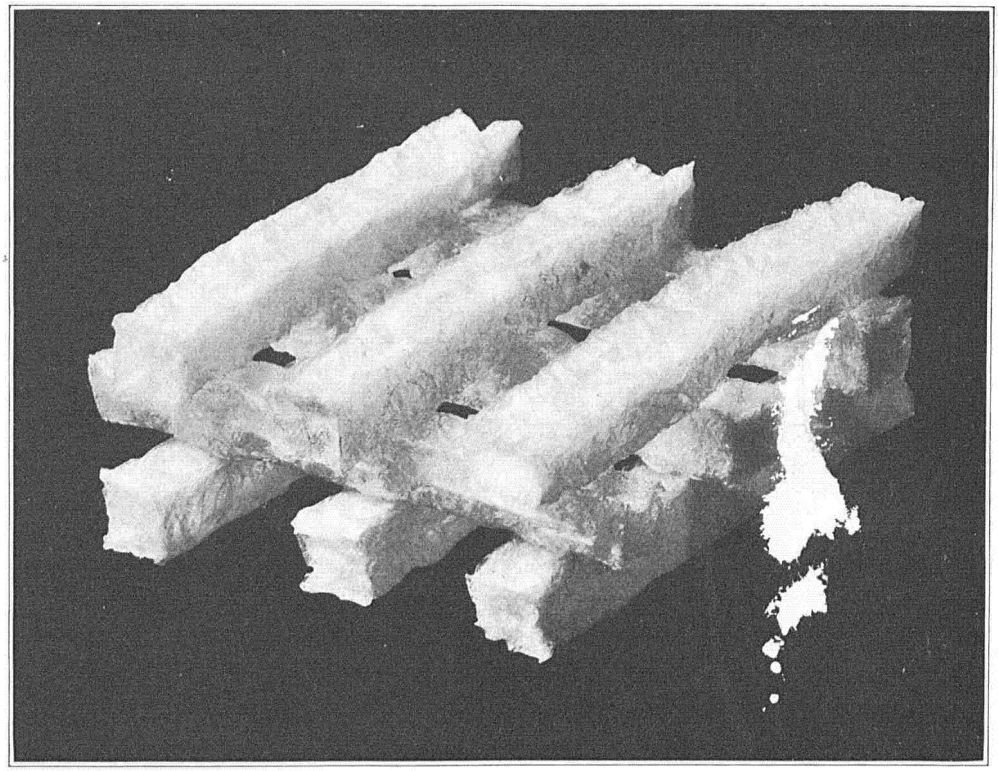
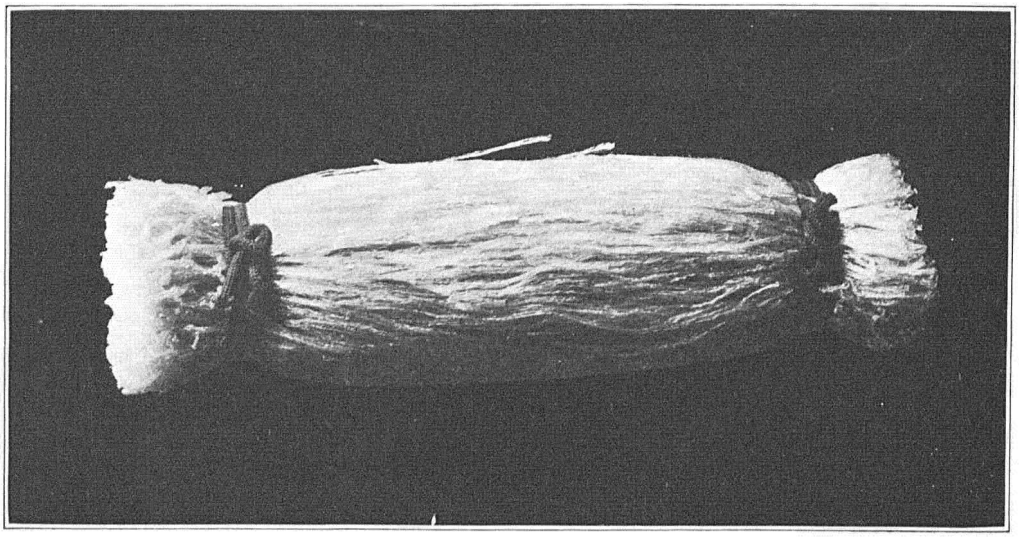
THE SEAWEED INDUSTRIES OF JAPAN.

By HUGH M. SMITH,
Deputy U. S. Fish Commissioner.

Blank page retained for pagination



BAR OR "SQUARE" KANTEN.



A BUNDLE OF "SLENDER" KANTEN.

KANTEN, OR SEAWEED ISINGLASS.

THE SEAWEED INDUSTRIES OF JAPAN.

By HUGH M. SMITH,
Deputy U. S. Fish Commissioner.

Seaweeds are among the most valuable of the aquatic resources of the Japanese Empire, and contribute largely to the prominent rank attained by the fisheries of that country. While marine plants are extensively utilized in France, Ireland, Scotland, and other European countries, in the East Indies, in China, and elsewhere, in no other country are such products relatively and actually so important or utilized in such a large variety of ways as in Japan.

The seaweed industries of Japan owe their importance to the great extent of the coast line (estimated at 18,000 miles); to the abundance and variety of useful algæ; and to the ingenuity of the people in putting the different kinds of plants to the most appropriate uses and in utilizing them to the fullest extent.

The value of the seaweeds prepared in Japan at the present time exceeds $2,000,000 annually, this sum excluding the value of very large quantities of marine plants which do not enter into commerce but are used locally in the families of the fishermen.

In view of the extent and long continuance of these industries, some diminution in the supply of economic algæ might reasonably be looked for, and this has in fact occurred; but while excessive gathering has influenced the abundance of some species, much more serious decrease has been brought about by conditions not connected with the seaweed industries. Investigations conducted by the imperial fisheries bureau have indicated that the disappearance of useful algæ on a number of sections of the coast has resulted from a temporary freshening of the littoral waters, probably owing to improper lumber operations near the headwaters of streams. The denuded areas have always been contiguous to the mouths of rivers or within the possible range of influence of streams during freshets. It is reported that in a few places certain algæ have been able partly to reestablish themselves, but the process is very slow, and complete replenishment will require many years, even if no lowering of water density ensues in the meantime. Some experimental planting in the denuded districts has been undertaken with favorable results, but on a very small scale. In other parts of Japan cultivation is extensively carried on, but as yet is directed to practically only one species, the laver (*Porphyra laciniata*).

It is noteworthy that the disappearance of seaweeds has injuriously affected another fishery—namely, that for abalones, which rank among the important water products of Japan. These mollusks feed among the algæ and are no longer found on large areas of bottom on which they formerly abounded.

The general name applied to algæ in Japan is nori, which is also often given to the prepared products. The term enters into numerous combinations, as will be seen in the following chapters. The seaweed preparations to which special attention is given are kombu, amanori, funori, kanten, and iodine. All of these can be made in the United States, and it is largely with a view to pointing out the possibilities for a successful business in some or all of these products that this report is submitted.

The information herewith presented embodies a brief account of the methods of taking and utilizing seaweeds in Japan, and is based on personal inquiries by the writer in 1903. Statistical and other useful data have been furnished by Dr. K. Kishinouye and Dr. K. Oku, of the imperial fisheries bureau, Tokyo. To Doctor Oku, especially, the writer is under great obligations for assistance and information, without which the preparation of this paper would have been impracticable. A number of manufacturers of seaweed products supplied samples, gave information, and accorded facilities for inspecting their establishments; among those to whom special acknowledgments are due are Messrs. Risuke Yamamoto, Hikobei Nakanisi, Hikobei Matsushita, Kingo Matsushita, and Manjiro Nakajima, all of Osaka.

The biological and commercial aspects of the Japanese seaweeds have been considered in various official reports, the most complete of which are published only in the Japanese language and are not available for foreign readers. The following publications have been consulted in the preparation of this paper, and some of the illustrations herein shown have been copied or adapted therefrom. Only the first three papers are in English.

JAPANESE BUREAU OF AGRICULTURE.

1893. Useful Algæ, in Descriptive Catalogue of Exhibits relating to the Fisheries of Japan at the World's Columbian Exposition. Tokyo, 40 pages.

1894. Utilization of Algæ, in The Fisheries of Japan. Compiled and arranged from the foregoing catalogue by Hugh M. Smith. Bulletin U. S. Fish Commission, 1893, pp. 419–438.

K. YENDO.

1902. Uses of Marine Algæ in Japan. Postelsia, The Year Book of the Minnesota Seaside Station, 1901, pp. 1–18. St. Paul, 1902.

1903. Investigations on Isoyake (decrease of seaweed). Journal of the Imperial Fisheries Bureau, Vol. XII, No. 1, 1903.

MIYABÉ, YAMAGAWA, AND OSHIMA.

1902. On the Laminariaceæ and Laminaria Industries of Hokkaido, being Part III of Report on Investigations of the Marine Resources of Hokkaido, pp. 212, numerous plates. Sapporo, 1902.

I. On the Laminariaceæ of Hokkaido. By Prof. Kingo Miyabé.
II. On the Laminaria Industries of Hokkaido. By Shin Yamagawa.
III. Chemical Analysis of Laminaria. By Prof. Kintaro Oshima.

T. NISHIMURA.

1903. Manufacture of Funori (seaweed glue) in the Prefectures of Tokyo, Osaka, and Miyé. Journal of the Imperial Fisheries Bureau, Vol. XII, No. 3, 1903.

K. OKU.

1904. Preparation of Kizami-kombu (green-dyed laminaria) in the Prefecture of Osaka. Journal of the Imperial Fisheries Bureau, Vol. XIII, No. 2, 1904.

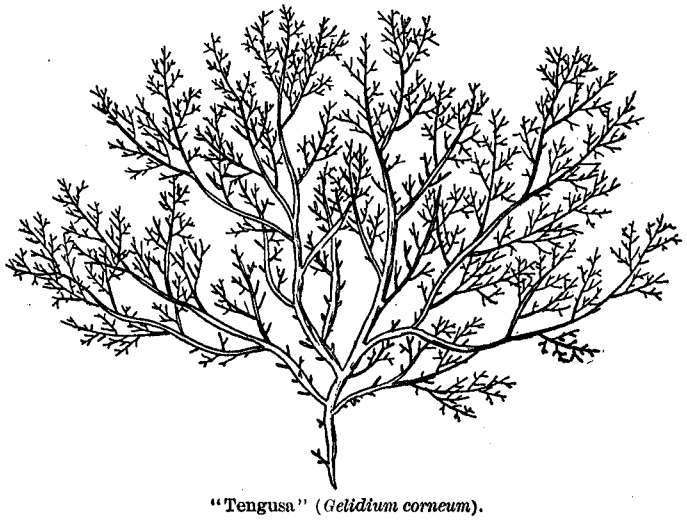
KANTEN, OR SEAWEED ISINGLASS.

NATURE AND IMPORTANCE OF KANTEN.

A very valuable and interesting product of seaweeds, comparable to isinglass and used for some of the same purposes, is known to the Japanese as *kanten*. This name is like so many of the fanciful terms with which the Japanese invest common objects; it means "cold weather," and has reference to the circumstance that this article is and can be made only during the colder months (December to February).

In 1903 there were in Japan 500 establishments for the manufacture of kanten, located in Osaka, Kyoto, Hyogo, Nagamo, and elsewhere. The average capacity of the factories is 3,000 kin, or about 4,000 pounds. The leading manufacturer has his warehouses and store in Osaka, and his factory at Hyogo, where 70 to 80 persons are employed. Mountainous regions are the best for this industry, because of the dryness and purity of the air.

