UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

15832

CULTIVATION AND PROCESSING OF SEAWEEDS

by Y.Blinova, Y.Voronova, VNIRO,Moscow, USSR

Seaweeds and seagrasses growths are characteristic of the costal shallow water areas. In moderate latitides they form veritable underwater meadows and forests composed primarily of brown Laminaria (Laminariales) and (Fucales) seaweeds and in tropical and subtropical zones - of sea grasses, red and sargass seaweeds. The world ocean numbers over 8 thousand species of macrophytes (seaweeds). However the major part of biomass is provided by a few genus and species. The largest amount of biomass is produced by Laminaria. The following geni of seaweeds are the most widespread ones - among the brown seaweeds: Laminaria, Marcocystis, Nereocystis Undaria, Alaria, Lessonia, Durvillea, Fucus, Ascophyllum,Sarngassum among the red weeds: Gracilaria, Gelidium, Eucheuma, Hypnea,Chondrus, Gigartina, Porphyra, Pterocladia, Furcellaria, Phyllophora, Ahnfeltia; among the green weeds: Ulva, Entermorpha, Gaulerpa and some others.

Marine vegetation of moderate latitudes is most abundant.

The seaweeds reserves in various areas have been assessed with a varying degree of comprehension and reliability. The overall reserves of seas and oceans benthic seaweeds might be assessed in very approximate terms as amounting to 150 mln t of fresh mass (Blinova, 1985). A potential world-wide seaweeds yield amounts to 18 mln t of fresh mass (Göran, 1975)

Most mariculture experts believe that the seaweeds farming constitutes a most perspective object of artificial cultivation. Many weeds species have a high growth-rate, they do not require great capital investments for their cultivation, a feed that is in short supply or expensive, they serve as a raw stock for obtaining irreplacabe substances (agar, carrageenen, alginates, monnitol) and make good foodstuffs and fodder.

The seaweeds mariculture has a number of advantages over their harvasting in natural conditions. Weeds may be cultivated in profit-lucrative areas convenient for exploitation. The most widespread cultivation method using artificial substrates suhmerged in water offers a substantially simpler way of harvesting. The plantation crop yield is higher than that of the natural one. Genetics and selection help create forms (grades) with a higher crop yield. It appears possible to cultivate large quantities of seaweeds even beyond the area of their natural habitat.

Out of several thousand species of benthic seaweeds as few as a little over 100 are harvasted and 20-25 species are currently cultivated. The present-day world yield of commercial seaweeds amounts to 3,5 mln t (Yearbook of fishery statistics,1984), 70% or around 2-2,2 mln t of that amount are cultivated.

The seaweeds are rich in microelements, iodium, A,B,C- groups vitamins, carbohydrates, ptoteins; they contain antibacterial syhstances capable of stepping up anticoagulative properties of blood. Seaweeds contain saccharoses that do not induce diabetes, an increased iodium content prevents goitre from developing.

Various species of red seaweeds provide valuable, sometimes irreplaceble gel-forming substances: agar, agaroid, carrageenan. They are widely-used primarily in medicine, pharmacology, phytopathology, foodstuffs industry, perfumery and many other sectors.

The brown seaweeds provide alginates and mannitols. Alginates employed as a binding, activating stabilizing and emulgating substance in foodstuffs, textile and other industries. They are capable of binding stroncium 90 which is important for being able to extract this element out of an organism affected by it. Mannitol is increasingly used for blood transfusions.

Since times immemorial seaweeds have been consumed as food particularly by the peoples of South-East Asia. Nowadays other peoples increasingly follow suit.

Seaweeds and their processing wastes are used for producing granules employed as an integral part (1-10%) of artificial feeds. Seaweeds enrich artificial feeds primarily with microelements and vitamins. Such articicial feeds step up general condition of the stock and increase the commercial output.

Provided seaweeds are used as fertilizers the structure of soil regenerates and the growth-stimulating microelements and substances are brought into it.

The cultivation of seaweeds dates back several hundred years but its industrial cultivation began in the 50-60s of this century primarily in Japan, China, North and South Korea, Philippines, Taiwan and some other countries. In 1980 the volume of cultivated weeds amounted to: in China-1441 thousand tons, in Taiwan-11 thousand tons, Lapan - 426 thousand tons, in South Korea - 196 thou t, in Philippines - 133 thou t; (Vard, 1983). In 1980 the world output of agar amounted to 7 thou t, that of carrageenan - 10 thou t, alginates - 22 thou t (Christeller, Furneaux Gordon et al., 1983). The world demand for seaweeds, their products and prices are increasing every year. In 1982 the US seaweed phycocoloids prices amounted to: agar (powder) and alginic acid - 30 US dollars a kilo, carrageenan (commercial) - 40 US dollars a kilo, k-, λ-, and i-carrageenan - 88 US dollars a hundred grams (Gellenbeck, Chapman, 1983).

In the Chineese People's Republic the principle mariculture objects are: Laminaria japonica, Porphyra, Gracilaria, Eucheuma; in Japan - Porphyra, Undaria, Laminaria, the greens; in North and South Korea - Laminaria and Porphyra, on the Philippines - Eucheuma. In a number of countries located in subtropical and tropical areas (China, Taiwan island, Philippines, Vietnam, India, Italy) agar- and carrageenan -containing algae and mainly Gracilaria and Eucheuma are cultivated.

They are grown as a monoculture or a polyculture with fishes, shrimps and crabes. A project has been developed in the USA for cultivating Macrocyctis at ocean farms for power purpuses.

All methods employed for algae farming may fall into 3 groups: 1 - totally marine (extensive)cultivation; 2 - individual, usually initial stages of cultivation take place in regulated conditions with the marine cultivation of the end product (intensive-extensive cultivation); 3 - the entire cycle of cultivation is conducted under regulated conditions (intensive cultivation). At the present time and in the near future the most lucrative method is going to be the second one. This method permits to get guaranteed, sufficiently high and shorter term yields compared to the first method. On the other hands it is substantially cheaper, requires lower material and power consumption involved against the third method. This method of mariculture is economically more beneficial for most countries and allows cultivation in the areas where there is no natural profit-making growths and beyond the limits of the natural area. The bulk of the yield for the currently cultivated algae (around 80%) is obtained using the second method.

The first method (totally marine cultivation) reqiures insignificant material and power consumption involved, however its yield is inferior to the other cultivation methods and it is highly affected by changing environmental conditons. This method is the cheapest one and should considerable manpower be available it might become widely used primarily for the algae cultivation in closed gulfs, lagoons, coastal salt-water ponds to grow red seaweeds as a raw stock for obtaining agar, carrageenan and other gel-producing substances and for consuming as food.

The third method requires highest material and power consumption involved, it is the most expensive one. At the present time the developed countries of North America, Europe and Asia conduct experimental cultivation in special tanks. This method of cultivation should prove lucrative when growing expensive algae to obtain valuable substances.

Tables 1 and 2 feature yields and products obtained with various methods of cultivation.

Table 1

The yield of algae when cultivated in the sea, lagoons, ponds (extensive and intens've-extensive methods)

Species	Purpuse	Country	Yield, dry weight t/ha
	Brown algae		
Laminaria	foodstuffs alginates	Japan China USSR	20 20 10-15
Macrocystis	fuel foodstuffs fertilizers alginates	USA	50-70
	Red algae		
Eucheuma	foodstuffs carrageenan	Philippines	13-30
Porphyra	foodstuffs	Japan	8
Gelidium	agar	Japan	2,5
Gloiopeltis	gel-former	Japan	0,45
Gracilaria	agar	Taiwan Italy	2,0 2,5

Table 2

The algae yield (dryweight)in regulatad systems , intensive cultivation method (according to Gellenbeck, Chapman, 1983)

Species	$g.m^{-2}$ day^{-1}
Chondrus crispus	25-30
Gelidium coulterii	17
Gigartina exasperata	11-20
Gracilaria foliifera	7-18 (late summer)
Gracilaria sp.	7-16
Hypmea muscifoimis	12-17
Iridaea cordata	23-26

Neoagarhiella baileyi	6 (winter)
	20-40 (spring,summe

Various methods of seaweed cultivation are employed: a stone and rock-based one, on sea-bottom terraces; on artificial reefs; on artificial substrates submereged in water; on silty and sandy grounds of lagoons, ponds and other enclosed water spaces; in special pools and regulated water tanks. The sea-bottom seaweed cultivation is not widespread. The artificial reef seaweeds farming has and will increasingly go on heving great importance for steppin up the natural productivity of coastal areas. A method of submerged cultivation on stationaty and movable facilities using artificial substrates (ropes, nets,bands made of conveyor belts, water hoses and tyres) is the most widespread one. Brown, red and green seaweeds are culivated that way.A soft ground of lagoons and other enclosed water bodies is employed to cultivate unattached forms of red seaweeds, primarily Gracilaria. The latter method of seaweed cultivation in special tanks with regulated optimal growth conditions is employed for cultivating the most valuable and expensive weeds both as monoculture or with objects of other trophic levels.

