	18.26 ± 0.74
C18:0	9.08 ± 0.40	6.22 ± 0.47
C20:0	0.08 ± 0.01	
monounsaturated		
C16:1(*n*−9)	1.60 ± 0.17	0.68 ± 0.06
C16:1(*n*−7)	2.25 ± 0.30	2.88 ± 0.17
C18:1(*n*−9)	30.97 ± 0.89	47.74 ± 0.80
C18:1(*n*−7)	3.45 ± 0.22	2.61 ± 0.02
C20:1(*n*−9)	1.25 ± 0.09	1.76 ± 0.07
polyunsaturated		
C18:2(*n*−6)	6.69 ± 0.48	13.03 ± 0.44
C18:3(*n*−6)	0.84 ± 0.14	
C18:3(*n*−3)	0.45 ± 0.06	
C18:4(*n*−3)	0.13 ± 0.02	1.07 ± 0.01
C20:2(*n*−6)	0.11 ± 0.04	
C20:3(*n*−6)	2.71 ± 0.10	1.00 ± 0.22
C20:4(*n*−6)	4.38 ± 0.41	1.63 ± 0.76
C20:4(*n*−3)	0.21 ± 0.03	0.24 ± 0.00
C20:5(*n*−3)	1.64 ± 0.17	0.93 ± 0.17
C22:4(*n*−6)	0.31 ± 0.03	
C22:5(*n*−3)	1.28 ± 0.17	
C22:6(*n*−3)	8.04 ± 0.53	1.93 ± 0.61
unknown	7.43 ± 0.77	2.35 ± 1.03

[a] Four replicated samples. [b] Three replicated samples. [c] Mean ± standard deviation.

The major saturated fatty acids of lipid from catfish roe were palmitic acid (C16:0, 16.28%) and stearic acid (C18:0, 9.08%) (Table 2). The principal monounsaturated fatty acid was oleic acid (C18:1, 30.97%), and the predominant polyunsaturated fatty acids were linoleic acid (C18:2, 6.69%) and docosahexaenoic acid [C22:6 (DHA), 8.04%]. Fatty acid composition of catfish roe was similar to the fatty acid composition of catfish muscle and mince as reported by Akoh and Hearnsberger (1992) and Liu (1992). Also, saturated, monounsaturated, and polyunsaturated fatty acid composition of mullet roe was similar to those of catfish roe, and the polyunsaturated fatty acids, stearidonic acid (C18:4) and eicosapentaenoic acid (C20:5), of mullet roe were much higher than that of catfish roe (Lu *et al.*, 1979).

The principal saturated, monounsaturated, and polyunsaturated fatty acids of swim bladder were palmitic acid (18.26%), oleic acid (47.74%), and linoleic acid (13.03%), respectively. The level of DHA in the swim bladder was much lower than that of catfish roe. Oleic acid C18:1(*n*−9) composed almost half of the fatty acid content of the total lipid.

Catfish roe contained comparatively high amounts of aspartic acid, glutamic acid, alanine, and leucine (Table 3). As in all fish roe previously examined, glutamic acid was present in greatest concentration (Iwasaki and Harada,

Table 3. Amino Acid Composition[a] (Milligrams per 100 Grams) of Catfish Roe and Isinglass from Catfish Swim Bladder

amino acid	roe	swim bladder
tryptophan	0.13 ± 0.01[b]	0.17 ± 0.01
aspartic acid	2.09 ± 0.08	9.12 ± 0.20
threonine	1.10 ± 0.04	3.52 ± 0.02
serine	1.18 ± 0.03	4.09 ± 0.03
glutamic acid	2.73 ± 0.09	9.57 ± 0.10
proline	1.20 ± 0.10	11.50 ± 0.31
glycine	0.75 ± 0.06	7.74 ± 0.90
alanine	2.05 ± 0.24	9.63 ± 0.27
cystine	0.26 ± 0.01	0.28 ± 0.01
valine	1.41 ± 0.10	2.98 ± 0.03
methionine	0.67 ± 0.02	1.92 ± 0.05
isoleucine	1.09 ± 0.08	2.00 ± 0.04
leucine	1.95 ± 0.14	3.42 ± 0.02
tyrosine	0.53 ± 0.11	1.54 ± 0.02
phenylalanine	0.74 ± 0.03	2.76 ± 0.04
histidine	0.53 ± 0.03	1.63 ± 0.04
lysine	1.53 ± 0.11	3.91 ± 0.04
arginine	1.24 ± 0.09	7.81 ± 0.16

[a] Three replicated samples. [b] Mean ± standard deviation.