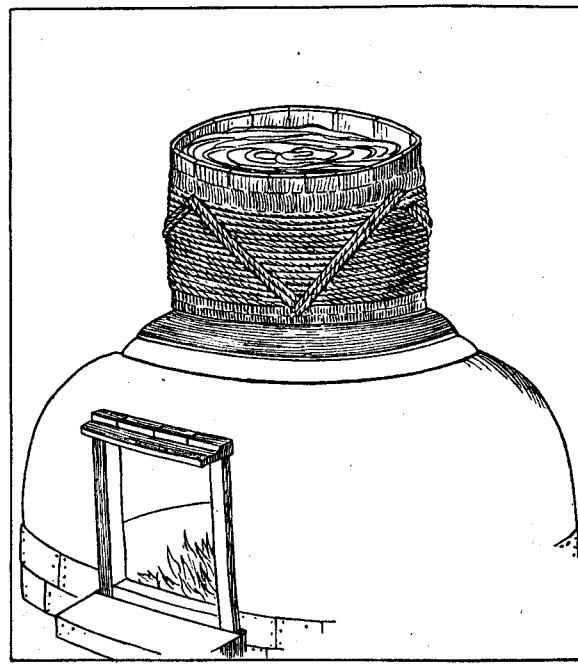
Kanten has been made since about 1760. In the early years it was simply a



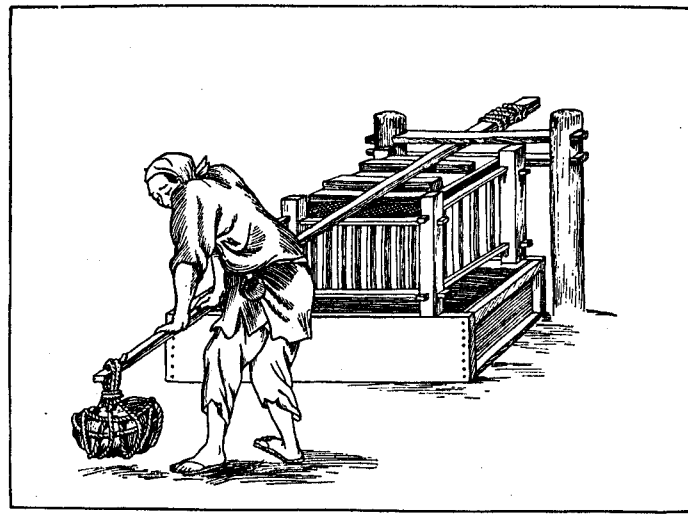
"Tengusa" (*Gelidium corneum*).

mass of jelly formed by the boiling of the seaweed, but at the present time the entire output is in the more convenient form of sticks and bars, a manner of preparation which was taken up quite accidentally; some soft jelly was thrown out of doors and congealed in the shape of slender sticks, suggesting the idea of preparing it in this form. Kanten is made from algæ of the genus *Gelidium*, the principal species being *G. corneum*. The Japanese name for the plant is *tengusa*, a contraction of *kantengusa*, meaning "weed for kanten." Several similar seaweeds are used as substitutes or adulterants, but are not so good as *Gelidium*. The algæ grow on rocks, and are taken by diving, the gathering season being May to October, though July and August are the best months. The principal supply comes from Hokkaido and the prefectures of Shizuoka, Miye, and Wakayama. The weed is dried on the shores, some bleaching taking place at the time of drying, and is then ready for sale to the manufacturers.

In 1903, the dried weed was selling in Osaka at 6 to 9 cents per pound; the substitute algæ brought 4 to 6 cents. The total crop of dried kanten algæ in 1900 was valued at $113,140; the fishermen's sales in 1901 were $125,282.



Furnace and tub for the boiling of *Gelidium*.



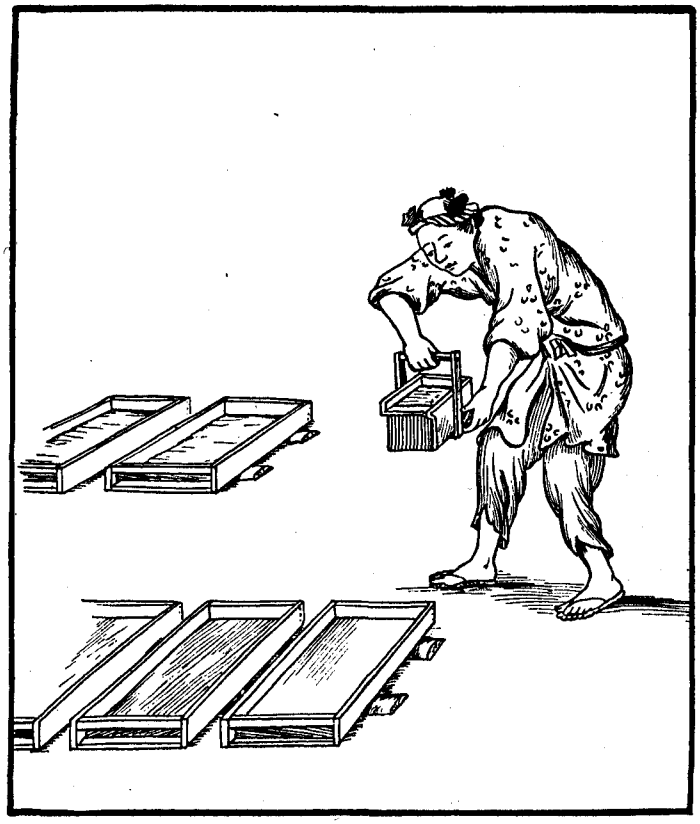
Press for straining crude sea-weed jelly.

THE PREPARATION OF KANTEN.

The process of making kanten is quite elaborate, although the appliances required are simple and inexpensive.

(1) The first step is the removal of all foreign matter from the masses of dried algæ. Calcareous and other hard particles are dislodged by beating and pounding, and other substances are picked out by hand. Further cleaning is effected by washing in running fresh water.

(2) The wet algæ are then spread in thin layers on flakes with bamboo or reed tops, through which the water drains. The principal object in thus spreading the algæ is to bleach them; this is done in warm weather, beginning in August, and is facilitated by dew. Under favorable conditions, twenty-four hours may be sufficient, but usually several days are required.



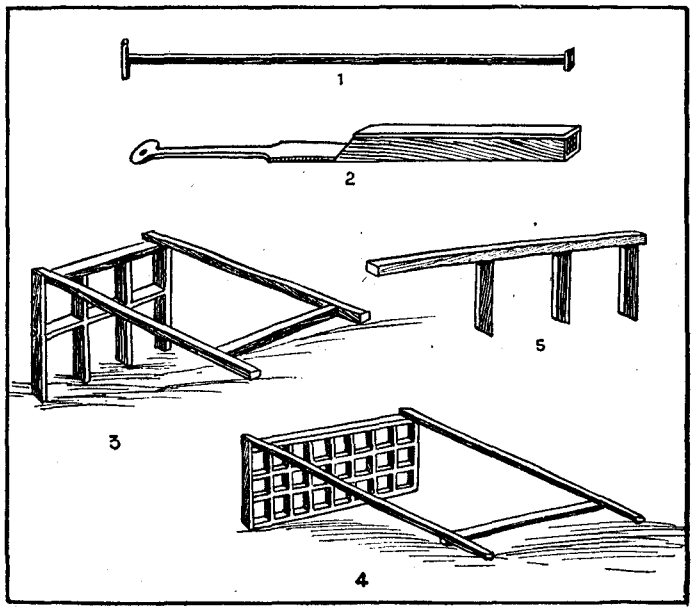
Pouring liquid kanten into cooling trays.

(3) As the drying goes on, the algæ become agglutinated and more or less fused, forming loose-meshed sheets. These sheets are loosely rolled and, as required, are boiled in fresh water in a large iron kettle or a wooden tub placed over a specially constructed oven or furnace. The boiling extracts the gelatin, and a thick, pulpy mass results. From the boiling kettle the jelly is strained or filtered through coarse cloths into a vat or tank, this preliminary straining being followed by a more thorough straining through linen bags of coarse mesh, which are placed in a crib and squeezed by means of a lever, the jelly falling into a large vat under the press.

(4) From the vat the jelly is dipped with a peculiar rectangular wooden vessel and poured into wooden trays to cool. These trays are about 2 feet long, 1 foot wide, and 3 inches deep, and are arranged in rows in the open air, resting on parallel poles so as to be clear of the ground.

(5) At a certain stage of the cooling and hardening process, the contents of the trays are cut into pieces of uniform size, in order to facilitate handling. The cutting is done by means of oblong iron frames, adapted to the shape of the trays, divided into squares of various sizes. One face of the frame has sharpened edges, and the cutting is done by inserting the frame along one side of the tray and drawing it horizontally through the jelly.

(6) The bars are then put one by one in a wooden box slightly larger than themselves and with a coarse wire grating over the lower end. A wooden piston with a broad end fits into this box, and is pushed against the bar of jelly, forcing it



Articles used in cutting sea-weed jelly into sticks and bars.

through the grating in the form of slender sticks. Another way in which kanten is prepared is in the form of blocks, 1¼ to 1½ inches square and 10 to 12 inches long, which are made with a cutting frame such as has been referred to. There is a shrinkage of one-third in bulk in the course of solidifying.

(7) The sticks and bars of hardening jelly are arranged in regular rows on flakes occupying an exposed position on a mountain or hillside. The congealing requires one to three days, according to wind and temperature, and a further drying of three or four days is usually allowed. A northwest wind is considered as giving the best results.

(8) The thoroughly dried pieces are trimmed to uniform lengths and baled for shipment. The thin sticks, known as *huoso-kanten* (slender kanten), are 10 to 14 inches

long and about one-eighth of an inch thick, and are tied into bundles weighing about 6 to 10 ounces ; the bundles are packed in bales holding 100 kin (133 pounds), incased in several layers of matting. The blocks, which are called *kaku-kanten* (square kanten), are not adapted for close packing, and make a very bulky bale; about 50 blocks weigh 1 pound.

THE USES OF KANTEN.

Kanten is pearly white, shiny, and semitransparent, having in block form a loose, flaky structure, and is tasteless and odorless. In cold water it swells but does not dissolve, but in boiling water it is readily soluble and on cooling forms a jelly.

In Japan kanten is used largely for food in the form of jellies (often colored), and as adjuvants of soups, sauces, etc. It is also used for purifying saké, the native wine made from rice. In foreign countries kanten is employed in a variety of ways, although chiefly in food preparations where a gelatin is required, such as jellies, candies, pastries, and many desserts, in all of which it is superior to animal isinglass. It is also used for the sizing of textiles, the stiffening of the warp of silks, the clarifying of wines, beers, coffee, and other drinks, the making of molds required by workers in plaster of Paris, and sometimes in the manufacture of paper. In China one of its uses is as a substitute for edible bird nests. The large consignments of square kanten to Holland are doubtless destined for the schnapps factories. A very important use in all civilized countries is as a culture medium in bacteriological work; the product is known in the scientific world under the name *agar-agar*, which is the Ceylonese equivalent of kanten. For this purpose a very pure grade of slender kanten is required.

The following chemical analyses of kanten have been made by Dr. O. Kellner, formerly a professor in the Agricultural College of Tokyo University, and by the Imperial Fisheries Bureau, respectively:

Substances.	I.	II.
	Per cent.	*Per cent.*
Water	22.80	22.29
Protein	11.71	6.85
Fiber	.....	6.73
Carbohydrates	62.05	60.32
Ash	3.44	3.81
Total	100.00	100.00

OUTPUT, EXPORTS, MARKETS, AND PRICES.

The quantity of kanten prepared in 1900 was 2,370,517 pounds, valued at 1,153,003 yen (or $576,500); and in 1901, 2,177,867 pounds, valued at 1,068,463 yen ($534,232). No later statistics of production are available, but judging from the exports of 1902, the output in that year was apparently larger than ever before, probably reaching 3,000,000 pounds, with a value of $750,000. The exports for a term of years and some detailed statistics of production are shown in the accompanying tables:

Kanten produced in Hyogo, Kyoto, and Nagano in the years 1897–1901.

