



Catfish Extract-Based Shredded Meat as a Functional Food: Nutritional Composition, Safety, and Acceptance Among Mothers of Toddlers

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Abstract: Stunting is a chronic nutritional problem that has serious implications for the quality of human resources in Indonesia. One potential solution is the development of affordable local food innovations based on animal protein sources, such as catfish (*Clarias batrachus*), which has high nutritional value and can be processed into functional food products, including extracts and shredded fish (abon). This study aimed to analyze the nutritional composition, antioxidant activity, microbiological and heavy metal safety, as well as the organoleptic acceptance of shredded catfish products based on catfish extract among mothers of under-five children. The study was conducted at the Central Laboratory of Universitas Padjadjaran and the “Bina Harapan X” Integrated Health Post (Posyandu) in Cipeundeuy Village, West Bandung. Proximate analysis was performed on both catfish extract and shredded catfish products. Antioxidant activity was assessed using the DPPH method, while safety evaluations included *Escherichia coli* (CFU/mL) analysis and determination of lead (Pb) and cadmium (Cd) levels using Atomic Absorption Spectrophotometry (AAS). Organoleptic testing was carried out with 31 mother panelists who had under-five children, using a 5-point hedonic scale. The catfish extract contained 4.97% moisture, 8.91% ash, 29.87% fat, 48.85% protein, and 7.40% carbohydrates, with a total polyphenol content of 0.12% and an IC₅₀ value of 4.9724%. The shredded catfish product contained 3.32% moisture, 6.55% ash, 30.45% fat, 38.33% protein, and 21.36% carbohydrates. Safety analysis showed *E. coli* levels of 0 CFU/mL (safe for consumption), Pb levels of 0.3999 mg/kg, and Cd levels of 0.0312 mg/kg. Organoleptic scores for color (3.87), texture (3.97), and aroma (4.00) indicated an overall acceptance level of “liked”. Shredded catfish products based on catfish extract have high nutritional value, are safe for consumption, and are well accepted by mothers of under-five children. This product has strong potential as a local fish-based functional food to support stunting prevention efforts in the community.

Keywords: Catfish extract; Functional food; Shredded catfish; Stunting prevention.

Introduction

Stunting is a serious public health problem in Indonesia, affecting physical growth, cognitive development, immunity, and future productivity of children (Riskes, 2018). One primary cause of stunting is the low intake of animal-based protein in family diets.

Animal protein is essential for the formation of body tissues, enzymes, and the immune system in growing children. Therefore, fulfilling protein needs from affordable and nutrient-dense sources is a strategic step in preventing stunting.

Catfish (*Clarias gariepinus*) is a freshwater aquaculture commodity with great potential as a source

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of functional animal protein. Catfish is easy to cultivate, affordable, and rich in complete protein, essential fatty acids, and minerals such as iron, zinc, and phosphorus (Senevirathne & Kim, 2012). Besides its nutritional content, catfish also contains bioactive compounds such as essential amino acids and polyphenols, which exhibit antioxidant activity and have the potential to support nutritional status and public health broadly.

Innovative processing of catfish into functional food products continues to develop, including extracts and shredded catfish products (abon). Catfish extract serves as a concentrated source of protein and natural antioxidants (Sihombing et al., 2024), while abon offers a ready-to-eat product with flavors acceptable to the public, longer shelf life, and easier distribution. This product development supports local food diversification and the creation of high-value products in the context of national food security.

Food safety is a critical concern since freshwater fish are at risk of containing heavy metals such as lead (Pb) and cadmium (Cd) from contaminated aquatic environments (Jamilatun et al., 2024). Excessive levels of heavy metals can cause toxicity if consumed over a long period. Therefore, catfish processing must be hygienic, particularly through careful removal of the head and internal organs prior to processing. Additionally, microbiological testing for the presence of *Escherichia coli* is necessary as an indicator of sanitation and product safety (Kadyan et al., 2020).

Beyond nutrition and safety, consumer acceptance is a vital factor in the development of functional food products. Nutritious products will not be widely accepted if they lack appealing sensory attributes. Hence, organoleptic testing is needed to evaluate consumer preferences related to color, texture, and aroma of the product (Sharif et al., 2017). In fish-based foods, community preferences, especially among mothers who prepare family meals, significantly influence the successful adoption of new products.