Laminariales and primarily Laminaria japonica constitute around 70% of global volume of weaweeds. They are followed volume-wise by Porphyra, Euheuma and Gracilaria. The above species constitute over 95% of biomass provided by all cultivated seaweeds. Most seaweeds (95%) are cultivated in the countries of South-East Asia where they are consumed as food and to a lesser extent employed for extracting agar, carrageenan and alginates used in the textile industry and for other purpuses. Nearly all cultivated species may be consumed as food.

A number of recent publications (Gellenbeck,Chapman, 1983; Meer,1983; North, 1983; Robinson,1985; Wheeler, Neushul, Waessner, 1979) deal with the universal problems of seaweeds cultivation in various countries and contain data on the present-day status of mariculture, principle species cultivated, their consumption, methods of mariculture, diseases,epiphytes and methods to fight them. Research is under way in the field of commercially cultivated species of seaweeds in order to advance biotechnology involved, to intensify anti-overgrowing measures, to select new, more productive sorts (clones) resistant to diseases and overgrowing. The studies are focused on biology, ecology, life history and production capacity of seaweeds - potential objects of mariculture.

The most significant ecological factors conditioning the growth and yield of seaweeds are: temperature, illumination, biogenes, water velocity and some others. For each particular geographical area one should select the species most adapted to primarily water temperature.Illumination is generally controlled by modifying the depth of cultivation. A shortage of biogenes is generally compensated by the introduction of mineral and organic fertilizers, waste water and by pulling up biogenes-rich depth waters.

At the present time and probably in the future laminarias, agar and carrageenan-containing seaweeds and porphyra remain the principl cultivated species. The main principles and stages for biotechnology of cultivation of these groups will be discussed below.

Various species of laminarias and primarily Laminaria japonica and Undaria belonging to brown laminarias are the most mass-scale object of cultivation. China cultivates world's largest volume of Laminaria (1,0-1,5 mln t of raw mass) This seaweed is the principle object of cultivation in North Korea, South Korea, Japan, USSR.

Biotechnology of cultivating laminaries is sufficiently well developed and described . The general scheme of their cultivation is universal but it has its modifications for individual species and regions.

In their development laminaries have two stages: the sporophyte and gametophyte ones. Different species and the same species from various regions differ by thalluses sizes, time of rippening of sporangiums and spores, optimal conditions for growth and development; time of growth and resorbtion for various stages and parts of thalluses.

The process of cultivating the laminaries seaweeds consists of the following principle stages: selection of areas for mariculture, preparing for mounting the framework of plantation, preparation of planting and outgrowth substrates and preparation of mother fronds, stimulation of simultaneous mass zoospore stemming from mother fronds by drying, settling of spores on planting and outgrowth substrates, delivering the substrates with fixed and outgrowing embriospores to the sea or to special tanks with the regulated environment parameters for growing seedlings, transplanting the seedlings, cultivating the commercial product in the sea. This process is completed by harvesting the crop and its initial treatment (drying, conservation, freezing).

When looking for a place to lay out seaweed farms, special attention should be paid to biological factors of the cultivated species, regional ecological conditions and socioeconomic factors.

In nearly all countries the framework of the plantation ([illegible] construction) comprises two basic horizontally tightened 40-120 m long carrier cables placed at a 5-6 m distance from each other. A cable is tightened by an anchor or pole guys. The cables are held at a certain depth by special fixers. Ropes and calbes of different diameters (5-60 mm) made of synthetic and vegetable fibres are used for the horizontal cables and planting and outgrowth substrates.

In order to obtain viable spores, mother fronds are made either of natural seaweeds growths or they are placed in plantation's specially prepared sectors where they are grown in thinned out beds out of the biggest seedlings. The composing and delivering. the mother fronds should not exeed 1-2 hours; they must be protected from exposure and rain. Mother fronds are dried to stimulate a rapid simultaneous zoospores withdrowal. For this purpuse the plants are aired for 4-18 ours under a roof. Another method consists in airing the suspended fronds for 1-4 hours until after all water has disappeared from the surface followed by their juxtaposition with paper, rolling them in rolls and keeping them in cases for 12-24 hours.

The spores are settling on the substrates (ropes, strings) in special tanks, pools, bodies of boats. Layers of dried fronds and substrates are placed into tanks, submergedin sea water and left for 24 hours. In most cases, however, sea water spores suspension is obtained first. It is filtered through a gauze or a cloth, dissolved to a required concentration followed by submerging the substrates into it for 24 hours. The spore-induced substrates are delivered to either a marine plantation or to regulated environmental parameters tanks at special seedlings growing facilities. 2-4 cm long bits of string with 1-2 cm long seedlings are employed as planting material or 10-100 cm long fronds are transplanted on fresh ropes 1-4 plants every 10-40 cm. When cultivating seedlings in the regulated conditions the substrates are mounted on frames of various constructions; prior to its use sea water is filtered, an optimal tamperature, lighting (natural or artificial), content of nutrative substances and aeration are maintained, water is changed, the development of bacteria and microalgae is continuously monitered. The luminaries seaweeds are usually cultivated within a year or two-years cycle. Substrates with seedlings are placed on horizontal cables in the sea every 40-100 cm to obtain a commercial product. When sea water is short of nutrative matter a fertilizer is made use of. The yield amounts to 50-200 t/ha (raw weight). The food-consumed Laminaria (Sea kale) should contain up to 20-22% of water. In the Chinese People's Republic 11 special facilities produce 3 billion seedlings annually and distribute them among all state and cooperative farms of the country to yield 1-1,5 mln t of commercial Laminaria japonica out of these seedlings. (Blinova, Belov, Maksimov, 1985; Tseng,1981) In China quality L. japonica is sold for 3 yuans a kilo (US 1 dollar is worth 2?2 yuans).

Undaria pinnatifida is cultivated mostly in Japan. The volume of cultivation reaches 100 thou t. excedding this species natural yield 8 times over. (Rhodes, 1985).

Giant kelps - Macrocystis pyrifera and Macrocystis angustifolia belonging to brown laminaries seaweeds are equally perspective for cultivation. They reach 20-40 m in length. The giant kelp-oriented major research is conducted in the USA along the California shore where there is an experimental farm. A daily increment amounts up to about 3,8%. The cultivation of Macrocystis is believed to become profitable when practiced on ocean farms-platform with the nutrative matter-inreached depth waters employed as a fertilizer (North, 1980; Harger, Neushul,1982). A hectar of plantation accomodates around 1 thousand plants yielding 300-500 t of raw weight annually. Other countries such as China and France are also interested in Macrocytis.

In Japan and other countries experiments are under way with Sargassum horneri and S.muticum. When cultivated on nets (1,8 x 19 m) within a period of November through April Sargassum yielded 200-785 kg of dry weight from 1 net . The biomass is recommended to be employed as a fertilizer and for treating waste waters.(Yamauchi, 1984).

Red algae Porphyra spp. is one of the most lucrative cultivated species in Japan, South Korea amd to a lower extent in China, USA and some other countries. This species is cultivated to be consumed as food, it contains up to 40% of proteins in dry mass as well as vitamines and microelements. The methods of cultivating Porphyra are developed quite well. Japan's demand in this produce is fully met. The annual Porphyra yield in Japan amounts to around 300-350 thou t.

Porphyra spp. has two stages of growth: up to 10-50 cm long lamellar gametophyte and fibre-like microscopic sporophyte (conchocellis phase) inhabiting shells . Gametophyte produce monospores (asexual reproduction), carpospores and spermatii (sexual reproduction). 15-45 m long, 1,2-2,4 m wide frame-mounted synthetic fibre nets with 15 x 15 cm cells serve as a substrate for cultivating Porphyra. The frames are fixed horizontally on poles in the sea drying off at low and submerging at high tide or else floating facilities may be built. Collectors, usually bunches of shells, are placed into porphyra's growths that collect the settling carpospores. Fibre-like conchocells develop on the collectors out of fertilized carpospores. The collectors with conchocells on them are submerged into pools and cultivated there in optimal conditions to obtain conchospores. The developed conchospores settle on the nets in the pools. In autumn the nets carrying the conchospores outgrowth are brought over to the sea to get a commodity mass. A part of nets with the outgrowth are packed into plastic bags and frozen at minus 20-25°C. When necessary these nets are brought into the sea. The commodity Porphyra is usually grown near river mouths when the salt content is reduced and there is an abundance of nutrative substances. There are 2-4 yields in November through March. A 18 x 2m net yields 35-105 kg of raw weight Porphyra. The yield is picked by special machines. It is flushed, dried, pressed in layers and finally dried off again. Though the cultivation of porphyra has long been industrialized, this process is elaborated still further. Much is being done in the field of selection, upgrading the quality of the product, creating a media for growing porphyra within the phase of conchocells, studying the diseases and a possible preservation of living mature thalluses and availability of conchocells all throughout the year. In China a research is conducted in the area of porphyra selection and of obtaining well developing seedlings out of monospores. (Miura, Merril, 1982; Li, 1984). There are porphyra growing farms on the US Pacific coast in the Pewjet Sound bay. In this area porphyra grows all around the year. There are several yields a year. The annual growth of demand in this product amounts to 10-30%. 40 mariculture farms equiped with 300 nets each would meet the US need for this product (Freeman, 1985)

The agar and carrageenan- containing red seaweeds are cultivated in three principle ways: on a silty and sandy bottom of shallow lagoons and artificial brackish water ponds; on nets and ropes submerged in the sea; in special tanks with partly or totally regulated environmental (habitat) parameters, that are mounted in the open air conditions or in hothouses. In general a large-scale yield is currently obtained using the first two methods of cultivating Eucheuma, Gracilaria ans to a lower extent Gelidium. Numerous successful experiments are under way with such seaweeds as Chondrus crispus, Gigartina, Hypnea, Iridaea, Pterocladia.

