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Quality Standardization of Snakehead Fish (*Channa striata*) from Limboto Lake as Traditional Medicine Raw Material

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ABSTRACT

Snakehead fish (*Channa striata*) has long been used by communities in Gorontalo, Indonesia, as a traditional remedy to accelerate wound healing and to increase serum albumin levels. The growing use of natural products underscores the need to assure quality and safety through standardization. This study aimed to standardize the specific and non-specific parameters of C. striata collected from Limboto Lake, Gorontalo Regency. The evaluated parameters included organoleptic properties, extractable matter, moisture content, loss on drying, total ash, acid-insoluble ash, and heavy metal contamination determined by atomic absorption spectrophotometry. The total protein content was 138.18 g (46.1%). For specific parameters, the sample was a fine powder with a slightly yellowish color and a characteristic snakehead odor; water- and ethanol-soluble extractive values were 8.8% and 4.6%, respectively. Non-specific parameters showed a loss on drying of 3.13%, moisture content of 5.9%, total ash of 2.83%, and acid-insoluble ash of 0.49%. Heavy metal levels were 0.15785 mg/kg for arsenic (As), 0.01705 mg/kg for cadmium (Cd), <0.00055 mg/kg for mercury (Hg), and <0.00055 mg/kg for lead (Pb), all of which complied with BPOM and Indonesian National Standards (SNI) safety criteria. Overall, C. striata from Limboto Lake met the required specific and non-specific quality parameters for traditional medicine raw materials, indicating its potential for further development as a safe, high-quality herbal drug ingredient. This study provides scientific support for the development of traditional medicines based on local aquatic resources.

Keywords:
Channa striata; Snakehead fish; Standardization; Specific parameters; Non-specific parameters; Limboto Lake

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1. Introduction

As the "*back-to-nature*" movement gains prominence, the use of herbal products with health related benefits has increased, accompanied by a growing volume of scientific studies on herbal medicines. Rising public awareness of health has also contributed to greater reliance on herbal remedies derived from plants, prepared and used in traditional and natural way practices that have been part of Indonesian communities since ancestral times. Many people continue to choose herbal medicines because their therapeutic effects are widely recognized, they are generally more affordable, and they tend to be associated with fewer—often minimal—adverse effects compared with conventional medicines [1].

Globally, the average prevalence of traditional medicine use is reported to range from approximately 20% to 28%. According to the 2018 Basic Health Research survey (RISKESDAS) conducted by Indonesia's Ministry of Health, 59.12% of Indonesian households still consume herbal medicines. In addition, self-medication with herbal products increased from 63.77% to 71.46% between 2016 and 2019. This trend may be driven by the widespread perception that herbal medicines are effective, affordable, and associated with minimal risk [2].

The use of herbal medicines has traditionally been focused on terrestrial resources, particularly plants. However, aquatic organisms also represent a promising yet often underappreciated source of bioactive materials for herbal products. A wide range of aquatic biota including phytoplankton and zooplankton can provide substantial benefits to humans and are utilized as food ingredients, medicinal products, cosmetics, and other value added materials. When managed and used responsibly, these resources may contribute to improved human welfare [3].

One aquatic organism with promising potential as a source of herbal medicine is the snakehead fish (*Channa striata*). This species contains a favorable nutritional profile, including protein (17.06%), moisture (75.01%), fat (0.44%), and ash (1.43%). C. striata is particularly rich in albumin, an important functional protein. A key advantage of snakehead fish is its comprehensive amino acid composition, encompassing both essential and non essential amino acids. In addition, it provides vitamins and minerals that support overall health [4].

Empirically, snakehead fish (*Channa striata*) has long been used in traditional medicine particularly among communities in Gorontalo to accelerate wound healing. This therapeutic use has also been supported by scientific evidence, as C. striata is rich in protein, especially albumin, which plays a critical role in wound repair and tissue regeneration [5]. In general, traditional treatment using snakehead fish (*Channa striata*) in Gorontalo is carried out by boiling the fish to obtain an extract, which is then administered orally to patients with malnutrition or to support recovery from postpartum surgical wounds [6]. Other studies have also investigated snakehead fish meat and reported that it can increase blood albumin levels, support recovery in various conditions such as diabetes, stroke, and malnutrition, and accelerate wound healing [7].

