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PROPERTIES OF SALTED GUTS OF SEA URCHIN
AND THEIR USE AS A FOOD PRODUCT

by Masamichi Kawachi, Asst. Prof.,
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Introduction:

Since shells and spines of sea urchin have been discovered in ancient ruins and shell mounds together with fish bones, it may be presumed that sea urchin has served as food for mankind since ancient times. We know that during the Horeki era, in the Katsuura area of the Yamaguchi Prefecture, sea urchins were offered to the feudal lords as a substitute for the rice normally paid as land tax. We are also told that the Shogunate families most prized sea urchins, salted entrails of trepang, and dried mullet roes out of the numerous gifts they received, calling them "the three rare delicacies of the world".

Thus it seems that sea urchins were already being processed and stored as salted guts during this period.

It is said that salted guts of sea urchins most probably began to be traded as a commodity around 1881 or 1882. During the rainy season, however, salted guts of sea urchins underwent abnormal fermentation, making storage

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over a long period of time difficult. About 1890, a method was devised to prevent this abnormal fermentation by the addition of cheap alcohol called "shochu" to the salted guts of sea urchins, and around 1898 they began to be packaged and sold in earthen ware. Since then, various technical improvements have been made, among them the replacement of "shochu" with alcohol. In this way, salted guts of sea urchins with an alcohol additive came to be produced as a specialty of Shimonoseki.

Salted guts of sea urchins are widely liked for their unique flavor, and with improvements in diet, demand for them has also increased.

Table 1. Production Yield of Salted Guts of Sea Urchins (t)

Year	Nationwide	Yamaguchi Prefecture
1965	2080	----
1966	2327	----
1967	2258	1197
1968	1615	706
1969	1584	760

However, as table 1 illustrates, the yield of salted guts of sea urchins is not increasing because of a scarcity of sea urchins. Almost 50% of the total national yield comes from the Yamaguchi Prefecture. However, in an attempt to expand the individual fisherman's income by increasing the value of shallow-sea products, each prefecture is actively giving instruction in the processing of the salted guts of sea urchins, which do not require heavy investment in equipment or special techniques. Meanwhile, in

July 1970 the JAS standard for jarred sea urchins was established. This proves that salted guts of sea urchins are no longer a specialty of one area or considered a delicacy, but have finally established themselves as popular food, both in terms of supply and demand.

I. Production Method of Salted Guts of Sea Urchins:

Salted guts of sea urchins are categorized as grained sea urchin and paste sea urchin. Grained sea urchin is produced either by adding table salt, or table salt and ethyl alcohol, to the sea urchin gonads, and letting them age. Paste sea urchin is produced either by adding table salt, or table salt and ethyl alcohol, to sea urchin gonads, then allowing the mixture to age and kneading it into paste

Since the methods of production of salted guts of sea urchins vary from region to region across the country, there is no basic method of production common to all areas. Still, with the addition or absence of alcohol as a criterion, salted guts of sea urchins can further be classified into two groups:

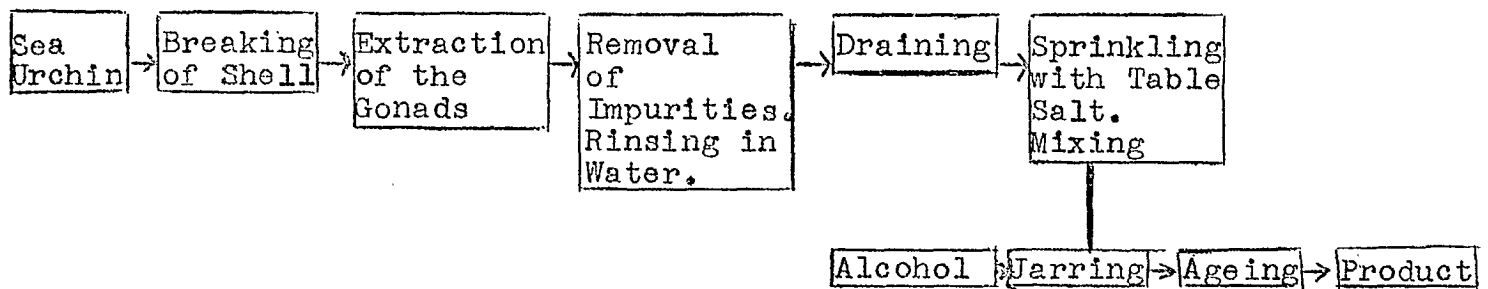
1) Grained Sea Urchin with Alcohol Additive

There are two production methods for this group, a small-scale method called the "Hamazume Method" (Jarred at the Beach), and a mass production method that should perhaps be called the "Taruzume Method" (Casking Method). Salted guts of sea urchins produced in all the fishing villages of

the Yamaguchi Prefecture are predominantly grained sea urchin produced by the Hamazume method. They are called Hamazume sea urchins, or at times, "Iso" (beach) sea urchins.

Diagram 1 outlines this method.

Diagram 1. Production Method of Grained Sea Urchins (Hamazume Method)



The gonads of fresh *Hemicentrotus pulcherrimus*, *Anthocidaris crassispina*, and *Pseudocentrotus depressus* are employed as raw materials. First, on the same day that the sea urchins have been gathered, or by the next morning, the shells are broken and the gonads immediately removed. This method of breaking the shells and extracting the gonads varies to some extent from area to area. For *Hemicentrotus pulcherrimus*, generally a method is used in which the mouth is tilted to the side and held, and the area around the mouth is pierced with a kitchen knife or a knife similar to a small straw cutting knife.