There is a great volume of cultivating Eucheuma spp;, a red tropical seaweed consumed as food and used for producing carrageenan. Philippines is the main center of cultivating it. In 1980 the volume of locally cultivated red seaweeds amounted to 133 thou t, the bulk of the yield being that of Eucheuma. The farms are located among the reefs on shallow waters protected from storms and with good streams available. Eucheuma is cultivated on nylon nets mounted horizontally (2,5 x 0.5 m). 1 hectar accomodates 800 nets with 100 thousand bunches of plants fixed to them each weighing 200 grams. An experienced worker plants 2-3 nets an hour. Annually there are 4 yild. amounting to the overall mass of 13-30 t/ha (dry weight).

Coral reff-located plantations of 2 species of Eucheuma have been launched in China where there are 250 ha of plantations with the annual yield of 300 t of dry seaweeds (Liu, Zhuang, 1983) Tanzania has set out to study 5 species of Eucheuma and to locate regions suitable for their farming. One of the species-Euchema musciformis is experimentally cultivated in tanks in the USA. A maximum daily mass increment amounts to 20-31% at 12,2 kg/m^2 plant density. Calculations indicate that in order to obtain 1000 t of dry seaweeds the cultivation pools surface should amount to 10 ha and the overall cultivation area - to 24 ha.

5 species of Gracilaria are cultivated at an industrial scale, but the main cultivated species is Gracilaria varrucosa. Gracilaria has a high growth rate, it is eurytherm, inhibits eutropic waters polluted by wastes at depths of 0,5-4 m; it may produce polyploids wich opens up wise opportunities for selection; it has a high agar content and may be consumed as food. There are attached and unattached fors of Gracilaria. The unattached form is of the vegetable reproduction. Within the life cycle of the attached form there is a juxtaposition ofisomorphic generations of gametophyte and sporophyte, it has a high reproductive potential. The unattaced form of Gracilaria is cultivated in shallow lagoons and ponds mainly where an optimum level of salinity, temperature and nuitrative matter is maintained by using non-organic and organic fertilizers and wastes. The yield amounts up to 3-10 t/ha of dry weight. When cultivating Gracilaria and some other red seaweeds species the overgrowing is a problen hard to solve. Gracilaria may be cultivated in policulture with crabes, shrimps and other objects.

When cultivating Gracilaria submerged in seawater the nets and ropes are mounted 0.5-2 m deep in a way similar to Porphyra cultivation and the ropes are attached to horizontal cables of the frame. Frond bunches weighing 20-100 gr are intertangled with ropes and nets. There several yields a year. Every yield amounts to 3,5 kg of dry mass per 1 m of rope annually. When cultivating Gracilaria in tanks one may expect to yield 24 t/ha of dry weight annually at 2-4 kg/m^2 planting density.

The largest amount of Gracilaria (several thousand ton) is cultivated in lagoons and ponds of the island of Taiwan.(Yang, Wang, 1983)

Gracilaria is also cultivated in ponds of Tailand: the annual yield amounts to 7 t/ha a year, agar content - 30%, agar output - 180 t.(Edwards, Tam, 1983). Gracilaria is also cultivated in a lagoon on the island of Sicily: the yield is 12 t/ha.In the Caribbean countries edible Gracilaria costs 6-6,5 US dollars a kilo. Intensively exhausted, the natural Gracilaria resources are getting reduced. The International Development Research Centre based in Ottawa, Canada has launched a program of cultivating this species back in 1980. In the West Indies an annual Gracilaria yield may be expected to reach 10 t/ha of dry weight (Smith, Nichols, McLachen, 1983,1984). The US annual tank-based Gracilaria yield amounts to 127 t of dry mass (Lapoint, Ryther, 1978). The Chinese Peoples Republic suggests to use the same plantations for cultivating Gracilaria jostedtii May through November and Laminaria japonica December through May. This joint cultivation is economically more profitable.(Li,Chong,Meng 1984)

Research and scientific efforts and the red algae experimental cultivation are under way in a number of countries (USA, Canada, France and some others). In California, USA there are experimental farms for studying and cultivating 2 Gelidium species. These species biomass increment amounts up to 1,26% a day. The Gracilaria cultivation farms are believed to be able to become profit-making by stepping up yields via fertilization and selection. Dry Gelidium's price is high (2 US dollars a pound) and goes on rising. (Harger, Neuchul, 1982).

The green algae are cultivated at a lower scale mostly in the countries of South-East Asia. They are consumed as food since they contain up to 26% of proteins, and also as fertilisers and for treating waste waters. A number of Monostroma, Ulva, Entromorpha, Caulerpa, Cladophora species are also cultivable. In Japan Monostroma litissimum is net-cultivated. A single 18x2m net yields thrice a year an overall amount of 26 kg of raw algae. In Philippines Caulerpa racemosa is cultivared in 5-100 cm deep artificial ponds and on the mangrove area littoral since 1950. (Horstmann, 1983)

Fighting diseases, epiphytes, grazing by the invertebrates constitutes a major problem of algae cultivation. 2 groups of diseases may be identified: those induced by unfavourable environmental conditions (physiological) and by various types of infections (infectious). The physiological diseases are dealt with by creating more favourable conditions for a further growth by reducing the density of planting, by fertilization, modifying the depth of cultivation, delivering the algae facilities to better water circulation areas etc. The same methods help treat the infectious diseases but various chemicals including antibiotics are also used. The epiphytes are fought against by the following methods: using specific algaecides, shaking the cultivated species, controlling and pulsing the nutrative matter in. The biological method of dealing with the epiphytes suggests the use of animals that selectively consume exclussively the epithytes. Only those species should be cultivated that undergo low epithytes overgrowing and selection should be conducted with this in mind.

In the Chinese People's Republic; Canada, Norway, USA, Sweeden and some other countries efforts are made to select productive, adapted to certain conditions, diseases and epithytes - resistant, containing an increased amount of nutrative substances clones of Laminaria, Porphyra, Gracilaria, Gelidium, Chondrus . For the last 25 years high temperature-resistant and highly productive clones of Laminaria japonica have been selected and cultivated in the Chinese People's Republic to yield over 1 mln t. The work is going on in this direction.

The chinese, US, sweedish experts in genetics and selection of aglae recur increasingly to the method of tissue culture. This method is employed to study, reproduce and preserve the genotypes of various types of algae.

A new way to cultivate algae consists in growing them in the atmosphere saturated with water vapours rather than in water. (Moeller, Garber, Griffin, 1984).

The USSR possesses considerable resources of natural algae, hence the emphasis was laid on probing into the natural raw resources and their rational exploitation. For the last 10 years attention was increasingly focused on mariculture due to a reduction in natural algae resources badly affected primarilly by the anthropogenic influence namely pollution, eutrophication and intensive exploitation. Besides, the demand in algae and its products is rising with every passing year. The cultivation of algae will remove a shortage in raw algae and will help preserve nature.

In the USSR the seaweeds cultivation is handled by scientific and research institutes of the USSR Ministry of Fishery and the USSR Academy of Sciences. The maint effort of these bodies in the field of commecial seaweeds cultivation is aimed at identifying the most lucrative species of seaweeds to be cultivated in various seas and regions, at developing the biotechnologies of cultivating seaweeds both as an extensive sea culture and as an intensive-extensive culture (seedlings in regulated conditions at special facilities with a further sea cultivation) and as an intensive culture (factory cultivation). It is highly probable that the intensive-extensive method of commercial seaweeds cultivation will emerge as the most lucrative one here like elsewere.