Town and year.	Quantity.	Value.	Town and year.	Quantity (square pieces).	Value.	Town and year.	Quantity (slender kanten).	Value.
Hyogo (Muko district):	*Pounds.*		Hyogo (Kawabe district):	*Number.*		Hyogo (Kawabe district):	*Pounds.*	
1897	265,334	$60,115	1897	2,226,667	$7,345	1897	7,659	$1,436
1898	283,867	73,395	1898	2,213,334	7,331	1898	6,934	1,560
1899	294,667	85,965	1899	2,346,667	7,701	1899	12,200	3,431
1900	317,334	83,563	1900	2,466,667	9,300	1900	15,854	7,664
1901	312,000	68,450	1901	2,626,667	9,713	1901	16,800	7,805

Town and year.	Quantity.	Value.	Town and year.	Quantity.	Value.
Kyoto:	*Pounds.*		Nagano:	*Pounds.*	
1897	211,471	$32,080	1897	275,012	$60,770
1898	171,951	36,444	1898	291,307	71,358
1899	74,851	16,510	1899	276,891	67,249
1900	204,615	68,865	1900	331,480	95,305
1901	259,330	55,520	1901	356,305	124,106

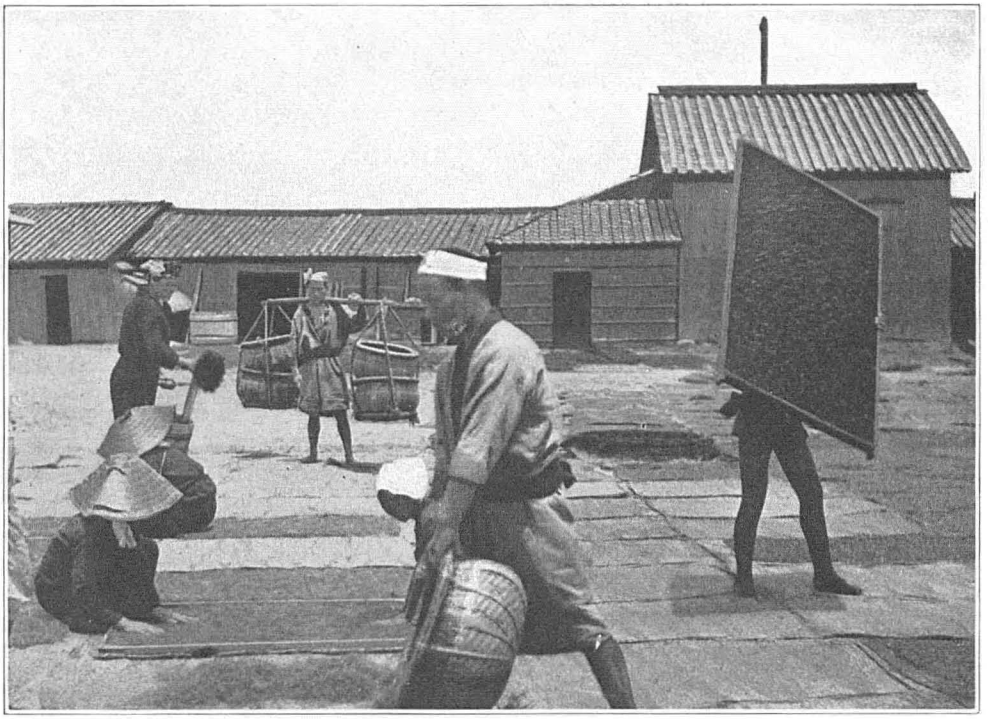
The importance of the kanten industry in Osaka is indicated by the following table, showing an output of over 1,190,000 pounds in 1901:

Statistics of kanten production in Osaka, 1897 to 1901, inclusive.

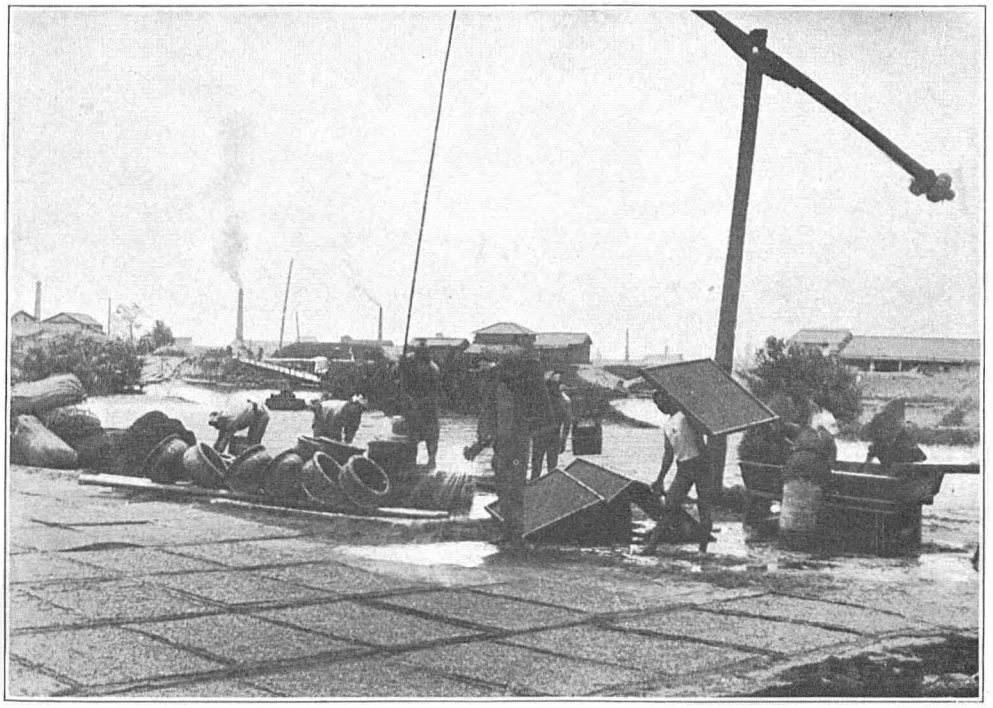
Year.	Slender kanten.	Square kanten.	Total.
	Kin.[a]	*Kin.*	*Kin.*
1897	765,000	160,125	925,125
1898	774,000	167,750	941,750
1899	810,000	172,500	982,500
1900	795,000	150,938	945,938
1901	758,800	134,550	893,350

[a] 1 kin=1.33 pounds.

The exports of kanten during the thirty-four years ending with 1902, as shown in the following table, were 37,196,466 kin (or 49,595,288 pounds), valued at 14,646,910 yen (or $7,323,455). The exports in 1902 were larger than ever before, amounting to 1,655,501 kin (or 2,207,335 pounds), valued at 1,108,544 yen (or $544,272). The average price per 100 kin increased from 29.80 yen (or $14.90) in 1869 to 76.80 yen (or $38.40) in 1901, and 66.60 yen (or $33.30) in 1902.



SPREADING THE WET SEAWEED ON MATS TO BLEACH AND DRY.



VIEW IN THE YARD OF A FUNORI FACTORY IN OSAKA.

THE MANUFACTURE OF FUNORI, OR SEAWEED GLUE.

Quantity and value of kanten exported.

Year.	Quantity.	Value.	Average value per 100 kin.
	Kin.	*Yen.*	*Yen.*
1869	221,771	66,263	29.9
1870	272,227	98,102	36.0
1871	283,606	108,387	38.2
1872	333,399	78,166	23.4
1873	364,286	102,920	28.3
1874	566,384	134,243	23.7
1875	776,364	201,655	26.0
1876	1,171,971	303,014	25.9
1877	1,120,494	245,761	21.9
1878	1,139,458	227,497	20.0
1879	1,169,825	269,867	23.1
1880	1,363,164	291,758	21.4
1881	1,302,461	333,048	25.6
1882	777,232	211,237	27.2
1883	946,606	242,405	25.6
1884	1,214,286	309,084	25.5
1885	1,300,802	345,719	26.6
1886	1,543,350	392,644	25.4
1887	1,538,064	337,879	22.0
1888	1,336,790	329,222	24.6
1889	1,147,713	270,511	23.6
1890	1,028,500	323,444	31.4
1891	1,300,237	453,124	34.8
1892	1,269,200	581,218	45.8
1893	1,452,725	682,140	47.0
1894	1,298,425	495,625	38.2
1895	1,118,775	449,271	40.2
1896	1,403,125	595,818	42.5
1897	1,326,900	591,057	44.5
1898	1,205,906	611,336	50.7
1899	1,207,275	674,435	55.9
1900	1,444,500	964,322	66.8
1901	1,585,144	1,217,195	76.8
1902	1,665,501	1,108,544	66.6
Total	37,196,466	13,646,911	.....

1 yen=50 cents.

As will be seen from the foregoing statistics, more kanten is exported than is consumed locally. Slender kanten is sent to China (Shanghai and Hongkong), British India, Australia, Germany, France, and Great Britain; small quantities have also been sold in the United States. The square kanten is exported only to Holland, with which country there has been a trade in this commodity for many years. The prices vary greatly, depending on quality of the product, the shape of the sticks, and the country in which sold. The best quality of square kanten brings as much as 55 or 60 cents a pound, and the best grade of slender kanten 40 cents a pound. The common qualities of the same articles are worth about 40 and 25 cents, respectively, per pound. Following is a detailed statement of the prices of the different grades of kanten in Osaka for a series of years:

Market prices of kanten per 100 kin.

Year.	Best quality.		Medium quality.		Common quality.	
	Slender.	Square.	Slender.	Square.	Slender.	Square.
	Yen.	*Yen.*	*Yen.*	*Yen.*	*Yen.*	*Yen.*
1897	55.0	115.0	48.0	98.0	43.0	85.0
1898	[a] 69.0 [b] 58.0	120.0	[a] 63.0 [b] 55.0	105.0	49.5	90.0
1899	[a] 80.0 [b] 68.0	128.0	[a] 73.0 [b] 63.0	115.0	57.0	100.0
1900	.....	138.0	[a] 86.0 [b] 80.0	125.0	74.5	110.0
1901	[a] 105.0 [b] 85.0	145.0	[a] 80.0 [b] 80.0	130.0	65.0	118.0

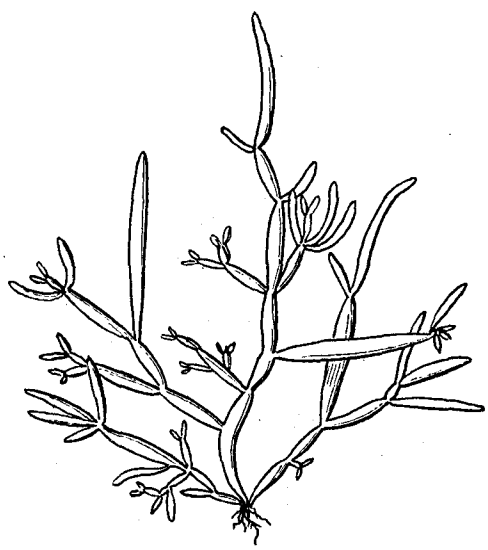
[a] For exportation to Europe. [b] For exportation to China.

FUNORI, OR SEAWEED GLUE.

NATURE AND GENERAL IMPORTANCE.

Funori is the name given to a kind of glue made from several species of algæ which also are called funori. The word means "material for stiffening fabrics," referring to the most common use of the substance.

The principal funori alga is *Gloiopeltis coliformis*, but *G. intricata* (known as *fukuro-funori*) is probably just as satisfactory. There are, however, various other succulent algæ, belonging to other genera, employed for this purpose, which do not yield so valuable a product as the funori algæ proper. *Gloiopeltis* grows on rocks on all parts of the Japanese coast, but chiefly on the outer (or Pacific) shores of the warmer parts of the Empire. It is gathered at all seasons—in winter in some places, in summer in others—being taken from the rocks by long-handled hooks.



"Funori" (*Gloiopeltis coliformis*).

According to Doctor Kishinouye, there is a limited cultivation of *Gloiopeltis coliformis* in the prefecture of Aomori. The method is quite primitive, consisting simply of throwing stones into the sea to afford a surface for the attachment and growth of the spores. As the stones of the mountains have rough, clean surfaces, they are preferred to others.

While the manufacture of funori is less extensive than that of kanten or kombu, it is nevertheless quite important, being carried on in over 100 establishments, each employing from 15 to 20 persons, located in about 30 different prefectures, the most northern being Hokkaido and the most southern Kagoshima. The industry flourishes most in southern Japan, and Osaka is the principal center. Funori has been made in Japan since about the year 1673.

THE PREPARATION AND APPLICATIONS OF FUNORI.

The process of converting the raw seaweed into the marketable product is much simpler than in the case of kanten or kombu. The dried algæ, as received from the fishermen, are first sorted and cleaned, and then soaked in fresh water, after which they are usually placed in thin layers on large shallow trays with reed or bamboo bottom, and tightly packed by hand so as to form a loose sheet. The sheets are then turned out on pieces of matting by inverting the trays, and are left to bleach and dry. Sometimes, however, the sheets are made directly on the mats without the use of trays. A tendency to curl in drying is overcome by sprinkling with a watering pot or a wet broom. When bleaching has proceeded as far as desirable, the drying is completed and the funori sheets are gathered in bundles of various sizes. The sheets are loose meshed, thin, flexible, and of quite uniform thickness. The usual

SPRINKLING THE SHEETS TO PREVENT CURLING.

GATHERING THE DRIED SHEETS FOR BALING AND SHIPMENT.

THE MANUFACTURE OF FUNORI, OR SEAWEED GLUE.

size is about 5 by 3 feet, but smaller sheets in neat packages are prepared for the retail trade. A favorite form of package for the wholesale trade is a roll 3 feet high and 6 or 7 inches in diameter, like Japanese matting.

Funori is readily converted into a glue or paste by immersion in boiling fresh water, and in that form is extensively used in Japan, and small quantities are exported. The principal objects for which it is employed are the glazing and stiffening of fabrics, its most common use being as a starch for clothing. Other uses are the stiffening and coating of papers, the cementing of walls and tiles, the stiffening

A roll of funori (about one-eighth natural size).

of threads, and the decorating of porcelain. The funori sent to Europe is for sizing textiles. Japanese women sometimes clean their hair with a thin solution, although the rationale of the operation is not evident.

