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Nutritional composition of sea squirts from Iwate Prefecture, Japan

Abstract

In this study, due to the effects of the Great East Japan Earthquake in 2011, sea squirts were not exported overseas and were discarded without being used for food. We addressed the disposal issue by raising awareness of sea squirts and incorporating them into food. When the general food composition of peeled sea squirts from Iwate Prefecture was analyzed, it was confirmed that they had a high ash content of 5.9% protein, 0.3% fat, 6.3% carbohydrates, and 2.9% ash, similar to shellfish. The mineral content of sea squirts from Iwate Prefecture revealed high levels of magnesium, iron, and zinc, similar to those of shellfish. The analysis of free amino acids in sea squirts revealed high levels of taurine, glutamic acid, proline, and alanine, indicating high amino acid content related to the taste of sea squirts, particularly sweetness and umami. It was confirmed that sea squirts are rich in minerals and amino acids, making them functional foods beneficial to human health.

Keywords: sea squirt, general food analysis, minerals, free amino acids, Iwate Prefecture

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Akiko Yamada Taniguchi, Machiko Kazami, Haruko Noguchi

Department of Agricultural Innovation for Sustainability, Faculty of Agriculture, Tokyo University of Agriculture, Japan

Correspondence: Akiko Yamada Taniguchi, Department of Agricultural Innovation for Sustainability, Faculty of Agriculture, Tokyo University of Agriculture, 1737 Funako, Atsugi, Kanagawa 243-0034, Japan, Tel +81-46-270-6220, Fax +81-46-270-6023, Email akiko@nodai.ac.jp

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Introduction

Sea squirts (Hoya), a marine animal primarily found along the Pacific coast of the Tohoku region in Japan, are cultivated in Iwate and Miyagi prefectures as food. Hoya is known for its unique flavor, a blend of seashore scent, sweetness, and bitterness. Hoya are harvested from March to August, during which they are rich in glycogen and impart a sweet and umami flavor. The sea squirts from Iwate Prefecture are mainly *Halocynthia roretzi* and are characterized by their deep orange color, orange interiors, and small pineapple-like shapes (Figure 1). Edible sea squirts are adults, while their larvae resemble tadpoles, possessing a notochord and nerve tube but lacking mouth or digestive organs. These larvae swim in the sea without feeding until they metamorphose. They attach to rocks and other objects to complete metamorphosis and become adults. Post-metamorphosis, they remain stationary, living by drawing in seawater containing plankton through an inlet pipe and expelling excess water and waste through an outlet pipe, functioning like a pump or filter.

Figure 1 Sea squirt from Iwate Prefecture, Japan.

Japan exported approximately 70% of its sea squirts overseas. However, due to the effects of the Great East Japan Earthquake in 2011, exports were banned, leading to frequent discarding without being used for food. To address the issues of sea squirt harvest volume and waste, it is essential to promote the deliciousness of sea squirts and boost their production and consumption.

This study analyses the components of sea squirt food, understands its functionality as food, and explores ways to use sea squirts as a food source. We hope to contribute to expanding sea squirt production and revitalizing the region.

Material and methods

Sample

The sea squirts were collected in May 2024 from Otsuchi Town, Iwate Prefecture, Japan. The edible parts, with shell removed, were used for analysis (Figure 2).

Figure 2 Sea squirt shell-less from Iwate Prefecture, Japan.

Measurement of general components

General components such as moisture, protein, fat, ash, and carbohydrates were measured following the Standard Tables of Food Composition in Japan. Moisture was determined using the normal pressure heat drying method,[1] protein by the Kjeldahl digestion method,[2] fat by the Soxhlet extraction method,[3] and ash by direct ashing.[4] Carbohydrates were calculated by subtraction.[5]

Measurement of mineral content

Mineral content was analyzed using atomic absorption spectrometry.[6] Samples were ashed and dissolved in 0.1 M hydrochloric acid. A Shimadzu AA-6300 atomic absorption spectrophotometer measured sodium (589.0 nm), potassium (766.5 nm), calcium (422.7 nm), magnesium (285.2 nm), iron (248.3 nm), zinc (213.9 nm), and copper (324.8 nm).