However, as the use of herbal medicines becomes increasingly widespread, ensuring the quality of traditional medicines remains a key challenge. Quality assurance should address not only therapeutic effects but also product safety. According to Regulation of the Indonesian Food and Drug Authority (BPOM) No. 4 of 2021, traditional medicines marketed in Indonesia are required to meet standards of quality, safety, and intended use.

Traditional medicines that lack adequate assurance of quality, efficacy, and safety may pose risks to consumers due to harmful contaminants, including microbial contamination and heavy metals such as lead, mercury, cadmium, arsenic, and chromium. In addition, insufficient quality control can result in variable and inconsistent product quality across batches. To improve the quality of standardized herbal medicines, scientific evidence of safety and efficacy is required, including preclinical testing, supported by the use of standardized raw materials [9].

Based on the considerations above, it is necessary to standardize the specific and non-specific parameters of snakehead fish (*Channa striata*) collected from Limboto Lake, Gorontalo Regency, to ensure its quality and safety prior to processing into a standardized herbal product for broader public consumption, particularly in Gorontalo Province.

2. Methods

This study was a laboratory based experimental investigation aimed at standardizing the specific and non specific parameters of snakehead fish (*Channa striata*). The assessments included determination of total protein content (TPC), organoleptic evaluation, extractable matter in selected solvents, qualitative phytochemical/chemical profiling, loss on drying, moisture content, total ash, acid-insoluble ash, and heavy metal contamination.

Materials and Equipment

This study used porcelain dishes, porcelain crucibles, a desiccator, crucible tongs, dropper pipettes, test tubes, and standard glassware including Erlenmeyer flasks, beakers, and graduated cylinders (Pyrex®). Additional equipment comprised a hot plate, an oven, a muffle furnace, an analytical balance (Osuka®), syringes, a digital centrifuge (6000 rpm), an atomic absorption spectrophotometer (AAS), and a UV–Vis spectrophotometer (Thermo Scientific).

Sample Preparation

Snakehead fish (*Channa striata*) samples were cleaned by washing and evisceration to remove impurities, viscera, head, and bones, leaving only fresh fish flesh. The flesh was then cut into small pieces (2–3 cm). Subsequently, the samples were dried in an oven at 40°C for 10 h. After drying, the material was ground into a fine powder using a blender [4].

Determination of Total Protein Content

Protein Isolation

A 300 g portion of the sample was weighed and mixed with 750 mL of distilled water, then homogenized using a blender for 15 min. The homogenate was stored in a refrigerator for 30 min prior to centrifugation at 4500 rpm for 30 min. Centrifugation yielded two phases: an upper layer containing water-soluble proteins and a lower sediment. The upper phase (protein supernatant) was carefully separated from the pellet using a Pasteur pipette and subsequently filtered through filter paper. The resulting protein isolate was then stored in a freezer [5].

Preparation of Standard Solution

Bovine serum albumin (BSA) (100 mg) was accurately weighed and dissolved in 100 mL of distilled water to obtain a 1000 ppm stock solution. Working protein standards with concentrations of 60, 80, 100, and 300 ppm were prepared from the stock solution. Next, 2 mL of each standard solution was mixed with 8 mL of Bradford reagent, vortexed until homogeneous, and incubated at room temperature for 10 min. Absorbance was measured using a UV–Vis spectrophotometer at 595 nm [10].

Total Protein Content

A 2 mL aliquot of the sample was mixed with 8 mL of Bradford reagent, vortexed until homogeneous, and incubated at room temperature for 10 min. The absorbance was then measured using a UV–Vis spectrophotometer at 595 nm [10].

Standardization of Specific Parameters

Specific parameter standardization of snakehead fish (*Channa striata*) included organoleptic evaluation, determination of water-soluble extractive content, and determination of ethanol soluble extractive content [11].

