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Aquatic Products as Functional Food Sources

Asep Awaludin Prihanto, Yeni Rizki Prananda

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CHAPTER 1

Fishery Products as Functional Food Sources of Selenium: Extraction and Potential

Endang Trowulan, Asep Awaludin Prihanto

Abstract

Selenium, an essential trace mineral element, plays various physiological roles in the human body. Its functions include acting as a potent antioxidant, anti-inflammatory agent, and providing antiviral protection against oxidative stress, thereby reducing the risk of several diseases. The limited scope of prerequisites and harmful consequences associated with selenium led to the development of the Selenium-Health Benefit Value (Se-HBV) as a metric for seafood safety. A positive Se:Hg ratio can help reduce the risk of mercury (Hg) toxicity. Fishery products typically contain both inorganic forms (selenite and selenate) and organic forms (selenoprotein, selenocysteine, and selenomethionine) of selenium simultaneously. The relatively high total Selenium content in fishery products presents an opportunity to develop Selenium-enriched functional foods. The methods for extracting selenium in total and quantifying species-specific Selenium content in these products are predominantly conducted in the liquid phase, often in combination with other techniques, to enhance efficiency while preserving the integrity of the various Selenium species. When considering the potential development of fishery products as viable sources of selenium in the diet, it is crucial to consider factors such as bioaccessibility and bioavailability to optimize their health benefits.

Keywords

Extraction, Functional food, Fishery products, Selenium

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1.1 Introduction

Selenium (Se), as a nutrient, is an essential trace mineral required by the body for several biochemical reactions (Natasha et al., 2018). It was initially discovered as a by-product of sulfuric acid and nitric acid industries (Kieliszek & Błazejak, 2013). It derived its name from the Greek word "Selene," meaning moon (Zhang, 2019). The growing interest in studying this element arises from its vital functions within the body, notably its role as a potent antioxidant, anti-inflammatory agent, and antiviral contributor (Wrobel et al., 2016). Within the body's biological spectrum, selenium is a cofactor for various enzymes, including triiodothyronine deiodinase, in the prevention of goiter (Adadi et al., 2019). It supports enzymes like glutathione peroxidase (GSH-Px), superoxide dismutase (SOD), and catalase (CAT) in safeguarding against free radical damage and lipoperoxides (Rai et al., 2019). This mineral is also instrumental in protecting the body against oxidative stress (Kieliszek, 2019). Maintaining an adequate selenium nutritional status has been linked to improved prognostic outcomes and a reduced risk of various diseases, including cancer, Alzheimer's disease, diabetes, cardiovascular disorders, mental disorders, fertility disorders, infection, and inflammation (Barchielli et al., 2022). This also extends to preventing and treating SARS-CoV-2-infected patients with selenium deficiency (Hekmatnia et al., 2021).

Selenium is a common element in the Earth's atmosphere, lithosphere, biosphere, and hydrosphere (Matos et al., 2017). The extensive utilization of selenium across various industries and its relevance in medical biotechnology and human health have elevated the commercial value of this metalloid, leading to increased research in recent years (Funari et al., 2021). Selenium deficiency poses a significant global challenge, with numerous instances of poverty linked to low selenium levels in specific terrestrial environments (Ullah et al., 2019). Selenium nutrient requirements can be met through dietary sources, and one well-known food rich in selenium is the Brazil nut (Bertholletia excelsa), containing a concentration of 19.91 μg/g (Adadi et al., 2019). The daily selenium intake recommended by the World Health Organization (WHO) is 40 μg/day (Sakr et al., 2018), with a tolerable intake limit of 400 μg/day (Tóth & Csapó, 2018). According to Tan et al. (2016), approximately 15% of the population is estimated to be selenium deficient, with an average daily intake of only 7 to 11 μg/day (Combs, 2001). Therefore, it is essential to implement strategies to address selenium deficiency, as its absence can lead to severe health problems and increase susceptibility to various diseases. These strategies may include developing functional foods enriched with selenium or supplementation (Adadi et al., 2019).

Functional foods are defined as foods that contain ingredients with health functions and have been approved to exert physiological effects on the human body, with documented health benefits (Crowe & Francis, 2013). The demand for functional foods containing selenium (Se) is also rising, driven by increasing knowledge of Se's health functions. While plant products can serve as a source of Se, those cultivated in lowlands typically have low Se content (Rayman, 2012). Animal-based foods can offer an alternative source of Se, as they can accumulate Se from Se-enriched feed or Se-fertilized plants (Meyer et al., 2014).

materials. Future research endeavors should prioritize the development of commercial extraction methods characterized by high efficiency and yield. This approach would enable the exploration of fishery products as functional foods in economically significant species and the by-products of the fishing industry that typically possess relatively lower economic value. Furthermore, the extracted products could be enhanced raw materials for selenium-source food supplements.