In the case of *Anthocidaris crassispina*, the area around the mouth is removed by using a kitchen knife or a jack knife. The body is then sliced in half perpendicular to the center plane. After the internal organs in the shell

have been removed, the gonads lining the inner surface are extracted with a teaspoon or a bamboo spatula. The extracted gonads are gathered in a bamboo basket and rinsed well in sea water with a smooth shaking motion. Impurities such as the internal organs, pieces of shell, and the spines are carefully removed with tweezers, and the gonads are fully drained.

The drained gonads are spread out on a chopping board that previously has been lightly sprinkled with table salt (refined salt or baked salt), and the rest of the table salt is evenly sprinkled on them. Then, after the gonads are stirred lightly with bamboo chopsticks, care being taken not to break them, they are put aside for a while. The amount of table salt sprinkled on the gonads is approximately 10% of their weight.

Parallel to this operation, the jar which is to contain the gonads is filled to approximately $1/6$ to $1/4$ of its capacity with 95% proof alcohol. The salted gonads are picked up with chopsticks and put into the jar. As the jar is rotated by hand, the gonads are mixed well ~~by~~ chopsticks, so that the alcohol thoroughly permeates them all. Ordinarily, jarring is completed when this operation has been repeated three or four times. If, however, the alcohol does not rise to the top of the gonads, a small amount of additional alcohol is poured in. The mixing is performed quickly before proteins are coagulated by the alcohol, yet carefully so that the grains are not broken.

The gonads that have been jarred are left for about thirty minutes, until they have absorbed the alcohol. When the gonads are completely coagulated, the jars are capped and sealed.

Also, at times *Hemicentrotus pulcherrimus* and *Anthocidaris crassispina* are jarred together. They are first separated, and each is sprinkled with salt. Then the colorful *Hemicentrotus pulcherrimus* is put into the jar and pressed against its sides; the tasty *Anthocidaris crassispina* is then put in the center.

2) Grained Sea Urchin without Alcohol Additive

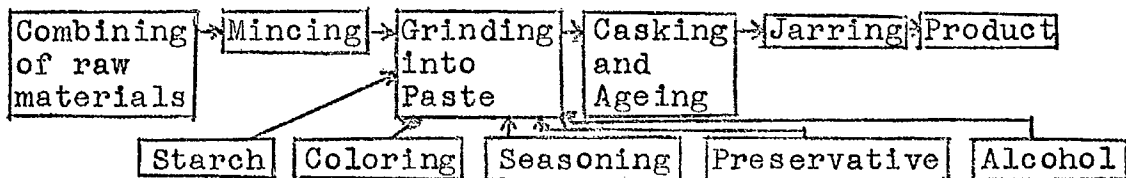
This is widely produced in all areas of the nation, and is called either mud sea urchin or salted sea urchin. Its method of production is similar to that of grained sea urchin with alcohol additive, the only differences being first that the dehydration of the drained gonads is performed thoroughly, and secondly that no alcohol is added. In other words, after the impurities are removed, the lightly drained gonads are spread on a bamboo basket or a slanted bamboo crate which previously has been sprinkled with table salt, and which has been placed over a thin cloth. The gonads are then sprinkled with the remaining table salt, lightly stirred, and fully dehydrated. These gonads, dehydrated through the addition of salt, are immediately jarred. *Anthocidaris crassispina* is the raw material mostly used, but occasionally a mixture of *Anthocidaris crassispina* and of

Hemicentrotus pulcherrimus is used. The amount of table salt to be sprinkled is approximately 20% of the weight of the gonads, and dehydration is carried out for fifteen to twenty hours in the shade.

3) Paste Sea Urchin with Alcohol Additive

Most of this is produced by a mass production method that should perhaps be called the "Taruzume method" (Casking Method). Diagram 2 illustrates the method of production. Refrigerated gonads such as Hemicentrotus pulcherrimus, Anthocidaris crassispina, Pseudocentrotus depressus, Strongylocentrotus intermedius, and Strongylocentrotus nudus from Sanriku, Hokkaido, Korea, or Okinawa are the raw materials used. They have been casked in advance after an addition of the appropriate amount of table salt or table salt and alcohol.

Diagram 2. Production Method of Paste Sea Urchin



Acceptable specimens are selected and combined from these refrigerated raw materials, so that the table salt and water content in the finished product will be correct. They are then minced and ground into paste with a grinder, while starch and coloring are added. Next they are seasoned with sodium glutamate, sugar, et al. Furthermore, various additives are mixed in to regulate taste and quality. Finally, alcohol is added, and all the ingredients are mixed

thoroughly. The mixture is then placed in a large container and sealed. After it has been aged for seven to ten days, it is jarred by a filling machine. The amount of starch and coloring added differs to a certain extent with the raw materials being used, but in general they are approximately 5% and 0.1% of the weight of the gonads respectively. The amounts of table salt and alcohol are similar to that for grained sea urchins. p. 75

4) Paste Sea Urchin without Alcohol Additive

This is a specialty of the Fukui Prefecture, and is known as "Echizen" sea urchin. The same procedure is performed as for grained sea urchin without alcohol additive, after which the gonads are dehydrated by the addition of salt, and placed in a large container and aged for approximately one week. They are then removed and placed on a wooden board, where they are kneaded in small amounts with a bamboo spatula to form a paste. Afterwards, they are put into a cask or a large pail and stored again. *Hemicentrotus pulcherrimus* is the raw material mostly used.

II. Raw Materials for Salted Guts of Sea Urchins:

It is known that as many as sixteen varieties of sea urchin are taken as food in our country, but of these, less than half are used as raw materials for salted guts of sea urchins. The latter is made from *Hemicentrotus pulcherrimus*, *Anthocidaris crassispina*, *Pseudocentrotus depressus*, *Strongylocentrotus intermedius*, *Strongylocentrotus nudus*, and *Tripneustes gratilla*.