PRICES AND OUTPUT.

The price of funori varies with the quality. The purest grade sold (in 1903) for 40 yen per 10 kwan, wholesale, or at the rate of 24 cents a pound; the medium quality brought 18 yen per 10 kwan (11 cents a pound), and the poorest grades, made from substitutes for *Gloiopeltis*, were worth only 5 or 6 yen per 10 kwan (3 to 3.6 cents a pound). The production during recent years has been from 2 to 3 million pounds annually; in 1901 it was 2,943,000 pounds. The following table shows the amount and value of the output between 1897 and 1901:

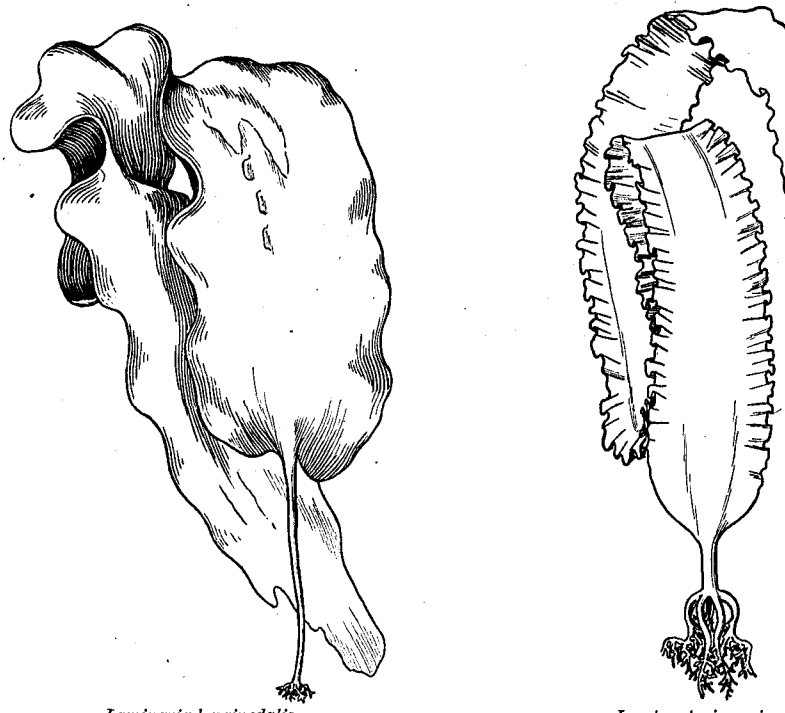
Year.	Quantity.	Value.
	Pounds.	
1897	1,429,111	$53,857
1898	987,862	41,478
1899	2,799,253	145,326
1900	2,135,677	77,033
1901	2,943,383	130,809

The exportation of funori is a small business, the shipments at the present time being valued at only $1,500, although they have at times reached $3,300. The countries supplied are Korea, China, Asiatic Russia, Russia, England, and France.

KOMBU.

NATURE AND GENERAL IMPORTANCE.

Under the name of *kombu* the Japanese recognize various kinds of food made from kelps. This is one of the most important of the marine vegetable preparations, the annual sales in Japan and China being enormous and steadily increasing, especially in China. Some of the products have occasionally been sent to the East Indies and San Francisco; but the sales in America are reported to have been small, and it



Laminaria longipedalis. *Laminaria japonica.*

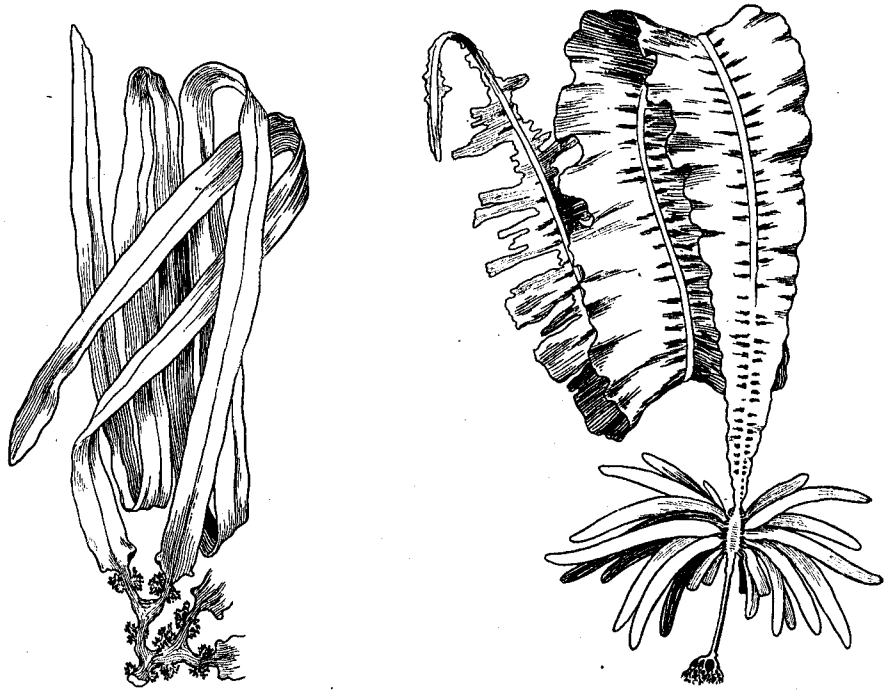
Kelps used in preparing kombu.

may be said that kombu is as yet unknown outside of Asia. Although not so valuable as kanten, it is really more important to the country, because of its comparative cheapness and the numerous ways in which it is used for food; furthermore, the gathering of kelp gives employment to more people than does the gathering of *Gelidium*, and the value of the raw products exceeds that of any other kind of seaweed.

The manufacture of kombu dates back to about 1730. The present methods are very primitive, and differ but little from those of the eighteenth century. The principal centers are Osaka, Tokyo, and Hakodate, the leading place being Osaka, where in 1903 there were 45 small factories, each employing from 10 to 30 men, women, and children.

THE RAW PRODUCTS.

The seaweeds used in the manufacture of kombu are coarse, broad-fronded members of the kelp family (Laminariaceæ), and are obtained almost entirely from Hokkaido, the most northern of the main islands of the Japanese archipelago. The kelps grow in abundance on all parts of that coast, but those of best quality—that is, with the widest and thickest fronds—are obtained from the northeastern coast, within the influence of the Arctic current. Those most used are of the numerically large genus *Laminaria*, and include the species *japonica*, *religiosa*, *angustata*, *longissima*, *ochotensis*, *yezoensis*, *fragilis*, *diabolica*, *gyrata*, and several others recently described by Professors Miyabé and Oshima. Other kelps which are utilized in kombu manufacture are *Arthrothamnus bifidus* and *kurilensis*, *Alaria fistulosa*, and various other species of *Alaria*.



Arthrothamnus bifidus. *Alaria crassifolia.*

Kelps used in preparing kombu.

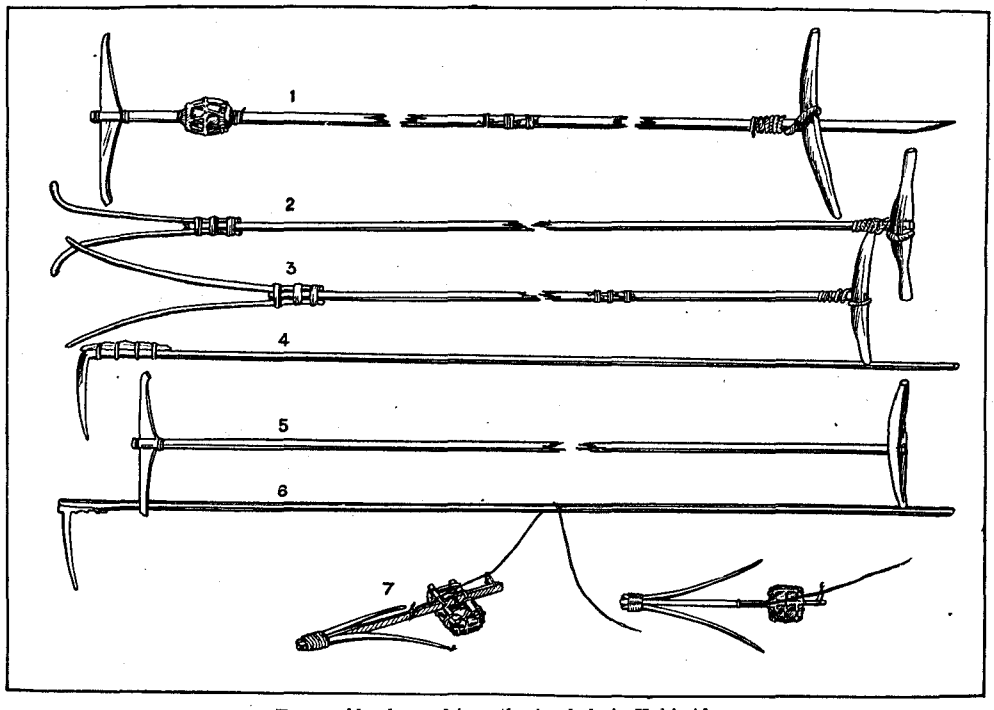
The gathering of kelp begins in July and ends in October, and is engaged in by many fishermen, among whom may be found some Ainus, the peculiar aboriginal inhabitants of Japan now confined to Hokkaido. The fishermen go to the kelp grounds in open boats, each boat with one to three men and a complement of hooks with which the kelp is torn or twisted from its strong attachment on the rocky bottom. The hooks are of various patterns; some are attached to long wooden handles, and some are weighted and dragged on the bottom by means of ropes while the boats are under way.

When the boats return to shore the kelp is carefully spread on the beaches in the vicinity of the villages and there left until thoroughly dried. The curing

accomplished, the plants are taken indoors and prepared for shipment. The stem is cut off, and at the same time the basal end of the frond is neatly trimmed. Plants of the same size and quality are tied together into long flat bundles of rather uniform size, and these bundles are sent by water to the kombu manufacturers.

KOMBU PREPARATIONS.

The forms in which kombu is made ready for consumption number a dozen or more, and illustrate the ingenuity of the Japanese in providing a varied regimen from a single article. Some of the preparations are not pleasing to the taste of



Forms of hooks used in gathering kelp in Hokkaido.

the average foreigner, but others are highly palatable and ought to prove very acceptable to Americans and Europeans.

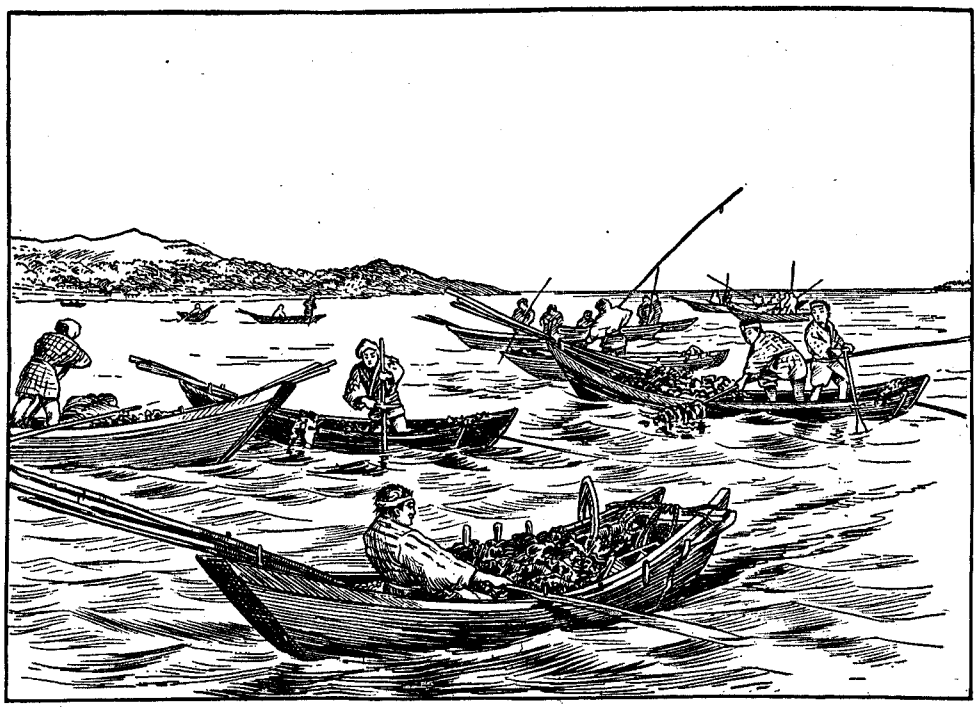
Shredded or sliced (kizami) or green-dyed (ao) kombu.—This is one of the most important preparations of kombu, being largely consumed at home and also extensively exported. The steps in the manufacture are as follows:

(1) The dried kelp, as received in bundles from the Hokkaido fishermen, is immersed in large, covered, stationary iron kettles or vats containing a strong solution of a dye in fresh water. A wood fire is kept under the kettles, and the solution is maintained at a boiling temperature, the kelp being left therein for fifteen to twenty minutes and stirred from time to time. The dyeing imparts a uniform color to the prepared product as placed on the market, and thus serves the same purpose as the dyeing of canned French peas. Formerly a copper salt (carbonate or

sulphate) was employed, but the use of copper in this way has recently been prohibited by the government, and an aniline dye (malachite green) is now employed, although the latter is regarded with less favor by the manufacturers. The kelp is thoroughly cooked, and is saturated with the dye, which remains insoluble.

