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Nutritional Composition and Protein Quality of the *Keropok Lekor* By-products

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ABSTRACT

The main by-products of processing *keropok lekor* include the fillet, frame, tail, head, and viscera. These materials, which are abundant and contain beneficial components like lipids, proteins, enzymes, and peptides, are frequently regarded as industrial waste. This study aims to ascertain the proximate nutritional content and essential amino acid (EAAs) profiles of four *keropok lekor* by-products in order to assess their potential for the production of value-added bio-products. *Keropok lekor* by-products, particularly the head, viscera, and frame, are high in both lipid and protein, ranging from 9.1 to 21.2% and 23.8 to 42.4%, respectively. Carbohydrate content can vary significantly, from 3.1% to 16.2%, depending on the specific by-product and processing method and the amount of ash and moisture contents did not differ significantly ($p > 0.05$). High quality of fish by-products protein based on EAAs content and the results showed that FBP4 (56.0%) and FBP3 (51.7%) predominantly consisted of EAAs. *Keropok lekor* by-products' high protein quality and nutritional composition indicate possibilities for biowaste-driven value-added products that illustrate the circular bio-economy ideas for sustainable development.

Keywords: Amino acid composition, *keropok lekor* by-products, nutritional composition, protein quality

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INTRODUCTION

Fish by-products are valuable raw materials that contain high-value components like collagen and derivates, enzymes, proteins, lipids, bioactive peptides, hydroxyapatite, vitamins, and minerals, that have numerous potential uses in a wide range of industries

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(Ideia et al., 2019). A significant amount of these fish by-products offers a rich and natural resource for the production or recovery of many valuable components, that can be valorised to create high-value products.

Problem Statement

Keropok lekor processing generates an enormous amount of solid fish by-products. The exploitation of fish by-products is consistent with the waste-to-wealth idea when waste is managed effectively.

Research Questions

What are the distinguishing attributes of fish by-products generated during the processing of *keropok lekor*?

In order to evaluate *keropok lekor* by-products' the suitability for the production of value-added bioproducts, this study attempts to determine their proximate nutritional content and essential amino acid (EAA) profiles.

MATERIALS AND METHODS

Collection and Processing of Fish By-products

Fish by-products were sourced from *keropok lekor* production sites located in Tumpat, Kelantan, and Kuala Terengganu, Terengganu. The obtained by-products were first thoroughly washed and then dried in an oven (UF450, Memmert, Germany) at 50°C for 48 hours. After drying, the materials were pulverised into a fine powder using a laboratory blender (model 7011HS, Waring, Japan).

Nutritional Composition

The proximate nutritional content of the various *keropok lekor* by-product samples was determined following the standards established by the Association of Official Analytical Chemists standards (Association of Official Analytical Chemists, 2005).

Determination of Essential Amino Acid Profile

Essential amino acids (EAAs) present in the fish by-products were identified and quantified using ultra-performance liquid chromatography (UPLC) with the ACQUITY UPLC system (Waters), following the method described by Danial et al. (2015). The results were expressed as grammes of amino acids per 100 grammes of the sample's dry weight.

RESULTS AND DISCUSSION

Types and Nutrient Composition of By-products from *Keropok Lekor* Production

We discovered that the ratio and composition of fish by-products produced by *keropok lekor* processing vary greatly based on the type of fish and the filleting technique used (Table 1). Low-value pelagic fish including round scad (*Decapterus macrosoma*) and sardine (*Sardinelle fimbriata*) are often utilised in the production of *keropok lekor*. The production of *keropok lekor* frequently uses low-value pelagic fishes because of their low bone content and tasty flavour (Rosidi et al., 2021).

