United States Department of the Interior, J. A. Krug, Secretary
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Fishery Leaflet 263

Chicago 54, Ill. September 1947

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AGAR-AGAR READY FOR SHIPMENT

THE JAPANESE AGAR-AGAR INDUSTRY

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THE JAPANESE AGAR-AGAR INDUSTRY [1/]

Summary

1. Japanese dominance in the production and exportation of agar-agar is so great that the product may be considered peculiar to Japan.

2. The five largest consuming countries of Japanese agar-agar, judged by their imports, were the United States, England, Germany, France, and the Netherlands East Indies.

3. The method of manufacturing agar-agar in Japan, while primitive, is essentially simple and effective. Little mechanical or stationary equipment is required and no expensive or scarce ingredients are used. Wood for fuel is the largest single item of supply. Four pounds of fuel are required for each pound of raw material used.

4. In the United States and most other countries agar-agar has many uses. Chiefly, it is used in the manufacture of confections, laxatives, cosmetics, and bread; in meat canning; in dental products; and for bacterial culture media. Other uses include the clearing of wines and vinegar, the glazing of textiles and upper leather; use in cordials and condiments and in welding fluxes. In Japan its chief use is as a food. Although agar-agar has practically no food value, when mixed with beans or various kinds of fruit, it is highly regarded by the Japanese.

5. Although some agar-agar was diverted for war use in the manufacture of shatterproof glass for airplanes, the industry is primarily a peacetime one. The method of gathering and processing the raw material employs a large number of persons. The product is of high quality and is in world demand.

6. The agar-agar bearing seaweed is abundant along the entire coast of Japan. The most important sources are the Izu Islands and the coast of Shizuoka Prefecture.

7. During the decade from 1930 to 1940 the average annual production was 2,476 metric tons, and the average value was ¥10,569,486. Sixty-one percent of the average production was exported. In 1945, because of a shortage of labor for gathering the seaweed, production fell to 716 metric tons. The value went up in proportion to the scarcity of the finished product, reaching a level of ¥5.7 per pound compared to the average price of ¥1.5 per pound in the years from 1930 to 1939 inclusive.

Photos courtesy of Japan Agar-Agar Distribution Control Company.

1/ This report is based on information gathered and compiled by Capt. Claude M. Adams, Fisheries Division, Natural Resources Section, General Headquarters, Supreme Commander for the Allied Powers, Tokyo. Report No. 42, June 28, 1946. (Reproduced by permission of the Civil Affairs Division, War Department).

THE JAPANESE AGAR-AGAR INDUSTRY

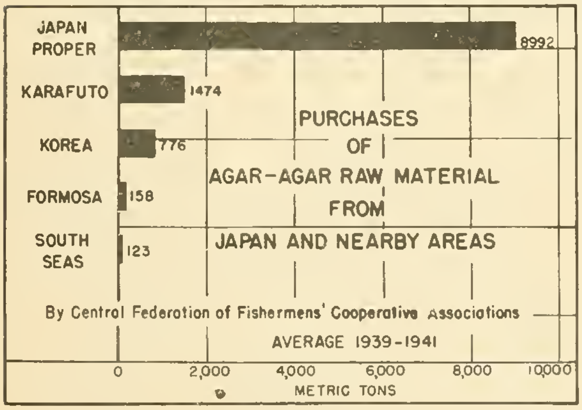
A. Raw Material

1. Agar-agar is made from the carbohydrate extracted from certain types of seaweed. The weed is boiled and filtered and the extract allowed to solidify. It is then subjected to a freezing and thawing process which removes nearly all of the impurities and moisture. The name agar-agar comes from the Malayan language and means seaweed. The name was originally used to describe a seaweed, Eueheuma spinosum, found in large quantities in the South Sea Islands.

2. Many kinds of seaweed are used in the manufacture of agar-agar. Each has a special purpose. The same variety may have different properties depending upon the location and the season in which it is gathered. To obtain a uniform product it is necessary to blend carefully seaweeds from different areas and of different varieties. This blending produces an agar-agar with a low setting point and viscosity and a high jelly strength. The season is important because seaweed from the first growth collected in May and June has a greater agar-agar content than that of the second growth. Table 1 gives the botanical names and common Japanese terms for most of the species of seaweed used.

3. The most important source of agar-agar from a standpoint of quality as well as quantity is the seaweed Gelidium Amansii. This variety is found in considerable quantity along the coast of Japan Proper. The most abundant sources are the Izu Islands off the Izu Peninsula and along the coast of Kanagawa and Shizuoka Prefectures.

4. The seaweed is gathered by fishermen and their families and by deep sea divers. Seaweed gathering rights, like fishing rights, are issued by the Central Federation of Fishermen's Cooperative Associations and give the fishermen



or the local association of fishermen the exclusive right to gather seaweed in specified areas. The regulations of the Central Federation governing the collection and distribution of seaweed require the fishermen to turn over the entire amount of seaweed collected to the Central Federation for distribution. The Federation allocates the raw material to branches of the Japan Agar-Agar Control Distribution Company in the various processing centers. The company in turn distributes it to individual plants.

5. The method of gathering the seaweed differs with the locality depending upon the customs of the various areas, the depth of the water, and the formation of the ocean bottom. Generally, the seaweed growing in shallow places is gathered by two methods: One consists of dragging raking instruments over the rocks and ocean bottom. Men and women wade into the water and scratch the seaweed off the rocks with long-handled rakes. Where the water is too deep to permit wading, the tools are weighted and lowered from boats or rafts. In the other method, women divers operate from surf boards, boats, rafts, and large wooden tubs. The tubs or rafts are propelled to the desired place by women who use wooden paddles for the purpose. The women dive from these tubs and pull the seaweed from the rocks and place it in the tubs. When the women are tired or the tub has a sufficient quantity of seaweed in it the women swim to shore, towing the tub (Figure 1). Women divers using no mechanical equipment except goggles operate to a depth of 30 feet. Women endure the cold water better than men because of their subcutaneous layer of fat. They have developed an abnormally large chest expansion and lung capacity. In gathering seaweed from rocks where the ocean depth is greater than 10 fathoms, men divers equipped with diving apparatus are employed. (Figure 2).

Figure 1. Women dive for agar-agar seaweed.

