Potential and Trends Processing of Shrimp Industry by-Products in Food: A Review

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Abstract. The shrimp processing industry represents the largest fisheries sector globally due to its high demand and market value. Generally, the only shrimp parts that are often produced in factories are in the form of headless and peeled shrimp (shrimp without skin and head), about 88.5%. During processing, by-products are produced and require proper treatment. Shrimp by-product production has increased dramatically in recent years, leading to waste collection, disposal and pollution problems. The trend of utilisation of shrimp by-products needs to be carried out because these by-products have the potential to produce innovative products that have added value and are sustainable. By-products such as shrimp heads and shells contain proteins, minerals, fats, amino acids and bioactive compound components that can be used as additives and raw materials. The purpose of this paper is to examine the potential utilization of shrimp processing industry by-products. By converting these by-products into value-added products such as bioplastic, flavouring, natural food pigments, shrimp oil, and protein hydrolysates. Processing using various conventional and enzymatic extraction methods has the potential to reduce by-products. Utilisation of shrimp by-products can provide an attractive alternative to reduce dependence on synthetic products in the food industry, while providing the added benefit of more efficient and environmentally friendly by-product management.

1 Introduction

Utilising by-products is one important component of efforts to protect the environment and reduce adverse impacts on ecosystems and public health. For many people and companies, it can also be a source of income and economic prospects. Food processing generates a large amount of by-products, leading to environmental pollution and wastage of resources [1]. By-products can be both liquid and solid, such as organic waste and packaging waste [2]. The composition of by-products varies depending on the type of food industry and the production techniques used. Food processing generates large amounts of organic waste, including liquid and solid

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waste. The specific characteristics of waste vary depending on the type of food industry, such as milk and dairy products, fruits and vegetables, grain and flour processing, poultry and meat, and many others [3].

Shrimp is a significant seafood item in the food industry due to its high market demand and economic value. It is one of the most important and perishable commodities traded internationally, with world production and trade steadily increasing over the years [4]. Shrimp farming and catch production contribute to total yields at sea, with aquaculture accounting for 45.6% of the total value of shrimp production.

Worldwide shrimp production is expected to increase to 7.28 million tonnes by 2025, with an annual growth rate of 6.1% from 2020 to 2025 [5, 6]. Litopenaeus vannamei, Penaeus monodon, Penaeus semisulcatus, Metapenaeus dobsoni dan Metapenaeus affinis are some of the species found in the shrimp industry [7]. Generally, about 88.5% of shrimp parts that are often produced in factories are only in the form of headless (headless shrimp) and peeled (shrimp without skin and head) depending on market demand [8]. Therefore, during shrimp processing between 30-45% of the total production is produced as a by-product, which includes the head and shell [9-11]. This by-product can cause environmental pollution because its utilization is still minimal so it is necessary to carry out proper processing innovations [12, 13].

Production of shrimp byproducts has increased dramatically in recent years, leading to waste collection, disposal, and pollution problems. The chemical processes that occur in shrimp waste release toxic chemicals into aquatic ecosystems, causing damage to flora and fauna [14]. Shrimp by-products containing bioactive compounds such as chitin, carotenoids, and protein hydrolysates are known to have anti-inflammatory, antihypertensive, antimicrobial, and antiproliferative properties [6], [15]. This compound can be applied in various products in the food industry. Shrimp byproducts have significant processing potential. They can be used to extract valuable bioactive compounds such as lipids and astaxanthin, which have a wide range of applications in the food and pharmaceutical industries [16]. In addition, the oil extracted from shrimp byproducts is rich in omega-3 fatty acids and astaxanthin, making it beneficial for health and suitable for use as a supplement [17]. Shrimp byproducts can also be used to produce chitosan and lipid mineral-rich caroproteins, which have multifunctional properties and can be used in various industries [18]. In addition, the utilization of shrimp by-products can contribute to environmentally friendly energy conversion, bioremediation, and waste treatment [19]. Overall, shrimp byproduct processing offers opportunities for valuable compound production and waste reduction in the shrimp processing industry.