Sea urchins are dioecious, but it is generally difficult to distinguish between the sexes because there is no great morphological difference. Furthermore, since the genital glands of the male and female bear a close resemblance, it is also difficult to distinguish between them with the naked eye during their period of immaturity. However, when they have reached maturity, the spermary acquires a whitish color and the ovary a yellowish brown, and the two can then easily be distinguished by their color. The sex ratio of sea urchins is not 1:1 in accordance with the principle of living things; rather, it is known to be 1:0.89 for *Hemicentrotus pulcherrimus*, and 1:0.71 for *Anthocidaris crassispina*. Because sea urchins used as raw materials for salted guts of sea urchins are generally gathered during a period when it is difficult to discern their sex, the correct sex ratio is unknown, but the percentage of ovaries is believed to be slightly greater.

The maturing process of sea urchin generative glands is divided into five periods: Period 1—disintegration and absorption; Period 2—growth of generative cells; Period 3—proliferation; Period 4—maturity; and Period 5—spawning. The beginning of each period differs in accordance with the variety of sea urchin, and with its environment. The spawning season for *Hemicentrotus pulcherrimus* is from mid-December to early March in Shimonoseki, from January to March in Shima, and from February to May in Asamushi. The spawning season

for *Anthocidaris crassispina* is generally from May to August, but from July to September in Miyagi Prefecture. *Pseudo-centrotus depressus* and *Strongylocentrotus intermedius* are both winter types, spawning from October to December and from September to November respectively. During the spawning period, sea urchin gonads are in a "melting" state, and it is impossible to process them as salted guts. Therefore, gonads can be used as processing materials only from Period 1 to the first half of Period 4. Furthermore, we know that *Hemicentrotus pulcherrimus* peaks in quality between the second half of Period 1 and Period 2, while *Anthocidaris crassispina* excels both in flavor and color during period 4, but becomes blackish and inferior in quality during December.

Small sea urchins have in general poor taste and color tone. Large sea urchins also make inferior raw material because their granules are coarse, and retain inferior properties such as being unpleasant to the palate, and because they are slightly blackish and tend to give off a bitter taste. The rate of growth for sea urchins differs significantly from area to area, but even within areas relatively close to one another, significant differences can be observed in accordance with differences in environment. Medium-sized sea urchins are most superior in quality as processing materials, and they correspond to two to three years of age on their growth curve.

The size and weight of sea urchin gonads depend on

the diameter of the shell, the maturing process, and environmental conditions. The weight of the gonads during the peak season for the catch is approximately 0.3g, 1.3g, and 3.2g for *Hemicentrotus pulcherrimus* with diameters of 20mm, 30mm, and 40mm respectively. Furthermore, their weight reaches its peak during the period of maturity, and is reduced to its lowest during the period of disintegration and absorption. The changes in *Strongylocentrotus intermedius* during the course of one year are very great, the variance between the maximum and minimum weight being approximately 300%. The changes in *Anthocidaris crassispina* across one year are also fairly great. For this reason, these particular sea urchins are gathered between the end of April and early August, when the weight of the gonads is heavy.

In the areas around Shimonoseki, the peak weight of *Hemicentrotus pulcherrimus* is reached during November, and the minimum weight during February, the variance being 200%. However, as there is no significant difference between those gathered from May to July, when their quality is at its best, and those gathered in November, *Hemicentrotus pulcherrimus* is gathered for the most part between May and July. In general, 85% of the total catch of sea urchins is obtained in the five months between April and August, with the peak season being from May to July.

Furthermore, the weight and color of the gonads differ in accordance with the variety and weight of the marine

plants which they ingest. It is known that in general, the weight of the gonads of sea urchins that have ingested varieties of green marine plants is high and their color fine, while sea urchins that have consumed a lot of brown plants have an inferior color tone. However, it is also known that when *Hemicentrotus pulcherrimus* is artificially cultivated with all kinds of marine plants, those fed with varieties of brown plants, especially "wakame" seaweeds, have a stronger reddish tinge than those which have ingested green marine plants. And although those fed on brown plants are slightly less bright, they still exhibit a fine and more brilliant coloring. Thus, since the quality and quantity of food ingested by sea urchins are related to the growth, color, and quality of the gonads, in the future it will be possible to evaluate the fishing grounds of sea urchins to be used as raw material for salted guts of sea urchins on the basis of the kinds of marine plants which are abundant there.

In addition, the gonads of sea urchins dwelling deeper than four meters from the surface are generally small with poor coloring. The sea urchins of new fishing grounds are usually old and large, and the color of the gonads blackish and lacking in brightness. They are also unpleasant to the palate. It is also known that the gonads of sea urchins dwelling in the vicinity of mouths of rivers are watery and inferior in quality. Table 2 illustrates the general yield rate of the gonads in comparison to the total weight (including the shells) of the various sea urchins used as processing

materials.

Table 2. Yield Rate (%) of Sea Urchin Gonads

Month Gathered	Yamaguchi Prefecture			Miyagi Prefecture	Ryukyu
	Hemicentrotus pulcherrimus	Anthocidaris crassispina	Pseudo-centrotus depressus	Anthocidaris crassispina	Tripneustes gratilla (?)
April	12.5	8.3	---	14.3	---
May	12.3	---	---	17.2	5.1-9.1
June	16.5	---	---	18.5	8.4-14.7
July	---	10.4	12.7	12.9	---
August	---	---	---	18.2	---

III. Components and Characteristics of Salted Guts of Sea Urchins:

The salted guts of sea urchins are processed goods, but the degree to which they are processed is extremely low. Thus the components and characteristics of the gonads used as raw materials directly affect the quality of the product. Moreover, the components and characteristics of these gonads differ in accordance with such factors as the variety, habitat, age, and sex of the sea urchin, and the maturing process of the gonads.

