Innovative Methods and Metrics for Agriculture and Nutrition Actions

Research Brief

September, 2022

Quantifying the nutrients in by-products from fish processing for use in sustainable aquaculture in Bangladesh

FINDINGS

- In Bangladesh, the traditional preparation/ filleting process of fin-fish leads to by-products that are approximately 15% of the total body weight of fish and 50-66% of the total body weight of shrimps and prawns.
- An analysis of the by-products found that they are sources of valuable nutrients such as protein, fat, and minerals, and that the nutritional composition of some by-products is similar to or even higher than the consumed portion.
- Four key micronutrients, Ca, Fe, Zn and Se were almost double to a few hundred times higher than in the consumed portion of the same species of fish and crustaceans.
- Scaling up these estimates to national production in Bangladesh, we estimate that by-products generated from processing of fish alone could amount to 52,673 tonnes of protein, and 71,769 tonnes of fat, annually.
- The estimated monetary value of by-products-based fish meal and oil could be USD 32.56-65.46 million annually.

RATIONALE

Fish offer high-value protein, essential micronutrients, vitamins, and omega-3 fatty acids. Although vegetable sources are increasingly important in the production of feed for fish, marine ingredients, mainly fish meal and fish oil are important protein and lipid sources. The production of 1 kg of fish meal requires 4 to 6 kg of raw fish, whereas, the production of 1 kg of fish oil requires 10-50 kg [1]. The majority share of fish meal (60%) and fish oil (80%) are used in the aquaculture industry. Globally, about 9.1 million metric tonnes (MT) of fish by-products are discarded annually at different stages of processing [2]. These traditional (high nutritional value, low monetary value) fish and crustacean by-products are un-used or under-utilized, despite containing an equivalent portion of protein and other essential nutrients to the raw fish. By-products are typically processed into inferior products like animal feed, fish meal, and fertilizer [3]. Furthermore, the nutritional value of some fishery products such as collagen, chitosan, minerals, essential amino acids, and PUFAs could be five times higher than the primary products [4]. The underutilization of Bangladeshi fish by-products remains largely undocumented. The goal of this study is to quantify the by-products produced, to characterize their nutritional value, and to discuss how these products might be used as feed ingredients and other products.

Table 1. Fish waste by species (n= >3,000 fish from n=200 markets, and n=20 households) during the process of filleting/ cleaning and from plate waste at household level.

Species	Total Production in 2019 (MT)	% contribution in WW of total fish production	By-products (±SD) in %	Plate waste in relation to total weight (mean±SD) in %	Consumable portion in relation to total weight (mean±SD) in %
Hilsa	532,795	12.15	9.3 ± 3.6	3.7 ± 0.5	88.3 ± 3.4
Pangus	458,307	10.45	11.9 ± 8.9	7.5 ± 1.3	76.6 ± 1.7
Rui	392,843	8.96	14.2 ± 4.4	8.5 ± 0.8	76.8 ± 4.3
Tilapia	390,559	8.9	18.8 ± 5.9	10.4 ± 1.5	70.0 ± 2.4
Silver carp	252,933	5.77	15.3 ± 6.9	7.0 ± 1.1	79.4 ± 2.8
Mrigal	242,223	5.52	15.8 ± 5.9	7.5 ± 1.4	79.4 ± 3.9
Catla	240,558	5.49	15.3 ± 6.6	12.0 ± 0.1	72.2 ± 0.2
Carpio	124,028	2.83	18.8 ± 7.6	7.4 ± 1.1	70.4 ± 5.3
Sarpunti	95,649	2.18	16.0 ± 5.0	10.2 ± 2.1	75.6 ± 3.9
Pabda	93,764	2.14	10.9 ± 4.2	4.4 ± 1.5	84.4 ± 5.5
Grass carp	69,217	1.58	15.8 ± 6.9	7.4 ± 2.1	78.1 ± 3.8
Shrimp	63,171	1.44	49.3 ± 2.6	0	50.5 ± 3.4
Koi	63,103	1.44	17.3 ± 4.6	19.8 ± 7.3	62.7 ± 8.9
Prawn	52,197	1.19	33.1 ± 2.9	0	66.9 ± 2.7
Kalbaus	39,020	0.89	17.0 ± 5.7	8.5 ± 0.7	74.1 ± 5.2
Bighead	15,292	0.35	14.4 ± 6.9	8.7 ± 1.0	77.0 ± 1.2

RESOURCES

- Traditional fish filleting data for the top 16 fish species in Bangladesh
- Nutrient data for different types of fish and crustacean by-products

OPPORTUNITIES

- Repurposing currently un-used or underutilized fish by -products could have substantial financial benefits along the food value chain
- Utilization of fish by-products as fish feed ingredients could provide a significant opportunity for sustainable aquaculture development.

METHODS AND FINDINGS

The study was conducted in the retail fish markets and urban households in Bangladesh. The selected 16 fish and crustacean species contribute at least 71.3% of the total fish production volume in Bangladesh [5]. The total length (TL in cm) and weight (g) were recorded for every species. After traditional filleting fish (n= >3000), by-products including fin, scale, gill, viscera, claw and shell were generated and weights were recorded accordingly.

The results show common carp generate the highest percentage of by-products (18.8±7.6) during the process of filleting compared to all other fish, whilst hilsa generates the lowest (9.3±3.6) (7). We found that the traditional cleaning process of fin fish in Bangladesh on average produces 15% of fish by-products (total wet weight (WW)). At the household level plate waste (as traditional filleting allows internal bones) ranged from 3.7 to 19.8% of the total weight of fish (Table 1). In the case of crustaceans, by-products are generated at 50-66% of the total body weight of shrimp and prawns, which are consistent with the findings of Klomklao et al. (2019) who stated that approximately 75% of the by-products are generated from crustacean species such as shrimp, crabs, prawns, lobster, and krill [8]. The micronutrient content, including calcium (Ca), iron (Fe), zinc (Zn) and selenium (Se) of by-products were analysed as described by Sprague (9).