(2) The dyed fronds are drained and then taken into the open air, where they are either spread on straw mats or suspended on poles to dry. In order to economize space, a tier of horizontal poles covered with kelp may be placed between two upright poles, and in the yards of many of the kombu works the lines of freshly dyed kelp may be seen high in the air.

(3) When the drying has proceeded to a point where the surface of the kelp is



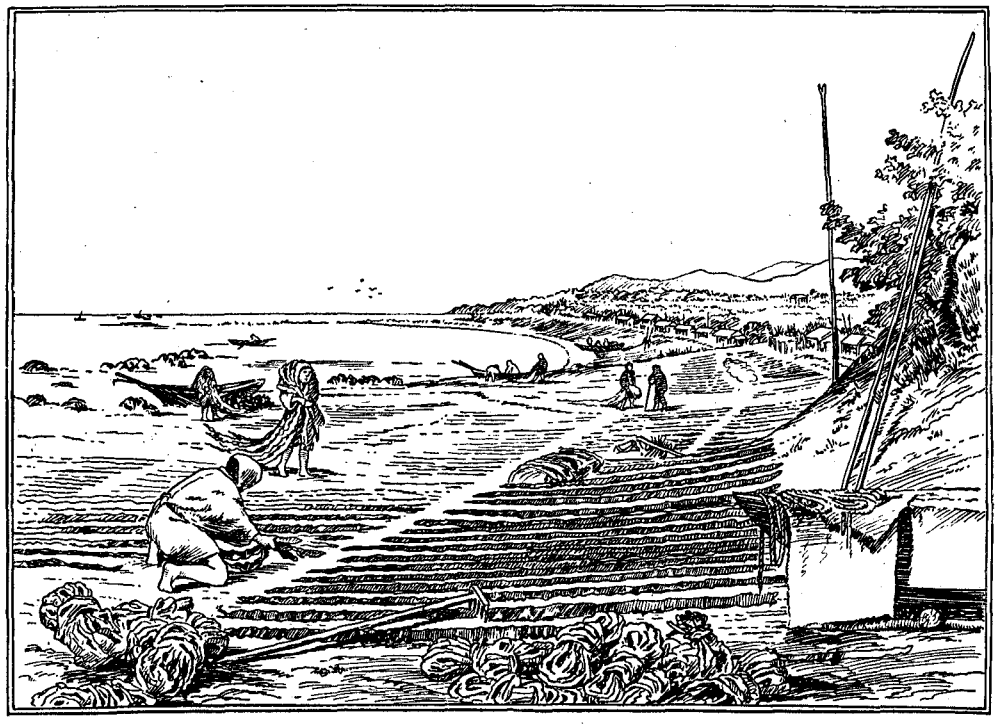
Kelp fishermen of Hokkaido.

no longer wet, the fronds, taken one at a time and carefully spread, are rolled into wheel-shaped masses about 1 foot in diameter, in order to facilitate subsequent handling. The rolls are tied by ropes to keep them in shape, and then go to women, who unroll the fronds one by one and arrange them flat in wooden frames, making a pile 1½ feet high, 5 or 6 inches wide, and the full length of the fronds. Each pile is then tightly compressed by four transverse cords, and cut by means of a knife into four equal lengths, each held by a cord.

(4) The cut pieces are then arranged by hand in a rectangular frame 4 to 5 feet square, its thickness corresponding to the length of the sections of seaweed. When the frame is filled by the evenly arranged pieces, which are sprinkled with water in order that they may pack more closely, the whole mass is highly compressed by

means of ropes, wedges, and levers. One of the side boards forming the frame is then removed, the frame is supported at a convenient height and tilted at a convenient angle, and the kelp is reduced to shreds by means of a hand plane, which cuts the fronds lengthwise along their edge. A factory has from 5 to 10 cutters, each with a separate press, and each using his plane in what to us seems an awkward manner—that is, he cuts by drawing the plane toward himself rather than by pushing it from him. Formerly the cutting was done with a knife held in the hand. The substitution of a plane, by which shreds of more uniform thickness are obtained and the work done more expeditiously, is practically the only improvement in method in nearly two centuries.

(5) The shredded kelp is spread on mats or on board platforms in the open air,

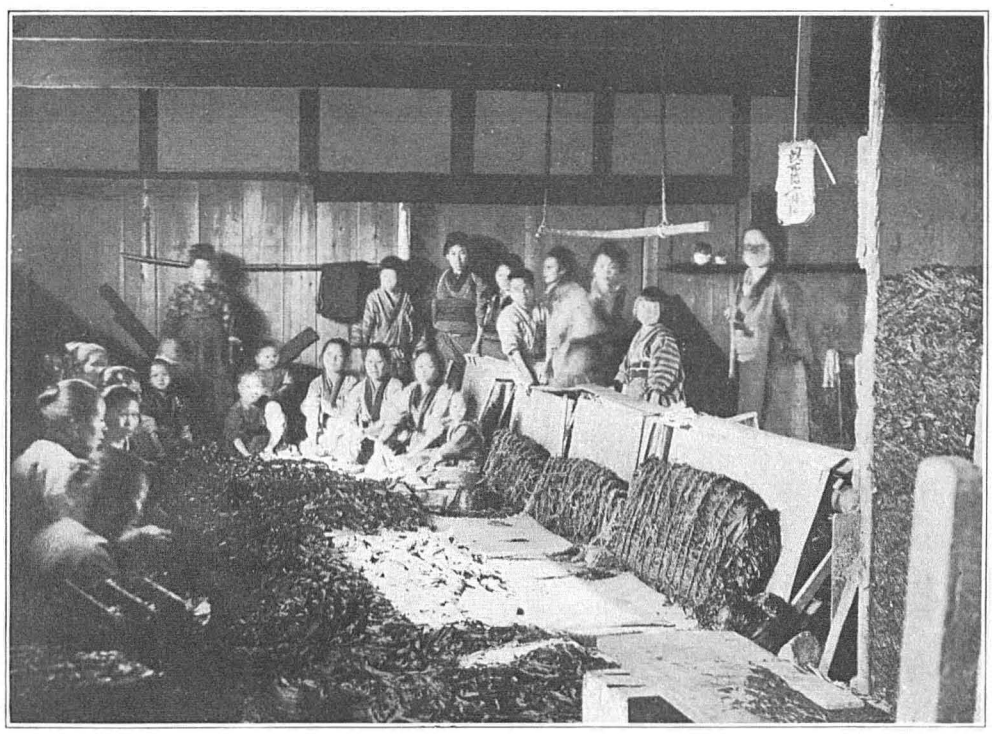


Drying kelp on the beach in Hokkaido.

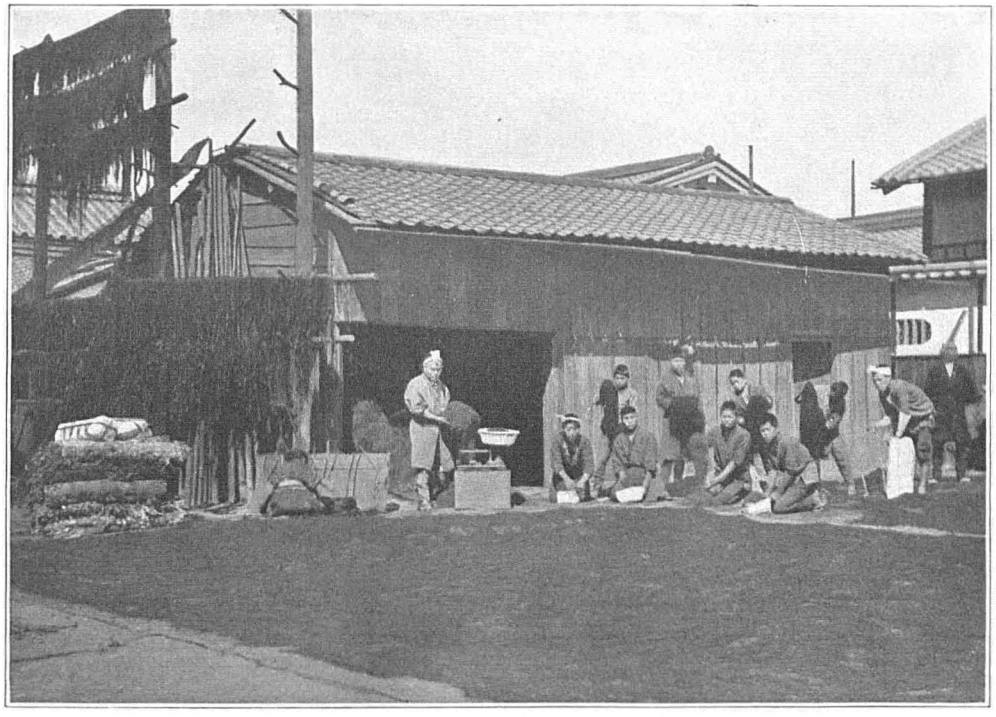
and repeatedly turned to secure uniform drying. When the surface has become dry, but the interior still retains its moisture as shown by the pliability of the shreds, the shavings are stored under cover and are ready for packing and shipment.

The completed product resembles in color, shape, and feel the "Spanish moss" which festoons the trees in the Southern States. For local use it is put in paper packages, for export to China in wooden boxes. If dry it will keep for a year or longer without deterioration.

Other kombu preparations.—Those species of kelp with the thickest and widest fronds are often dried with special care, so that they will lie flat and smooth, and are used in making kombu products for which the thin, narrow-fronded species are not well adapted. The different kinds of kombu now to be mentioned have been



WOMEN ENGAGED IN SORTING THE CRUDE KELP.

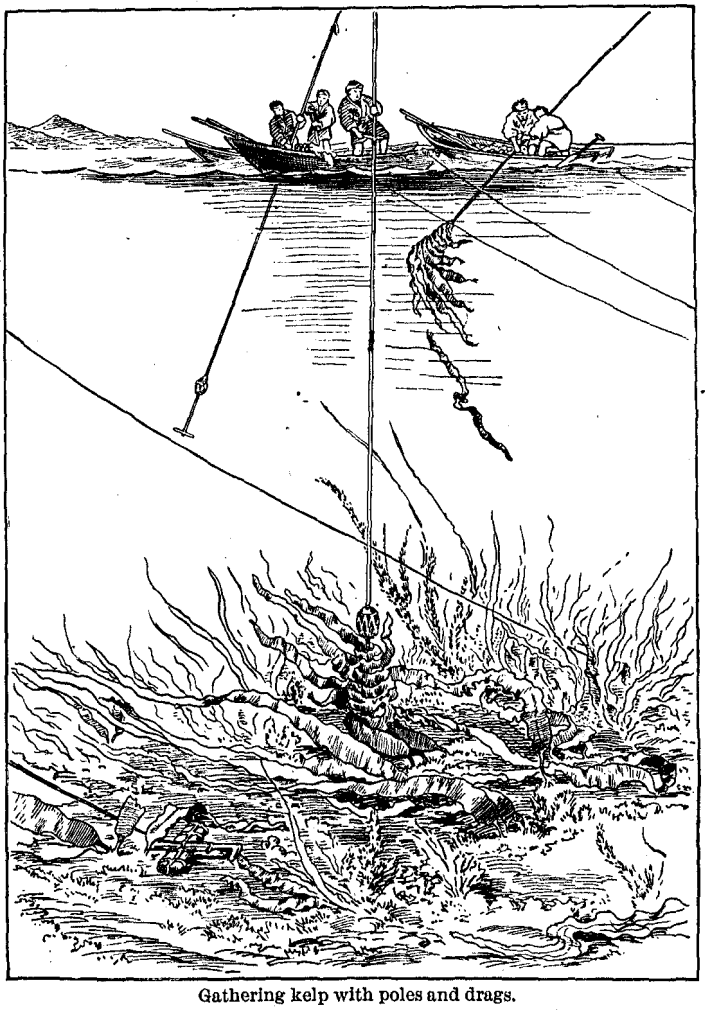


DYED KELP DRYING ON POLES; SHREDDED KOMBU DRYING ON MATS AND READY FOR BALING.