Organoleptic

The organoleptic properties of the sample, including shape, color, taste, and odor, were evaluated.

Solvent Soluble Extractive Content

A 5 g portion of the sample was macerated for 24 h with 20 mL of water. The filtrate (20 mL) was then filtered into a Petri dish and heated at 105°C until a constant weight was obtained. The percentage of water-soluble extractive content was calculated based on the initial extract. The formula used to determine the water-soluble extractive content is as follows: [12] .

$$\text{Soluble Extractive Content (\%)} = \frac{W2-W0}{W1} \times 100\%$$

Note:
W0 : Weight of the empty dish (g)
W1 : Initial extract weight (g)
W2 : Weight of the dish + extract after heating (g)

Standardization of Non-Specific Parameters

Non-specific parameter standardization of snakehead fish (*Channa striata*) included the determination of loss on drying, moisture content, total ash content, acid-insoluble ash content, and heavy metal contamination [11].

Loss on Drying (LOD)

A 1 g portion of the sample was accurately weighed into a pre-weighed, tared porcelain crucible, then dried at 105°C for 1 h and weighed. Drying and weighing were continued at 1 h intervals until a constant weight was achieved. Loss on drying was calculated relative to the initial sample weight

$$\text{Loss on Drying (LOD) (\%)} = \frac{W0-W1}{W0} \times 100\%$$

Note:
W0 : Initial weight (g)
W1 : Final weight (g)

Moisture content

A porcelain dish was weighed, then dried in an oven at 105°C for 5 h and placed in a desiccator for 30 min. The dish was reweighed afterward. Approximately 1 g of the sample was then placed into the porcelain dish and dried at 105°C for 5 h, followed by cooling in a desiccator for 30 min, and weighed. The drying–cooling–weighing cycle was repeated until a constant weight was obtained. The moisture content (%) was calculated using the following formula.

$$\text{Moisture content (\%)} = \frac{W0-W1}{W0} \times 100\%$$

Note:
W0 : Initial sample weight (g)
W1 : Final sample weight after heating (g)

Total Ash Content

A 2 g portion of the sample was accurately weighed (W1) into a pre-weighed, tared porcelain crucible (W0). The crucible was then placed in a muffle furnace at 700°C for 4–6 h. The residue was gently stirred until no charcoal remained, then cooled in a desiccator and weighed to a constant mass (W2).

$$\text{Total Ash Content (\%)} = \frac{W2\text{-}W0}{W1} \times 100\%$$

Note:
W0 : Weight of the empty crucible (g)
W1 : Initial sample weight (g)
W2 : Weight of the crucible + residue (g)

Acid Insoluble Ash Content

The ash obtained from the total ash determination was boiled with 25 mL of hydrochloric acid for 5 min. The acid-insoluble portion was collected and filtered through filter paper, and the residue was washed with hot water. The residue was then heated to a constant weight and weighed. The acid-insoluble ash content (%) was calculated relative to the initial sample weight.

$$\text{Acid-Insoluble Ash Content (\%)} = \frac{W2}{W1} \times 100\%$$

Note:
W1 : Initial sample weight (g)
W2 : Weight of the crucible + residue (g)

Heavy metal contamination

Heavy metal contamination was determined using an Atomic Absorption Spectrophotometer (AAS) to quantify lead (Pb) and cadmium (Cd) levels. Both metals were analyzed following dry ashing. Briefly, 5 g of *Channa striata* sample was placed in a muffle furnace and ashed at 500–700°C for 4–6 h. The resulting ash was allowed to cool. An aliquot of the ash (equivalent to 5 g of sample) was then transferred into an Erlenmeyer flask, dissolved in 50 mL of distilled water, and 5 mL of concentrated nitric acid (HNO_3) was added. The mixture was heated on a hot plate, cooled, and filtered through Whatman No. 42 filter paper into a 50 mL volumetric flask. The filtrate was then made up to volume with distilled water (to the calibration mark) prior to AAS measurement.

3. Results and Discussion

Identification of Snakehead Fish

The snakehead fish sample used in this study was taxonomically identified at the Laboratory of Biotechnology and Aquatic Biota Characterization. The identification results confirmed that the sample was snakehead fish (*Channa striata*).