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Table 3 illustrates the general components of fresh sea urchin gonads. Their water content generally decreases as the gonads mature, but protein content is in reverse proportion to water content. Fat content is highest in the third period. As for the water content of *Hemicentrotus pulcherrimus* in early October, it is 70.8% to 75.1%, in the spermary and evidently larger than in the ovary where it is 58.0% to 67.4%. Proteinous nitrogen represents approximately 80% of the total nitrogen, and 3% of the proteins are water-soluble.

Table 3. General Components (%) of Various Sea Urchin Gonads

Kind	Month Gathered	Habitat	Water Content	Unrefined Protein	Pure Protein	Unrefined Fat	Carbo-hydrates	Mineral Content
Hemi-centrotus pulcher-rimus	April	Senzaki	65.5	15.5	---	8.0	---	---
	June	Shimonoseki	57.1	19.2	14.4	7.9	14.1	1.7
	July	"	54.2	20.4	15.1	7.0	16.9	1.5
	"	Aomori	67.6	16.3	---	1.4	13.0	1.7
	August	Fukui	58.2	15.8	---	9.6	---	---
Antho-cidaris crassis-pina	February	Senzaki	63.2	12.5	---	11.9	---	---
	March	"	61.9	12.1	---	14.3	---	---
	April	"	63.7	13.2	---	13.0	---	---
	June	"	59.4	13.8	---	14.3	---	---
	"	Shimonoseki	62.6	17.8	12.6	7.7	10.1	1.8
	July	"	55.8	15.4	11.5	11.3	15.8	1.7
Pseudo-centrotus depressus	June	Senzaki	54.5	14.3	---	15.8	---	---
	July	"	57.7	---	---	13.2	---	---
Strongylo-centrotus inter-medius (Male)	June-August	Hokkaido	69	16.9	13.5	4.1	8.0	2.0
			65	17.5	15.0	6.0	9.5	2.0

Furthermore, amino-nitrogen represents approximately 23% of the non-proteinous nitrogen.

Table 4 illustrates the main component fatty acids of sea urchin lipids and their content. As the table shows, the kinds of component fatty acids and their content are similar in all cases regardless of the variety or habitat of sea urchins, but the highly unsaturated acid content differs to some extent, being highest in *Pseudocentrotus depressus* and lowest in *Anthocidaris crassispina*. Furthermore, fatty acids of sea urchin lipids have a peculiar composition which differs from those of either marine animal lipids or of marine plant lipids. It is known that sea urchins have a large amount of phospholipids. Thus approximately 70% and 30% to 40% of the lipids in *Hemicentrotus pulcherrimus* and *Strongylocentrotus intermedius* respectively are phospholipids. Lecithin is the major component of phospholipids, composing approximately 50% of the total phospholipids. Phosphatidylethanolamine and Phosphatidylserine come next in quantity. Unsaponifiable materials compose 8% to 9% of the total lipids. Of this amount, approximately 60% is cholesterol and 30% pigments.

The main pigment of sea urchin gonads is the carotenoid group. In addition, we know that echinochlorm, which belongs to the naphthoquinone group, is also found in small quantity. Compared to other sea urchins, *Hemicentrotus pulcherrimus* has an especially high carotenoid content,

Table 4. The Main Component Fatty Acids of the Lipids of Sea Urchin Gonads and Their Content (%)

Fatty Acid	Hemicentrotus pulcherrimus	Anthocidaris crassispina (1)	Anthocidaris crassispina (2)	Pseudocentrotus depressus	Strongylocentrotus nudus
14:0	8.0	15.9	11.4	8.3	6.9
16:0	16.7	16.5	16.5	15.5	14.2
1	3.0	4.1	4.6	4.5	4.9
4	4.2	0.9	0.8	0.2	0.5
18:1	5.8	6.5	7.3	6.1	4.6
4	8.1	5.0	5.2	6.6	6.3
20:0	5.2	2.3	2.4	2.8	3.0
1	5.3	10.1	7.8	8.5	6.3
(?)2	5.5	8.8	8.0	5.3	6.7
3	7.4	5.8	7.9	10.3	8.1
5	9.5	5.4	8.6	11.8	16.2
22:1	3.1	2.2	2.7	2.7	2.5

Hemicentrotus pulcherrimus: Shimonoseki grown, fresh material

Anthocidaris crassispina (1): Shimonoseki grown, fresh material

Anthocidaris crassispina (2): Korea grown, refrigerated material

Pseudocentrotus depressus: Korea grown, refrigerated material

Strongylocentrotus nudus: Hokkaido grown, refrigerated material

approximately 300% that of Anthocidaris crassispina, and approximately 800% that of Strongylocentrotus nudus.

Red echinenone is the largest component of the carotenoid group, composing from 70% to 90% of the total carotenoid content. B-carotin and a-carotin are the next largest components. It is known that in comparison to other sea urchins Hemicentrotus pulcherrimus contains an especially large amount of a-carotin. It is also known, for example, that gonad color differs in accordance with the varieties of

marine plants which the sea urchins ingest, and that the color tone of sea urchins that dwell in deep water is generally inferior.

Sea urchin gonads contain various vitamins such as Vitamin A, B₁, B₂, B₆, B₁₂, C, E, and nicotinic acid. They contain an especially large amount of provitamin D, and it is believed that this amount is greater than that present in any other marine product.

