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Chemical Properties of Liquid Broth Extracted from Freshwater and Marine Shrimp Shells Waste

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Abstract

Indonesia's shrimp industry is growing rapidly, but a surge in shrimp waste such as shells and heads' shrimps are increasing as well. These waste products contain important components such as protein, minerals, and amino acids. This study aims to determine the chemical properties of liquid broth extracted from freshwater and marine shrimp shells, including ash, protein, fat, monosodium glutamate (MSG), and antioxidant. The liquid broth was extracted by boiling shrimp shells and heads in water with a ratio of 1:2 for 1 hour at 80°C. Results indicate that the type of shrimp used did not affect the broth's ash, fat, protein, MSG, or antioxidant content. Marine and freshwater shrimp liquid broths contain 0.56% and 0.28% ash, 0.10% and 0.50% fat, 2.19% and 1.97% protein, 1.5291% and 1.6274% MSG, and 2263.73 ppm and 2786.2 ppm antioxidant.

Keywords: chemical; liquid broth; protein; shrimp shell; waste.

INTRODUCTION

Shrimp is one of the leading commodities of Indonesia's fisheries industry. According to the data, shrimp ranks first with the largest export value of 239.28 million kg and US$ 2.04 billion. Shrimp export volume increased by 28.96% compared to 2019, reaching 207.70 million kg. Shrimp also contributed 18.95% of the total export volume of fishery products last year (Ministry of Marine Affairs and Fisheries Republic of Indonesia, 2021). However, as shrimp production increases, the waste generated from shrimp shells and heads also rises since these byproducts in the industry are approximately 60% of total production (Abdollahi & Undeland, 2020). The shrimp shells and heads have been used as additives in aquaculture feeds but are commonly discarded and polluting the environment (Saini et al., 2020). Shrimp shells and heads still contain important components such as protein, astaxanthin pigment, minerals, and amino acids (Liu et al., 2021), making utilizing these contents as products possible.

The broth is a result of an extracting certain food ingredients such as chicken meat, beef, seafood, and vegetables which can be used to enhance the umami taste of dishes (Mosby, 2009; Rostini & Pratama, 2018). The extract can be obtained by boiling to dissolve the water-soluble components inside the ingredients into the water. Marine and freshwater shrimp differ in taste and texture, whereas marine shrimp has a richer and sweeter taste than freshwater shrimp (Liang et al., 2008). Moreover, the shrimp pigment called astaxanthin is believed to have an important antioxidant activity that is beneficial to human health (Fakhri et al., 2018). The previous study (Saleh et al., 1996) applied the liquid broth extracted from shrimp heads into crackers, but there is no further investigation on the various chemical properties. The study on characteristics differences of liquid broth obtained from marine and freshwater shrimp shells has yet to be reported. Therefore, this study aims to determine the chemical properties of liquid broth obtained from the shells and heads of marine and freshwater shrimp.

MATERIALS AND METHODS

Materials and Equipment

The raw materials used in this study were the shells and heads of marine and freshwater shrimp obtained from the Gudang Lelang Market in Bandar Lampung, Indonesia. Other materials used included chemicals for chemical analysis and titration. The equipment included a digital scale, beaker, hot magnetic stirrer, stirring rod, and stainless-steel strainer. The chemical analysis of the broth was carried out using a set of titration tools, chemical glassware, a furnace oven, a Soxhlet apparatus, a Kjeldahl apparatus, and a UV-Vis spectrophotometer (Hitachi U-2010).

Liquid broth preparation

This study was carried out in several steps, including preparing shrimp shells and heads, the boiling process, and the characterization of the boiled shrimp shell and head broth. All stages of the research were carried out on samples of marine and freshwater shrimp. The shrimp shells and heads were washed with running water until clean and drained, then placed in a beaker glass. Water was added at a ratio of shrimp to the water 1:2 and then boiled using a hot magnetic stirrer at 80°C for 60 minutes (Meiyani et al., 2014). The broth was then filtered to separate the shrimp shells and heads from the broth, and then cooled before being characterized. The characteristics of the broth analyzed included the proximate analysis of protein, fat, ash (AOAC, 2005), monosodium glutamate (Sulastri, 2017), and antioxidant activity (Rahmawati et al., 2016).