6. The quality of seaweed gathered in shallow places is not so desirable as that gathered from deeper areas. The season for harvesting the seaweed is from April to September depending on the locality. The first growth is gathered from April to June and the second growth from July to September. The seaweed is spread on bamboo racks along the beach to dry and is partially bleached by the action of sun and rain. The time required for proper drying depends upon the locality and the temperature. The dried material is stored in barns in the same manner that hay is stored. It may be held in this state from

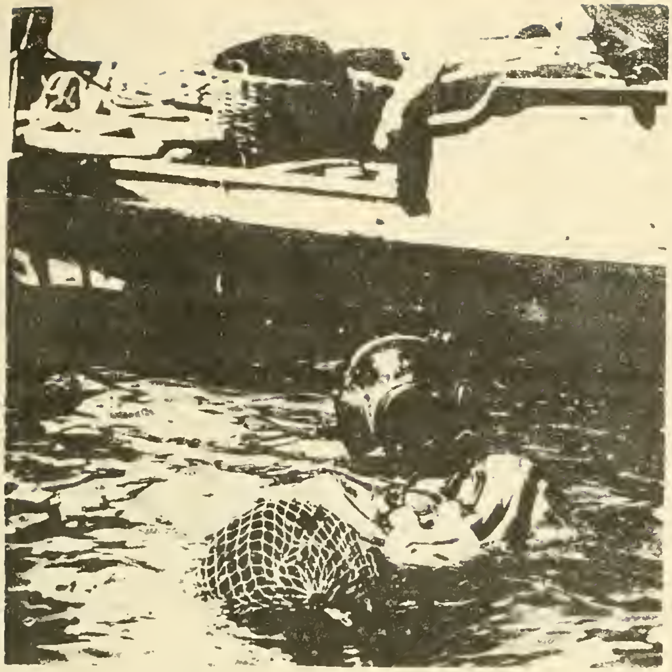


Figure 2. Men dive for agar-agar seaweed in depths greater than 10 fathoms.

one year to the next without fear of deterioration. The "kanten genryo" or agar-agar raw material, packed in bundles weighing from 60 to 80 pounds, is shipped by rail to the processing centers.

7. Agar-agar may be extracted from the dried seaweed in individual homes by a simple boiling process. Agar-agar when used as food is eaten either plain or mixed with other foods such as beans, or with fruits for a desert. During the present food shortage much of the seaweed has been sold direct to consumers for use in this manner. This direct sale of agar-agar bearing seaweed through unauthorized channels has resulted in the present low production of agar-agar for commercial use. The jelly obtained from this simple boiling process is called tokoroten. It is highly regarded as a food, especially during the summertime when it is considered a great delicacy.

8. In the production of agar-agar in Japan, about thirty species of seaweed are used. These species are classified in seven groups under the following names: tengusa, oni, toriashi, ego, ogo, igisu, and hirakusa. Four of the groups, tengusa, oni, toriashi, and hirakusa are classified as hard weeds, and the others, ego, ogo, and igisu are classified as soft weeds.

B. Processing Plants

1. The choice of a site for a processing plant is extremely important as the freezing and thawing method of dehydration and purification requires a combination of ideal weather and water conditions. Ideal weather conditions include freezing at night with the temperature remaining above 7° to 8° below zero Centigrade and clear, sunny days with light southerly winds. Strong winds would blow dust and soot onto the drying gelatin, resulting in an impure product. Because of the altitude of the processing areas and the season of the year, north winds usually cause a low temperature that drops below the desired point at night and retards the thawing process during the day. Soft water should be used in the process.

2. The five largest processing areas on Honshu are located in the mountainous regions of the following prefectures: Osaka, Kyoto, Hyogo, Gifu, and Nagano. The largest plants are in Nagano Prefecture where the average capacity is 225 kilograms of raw material per batch or day's run. The capacity of the plants in Gifu Prefecture is 187 kilograms; the plants in Osaka, Kyoto, and Hyogo average 131 kilograms. The processing season usually extends from the first part of December to the latter part of February with an average of 70 production days, except in Nagano Prefecture where the season is five days longer.

3. The Ministry of Agriculture and Forestry registers and gives permits to the operators of processing plants. Permits were issued to 536 plants in 1945. Of this number only 170 plants actually operated because of the scarcity of raw material. In order to continue in business, the operators of two to four plants combined their supply of raw material and processed it in one plant, using a combination of laborers and technicians from the several plants as a crew.

4. A typical, fairly large processing plant consists of several buildings and fenced-in drying yards occupying an area of about one-half acre. The buildings usually consist of a warehouse, where both the raw material and the finished product are stored; an office building; a washing shed in which the dried seaweed is soaked and washed; a boiling house where the gelatin is extracted from the seaweed and placed in trays for the final process; and the sheds where the finished material is sorted and tied into bundles of a convenient size for handling and storage.

5. Each plant requires an average of eight men for full operating strength in normal times. As personnel have been combined in the 170 plants now in operation, a total of 1,700 persons is employed in the industry. In 1947 conditions are expected to approach a more normal state, and possibly 600 plants will operate, employing a total of about 4,800 men.

C. Manufacturing Process 2/

1. Soaking and Washing

a. The dried seaweed is placed in cement bins approximately 10 by 3 by 1.5 feet in size and covered with cold water. This step in the process has a twofold purpose. The tanks are located to take advantage of the maximum amount of sunlight each day, and the material is stirred frequently so that all of the surfaces are exposed to the light, resulting in a bleaching of the product. This is one of the purposes of the soaking operation. The other is the removal of foreign material,

2/ The description of manufacturing methods is based on observations of plants in Nagano Prefecture. Methods used in other areas are similar, although plant capacities are smaller.

such as tiny shells and lime particles, salt, and sand from the seaweed.

b. The so-called hard weeds are soaked for periods to 25 hours; the soft varieties from 12 to 15 hours. The water used in the soaking tanks must be soft and should never be over 10° C as the seaweed will spoil at this point in the process at a higher temperature.

c. When the soaking is completed the material is washed until as much as possible of the foreign matter is removed. Formerly, the washing was done by primitive methods such as placing the seaweed in pits and pounding it with mallets attached to long poles. This was done by hand. Eventually, the mallets were suspended from an overhead eccentric shaft, and the process was mechanized (Figure 3).

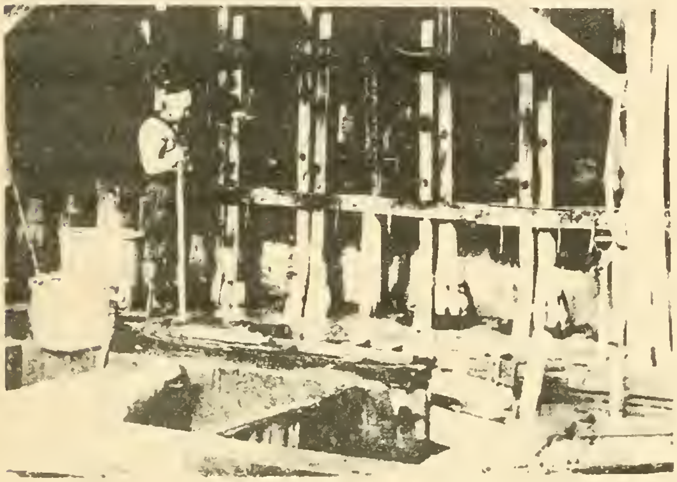


Figure 3. Soaking and bleaching tanks and mechanical pounders for hard varieties seaweed.

d. The use of washing machines is a more recent innovation. The tubs are open on the bottom and rotate on a perforated disc in an eccentric circle. At the same time the plunger, which is slightly smaller in diameter than the washing tub, presses the seaweed; a stream of water is run through the machine from a half-inch hose. The seaweed remains in the washing machine on an average of one-half hour. The length of time depends on the amount of lime and shell particles or sand adhering to the seaweed. Although the washing machine has been satisfactory for soft weeds (Figure 4) hard varieties are still subjected to mechanical pounding to soften them in order to aid in the extraction of the agar-agar.

e. After being washed the material is placed in clean cement tanks to drain until a batch of about 225 kilograms has been accumulated. As each batch is brought to the boiling sheds for the next step in the process (Figure 5), it is given another soaking for about two hours. This aids in the bleaching and keeps the weeds soft and pliable.

