PILOT-SCALE VALORIZATION OF HAIRTAIL (*Trichiurus lepturus*) HEAD BY-PRODUCTS INTO LOW-MOLECULAR-WEIGHT FISH PEPTONE POWDER

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ABSTRACT

Fish head by-products generated during seafood processing are often underutilized despite their high protein potential. This study developed and validated a pilot-scale, enzyme-assisted process to convert hairtail (*Trichiurus lepturus*) head by-products into fish peptone powder as a value-added protein ingredient. Hairtail heads (78.42 kg) were processed through cooking and defatting, followed by enzymatic hydrolysis using Protamax (0.2%) with purified water (1,568 L) at 45–50°C for 16 h. The hydrolysate was then heat-inactivated, filtered (20–25 μm), concentrated (85 kg; 6.66 °Bx), and dried. Freeze-drying produced 6.46 kg of final peptone powder, while spray drying yielded 76.98 g powder with a 15.39% (w/w) yield under inlet/outlet temperatures of 180–200°C and 90–95°C, respectively. Total nitrogen and amino acid nitrogen in the pilot-scale hairtail peptone were 6.70% and 1.67%, indicating that hydrolysis characteristics were maintained after scale-up. Gel permeation chromatography confirmed a predominantly low-molecular-weight peptide fraction (Mn 432 Da; Mw 1,697 Da; MP 492 Da), supporting its potential for downstream functional evaluation and formulation. Histamine was not detected in the hairtail peptone powder, suggesting acceptable safety for further development. Overall, the proposed pilot-scale process provides a practical route for valorizing hairtail head by-products into a standardized peptone ingredient for food- and bioindustry-related applications.

METHODS & RESULTS

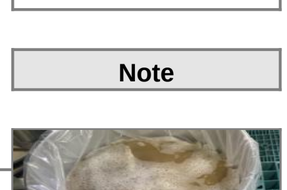
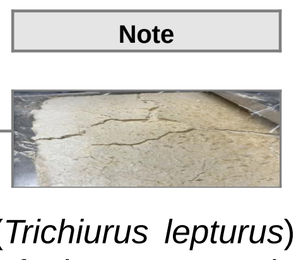
Step1	Main contents	Note
Cooking	▪Hairtail head by-products (78.42 kg) were loaded into a 5-ton extractor and cooked at 100°C for 1 h.	
⇩		
Step2	**Main contents**	**Note**
Oil removal	▪Process water was drained from the extractor, and the tank interior and raw material were rinsed with water to remove residual oil.	-
⇩		
Step3	**Main contents**	**Note**
Enzymatic hydrolysis	▪Purified water (1,568 L) and enzyme (0.2%, 3.14 kg) were added, and hydrolysis was conducted at 45–50°C for 16 h. The resulting hydrolysate showed 0.5 °Bx and pH 7.37.	
⇩		
Step4	**Main contents**	**Note**
Enzyme inactivation	▪The hydrolysate was transferred to a storage tank and heated to ≥90°C for 18 min (Jul 30, 10:42–11:00) for enzyme inactivation, then cooled to 50°C.	-
⇩		
Step5	**Main contents**	**Note**
Filtration	▪The hydrolysate was filtered using a 20–25 μm filtration condition.	-
⇩		
Step6	**Main contents**	**Note**
Concentration	▪Concentration was performed using an agitated concentrator at 55–60°C targeting ≥6.9 °Bx. The concentrate obtained was 85 kg, 6.66 °Bx, and pH 8.7.	
⇩		
Step7	**Main contents**	**Note**
Freeze-drying	▪The concentrate was freeze-dried for 72 h, yielding 6.46 kg of final powder.	

Figure 1. Pilot-scale process flow for producing hairtail (*Trichiurus lepturus*) head by-product peptone powder, including cooking/defatting, enzymatic hydrolysis, enzyme inactivation, filtration, concentration, and freeze-drying, with key operating conditions and yields.

Table 1. Total nitrogen, amino acid nitrogen, and histamine contents of hairtail (Trichiurus lepturus) head by-product peptone powder.

	Total nitrogen (%)	Amino acid nitrogen (%)	Histamine(mg/kg)
Hairtail head Protein Hydrolysate	6.70	1.67	ND

Table 2. Proximate composition of hairtail (*Trichiurus lepturus*) head by-product peptone powder, including carbohydrate, moisture, ash, protein, and lipid contents.

	Carbohydrates (g/100g)	Moisture (%)	ash (%)	Protein (g/100g)	Fat (g/100g)
Hairtail head Protein Hydrolysate	2.48	4.36	50.68	42.36	0.11

Table 3. Microbial counts of hairtail (*Trichiurus lepturus*) head by-product peptone powder, including total aerobic bacteria (aerobic plate count), coliforms, and fungi/yeasts.

	bacterial count (/g)	Coliform group (/g)	Fungus (/g)
Hairtail head Protein Hydrolysate	1700	0	0

Table 4. Foodborne pathogen screening results for hairtail (*Trichiurus lepturus*) head by-product peptone powder: *Salmonella* spp., *Staphylococcus aureus*, *Listeria monocytogenes*, and *Bacillus cereus*.

	Salmonella	Staphylococcus aureus	Listeria monocytogenes	Bacillus cereus
Hairtail head Protein Hydrolysate	Negative	Negative	Negative	Negative

Table 5. Constitutive amino acid composition and free amino acid profile of hairtail (*Trichiurus lepturus*) head by-product peptone powder.

Hairtail head Protein Hydrolysate	Constitutive amino acids (mg/kg)	Free amino acids (mg/kg)
Aspartic acid	41923.3503	1976.6284
Glutamic acid	68101.2554	3892.0581
Asparagine	N.A	813.6280
Serine	14870.1235	1147.9647
Glutamine	N.A	676.8814
Histidine	6314.6063	N.A
Glycine	43611.2992	1752.9361
Threonine	17226.2128	1291.7666
Citrulline	687.6287	517.9830
Arginine	20859.3176	741.5950
Alanine	26649.4547	3247.3823
Taurine	8050.2367	6860.1996
GABA	N.A	111.2695
Tyrosine	9948.0498	3630.2261
Valine	14575.8293	2455.9750
Methionine	N.A	1289.7336
Tryptophan	N.A	360.0859
Phenylalanine	11506.3409	2807.1060
Isoleucine	13390.3128	1542.0258
Ornitnine	N.A	410.6394
Leucine	20263.1948	3041.9674
Lysine	35925.5096	10798.6549
Proline	19447.0104	N.A

Reference

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