Data analysis

The results of several analyses were processed, and the significance of the differences was analyzed using a T-test with the IBM SPSS version 23 application.

RESULTS AND DISCUSSION

Chemical properties of liquid Broth

The parameters analyzed to obtain the characteristics of the broth from freshwater and marine shrimp shells included ash, fat, protein, MSG, and antioxidants. The results of these parameter tests are presented in Table 1. Based on the results presented in Table 1, it is known that the ash, fat, protein, MSG, and antioxidant content of the broth from freshwater shrimp shells were 0.28%, 0.50%, 1.97%, 1.6274%, and 2786.2 ppm, respectively. Meanwhile, the values for the broth from marine shrimp shells were 0.56%, 0.10%, 2.19%, 1.5291%, and 2263.73 ppm, respectively. The T-test statistical analysis showed no significant difference in chemical properties between the broth from freshwater and marine shrimp shells.

Table 1. Chemical properties of liquid broth from freshwater and marine shrimp shells

Analysis	Freshwater shrimp	Marine shrimp
Ash (%)	0.28±0.01 a	0.56±0.03 a
Fat (%)	0.50±0.04 a	0.10±0.01 a
Protein (%)	1.97±0.31 a	2.19±0.02 a
MSG (%)	1.6274±0,02 a	1.5291±0.04 a
Antioxidant (ppm)	2786.2±125.27 a	2263.73±201.67 a

Note: The numbers followed by different letters on the same row indicate significant differences based on the T-test.

Ash content

The ash content of the liquid broth obtained from the shells and heads of freshwater shrimp is lower than marine shrimp. Specifically, the ash content of the liquid broth from freshwater shrimp is 0.28%, while from marine shrimp is 0.56%. However, a T-test analysis shows no significant difference in the ash content of the broth between marine and freshwater shrimp. This indicates that the type of shrimp does not significantly impact the ash content in the shrimp broth, and it is inferred that the ash content was more likely affected by the boiling period. Another study (Silab et al., 2022) reported that the longer boiling period of pig bones resulted in higher ash content. Ash content in broth is related to the presence of minerals in a substance. The boiling process using water can only dissolve water-soluble minerals. The longer boiling period makes more water-soluble minerals come out of the tissue and dissolve in the water (Liu et al., 2021).

Fat content

The fat content of the liquid broth obtained from the shells and heads of freshwater shrimp is higher than marine shrimp, specifically from freshwater shrimp and marine shrimp, which are 0.50% and 0.10%, respectively. Since the t-test shows no significant difference in the fat content, it indicated that the type of shrimp does not affect the fat content in the shrimp broth produced. The fat content in the broth can be more influenced by the length of boiling time. Another finding (Silab et al., 2022) showed a significant increase in the fat content of broth produced from boiling pig bones with rising boiling time. The fat will leach outside the tissue and move into the water media. The longer boiling process will break down more fat components and dissolve them into the boiling water, increasing the fat content in the broth. The boiling process with water causes hydrolysis to break down fat into glycerol, soluble in water, and fatty acids, and also significantly changes the saturated and unsaturated fatty acids profile (Saborowski et al., 2022).