The USSR is interested in advancing the research to perfect the biotechnology, to create more productive cloned of seaweeds with predetermined properties, in prevention and fighting diseases and epiphytes,in raising the profitability of the mariculture farming and in identifying the regions suitable for cultivating commercial seaweeds from the ecological, social and economic viewpoint.

In the USSR boral seas and primarily in the Sea of Japan, White and Barents seas Laminarias appear to be the most perspective species for the cultivation (Blinova, 1984) The japanese laminaria (Laminaria japonica) is cultivated in the Sea of Japan since 1972 and currently there are three farms here with a total plantation area of over 100 hectars. The cultivation is conducted in a two-year cycle. The yield amounts to 70-100 t/ha (raw weight); The Laminaria plantations are located in different ecological and climate zones, hence the different periods of ripenning for zoospor formation of substrate spores, appearance of seedlings and yield collection of various farms. The periods of sporification and those of substrates sporing, most favourable ecological conditions for the development of different stages of Laminaria japonica, particularities and growth-rate of sporophytes in various seasons of the first and the second year,deadlines for pulling up and lowering the outgrowth substrates have all undergone study and the deadlines for collecting the yield have been positively identified. Work has begun to shorten japanese laminaria's two-year cultivation cycle so that it would become a year-long cycle.

This necessitated an aquisition of early ripe zoospores (July-August). Methods of selecting the fronds having a tendency towards an early sporofication have been found. A method has been worked out to stimulate an early zoospores ripenning by a specially chosen regime of feeding and exposure for a faster accumulation of amino-acids promoting frond's reproductive tissues growth. . A technological scheme has been elaborated for a short-term shop-based cultivation of laminaria seedlings. The chemical composition of the Laminaria japonica cultivated thalluses has been studied. (Makienko, Maltsev, Krupnova,1981; Buyakina, Podkorytova, 1983) In order to produce more alginates it is necessary to begin cultivating Costaria costata in the Sea of Japan. This species has a number of advantages over Laminaria japonica: a shorter life cycle (1 year), the spores ripen and outgrowths break out earlier and they are less demanding to the environment (Makienko, Moiseyenko, 1980).

In the USSR boral seas Laminaria saccharina , L, digitata are the most lucrative species for the artificial cultivation. (Blinova,1984;Makarov,1982). Since 1975 biology has been studied and biotechnology developed for cultivating Laminaria saccharina in the Barents and White Seas. It was proven that Laminaria saccharina might be cultivared in the Barents and White Seas in the two-year cycle. The average length of laminaria's frond grown on the rope-based substrates submerged in sea water amounts to 2-3 m, their mass is 400-500 g, the maximum mass being 1-1,5 kg, the expected yield - 50-100 t/ha, the yield is collected in July-August.

An experimental plantation was set up in the Barents Sea in 1983. The experimental large-scale cultivation of L. saccharina at the plantation facilities has made it possible to test the results of research condusted for so many years. The plantation-grown laminaria was good both for using it as food and for extracting alginates and mannitol. The yild amounted to 55-60 t/ha of raw weight. (Blinova, Makarov, Khokhryakov, 1986) The Barents Sea-based Laminaria saccharina yield is similar to the one collected on the Laminaria japonica plantations located in the USSR Far East and in Japan.

The problem of agar-containing algae mariculture appears quite urgent and practically important. Unfortunately most high yield agar-containing algae of the USSR seas have a slow growth-rate, they reproduce their resources poorly and in general their cultivation is deficient. The most perspective spicie from the viewpoint of cultivation is Gracilaria verrucosa having a high growth-rate (Makienko,Maltsev,Krupnova,1981). The biological study of G. verrucosa and the elaboration of its cultivation's biotechnology are conducted at sea and in regulared tanks conditions in the Sea of Japan and the Black Sea. A factory method of cultivating Ahnfeltia and Gracilaria is being developed in the Far East.

Experiments are under way aimed at increasing the overall mass of Furcelaria, a commercially lucrative red weed found in the Baltic Sea area by setting up artificial reefs and mounting additional fixed substrates at sea. The initial inspiring results have been obtained.

At the present stage the industrial algae processing has reached significant proportions. Primarily it is related to a substantial content of organic substances in algae (up to 70% of polysaccharides, around 30% of alginic and other acids). The algae tissues are marked by a lable content of dry substances - 8 through 30%, the accumulation of minerals - 10 through 25 correspondingly, a level of organic substances content depends on biological and ecological causes, the season and the area where the algae are located.

Table 3

Plant group	Ether soluable	Protein N x 6,25	Cellulose	Other nonnitrogenous non-lipid organic matter	General organic matter content
Red algae Porphyra-3 species Gelidium, Ahnleltia Furcellaria, Phyllophoria etc.	0,1-2,8	12,0-44,4	5,1-15,8	45,1	76,4-94,0
Brown algae Laminaria-12 species Sargassum-5 species Fucus -8 species Costaria, Alaria etc.	0,35-3,8	4,6-23,5	5,7-14,4	32,6	50,0-76,0
Green algae Ulva, Enteromorpha	0,7-2,3	10,1-25,0	2,1-6,5	61,1	75,6-88,6

The seaweed raw material is stored by harvesting cultivated and natural growths at their habitat.or by collecting washed away weeds. Freshly harvested seaweeds are unstable due to organic matter decomposition, therefore they are consumed either fresh or they are conserved by way of natural and artificial drying, freezing and chemical conservants treatment. (Chapman, 1980)

The red and brown seaweeds are specifically valuable by the content of their organic matter which makes it possible to obtain the products that are impossible to get from the land-grown plants. The red seaweeds industrial processing is aimed at extracting polysaccharides-carrageenan (fractions: kappa,lambda, jota), furcellaran, agar, employed by the foodstuffs industry as gel-formers and thickenners. These polysaccharides have a common characteristic feature determining a universal technological approach to their extraction. These polyssacharides always contain monomeric galactose, the relationship between gelactose remnants -$\alpha(1 \rightarrow 3)$ and $\beta(1 \rightarrow 4)$; they contain a galactose derivative -3,6 -anhydrogalactose; a considerable amount of sulfate, the amount of sulfate content in agar is below 6 %, in danish agar-furacellars -13-18%, in carrageenans - 20-35%; agars and carrageenans molecular weight is within the range of 100 thou. As to the structure of agars, they contain two polysaccarides - agarose and agarpectin. Whereas agarose contains no sulfate at all, agaropectin contains around 10% of it as well as D - glucuronic and pyruvic acids. Furcellarans and (kappa, lambda and jota) carrageenans contain D-galactose and 3,6-andhydrogalactose with a certain sulfate content varying in different types of carrageenan.

Carrageenans, agar, furcellaran are employed in the foodstuffs industry due to their valuable qualities: a capability to form gels and availability of viscous and a number of other technological properties. They are soluble in water: sodium carrageenan and lambda -carrageenan - in cold water; kappa-carrageenan-in hot water at 50°C, furcellaran - at 70°C, agars - when boiling. Under the influence of electrolyges the carrageenans gel-formation is stepped up and when substituting sodium by calcium they form thermotransformeble gels. Mixing the carrageenans permits to reach necessery elasticity or texture . At the carrageenans reaction with proteins and saccharines they stabilize milk and fruit mixtures. The 1,0-1,5% carrageenans solutions gels have their melting point within the range of 35-80°C (Dano,1976).

The carrageenans may be extracted of the following seaweeds: Chondrus, Gigartina, Iridaea, Eucheuma, Hypnea, Furcellaria, Phyllophora. It is noteworthy that carrageenans of these seaweeds contain two fractions, for instance the kappa or jota gel-forming fraction and the lambda thickener fraction.

In a number of countries (USA, France, Denmark, Philippines, Spain, Great Britain, Rumania as well as Japan) the production of carrageenans, furcellarane is based on the technology made up of the following major processes: extraction; purification of carrageenan, bringing it out of solution and drying (Martin, 1984).

The sxtraction of carrageenans boils down to keeping washed seaweeds in an alcali or salts warmed or lukewarm solutions. Depending on the product to be extracted, the temperature of extraction, concentration and a reactive and raw material ratio are selected accordingly.

When extracting lambda carrageenan the operation is carried out in a large hydromodule at a moderate temperature; while extracting kappa and jota carrageenan the process requires an increased temperature and a low hydromodule to be employed.

Upon mixing the carrageenan solution with diatomite, a cellulose powder, carrageenan is purified by filtration. The alkali solution-based derivation of carrageenan is accompanied by a simultaneous extraction of soluable salts, pigments whereas the totality of cellulose components, hemicelluloses and a larger part of protein remain unsolved and are removed.

The extraction of carrageenan from the solution (filtrate) is alcohol-based. A water extract containing 1% of dry matter is poured into alcohol (isopropanol or ethanol). Efforts are made to decrease the amount of alcohol used for extracting carrageenan. There are methods of carrageenan's purification, concentration and clarification by treating the extract in different filtration modules of different designes equiped with ultrafilters (Strong, 1975, Kosaka Masumi, 1984).