Total Protein Content

Protein Isolate

Table 1. Results of Snakehead Fish (*Channa striata*) Protein Isolate

Sample	Solvent	Solvent Volume (mL)	Sample Mass (g)	Isolate Volume (mL)	Yield (%)
Snakehead fish (*Channa striata*)	Aquadest	750	300	230	76,67

As shown in **Table 1**, protein isolation from 300 g of snakehead fish (*Channa striata*) extracted with 750 mL of distilled water produced 230 mL of protein isolate, corresponding to a yield of 76.67%.

Determination of Standard Solution Absorbance

Table 2. Absorbance Values of Bovine Serum Albumin (BSA) Standard Solutions Using UV–Vis Spectrophotometry

Concentration (ppm)	Absorbance
60	0,454
80	0,494
100	0,521
300	0,724

Table 2 shows the linear relationship between the concentration of Bradford standard solutions and the absorbance measured by UV–Vis spectrophotometry at the maximum wavelength of 595 nm. Increasing the concentration from 60 ppm to 300 ppm resulted in an increase in absorbance from 0.454 to 0.724.

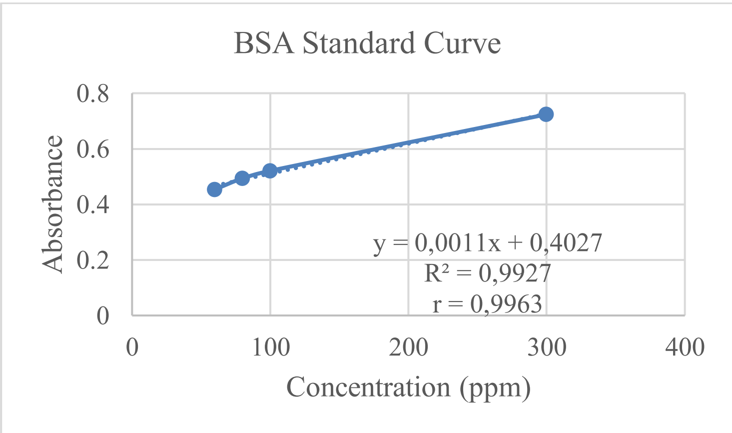

Figure 1. Standard Calibration Curve of Bovine Serum Albumin Using the Bradford Reagent

Figure 1 presents the Bradford reagent standard curve for bovine serum albumin (BSA), showing a linear relationship between concentration and absorbance at 595 nm. The regression equation obtained was $y = 0.0011x + 0.4027$, with an R^2 value of 0.9927. The R^2 value close to 1 indicates excellent linearity, supporting the use of this calibration curve as a reference for quantitative determination of protein content in snakehead fish (*Channa striata*) with high reliability.

Table 3. Total Protein Content (TPC) Results of Snakehead Fish (*Channa striata*)

Sample	Absorbance	Concentration (mg/mL)	Total Protein Content (g/300 g)	Protein Content (% w/w)
Snakehead fish (*Channa striata*)	0,535	120,156	138,18	46,1 %

Table 3 presents the results of total protein content (TPC) analysis of snakehead fish (*Channa striata*). The sample contained 138.18 g of total protein (46.1%) in 300 g of snakehead fish flesh. These data indicate that snakehead fish flesh has a relatively high total protein content. This finding may help explain the traditional use of snakehead fish

extract as a nutritional source to support recovery during the post-operative and postpartum periods, or under conditions of nutritional deficiency. The aqueous extraction method used in this study (distilled water without the addition of chemical reagents) closely reflects traditional processing practices; therefore, the results are relevant to real-world community use [7].

Standardization of Specific Parameters

Organoleptic

Table 4. Organoleptic Evaluation Results of Snakehead Fish (*Channa striata*)

Organoleptic Parameter	Observation
Physical Form	Fine Powder
Color	Slightly Yellowish
Odor	Characteristic Odor of Snakehead Fish

Table 4 shows the results of the organoleptic evaluation of the snakehead fish (*Channa striata*) sample. The sample was a fine powder, slightly yellowish in color, and had a characteristic odor of snakehead fish (*Channa striata*). This assessment was conducted to provide an initial, objective, and straightforward characterization of the sample based on direct visual and sensory observation.