The carbohydrate content of *Hemicentrotus pulcher-* p. 77
rimus and *Anthocidaris crassispina* is 10% to 20%, their saccharine content 6% to 10%. Most of the saccharinity is glycogen, and the amount of direct reducing sugar is comparatively small, being approximately 0.75% to 2.0%.

Strongylocentrotus intermedius and *Strongylocentrotus nudus* have a small carbohydrate content—1% to 3%, with glycogen composing approximately 60% of it. It is known that the main component monosaccharide of sea urchin saccharinity is D-glucose, and that small quantities of D-galactose, D-mannose, D-ribose, and L-fucose are also present.

Of the inorganic components, the largest is the phosphate radical, composing 30% to 40% of the inorganic matter. It is believed that most phosphate radical exists in the form of organic phosphate compounds. The next largest components are potassium and sodium. Relatively large quantities of chlorine, magnesium, and calcium are also present.

Sea urchins contain abundant extract compounds, and 8% to 10% of the hydrothermally drawn extract components are free amino acids. Of these, there are especially large concentrations of glycine and alanine. Together they form approximately 50% of the free amino acids. In addition, comparatively large amounts of serine, leucine, valine, taurine, glutamic acid, lysine, and alginine are also present. The content of the nucleotide family is small, and their composition differs radically from one specimen to another even when they belong to the same species of sea urchin. However, cytidylic acid is generally the largest component of the nucleotides, followed by adenylic acid. Among the nucleotides which impart flavor, guanylic acid is present in a small amount, while inosinic acid usually either is not present or is present only in minute quantity. The organic base content is extremely minute, and glycine betaine is present in a small amount. The organic acid content is equally small, about 84 to 166mg% in the finished product. Succinic acid, the delicious flavoring component of shellfish, is almost nonexistent. Of the carbohydrates, a small amount of glucose is present. Table 5 illustrates the representative components of extracts and their content.

The flavor of sea urchins is mainly derived from amino acid and 5' nucleotide. Glycine, alanine, valine, glutamic acid, and methionine are the amino acids most contributing to the flavor of sea urchins, while among

Table 5. The Main Components of the Extracts of *Hemicentrotus pulcherrimus*, and Their Content (mg figure of extracts in 100g of anhydrous matter)

Component	Content	Component	Content
Glycine	2599	Isoleucine	307
Alanine	805	Tyrosine	489
Valine	474	5' Cytidylic acid	82.1
Glutamic acid	318	5' Adenylic acid	32.3
Methionine	145	5' Guanylic acid	6.0
Taurine	325	5' Inosinic acid	7.0
Serine	401	Levulinic acid	67.4
Leucine	544	Lactic acid	47.9
Lysine	663	Glucose	597
Alginine	975		

Omata, Yasushi: Journal of Japan Fisheries Association, 30, (9), 750 (1964).

the nucleotides, inosinic acid and guanylic acid are most contributing. Of these, glycine and alanine account for the sweet taste of sea urchins, valine for their peculiar bitter taste, glutamic acid, inosinic acid, and guanylic acid for their delicious taste, while methionine is singularly contributing to their distinctive taste. It is known that when methionine is missing, almost all distinctive taste of sea urchins disappears. Furthermore, it is believed that glycogen and lecithin, present in sea urchins p. 78 in considerable quantities, affect the tactile impression of sea urchins, and account for their taste.

The raw materials for salted guts of sea urchins include refrigerated gonads that have been salted previously as well as fresh gonads. During storage, protein degeneration

and decomposition of components occur in these refrigerated materials, hence their composition differs greatly from that of fresh materials.

In refrigerated materials, large amounts of chemical compounds of low molecular weight such as amino acid, volatile basic nitrogen, and reducing sugar are present, and the pH value is significantly low. The changes which occur in these components during refrigeration are especially conspicuous during the first two months. The microorganisms that exist within the gonads also differ to some extent in fresh and refrigerated materials. Both of them contain numerous ordinary bacteria, but yeast can be found in large quantities only in refrigerated materials.

Such discrepancies in the components of the gonads used as raw materials directly influence the properties of the product, and are also related to the component changes of the product during storage. Tables 6 and 7 illustrate the chemical composition of various retailed products. Paste sea urchins have a small water and alcohol content compared to grained sea urchins, and grained sea urchins with an alcohol additive contain a somewhat smaller amount of salt than other products. In the "beach-jarred" products, immediately after production the nitrogenous compound content of low molecular weight is clearly smaller when compared to the mass-produced products, and the pH value is considerably higher.

Table 6. General Components (%) of the Retailed Salted Guts of Sea Urchins

Kind		Raw Material	Habitat	Water and Alcohol Content	Unrefined Protein	Unrefined Fat	Mineral Content	Table Salt
Grained Sea Urchin	With Alcohol Additive	Hemicentrotus pulcherrimus	Yamaguchi	56.5	19.4	---	0.5	10.8
		Anthocidaris crassispina	Iki	58.3	15.2	---	1.0	11.7
		Hemicentrotus pulcherrimus (80%)	Iki	59.1	26.6	---	0.4	2.6
		Anthocidaris crassispina (20%)		64.3	15.7	---	0.3	10.7
		Anthocidaris crassispina (20%)	Tsushima	64.3	15.7	---	0.3	10.7
		-----	Aomori	47.0	29.5	---	0.4	18.1
	Without Alcohol Additive	Hemicentrotus pulcherrimus	Iki	47.9	---	---	---	11.2
		Anthocidaris crassispina	Amakusa	55.1	16.4	---	0.1	15.7
Anthocidaris crassispina		Mie	50.2	23.5	---	0.7	12.0	
Strongylocentrotus intermedius		Hokkaido	48.1	---	---	---	15.0	
Paste Sea Urchin	With Alcohol Additive	-----	Shimonoseki	43.6	27.0	---	0.5	11.2
		-----	Yamaguchi	48.7	21.6	---	0.5	13.3
		-----	Fukui	44.4	23.3	---	0.7	12.2
	Without Alcohol Additive	Hemicentrotus pulcherrimus	Fukui	39.4	16.6	10.0	---	11.3
		Hemicentrotus pulcherrimus	Fukui	38.2	18.4	8.7	---	15.0