Carrageenan falls out as a sediment in highly concentrated alcohol. In certain cases it is gel-like. Potassium chloride is added prior to the alconol treatment to ameliorate the dehydration of tissues. The sedimentation is also possible when carrageenan is frozen. With this method employed for the seaweeds containg a large amount of kappa-carrageenan (phyllophores, furcellarias), potassium chloride is added to the filtrate. A gel-like sediment is collected and frozen with a resulting separation of crystallized water. After washing it up in the potassium chloride solution, the sediment is pressed to remove the largest amount possible of the salt solution. After this the sediment is vacuum-dried till a 10% humidity is attained in it, then it is pulverized so thar the diameter of perticles ranges 200-300 microns.

The method of extracting, say, jota - carrageenan differs. (US Patent 3849395). When extracting jota - carrageenan out of Eucheuma spinosum, Agardiella tenera in order to step up a gel-forming capacity it is modified in the potassium hydroxide solution followed by its neutralization till it reaches pH 8. The Citric acid (pH 3) is added to the jota-rarraggenan solution which is followed by heating till 82°C and held that way for 4 hours. Then sodium alkali is added till pH 7 and the solution is cooled. The processes that follow are similar to those employed for extracting other carrageenans. The use of the above technology allows to extract rather pure carrageenans.

In conformity with the carrageenans quality and properties, assessment chart worked out by The National Center for Coordination of Foodstuufs Researgh (France) they should meet the following requirements (Rioux, 1984):

Appearance - yellowish or colourless powder

Taste - vegetable slime

Content:

humidity - below 12% following a 4-hour long 105°C drying

ethanol or
isopropanol - below 1%
(dry matter)

sulfates - over 15% and under 40%

ash unsolved in
1% sulphuric acid
solution - under 2%

ash - over 15% and under 40% of dry matter following a 550°C calcination.

viscosity of 1.5%

solution

at 75°C - over 5 cP

In accordance with the established norms the content of metalli impuriries (mg/kg) constitutes: zinc -10; arcenic -3; copper -25.

In the USSR the agaroid and furcellaran gel-formers are derived from Phyllophora nervosa and Furcellaria fastigiata seaweeds containing carrageenan at an industrial scale.

The technology of extracting these gel-formers varies due specific natural features of the seaweeds containing polisaccarides but basically the production is similar to the technologies of processing the carrageenan-containing seaweeds employed in other countries.

When extracting agaroid and furcellaran, particular attention should be attached to the preparation of seaweeds prior to the extraction allowing to remove soluable salts, nitrogenated matter, low-molecular polysaccarides; it modifies the structure of high-molecular polysaccharides and substantially shortens the time and reduces the effort spent on extracting the product. Processing Phyllophora with the hydrochloric acid followed by the sodium alkali neutralization results in ptoducing agaroid used for making sugar-based mixtures because the use of this treatment affects the stability of water solution agaroid gel. (The USSR Inventor's Certificate 938902)

Treating seaweeds with hot sodium alkali solution (2% concentration and more) suggested for extracting from Phyllophora a gelformer named "Phyllophorin" makes it possible to extract a highly stable gel product, especially so when mixed with 70% of sugar, and amiliorates gel-formation properties of water solution (The USSR inventors certificate, 603367)

To secure a relatively total gel-formers extraction it is conducted at pH 6,5-7,5, within the 1:15 through 1:30 raw material and extragent ratio range at the temperature of 98-100°C in a battery of extractors or using the method of continuous diffusion which proves to be most effective (Boydyk, 1974). The effectiveness of extracting furcellaran in a week alkali has been substantiated (Pyay, 1980).

The choice of the technology for extracting carrageenan is determined by the direction of its further use. From the economic viewpoint it is lucrative to extract a purified product (making use of the technologies employed in the countries of Western Europe and Japan). This product could be effectively utilized very sparingly in the foodstuffs technology which would decrease its consumption as a whole.

The data concerning the use of carrageenans for producing foodstuffs is summarized in Tables 4 and 5 (Martin, 1984)

Table 4

Volume of world sale and consumption of carrageenans (1982)

Country	Population, mln	Carrageenans sales, t	Carrageenans consumption: Foodstuffs Industry, t	Carrageenans consumption: annual per capita, g
USA	240	3200	2700	11
Great Britain	55	1700	600	11
Japan	110	1700	1400	13

Germany	60	1700	1100	18
France	55	1500	1000	18
Other countries		4200	2800	
	Total	14000	9600	

Table 5

Use of carrageenens in France

Use	Foodstuffs	Principle functions	Doses used, %
In water	desserts	gel-formation	0,8-1,2
	Low-calories jams	gel-formation (little sugar)	0,5-1,0
	additives to fruit juices, syrups	suspensions	0,1-0,5
	edible dressing (for frozen fish)	gel-formation	0,8-1,2
	jell souces	thickenning	0,4-0,6
In milk	concentrated milk	fat, protein particles stabilization	0,01-0,02
	cocoa with milk	prevents cocoa from subsiding	0,02-0,03
	pastry cream	thickenning	0,2-0,3
	milk jelly	gel-formation	
	ice-cream	mixed with other stabilizers	0,01-0,05
	milk drinks	giving shape	0,1-0,4
	whipped cream	stabilization	0,05-0,5

In the USSR agaroid, fur-cellaran along with food agar are mainly used for producing confectionaries and ice-cream.

Table 6

Use of agaroids, furcellarane and agar in the USSR

Items	Doses used, %		
	agaroid	furaccelaran	agar
Fruit jellies	0,3	0,2	-
Fruit fudge	-	-	0,6
Marshmallow	-	-	0,9
Pastry cream dressing	-	0,8	0,04-0,15
Pasry cream	-	0,8	0,04-0,15
Candies filling	4,0	-	1,5
Ice-cream	0,01	-	0,01

Gelidium (16 species), Pterocladia (4 species), Gracilaria (6 species), Ahnfeltia (2 species) are used for extracting agar.

In recent years while extracting agar the attention is focused on treating the seaweeds prior to extraction. It consists in cold and hot water washing, soaking in alkali and acid solutions and it is aimed at raising the yield and stability of agar-gel. In Argentina, Mexico, India, Shri-Lanka, Chili, Japan and Vietnam Gracilaria is treated by a 2-10% concentration sodium hydroxide solution. In Japan the use of this method stipulates that the quality seaweeds are processed for 2-3 hours at 85-90°C, whereas the low-grade weeds are treated for 0,5-2,0 hours at 70-75°C correspondingly (Okazaki, 1970).

In a number of countries seaweeds are processed by acid solutions, sometimes after soaking in alkali. At a plant in Chile Gracilaria is first soaked in a 2,5% solution of sodium hydroxide for 1,5 hours, then washed in a 0,3% sulphuric acid solution, washed again following which agar is extracted.(Chapman,1980).

The employment of alkali or acid treatment speeds up considerably the agar extraction process. In the case of Gelidium it goes down from 4 to 0,5 hours. In Japan the temperature employed for extracting agar depends primarily on the type of material: the extraction out of Gracilaria, easily boiled soft is carried out at 100°C, and that out of Gelidium, that is hard to boil - at 125°C in autoclaves.

The purification of extracts is made up of sedimentation, filtration and centrifugation whereas water soluble, dying , protein and mineral matter is removed by washing and gel-pressing, ion exchanging resins treatment,extract's diatomite treatment and treating it by activated carbon (Cooper, 1977; Selby et al., 1973).

The dehydration of purified extracts (gels) holding 99 and 90-94% of water is an important and complicated operation. In Japan when extracting quality agar from Gelidium Annafeltia gel8s freezing out in natural conditions is recurred to. The agar dehydration for the purpuses of food is carried out by pressing gel like agar, out and its drying. Most agar-extracting enterprises in Spain, Latin America, South-East Asia employ atomization to dry the agar extract or its drum drying which is detrimental due to a modification in gel-forming properties, stepping up production's power consumption at the same time.

In the USSR agar is extracted from Ahnfeltia plicata inhibit the White Sea and Ahn. tobuchiensis of the the Far-East Seas. The agar-extracting technology involves a raw material treatment by 0.3-0.5 solutions of calcium hydroxide. Polisaccharide is obtained by continuous avtoclave extractions at 120-125 C at 1:12 raw material - extract ratio. In order to remove mechanic impurities the extract is filtered and decanted. After having been decanted the extract is cooled. The gel is cut in plates, washed in water, bleached in sodium hypochloride. The most effective method of purification consists in sedimentation of non-agar matter by adding a calcium carbonate suspension to the Ahnfeltia agar extract on the basis of 200-300% of calcium oxide to the extract dry matter and a consequent centrifugation.(Kaslyukov, 1971).