Table 1
Types of fish, component parts, proportions, and nutritional composition of keropok lekor *fish by-products (FBPs)*

	Fish by-products			
FBPs	**FBP1**	**FBP2**	**FBP3**	**FBP4**
Species	*S. fimbriata*	*Decapterus species*	*D. macrosoma*	*D. macrosoma*
FBPs composition	Tail Fillet Frame Scales	Tail Fillet Frame	Tail Fillet Frame Fin Head Visceral	Head Viscera
Ratio	(2:2:4:2)	(2:2:6)	(1:1:2:1:2:2)	(5:5)
Nutritional composition (%)				
Protein	39.6 ± 0.5^{a}	40.4 ± 0.8^{a}	42.4 ± 0.18^{a}	23.8 ± 0.07^{b}
Lipid	9.1 ± 0.2^{b}	10.6 ± 0.2^{b}	19.3 ± 0.4^{a}	21.2 ± 0.4^{a}
Ash	33.4 ± 0.0^{a}	28.8 ± 0.0^{a}	26.9 ± 0.1^{a}	28.5 ± 0.0^{a}
Fibre	0.4 ± 0.0^{a}	0.8 ± 0.0^{a}	0.3 ± 0.0^{a}	0.3 ± 0.0^{a}
Carbohydrate	4.2^{b}	5.4^{b}	3.1^{b}	16.2^{a}
Moisture content	13.3 ± 0.6^{a}	14.0 ± 0.5^{a}	8.0 ± 0.4^{a}	10.0 ± 0.3^{a}

Values are given in percentage [%] on a dry matter basis. Each value is presented as mean ± SD, and within a row, means that do not share the same superscript letter are significantly different at $p < 0.05$ as determined by one-way ANOVA.

Proteins derived from fish frames, tails, scales, heads, viscera, fins, and fillets (often containing some backbone remnants post-filleting) constituted between 23.8% and 42.4% of the total fish by-products. The highest percentage of protein content is observed in FBP3 (42.4%), followed by FBP2 (40.4%) and FBP1 (39.6%). Lipids range from 9.1 to 21.2%, mainly from the heads, frame, and viscera. As predicted, due to the high lipid content of heads and visceral, FBP3 (19.3%) and FBP4 (21.2%), which are made up of these parts, had higher lipid contents than other fish by-products ($p < 0.05$). All of the fish by-products had ash and moisture concentrations that were not statistically different from one another ($p > 0.05$), and their carbohydrate content varied from 3.1% to 16.2% of the composition.

The protein and lipid contents of the *keropok lekor* by-products used in this study were comparable to those of earlier research on fish by-products of gilthead sea bream, meagre, and scad shortfin conducted by Ishak and Sarbon (2018) and Kandyliari et al. (2020). Generally, each part of fish by-products exhibits a different nutritional composition. According to Marti-Quijal et al. (2020), depending on the species and size, the frame and head normally have protein contents between 32.5 and 58.5% and fat contents between 15.2 and 40.7%, which makes them suitable for possible use as fish oil and fish protein hydrolysate (FPH).

Evaluation of Protein Characteristics in Fish Processing By-product

The excellent quality of protein contained in fish by-products is determined by the total EAA According to Table 2, the findings indicated that FBP1 (48.1%) and FBP2 (35.1%) were primarily non-essential amino acids (NEAAs), whereas FBP4 (56.0%) and FBP3 (51.7%) were primarily composed of EAAs.

For FBP1, FBP2, FBP3, and FBP4, Lys, Val, and Leu accounted for approximately 87.0%, 70.9%, 54.2%, and 60.1% of all fish by-products, respectively. The FBP1 and FBP2, however, lacked His and Trp and Trp was the least amount of EAA found in FBP3 and FBP4. Furthermore, in terms of NEAA composition, the most common NEAAs in FBP2 and FBP3 were Ala and Glu, which accounted for approximately 67.8% and 41.9% of all NEAAs, respectively. For FBP1 and FBP4, the most common NEAAs were Asp and Glu (54.5%) and Ala and Gly (57.8%), respectively. The presence of the head part, which has a higher concentration of connective tissue, is associated with the high Gly content in FBP3 (0.7 g/100 g) and FBP4 (1.1 g/100 g). Ser and Tyr were also the least abundant NEAAs in all fish by-products.

The nutritional components of EAAs demonstrated the existence of high-quality protein and were crucial in controlling metabolic processes to provide positive outcomes (Corsetti et al., 2024). A prior investigation of fish by-products from *D. maruadsi* revealed that Leu (10.1%), Val (6.7%), and Lys (13.9%) were the most prevalent EAAs, which was consistent with the findings of this work (Thiansilakul et al., 2007). Leu, Lys, and Val have been linked with human health improvement and disease prevention by regulating the immune system (Luo et al., 2014). Variations in the nutritional content and amino acid profiles of *keropok lekor* by-products can be attributed to differences in the fish species utilised, the specific composition of the by-products, and their proportional use. These factors collectively affect the types of proteins extracted, including myofibrillar, sarcoplasmic, and stromal proteins.