Various studies on the use of by-products in the food industry that allow to reduce waste and maximize the potential of the shrimp industry. This review will review the use of shrimp by-products, with various methods, by summarizing various studies published by scientists.

2 Potential and Processing of Industrial By-Products

The utilization of shrimp by-products in the food industry not only reduces by-products and environmental impacts but can also add economic value and provide a high-value source of raw materials. The Shrimp Processing Industry has produced a
lot of products that can be used for various needs because it has advantages, especially in the food industry. The content of bioactive compounds found in shrimp by-products are chitin, pigments, amino acids, and fatty acids, which have the potential to be used in various food, cosmetic, and medical industries [20]. In addition, shrimp by-products have inhibitory abilities against certain microorganisms due to antimicrobial activity [21]. Now, awareness of the negative impact of by-products on the environment has increased. This has prompted communities, businesses, and governments to look for ways to minimize it. Advances in technology have enabled the development of more efficient and environmentally friendly by-product processing techniques. This technique includes better processing methods, equipment and management systems. Various products and methods in processing industrial by-products can be seen in Table 1.

<table>
<thead>
<tr>
<th>Product</th>
<th>Source</th>
<th>Content</th>
<th>Extraction method</th>
<th>Utilization</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bioplastic</td>
<td>Shrimp shell</td>
<td>Chitin</td>
<td>Demineralization</td>
<td>As an environmentally friendly packaging material with biodegradability, edible, and has the ability of antimicrobial and antibacterial activity</td>
<td>[22]</td>
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<td></td>
<td></td>
<td></td>
<td>deprotenization</td>
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<td>[23]</td>
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<td>deacetylation</td>
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<td>[24]</td>
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<td></td>
<td></td>
<td>Chitin</td>
<td>conventional extraction</td>
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<td>[25]</td>
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<td></td>
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<td></td>
<td>deacetylation</td>
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<td>[26]</td>
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<td></td>
<td></td>
<td>microwave-assisted extraction</td>
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<td>Food coloring</td>
<td>Shrimp shell</td>
<td>Carotenoids (axthasantin)</td>
<td>extraction with trypsin</td>
<td>Can be a source of natural pigments rich in antioxidants and can inhibit lipid peroxidation in oil</td>
<td>[27]</td>
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<td></td>
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<td>extraction with hydrochloric acid</td>
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<td>extraction with alkaline</td>
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<td>[29]</td>
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<td></td>
<td>extraction with solvent hexan</td>
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<tr>
<td>Flavouring</td>
<td>Shrimp head and shell</td>
<td>Proteins, amino acids, volatile compounds</td>
<td>extraction with enzyme bromelin</td>
<td>As a natural food additive that can improve and improve nutrition and</td>
<td>[30]</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>conventional extraction</td>
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<td>[31]</td>
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<td></td>
<td>Roasting</td>
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<td>[32]</td>
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<td>taste in food products</td>
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<tr>
<td><strong>Shrimp Oil</strong></td>
<td><strong>Shrimp head</strong></td>
<td>Omega-3 fatty acids</td>
<td>Can be added to food products to improve nutrition and as a source of antioxidants and has health benefits</td>
<td>[33]</td>
<td></td>
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<td></td>
<td><strong>and shell</strong></td>
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<td></td>
<td>extraction with solvent hexana</td>
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<td><strong>Hydrolysate</strong></td>
<td><strong>Shrimp by-</strong></td>
<td>Proteins, amino acids</td>
<td>Can be used as a dietary supplement or food fortification ingredient that has the ability as an antioxidant DPPH, ABTS radical scavenging activity and Fe metal holding activity, emulsiifier, foam-forming ability, and high protein solubility</td>
<td>[34]</td>
<td></td>
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<td><strong>Protein</strong></td>
<td><strong>product</strong></td>
<td>Alkalase enzyme hydrolysis</td>
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</table>