Table 7. Chemical Components of "Beach-Jarred" Products and Mass-Production Products and Their Changes

Production Method	Raw Materials		Storage Period of the Product	pH	Water Content (%)	Total Nitrogen (%)	Percentage within Total Nitrogen			
	Habitat	Kind					Water Soluble N	Non-proteinous N	Amino N	Volatile Basic N
"Beach-Jarred"	Shimono-seki	Hemicyclops pulcherimus (70%)	0	6.50	39.2	2.4	27.9	18.3	11.4	0.6
		Anthocidaris crassispina (30%)	1 year	6.18	36.3	2.4	46.6	41.2	14.8	1.0
Mass Produced	Rishiri	Strongylocentrotus intermedius (40%)	0	6.01	43.2	2.1	37.8	26.3	16.9	1.0
	Amakusa	Anthocidaris crassispina (60%)	3 months	6.21	45.0	2.2	39.0	26.2	15.4	1.4

However, with "Beach-jarred" products employing fresh materials, component changes occur gradually during storage, and nitrogenous compounds of low molecular weight increase considerably. In comparison, component changes after jarring are minute in mass-produced products employing materials which have already decomposed to some extent.

A conspicuous discrepancy can be detected between these two in the change in pH value. In "beach-jarred" products, pH is in the vicinity of 6.5 immediately after production, suddenly drops to the vicinity of 6.2 in the first two months after jarring, and then falls gradually thereafter. In mass produced products, in contrast, pH has already dropped to the vicinity of 6.0 during storage of materials, rises once to the vicinity of 6.2 in approximately the first month after jarring, and then drops gradually thereafter. Thus the phases of the component changes during the first stage after the addition of alcohol differ radically in the two materials.

The addition of alcohol to salted guts of sea urchins was originally started to prevent abnormal fermentation by yeast. Alcohol, however, has not only a bacteriostatic effect, but also degenerates protein through coagulation, obstructs the action of enzymatic self-digestion, and suppresses significant component changes during storage. Furthermore, because of protein degeneration the fishy odor vanishes, and fragrant components of the sea urchin and

the smell of alcohol harmonize perfectly to produce the peculiar aroma of salted guts of sea urchins. Moreover, when alcohol is added, the coloring of the carotenoid pigments becomes bright, and the color tone also turns into a beautiful reddish amber.

It is generally believed that the distinctive flavor of salted guts of sea urchins results from ageing. In the case of grained sea urchins, however, as the preservation of freshness and the grained shape are highly valued, extreme ageing is normally avoided. Still, grained sea urchins aged for a certain period of time are preferred to those taken immediately after production. This means that light ageing is desirable so that the table salt and alcohol that have been added can penetrate into and harmonize with the gonads used as raw materials, and the direct stimulating smell of the alcohol can disappear. At the same time, light ageing is also desirable so that slight decomposition can occur, while appropriate hardness and viscosity are maintained, and the sea urchins can reach their full flavor. In grained sea urchins, vigorous mixing and stirring are avoided in order to prevent the destruction of their granules during production. For this reason, for some time after production the distribution of table salt and alcohol is uneven, and the analysis value of each component also changes irregularly. It is approximately one to two months after production before an almost stabilized value is reached. This shows that approximately

this length of time must elapse for the added substances to permeate evenly through the grains of sea urchins, after which a satisfactory taste appears. Nevertheless, in the case of mass produced products using refrigerated materials for production, changes in the components have already progressed during storage of materials, and freshness has been lost. In such instances, the aim should be to bestow a rich mellow taste if not a fresh taste through appropriate seasoning.

IV. Their Properties:

It is necessary for grained sea urchins to maintain their granular structure and to possess appropriate hardness and viscosity. For this reason, salted guts of sea urchins present a semi-solid gel state of a heterogeneous system, and the evaluation of their properties should be based on the two factors of viscosity and elasticity. However, since the viscous factors of hardness (the major elements of which are viscosity and plastic viscosity) greatly affect the quality of salted guts of sea urchins, a sensory examination focused on these properties is generally performed.

Table salt and alcohol that are added to the salted guts of sea urchins are in a complex manner contributing to the coagulation or solubility of proteins in raw materials. Thus they not only contribute directly to the properties of salted guts of sea urchins, but they also indirectly

prevent deterioration of these properties by obstructing the action of enzymatic autolysis and micro-organic action, thereby controlling the decomposition of the components during storage. The higher their concentration, the harder the materials become, and the destruction and softening of the granular shape that accompany the decomposition of components are insubstantial. When their concentration is lowered, however, protein coagulation becomes insufficient, the granular structure is destroyed during storage, and the materials either become paste-like, losing hardness, or the solution separates and sinks to the bottom, losing its quality as a product.

When the table salt concentration is 8%, and the alcohol concentration is set below 9%, protein coagulation becomes somewhat imperfect and the hardness inferior. When the alcohol concentration is raised above 11%, however, the entire texture of the meat becomes too hard, loses viscosity, and becomes dry to the palate. Yet if the alcohol concentration is set at 5%, protein coagulation does not occur, and the whole material becomes a liquid and runs, thereby losing its distinctive character of salted guts of sea urchins with alcohol additive.

