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Chemical Composition and Nutritional Value of Processing Discards of Cod (*Gadus morhua*)

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ABSTRACT

*Cod offal from Atlantic species (*Gadus morhua*) during the intense summer inshore fisheries, June–August, was analyzed for its chemical composition and energy value. The crude protein content of the samples was 14·3% and this included 2·55% collagen. The total lipid content of the offal was 4·3% and its ash content averaged 3·95%. Thus, the energy value of the offal was calculated as 413 kJ/100 g. The offal had an increased content of glycine, alanine, serine, proline and hydroxyproline as compared to the cod muscle proteins. Based on the content of selected amino acids, the calculated PER value for the offal was 1·88–2·36 as compared to 2·86–3·24 for the cod muscle. The fatty acid composition of the offal was similar to that of the cod-liver oil.*

INTRODUCTION

Renewable marine resources are important origins of human food supply. More importantly the advent of the polyunsaturated fatty acids and specifically eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA),

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and their beneficial health effects in reducing cardiovascular disease, has brought about an increase in the consumption of seafoods in general. However, depletion of cod stocks and other marine resources, due to over-fishing, has had an important effect on the development of aquaculture industries in Canada as well as in other parts of the world.

In Newfoundland, the Seaforest Plantation Company has initiated a cod-farming operation in several locations around the province. In contrast to many other aquaculture operations, cod are trapped and are transported to near-shore cages by boats. The caged cod are then fed intensively on either underutilized fish species such as capelin or on pelleted feed.

Feed costs have been estimated to account for the major part of expenses for aquaculture operations and animal feed costs and this has, therefore, created a great interest in the utilization of fishery by-products.

In order to develop successful feed formulae, information on the nutrients and chemical composition of fishery by-products and their caloric values is required. It is important for feed to be nutritionally sound and economical. Cod offal constitutes about two-thirds of the total weight of fish and these are not presently utilized. The offal is generally dumped into the ocean and this in turn has brought about serious concerns for its ecological and environmental effects. Therefore, utilization of cod offal not only presents the aquaculture industry with a sustainable and economically attractive feed supply, but also serves as an effective means of controlling pollution.

Although preparation of silage from fish discards has been successfully considered (Hardy *et al.*, 1983; Wood *et al.*, 1985), evaluation of the nutrient content of discards, as such, has not taken place. Acidification also offers the advantage of eliminating microbial contamination. The present study was undertaken in order to evaluate the chemical, amino acid and fatty acid compositions as well as caloric value of cod offal, from summer inshore fisheries, as a potential component for aquaculture or animal feed. Summer inshore fisheries in Atlantic Canada constitute the major part of the annual harvest of cod (about 80%, Newfoundland and Labrador Department of Fisheries, personal communication). Therefore, this study was concentrated on the use of discards during their bulk production only.

MATERIALS AND METHODS

Offal from four sets of trapped cod, each set consisting of a dozen fish, were ground thrice using a Hobart industrial grinder. The offal constituted head, viscera and skeletal frames. The samples were then homogenized and vacuum-packed and kept frozen at −20°C until use.

Moisture content of the samples was determined by oven-drying about 2 g of the homogenized samples at 105°C to a constant weight. The total lipids were extracted and determined according to the Bligh and Dyer (1959) method. The ash content of the samples was determined by their mineralization at 550°C according to the AOAC (1980) method of analysis. Total protein (crude protein, N × 6·25) content was determined according to the AOAC (1980) methods.

The tryptophan content was determined by hydrolyzing the samples with a 3N solution of mercaptoethane sulfonic acid for 24 h at 110°C. The resultant amino acids were then separated on a Beckman 121MB amino acid analyzer. Other amino acids were hydrolyzed for 24 h at 110°C with 6N HCl (Blackburn, 1968) and were separated as before. Tryptophan was determined separately according to the method of Penke *et al.* (1974).

For fatty acid analysis, the lipid extracts were subjected to trans-methylation in acidified methanol. Methyl heptadecanoate was used as an internal standard. The methyl esters were then separated in a 30 m × 0·25 m capillary column coated with SP2330 (Supelco Inc., Bellefonta, PA) in a Perkin–Elmer 8500 gas chromatograph. Oven temperature was 180°C, and the injection port and flame ionization detector oven temperatures were 230°C. Quantification was accomplished with the data handling and control unit of the instrument.

The energy contents of the samples were calculated by the Atwater conversion method (Bogert *et al.*, 1973) using their protein and lipid contents. Protein efficiency ratio (PER) values of cod offal and cod fillets were calculated using equations developed by Alsmeyer *et al.* (1974) and Lee *et al.* (1978) (See Table 2 below).

The collagen content of the fish offal was calculated by multiplying the hydroxyproline contents by a factor of 7·25 as given by Cross *et al.* (1973).

RESULTS AND DISCUSSION

The nutrient composition and caloric values of cod offal and cod muscle are summarized in Table 1. Based on these results, cod offal has a significantly larger content of collagen, lipids and ash than those of cod fillets. However, their moisture content was on average somewhat less than that of cod fillets. The enhanced lipid content in the offal is due to the presence of livers which contain about 50% oil, and their high ash content is due to the inclusion of bones in the offal. The high collagen content in the resultant offal arises from the inclusion of skin and connective tissues from joints, etc. in the products. Based on the results in Table 1 the energy value of cod offal was calculated to be 413 ± 43 kJ/100 g and this compares favourably with a value of 344 kJ/100 g calculated for cod fillets. However, the caloric value of cod offal

TABLE 1
Chemical Composition (%) and Caloric Value of Cod Offal and Cod Muscle

Component/quality	*Cod offal*[a]	*Cod muscle*[b]
Moisture (%)	77·61 ± 0·35	81·22 ± 0·04
Crude protein (N × 6·25) (%)	14·3 ± 0·61	17·8 ± 0·04
Collagen (%)	2·55 ± 0·46	—
Lipids (%)	4·30 ± 0·78	0·67 ± 0·01
Ash (%)	3·95 ± 0·25	1·16 ± 0·01
Carbohydrates (%)	<0·1	0·00
Caloric value (kJ/100 g)	413 ± 43	344

[a] Values are mean values of 4 to 8 replicates for four sets of samples (each consisting of a dozen offal samples), ± standard deviation.
[b] From Nutrition Monitoring Group (1987).

depends primarily on the size and the lipid content of the livers. Nearly 40% of the energy value of the samples tested came from their fat components.