2. Boiling

a. This is the most important and critical step in the manufacture of agar-agar. The correct blending of different species of seaweed in proper proportions and temperature control are of vital

Figure 4. Modern machine method for washing soft varieties of seaweed.

importance in the production of a pure product of high quality., Table 2 shows the most desirable proportions of the various kinds of seaweeds blended in each batch. The tanks used for the boiling process are made of wood and are large enough to hold one batch or about 225 kilograms of seaweed and about 3,400 liters of water. A description of the boiling process in a typical plant follows.

b. The water is placed in the boiling tank and a fire is started in the brick fire box under the tank at 1800 hours. Wood should be used for this purpose to minimize the dust and soot in the vicinity of the drying agar-agar. The water should be boiling by 2000 hours; at this time the hard varieties of seaweed are added. The addition of the seaweed stops the boiling. When it is resumed, approximately 740 grams of sulphuric acid are added to help break down the hard outer covering of the seaweed and to control the Ph value of the batch. Care must be taken to see that too much sulphuric acid is not added, as the Ph value of the finished product should not be above 6.3 or 7.0. Hard weeds are boiled for one and one-half hours, and then the soft weeds, igiso and ogo, are added. This mixture is boiled for 15 minutes. Then the softest weed, ego, is added. When the ego is added, no more wood is placed in the fire box, and the active boiling stops. The entire batch is simmered for 12 hours or until about 1000 hours the following day.

c. When this boiling is completed, the so-called "second boiling" of the previous batch (explained in a later paragraph) is added and remains in the tank for four hours. This is an overall time of between 16 and 18 hours for the complete boiling process of one batch. During this process it is important that the water not boil too vigorously and that the seaweed be stirred frequently to permit a good circulation of heat. Prior to the war about five minutes before the liquid was removed from the boiling tank two pounds of sodium dioxide were added. This chemical was used as a bleaching agent. Since it was imported from Germany, imports have now stopped. Consequently, none of this chemical has been used in the last few years, and the agar-agar produced has not had such a white color as when the bleach was used.

Figure 5. "Transporting" clean seaweed from washing sheds to boiling tanks.

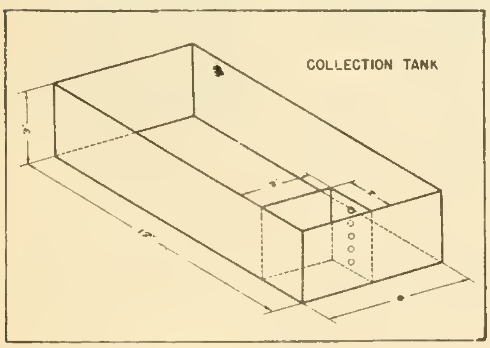
d. After the fire is permitted to die down, the temperature of the batch drops about 1° C per hour. When the gelidium from the second boiling is added, the temperature drops another 3°, making a total reduction of 17° to 20°. The temperature of the batch at the completion of the process is between 80° and 83° C. As the temperature drops, the seaweed settles to the bottom of the tank, making the dipping out of the liquor a simple process.

e. The residue of seaweed from each batch is placed in another tank and about 1,230 liters of water are added. This mixture is boiled for 10 hours and strained separately. The strained liquid from this batch is called the "second boiling". It is added to the next regular batch in the manner previously described.

f. The residue seaweed from the second boiling is dried and used as a fertilizer. From 225 kilograms of raw material, approximately 52 kilograms of seaweed residue are left. As this material is rich in potassium and contains some nitrogen and lime, and as a critical shortage of potassium fertilizer exists in Japan, the residue is valuable. Most of it is used on farms belonging to owners and employees of the plants. The balance is sold.

3. Straining and solidifying

a. The mother liquor containing the gelidium jelly in suspension is dipped from the boiling vats into straining tanks (Figure 6). The tanks are about 5 by 3 by 2.5 feet in size and are perforated on the bottom and lined with small bamboo rods. A filter cloth is placed in the tanks for straining. This cloth, which is made of cotton, is referred to as a 20-mesh filter and contains 400 holes per square inch. About two hours are required to strain one batch of liquor.



b. The strained liquor drops into a collection tank which is about 12 feet long, 6 feet wide, and 3 feet deep (See sketch). The tank bottom is pitched so that the liquid will gravitate to one end as the gelatin is skimmed off. The liquid is allowed to settle for two hours before being skimmed. A small section, 3 by 2 by 3 feet, is partitioned off at the lowest corner of the tank to act as a skimming tank. The partition is solid on one side and has five 2-inch holes with 6-inch centers in the end facing the lowest point of the settling tank bottom. Plugs are inserted in the holes before the tank is filled. As the impurities settle and the gelidium jelly rises to the surface and begins to congeal, the plugs are removed in order, from top to bottom, as the level of the liquid in the settling tank falls. The material in the last two inches, which contains most of the impurities, is processed separately and sold as a cheap grade. As the liquid is drawn from the settling tank, it is dipped into a bucket having a pouring spout and then poured into trays for the final process of dehydration. The bucket is marked so that 14 liters of liquid are drawn off each time.

4. Dehydration

a. Trays used for the precooling process are 3 feet long, 1 foot wide and 3 inches deep. The trays are filled to within two centimeters of the top. Filled in this way, the trays hold 14 liters each. From each batch of 225 kilograms of seaweed enough liquid containing the gelidium in solution is obtained to fill 330 trays. This represents about 4,620 liters of liquid (Figure 7).

b. The liquid-filled trays are placed in racks and left for seven hours. By this time the temperature has dropped to about 40° C. During this period the material has solidified enough to be cut into oblong blocks for the freezing and thawing process. The importance of keeping the Ph below seven is evidenced at this point. A batch having a higher Ph will not solidify to the desired degree. A rake type instrument with knife tines is pulled through the trays of gelatin cutting the material into oblong sections 2 1/4 by 3 by 18 inches. The oblong sections are cut into other sizes, depending on the use to which the agar-agar is to be put. For home consumption some of the oblong sections are cut to half the width: some are left whole.

c. For export to China and a few other countries the material is shredded. Shredding is done

Figure 6. Boiling vats and straining tanks.

Figure 7. Transferring congealed gelatin to drying yard.

by placing an oblong of gelatin in a box and pushing it through a screen in the bottom with a plunger. The screen is 4 inches by 3 inches and the mesh is 15 by 10 (Figure 8). The shredded material and the oblong sections are transferred to larger trays to allow better circulation of air (Figures 9 and 10). The trays are stacked and left in the field for from two to three days for preliminary freezing and hardening and then are spread out for the completion of the process.

d. The dehydration process consists of successive slow freezing of the material during the night and thawing and drying during the day. The principle of this process is that by the slow freezing of the water content of the material, large ice crystals form, and when the thawing takes place, the water runs off, carrying with it those impurities which are water soluble and those which are in suspension in the colloidal gelatin. During the process the trays containing the gelatin are placed in a tilted position to permit water to drain off as rapidly as possible (Figures 10 and 11).

e. This process is continued for a period of about two weeks. The length of time required depends upon the weather conditions. It is sometimes necessary to extend the time as much as one week. When snow or rain occurs, the drying material is moved into a covered shed to avoid absorption of water and impurities by the gelatin.