Our findings showed that the viscera are high in micronutrients (Table 2), our figures are similar to studies from elsewhere [6]. We found that the protein content of fish scales ranged from 20-30g per 100g raw weight and the total lipid content ranged from 1.0 to 3.1g, similar to Rustad et al. (2011) [10].

Table 2. Nutrient content of fish by-products (viscera) of top 16 fish and crustaceans in Bangladesh

Species	Anatomical part measured	Protein (g/100g)	Lipid (g/100g)	Ca (mg/100g)	Fe (mg/100g)	Zn (mg/100g)	Se (µg/100g)
Hilsa	Viscera	9.4 ± 6.2	11.8 ± 3.4	615.8 ± 78.1	581.0 ± 34.9	66.7 ± 7.9	40 ± 3.9
Pangas	Viscera	17.9 ± 3.0	21.4 ± 2.0	1,381.0 ± 201.1	2,568.6 ± 149.9	87.6 ± 27.5	81 ± 12.1
Rui	Viscera	10.4 ± 2.2	21.8 ± 3.0	618.5 ± 112.6	1,728.1 ± 477.9	297.5 ± 29.5	106 ± 23.8
Tilapia	Viscera	9.0 ± 2.4	30.7 ± 6.8	487.2 ± 39.9	246.6 ± 88.7	41.5 ± 13.0	89 ± 24.0
Silver carp	Viscera	4.3 ± 0.7	5.8 ± 0.8	839.1 ± 190.4	6,300.7 ± 789.7	24.9 ± 2.0	138 ± 13.3
Mrigal	Viscera	6.4 ± 0.9	9.0 ± 0.5	839.0 ± 84.0	1,862.8 ± 209.5	102.2 ± 17.4	44 ± 2.0
Catla	Viscera	13.4 ± 0.9	18.6 ± 1.7	1,998.4 ± 377.9	2,855.4 ± 409.8	110.1 ± 34.0	27 ± 3.0
Carpio	Viscera	21.2 ± 5.3	1.8 ± 0.7	607.5 ± 103.8	667.6 ± 46.0	2,095.8 ± 489.1	0.03 ± 0.01
Sarputi	Viscera	25.7 ± 6.1	7.6 ± 3.2	312.3 ± 133.1	1,287.6 ± 208.6	47.5 ± 11.1	0.05 ± 0.02
Pabda	Viscera	16.7 ± 2.9	6.6 ± 0.1	5,035.6 ± 876.9	852.5 ± 39.9	91.7 ± 18.0	0.04 ± 0.01
Grass carp	Viscera	19.8 ± 4.8	19.7 ± 0.9	525.6 ± 57.0	1,229.9 ± 309.6	126.7 ± 10.0	0.08 ± 0.02
Koi	Viscera	26.2 ± 4.9	3.8 ± 1.1	3,565.9 ± 199.6	1,053.9 ± 109.0	82.5 ± 4.9	0.04 ± 0.01
Kalibaush	Viscera	6.4 ± 1.8	28.2 ± 8.7	751.3 ± 77.8	3,589.4 ± 569.7	216.1 ± 23.1	0.09 ± 0.01
Bighead	Viscera	21.3 ± 2.1	6.2 ± 1.3	784.0 ± 59.7	8,916.9 ± 209.8	223.8 ± 32.9	0.08 ± 0.01
Shrimp	Head*	15 ± 1.4	2.3 ± 0.2	2,662 ± 300	6.2 ± 0.3	126 ± 18	33 ± 5
	Shell*	17 ± 0.3	1.1 ± 0	4,788 ± 547	5 ± 0.3	100 ± 11	19 ± 1
Prawn	Head*	13.5 ± 1	2 ± 0.2	1,409 ± 153	8.6 ± 1	78 ± 12	8.8 ± 0.6
	Shell*	17 ± 0.3	1.3 ± 0.4	5,247 ± 434	8.7 ± 0.4	93 ± 3	5 ± 0.9
	Claw muscle*	17.6 ± 0.5	1.8 ± 0.2	147 ± 12	0.4 ± 0.1	144 ± 10	11 ± 1
	Brain*	7 ± 0.1	47 ± 2	16 ± 2	7 ± 0.6	66 ± 5	10 ± 1

At current levels of fish production, the estimated by-products from the 16 species of fish studied, could result in 281,161- 565,332 MT on a WW basis. That could contribute 6.5-13.1% in volume of fish meal production, and support sustainable aquaculture in Bangladesh. The value of this is almost 32.56 -65.46 million USD.

Fish and crustacean by-products provide essential nutrients that could be used for pet animal feed or as raw materials for agriculture, pharmaceutical, and cosmetic industries.

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NEXT STEPS FOR FISH BY-PRODUCTS

- The aquaculture industry is quickly being industrialized, 'fish by-products meal' (FBM) could provide a novel opportunity to cut the cost of producing aquaculture inputs. Feed businesses could switch from fish meal or oil to FBM/O and so provide a nutritionally dense product that is environmentally sustainable
- Fish and crustacean by-products could be used as raw material for recycling or converting into valuable products such as fertilizer, fish silage, gelatin, chitosan, collagen, animal feed, fish oil, cosmetic, and pharmaceuticals, all of which play important roles in the circular economy.
- Future studies could include sampling more fish and crustacean species, larger sample sizes, vitamin, amino acid and fatty acid profiling. The fish and crustacean processing industry could also be considered.

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