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Unused resource "Sea Squirt Tunics" used as compost: impact on the growth and nutritional value of agricultural product "radish"

Abstract

Sea squirts ("Hoya" in Japanese) are tunicates, marine animals mainly distributed along the Pacific coast of Hokkaido and the Tohoku region in Japan. This study investigates the effects of using sea squirt tunics, an underutilized resource, as compost to cultivate agricultural products. This report details the results of cultivating Japanese radishes using sea squirt tunics compost, examining their growth and nutritional value.

This research aims to effectively utilize sea squirt tunics, an underutilized resource, and investigate their use as compost, thereby contributing to the recovery efforts following the 2011 Great East Japan Earthquake. The objective was to effectively utilize sea squirt tunics and address the waste problem.

Component analysis of sea squirt tunics from Miyagi Prefecture revealed that they contained 84.6% moisture, 5.9% protein, 0.3% lipids, 6.3% carbohydrates, and 2.9% ash. Excluding moisture, protein, carbohydrates, and ash were found to be high. Mineral analysis of the sea squirt tunics showed high levels of sodium and magnesium. Radishes grown using sea squirt tunics as compost had larger roots and leaves compared to Control radishes, and their composition showed higher levels of protein and ash. Furthermore, these radishes were higher in sugar, vitamin C, and glutamic acid, a flavor component.

Using sea squirt tunics as compost allowed crops like radishes to grow larger, and the high nutritional content confirmed that sea squirt tunics can be effectively utilized as compost.

Keywords: sea squirts tunics, compost, radish, nutritional value, reconstruction support of Great East Japan Earthquake

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Introduction

Sea squirts (Hoya) are tunicates, marine animals mainly distributed along the Pacific coast of Hokkaido and the Tohoku region in Japan. Japanese sea squirt species include "*Mahoya* : *Halocynthia roretzi* " and "*Akahoya: Halocynthia aurantium* " both of which are farmed for food. Sea squirts are characterized by a unique flavor that combines the aroma of the sea, sweetness, and bitterness. The sea squirt harvesting season is from April to July, and sea squirts harvested during this period are particularly sweet and flavorful. Sea squirts are a deep reddish-orange color and have a pineapple-like shape (Figure 1). Edible sea squirts are adults; larvae resemble tadpoles, possessing a notochord and neural tube, but lacking a mouth or digestive organs, and drift in the sea. The larvae attach to rocks and other surfaces to become adults. After that, they do not move and feed on plankton.

Figure 1 Sea squirt from Miyagi Prefecture, Japan.

Sea squirts are covered in a hard tunic called a tunic. While the flesh of sea squirts is edible, the outer tunic is hard and unsuitable for consumption and is currently discarded in large quantities as waste (Figure 2). Therefore, this study focused on the sea squirt tunics, a marine resource that has previously been an underutilized waste resource. Sea squirt tunics are discarded in large quantities during the processing of sea squirt flesh. We considered utilizing this underutilized resource as compost.

Figure 2 Sea squirt tunics.

Right photo: The sea squirt shells used were sun-dried

on outdoor asphalt at approximately 30°C for three days.

This study aimed to utilize sea squirt tunics as compost as an effective use of underutilized marine resources. This study investigated the effects of compost by using sea squirt tunics to grow radishes, analyzing their growth and nutritional value. Furthermore, we hoped to contribute to supporting the fisheries industry in response to the 2011 Great East Japan Earthquake, expanding sea squirt production, and revitalizing local communities.

Material and methods

Sample

The sea squirt used was Mahoya Halocynthia roretzi, caught in Miyagi Prefecture, Japan, specifically the tunics of sea squirts caught in June 2025. The radish used was Japanese white radish.

Cultivation method

Cultivation was carried out at the practical training field on the Atsugi Campus of Tokyo University of Agriculture in Atsugi City, Kanagawa Prefecture.[1]

Ten radish plants were planted in rows with a spacing of 70 cm between rows, 40 cm between plants, and a row height of 30 cm. The radishes were cultivated for approximately 100 days, with sowing in early September and harvesting in mid-December.

We created two types of radishes: One was grown in a field mixed with sea squirt tunics compost (3kg/m²) (hereinafter referred to as "Sea squirt tunics radish"), and the other was grown in a field without compost (hereinafter referred to as "Control radish").

Two types of radishes were created. One was grown in a field mixed with sea squirt shell compost (3kg/m²) (hereinafter referred to as "sea squirt shell radish"), and the other was grown in a field without compost (hereinafter referred to as "control radish").