Solvent-Soluble Extractive Content

Table 5. Determination of Compound Concentrations in Selected Solvents

Sample	Parameter	Determination (%)	Mean (%)
Snakehead fish (*Channa striata*)	Water-Soluble Content	8,8	8,8
		8	
		9,8	
	Ethanol-Soluble Content	4,5	4,6
		5	
		5	

Table 5 shows that the mean water-soluble extractive content was 8.8%, whereas the mean ethanol-soluble extractive content was 4.6%. The determination of water- and ethanol-soluble extractives was conducted to estimate the amount of constituents soluble in water (polar) and ethanol (semi-polar to non-polar), respectively [13]. The results showed that a greater proportion of constituents was soluble in water than in ethanol. Water is a polar solvent with a strong hydrogen-bonding capacity, making it more effective at dissolving polar compounds such as proteins, amino acids, peptides, and other soluble nitrogenous substances. Snakehead fish (*Channa striata*) is known to contain high levels of protein and amino acids, particularly albumin, which is hydrophilic and readily soluble in water. Therefore, the higher water-soluble extractive value likely reflects the chemical characteristics of snakehead fish tissue, which is rich in polar constituents [10].

Standardization of Non-Specific Parameters

Loss on Drying (LOD)

Table 6. Results of Loss on Drying (LOD) Analysis

Sample	Determination (%)	Mean (%)	Specification	Compliance
Snakehead Fish (*Channa striata*)	2.2 1.5 5.7	3.13	≤ 10% [14]	Complies

Table 6 shows that the mean loss on drying of the snakehead fish (*Channa striata*) sample was 3.13%, indicating that the proportion of volatile components removed during drying was relatively low. This value also meets the acceptable criterion for loss on drying, which should not exceed 10% [13]. A high loss on drying value is associated with reduced quality stability, as the material becomes more susceptible to physical and chemical changes during storage [15]. Therefore, if the loss on drying exceeds the specified limit, the material would not meet quality requirements and the drying process should be evaluated and improved. Overall, the snakehead fish (*Channa striata*) sample in this study can be considered to have good stability and is less prone to deterioration during processing.

Moisture Content

Table 7. Results of Moisture Content

Sample	Determination (%)	Mean (%)	Specification	Compliance
Snakehead fish (*Channa striata*)	8.8 4.9 4.1	5.9	≤ 10% [14]	Complies

Table 7 shows a mean moisture content of 5.9%. This value indicates that the moisture level of the snakehead fish simplicia meets the safety and quality requirement for natural medicinal raw materials, i.e., not more than 10% [14]. Low moisture content is important because it can inhibit the growth of microorganisms, such as bacteria and fungi, which generally require moist conditions to proliferate. The lower the water content of a material, the lower the risk of chemical and biological deterioration, including spoilage and degradation of active constituents. This is consistent with Rosidah (2020), who reported that low moisture content can suppress microbial activity, thereby improving material stability during storage.

Total Ash Content

Table 8. Determination of Total Ash Content

Sample	Determination (%)	Mean (%)	Specification	Compliance
Snakehead Fish (*Channa striata*)	3 2 3.5	2.83	≤ 3% [17]	Complies

Table 8 shows that the mean total ash content was 2.83%. This value is considered low and complies with the requirement for ash content according to the Indonesian National Standard SNI 01-2715-1996, which specifies a maximum limit of 20–30%. Total ash determination was conducted to estimate the mineral content present in the sample, including both organic and inorganic salts. The ash value is an important quality indicator for assessing the suitability of the material for further processing, as it reflects the purity and overall quality of the raw material. An ash content exceeding the specified limit may indicate an excessive amount of inorganic matter, potentially originating from contamination such as sand or soil, suggesting low quality and inadequate purity that does not meet standard requirements [18]. Thus, the snakehead fish (*Channa striata*) sample can be considered to have good quality and did not indicate excessive mineral contamination.