VIEWS AT AN OSAKA KOMBU FACTORY.

made for nearly two centuries, and the consumption at the present time is larger than ever before. The various grades, as will be seen, represent simply successive steps in the treatment of the kelp, one frond yielding a sample of each variety of kombu.

(*a*) The entire frond is dipped in vinegar until thoroughly soaked, then drained and dried in the open air. The vinegar used is of Japanese make and of the best quality, and is diluted with a very little water. The vinegar softens the frond and



Gathering kelp with poles and drags.

leaves it pliable; it also imparts a flavor and doubtless has a slight preserving effect. Its chief supposed or intended action, however, is to permit the special treatment which will be described. Fresh water would have the same softening effect, but would spoil the seaweed for the purpose in view.

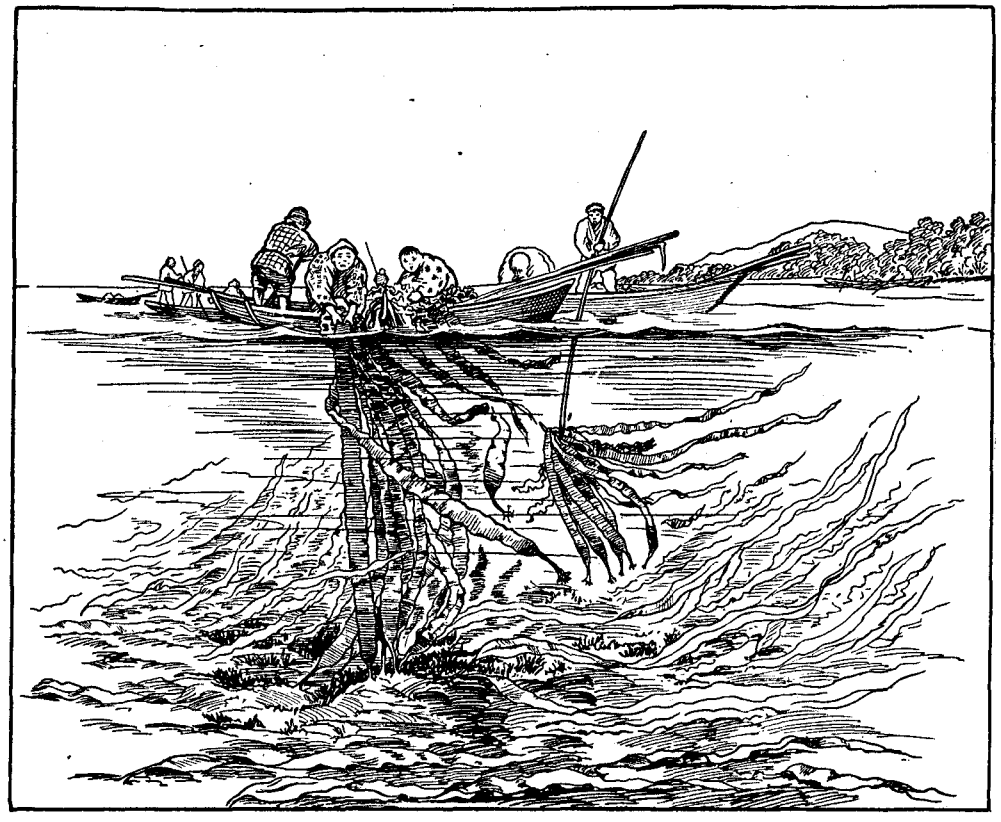
(*b*) With a raw-edged knife shaped like a mince-meat chopper, the Japanese artisan, holding the broad frond taut with hand and foot, scrapes the epidermis from both sides. This outer skin, which comes away in shreds, is the cheapest grade of

kombu, containing more or less grit or dirt. A second scraping brings away all of the remaining green covering, and leaves only the thick white core of the frond. This product is called *kuro-tororo* (black pulpy) kombu.

(*c*) The scraping is continued with a raw-edged knife, and a fine, white, stringy mass results, which is known as *shiro-tororo* (white pulpy) kombu.

(*d*) A sharp-edged knife may be used after the green coats are removed, and the scrapings then take the form of exceedingly thin and delicate filmy sheets of irregular sizes; this preparation is named *oboro* (filmy) kombu.

(*e*) The remaining central band of the frond, now very thin and no longer



Gathering kelp.

workable in this way, is pressed into bundles with similar pieces, divided into equal lengths, and with a plane cut edgewise into shreds after the manner of the green-dyed kombu. The shavings resemble coarse hair, and the preparation has received a name (*shirago kombu*) which means white-hair kombu.

(*f*) Fronds from which the outer green skin has been more or less completely scraped are often cut into small pieces of various shape—strips, squares, oblongs, circles, fans, etc.—which are then dried over a fire and made crisp; the long strips are frequently tied into peculiar loose knots. These pieces are placed on the market in this form, when they are known as *hoiro* (dried-on-the-fire) kombu; or they are coated with a hard white or pink icing and called *kwashi* (sweet-cake) kombu.

(*g*) The dried pieces just mentioned are sometimes pulverized and put through a fine wire sieve like a flour sieve, yielding a slightly greenish or grayish flour. A white and still finer powder is made from the deeper layers of the frond. The powdered preparations are named *saimatsu* (finely powdered) kombu. Such powders are sometimes compressed into small cakes of various shapes and coated with sugar.

(*h*) A form of kombu known as *cha* (tea) kombu is prepared by taking fronds which have been subjected to the first scraping process, reducing them to shreds in the usual way by planing and, after drying, cutting the shreds into half-inch lengths comparable to the rolled leaves of green tea.

FOOD QUALITIES OF KOMBU.

Kombu enters into the dietary of every Japanese family, and is one of the standard foods of the country, the various preparations having different flavors and being used for different purposes. The green-dyed and shredded kombu is cooked with meats, soups, etc., and is also served as a vegetable. Strips of the dried untreated fronds are cooked with soups, fish, and vegetables, for the purpose of imparting a flavor. Fronds after being scraped once are cut in ¾-inch squares and boiled in soy-bean sauce, which treatment preserves them for a long time, and these pieces make an excellent relish, tasting like caviare or anchovy sauce. The Japanese name, *tsukudani*, means "boiled with soy-bean sauce." The tea kombu and the green and white powdered kombu are used as tea, boiling water being poured on a small quantity of the preparation and a palatable drink resulting. In Osaka the pulpy or pasty residue is eaten. The powders are also used in sauces, in soups, and on rice, like curry powder. These are put on the market in bottles or tins holding about one-quarter of a pound.

The kombu cut into small pieces and dried is very palatable, whether eaten dry or after immersion in hot water, having a nutty flavor. The crisp, sugared strips are excellent. Filmy sheet kombu is cooked with sauces, soups, and other dishes, like the dried, untreated strips, to impart flavor.

The chemical composition of various species of seaweed used in the manufacture of kombu is shown in the following table. The specimens were collected in the Sea of Hokkaido, and the analyses were made by Prof. K. Oshima, of the Agricultural College of Sapporo. The figures are calculated for 100 parts of original samples of kombu:

Species.	Water.	Protein.	Fat.	Soluble non-nitrogenous matter.	Fiber.	Ash.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Laminaria angustata	22.823	5.491	1.520	47.031	4.549	18.686
longissima	25.944	6.724	1.730	31.896	6.415	27.290
japonica	22.968	4.959	1.590	47.493	5.834	17.156
ochotensis	23.986	6.646	.860	41.924	6.026	20.308
religiosa	22.754	4.722	.820	42.845	10.196	18.633
fragilis	23.100	4.027	.654	40.385	7.152	24.662
Arthrothamnus bifidus	24.443	5.822	.738	45.572	6.437	16.988

OUTPUT AND PRICES OF KOMBU.

Official figures are available showing the quantity and value of the kelp gathered, dried, and sold by the fishermen during recent years. In 1901 the output was over 76,000,000 pounds, for which the fishermen received $464,000.

Year.	Pounds.	Value.
1901	76,806,975	$464,082
1900	53,750,650	301,389
1899	58,929,983	417,332

There appear to be no statistics of the quantity and value of prepared kombu put on the maket, but the addition of 60 to 75 per cent to the cost of the raw materials would doubtless approximate the value of the manufactured article.

In Osaka the output of green-dyed kombu in 1902 was as follows: For home consumption, 4,728,640 pounds; for export to China, 7,092,960 pounds; total, 11,821,600 pounds, valued at $132,968. The operations of one Osaka manufacturer in 1902 are represented by raw materials used, 9,900 bushels, costing $4,950; green-dyed kombu made, 600,000 pounds, valued at $8,550.

Following are the average wholesale prices of the various kinds of kombu in Osaka in 1903: Green-dyed kombu, good quality, 5 yen per 100 kin (133 pounds); black pulpy kombu, from 0.35 yen for cheapest to 0.70 yen for best per kamme (8.28 pounds); white pulpy kombu, from 0.80 yen for cheapest to 1.10 yen for best per kamme; white hair kombu, from 0.50 yen for cheapest to 0.80 yen for best per kamme; finely powdered kombu, 2 yen per kamme; filmy kombu, from 0.60 yen for cheapest to 1.30 yen for best per kamme; tea kombu, 1.20 yen per kamme; kombu chips (dried on fire), from 1.80 yen to 2.40 yen per kamme; sweet cake kombu, from 1.50 yen to 1.80 yen per kamme; kombu chips in soy sauce, 1.10 yen per kamme. The powdered kombu sells at wholesale for 0.08 yen per quarter-pound tins, and 0.10 yen for quarter-pound bottles.

A very large part of the supply of green-dyed kombu is exported to China. Official figures of the quantity and value of the exports for the eleven years ending in 1902 are here given. It appears that in 1901 the foreign trade was larger than in any previous year, the shipments exceeding 81,000,000 pounds.

Year.	Pounds.	Value.	Year.	Pounds.	Value.
1892	57,615,465	$497,313	1898	53,031,761	$355,646
1893	52,871,341	469,710	1899	61,596,594	473,041
1894	55,800,505	303,514	1900	48,054,681	441,864
1895	59,773,348	315,146	1901	81,212,970	774,164
1896	46,593,772	304,792	1902	52,491,166	404,744
1897	60,153,405	415,732			

AMANORI OR LAVER.

THE SEAWEEDS AND THEIR CULTIVATION.

The Japanese have from a very early period made use of the red laver (*Porphyra*), formerly a popular food in the British Isles and sparingly eaten in the United States. The Japanese species is similar to or identical with that found in Europe and America (*Porphyra laciniata* or *vulgaris*), and grows abundantly in bays and near river mouths on all parts of the coast, but the supply is obtained almost exclusively from cultivated grounds. The local name for the seaweed is

"Amanori" or laver (*Porphyra laciniata*).

amanori, while the prepared product is called *asakusanori*. The following description of the species has been given:

Fronds livid purple, gelatinous, but firm, membranaceous, composed of a single layer of brownish-red cells; fronds 3 inches to 1½ feet long, persistent throughout the year, at first linear, but becoming widely expanded and finally much lobed and laciniate; antheridia and spores forming a marginal zone, usually borne on different individuals, or when borne on the same individual not mixed, but on separate portions of the frond. Found in all parts of the world; abounds on rather smooth stones and pebbles, near low-water mark, and when the tide falls covers them with slimy films, which make walking over them difficult. (FARLOW.)

The cultivation of *Porphyra* is one of the most important branches of the seaweed industry, and gives to Japan a unique position, for, so far as known to the writer, in no other country is this form of aquiculture practiced. The financial results are quite remarkable, and are surpassed by but few branches of agriculture, comparing the average yield per acre.

The date of the beginning of seaweed culture has not been determined, but the business is known to be very old and probably began in Tokyo Bay, which has long

had the most celebrated cultivated grounds. The next important point is Hiroshima, on the Inland Sea. The Japanese government collects very accurate statistics of this industry, and has furnished the accompanying data showing the area of the laver

Preparing brush for laver cultivation.

farms, the annual crop, etc. In 1901, the grounds under cultivation had an area of 2,242 acres, and the output was valued at $239,536, representing about 4,769,000 pounds of dried seaweed.

Porphyra cultivation in 1901.