Table 4. Vitamin and Cholesterol Content of Catfish Roe

	mg/100 g		mg/100 g
vitamin A[a]	2.05 ± 0.40[c]	vitamin C[b]	0.26 ± 0.03
vitamin D[a]	0.20 ± 0.00	cholesterol[b]	639.03 ± 55.80
vitamin E[a]	0.10 ± 0.03		

[a] Four replicated samples. [b] Three replicated samples. [c] Mean ± standard deviation.

1985; Lu *et al.*, 1979). Even at different stages of maturity in Baltic herring and rainbow trout, glutamic acid was the predominant amino acid in roe (Kaitaranta, 1980). The major amino acids in catfish roe were similar to those found in most marine fish roe (Iwasaki and Harada, 1985). However, the amino acid composition of catfish roe was somewhat different from that of mullet roe in which glutamic acid, lysine, and proline predominated (Lu *et al.*, 1979).

Major amino acids in isinglass from catfish swim bladder were aspartic acid, glutamic acid, proline, and alanine. Amino acid composition in isinglass of some marine fishes, such as threadfin (*Polynemus* spp.), jewfish (*Sciaena* spp.), catfish (*Arius* spp.), and eel (*Muraena* spp.), is quite different from that of catfish isinglass (Qadri *et al.*, 1969). In these fishes, glycine, hydroxyproline, and proline were the amino acids with the highest levels. In hake isinglass, which has been used as a clarification agent in the food industry, amino acid composition was similar to that of catfish isinglass (Qadri *et al.*, 1969). Also, amino acid profiles of ox collagen were also very different from that of catfish isinglass, but its content of hydroxyproline was similar to that of marine fish isinglass (Qadri *et al.*, 1969).

Catfish roe contained 2.05, 0.2, and 0.1 mg/100 g of vitamins A, D, and E (Table 4). Major pigments found in eggs of salmonids were carotenoids, which may serve as biological antioxidants (Kjorsvik, 1990). The comparatively high level of vitamin A in catfish roe could be due to the carotenoids. Catfish roe also contained 0.26 mg/100 g of vitamin C. Hilton *et al.* (1979) also found a high content of vitamin C in rainbow trout eggs. The vitamins in catfish roe might vary depending on the catfish diets. These values were for catfish from one catfish processing plant only.

Like most other eggs, catfish roe was high in cholesterol, 639 mg/100 g. The cholesterol content of catfish roe was higher than that of mullet roe (Lu *et al.*, 1979).

Major minerals of catfish roe were potassium and phosphorus, 122.5 and 4700 ppm, respectively (Table 5).

Table 5. Mineral Content of Catfish Roe

mineral[a]	ppm	mineral[a]	ppm
Fe	1.73 ± 0.17[b]	Zn	6.33 ± 0.10
Cu	0.03 ± 0.01	Mg	29.5 ± 1.00
Na	23.0 ± 2.60	Mn	trace
Ca	36.0 ± 1.40	P	4700 ± 200
K	122.5 ± 11.36		

[a] Four replicated samples. [b] Mean ± standard deviation.

Table 6. Identified Microflora and Total Plate Count in Catfish Roe

P. shigelloides	*E. vulnaris*
E. agglomerans	*Corynebacterium* sp.
V. alginolyticus	*Pseudomonas* sp.

Total plate count: 0.7×10^4 to 2.4×10^5 CFU/g

Catfish roe also contained high amounts of sodium, calcium, and magnesium. The roe of Alaska pollack reportedly contained high amounts of sodium and potassium (Chiou *et al.*, 1989). The high amount of sodium in Alaska pollock roe would reflect the marine origins.

Total plate count and identified microflora in catfish roe are provided in Table 6. *Plesiomonas shigelloides* and *E. vulnaris* were the two dominant species. *Enterobacter agglomerans, Vibrio alginolyticus, Corynebacteria* sp., and *Pseudomonas* sp. were also found in catfish roe. Identified bacteria in catfish roe were found also in channel catfish (MacMillan, 1985). The total plate count for catfish roe ranged from 0.7×10^4 to 2.4×10^5 CFU/g.

CONCLUSION

Roe is one of the most valuable food products from fishery sources. During the season, catfish roe and swim bladder are available in large quantities from processing plants for cultured catfish. Results of this study indicate that catfish roe could be a source of food products for human consumption, and swim bladder might be utilized as a clarification agent for the food industry. Use of catfish roe and swim bladder for food products and food ingredients could help catfish processing plants become more profitable and reduce waste.

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