Measurement of general food components of sea squirt tunics and radishs

The general components of sea squirt tunics and radishes were measured according to analytical methods based on the Standard Tables of Food Composition in Japan, with moisture, protein, fat, ash, and carbohydrates being measured. Moisture was measured by atmospheric pressure heating and drying method.[2] Protein content was measured by Kjeldahl decomposition method,[3] fat by Soxhlet extraction method,[4] and ash by direct ashing method.[5] Carbohydrates were calculated by subtraction method.[6]

Measurement of nitrogen and mineral content

Nitrogen content was measured using the Kjeldahl decomposition method.[3] Mineral content was analyzed by atomic absorption spectroscopy.[7] After ashing, the sample was dissolved in a 0.1M hydrochloric acid solution. A Shimadzu AA-6300 atomic absorption spectrophotometer was used to measure sodium (589.0nm), potassium (766.5nm), calcium (422.7nm), magnesium (285.2nm), and iron (248.3nm). Phosphorus was measured using the molybdenum blue spectrophotometric method.[8]

Nutritional components of sea squirt tunics radish

The nutritional components of sea squirt tunics radish were measured for sugar content, vitamin C content, glutamic acid content, and pH. Sample preparation involved grinding radishes in a blender, followed by centrifugation (10,000 rpm, 10 minutes, 4°C) to obtain the extract.

Sugar content was measured using the Brix meter method,[9] vitamin C content using the hydrazine method,[10] and glutamic acid content using the L-glutamic acid measurement kit "Yamasa Neo".[11]

Results and discussion

General components of sea squirt tunics

The general components of sea squirt tunics were measured (Table 1), and the results showed water content at 84.6%, protein content at 5.9%, fat content at 0.3%, carbohydrate content at 6.3%, and ash content at 2.9%. After removing the water, it was confirmed that the tunics contained high levels of protein (38%), carbohydrates (41%), and minerals (19%). It is known that the carbohydrates in sea squirt tunics are mostly cellulose.[12]

Table 1 The general components of sea squirt tunics (g/100g)

Moisture	Protein	Fat	Carbohydrates	Ash
84.6	5.9	0.3	6.3	2.9

Mineral content of sea squirt tunics

Since the ash content of sea squirt tunics was confirmed to be high at 2.9%, further mineral content measurements were performed (Table 2). The mineral content of sea squirt tunics was high, with sodium 860mg/100g, magnesium 120mg/100g, calcium 62mg/100g, potassium 44mg/100g, phosphorus 11mg/100g, and iron 2mg/100g. This confirmed that sea squirt tunics contain sufficient minerals for compost. Minerals necessary for compost include magnesium, calcium, and iron, which are essential elements supporting plant growth, and these minerals were found in abundance in sea squirt tunics. Since sea squirt tunics are a marine product, it is likely that they also contain sufficient minerals that were not measured in this study. Minerals are known to activate microorganisms, improve soil aeration and water retention, and create soil resistant to pests and diseases.

Table 2 Mineral content of sea squirt tunics (mg/100g)

N	Na	Ca	K	Fe	P	Mg
944	860	62	44	2	11	120

Magnesium is a component of chlorophyll, which is necessary for photosynthesis. Calcium is involved in the formation of cell membranes and has the effect of promoting root growth. Phosphorus and iron are minerals involved in photosynthesis, respiration, and physiological activity, and these minerals are also thought to be involved in growth.[13]

The size of "Sea squirt tunics radish"

The size of the radishes (roots) and leaves of radishes of Sea squirt tunics radish and Control radish were measured and compared (Figures 3&4).

Figure 3 Radish grown using sea squirt tunics as compost (Left: Radish grown using sea squirt tunics as compost "Sea squirt tunics radish"; Right: "Control radish").

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Figure 4 Radish leaves grown using sea squirt tunics as compost.

((Left: Sea squirt tunics radish; Right: Control radish)

The root length of Sea squirt tunics radish was 45.8 cm, while that of Control radish was 37.5 cm, and the leaves were 32.1 cm and 23.5 cm. It was confirmed that the radishes grew 1.2 to 1.3 times larger with sea squirt tunics compost (Table 3). This suggests that the sea squirt tunics compost had an effect, and that sea squirt tunics contain many minerals and other components necessary for radish growth.

Table 3 The size of "Sea squirt tunics radish" (cm)

	Radish root	Radish leave
Sea squirt tunics radish	45.8	32.1
Control radish	37.5	23.5

Component analysis of "Sea squirt tunics radish"

Analysis of the general nutritional content of the Sea squirt tunics radish revealed that the water content was 94.8%, a protein content at 0.6%, a fat content at 0.1%, a carbohydrate content at 3.8%, and an ash content at 0.7% (Table 4). The Control radish had a water content of 94.7%, a protein content of 0.5%, a lipid content of 0.1%, a carbohydrate content of 4.1%, and an ash content of 0.6%, indicating that the protein and mineral content was lower compared to the Sea squirt tunics radish. As a result, it was found that using sea squirt tunics as compost increases the food components and improves the nutritional value of radishes.