Prefecture.	Grounds.		Yield.	
	Number.	Area (tsubo).[a]	Quantity (kamme)[b].	Value (yen).
Tokyo	[c]3,493	1,151,314	37,478	297,723
Kanagaw	1	7,120	98	345
Aichi	12	221,800	30,250	15,527
Iwate	14	185,743	7,715	7,465
Hiroshima	846	589,627	[d]376,700	126,015
Yamaguchi	6	147,800	8,154	4,515
Wakayama	2	43,027	105,000	16,800
Ehime	2	600	350	160
Fukuoka	7	147,800	485	1,996
Oita	2	3,600	[e]78,820	394
Kumamoto	2	74,000	5,949	7,019
Kagoshima	8	140,000	890	1,113
Total	4,395	2,712,431	.....	479,072

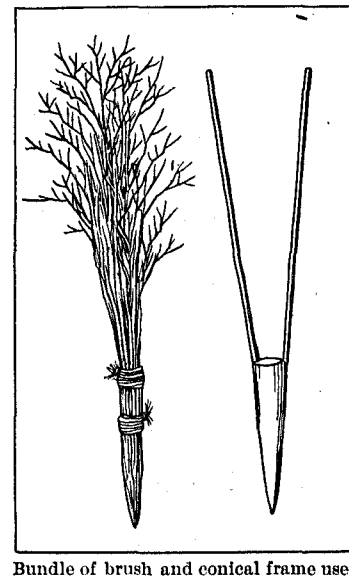
[a] A tsubo=4 square yards. [b] A kamme=8.28 pounds. [c] Number of families of fishermen.
[d] Fresh plants. [e] Number of sheets of prepared *Porphyra*.

The following more detailed statistics show the extent of this industry in the Tokyo region during three years. In 1901 the area of the planted grounds was 951.5 acres, and the value of the crop was $148,862, or about $156 per acre. It is reported that in 1903 the yield was valued at 600,000 yen ($300,000).

Porphyra cultivation in Tokyo Bay.

Year and district.	Families of fishermen.	Area of grounds.	Crop.	
			Quantity.	Value.
1899.		*Tsubo.*	*Kamme.*	*Yen.*
Shiba	160		1,010	6,600
Fukagawa	161		6,602	39,918
Kyobashi	5		5	62
Ebara	2,063		15,717	98,500
Minami Katsushika	837		10,467	104,662
Nishitama	1		16	2,000
Total	3,227		33,817	249,942
1900.				
Shiba	153	113,850	6,670	50,100
Fukagawa	161	223,500	2,986	29,860
Kyobashi	9	10,000	40	620
Ebara	3,028	771,047	17,696	136,798
Minami Katsushika	837	93,999	5,382	33,641
Total	3,188	1,212,396	32,776	251,019
1901.				
Shiba	99	127,800	4,360	26,700
Fukagawa	476	123,083	4,479	31,432
Kyobashi	6	15,900	810	7,482
Ebara	2,030	781,965	12,336	107,940
Minami Katsushika	883	102,566	15,489	123,809
Total	3,493	1,151,314	37,474	297,723

In October and November (in Tokyo Bay) the grounds are prepared for the seaweed crop by sinking into the muddy bottom, in water up to 10 or 15 feet deep at high tide, numerous bundles of bamboo or brush. These bundles are prepared on shore and taken to the grounds in boats at low tide, one or two men constituting a boat's crew. The bundles of brush are planted in regular lines, deep holes being made for them by means of an elongated conical wooden frame with two long, upright handles, which is forced into the mud by the weight of the fisherman.



Bundle of brush and conical frame used in planting brush on soft bottom.

The object of these lines of brush is to intercept and afford a lodgment for the floating spores of *Porphyra*. The spores become attached to the twigs and grow rapidly, so that by the following January the plants have attained full size and are harvested from January to March, being cut from the brush as they grow. They die about the time of the vernal equinox, and the active business is at a standstill until the ensuing fall. During summer, however, the old brush is removed from the grounds, and fresh material is collected and prepared.

The best grounds for growing *Porphyra* are in great demand, and the fishermen are often in conflict over them. The local

Planting bundles of brush on which laver is to grow.

governments lease the planting privileges. In Tokyo, where five classes of licenses are issued, depending on the yield of the grounds, the license tax is from 0.20 to 0.70 yen.

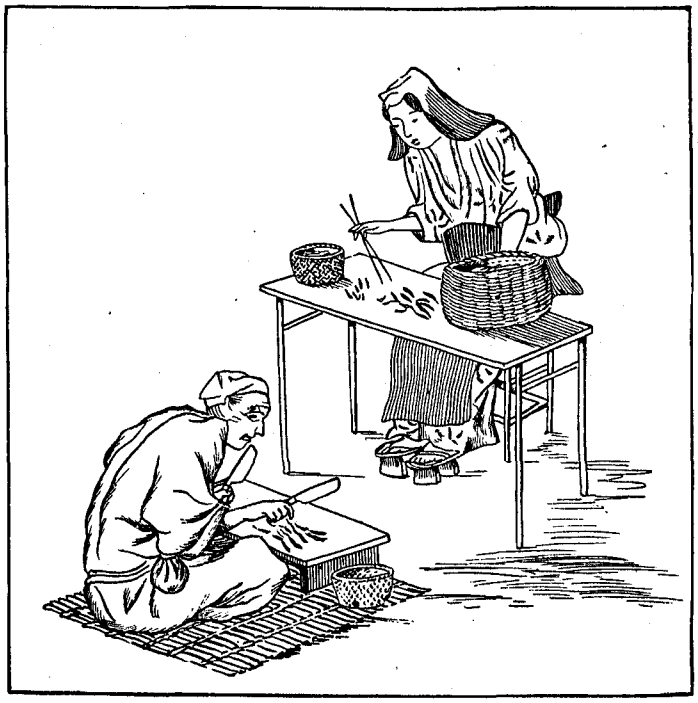
It is reported that the quality of the cultivated *Porphyra* depends very much on the weather, and is best when frequent rains and falls of snow have rendered the shallow water more or less brackish. Too large a proportion of sweet water is unfavorable to the growth of the plant. A century or two ago amanori was gathered in large quantities at the mouth of the Sumidagawa, near Asakusa in Tokyo; but as the river carried down with it a large quantity of gravel, its mouth advanced more and more into the sea, and, the water near Asakusa becoming too fresh, the plant disappeared. Owing to this circumstance, the above-described mode of cultivation was instituted. The plant has, however, preserved its former name of *Asakusa-nori*.

Washing laver prior to sorting and cutting.

PREPARATION AND UTILIZATION OF PORPHYRA.

While small quantities of amanori are eaten fresh, most of the crop is sun-dried before reaching the consumer. When gathered from the twigs, the seaweeds contain sand, mud, and other foreign substances, to remove which they are washed in tanks or barrels of fresh water. After being picked and sorted they are chopped fine with hand knives. The chopped fronds are then spread on small mats of fine bamboo splints and made into thin sheets, a uniform size being attained by means of a frame applied to the mats. The mats are first placed

in piles and later spread on inclined frames in the open air. Drying proceeds quickly, and when completed the sheets are stripped from the mats and, after pressing to make them flat, are arranged for market in bundles of ten. The sheets are about 10 by 14 inches, thin and flexible like writing paper, and have a dark mottled brownish-purple color and a glossy surface.



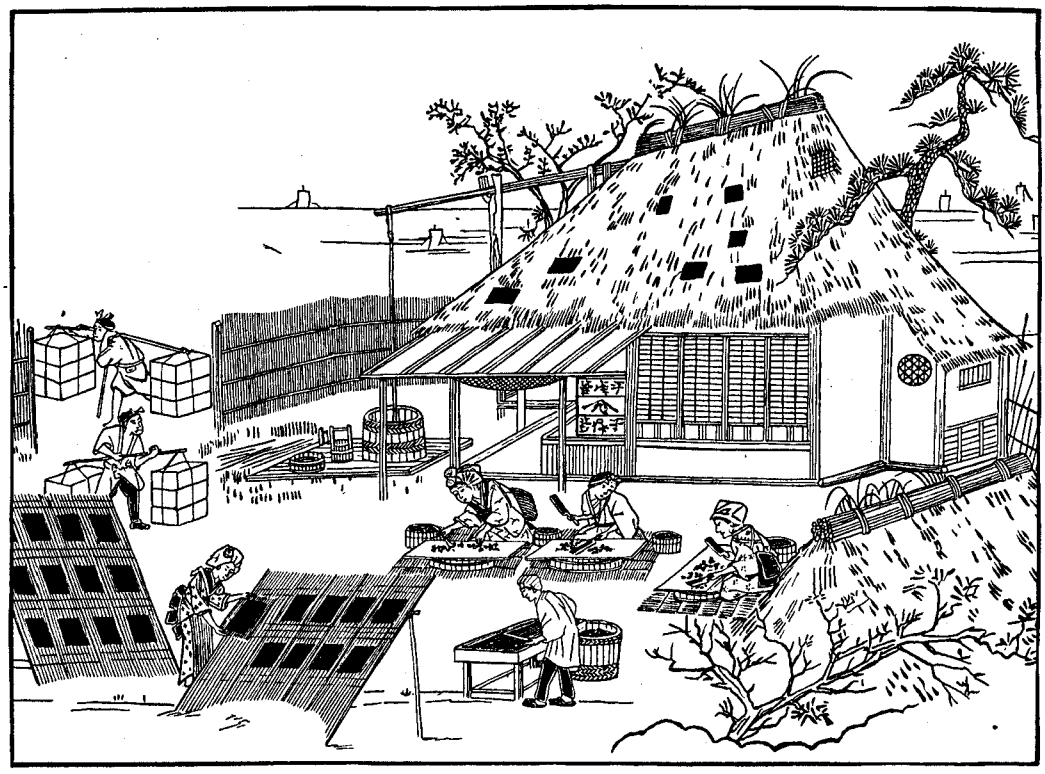
Sorting and cutting laver.

Before the dried *Porphyra* is eaten it is put over a fire to make it crisp, its color changing to green under this treatment. It is then crushed between the hands and dropped into sauces, soups, or broths to impart flavor. Pieces dipped in sauce are also eaten alone and there are various other culinary uses of this article, which is found in every Japanese kitchen. Recently it has been boiled with Japanese (soy bean) sauce and put up in tins. At railway stations, at street stands, and in the push carts of vendors, as well as in private families, a common seaweed food article in all parts of Japan takes the place of a sandwich in America, and is called *sushi*. On a sheet of amanori boiled rice is spread, and on the rice strips of meat or fish are placed; the whole is then made into a roll and cut into transverse slices. From the following analyses furnished by the Imperial Fisheries Bureau it appears that amanori is rich in proteid matter and is a nutritious food:

Preparing laver sheets.

Composition of Porphyra.

Locality.	Weight of 10 sheets.	Water.	Protein.	Fat.	Ash.
	Grams.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Suna	41	14.575	32.444	0.700	9.000
Do	37	16.395	35.625	.500	9.340
Fukagawa	32	20.415	36.263	1.210	8.830
Shinagawa	30	15.475	34.350	.650	10.685



The preparation of *Porphyra*. From a Japanese print.

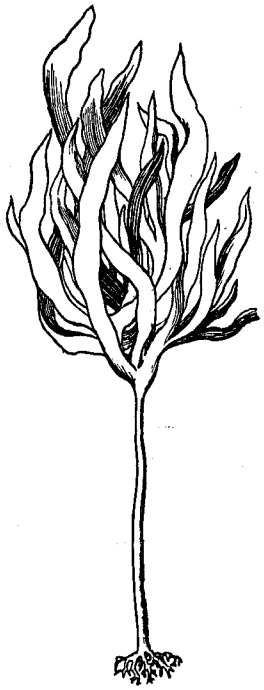
SEAWEED IODINE.

GENERAL INFORMATION.

Although the manufacture of iodine from seaweeds is of comparatively recent origin in Japan, that country now supplies a considerable part of this commodity used in the world, supplanting Scotland, which formerly produced most of the iodine extracted from marine plants. Up to ten years ago the business was very profitable, but, owing in part to competition and in part, perhaps, to a scarcity of suitable raw material, it has become less remunerative.

The chief localities for the manufacture of iodine are in Hokkaido and the prefectures of Chiba, Kanagawa, Yamaguchi, and Shizuoka. No general statistics are available, and it is not known how extensive the business now is, but the following extract from the Yokohama Shimpo gives some idea of its importance (1903):

Although the manufacture of iodine in Japan can not as yet be said to be carried on extensively, yet it is a matter for congratulation that it has been so far advanced as to put a complete stop to the importation of the foreign article, and the manufacturers in all parts of the country are making pretty good profits out of the business. The general tendency is that, with the increase of demand for the chemical, the business would become one of the most important industries in the Empire. In the case of Kanagawa prefecture, Mr. Sudzuki, of Hayama, near Yokohama, started the manufacture of iodine



"Kajime" (*Ecklonia cava*).