There are sevsral methods of dehydrating the agar-containing gels in the practice of processing Ahnfeltia. One of them consists in melting the washed gel, separating the remaining impurities out of the solution thus obtained, concentrating it in a vacuum-drier and drying it by atomization or by drum-drying. Another method is used for extracting quality agar. It stipulates that the product is dried following the defrostation of agarold obtained by freezing both in natural conditions or after gel's dehydration by pressing. (Kaslyukov,1971).

In recent years a sublimation drying method is increasingly applied for drying agar gels, permitting to obtain a quality product.

Methods of extracting agar in the world practice of processing the agar-containing seaweeds are similar. A certain difference is due to varying raw materials and production potentials.

The share of extracting and using agar for making foodstuffs is lower than that of carrageenans in all countries (excluding

Japan). The unique properties of frozen agar, that is its ability to produce elastic, stable and transparent gels are effectively employed in other sectors, basically in medicine.

A biochemical particularity of Laminaria, Boklonia, Macrocystis, Bisenia, Fucus, Ascophyllum, Sargassum brown seaweeds consists in the amount of alginic acid salts they contain.(around 30%). The alginic acid, some commercial alginates are characterized by a high molleculor weight -around 200 thou., and their solutions have considerable viscosity ranging 100-600 centipoises (cP).

The industrial production of alginates in the USA, France, Norway, Japan and the countries of South America generally embraces: a pretreatment of seaweeds, extraction of alginates, filtration of their solutions, sedimentation of the alginic acid, obtaining a soluble form of alginate.

Acid pretreatment of seaweeds permits to remove soluble mineral and organic matter, to make alginic acid salts soluble (Hardihorst, 1977; Mateus et al., 1877; Duville et al.,1974). Then the alginates are extracted from seaweeds in an alkali solution (pH 10) making use of mainly sodium carbonite (Haug, 1868; Okazaki, 1971). After having been mixed with an adsorbent the alginates solutions are purified with various types of filters, used consequtively, centrifuged, separated, floated. A combination of these methods is frequently employed. (Chapman,1960; Wright 1973; Hasebe, 1978)

The sedimentation of the alginic acid is caused by oxidizing the purified solutions till it reaches pH 1.5-3.0. The sediment of alginic acid is washed in cold and hot water, bleached in sodium hypochlorite, washed in alcohol, then dried in vacuum in an infra-red source drier and powedered (Chapman, 1980). The alginic acid serves as a semifinished item for obtaining various alginates including sodium alginate and calcium alginates employed in foodstuffs technology.

At the present moment the USSR does not extract alginate for food producing technical sodium alginate instead. However the research centers of the country are active in searching for the ways to perfect technologies of extracting the alginic acid and alginates out of Laminaria saccharina, Laminaria digitata, Laminaria japonica (also the cultivated one), Fucus vesiculosus, F. serratus.

Thus it has been positively established that treating Laminaria with weak mineral acids solutions to remove salts and organic compounds promotes an increased alginates yield and a stepped up viscosity of its solutions (Podkorytova,1985). The purification of alginate solutions consisting in filtration of watersolved animal glue after sedimentation followed by removing seaweeds minute particles by way of electroflotation has also proven effective (Vrishch, 1976). A suggestion has been put forward to treat Laminaria twice by a weak solution of hydrochloric acid followed by washings and the extraction of sodium alginate to increse the yield and to shorten the duration of the process. The yield of alginate constitutes 21% of dry seaweeds, the molecular weight is 90 thou. This technology excludes the operations of alginic acid sedimentation and its washing. (The USSR inventor's Certificate,1113078).

The world practice of extracting the alginates (in Great Britain, USA; Norway, France, Chile and India) used also for foods among other things is indicative of the economic effectiveness of processing brown seaweeds. Along with the carrageenans, alginates are widely used in foodstuffs technology. The effect of these hydrocolloids is similar to that of carrageenans apart from the fact that along with the texture formation they are capable of imparting the necessary organoleptic properties to food mixtures making them elastic, stable and thickened.

Table 7 indicates characteristics and principle uses of some alginates produced by Protan company (Norway).

Table 7.

Use of alginates in Norway

№	Trademarks of alginates	Viscosity % solution cP	Principle use	Notes
1	2	3	4	5
1.	Protanal S	600	Foodstuffs	1-8 - sodium alginates;
2.	Protanal SF	600	same	
3.	Protanal L	250	same	
4.	Protanal LF	250	same	9 and 10 - sodium-calcium algonates
5.	Protanal DG3	250	gel	
6.	Protanal JC	250	ice-cream	
7.	Protanal JCL	250	ice-cream	the colour of dry alginates is white;
8.	Protan Frostgel powder S.	10-30	meat, fish freezing	
	Protan BR, SF, ABHF, ABH, ABHR, ABHF, SPH, SFPH	10-30		pH of solutions - 6-7
9.	Protanal VR		cakes	
10.	Protonal VR 687		cakes	

Hydrocolloids extracted from seaweeds should not be considered as food seasonings because they are known not to be digested by human organism, but in a number of cases they constitute an indispensable technological additive making a product formation possible. In the countries of the European Economic Community (EEC) (in France and FRG, for instance) a permitted daily consumption dose for adults is: carrageenan - 19,3-22,7; alginates - 8,6-10.1; agar - 7.7-9.1 (Kuhnert, 1980).

The strategy of controlling a content of hydrocolloids in food their intensification and the requiremants they are to meet, methods of analyzing their content (reliability, quickness, precision and reproducability of results) - all these problems were treated at the "-nd International Conference on the "Gums and stabilizers in the foodstuffs industry" that took place in Wrexham , Wales, G.B in June 1983 (Phillips, 1984). Besides, in the framework of the EEC countries the discussion focused on using hydrocooloids in various foodstuffs including the canned ones. Also discussed were the problems of permissible doses for a daily consumption and those of specifying their purity.

Research is conducted to standartize the equipment (rheolographs, viscoelastometers, texturometers) securing high- precision results of a modification of characteristics for the systems mixed with hydrocolloids to determine the optimal regimes for processing and preserving foods.(Fiszmenn et al.,1982). At the same time the necessity is discussed of reducing a great deal of rheological characteristics and of selecting several parameters reflecting the conduct of hydrocelloids in solutions and gels.

A number of countries, primarily those of Far East Asia (Japan, China, North and South Korea, Philippines etc.) widely consume natural and cultivated seaweeds as food.

In this situation the attention is focused on working out the processes of their conservation to retain their nutrative value and attractive commercial.appeal. Fresh seaweeds to be preserved by freezing or drying undergo decoloration by acetic acid treatment with an ensuing washing and airing in the sun or by hydrogene peroxide treatment with the presence of acetic anhydride (Masaro Sigehiro, 1974.) In Japan around 30 items of fish, mollusc, vegetables, vinegar, sugar, souces, flour (noodles, vermicelli) mixetures based solely on Laminaria are produced and sold.

Tableted and granulated grain-like flour or lactose-based fresh products are prapared from Undaria to make the maximum use of components beneficial for human organism. (Ikue Takao, 1981).

In the Mediteerenean countries Sargassum is used for preparing semifinished dishes packed in plastic bags, freeze-mixed with carrots, fish or tomato souce. The products have a low calories content, however they incorporate vitamin C, iron, iodium, thus meeting adult's daily demand in them. (El-Dashlouty, 1982).

The peoples of the Orient (Japan, Philippines, Vietnam) traditionally employ liquid taste seasonnings based on consentrated extracts from brown seaweeds and glutominates. Sweet sandwich pastes are also prepared that contain Laminaria and Underia-extracted paste-like mass mixed with a fat-free fish meal, dry milk, sugar, white miso, honey, crushed sesame seeds (Kobaynsi Tosikharu, 1980).

Upon completion of the compaign of aluating the digestability of various foods containing seaweeds-based dishes, highly nutrative products containing Laminaria powder or paste added in 2-15% to meat, bakery, stuffed sterilized fish products as an edible dressing for packaged filets are growing ever more popular. (Askar,1982; Herve, 1984; Pilnik et al., 1984, Ofstad, 1983).

In the USSR food-used Laminaria japonica and Lam. saccharina apart from being crushed to powder, flour, granules are also preserved in frozen, dried, salted and marinated state. They are commonly used in cooking and the canned foods production. Depending on the type of canned food it is made up of vegetables, fish, mollusc meat, sugar syrup, tomato juice and spices along with seaweeds. (Yevleva, 1979).