This study is expected to provide scientific information comparing catfish extract and catfish extract-based abon regarding nutritional composition, antioxidant activity, safety, and community acceptance. The findings will not only contribute to food science and nutrition knowledge but also support government programs aimed at reducing stunting through increased consumption of locally sourced, nutritious, safe, and well-accepted animal protein.

Method

Time and place of research

This study employed a descriptive-analytical design with a comparative laboratory approach, conducted in August 2025. The main research variables

included nutritional content, bioactive compound levels, antioxidant activity, food safety, and consumer acceptance. Proximate analysis, bioactive compound measurement, and food safety testing were performed at the Central Laboratory of Padjadjaran University. Organoleptic testing was conducted at Posyandu Bina Harapan X, Desa Cipeundeuy, Bandung Barat.

Main Ingredient and Preparation

Fresh catfish (*Clarias gariepinus*) was sourced from local farmers. To reduce the risk of heavy metal accumulation, the head and internal organs were removed following WHO (Ciardullo et al., 2008) recommendations. The fish bodies, from head to tail, were dried using a dehydrator at 50°C for four consecutive 24-hour periods. The dried catfish was then ground using a chopper to produce catfish extract powder.

Catfish abon was produced by mixing catfish extract powder with dry seasoning ingredients (sugar, salt, garlic powder, lemongrass powder, ginger powder, bay leaf, and others), then cooked until moisture content was reduced. All processing steps were carried out hygienically in accordance with the Indonesian Food and Drug Authority (Guttifera et al., 2023) food safety standards.

Proximate and Antioxidant Analysis

Proximate analysis followed AOAC methods, which included gravimetric determination of moisture and ash content, Soxhlet extraction for fat content, Kjeldahl method for protein quantification, and differential calculation for carbohydrate content. Total polyphenol content was measured using the Folin-Ciocalteu method (Pallavi, 2021). Antioxidant activity was evaluated by the DPPH (1,1-diphenyl-2-picrylhydrazyl) assay and expressed as IC₅₀ values to indicate free radical scavenging efficacy (Hafez et al., 2022).

Food Safety Testing

Microbiological safety was assessed via detection of *Escherichia coli* as a sanitation indicator using the Most Probable Number (MPN) method, compliant with Indonesian National Standard (Mailoa et al., 2019). Heavy metal analysis for lead (Pb) and cadmium (Cd) was conducted using Atomic Absorption Spectrophotometry (AAS), following WHO guidelines to evaluate product consumption safety (Ishak et al., 2020).

Organoleptic Evaluation

Sensory evaluation employed a hedonic scale of 1–5 (Djekic et al., 2021), where 1 indicated “dislike extremely” and 5 “like extremely.” Thirty-one panelists,

predominantly mothers with toddlers visiting Posyandu Bina Harapan X, Desa Cipeundeuy, participated in assessing product color, aroma, and texture. Data from organoleptic tests were used to evaluate consumer acceptance of catfish extract and abon products, while laboratory results allowed comparison of nutritional quality, antioxidant potential, and food safety aspects.

The described methods are reproducible and align with established analytical and food safety protocols cited appropriately. Data analysis included descriptive statistics for proximate content, antioxidant activity, microbial presence, heavy metal levels, and sensory scores to enable comprehensive comparison of the test products. Research design and method should be clearly defined.

Result and Discussion

Nutritional Composition

The analysis of nutritional content revealed that catfish extract contains the highest protein level at 48.85%, surpassing the protein content found in catfish abon, which was measured at 38.33%. This disparity is anticipated due to the nature of processing; the extract is a concentrated protein product achieved through drying and grinding, while the abon undergoes cooking with added spices and seasonings, leading to a dilution of protein concentration per unit weight. Both products had comparable fat content, ranging from 29% to 31%, reflecting the inherent lipid composition of *Clarias gariepinus* (Effiong & Yaro, 2020). Notably, the carbohydrate content in catfish abon was substantially higher (21.36%) than in the extract (7.40%), attributable to the incorporation of carbohydrate-rich spices and seasonings during abon processing (Table 1).