Figure 8. Shredding of gelatin.

f. When the dehydration is completed, the agar-agar is taken to the packing shed (Figure 12) to be sorted according to size, shape, and color and is tied in bundles of a convenient size (Figure 13). From the original 225 kilograms of dried seaweed used in one batch, about 53 kilograms (23 percent) of pure agar-

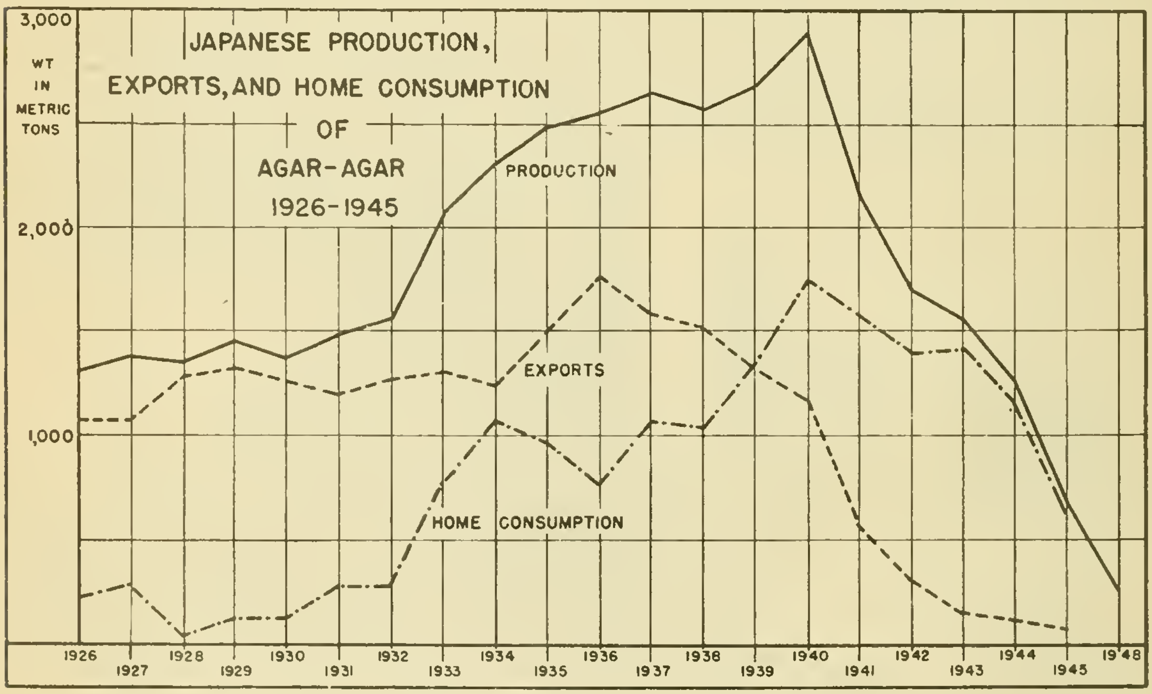
agar is obtained.

Figure 9. Filling and stacking drying trays.

g. Since 1923 various experiments have been made in Japan to modernize the drying and purifying of agar-agar by using mechanical refrigeration and artificial drying. So far the cost of mechanical methods has been prohibitive under Japanese conditions of plentiful, cheap labor.

D. <u>Production and Export</u>

1. The average production of agar-agar during the years from 1930 to 1940 inclusive, was 2,476 metric tons per annum and the average value was ¥10,569,486. The average amount exported per annum in this period was 1,525 metric tons or 61 percent of the average production. The production for the year 1945 was 716 metric tons with a total value of ¥10,390,945. The price of ¥12.8 per kilogram was more than three times the average of that



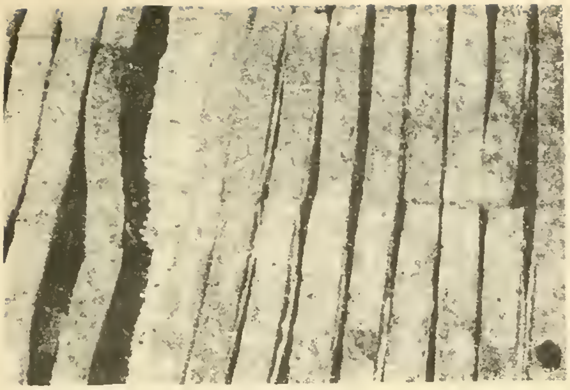
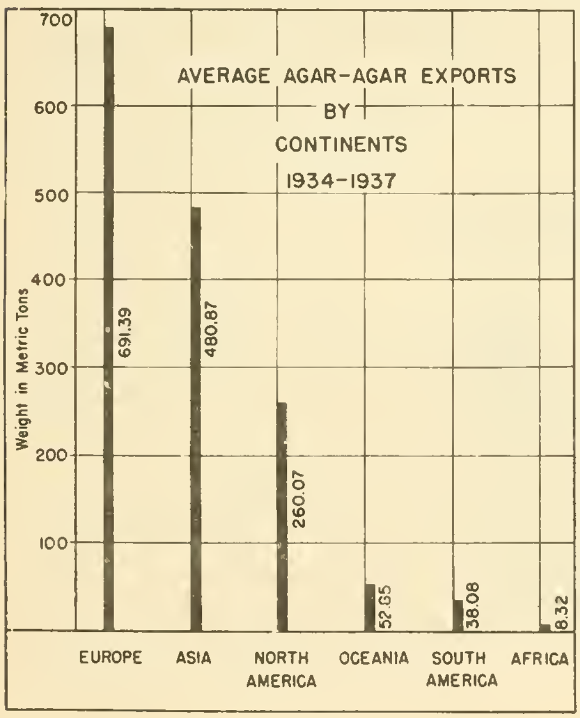


Figure 10. Dehydration of agar-agar

produced from 1930 to 1940. Production continued to decline and in 1946, only 241 metric tons were produced.

2. In 1926 Japan exported 1,083 metric tons of agar-agar or 82 percent of the total production of 1,308 metric tons. Production figures rose sharply in 1933 to 2,081 metric tons. Since the world market could not absorb this increase, exports accounted for only 63 percent of the total production. Production continued to increase, and the percentage exported declined until in 1940 less than half of the total production was exported. As four of the five largest foreign users of Japanese agar-agar were nations allied against Japan, exports of agar-agar fell off abruptly immediately preceding the war against these nations. Exports continued to decline during the war years until finally in 1945, only 77 metric tons, or 10 percent of the production, was exported (Table 3).