Protein content

The protein content of the liquid broth obtained from the shells and heads of freshwater shrimp is lower than marine shrimp. Specifically, the protein content of the broth from freshwater shrimp is 1.97%, while from marine shrimp is 2.19%. The t-test results show no significant difference in the protein and indicate that the type of shrimp does not affect the protein content in the broth. The protein content in this study is lower than in another study. The protein content of liquid broth from marine shrimp heads, black tiger shrimp (Penaeus monodon), ranges from 2.24% to 3.73% and varies depending on the boiling time and temperature (Saleh et al., 1996). The protein content of the liquid broth is affected by the length of the boiling time. This statement is supported by other findings (Silab et al., 2022) that showed the protein content of broth produced from boiling pig bones showed a significant increase with increasing boiling time. The longer the boiling time, it is suspected to soften the tissue on the shrimp shell so that the protein components in the shrimp connective tissue will be extracted into the broth liquid. Processing temperature could affect the protein content of boiled water at the same boiling time. Another study (Saleh et al., 1996) reported that boiled water from the heads of tiger prawns at 100°C had a protein content of 2.68% and significantly increased to 3.73% at a boiling temperature of 115°C. This is suspected by the increase in protein solubility at the higher processing temperature.

Monosodium glutamate (MSG)

The monosodium glutamate (MSG) content in broth from marine shrimp is slightly lower than freshwater shrimp, which are 1.5291% and 1.6274%, respectively. However, a T-test analysis shows no significant difference in the ash content of the broth between marine and freshwater shrimp, which indicates that the type of shrimp does not affect the MSG content in the shrimp broth produced. The MSG concentration in the liquid broth correlates with the glutamic acid content of shrimp shells and heads. According to (Liu et al., 2021), the combined total glutamic acid concentration of shrimp heads (1.56% - 1.76%) and shells (1.69% - 1.83%) is more than that of the flesh (3.00% - 3.10%). The MSG content in the broth can be more influenced by the length of boiling time. The longer boiling time is suspected of causing the protein to be denatured and break down into amino acids, including glutamic acid, which has a high solubility in water (Kingwascharapong & Benjakul, 2016). Boiling process will cause protein breakdown, producing amino acids that are easier to absorb by the body (Anwa et al., 2007).

Antioxidant

Antioxidants in shrimp play a role in delaying, slowing down, and preventing free radical oxidation in lipid oxidation (Nikoo et al., 2021). Astaxanthin, a xanthophilic carotenoid compound with two hydroxyl groups, is one of the antioxidants found in shrimp skin. This compound is more soluble in methanol and ethanol and can be extracted by bleaching method against β-carotene. Astaxanthin extracts from shrimp shells have an antioxidant activity of 88% against β-carotene (Saleha & Murniana, 2009). In this study, the antioxidant content of the freshwater shrimp broth extracted from shrimp shells and heads was 2786.2 ppm and 2263.73 ppm. According to the t-test analysis, it did not show a significant difference. During boiling, the antioxidant content correlated with the astaxanthin pigment extracted from shrimp shells and head tissue into the water. This result is higher than another study (Liu et al., 2021), which reported the astaxanthin content of shrimp heads, shells, and tails that ranges from 2.91 ppm to 19.20 ppm. During soaking and boiling, when shrimp parts come into contact with water, some proteins, including carotenoproteins (such as astaxanthin), were partially leached out. As a result, fewer pigments were retained in the meat, making the boiling water reddish (Kingwascharapong & Benjakul, 2016). The amount of astaxanthin in shrimp is impacted by the composition of their feed, as proven by research (Ruangdej & Laohavisuti, 2014) that showed shrimp fed with astaxanthin-enriched diets had higher pigmentation and total carotenoid levels than those given without it.

CONCLUSIONS

The chemical properties of liquid broth produced from freshwater and marine shrimp shells, including ash, fat, protein, MSG, and antioxidants, have been studied. The liquid broth obtained from marine shrimp shells has higher protein content, MSG content, and antioxidants than the broth obtained from freshwater shrimp shells. However, the ash and fat content are lower in marine shrimp shell broth than in freshwater shrimp shell broth. These chemical properties are not affected by the type of shrimp used. Further study is needed to vary the time and temperature boiling process with another analysis, such as amino acids and fatty acid profiles.

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***Competing Interests*:** The authors declare that there are no competing interests.

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