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CHAPTER 2

Taurine from Aquatic Resources: Extraction and Functional Properties

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Abstract

Taurine is a neutral β-amino acid that originates from metabolizing sulfur amino acids. It distinguishes itself by having a sulfonic acid group in its chemical structure instead of a carboxylic acid group. Taurine can be obtained from a substance through an extraction process. As a functional compound, taurine serves various physiological functions in humans, such as protecting against tissue damage caused by free radicals, facilitating efficient fat absorption and dissolution, reducing the risk of hypertension, enhancing immune endurance, and serving as a critical antioxidant scavenging reactive oxygen species. This review provides an overview of extraction methods, physiological functions, and the prospective development of functional food products derived from taurine. The appropriate selection of extraction methods significantly influences the production of taurine compounds. Non-conventional methods, particularly Ultrasound-Assisted Extraction, stand out as environmentally friendly and highly effective strategies for extracting taurine compounds from materials. The physiological functions encompass antioxidant, anti-cancer, anti-inflammatory, and neuroprotection activities. Despite the limited utilization of taurine in functional foods, there is an opportunity to develop helpful food products by incorporating or supplementing taurine into foods.

Keywords

Extraction methods, Physiological functions, Taurine

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2.1 Introduction

Taurine, a neutral β-amino acid, is a product of the metabolic processes involving sulfur-containing amino acids, as elucidated by El-Sayed in 2014. Its chemical structure sets taurine apart, which features a sulfonic acid group instead of a carboxylic acid moiety. This unique characteristic means that taurine is not integrated into proteins but rather exists freely within the body, as highlighted by studies conducted by Huxtable in 1992 and Suresh et al. in 2011. Taurine is classified as a semi-essential amino acid in humans because it is synthesized endogenously from methionine and cysteine, facilitated by the presence of vitamin B6, as documented by Sirdah et al. in 2002.

The biosynthesis of taurine exhibits significant variability among individuals and is contingent upon factors such as nutritional status, protein consumption, and the accessibility of cysteine. The availability of cysteine, in turn, hinges on the metabolic equilibrium between homocysteine and methionine, a process influenced by folic acid, vitamin B12, and the enzymatic activity of methyltetrahydrofolate reductase, as elucidated in a study by De Luca et al. in 2015. Due to limited taurine biosynthesis capacity in humans, alternative sources include dietary intake from meat and seafood (Salze & Davis, 2015). Taurine deficiency does not directly pose health problems, but long-term insufficiency can impact numerous metabolic pathways (Huang et al., 2014).

As a functional compound, taurine provides various physiological functions in humans, such as offering protection against tissue damage from free radicals (Jagadeesan & Pillai, 2007), facilitating efficient fat absorption and dissolution (Devi et al., 2009; Schaffer et al., 2014), reducing hypertension risk (Yamori et al., 2010), enhancing immune endurance (Miyazaki et al., 2004; Zhang, Izumi, et al., 2004), and serving as a primary antioxidant scavenging reactive oxygen species (Oja & Saransaari, 2017).

Taurine is primarily sourced from fish, shellfish, and animal proteins (Stapleton et al., 1997). Shellfish contain higher taurine concentrations than finned fish, with taurine content reaching 800 mg/100 g in shellfish (Laidlaw et al., 1990). Additionally, red algae are considered a good taurine source for consumption (Kawasaki et al., 2017).

The extraction process is used to obtain taurine compounds from a substance. Non-conventional extraction methods have emerged to address the limitations associated with traditional extraction techniques, including prolonged extraction durations, excessive solvent usage, high energy requirements, and the potential degradation of sensitive compounds, as highlighted in a study by Ummat et al. in 2021. Various non-conventional extraction approaches, such as Microwave Assisted Extraction, Ultrasound Assisted Extraction, Enzyme Assisted Extraction, Supercritical Fluid Extraction, and Pressurized Liquid Extraction, have been applied to extract a range of bioactive substances, as discussed by Kadam et al. in 2014. These technologies offer advantages such as reducing or eliminating the need for harmful chemical solvents, improving extraction yields and quality, shortening extraction times, and minimizing energy consumption, as emphasized by Ummat et al. in 2021.

No	Sample	Taurine Supplementation	Results	Reference
11	Flatfish	Microcapsules supplemented with taurine (3% of the total composition)	Taurine diet supplementation may be crucial during this stage, contributing to enhanced larval growth potential and metamorphosis improvement	(Pinto et al., 2010)
12	Obese Woman	Capsules containing 3 g pure taurine powder consumed 2 hours before physical exercise and during fasting on other days	Taurine supplementation can increase irisin levels in obesity conditions and result in higher resting metabolic rates	(Batitucci et al., 2019)
13	-	Addition of taurine at 25, 35, and 50 mg in beverages	High selectivity, optimal analytical parameter values, and a wide range of applications for pharmaceutical and toxicological purposes	(Draganov, 2014)

Taurine possesses physiological functions that humans can effectively utilize. Nonetheless, the utilization of taurine in human dietary supplementation remains constrained compared to its application in animal feed. This is despite the human body's need for an external source of taurine due to the limited activity of the rate-limiting enzyme (cysteine sulfinate decarboxylase) in taurine biosynthesis (Chang et al., 2013; Vitvitsky et al., 2011). Therefore, further research is needed to explore taurine supplementation for human food, which could provide opportunities and development for existing functional food products.

