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| Author(s) | TANIKAWA, Eiichi |
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STUDIES ON THE NUTRITIVE VALUE OF THE MEAT OF SEA CUCUMBER (*STICHOPUS JAPONICUS* SELENKA) *

I. General Introduction and Explanation of Plan of Investigations

Eiichi TANIKAWA

Faculty of Fisheries, Hokkaido University

It has been reported that more than one hundred species of sea cucumbers (Holothuroidea) inhabit the waters near Japan, most of them living in the southern areas. But the edible species utilized commercially as either raw or dried materials are restricted to about 20 species. Of these species, *Stichopus nigripunctatus* ("Okiko", in Japanese, in Miyagi Prefecture and "Kurohoshi-Namako" in Hokuriku District), *Cucumaria japonicus* ("Fujiko", in Japanese) and *Stichopus japonicus* ("Namako" in Japanese) are common, and among them the last one is the most important because of the large amount of catch, being highly regarded as commercial goods. *Stichopus japonicus* has different Japanese names according to the localities, e. g., "Akako", "Kuroko", "Torako", "Tawarago" and so on.

The dried goods, after boiling, of the sea cucumber, *Stichopus japonicus* produced in Japan has been one of the important exportations to China from old times.

As the holothurians which have, or have not, papillae on the surface of the body wall according to the species, the dried materials are also classified into two kinds by the presence or absence of papillae. In China the dried sea cucumber having papillae is called "Tsusan", while those without papillae is called "Kosan". In the commercial market the former is called "Haisan" (dried black sea cucumber) and the latter "Paisan" (dried white sea cucumber). In Honshu of Japan the dried sea cucumber for the market is manufactured using only the species having papillae, but a small quantity is manufactured from the species without papillae in the Bonin and Loochoo Islands. The materials of dried goods manufactured in Hokkaido, Honshu, Shikoku and Kyushu are almost entirely confined to a single species having papillae, *Stichopus japonicus*. It is an interesting fact that in sea cucumber the number of papillae decreases and the projection of papillae becomes blunt in the various species found from north to south, the papillae being replaced by mere swollen knobs in the materials from south eastern Kyushu.

The quality of the dried merchandise of sea cucumber is largely graded by the size, i. e., by height and sharpness of the papillae. The materials with conspicuous papillae are regarded as high class. In this respect the dried merchandise manufactured

* This "Studies on the nutritive value of the meat of sea cucumber" is the first part of "Chemical studies on the meat of sea cucumber (*Stichopus japonicus* SELENKA)".

from *Stichopus japonicus* in Hokkaido has the highest quality, while that from southern areas is lower. Both *Stichopus nigripunctatus* in Miyagi Prefecture and *Cucumaria japonicus* in Hokkaido have no papillae, so that their marketable value is low, and the sea cucumber in Amami-Oshima, Bonin Islands, Loochoo Islands and South Sea Islands, though there are many edible forms, are also considered low in quality due to absence of papillae.

The raw meat of the body wall of sea cucumbers is utilized for food in Japan by cutting and vinegaring; salted internal organs (called "Konowata" in Japanese) are also used. Drinkers are reportedly very fond of both.

Before World War II the production of dried sea cucumber merchandise was amounted to 1000000 Yen a year, but it has been suspended since the War because of the stopping of trading between Japan and China.

Recently the dried sea cucumber has again been regarded with keen interest as a possible important export commodity.

The author has recently succeeded in preparing canned sea cucumber. The canned food has various advantages for use in various sorts of cooking, and it is expected to be suitable to the taste of the Chinese.

It has been said that there are many differences between the meat of sea cucumber and that of fish, but the chemical properties of the meat of the former are still unknown in detail. Accordingly various difficulties remain in canning process. There have been published a few reports on the chemical properties of the meat of sea cucumber, *Stichopus japonicus*. Sekine¹⁾ and Fränkel & Jellinek²⁾ have studied the nitrogen distribution of the meat of sea cucumber, and Tsujimoto³⁾ on the fat. Igarashi⁴⁾ has analysed the dried market sea cucumber, reporting the general chemical components.

Some of the biological reports will be referred to here, because the chemical properties of the meat are greatly influenced by the conditions of life of animals, e. g., breeding and hibernation. Mitsukuri⁵⁾ and Tokuhisa⁶⁾ made observations on the life history of sea cucumber and Inaba⁷⁾ has tried artificial fertilization. Feeding and breeding habits were investigated by Kinoshita^{8,9)} in Hokkaido.

In a series of investigations on the chemistry of the meat of sea cucumber, the present author as the project leader has attempted to do research in the order of (1) nutritive value, (2) post-mortem changes and (3) properties of the protein. The investigations under the present main title, take the form of "chemical studies on the meat of sea cucumber, *Stichopus japonicus*," mainly dealing with its nutritive value. It is expected that the various methods of manufacture of sea cucumber will be more developed when the chemical and physical properties of the meat are clarified in detail.

Before going further, it will be necessary to touch on the body system of a useful sea cucumber, *Stichopus japonicus*. Originally the body system of the

holothurians is arranged in radial symmetry as in other echinoderms, e. g., sea urchins, sea stars and so on. However, in holothurians the animals are crawling on and burrowing into the sand of the sea bottom with their bodies kept horizontal. Because of the position of the body and habit of movement, the underside of the body facing toward the sea bottom is somewhat differentiated in structure. Therefore, for practical convenience in the present report, the side of the body facing upward is called the dorsal side of the body and the side facing downward is called the ventral side.

According to the histological observations,* so-called meat, i. e., edible part, of sea cucumber mainly consists of loose connective tissue together with the thin surface skin (epidermis) and inner membrane (epidermis) facing to the body cavity (coelom). The muscular tissue is very rare. There are only five radial bands of muscle and thin muscular layer along the inner layer of the body wall. That is to say, the edible part which is usually called meat of sea cucumber is histologically not composed of muscular tissue, but mainly of connective tissue. Such tissue consists of collagen fibers forming a network together with a small quantity of muscular tissue. In the present investigations a large part of the connective tissue together with a small part of the muscular tissue are treated as the meat samples for chemical studies.

The flesh meat of *Stichopus japonicus* contains a large amount of water, the water content being about 90%. When the body of *Stichopus* is dried after boiling, the size is decreased by 1/5 or 3/10, and the weight is decreased by about 1/20.

In the following articles numbered II, III, IV, ... the plan is to report "Studies on the nutritive value of the meat of sea cucumber, *Stichopus japonicus*," the results of estimation of the chemical components, digestibility, the kinds and contents of amino acids composing meat protein and chemical components of meat extractive matter.

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* This histological observation has been aided by Mr. Eihiro Niiyama