Complex processing of seaweeds (in Japan, China) is a principally novel trend that is economically sound especially for the cultivated brown seaweeds because it is aimed at maximum possible extraction of this material's valuable components. Using stage extraction and organic solvents, fractions are extracted of lipids, vitamins and other biologically active matter (mannit, pigments) to be employed in medicine and other sectors. Hot water is used for extracting the alginic acid, polysaccharides (for the foodstuffs industry) and seaweed sediment (for feeds) (Tomikanera Takasi, 1984)

The development of industrial stock-breeding causes a necessity to search for the ways to utilize seaweeds as animal feed. It is widely known that the brown seaweeds (fresh, water washed, chopped, boiled) are used as an independent feed or as an additive to the daily diet of animals. The complex of valuable matter contained in seaweeds permits to use them primarily as a vitamin and mineral additive. (Table 5).

Since long ago and up to the present time the animal atock of various coastal countries of the worls is kept on "marine" pastures during the ebb-time where they feed on seaweeds. In Iseland sheep, cows and horses graze on such pasrures throughout the winter and in certain regions in summer too. Generally horses prefer Laminaria fedding on young thalluses, cows appreciate Rhodymenia and Alaria.

In Norway sheep are regularly kept in coastal areas. In Scotlend cows and sheep graze on coastal pastures where they feed on various species of seaweeds. In the Orkney Islands and other small islands there are local breeds of sheep that graze seaweeds all their life through. In France, in Normandy and Bretagne along with the natural breeding on pastures, there is a stall breeding when the animals are fed with a mixture of [illegible] seaweeds washed in fresh water and bran. On the american coast too cows and poultry feed on fresh seaweeds. On the Comaror Islands seaweeds are an integral part of the daily diet of Arctic foxes. The experiments carried out in Cuba have indicated thet an Ulva additive amounting to 10% of the daily diet has increased the growth-rate of poultry.

The production of flour based on seaweeds has been launched in a number of countries. The world production amounted to over 100 thou t with Norway occupying the leading position(Lavrovskaya,[illegible]

The seaweeds-detived flour steps up the yield of dairy milk, poultry eggs and sheel wool yield and cuts down the incidence of animal tuberculosis and stomatit. The addition of 3% of flour t daily diet meets aminals demand in calcium, phosphorus and vitamins (Kizewetter, 1980. The Ascophyllun- based flour digestion ratio (per dry weight) constitutes only 29.7% for sheep, 26.2% for pigs, whereas in the case of the Laminaria flour - 66.2 and 71% correspondingly. This is indicative of varying levels of nitrogene matter in the brown seaweeds (Chapman, 1970)

Table 8

Comparative chemical composition (% of dry matter) of brown seaweeds, flour, conventional feeds. (Chapman, 1970)

Macrophyte seaweeds	Water	Proteins	Fats	Ash	Cellulose	Carbohydrates
Fucus vesiculosus +Fuc. serratus	12.4	5.0	2.0	13.1	5.5	62.0
Fucus serratus + Fuc. balticas	12.3	4.4	0.8	16.0	5.7	68.0
Ascophyllum nodosum	11.1	6.0	3.1	17.8	5.8	56.0
Laminaria hyperborea	12.4	5.9	0.8	13.7	3.6	63.7
Laminaria saccharina	14.6	6.4	0.7	16.6	3.3	59.4
Laminaria digitata	18.6	5.8	0.6	1.3	26.7	36.6
Brown seaweeds californian flour	9.1	5.6	0.4	38.5	5.8	40.6
Brown seaweeds norway flour	3.5	7.5	3.0	19.0	8.0	52.0
Danish flour	5.0	13.1	1.1	5.9	9.0	66.7
Scotch flour	15.5	0.9	1.5	27.5	9.3	35.3
Oats	3.3	10.3	4.8	-	10.3	58.2
Potato tops	-	7.3	0.4	5.1	2.8	84.5
Hay	14.3	9.7	2.5	-	26.3	41.4

It is counter-productive to use red seaweeds as an animal feed component since they contain such a valuable matter as agar and carrageenan. Besides these polymers are stable in withstanding the action of digestive ferments which should not be ignored when assessing a nutrative value of seaweeds.

In the USSR the processing of seaweeds is acompanied by the utilization of production wastes (after axtracting the gel-formers) to obtain the suorce products for deriving proteins and amino acids. For this purpuse the seaweed wastes endergo an additional treatment. It is recommended to reccur to the technology of extracting feed hydrolizate from Ahnfelčia wastes which incorporates a hydrochloric acid treatment of wastes to achieve demineralization with the ensuing sulphuric acid hydrolysis and dry calcium oxide neutralization. (Zimina, 1979).

Hydrolyzate constitutes a protein additive for a balanced amino acid and mineral composition of feeds.

This product appears as a dark-brown liquid smelling of dried mushrooms. It incorporates (%): dense matter - 29.5, general nitrogen - 2.1, non-organic matter -1,15, including both biogenic macro and micrirlrments.

The method of producing the seaweed aminopeptide feed powder of high biological activity from Phylophora and Furcellaria has been developed and extensively tested.5The USSR Inventor's Certificate, 1487876). This product incorporated: crude protein (55-60 amini acids (45%). The ratioes of luceine, irreplaceable and replaceable amino acids are optimal. The seaweeds aminipeptide is effectively employed for fish farming in ponds. (Boiko et al., 1979)

Despite a growing output of fertilizers , numerous countries particularly the newly independant ones are short of them, whereas macrophyte seaweeds are rich in organic andmineral matter. Apart from nitric extracts, the unfixed amino acids are biologically the most prominent ones. Their content in brown seaweeds constitutes 17ρ - 87.4 mg%, in red algae - 19-221 and in green ones - 44-86 mg% of the dry matter. Nitric bacteria cultures introdused in the peat and chernozyom soils are protected from a deterioration by carbohydrates incorporated in seaweeds (40-70% content) whereas the alginic sodium salt causes sandy soils to become denser aquiring better physical properties due to lumping. (Chapman,1980)

All seaweeds incorporate a relatively high amount of calium but little phosphorous: green ones - 2,7%, brown and red ones - up to 0,3% of the dry matter (Romankevich). Phosphorus salts should be added to render effective the seaweeds fertilizers. Generally the seaweed ash should have a diverse content of macro- and microelements. It is commonly known that provided they are used correctly microelements substantially upgrade the quality of produced plants.

The utilization of seaweeds (mixture of brown and green seaweeds) as fertilizers in the agriculture of coastal areas of a number of countries has been practiced for centuries. The seaweeds are put into the soil fresh and uncut or chopped and mixed with peat or organic fertilizer to form a compost, or else they are used as specially prepared extracts. Brown seaweeds swept up on the shore are employed as fertilizers mostly when mixed with some others. Red seaweeds are rarely employed for this purpuse. The ferilizing quality of seaweeds depends on their time of drifting in the sea, weather and the strength of waves.

In Ireland, Scotland, France and in Alaska and on the america pacific coast such seaweeds as, say, Ascophyllum and Laminaria are used primarily for growing potatoes. In Great Britain the volume of seaweeds fertilizing the soil amounts to 4o t/ha. This prevents virus deseases from expanding, the potato "mange" from developing and decelerates the growth-rate of the potato weeds. In Scotland the fertilizer seaweeds are chopped and buried 10-15 cm deep at the rate of 65-75 t/ha. In Ireland plantations are fertilized with seaweeds in the stubble period in autumn. In South Africa mixed Koklonia and Laminaria seaweeds are used as a soil conditioner.

Maxicrop, Algynure and Scargo fertilizers produced by dehydrating Fucales with alkali are used in hothouses, hotbeds and in gardens. Maxicrop incorporates 94,8% of dry matter: organic components - 51,2%, ash -43,6%, humidity -5,2% (Chapman, 1980)

The use of red seaweeds for fertilizing or the amelioration of the soils by the lime pretreatment of acidified areas is widespread in France. It is believed that the effect of this seaweed fertilization is slow in comimg, therefore they are not to be appli each year. In the Bretagne province seaweeds are used as compost mixed with organic fertilizers. Such a fertiliser is used for growing alfalfa and meadow grasses. In India and Shri-Lanka many specic of seaweeds, Gracilaria among them, are mized with low-grade fish and put into the soil to fertilize coffee plantations.

In the USSR the wastes of processing Furcellaria (after extracting furcellaran) are used as fertilizers on agricultural fields.

The development of the direction making use of biologically active substances - growth regulators (auxins, hybberelpins, cytocinins) individually extracted from brown Laminaria, Ecklona, Fucus as a means of agricultural plants treatment to enhance their yields and to ameliorate the quality of plants appears very important (Zaitsev et al., 1980).

The data that has been used does not exhaust all possible options for utilizing the seaweeds. Numerous research efforts exerted around the world within the framework of seaweeds processing indicate that there are real opportunities of expanding their use, particularly so provided the raw material base is stabilized by cultivating the seaweeds.

A growing amount of extracted carrageenans and alginates will make it possible to remove such a valuable product as agar is from the technology of foods processing and to use it exclusively in madicine for preparing diagnostics nutrative media, vaccines for the benefit of human health and that of the animals.