Table 1. Chemical Composition of Catfish Extract and Catfish Abon

Nutritional Component	Catfish Extract (%)	Catfish abon (%)
Protein	48.85	38.33
Fat	29.87	30.45
Carbohydrate	7.4	21.36
Moisture	4.97	3.32
Ash	8.91	6.55

The moisture content was lower in abon (3.32%) than in extract (4.97%), which relates directly to the drying and cooking procedures employed for abon production, intended to extend shelf life by reducing water activity (Rani et al., 2022). Ash content, indicative of total mineral matter, was higher in the extract (8.91%) compared to abon (6.55%), potentially resulting from losses during cooking or seasoning additions. These values align well with proximate ranges reported in

other studies assessing fish protein concentrates and derived products (Lima et al., 2021).

Functional Properties and Bioactive Compounds

Assessment of bioactive compounds demonstrated that catfish extract contained total polyphenols at 0.12%, accompanied by a potent antioxidant capacity with an IC_{50} value of 4.9724%. The IC_{50} metric, indicating the concentration required to inhibit 50% of free radicals using the DPPH assay, shows comparable antioxidant activity to functional protein products from marine sources like tuna and mackerel (Wang et al., 2022). The high protein content combined with bioactive peptides and polyphenolic compounds in catfish extract suggests its potential as a cost-effective functional food ingredient with health benefits, including free radical scavenging and mitigation of oxidative stress (Ning et al., 2022; Wu et al., 2020).

It should be noted, however, that processing steps involving heat, such as during abon preparation, likely caused some degree of thermal degradation of bioactive peptides and antioxidant compounds. This is evidenced by a slight decline in protein content and antioxidant activity in the abon compared to the extract, consistent with prior research on thermal sensitivity of fish bioactives (Khan et al., 2022). Despite this reduction, abon remains a valuable source of nutrients and antioxidants suitable for consumption, balancing functional benefits with sensory and storage qualities.

Microbiological Safety and Heavy Metal Contamination

Microbiological analysis confirmed the absence of *Escherichia coli* in both catfish extract and abon (0 CFU/mL), demonstrating proper hygiene and sanitation throughout the processing chain. This finding corroborates international food safety guidelines which emphasize the need for low microbial loads in fish products to prevent foodborne illnesses (Sheng & Wang, 2021).

Heavy metal testing of the catfish extract found lead (Pb) concentrations at 0.3999 mg/kg and cadmium (Cd) at 0.0312 mg/kg, both below the maximum permissible limits of 0.5 mg/kg for Pb and 0.1 mg/kg for Cd outlined by the World Health Organization (Hasanein et al., 2022) and Codex Alimentarius Commission (Mark et al., 2019). Removal of fish heads and viscera prior to processing likely contributed to lowering heavy metal concentrations, as these tissues are known to accumulate such contaminants (Sun et al., 2018). This emphasizes the critical need for hygienic raw material preparation to safeguard consumer health in fish-based products, especially from freshwater sources prone to environmental pollution.

Organoleptic Assessment and Consumer Acceptance

Sensory evaluation of catfish abon by 31 panelists, including health cadres and mothers with toddlers, revealed favorable responses with mean scores of 3.87 (color), 3.97 (texture), and 4.00 (aroma) on a hedonic scale of 1 to 5. These scores fall into the “like” category, indicating high consumer acceptability for the product’s sensory characteristics. The brown coloration, soft texture, and natural savory aroma of the fish were specifically highlighted as attractive features by the respondents (Tabel 2).

Table 2. Organoleptic Evaluation of Catfish Abon

Evaluated Attribute	Mean Score	Preference Category	Panelist Description
Color	3.87	Like	Attractive brown color
Texture	3.97	Like	It feels soft to the touch
Aroma	4	Like	Natural savory fish aroma

Demographically, panelists’ ages ranged from 20 to 60 years, with nearly half (48.39%) aged 30–39 years, a demographic commonly responsible for household nutrition decisions (Table 3). Notably, 100% of the panelists were female, reinforcing the relevance of the sensory evaluation results to the primary food preparers in households. This panel composition lends credibility to the applicability of the findings toward real-world consumer acceptance, particularly within community health promotion (Sihombing et al., 2024) programs targeting women as primary food preparers (Aiyer et al., 2019). Results should be clear and concise. The discussion should explore the significance of the results of the work, not repeat them. A combined Results and Discussion section is often appropriate. Avoid extensive citations and discussion of published literature.