Nevertheless, even with an alcohol concentration of 5%, if the table salt concentration is set at 15%, the protein coagulates completely, and the product acquires the appropriate hardness and viscosity.

In the case of grained sea urchins using *Strongylocentrotus intermedius* as raw material, if the table salt and alcohol concentrations are made low when the water content is above 56%, the juice separates to the bottom of the jar, viscosity is lost, and the sea urchins become rough to the palate. However, when water content is below 52%, separation does not generally occur, regardless of these concentrations. In the case of grained sea urchins using spermaries alone as raw material, the particles become rough, dry, and crumbly, and are unpleasant to the palate. If the water content is above 52%, and the alcohol concentration is high, they easily become dry and crumbly. But when the water content is below 52%, this state occurs even when the alcohol concentration is low. Water content is closely related to such crumbling, and it is known that alcohol contributes to it more than table salt.

Thus the properties of salted guts of sea urchins are influenced both by table salt and alcohol concentrations. It is believed that water, lecithin, glycogen contents, etc... also affect their properties, whether directly or indirectly.

V. Problems in Processing and Storing:

The water content of the gonads used as raw materials, and the concentrations of table salt or table salt and alcohol, pose particular problems in the processing of salted guts of sea urchins.

The JAS standard provides that in both grained and

paste sea urchins, the water and alcohol content should be less than 60% in a product of superior quality, and less than 65% in a product of average quality. However, fresh gonads used as raw materials for salted guts of sea urchins generally have a water content as high as 54% to 63%, and an appropriate amount of alcohol must be added to this. Furthermore, the water content of the gonads used as raw materials is intimately related to the storage quality of salted guts of sea urchins, and is also indirectly related to the amounts of table salt and alcohol to be added. Accordingly, it is necessary to drain properly the gonads used as raw materials before jarring. The draining of gonads is usually completed in thirty to forty minutes. Even if they are drained for an additional length of time, it does not make much difference. Draining and drying are most important operations for salted sea urchins in particular. If they are not adequately dehydrated, they will soften during storage and fermentation will occur. To guarantee adequate dehydration, the gonads either are spread thinly over a mat or bamboo crate and drained and dried in the shade for ten to twenty hours, or they are dehydrated by adding salt. To reduce the water content by 50% through dehydration, by the addition of salt, more than eight hours of draining is a necessary minimum. As for the degree of dehydration, it is known that when the amount of table salt added is in excess of 15%, no difference due to the excess amount can be observed, but that it is influenced by the length of dehydration. p. 80

In the case of salted sea urchins without alcohol additive, unless a large amount of table salt is added, as is done with ordinary varieties of salted guts, storage over a long period of time becomes difficult. In other words, if the water content is low, fermentation can be controlled to some extent even if the salt concentration is approximately 20%. But when the water content exceeds 50%, fermentation cannot be completely prevented even if the salt concentration is 25%.

In most cases, the water and alcohol content of retailed "beach-jarred" sea urchins which are of superior quality is approximately 62% to 64%. Thus since the water content of the gonads used as raw materials does not have as great an effect on the storage quality and properties of the product in the case of the salted guts of sea urchins with alcohol additive as in salted sea urchins, excessive dehydration is ordinarily not performed.

Nevertheless, to produce a JAS product of superior quality, since alcohol is to be added, it is necessary to dehydrate in advance the gonads used as raw materials. For this purpose, it is recommended that an appropriate amount of table salt be sprinkled, and that dehydration through addition of salt be performed for about an hour.

The flavor, properties, and changes during storage of salted guts of sea urchins with alcohol additive are complex in comparison to those in salted sea urchins. Antisepsis is primarily performed by the action of

alcohol, but table salt also simultaneously contributes to it. That is to say, the purpose of antiseptics is achieved for the most part when the alcohol concentration exceeds 11%, even if the amount of table salt is small. However, when only a small amount of table salt is used, autolysis progresses gradually during storage, and the salted guts of sea urchins become somewhat soft. Also, their color darkens and their color tone becomes inferior, so that it is desirable for the products either to be consumed in a short time or be refrigerated.

On the other hand, if the alcohol concentration is less than 5%, decay cannot be prevented unless a large amount of table salt is added. Moreover, in this case protein coagulation becomes incomplete and a fishy odor can be sensed to some degree. In general, when the alcohol concentration exceeds 11%, alcohol stimulation becomes strong, and decreases the desirable taste. As the action of enzymatic autolysis is obstructed by the addition of alcohol to the salted guts of sea urchins, no significant increase during storage of the taste producing components such as amino acids can be detected. Accordingly, the suppression or softening of the salty taste caused by the increase in taste producing components seen in ordinary varieties of salted guts does not occur. And when the salt concentration exceeds 9%, the salty taste becomes conspicuously strong.

In the final analysis, it is essential to determine

the concentrations of table salt and alcohol appropriate for the overall flavor, taking into consideration the three factors of flavor, properties, and storage quality.

Usually, the appropriate concentration is approximately 8% of table salt (10g/100g of raw material), and approximately 9% of alcohol (95% proof alcohol 14ml/100g of raw material).

However, in view of current demands, it seems that salted guts of sea urchins are preferred when the amount of these additives is decreased to a certain extent. For purposes of taste, their concentrations can be decreased by approximately 1% each, but unless measures such as addition of preservatives or cold storage are taken simultaneously, storage over a long period of time becomes difficult.