### 3 Bioplastic

Food packaging is an important component in the food industry. This packaging is mostly made of polymers derived from petroleum and is concerned with the protection and preservation of all types of food. With increasing environmental problems caused by the abundance of plastics, a sustainable alternative to the development of environmentally friendly packaging materials is needed, packaging known as "bio-plastic" that not only works better but is also easily recycled and reused. Bioplastics are plastics made from polymers that can be biodegraded or can be made into compost, or plastics made from renewable resources (biobased)[35].
Currently, only 1% of the 320 million tons of plastic produced annually is made from bioplastics. Global bioplastics production capacity is expected to increase from about 2.05 million tons in 2017 to about 2.44 million tons in 2022 [36]. Therefore, alternatives are needed to reduce the use of plastic. The process of turning food waste into bioplastics for use in food packaging has gained popularity in recent years. This process utilizes the presence of such proteins, hemicellulose, polyphenols, cellulose, lignin, and starch [37]. The fishing sector is one of the many industries that produce food by-products, and appears to be a considerable contributor. Bioplastics can be created from shrimp byproducts, particularly shrimp shells. Chitin, the main component of shrimp shells, can be isolated and turned into chitosan, a biopolymer with a wide range of applications. Various methods are used to produce chitin through the stages of demineralization and deproteination processes. The quality of chitin used to produce chitosan also greatly affects the characteristics of chitosan used. The application of chitin and chitosan is strongly influenced by the characteristics of both, namely the character of the degree of deacetylation, solubility, viscosity, and molecular weight [38]. By using chitosan-based additives, the mechanical characteristics of the polymer can be improved. Chitosan is a material used in the crosslinking process that produces polymers that can increase strength. Natural fillers supplemented with chitosan hold great promise as a substitute for synthetic food packaging.

4 Food Coloring

Natural pigment sources that have great potential can be found in shrimp by-products, because shrimp shells contain rubberonoids in the form of astaxanthin, β-carotene, and lutein which can function as natural food coloring and can be used as additives in the food, cosmetics, and feed industries [27, 39, 40]. The high antioxidant capacity of shrimp by-products makes it a potential source of pigment [41]. Astaxanthin (3,3′-dihidroksi-β, β-karoten-4,4′-dione) It is an orange-red keto-carotenoid pigment and is lipophilic often found in marine animals [42, 43]. The content of pro-vitamin A and anti-oxidants in carotenoids is beneficial for health [44, 45]. Astaxanthin compounds can be obtained using extraction methods with different types of solvents [46]. Astaxanthin has high stability, astaxanthin stability around pH 4-11 and below 70 °C and is more stable in lipid environments [47]. The stability of astaxanthin is influenced by several factors, namely environment, packaging and storage [29]. In the future, the use of this pigment will contribute to various aspects in various industries because it has enormous potential. People will be increasingly aware of the importance of using natural ingredients as additives to food products. The use of natural pigments will encourage industries to develop new and sustainable innovative products from various other by-products. The use of natural pigments will be an attractive alternative in an effort to reduce dependence on the use of synthetic dyes which has always been controversial.