3. From 1934 to 1940 Japan exported agar-agar to more than fifty countries. The largest users of agar-agar during this period with the average annual imports in metric tons were the United States, 257; United Kingdom, 181; Germany, 178; France, 161; and the Netherlands East Indies, 128. The annual average export to all countries in the same period was 1,455 metric tons. According to these totals, the United States imported about 18 percent of all the agar-agar exported by Japan during the years from 1934 to 1940 inclusive.



a. Table 4 gives the total exports by country for the years from 1934 to 1940 with the exception of 1938. Complete figures for 1938 are not available at this time because this was the year when the Japan Agar-Agar Control Company was first formed, and some statistics were misplaced during the confusion following the organization of a central statistical office.


Figure 11. Drying shredded and oblong agar-agar.

4. The examination and grading of agar-agar is the responsibility of the Japan Agar-Agar Distribution Control Company. The classification of quality is based on a visual examination for shape, color, degree of hardness, and nonsoluble impurities remaining in the product, and a calculation by chemical analysis and mechanical means of the jelly strength, viscosity, solubility in hot water, speed of solution, moisture, and crude protein present.

5. The laboratory test for degree of solidity is made in the following manner: 1.5 grams of agar-agar are mixed in 100 cc of water and placed in a cup. The mixture stands for 15 hours at 20° C. A plunger slightly smaller in diameter than the cup and weighing 100 grams with a cylindrical tip one square centimeter in area is placed on the resulting jelly for 20 seconds. If the plunger enters the jelly, the material is graded as not suitable for export. If the plunger will not enter the jelly, the material is graded tentatively as third grade (100) or better. Next, a 200 gram weight is placed on the plunger, and the test is repeated. If the material passes this test, it is graded tentatively as 200 or second grade. Finally, a 300 gram weight is used, and material passed is graded as 300 or first class.

Figure 12. Transferring dried agar-agar to sorting shed.

6. The amount of crude protein is measured chemically; the results must show that less than three percent by weight of crude protein is present in the product in order for the batch to be considered for export. In the past, complaints were received from buyers in foreign countries that some shipments of agar-agar were

Figure 13. Agar-agar ready for shipping to distribution points.

discolored. Investigations revealed that the crude protein content of the shipments in question was greater than three percent. The amount of crude protein present in the finished product is controlled by the slow freezing during the dehydration process. This is another example of the importance of ideal weather conditions in the processing areas.

7. The quantity of insoluble materials is measured at the same time, and the amount must be less than four percent for export purposes. The moisture content is also determined at this time, and the finished product must have no more than 22 percent by weight to be considered for export.

8. The melting point of agar-agar is determined in the following manner: 1.5 grams of agar-agar are mixed with 100 cc. of water; 10 cc. of the resulting jelly are placed in a test tube, and a thermometer is inserted through the jelly. The material is held overnight at room temperature to allow the jelly to harden. When the test is made, five grams of mercury are added, and the test tube is placed in a beaker containing 400 cc. of water. The water is heated over a Bunsen burner so that the temperature increases 1° C in one minute. When the mercury begins to pass through the jelly, the melting point is reached, and the temperature reading of the thermometer is recorded. The test is repeated several times on each batch in order to obtain an average figure.

9. Previously, when sodium dioxide was added to the batch as a bleaching agent, a test was made to determine the amount still present in the finished product. No tolerance was allowed for material used for export; only .00025 percent was permitted for domestic use.

10. Visual inspection to determine the quality in regard to shape, color, and packaging is made when the material is prepared for shipment. The agar-agar is compressed and packed in large bundles weighing about 116 kilograms each.

11. The following table gives the grading of agar-agar for export:

	Solidity	Crude Protein percent	Insoluble Material percent
1st grade	300	less than 1.5	less than 2
2nd grade	200	less than 2	less than 3
3rd grade	100	less than 3	less than 4

If SO_2 was added: No tolerance.
Moisture: Less than 22 percent by weight.

E. Production in Areas Outside Japan Proper

1. In 1915 Japan started the production of agar-agar in Karafuto (Sakhalin Island). *Ahnfeltia plicata* and *A. plicata* var *Tobuchiensis* are found in fair quantities in the Karafuto and Kuril Islands area. These species are called Itaniso by the Japanese. Unlike the other species, itaniso is not mixed with other kinds of seaweed in the manufacture of agar-agar. Production in Karafuto was increased yearly until recently the annual production amounted to 825 metric tons or 23 percent of the total production of Japan. (Karafuto production is included in the figures given for Japanese production in the accompanying tables.)

2. In 1917 Japanese industrialists started manufacturing agar-agar in Korea. Most of the various species of seaweed used are available in considerable quantity along the coast of Korea. At present the annual agar-agar production capacity of Korea is 635 metric tons. Since the Japanese manufacturers have left Korea, it is reported that only a few plants are operating and that production is negligible.

3. Dutch industrialists of the Netherlands East Indies started production of agar-agar when China placed a boycott on Japanese goods. They constructed plants in several South Sea Islands where raw material is found in sufficient quantity. Production figures of this enterprise are not in the possession of the Japan Agar-Agar Control Company. Exports from Japan to the Dutch East Indies fell off from 228 metric tons in 1934 to 64 in 1940.

4. In 1937 some Japanese agar-agar manufacturers went to Chintow, China, to attempt the organization of a like industry in that area. Raw material was found along the coast in small quantity, but, as the water in the processing area was not of suitable quality, the project failed.