The only preservatives permitted for use with salted guts of sea urchins are sorbic acid and Vitamin K₃. Sorbic acid is widely used to prevent decay of the Echizen sea urchin, and it is known to be extremely effective at a concentration of 1/2000. But if it is used in a large quantity, volatile acid increases and the pH declines during storage. Not only does this heighten the bitter taste to some degree, but brilliance also disappears and the color tone becomes inferior. We know that at a concentration of 1/1000, Vitamin K₃ can completely prevent abnormal fermentation by yeast in salted sea urchins. But when it is used, during storage the gonads at the top of the jar gradually

acquire a dark brown color, and in an extreme case, they turn blackish, causing a strong oxidized odor. Even in the case of salted guts of sea urchins with alcohol additive, while the addition of these preservatives considerably controls the growth of microorganisms, their effect is much inferior to the bacterial static effect possessed by approximately 5g of table salt/100g raw material and 7ml of alcohol/100g raw material. Even if these preservatives are added, one should expect no further germ-controlling effect. Also, it is not desirable to add ascorbic acid in order to prevent color change due to oxidation. Ascorbic acid is known in certain cases to become the center of amino-carbonyl reaction, and in the case of salted guts of sea urchins, the addition of ascorbic acid also tends to make salted guts turn brown.

In the case of grained sea urchins, raw materials of comparatively fine quality are used, and since vigorous mixing and stirring are avoided in order to preserve the granules, it is rare to add anything except seasonings. This is especially so for "beach-jarred" sea urchins, where nothing ordinarily is added except table salt and alcohol. As for paste sea urchins with alcohol additive, ingredients such as quality enhancing agents and fillers are used in addition to preservatives, coloring agents, and seasonings, since a large part of the raw materials are refrigerated materials whose components have already changed to some degree. A

mixture of reddish and yellowish tar pigments is often used as coloring agent. The ratio of the mixture differs with the color tone of the gonads used as raw materials, but in general the amount added is approximately 0.1% to 0.05%. Both of these pigments are retailed as sodium salt; hence in the case of salted guts of sea urchins containing table salt of comparatively high concentration, the salting out and separation of the pigments frequently occur during low temperature storage in wintertime. The use of tar group pigments is also undesirable in terms of food hygiene, so in the future, coloring should be performed with carotenoid pigments. Sugar and sodium glutamate are used primarily as seasonings, and various chemical seasonings which bring out the taste of sea urchins are also used. The gonads of sea urchins contain only a small amount of reducing sugar, and a significant increase in it cannot be observed even during storage. For this reason, browning caused by amino-carbonyl reaction does not pose much of a problem. Still, when a large amount of sugar is added as seasoning, browning does occur during storage, and in extreme cases the gonads acquire a chocolate color. Thus it is necessary to add seasonings carefully, considering their effect on color tone and on other qualitative factors. The addition of various condensed phosphates are being experimented with as quality enhancing agents. In ~~fresh~~ sea urchins, the permeable amount of salt and the water-hold capacity of protein increases with the addition of phosphates, and the yield rate improves. At

the same time, it is also known to have other desirable effects, such as toning down the bitter taste caused by the addition of sorbic acid, and preventing the eduction of salt crystallization. However, in the case of salted guts of sea urchins with alcohol additive, deterioration of the properties and flavor when the concentration of salt and alcohol are decreased is almost never corrected by the addition of phosphates.

Refrigerated sea urchins from all areas are appropriately combined as raw materials for paste sea urchins. The water content and amount of table salt in each raw material are regulated for this act of combining, but at times various fillers are added to achieve this purpose. In former times, "sake" lees used to be employed as fillers, but they are not used much today. Rather, it seems that high polymer polysaccharides such as wheat starch and tamarind seed polysaccharides, and animal proteins such as milk protein and soybean protein, are used.

The JAS standard provides that starch must not be included in a product of superior quality, and that starch content in a product of average quality must be less than 8%. These fillers not only deteriorate the original and natural flavor of sea urchin, but are also a problem in terms of food hygiene, and their use should be avoided as much as possible.

VI. Kneading with Other Foods:

Kneading of sea urchins with other foods is divided into two categories--the addition of suitable food to salted guts of sea urchins in order to enhance their taste and increase their popularity; and the mixing of a small amount of sea urchin with another food in order to endow it with the distinctive flavor of sea urchins.

Some of the representative products of the former category are jellyfish sea urchin, herring roe sea urchin, and abalone sea urchin. Additional examples are top shell sea urchin and cuttlefish sea urchin. The secondary raw materials that are added are all marine products which lack a distinctive flavor, but are difficult to chew. When these salted guts of sea urchins are stored, the water content of the secondary raw materials oozes out and not only lowers the quality, but also causes decay, making storage during a long period of time difficult. For this reason, in the case of abalone sea urchin, measures are taken such as cutting the raw abalone into tiny pieces, salting them, and furthermore soaking them in "sake" lees. Only after this procedure are they added to the salted guts of sea urchins.

The representative products of the latter category are, for example, egg sea urchin, sea urchin butter, sea urchin "rice-in-tea", and sea urchin buns. Only foods which are compatible with the distinctive flavor of sea urchins are chosen for this purpose.

VII. Conclusion:

Concentrating on the salted guts of sea urchins with alcohol additive, I have dealt thus far with outlining the production method and the properties. However, salted guts of sea urchins are produced as a specialty with methods characteristic to each area across the nation. It is believed that as a result their properties differ, but I was unable to give a full account due to lack of records.

"Beach-jarred" sea urchins to which almost no additions are made except table salt and alcohol can be described as a purely natural food possessing freshness and a light, plain taste, but one defect is that its production is limited to the period of catch of the sea urchins to be used as raw materials.

It is hoped that in the future, this may be overcome (by, for example, improving the method of preservation of sea urchin raw materials) and that increasingly greater development may be achieved.

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