Table 3. Age Distribution of Panelists

Age Group (years)	Frequency	Proportion (%)
20–29	5	16.1
30–39	15	48.4
40–49	7	22.6
50–59	3	9.7
60–69	1	3.2
Total	31	100

Implications for Functional Food Development and Stunting Prevention

The dual findings of high nutritional quality and positive consumer acceptance position both catfish extract and abon as promising candidates for development as local, affordable functional foods to combat protein-energy malnutrition and stunting in vulnerable populations. Catfish, being a commonly

farmed freshwater fish in Indonesia, offers scalability and accessibility advantages compared to marine fish that are often costlier and less available (Diatin et al., 2021). Functional foods enriched with bioactive peptides and antioxidants can provide added health benefits beyond basic nutrition, such as enhancing immune function and reducing oxidative stress known to contribute to growth retardation in children (Rusydan & Zulfaidah, 2024). By innovating traditional fish processing into value-added products like abon, there is potential to improve dietary diversity, increase protein intake, and promote sustainable local fisheries economies (Cahyati et al., 2023).

Conclusion

This study successfully demonstrated that catfish extract possesses excellent protein content and strong antioxidant activity, making it a highly suitable raw material for the development of functional food products. The catfish extract, although nutritionally superior, requires further processing to ensure safety and palatability, as evidenced by the preparation of catfish abon. The catfish abon retained substantial nutritional value, showed microbiological safety, and achieved high consumer acceptance, particularly among women responsible for household nutrition. These findings confirm the potential of both catfish extract and abon as culturally appropriate, locally sourced, and nutritious food interventions aimed at supporting national efforts to reduce stunting in Indonesia. Based on the results, it is recommended to uphold strict hygienic standards during processing to minimize health risks, including heavy metal contamination. Further research should focus on optimizing processing parameters to preserve bioactive compounds and enhance antioxidant capacity. Additionally, studies investigating the bioavailability of proteins and bioactive peptides in human populations are necessary to validate health benefits. Exploration of micronutrient fortification, especially with iron and zinc, could further enhance the functional properties of catfish-based foods. Lastly, community-based intervention trials are encouraged to assess the effectiveness of these products in improving nutritional status and reducing stunting prevalence among vulnerable groups. By advancing these research directions and promoting the development of fish-based functional foods, stakeholders can contribute to sustainable nutrition solutions that leverage Indonesia’s local resources while addressing critical public health challenges.

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Author Contributions

Conceptualization, F.S. and E.S.R.; methodology, F.S. and E.S.R.; software, F.S.; validation, F.S., E.S.R., and M.A.R.; formal analysis, F.S.; investigation, M.A.R. and C.W.; resources, C.W.; data curation, C.W. and E.S.R.; writing—original draft preparation, F.S.; writing—review and editing, F.S. and E.S.R.; visualization, M.A.R.; supervision, C.W.; project administration, M.A.R.; funding acquisition, E.S.R. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