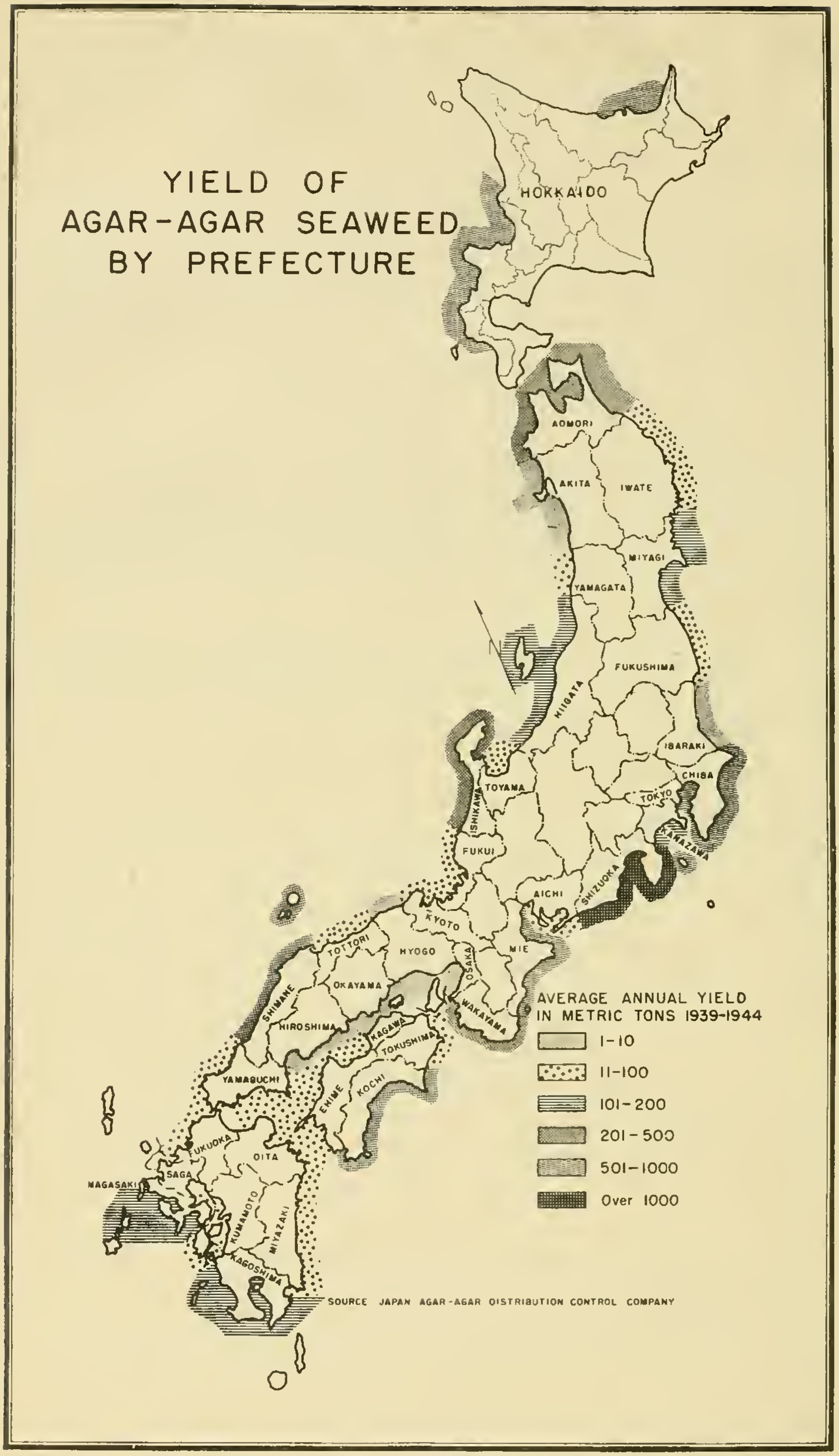
5. Australia and New Zealand began the production of agar-agar during the war years, and Australia is now producing about 80 metric tons

a year with the possibility of a much larger production. New Zealand produces about 15 tons a year, but this agar is of much higher quality than other agar-agars and is ideal for bacteriological use. A solution of 0.65 percent gives a solid medium; the agar-agar is colorless with low ash and organic content.

6. The United States entered the agar-agar production field as late as 1937 but, because of a lack of raw material, was only able to produce an amount sufficient to meet military demands and to maintain a stockpile during the war years. As little agar-agar bearing seaweed is found along the coast of the United States, most of it must be imported from Mexico. A considerable quantity of this raw material is found along the coasts of Lower California and Mexico Proper.

7. An inferior grade of seaweed of several species called "kirinso" by the Japanese was formerly imported from Formosa. A substance used medicinally was extracted from the weed; the residue was used in the manufacture of agar-agar. An annual average import of 110 metric tons of high-grade agar-agar bearing seaweed was also made from Formosa.

8. Table 8 shows the amounts of raw material imported into Japan from sources in the Far East during the years from 1939 to 1945 inclusive.



YIELD OF AGAR-AGAR SEAWEED BY PREFECTURE

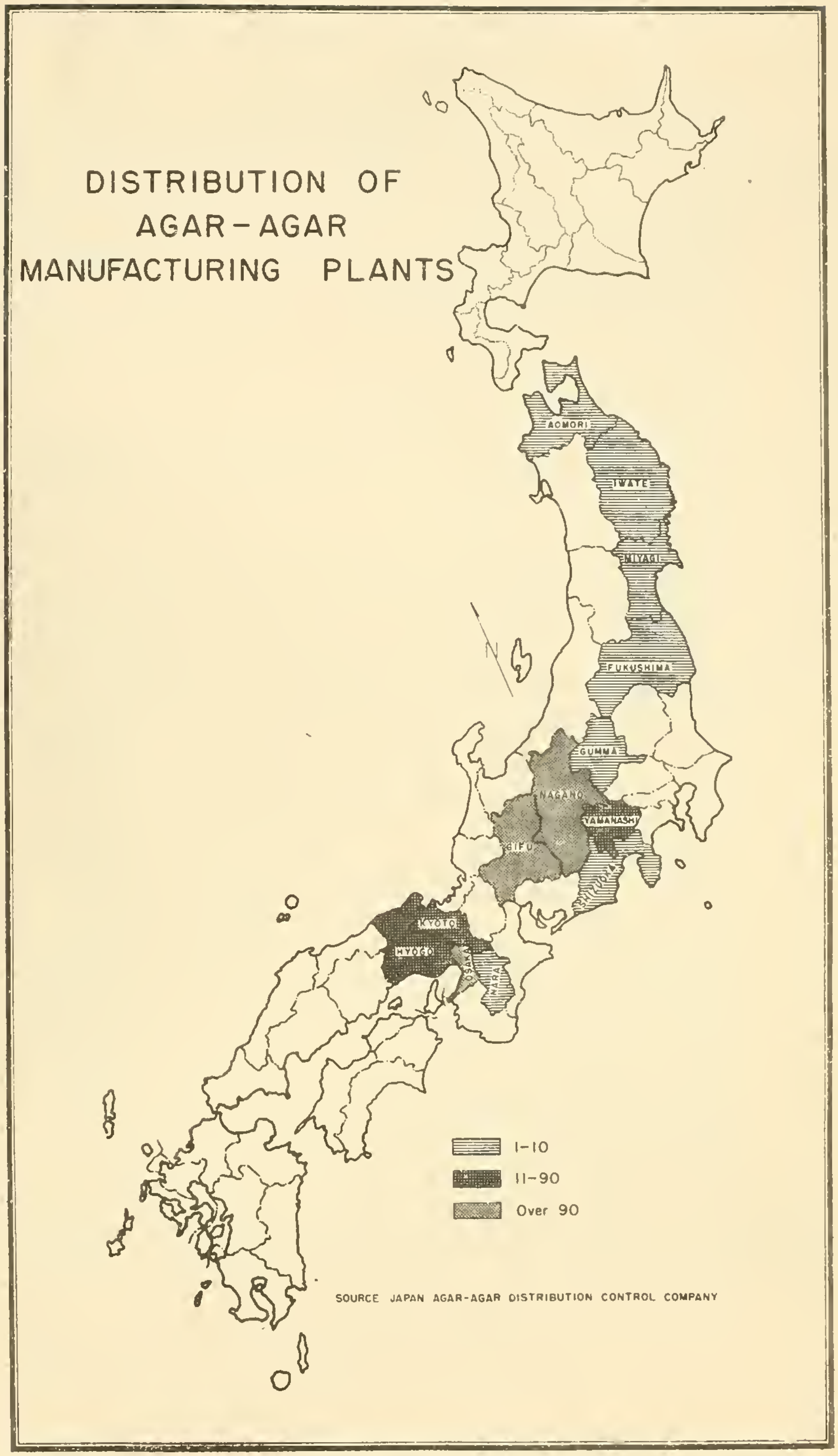

DISTRIBUTION OF
AGAR-AGAR
MANUFACTURING PLANTS
N
AOMORI
IWATE
MIYAGI
FUKUSHIMA
GUMMA
NAGANO
YAMANASHI
GIFU
KYOTO
HYOGO
OSAKA
NARA
1-10
11-90
Over 90
SOURCE JAPAN AGAR-AGAR DISTRIBUTION CONTROL COMPANY