Acid Insoluble Ash Content

Table 9. Determination of Acid Insoluble Ash Content

Sample	Determination (%)	Mean (%)	Specification	Compliance
Snakehead Fish (*Channa striata*)	0.53 0.65 0.31	0.49	≤ 2,3% [19]	Complies

Table 9 shows that the acid-insoluble ash content was 0.49%. This value is considered low and meets the specified requirement of not more than 2.3% [19]. The acid insoluble ash test is performed to assess contamination by sand and soil. Acid insoluble ash serves as a purity parameter to evaluate the presence of mineral contaminants that should not be present in the material. The lower the acid-insoluble ash value, the better the quality and purity of the sample, as it indicates a smaller amount of insoluble inorganic residue [16]. A low acid-insoluble ash value generally suggests that the processing steps were properly conducted and that no extraneous inorganic matter was introduced into the sample. From a safety perspective, acid-insoluble ash levels exceeding the standard may also indicate a risk of harmful mineral contamination, which could potentially pose health concerns if the material is used as food or as a raw material for pharmaceutical preparations. Based on these results, it can be concluded that the sample contained only minimal acid-insoluble inorganic contaminants, such as sand or silica.

Heavy Metal Contaminant

Table 10. Determination of Heavy Metal Contaminant Concentration

Heavy Metal	Contaminant Concentration (mg/Kg)	Permissible Limit (mg/Kg)	Compliance
Arsenic (As)	0.15785	≤ 5	Complies
Cadmium (Cd)	0.01705	≤ 0.3	Complies
Mercury (Hg)	< 0.00055	≤ 0.5	Complies
Lead (Pb)	< 0.00055	≤ 10	Complies

Table 10 presents the results of heavy metal contamination analysis in snakehead fish, showing an arsenic (As) level of 0.15785 mg/kg. This value remains below the maximum permissible limit for arsenic contamination set by the BPOM (2023), i.e., not more than 5 mg/kg, and is therefore considered safe. Arsenic may originate from natural sources or anthropogenic activities, and at low levels it may still be tolerated by the body. The cadmium (Cd) level in the snakehead fish sample was 0.01705 mg/kg, which is far below the maximum limit stipulated by BPOM (2023), i.e., not more than 0.3 mg/kg. Cadmium is a toxic heavy metal that can accumulate in the body; thus, the low level observed indicates that the sample is safe for consumption [20]. Furthermore, the mercury (Hg) level detected in the sample was <0.00055 mg/kg, which is extremely low and well below the maximum limit set by BPOM (2023), i.e., not more than 0.5 mg/kg. Mercury is highly hazardous due to its neurotoxic effects; therefore, this very low concentration suggests that the snakehead fish is relatively free from mercury contamination [9].

The lead (Pb) level was also <0.00055 mg/kg, which is far below the maximum allowable limit for lead contamination established by BPOM (2023), i.e., not more than 10 mg/kg. Lead may cause adverse health effects when accumulated in the body; hence, the very low level indicates that the environment from which the snakehead fish originated was not significantly contaminated with lead [21]. Overall, the results demonstrate that the levels of As, Cd, Hg, and Pb in the snakehead fish (*Channa striata*) sample were below the maximum permissible limits set by BPOM. This indicates that the sample is safe for use as a food source and as a raw material for further processing, and it meets safety requirements based on quality standards.

This study has several limitations. First, the investigation focused on samples from a single geographical area and did not evaluate seasonal, biological, or batch-to-batch variability; therefore, the findings cannot be generalized to all snakehead fish (*Channa striata*) from Limboto Lake or other regions. Second, the quality assessment was limited to selected physicochemical parameters and four heavy metals, without evaluating microbiological quality, veterinary drug residues, lipid oxidation, or storage stability. Third, the analytical procedures were not reported with complete validation data, including accuracy, precision, recovery, limits of detection and quantification, and the use of certified reference materials or spiked controls. Accordingly, the quantitative results, particularly the protein and trace-metal concentrations, should be interpreted cautiously. Finally, this study did not assess biological efficacy, bioavailability, or clinical safety. Thus, the results should be considered preliminary baseline data rather than definitive evidence that the material is safe and suitable as a standardized traditional medicine raw material. Future studies should include multi-batch and multi-season sampling, validated analytical methods, broader contaminant and microbiological testing, stability evaluation, and appropriate preclinical or clinical assessment.