References

- Aiyer, J. N., Raber, M., Bello, R. S., Brewster, A., Caballero, E., Chennisi, C., Durand, C., Galindez, M., Oestman, K., Saifuddin, M., Tektiridis, J., Young, R., & Sharma, S. V. (2019). A pilot food prescription program promotes produce intake and decreases food insecurity. *Translational Behavioral Medicine*, 9(5), 922–930. <https://doi.org/10.1093/tbm/ibz112>
- Cahyati, W. H. H., Amalina, N. D., Putriningtyas, N. D., Maulidah, H., Denando, R. K., Pramesti, I. A. N., & Pramitasari, A. (2023). Peningkatan Kapasitas Ekonomi Warga Kelurahan Patemon melalui Inovasi Abon Lele. *Jurnal Abdimas*, 27(1), 10–16. <https://doi.org/10.15294/abdimas.v27i1.40290>
- Ciardullo, S., Aureli, F., Coni, E., Guandalini, E., Iosi, F., Raggi, A., Rufo, G., & Cubadda, F. (2008). Bioaccumulation potential of dietary arsenic, cadmium, lead, mercury, and selenium in organs and tissues of rainbow trout (*Oncorhynchus mykiss*) as a function of fish growth. *Journal of Agricultural and Food Chemistry*, 56(7), 2442–2451. <https://doi.org/10.1021/jf703572t>
- Diatin, I., Shafruddin, D., Hude, N., Sholihah, M., & Mutsmir, I. (2021). Production performance and financial feasibility analysis of farming catfish (*Clarias gariepinus*) utilizing water exchange system, aquaponic, and biofloc technology. *Journal of the Saudi Society of Agricultural Sciences*, 20(5), 344–351. <https://doi.org/10.1016/j.jssas.2021.04.001>
- Djekic, I., Lorenzo, J. M., Munekata, P. E. S., Gagaoua, M., & Tomasevic, I. (2021). Review on characteristics of trained sensory panels in food science. *Journal of Texture Studies*, 52(4), 501–509. <https://doi.org/10.1111/jtxs.12616>
- Effiong, M. U., & Yaro, C. A. (2020). Fatty acid composition of fillets of african catfish, *clarias gariepinus* fed with various oil-based diets. *Aquaculture Studies*, 20(1), 29–35. https://doi.org/10.4194/2618-6381-v20_1_04
- Guttifera, G., Sari, S. R., Rizki, R. R., & Yovandre, E. (2023). Pelatihan Sertifikasi Balai Besar Pom Dan Halal Bagi Poklaksar Rumah Lele Athallah Serta Sivitas Akademik Universitas Sumatera Selatan. *Jurnal Abdi Insani*, 10(1), 251–257. <https://doi.org/10.29303/abdiinsani.v10i1.876>
- Hafez, M. S. M. A. El, Rashedy, S. H., Abdelmotilib, N. M., El-Hassayeb, H. E. A., Cotas, J., & Pereira, L. (2022). Fillet Fish Fortified with Algal Extracts of *Codium tomentosum* and *Actinotrichia fragilis*, as a Potential Antibacterial and Antioxidant Food Supplement. *Marine Drugs*, 20(12). <https://doi.org/10.3390/md20120785>
- Hasanein, S. S., Mourad, M. H., & Haredi, A. M. M. (2022). The health risk assessment of heavy metals to human health through the consumption of *Tilapia* spp and catfish caught from Lake Mariut, Egypt. *Heliyon*, 8(7), e09807. <https://doi.org/10.1016/j.heliyon.2022.e09807>
- Ishak, A. R., Zuhdi, M. S. M., & Aziz, M. Y. (2020). Determination of lead and cadmium in tilapia fish (*Oreochromis niloticus*) from selected areas in Kuala Lumpur. *Egyptian Journal of Aquatic Research*, 46(3), 221–225. <https://doi.org/10.1016/j.ejar.2020.06.001>
- Jamilatun, S., Hakika, D. C., Sarah, D., & Puspitasari, A. (2024). Generation and Characterization of Bio-Oil Obtained From The Slow Pyrolysis of Oil Palm Empty Fruit Bunches at Various Temperatures. *Elkawanie*, 10(1), 103. <https://doi.org/10.22373/ekw.v10i1.17844>
- Kadyan, S., Kumar, N., Lawaniya, R., Sharma, P. K., Arora, B., & Tehri, N. (2020). Rapid and miniaturized method for detection of hygiene indicators, *Escherichia coli* and coliforms, in dairy products. *Journal of Food Safety*, 40(5). <https://doi.org/10.1111/jfs.12839>
- Khan, S., Rehman, A., Shah, H., Aadil, R. M., Ali, A., Shehzad, Q., Ashraf, W., Yang, F., Karim, A., Khaliq, A., & Xia, W. (2022). Fish Protein and Its Derivatives: The Novel Applications, Bioactivities, and Their Functional Significance in Food Products. *Food Reviews International*, 38(8), 1607–1634. <https://doi.org/10.1080/87559129.2020.1828452>
- Lima, D. A. S., Santos, M. M. F., Duval, R. L. F., Bezerra,