5 Flavoring

The use of flavorings in food has become quite common in the modern food industry. Flavoring processing techniques are one of the important aspects in the food industry to improve the taste of products. The development of the seafood flavor industry
seems to be increasingly in demand by the community [48]. Processing shrimp by-products into flavorings is an important step in marine resource management and can also contribute to the creation of more sustainable food products. Natural flavoring is usually obtained directly from plants or animals that go through processes either enzymatically, physically, or microbiologically [49]. Plant and animal food products such as fishery products, mushrooms, soybeans and other ingredients have received special attention because they are umami source compounds [50–52]. The use of natural ingredients that are around with the potential for high protein content is very likely to be used as an ingredient in making natural flavorings [53]. By-products in the form of shrimp heads and shells contain about 15–45% protein, minerals (40–55%), chitin (15–20%), karetonoids (15%) and flavor components so that they have the potential to be natural flavoring [54–56]. Flavoring is a food additive added to cooking to enhance, add or strengthen the taste of food [32, 57–59]. Generally, flavoring is made from extracts of certain ingredients such as beef, chicken, seafood, vegetables with the addition of spices then combined [60, 61]. The use of herbs and spices in flavoring processing can be a characteristic that distinguishes one dish from another. Instant food products and processed foods often rely on flavoring to provide distinctive flavors. Flavorings can be added to soups, sauces, crackers, nuggets, biscuits or other food products [62–64]. Produk samping udang merupakan salah satu bahan pangan yang mempunyai cita rasa yang kuat serta mempunyai rasa umami yang khas [65]. Shrimp by-products can provide an attractive alternative to reduce reliance on synthetic flavorings in the food industry, while providing the added benefit of more efficient and environmentally friendly by-product management.

6 Shrimp Oil

Processing shrimp by-products into oil can help reduce product by-products and increase efficiency within the fishing industry. Shrimp oil is one of the products that can be produced from shrimp by-products. Shrimp by-products can be used to extract shrimp oil because the shell, head, and skin of shrimp are rich in omega-3 fatty acids (PUFAs) and astaxanthine which have many health benefits [33, 66]. Shrimp oil can be used as raw material in various food and pharmaceutical industries [66, 67]. Omega-3s have an important role in food because they have health benefits such as cardiovascular, diabetes, cancer, anti-inflammatory and neuroprotective properties, and immune system enhancement [68, 69]. Shrimp oil can be used as an attractive alternative in the community, because of the higher level of public concern for health and nutrition. Efforts to process shrimp by-products into oil are an effort to reduce the negative impacts caused, especially on the environment. In addition, shrimp oil processing can create new business opportunities and can improve the economy for the processing industry.

7 Hydrolysate Protein

Protein hydrolysate is a product of the breakdown or breakdown of proteins into short-chain peptides through various chemical, thermal, fermentation, and enzymatic processes [70–72]. Protein hydrolysates can be both liquid and powder [73]. Enzymatic hydrolysis is more widely used because it is easier to control, does not damage the structure of amino acids, is safe for food products and contains better
nutrients [74, 75]. Bioactive peptides have a strong biological activity from the properties of this substance, so they are gaining popularity and are widely used in the cosmetic, pharmaceutical and functional food fields [76]. Protein hydrolysates have a high nutritional value of their amino acids so they can be used to improve taste and have bioactive properties such as antioxidant, antibacterial, anticancer, and antihypertensive, protein hydrolysates are usually used as dietary supplements to increase protein intake [77, 78]. The bioactivity of protein hydrolysates is influenced by the substrate source, the type of enzyme used, temperature, pH, and the amount of time spent hydrolyzing it [79]. The high protein content of shrimp by-products can be an alternative protein source to overcome the lack of protein availability. Protein is essential for tissue regeneration during growth in all walks of life. The development of protein hydrolysate from shrimp by-products can be used as a substitute or fortification material in food products to increase and improve the value of product characteristics [80]. Protein hydrolysates can be applied as food additives due to their high protein solubility of about more than 91% over a wide pH range (3-9) and their antioxidant ability DPPH, ABTS radical activity, Fe metal chelating activity, emulsifiers, and ability to form foams [34, 81]. The utilization of shrimp by-products into protein hydrolysates has enormous potential in the food industry in the future so it is important to follow this hydrolysate development trend to create more innovative products.

### 8 Conclusion

Various studies have shown the potential of shrimp by-products as raw materials and additives that can be used in the food industry. The components of bioactive compounds contained in by-products have various functional properties, antioxidant compounds, antibacterial activity, antimicrobial activity and carotenoid content which can be a source of natural pigments and can inhibit lipid peroxides. So the importance of alternative utilization of shrimp by-products to reduce dependence on synthetic products and can minimize the by-products of the shrimp processing industry.

### References