TABLE 1. - SPECIES OF SEAWEED USED IN THE MANUFACTURE OF AGAR - AGAR IN JAPAN

MANUFACTURERS' TERM	SCIENTIFIC NAME	COMMON NAME
Tengusa	Gelidium Amansii Lmx	Tengusa
Tengusa	Gelidium Pacificum Okam.	Obusa
Tengusa	Gelidium divaricatum Martens	
Tengusa	Gelidium crinale (Turn) Lmx	
Tengusa	Gelidium liatulum Okam.	
Tengusa	Gelidium pusillum (Stckh) Je. Jol.	
Tengusa	Gelidium subfastigiatum Okam.	
Tengusa	Gelidium vagum Okam.	
Tengusa	Pterocladia capillacea (Gmel.) Born. et Thur.	Obakusa
Tengusa	Pterocladia tenuis Okam.	Obakusa
Tengusa	Pterocladia densa Okam.	
Tengusa	Pterocladia nana Okam.	
Tengusa	Gelidialla acerosa Feldm. et Hamel.	
Oni	Gelidium Japonicum (Harv.) Okam.	Onikusa
Toriashi	Acanthopeltis Japonica Okam.	Toriashi
Ego	Ceramium Hypnaeoides (J. Ag.) Okam.	Egonori
Ogo	Gracilaria confervoides (L.) Grev.	Ogonori
Ogo	Gracilaria gigas Harv.	O-ogonori
Ogo	Gracilaria chorda Holm.	Tsuru-shiramo
Ogo	Gracilaria compressa (Ag) Grev.	Shiramo
Ogo	Graulana Blodgetti Haru	
Ogo	Graulana lichenoides (L.) Haru.	
Igisu	Gelidium linoides Kutz	Higekusa
Igisu	Ceramium rubrum J. Ag.	Igisu
Igisu	Ceramium Boydenii Gepp.	Amikusa
Igisu	Ceramium crassum Okam.	
Hirakusa	Gelidium subcostatum Okam.	Hirakusa
Hirakusa	Gelidium tenue Okam.	Hirakusa
Hirakusa	Gelidium planiusculum Okam.	Hirakusa
Kirinso	Eucheuma muricatum (Gm.) Web V.B.	Kirinsai
Kirinso	Eucheuma gelatinae (Esp.) J. Ag.	Katamen - kirinsai
Kirinso	Eucheuma amakusaensis Okam.	Amakusa - kirinsai
Kirinso	Eucheuma crustaeforme Web V. Bos.	
Itaniso	Ahnfeltia plicata (Huds.) Fr. Scau var Tobuchiensis Kanno	Itanigusa

Note: Gelidium Amansii and G. Pacificum are by far the most important species in the production of agar-agar (Kanten) in Japan. They are known as "genuine grass" (Hon-so or Oya-kusa). The other species are called "weeds" (Zasso).

TABLE 2. - JAPANESE AGAR-AGAR MANUFACTURE

Most desirable proportions of the various species of seaweed used in one batch as listed by Japanese group name:

Group Name	Percent	Pounds
Tengusa	45	225
Oni	10	50
Toriashi	5	25
Ego	10	50
Ogo	15	75
Igisu	5	25
Hirakusa	10	50
TOTAL:	100	500

Note: Two other groupings, Kirinso and Itaniso, are found only in Formosa and Karafuto and are not generally used in Japan.

TABLE 3. - JAPANESE PRODUCTION, EXPORTS, DOMESTIC CONSUMPTION AND CARRY OVER OF AGAR-AGAR, 1926-1945

	PRODUCTION	EXPORTS		DOMESTIC CONSUMPTION AND CARRY OVER	
	Metric Tons	Metric Tons	Percentage	Metric Tons	Percentage
1926	1,308	1,083	82	225	18
1927	1,384	1,089	78	295	22
1928	1,358	1,290	95	68	05
1929	1,451	1,322	91	129	09
1930	1,387	1,267	91	120	09
1931	1,491	1,209	81	282	19
1932	1,573	1,282	81	291	19
1933	2,081	1,312	63	769	37
1934	2,320	1,256	54	1,066	46
1935	2,495	1,510	60	985	40
1936	2,550	1,769	69	781	31
1937	2,655	1,591	60	1,064	40
1938	2,579	1,522	59	1,059	41
1939	2,694	1,344	50	1,351	50
1940	2,934	1,194	40	1,740	60
1941	2,150	589	27	1,561	73
1942	1,715	315	18	1,400	82
1943	1,578	157	10	1,421	90
1944	1,280	119	9	1,161	91
1945	716	76	10	640	90

SOURCE: Japan Agar-Agar Distribution Control Company.

TABLE 4. - AGAR-AGAR EXPORTS FROM JAPAN BY COUNTRY OF DESTINATION 1934-1940 a/
(Quantities in kilograms)

DESTINATION	1934	1935	1936	1937	1939	1940
A. ASIA						
Manchukuo	1,680	2,280	7,560	18,780	32,846	59,226
Kwantung	16,680	24,960	52,500	49,560	96,187	116,060
China	35,220	49,440	51,660	34,080	82,023	71,824
Soviet Asia	---	1,080	---	---	---	---
Hong Kong	25,380	29,280	32,580	15,360	420	120
French Indo China	16,560	37,500	44,100	14,160	3,120	2,880
Siam	30,780	36,600	35,580	24,960	7,980	4,470
British Malaya	---	---	60	---	3,330	2,046
Straits Settlements	108,600	93,600	100,440	70,020	23,306	15,330
British India	23,700	32,400	33,240	28,080	6,588	1,830
Ceylon	840	300	2,040	1,200	---	---
Iran	---	---	---	60	---	---
Iraq	180	---	---	---	---	---
Palestine	780	1,560	4,560	1,800	---	---
Saudi Arabia	----	120	480	60	---	---
British Borneo	180	300	60	180	---	---
Netherlands Indies	228,780	131,220	150,060	126,720	70,481	64,050
Philippine Islands	14,040	24,360	27,960	26,760	13,755	9,483
Others	300	---	120	---	16,560	20,628
Total Amount	503,700	465,000	543,000	411,780	356,596	367,947
Total Value, Yen	1,291,550	1,238,922	1,580,728	1,666,242	ND b/	ND
B. EUROPE						
United Kingdom	136,800	187,980	243,420	198,180	156,135	163,680
France	97,140	218,640	245,580	233,340	89,643	83,640
Germany	194,280	259,560	154,260	236,940	162,678	63,540
Italy	10,860	22,740	6,840	12,600	11,756	22,050
Poland-Danzig	300	7,020	13,560	5,340	4,200	---
Belgium-Luxemburg	2,160	4,680	7,680	8,040	---	---
Holland	13,080	19,020	29,520	34,380	36,960	20,152
Denmark	8,280	9,720	18,780	1,320	3,360	7,680
Finland	---	1,200	18,840	4,860	---	---
Sweden	13,020	20,880	30,960	11,880	10,320	4,560
Norway	---	---	360	840	---	---
Spain	240	3,780	6,600	---	---	---
Irish Free State	---	---	---	1,200	---	---
USSR	---	---	---	1,020	---	---
Others	2,220	---	2,640	3,000	114,300	---
Total Amount	478,380	755,220	779,040	752,940	589,352	365,302
Total Value, Yen	1,226,862	2,225,644	2,466,710	3,279,400	ND	ND
C. NORTH AMERICA						
United States	191,340	203,880	295,680	303,660	225,435	322,511
Canada	5,940	5,100	14,580	13,500	16,788	11,700
Mexico	240	120	1,920	960	---	---
Cuba	---	---	360	---	---	---
Others	---	---	3,000	---	---	---
Total Amount	197,520	209,100	315,540	318,120	242,223	334,211
Total Value, Yen	495,672	556,165	1,070,158	1,307,244	ND	ND