2.5 Conclusion

The selection of appropriate extraction methods greatly determines the taurine compounds produced. The use of non-conventional methods, particularly ultrasound-assisted extraction (UAE), is one of the environmentally friendly extraction methods that is highly effective and efficient in extracting taurine compounds from a material. The physiological functions of taurine can be harnessed to create functional food products such as antioxidants, anti-cancer, anti-inflammatory, and neuroprotective agents. The utilization of taurine compounds in functional foods still needs to be improved, presenting opportunities for developing helpful food products by adding or supplementing taurine in foods.

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CHAPTER 3

The Potential of Protein Hydrolysate from Fisheries By-Products as Therapeutic Food for Energy-Protein Malnutrition in Children

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Abstract

This article explores the possibility of protein hydrolysates obtained from fisheries by-products as a medicinal remedy for addressing energy-protein deficiency in children. Energy-protein malnutrition is a major global health problem, especially in areas with limited availability of varied and nourishing food options. The study centers on the sustainable exploitation of fisheries by-products to transform these underutilized resources into valuable, easily absorbed therapeutic foods. The research uses thorough nutritional analysis to evaluate the hydrolysates' protein composition, amino acid profile, and bioactive components. It emphasizes the potential of these hydrolysates to be used as effective nutritional therapies. The paper highlights the significance of considering both the nutritional effectiveness and sustainable acquisition of resources when devising strategies to address malnutrition. The research examines the bioavailability and digestibility of protein hydrolysates to determine their appropriateness for meeting the unique dietary requirements of malnourished children. This study adds to the ongoing discussion on creative and sustainable methods to address childhood malnutrition. It highlights the significance of using fishery by-products as a helpful resource in creating therapeutic foods. The results promote additional investigation and advancement of these protein hydrolysates to generate significant interventions worldwide to enhance infant nutrition.

Keywords

Dietary, Energy, Fish by-product, Malnutrition, Protein

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3.1 Introduction

The per capita fish consumption has continuously increased over the past five years. Statistical data from the Ministry of Marine Affairs and Fisheries of the Republic of Indonesia (2014) indicates that fish consumption between 2009 and 2013 increased from 29.08 kg per capita to 35.14 kg per capita, representing a growth of 20.83%. In 2010, the cumulative volume of captured fisheries production reached 5,384,418 tons and witnessed significant growth until 2013, culminating in 5,863,170 tons. This growth potential corresponds directly to the potential yield of generated by-products (Rohmah et al., 2015).

Fishery by-products comprise bones, skin, fins, heads, scales, and internal organs. Fishery by-products represent one of the most significant challenges in the fish processing industry (Atma, 2016). Improper management of these by-products can lead to environmental issues, especially when the organic content in fish processing waste becomes a nutrient source for microbial growth (Syahrul and Dewita, 2016).

Fishery by-products have significant economic value when appropriately handled. These by-products still contain relatively high levels of protein and amino acids. Generally, fish waste contains various elements such as nitrogen, potassium, phosphorus, and others that contribute to the composition of fats and proteins. Based on this analysis, fishery by-products have the potential to be developed into fish protein hydrolysate products (Utomo et al., 2014). Transforming fishery by-products into products such as fish protein hydrolysates can reduce environmental pollution and enhance the value of fisheries products (Atma, 2016).

Fish Protein Hydrolysate (FPH) is derived from fish and fishery by-products through protein hydrolysis techniques. This process entails decomposing proteins found in fish tissues into smaller peptides, ultimately forming amino acids (Petrova et al., 2018). FPH is a fundamental component in food additives and dietary supplements, primarily enhancing protein consumption and mitigating protein-related malnutrition (Utomo et al., 2014).

According to Gunawan et al. (2011), malnutrition is when the body experiences energy, protein, and nutrient deficiencies. Protein-energy malnutrition (PEM) or Malnutrition with Energy and Protein Deficiency (MEP) are specific conditions related to defects in energy and protein. Nutritional deficiencies, especially energy-protein ones, remain a significant health issue in Indonesian society. The prevalence of undernourished or underweight children is still high. According to the Basic Health Research Ministry of Health of the Republic of Indonesia results of 2016, from 2007 to 2013, there has been no improvement and even a slight increase in these numbers. The province with the highest percentage of underweight children is East Nusa Tenggara (33%). Widjajanti et al. (2019) state that acute MEP is very dangerous, with a high risk of death if not properly managed.

Over the past two decades, hospitals have typically treated and managed acute MEP. However, recently, certain groups have approached this issue differently. This approach includes researching alternative products to prevent and treat uncomplicated MEP cases. One such product is Ready-to-Use Therapeutic Food (RUTF) (Schoonees et al., 2019). RUTF was first developed in Nigeria as a paste, primarily using peanuts (a local ingredient). Peanuts are high in fat but low in protein (Komari and Astuti, 2012). Therapeutic food products are typically made from main ingredients like rice or cereals enriched with plant-based rather than animal protein.

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