Measurement of free amino acids

Free amino acids in the edible parts were measured. Samples were prepared by homogenizing the tissues (Hiscotron, 10,000 rpm, 3 min, 4°C) and centrifuging (10,000 rpm, 10 min, 4°C) to obtain an extract. The extract's protein content was adjusted to 0.5 mg/100 ml and filtered through a 0.2 µl aqueous filter. Analysis was performed using an automatic amino acid analysis system (L-700, Hitachi, Ltd.) with a custom ion exchange resin column (4 mm I.D. × 150 mmL), at 35°C, a flow rate of 0.4 ml/min, and a sample injection volume of 10

μl. Detection was done using the OPA fluorescence method (EX 340 nm, EM 450 nm).

Results and Discussion

General components of sea squirts

The general components of sea squirts from Iwate Prefecture (Table 1) showed water content at 84.6%, similar to oysters (85.0%), protein at 5.9%, close to clams (6.0%), and lipid (0.3%) and carbohydrate (6.3%) contents similar to abalone (0.4%, 6.8%). The ash content (2.9%) was comparable to clams (3.0%). Although sea squirts are not shellfish, the general components are similar to those of shellfish.[7]

Table 1 Food composition of sea squirts shell-less from Iwate Prefecture (g/100g)

Moisture	Protein	Lipid	Carbohydrate	Ash
87	6.3	0.8	0.9	5

Mineral content of sea squirts

Given the high ash content (2.9%) of sea squirts from Iwate Prefecture, their mineral content was further analyzed (Table 2). The results showed significant levels of minerals: 860 mg/100g sodium, 44 mg/100g potassium, 62 mg/100g calcium, 120 mg/100g magnesium, 5.8 mg/100g iron, and 5.0 mg/100g zinc, confirming their high functionality. Sea squirts are particularly rich in iron and zinc, a finding consistent with previous knowledge. Compared to commonly consumed clams in Japan, sea squirts contain 1.2 times more magnesium, 1.3 times more iron, and 5 times more zinc. Given that Japanese diets often lack sufficient minerals, especially magnesium and iron, these findings suggest that sea squirts are a valuable source for addressing mineral deficiencies.

Table 2 Mineral content of squirts shell-less from Iwate Prefecture (mg/100g)

Na	K	Ca	Mg	Fe	Zn
860	44	62	120	1.8	5

Free amino acid content in sea squirts

Analysis of the free amino acid content in sea squirts from Iwate Prefecture revealed high levels of taurine (638 mg/100 g), glutamic acid (555 mg/100 g), proline (550 mg/100 g), and alanine (435 mg/100 g) (Table 3). Similar to shellfish, the high taurine content indicates significant functionality. The sweetness of sea squirts is likely due to the abundance of proline, alanine, and glycine, while their strong umami taste can be attributed to high levels of glutamic and aspartic acids. The slightly bitter taste is probably due to the presence of bitter amino acids. Additionally, the lower arginine content compared to vertebrates is characteristic of invertebrates.[8]

Table 3 Free amino acid composition of sea squirts shell-less from Iwate Prefecture

Amino acid	mg/100g
Tau	638
Glu	555
Pro	550
Ala	435
Asp	335
Leu	240
Gly	175
His	172
Val	170
Phe	142
Met	139
Tyr	134
Thr	130
Trp	125
Lys	121
Ser	115
Arg	114
Ile	110
Cys	98

Conclusion

This study was initiated to address the issue of sea squirts being discarded due to the lack of export opportunities following the Great East Japan Earthquake in 2011. Our goal was to raise awareness about sea squirts from Iwate Prefecture, boost their production and consumption, and develop appealing food products featuring sea squirts.

The general food composition of sea squirts from Iwate Prefecture revealed 5.9% protein, 0.3% fat, 6.3% carbohydrate, and 2.9% ash, similar to shellfish, confirming a high ash content. Mineral analysis showed significant levels of magnesium, iron, and zinc, similar to shellfish. Free amino acid analysis indicated high levels of taurine, glutamic acid, proline, and alanine, suggesting these amino acids contribute to the sweetness and umami taste of sea squirts. These findings confirm that sea squirts are rich in minerals and amino acids, making them functional foods beneficial to human health. Future plans include developing food products using sea squirts.

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Conflicts of interest

The author declares that there are no conflicts of interest.

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