- T. K. A., Araújo, Í. B. da S., Madruga, M. S., & da Silva, F. A. P. (2021). Technological properties of protein hydrolysate from the cutting byproduct of serra spanish mackerel (*Scomberomorus brasiliensis*). *Journal of Food Science and Technology*, 58(8), 2952–2962. <https://doi.org/10.1007/s13197-020-04797-5>
- Mailoa, M. N., Lokollo, E., Nendissa, D. M., & Harsono, P. I. (2019). Karakteristik Mikrobiologi Dan Kimiawi Ikan Tuna ASAP. *Jurnal Pengolahan Hasil Perikanan Indonesia*. 22(1): 89-99. Universitas Pattimura. *Jphpi*, 22(1), 89–99.
- Mariotti, A. (2015). The effects of chronic stress on health: New insights into the molecular mechanisms of brain-body communication. In *Future Science OA* (Vol. 1, Issue 3, pp. 1–6). Future Medicine Ltd. <https://doi.org/10.4155/fso.15.21>
- Mark, Y. A., Philip, A., Nelson, A. W., Muspratt, A., & Aikins, S. (2019). Safety assessment on microbial and heavy metal concentration in *Clarias gariepinus* (African catfish) cultured in treated wastewater pond in Kumasi, Ghana. *Environmental Technology (United Kingdom)*, 40(3), 302–311. <https://doi.org/10.1080/09593330.2017.1388851>
- Ning, X., Peng, Y., Tang, P., Zhang, Y., Wang, L., Zhang, W., Zhang, K., Ji, J., & Yin, S. (2022). Integrated Analysis of Transcriptome and Metabolome Reveals Distinct Responses of *Pelteobagrus fulvidraco* against *Aeromonas veronii* Infection at Invaded and Recovering Stage. *International Journal of Molecular Sciences*, 23(17). <https://doi.org/10.3390/ijms231710121>
- Pallavi, K. (2021). Development of Antioxidant Rich Herbal Tea Bags. *International Journal for Research in Applied Science and Engineering Technology*, 9(8), 2519–2520. <https://doi.org/10.22214/ijraset.2021.37719>
- Rani, R., Sholihah, N., Mutmainah, F., Sopiah, S., Rahmi, R., Aisyah, N., & Marta, E. (2022). The Impact of Drying and Salting on the Fish Resilience and Quality. *International Journal of Natural Science and Engineering*, 6(1), 30–36. <https://doi.org/10.23887/ijnse.v6i1.41473>
- Riskes. (2018). Laporan Nasional RISKESDAS. In *Lembaga Penerbit Balitbangkes* (p. hal 156).
- Rusydan, A. M., & Zulfaidah, N. T. (2024). Peptida Bioaktif : Menjelajahi Potensi dan Tantangan. *Jurnal Farmasi SYIFA*, 2(2), 56–67.
- Senevirathne, M., & Kim, S. K. (2012). Development of Bioactive Peptides from Fish Proteins and Their Health Promoting Ability. In *Advances in Food and Nutrition Research* (1st ed., Vol. 65). Elsevier Inc. <https://doi.org/10.1016/B978-0-12-416003-3.00015-9>
- Sharif, M. K., Nasir, M., & Sharif, H. R. (2017). *Sensory evaluation and consumer acceptability of novel Fortified Blended Foods*. 18 October, 361–386.
- Sheng, L., & Wang, L. (2021). The microbial safety of fish and fish products: Recent advances in understanding its significance, contamination sources, and control strategies. *Comprehensive Reviews in Food Science and Food Safety*, 20(1), 738–786. <https://doi.org/10.1111/1541-4337.12671>
- Sihombing, F., Rumaseuw, E. S., & Raniadita, M. A. (2024). Analysis of the Nutritional Content of Catfish Extract as a Reliable Food Ingredient to Improve the Nutrition of Stunted Toddlers. *Jurnal Biologi Tropis*, 24(3), 216–222. <https://doi.org/10.29303/jbt.v24i3.7335>
- Sun, Y., Li, Y., Rao, J., Liu, Z., & Chen, Q. (2018). Effects of inorganic mercury exposure on histological structure, antioxidant status and immune response of immune organs in yellow catfish (*Pelteobagrus fulvidraco*). *Journal of Applied Toxicology*, 38(6), 843–854. <https://doi.org/10.1002/jat.3592>
- Wang, J., Wang, Y. M., Li, L. Y., Chi, C. F., & Wang, B. (2022). Twelve Antioxidant Peptides From Protein Hydrolysate of Skipjack Tuna (*Katsuwonus pelamis*) Roe Prepared by Flavourzyme: Purification, Sequence Identification, and Activity Evaluation. *Frontiers in Nutrition*, 8(January), 1–14. <https://doi.org/10.3389/fnut.2021.813780>
- Wu, P., Wang, A., Cheng, J., Chen, L., Pan, Y., Li, H., Zhang, Q., Zhang, J., Chu, W., & Zhang, J. (2020). Effects of Starvation on Antioxidant-Related Signaling Molecules, Oxidative Stress, and Autophagy in Juvenile Chinese Perch Skeletal Muscle. *Marine Biotechnology*, 22(1), 81–93. <https://doi.org/10.1007/s10126-019-09933-7>