"Arame" (*Ecklonia bicyclis*).

at that place a few years ago with a small capital. The business has now proved so successful that he has enlarged the business to such an extent as to enable him not only to meet the demand at home but also to export some of the product to foreign countries. Probably this is now the largest factory of the kind in Japan. It is said that, as a result of careful investigations, he has now discovered that the residue left after extracting iodine from seaweed can be used as material for making nitrate of soda and chloride of sodium, and that he at present turns out some 12,000 yen worth of the latter article in a year. The difficulty, however, seems to be that it is no easy work to collect such a quantity of seaweed as is required in the manufacture.

THE ALGÆ UTILIZED.

Iodine exists in many species of marine algæ, and in Japan is obtained from about ten species, representing three or four genera. In Hokkaido only "kombu" (kelp) of various kinds is used, but in other sections the seaweeds in greatest favor

are "kajime" (*Ecklonia cava*), "arame" (*Ecklonia bicyclis*), and "ginbaso" (*Sargassum*). The following table, based on the analyses of the Imperial Fisheries Bureau, shows the proportion of iodine in different algæ. It will be seen that the percentage of iodine in *Sargassum* is very small, while kelp (*Laminaria*) contains by far the largest percentage in a given quantity of ash and *Ecklonia* the largest percentage in the fresh weed.

Analyses of seaweeds from which iodine is extracted.

Japanese name.	Scientific name.	Locality.	Iodine in raw weed.	Ash in 100 parts weed.	Iodine in 100 parts ash.
			Per cent.	*Per cent.*	*Per cent.*
Kajime	Ecklonia cava	Chiba Prefecture	0.232	54.828	0.424
Do	do	Yamaguchi Prefecture	.251	47.223	.531
Arame	Ecklonia bicyclis	do	.271	50.904	.531
Ginbaso	Sargassum sp.	do	.054	52.042	.104
Do	do	Chiba Prefecture	.029	51.941	.057
Kombu	Laminaria angustata	Hokkaido	.180	18.686	.990
Do	Laminaria longissima	do	.173	27.290	.634
Do	Laminaria japonica	do	.106	17.156	.619
Do	Laminaria ochotensis	do	.188	20.308	.922

The iodine salts are not uniformly distributed in the different parts of the plants, and moreover vary in quantity from month to month. These points are brought out in detail in the following interesting series of analyses of "kajime" (*Ecklonia cava*) from the Chiba coast, made by the Imperial Fisheries Bureau:

Analysis of Ecklonia cava.

	March.	April.	May.	June.	July.	August.	September.
Young stalk:							
Iodine in 100 parts of material	0.061	0.067	0.093	.....	.....	.....	0.177
Ash in 100 parts of material	45.42	46.78	44.28	.....	.....	.....	45.63
Iodine in 100 parts of ash	.134	.144	.209	.....	.....	.....	.388
Young leaf:							
Iodine in 100 parts of material	.063	.060	.084	.....	.....	.....	.143
Ash in 100 parts of material	47.27	45.75	43.17	.....	.....	.....	48.90
Iodine in 100 parts of ash	.134	.130	.195	.....	.....	.....	.290
Old stalk:							
Iodine in 100 parts of material	.118	.118	.147	0.255	0.216	0.142	.267
Ash in 100 parts of material	46.77	44.64	48.76	49.95	42.95	48.30	45.07
Iodine in 100 parts of ash	.252	.263	.302	.507	.507	.346	.592
Old leaf:							
Iodine in 100 parts of material	.101	.114	.076	.294	.294	.142	.592
Ash in 100 parts of material	48.42	43.64	45.28	50.16	41.00	54.12	43.89
Iodine in 100 parts of ash	.209	.261	.167	.586	.717	.262	.528

The seaweeds are gathered chiefly in summer, some from the shores where they have been washed, some from submerged rocks and small stones by means of a knife attached at right angles to a bamboo pole. It is reported that the supply of algæ most valuable for iodine manufacture is diminishing.

TREATMENT OF THE ALGÆ.

The weeds are dried on the shores in the sun, then heaped and burned. The ash is collected and either sold to the manufacturers or treated by the fishermen themselves. Following is an outline of the reducing process:

The ash is washed with fresh water, and the soluble parts are thus extracted. The extract is then evaporated in iron pans over a fire, and a concentrated brine is obtained. Besides iodine, this brine contains potassium chloride, sodium chloride, magnesium chloride, and calcium sulphate, which during further evaporation crystallize out, leaving magnesium and potassium iodides in solution. The extract is finally placed in a glass or porcelain retort with sulphuric acid and potassium permanganate, and boiled, the iodine passing over and depositing in crystals. This product, however, is not strictly pure, and refining is necessary. Refining factories are located in Tokyo and Osaka.

The fishermen send their ash to the manufacturers in straw bags like those used for rice. As the ash is sold by weight, the fishermen are said to be not over careful to exclude sand and other foreign matter.

The output of crude iodine in Hokkaido in 1901 was 12,405 pounds, valued at $15,866.

OTHER JAPANESE ALGÆ AND THEIR USES.

The foregoing are the principal seaweeds and their applications in Japan, but there are many other species utilized in various ways. Many algæ are not objects of trade, but are employed for home purposes, and the annual consumption of these is very large. Some are used for making jellies, some as vegetables, some as salads, some as condiments, and some for decorative purposes. Large quantities are also used for fertilizers. In few countries is agriculture more thoroughly intensive than in Japan, and the need and demand for fertilizers are most pronounced. Among the minor species which are especially sought and are most used, the following may be mentioned. For the information concerning them the writer is chiefly indebted to Dr. K. Oku, chemist of the Imperial Fisheries Bureau, and to the paper by Yendo on "Uses of Marine Algæ in Japan."

"Arame" (*Ecklonia bicyclis*).—This alga, which is employed in the manufacture of iodine, is also used as food and fertilizer. It grows on reefs on the coast of various provinces, and is gathered from March to July. Its greatest length is about 2 feet. The chemical composition of the plant, as determined by Prof. Dr. Edward Kinch, formerly of the Agricultural College of Tokyo University, is water, 13.17 per cent; protein, 8.99 per cent; carbohydrates, 45.09 per cent; fiber, 7.40 per cent; and ash, 24.74 per cent. "Arame" is chiefly eaten as an ingredient of soups, as a salad, or mixed with soy-bean sauce. In localities where it grows abundantly it is sometimes spread on the land. The dried stem is very hard and may be used as handles for knives or other such implements. "Kajima" (*Ecklonia cava*) is not used for food, but is extensively employed for the decoration of houses on festive occasions.

"Hijiki" (*Cystophyllum fusiforme*) grows on rocks that are exposed at low tide, and is gathered therefrom between January and May. In January and February, when it is very small and tender, its quality is better than in other months; the largest size attained is 6 to 8 inches. This species is sun dried and is ready for use after boiling in fresh water or cooking with soy-bean sauce. Following is the chemical composition, according to Doctor Kinch: Water 16.40 per cent, protein 8.42, carbohydrates 41.92, fiber 17.06, and ash 16.20.

"Wakame" (*Undaria pinnatifida*) is dried and sold in bales, and is a common food article in parts of Japan. Before being used it is washed with fresh water, and then eaten as a salad, cooked with soy-bean sauce or put in soups. Yendo states that the peasants in northern Japan cut off the ripe sporophyls (fronds bearing sacs) and press them into a slimy liquid which is eaten after mixing with boiled rice. In some places "wakame" is treated much like "ama-nori" before being eaten; that is, it is put in a basket or tray with a wire mesh bottom and parched over a slow charcoal fire. Another method of preparation, peculiar to the province of Shima, is to cut the dried weed into 1-inch lengths and put them in cans or other vessels with sugar. The thick root of "wakame," called "mehibi," is often dried, shaved, or cut into thin slices, and eaten with sauce (miso). "Wakame" usually grows on rocks in currents or where the water is not sluggish, at depths of 20 to 40 feet. It is gathered in many provinces during winter by means of long poles terminating in a radiating cluster of long teeth or prongs, the weeds being torn from their attachment by a twisting motion.

"Suizenji-nori" (*Phylloderma sacrum*).—This species derives its name from the place where it is prepared. Suizenji is a park in Higo Province near Kumamoto, belonging to an old lord of the famous Hosokawa family. In this park is a large fresh-water pond, and at the lower end of this pond is a small lake from which "suizenji-nori" is gathered, and on the shore of which it is dried.

This product is ordinarily eaten with raw fish (*sashimi*); the dry weed is soaked in fresh water, and after it has swelled boiling water is sprinkled over it and then soy-bean sauce is added. In the time of the feudal system this preparation was regularly presented to the local daimyo.

"Awo-nori" (*Enteromorpha compressa*, *E. intestinalis*, and *E. linza*) grows in river mouths where fresh and salt water mix, and is cropped from November to April, being preserved by drying in the sun in sheets or bunches. Dr. O. Kellner gives the following analysis of dried *E. compressa:* Water 13.60 per cent, protein 12.41, fat and carbohydrates 52.99, fiber 10.58, and ash 10.42. "Awo-nori" is eaten after being gently heated over a charcoal fire and crushed or powdered; it has a very good flavor, and is used chiefly as a condiment. The first two species are abundant on the United States coasts.

"Aosa" (*Ulva lactuca*), the well-known sea lettuce of the United States, is much used in Japan in the same way parsley and lettuce are often employed by Americans—that is, as a garnishment for meats, fish, and salads.

"Miru" (*Codium tomentosum*, *C. mucronatum*, *C. lindenbergii*).—These species grow on rocks and stones along the shores of various provinces, and are cropped in April or May. After drying they are preserved in ash or salt. They are prepared for food by boiling or baking in water, and are put in soups; or, after washing, by mixing with soy-bean sauce and vinegar.

"Haba-nori" (*Phyllitis fascia*).—This plant is prepared for use after the manner of "awa-nori" (*Porphyra*), principally by peasants of the provinces of Awa and Sagami. The young fronds are dried in the sun in sheet form and subsequently parched, powdered, and mixed with soy-bean sauce.

"Matsuma" (*Chordaria abietina*).—This species, which resembles a spray of fir, abounds in northern Japan, and is consumed in large quantities by the peasantry.

It is preserved by packing in salt, and is cooked with soy-bean sauce. Yendo refers to an interesting use to which it is put, namely, the preservation of mushrooms. The mushrooms are washed in fresh water and then packed in tight barrels in layers alternating with layers of salted seaweed.

"Mozuku" (*Mesogloia decipiens*) reaches a length of about 1 foot, and is gathered in April or May while young. It is preserved by salting, and is eaten after washing out the salt and immersing in soy-bean sauce or vinegar.

"Hondawara" (*Sargassum enerve*) grows on reefs on the seacoasts, and is used as fertilizer after being piled on the shore and allowed to decompose. When the plant is young it is eaten in soup or with soy-bean sauce. It has a bright green color when dried, and has been employed from a very remote time, intertwined with *Laminaria*, in New Year's Day celebrations. Numerous other species of *Sargassum*, collectively called *mo* or *moku*, are employed as fertilizer in middle and southern Japan.

"Somen-nori" (*Nemalion vermiculare*) grows on rocks on various parts of the coast, being particularly abundant in San-in, Hoku-roku, and the northeastern districts, and rarely found in the Sea of Tokaido. Its length is 5 to 12 inches. It is generally preserved by simply drying, or by mixing with ash or salt, and is eaten in soup or after mixing with vinegar and soy-bean sauce. In some places "umi-zomen" (*N. lubricum*) is dried, bleached, and eaten like the foregoing species.

"Tosaka-nori," meaning crest-like seaweed (*Kallimenia dentata*), grows on reefs of Kozu Island and also in the provinces of Ise, Shima, and Higo, at depths of 8 feet to several fathoms, and is collected on the shores in August and September after a strong wind. It is preserved by drying, and is eaten as a condiment or mixed with soy-bean sauce.

"Tsuno-mata," "hosokeno-mimi" (*Chondrus crispus*, *C. ocellatus*, etc.).—The well-known "Irish moss" occurs on the coast of Japan and, with related species, is employed in a variety of ways, after first being dried in the sun. When boiled to form a jelly, these plants are used as food, as starch for stiffening linens, as a washing medium, and as a substitute for agar-agar.

"Ogo-nori" (*Gracilaria confervoides*).—According to Yendo, this is a favorite seaweed for garnishment in Tokyo, after being treated with lime water or dipped in hot water to change the color from pink to green.

Other Japanese algæ which are dried and eaten or utilized in various other ways are: "Cata-nori" (*Gigartina teedii*), "comen-nori" (*Grateloupia affinis*), "mukade-nori" (*Grateloupia filicina*), "makuri" (*Digenea simplex*), "ego" (*Campylaephora hypneoides*), "okitsu-nori" (*Gymnogondrus flabelliformis*), and "tosaka" (*Sarcodia* species).