Table 2
Amino acid profiles of keropok lekor *fish by-products (FBPs)*

Amino acid (g/100 g)	FBP1	FBP2	FBP3	FBP4
EAA				
Histidine	0.00 ± 0.0^{b}	0.00 ± 0.0^{b}	1.56 ± 0.2^{a}	1.33 ± 0.2^{a}
Threonine	0.14 ± 0.0^{b}	0.60 ± 0.4^{b}	2.76 ± 0.4^{a}	0.55 ± 0.2^{b}
Lysine	0.51 ± 0.1^{b}	1.15 ± 0.1^{b}	5.98 ± 0.5^{a}	6.76 ± 1.6^{a}
Methionine	0.05 ± 0.0^{b}	0.51 ± 0.3^{ab}	1.24 ± 0.1^{a}	1.06 ± 0.7^{a}
Valine	4.65 ± 0.5^{a}	3.27 ± 1.1^{a}	4.09 ± 0.1^{a}	5.11 ± 0.8^{b}
Isoleucine	0.51 ± 0.0^{b}	0.78 ± 0.5^{b}	3.17 ± 0.6^{a}	4.00 ± 0.3^{a}
Leucine	1.01 ± 0.3^{b}	2.44 ± 0.3^{b}	6.49 ± 2.4^{a}	4.69 ± 0.4^{a}
Phenylalanine	0.23 ± 0.1^{b}	0.87 ± 0.2^{b}	4.46 ± 0.6^{a}	3.17 ± 0.4^{a}
Tryptophan	0.00 ± 0.0^{b}	0.00 ± 0.0^{b}	0.64 ± 0.3^{a}	0.37 ± 0.1^{a}
Total EAA	7.08	9.66	30.50	27.09
NEAA				
Serine	0.00 ± 0.0^{b}	0.69 ± 0.4^{b}	1.43 ± 0.1^{a}	0.28 ± 0.0^{b}
Arginine	1.20 ± 0.3^{a}	0.87 ± 0.4^{b}	2.94 ± 0.2^{a}	0.69 ± 0.1^{b}
Glycine	0.64 ± 0.6^{b}	2.25 ± 0.3^{a}	3.27 ± 0.4^{a}	5.06 ± 0.6^{a}
Aspartic acid	2.39 ± 0.5^{ab}	1.01 ± 0.0^{ab}	3.31 ± 0.1^{a}	1.79 ± 0.1^{b}
Glutamic acid	1.75 ± 0.3^{b}	7.13 ± 2.2^{a}	6.26 ± 0.7^{a}	3.40 ± 0.2^{ab}
Alanine	1.20 ± 0.6^{b}	4.97 ± 0.2^{ab}	5.70 ± 0.3^{a}	7.22 ± 2.6^{a}
Proline	0.18 ± 0.2^{b}	0.64 ± 0.2^{b}	1.33 ± 0.1^{a}	2.39 ± 0.5^{a}
Tyrosine	0.14 ± 0.0^{b}	0.18 ± 0.0^{b}	4.19 ± 1.7^{a}	0.74 ± 0.1^{b}
Total NEAA	7.59	17.85	28.52	21.25
TAA	14.72	27.51	59.02	48.39

EAA: Essential amino acids; NEAA: Non-essential amino acids; TAA: Total amino acid. Each value is expressed as mean ± SD, and within each row, means that do not share the same superscript letter are significantly different at $p < 0.05$, as determined by one-way ANOVA

CONCLUSION

The nutritional makeup and quality of proteins in *keropok lekor* by-products show significant variation depending on the specific parts used, the composition of fish by-product blends, and the fish species involved. To identify the best substrate, several fish by-products (FBP1, FBP2, FBP3, and FBP4) were characterised and evaluated. FBP3 had greater nutritional composition and protein quality than the other FBPs. Therefore, further study on the FBP3 as the substrate for producing FPH is warranted.

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