Table 4 Component analysis of "Sea squirt tunics radish" (g/100g)

	Moisture	Protein	Fat	Carbohydrates	Ash
Sea squirt tunics radish	94.8	0.6	0.1	3.8	0.7
Control radish	94.7	0.5	0.1	4.1	0.6

Nutritional components of "Sea squirt tunics radish"

Nutritional analysis of the Sea squirt tunics radish revealed a sugar content of 6.1%, vitamin C content of 54mg/100g, and glutamic acid content of 81mg/100g (Table 5). The sugar content of the radish was 1.1 times higher than that of the Control radish (5.5%). The vitamin C content of the Sea squirt tunics radish was 1.3 times higher than that of the Control radish (40mg/100g).

Table 5 Nutritional components of "Sea squirt tunics radish"

	Sugar (%)	Vitamin C (mg/100g)	Glutamic acid (mg/100g)	pH
Sea squirt tunics radish	6.1	54	81	5.4
Control radish	5.5	40	45	5.5

The glutamic acid content of the Sea squirt tunics radish was 1.8 times higher than that of the Control radish (45mg/100g).

It was confirmed that using sea squirt tunics compost increased the content by approximately twofold. The high amount of glutamic acid, an umami component, suggests that other amino acids are also present in large quantities. The increase in glutamic acid content in radishes is thought to be due to the influence of nitrogen compounds contained in sea squirt tunics, or to the stimulation of plant metabolic pathways by substances contained in sea squirt tunics. We would like to consider this further in the future.

The Sea squirt tunics radish is rich in vitamin C, has functional properties, and may contain many other functional components; determining the content of these other components is a subject for future research. The pH of the Sea squirt tunics radish was slightly lower than that of the Control radish, suggesting an increase in organic acids such as glutamic acid.

Mineral content of "Sea squirt tunics radish"

When the mineral content of the Sea squirt tunics radish was examined, the Na content was 36mg/100g, the K content was 255mg/100g, the Ca content was 76mg/100g, and the P content was 25mg/100g. Compared to the Control radish, the content of all minerals was higher (Table 6). It was confirmed that using sea squirt tunics as compost can produce functional radishes with high mineral content.

Table 6 Mineral content of "Sea squirt tunics radish" (mg/100g)

	Na	K	Ca	P
Sea squirt tunics radish	36	255	76	25
Control radish	24	244	58	18

Conclusion

This research was initiated to address the problem of sea squirt waste, which occurred due to the impact of the 2011 Great East Japan Earthquake, resulting in sea squirts not being exported overseas and being discarded without being used for food. We also aimed to contribute to supporting the fisheries industry in response to the 2011 Great East Japan Earthquake, expanding sea squirt production, and revitalizing local communities.

Sea squirts are covered in a hard tunic called a tunic. While the flesh of the sea squirt is edible, the outer tunics is hard and unsuitable for consumption, resulting in large quantities of waste during the processing of the sea squirt flesh.

This study aimed to utilize sea squirt tunics as compost as an effective way to utilize underutilized marine resources. This study used sea squirt tunics as compost to grow radishes, analyzing their growth and nutritional value to investigate the effects of the compost.

A chemical analysis of sea squirt tunics from Miyagi Prefecture revealed that the water content was 84.6%, protein content at 5.9%,

lipid content at 0.3%, carbohydrate content at 6.3%, and ash content at 2.9%. Excluding water, it was confirmed that the tunics were high in protein, carbohydrates, and ash. Mineral analysis of the sea squirt tunics showed high levels of sodium and magnesium.

When the size of the radishes (roots) and leaves of the Sea squirt tunics radish were measured and compared with those of the Control radish, it was confirmed that both the roots and leaves of the Sea squirt tunics radishes grew 1.2 to 1.3 times larger than those of the Control radishes. Furthermore, the Sea squirt tunics radish was rich in protein and ash, and also contained high levels of the sugar, the vitamin C, and the glutamic acid, the umami component.

This study confirmed that using sea squirt tunics as compost allows crops like radishes to grow larger and contains more nutrients, demonstrating the effective use of sea squirt tunics as compost.

In this experiment, there was no significant difference in soil texture between the plot planted with sea squirt tunics and the control plot. We did not investigate the soil microorganisms, which will be a future research topic.

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Conflict of interest

Authors declare that theere is no confict of interest.

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