TABLE 4. - AGAR-AGAR EXPORTS FROM JAPAN BY COUNTRY OF DESTINATION 1934-1940 a/ (CONT'D)
(Quantities in kilograms)

DESTINATION	1934	1935	1936	1937	1939	1940
D. SOUTH AMERICA						
Venezuela	360	---	1,080	120	ND b/	ND b/
Peru	1,920	1,920	2,160	2,820	ND	ND
Chile	240	---	---	6,660	ND	ND
Argentina	23,100	22,500	42,240	25,560	ND	ND
Brazil	1,320	2,280	8,280	9,240	ND	ND
Uruguay	180	---	---	---	ND	ND
Dutch Guiana	---	120	---	---	ND	ND
British Guiana	---	---	60	180	ND	ND
Total Amount	27,120	26,820	53,820	44,580	49,170	52,788
Total Value, Yen	73,325	83,547	191,297	213,636	ND	ND
E. AFRICA						
Union South Africa	6,360	4,920	11,160	7,080	ND	ND
Madagascar	---	---	420	300	ND	ND
Kenya, Uganda,) Tanganyika)	---	120	480	480	ND	ND
Mozambique	120	120	---	---	ND	ND
Algeria	---	---	---	60	ND	ND
Others	1,560	---	---	120	ND	ND
Total Amount	8,040	5,160	12,060	8,040	3,360	4,620
Total Value, Yen	20,484	14,442	34,117	37,658	ND	ND
F. OCEANIA						
Australia	33,720	36,600	46,980	40,560	68,737	44,414
New Zealand	5,220	9,420	15,180	11,640	9,090	22,800
New Caledonia	---	420	---	---	---	---
Hawaii	2,160	1,980	3,540	4,020	1,661	1,656
Total Amount	41,100	48,420	65,700	56,200	79,488	68,870
Total Value, Yen	107,225	142,925	231,448	206,812	ND	ND

a/ Data for 1938 unavailable.
b/ No data available
Source: Japan Agar-Agar Distribution Control Company

TABLE 5. - AGAR-AGAR EXPORTS FROM JAPAN
1926-1945 Inclusive

YEAR	AMOUNT IN METRIC TONS	VALUE IN YEN	VALUE PER KILOGRAM, YEN	VALUE PER POUND, YEN
1926	1,083	3,742,040	3.4	1.5
1927	1,089	3,249,314	3.0	1.3
1928	1,290	4,142,039	3.2	1.4
1929	1,322	4,649,409	3.5	2.0
1930	1,267	3,833,027	3.0	1.3
1931	1,209	3,415,903	2.8	1.2
1932	1,282	3,165,540	2.4	1.1
1933	1,312	3,198,956	2.4	1.1
1934	1,256	3,215,118	2.5	1.1
1935	1,510	4,261,797	2.8	1.2
1936	1,769	5,574,452	3.1	1.4
1937	1,591	6,760,992	4.2	1.9
1938	1,522	6,201,217	4.0	1.8
1939	1,344	8,144,217	6.0	2.8
1940	1,194	11,240,974	9.4	4.2
1941	589	4,953,000	8.4	3.8
1942	315	2,648,200	8.4	3.8
1943	157	1,447,0[illegible]	9.1	4.1
1944	119	1,495,120	12.4	5.6
1945	76	974,667	12.8	5.7

Source: Japan Agar-Agar Distribution Control Company.

TABLE 6. - JAPANESE AGAR-AGAR
AMOUNT CONSUMED LOCALLY AND AMOUNT CARRIED OVER
1940-1945 Inclusive
Unit: Metric tons

YEARS	USED IN HOME CONSUMPTION	CARRIED OVER
1940	2,748	312
1941	1,582	880
1942	2,424	172
1943	1,474	276
1944	1,180	385
1945	445	589

TABLE 7. - ESTIMATE OF AGAR-AGAR PRODUCTION IN JAPAN PROPER
DEC 1946-FEB 1947
BASED ON COLLECTION OF MAXIMUM AMOUNT OF RAW MATERIAL

PREFECTURE	NUMBER OF PLANTS	RAW MATERIAL USED	PRODUCTION OF AGAR-AGAR
Osaka	178	1,635	376
Kyoto	63	578	133
Hyogo	58	532	122
Nara	1	9	2
Gifu	94	1,233	283
Nagano	170	2,868	660
Yamanashi	21	354	81
Shizuoka	8	104	24
Gumma	2	26	6
Fukushima	4	52	12
Miyagi	2	26	6
Iwate	2	26	6
Aomori	1	13	3
TOTAL	604	7,456	1,714

TABLE 8. - AMOUNT OF RAW MATERIAL PURCHASED BY THE CENTRAL FEDERATION OF FISHERMEN'S COOPERATIVE ASSOCIATIONS, 1939-1945, FROM THE JAPANESE MAINLAND AND NEARBY SOURCES
Amount in Metric tons - Value in Yen

YEAR	JAPAN PROPER		KARAFUTO		KOREA	
	Amt	Value	Amt	Value	Amt	Value
1939	11,477	17,404,968	1,687	554,850	909	662,510
1940	7,879	14,058,185	1,424	551,000	780	669,347
1941	7,621	9,043,139	1,312	330,050	640	357,147
1942	4,933	6,160,964	1,124	304,500	984	1,196,394
1943	5,451	7,700,794	---	---	100	41,138
1944	4,208	5,712,329	---	---	---	---
1945	1,160	2,867,126	---	---	17	5,103

YEAR	FORMOSA		SOUTH SEA ISLANDS		TOTAL	
	Amt	Value	Amt	Value	Amt	Value
1939	168	216,760	233	89,525	14,474	18,928,633
1940	160	242,650	137	62,192	10,380	15,583,375
1941	147	145,762	---	---	9,720	9,876,100
1942	127	76,578	36	11,680	7,340	7,750,117
1943	65	36,200	113	38,653	5,728	7,816,787
1944	55	53,364	---	---	4,253	5,765,693
1945	34	32,251	8	637	1,211.8	2,905,117

Source: Japan Agar-Agar Distribution Control Company.