4. Conclusion

Based on the study findings, it can be concluded that the snakehead fish (*Channa striata*) simplicia from Danau Limboto exhibits good quality and meets both specific and non specific parameter criteria in accordance with the quality requirements for traditional medicinal raw materials. Therefore, snakehead fish has strong potential to be further developed as a safe and quality-assured raw material for standardized herbal medicine. This study is expected to provide a scientific basis for the development of traditional medicines derived from local aquatic resources.

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Conflicts of Interest:

The authors declare no conflict of interest regarding the publication of this paper.

References

[1] I. Mustrini, M. Mappiratu, and N. Nurakhirawati, “Utilization of biduri latex in the production of snakehead fish (*Ophiocephalus striatus*) albumin,” *Kovalen: Jurnal Riset Kimia*, vol. 2, no. 3, 2016. [Online]. Available: https://doi.org/10.22487/j24775398.2016.v2.i3.7532

[2] M. R. Adiyasa and M. Meiyanti, “Utilization of traditional medicine in Indonesia: Distribution and influential demographic factors,” *Jurnal Biomedika dan Kesehatan*, vol. 4, no. 3, pp. 130–138, 2021. [Online]. Available: https://doi.org/10.18051/JBiomedKes.2021.v4.130-138

[3] Y. P. Utami and Ruslin, *Marine Pharmacy as Medicine*. Purbalingga, Indonesia: CV Eureka Media Aksara, 2024. [Online]. Available: https://repository.penerbiteureka.com/publications

[4] C. Prastari, S. Yasni, and M. Nurilmala, “Characterization of snakehead fish protein with potential antihyperglycemic activity,” *Jurnal Pengolahan Hasil Perikanan Indonesia*, vol. 20, no. 2, p. 413, 2017. [Online]. Available: https://doi.org/10.17844/jphpi.v20i2.18109

[5] M. A. Alamsjah, G. A. Kusumaningrum, and E. D. Masithah, “Albumin level test and growth of snakehead fish (*Channa striata*) with different commercial feed protein levels,” *Jurnal Ilmiah Perikanan dan Kelautan*, vol. 6, no. 1, pp. 25–30, 2014. [Online]. Available: https://doi.org/10.20473/jipk.v6i1.11377

[6] R. Tungadi, “Potential of snakehead fish (*Ophiocephalus striatus*) in accelerating wound healing,” *Jambura Fish Processing Journal*, vol. 1, no. 1, pp. 46–55, 2020. [Online]. Available: https://doi.org/10.37905/jfpj.v1i1.4505

[7] H. Djohan, P. J. Trifani, and L. Kamilla, “Protein content analysis in fermented snakehead fish (*Channa striata*) pekasam,” *Jurnal Laboratorium Khatulistiwa*, vol. 6, no. 2, p. 37, 2023. [Online]. Available: https://doi.org/10.30602/jlk.v6i2.929

[8] National Agency of Drug and Food Control of the Republic of Indonesia, *Certification of Good Traditional Medicine Manufacturing Practices*. Jakarta, Indonesia: BPOM RI, 2021. [Online]. Available: https://jdih.pom.go.id

[9] Zulharmita, M. Zulfaretna, and S. Misfadhila, “Analysis of heavy metal contamination in herbal medicine preparations at Siti Rahmah Islamic Hospital Padang using atomic absorption spectrophotometry,” *Jurnal Farmasi Higea*, vol. 9, no. 2, pp. 159–164, 2017. [Online]. Available:

https://jurnalfarmasihigea.org/index.php/higea/article/view/175

[10] Nurfaidah, Metusalach, Sukarno, and M. Mahendradatta, "Protein and albumin contents in several freshwater fish species of Makassar, South Sulawesi, Indonesia," *International Food Research Journal*, vol. 28, no. 4, pp. 745–751, 2021. [Online]. Available: https://doi.org/10.47836/ifrj.28.4.11