The predicted protein efficiency ratio (PER) value of cod offal was about 30% less than those of the cod fillets. The method of calculation is given in Table 2. Although the numerical values estimated from each of the five equations (Table 2) were different, these values were substantially lower for cod offal. Presumably the enhanced collagen content of the offal is responsible for this phenomenon. The amino acid composition of muscle

TABLE 2
Calculated Protein Efficiency Ratio (PER) Values of Cod Offal and Cod Muscle

No.	*Prediction equations*[a]	*PER*	
		Cod offal	*Cod muscle*
1	−0·684 + 0·4565 [LEU] −0·047 [PRO]	1·88	2·86
2	−0·468 + 0·454 [LEU] −0·105 [TYR]	2·09	2·87
3	−1·816 + 0·435 [MET] + 0·780 [LEU] + 0·211 [HIS] −0·944 [TYR]	2·36	3·24
4	0·08084 [$\sum AA_7$] − 0·1094	2·31	2·99
5	0·06320 [$\sum AA_{10}$] − 0·1539	2·33	2·90

[a] Equations 1–3 are according to Alsmeyer *et al.* (1974), and eqns 4 and 5 are according to Lee *et al.* (1978).
LEU = Leucine; PRO = Proline; TYR = Tyrosine; MET = Methionine; HIS = Histidine.
$\sum AA_7$ = Threonine + valine + methionine + isoleucine + leucine + phenylalanine + lysine.
$\sum AA_{10} = \sum AA_7$ + histidine + arginine + tryptophan.

TABLE 3
Amino Acid Composition (g/100 g protein) of Cod Offal and Cod Muscle

Amino acid	*Cod offal*[a]	*Cod muscle*[b]
Aspartic acid	9·05 ± 0·75	10·24
Hydroxyproline	2·38 ± 0·45	—
Threonine	4·15 ± 0·37	4·39
Serine	5·35 ± 0·58	4·08
Glutamic acid	12·56 ± 1·05	14·92
Proline	5·57 ± 0·81	3·54
Glycine	11·72 ± 2·03	6·05
Alanine	6·82 ± 0·76	4·80
Valine	3·80 ± 0·27	5·15
Cystine	0·85 ± 0·07	1·07
Methionine	2·78 ± 0·24	2·96
Isoleucine	3·30 ± 0·30	4·61
Leucine	6·18 ± 0·50	8·13
Tyrosine	2·36 ± 0·12	3·38
Phenylalanine	3·18 ± 0·23	3·90
Tryptophan	1·01 ± 0·10	1·12
Lysine	6·53 ± 0·49	9·18
Histidine	1·79 ± 0·12	2·94
Arginine	6·50 ± 0·75	5·99

[a] Results are mean values of 3 replicates of four sets of samples, each including a dozen offal samples ± standard deviation.
[b] From Nutrition Monitoring Group (1987).

and offal from cod is given in Table 3. While glycine, proline and hydroxyproline were more abundant in the offal, the contents of valine, leucine, isoleucine, tyrosine, lysine and histidine were somewhat lower in the offal. Therefore, in any food formulation design these factors have to be taken into consideration.

Table 4 summarizes the results for the fatty acid composition of the lipids in the offal and in the cod liver oil. As expected, the fatty acid composition of the offal resembles that of the cod liver oil.

CONCLUSIONS

The caloric value of cod offal compares favourably with that of the cod muscle. However, its protein component contains over 17% collagen. Therefore, this has a negative effect on its protein efficiency ratio (PER).

TABLE 4
Fatty Acid Composition (% in total lipid) of Cod Offal and Cod Liver[a]

Fatty acid	*Cod offal*	*Cod liver*[b]
14:0	2·0 ± 0·3	3·7
14:1	0·3 ± 0·1	0·1
16:0	11·0 ± 1·1	11·6
16:1	6·4 ± 0·3	13·3
18:0	4·0 ± 0·1	2·3
18:1	20·3 ± 0·2	21·7
18:2	3·8 ± 0·3	0·8
18:3	0·5 ± 0·1	0·2
18:4	2·6 ± 0·2	3·0
20:0	0·4 ± 0·1	0·2
20:1	7·4 ± 0·4	13·4
20:2	0·4 ± 0·1	0·2
20:4	0·8 ± 0·1	0·1
20:5	8·9 ± 0·3	7·7
22:1	5·1 ± 0·4	7·8
22:4	0·5 ± 0·1	—
22:5	1·3 ± 0·2	1·3
22:6	13·3 ± 0·2	11·4
24:0	0·7 ± 0·1	—
24:1	1·6 ± 0·5	—

[a] Results are mean values of 3 replicates of four sets of samples, each containing a dozen homogenized offal samples.
[b] Average of 2 determinations and range within ±0·1.

Based on its amino acid and fatty acid compositions, cod offal may serve as a potential nutrient component in any formulated feed product intended for animal and/or aquaculture feed. Possible microbial contamination from the use of offal may be prevented by perhaps a sterilization process or acidification.

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