[11] Ministry of Health of the Republic of Indonesia, *General Standard Parameters of Medicinal Plant Extracts*. Jakarta, Indonesia: Ministry of Health of the Republic of Indonesia, 2000. [Online]. Available: https://repository.poltekkes-kaltim.ac.id/1147/1/Parameter%20Standar%20Umum%20Ekstrak%20Tumbuhan%20Obat.pdf

[12] M. P. Marpaung and A. Septiyani, "Determination of specific and non-specific parameters of thick ethanol extract of yellow root stem (*Fibraurea chloroleuca* Miers)," *Jurnal Pharmacopolium*, vol. 3, no. 2, 2020. [Online]. Available: https://doi.org/10.36465/jop.v3i2.622

[13] A. Saifuddin, V. Rahayu, and H. Y. Teruna, *Standardization of Natural Medicinal Materials*. Yogyakarta, Indonesia: Graha Ilmu, 2011. [Online]. Available: https://onesearch.id/Record/IOS2726.slims-105606

[14] National Agency of Drug and Food Control of the Republic of Indonesia, *Smart Guide to Choosing and Using Safe Traditional Medicines*. Jakarta, Indonesia: Directorate of Community Empowerment and Business Actors for Traditional Medicines, Health Supplements, and Cosmetics, 2023. [Online]. Available: https://www.pom.go.id

[15] B. F. Jamal, N. A. Umar, and S. Budi, "Analysis of albumin content of snakehead fish (*Channa striata*) from river and swamp habitats in Morowali Regency," *Journal of Aquaculture and Environment*, vol. 5, no. 1, pp. 14–20, 2022. [Online]. Available: https://doi.org/10.35965/jae.v5i1.1951

[16] I. Rosidah, Z. Zainuddin, K. Agustini, O. Bunga, and L. Pudjiastuti, "Standardization of 70% ethanol extract of chayote fruit (*Sechium edule* (Jacq.) Sw.)," *Farmasains: Jurnal Ilmiah Ilmu Kefarmasian*, vol. 7, no. 1, pp. 13–20, 2020. [Online]. Available: https://doi.org/10.22236/farmasains.v7i1.4175

[17] National Agency of Drug and Food Control of the Republic of Indonesia, *Certification of Good Traditional Medicine Manufacturing Practices*. Jakarta, Indonesia: BPOM RI, 2021. [Online]. Available: https://jdih.pom.go.id

[18] M. Yusril, E. L. S. Herny, and M. R. Erladys, "Determination of non-specific standardization parameters of forest onion tuber extract (*Eleutherine americana* Merr.)," *Pharmacon: Jurnal Ilmiah Farmasi*, vol. 12, no. 2, 2023. [Online]. Available: https://ejournal.unsrat.ac.id/v3/index.php/pharmacon/article/view/48167

[19] Y. H. Aulia, M. Andrie, and W. Wintari, "Standardization of snakehead fish (*Channa striata*) concentrates obtained from Sungai Itik Village, Kubu Raya District, West Kalimantan," *Media Farmasi: Jurnal Ilmu Farmasi*, vol. 21, no. 2, pp. 72–79, 2024. [Online]. Available: https://doi.org/10.12928/mf.v21i2.26746

[20] D. Anggriana, "Analysis of lead (Pb) and cadmium (Cd) heavy metal contamination in well water in the PT Kima area using atomic absorption spectrophotometry," Undergraduate thesis, Makassar, Indonesia, 2011. [Online]. Available: https://repositori.uin-alauddin.ac.id/

[21] D. C. Harris and C. A. Lucy, *Quantitative Chemical Analysis*, 9th ed. New York, NY, USA: W. H. Freeman and Company, 2016. [Online]. Available: https://www.macmillanlearning.com/college/us/product/Quantitative-Chemical-Analysis/p/146413538X