The industrial processes of the world-wide production of carrageenan, agar and alginates extracted from the seaweeds may be summarized for the ends of comparison as follows (Schemes I-III):

I	II	III
red seaweeds containing carrageenan	red seaweeds containing agar	brown seaweeds containing alginic acid
↓ extraction	↓ prerxtraction	↓ preextraction
↓ extract purification	↓ agar extraction	↓ alginate extraction
↓ carrageenan extraction	↓ purification	↓ settling of alginic acid
↓ drying	gel / extracts	↓ conversion of alginic acid into alginate
↓ carrageenan	↓ drying	↓ alginate
	↓ agar	

The leading producer-countries in this field focus their sfforts on perfecting various technologocal methods with the view of upgrading the quality and expanding the output of gel-formers and thickeners. The experience accumulated by these countries in the field of industrial production should be shared by other countries to launch or to expand their production. For example: agar from cultivated Gracilaria in Vietnam as well as alginate from Sargassum; alginate from cultivated Laminaria in North Korea; alginate from Macrocystis in Peru; in the future - carrageenan from Eucheuma in Tanzania

In "Guidelines for the Economic and Social Development of the USSR" a great deal of attention is attached to creating and perfecting biotechnologies. A business-like cooperation with other countries including the CMEA countries will promote a successful solution of these tasks. The USSR is developing business contacts with a number of countries. Due to the fact that the countries of South-East Asia have centuries-old traditions and make great strides forward in commercial seaweeds cultivation our country has sent a number of scientific groups to study the experience of cultivating the seaweeds in Korean People's Democratic Republic, Cninese Prople's Republic and Japan.

It is especially important to launch a program of using and cultivating ~~the~~ seaweeds in the countries of Africa, Central and South America. The major commercial species found here are: Macrocystis, Lessonia, Durvillaea among brown algae inhibiting moderate and Sargassum dwelling in tropical lattitudes. There are several species of red seaweeds: Gracilaria, Pterocladia, Gelidium, Hypnea, Gigartina, Eucheuma, Porphyra (de Oliveira,1981).

These same species may become the objects of mariculture.

In the countries of Central and South America and in Africa including the developing countries, seaweeds are traditionally ignored or used as food at a very low scale even in the conditions of severe foods shortage. Taking into consideration seaweeds very high nutrative value and an extremely beneficial health effect the use of seaweeds as food products should be extensively publicized in these and other countries of the world. Owing to the fact that the natural resources in a number of countries are limited and in some of the others they could be easily dwindled by a large-scale exploitation, it is necessary to elaborate the cultivation technology for the leading objects of mariculture in the coastal waters of various regions keeping in mind geographical, ecological social and economic particularities of the countries.

The seaweeds constitute a national asset, a treasure of every coastal country of the world, a valuable raw material source. The use of seaweeds especially within the framework of a more extensive complex extraction of organic matter will promote man's well-being, will influence the economy, including that of the developing countries despite the expenditures made, human effort consumed in the area of cultivation and processing of this source of raw materials.

REFERENCES

Inventor's Certificate 487867 (USSR) Method o. producing aminic acids and peptides. Inventors Y.Medvedeva, K.P ..henko, Y.Petrenko L.Boiko et al., Publ. in B.I., 1975, №38; M. Cl.A 23L1/04.

Inv. Cert.603367 (USSR). Mrthod of extracting agaroid from Phyllophore/ Inventors. N.Boidyk, R.Zambriborshch, D.Mikul'ch, N.Rekhina, A.Usov. Publ.in B.I., 1978, №15, M.Cl.A 23L/04.

Inv.Cert. 938902 (USSR) Method of extraction of agaroid from red Phyllophore seaweed/Inv-s S.Stavrov, A.Shilkin, L.Rosenstain et al. Publ. in B.I., 1982, №24; M.,Cl.A 23L1/04.

Inv.Cert. 1113078 (USSR) Method of extracting sodium alginate from seaweeds/Inv-s V.Baranov, V.Kudryavcsev, R.Kuchumova et al., Publ. in B.I., 1984,№34, M.CL.A 23L1/04.

Blinova Y. Present state and perspectives of seaweeds mariculture development. "Rybnoye Khoziaystvo, 1984,№8, p. 33-34.

Blinova Y. Seaweeds Resources. - In coll. "Ocean's biological resources.- M.:"Agropromizdat", 1985, p.223-240.

Blinova Y., Belov V., Maksimov B. Sea fishery mariculture in Chinese People's Republic. -Rybnoye Khoziaystvo,1985,№6; p.42-45.

Blinova Y., Makarov V., Khokhryakov K. Experimental and industrial cultivation of Laminaria saccharosa in the Barents sea: results and perspective. --Rybnoye Khoziaystvo, 1986, №5, p.28-30.

Boidyk N., Kaganovich Y.,Firsov A., On the use of the continuous diffusion method for extracting agaroid from Black Sea Phyllaphore -Rybnoye khoziaystvo, 1974,№9, p.63-64.

Boiko L.,Medvedeva Y., Speshilov L. The use of seaweed aminic acid preparation as a feed additive to two-year-old trouts. -Rybnoye khoziaystvo, 1978,№7, p.36-38.

Buyankina S., Podkorytova A. Biological characteristics of cultivated Laminaria. -In col.: Proc. IV All-Union Conf. on scient. and techn. problems of mariculture, 27 Sept.-1 Oct., Vladivostok, 1983, p.120-121.

Vrishch E. On the use of electrofloatation method for sodium alginate solution purification. - Izv.TINRO, 1976, vol.99,p.116-120.

Zaitsev V., Azhgikhin I., Gandel V. Complex use of marine organisms. -M., Pishtshevaya Promyshlennost, 1980, p.273-282.

Zimina L. Study on seaweeds wastes hydrolysis regimes when deriving feed hydrolyzates. - Study on fish products technology/TINRO -Valdivostok,1979, inst. 9,p.81-86.

Yevleva I. Perfecting the use of seaweeds for feeds and technical purpuses: Information survey/CNIITEIRH.-M., 1979, rel.4, p1-35. - Fish and sea products processing.

Kizevetter I. Chemical composition and economic importance of commercial marine macrophytes. In col.: The use of World Ocean's biol. resources. -M., Nauka, 1980, p.131-150.

Kizivetter I.,Sukhoveyeva M., Shmelkova L. Commercial marine seaweeds and grasses of Far-East seas. -M., Pishtchevaya Promyshlennost 1981. -113 p.

Lavrovskaya N., Macrophyte seaweeds used as feeds: Survey information/CNIITEIRH. -M., 1979; rel.3, p.1-20. Fish economy-oriented employment of the World Ocean resources.

Makarov V. Instruction on biotechnics of biannual cycle Laminaria saccharina cultivation in the White Sea conditions. PINRO, Murmansk, 1982, 50 p.Makiyenko V., Maltsev V., Krupnova T., Seaweeds cultivation in the Far East. Rybnoye khoziaystvo,1981,N°10,p.51-53.

Makiyenko V., Moisseyenko T., Biology of Costaria and its perspective cultivation as a raw material for extracting alginates. -Proc. III All-Union Conf. on Sci. and Techn. Problems of Maricult. Vladivostok, rel. 1, 1980, p.21-22.

Maslyukov Y. Influence exerted by calcium carbonate purification of agar solution on its physical properties and chemical composition. -Rybnoye khoziaystvo, 1971, №1, p.79-80.

Maslyukov Y. Some results of probing into the process of agar gel dehydration by pressing. - In: Research on technology of fish products /TINRO. -Vladivostok, № 5.

Podkorytova A. Influence of sea kyle pretreatment conditions on yield and quality of sodium alginate. -Rybnoye khoziaystvo, 1985,№1,p.73-

Pyayv P. Research and perfecting the technology of extracting furcelleran and agar. -Rybnoye khoziaystvo, 1980, №9, p.58-61.

Romankevich Y.A. Geochemistry of organic matter in the ocean,-M,: Nauka, 1971, 256 p.

Patent 48-31800 (Japan) Method of seaweed decoloration /Inventor M.Sigehiro,-Filed 19.05.70; Publ. 02.10.73., Cl.8S 12 A23L1/100, Publ.-Chemistry, 1974,№15,15R 169.

Patent4831800(Japan)Method of producing seaweed paste/Inventor K. Tosiharu,-Filed 25.09.78, Publ.31.03.80. Cl. A23L1/337, Publ. -Chemistry, 1981, №4, 4R 125P.

Patent5941203 (Japan) Method of purifying and consentrating seaweeds. /Inventor T.Kimihiko, Filéd , Publ.07.03.8 , Mki C 08 V37/12 A23L1/337, Publ.-Chemistry, 1985, №5, 5R .439P.

Patent 5927835 (Japan). Method of extracting various plant objects. /Inventor T.Takasi,-Filed 05.08.82,Publ. 07.03.84. Mki C 07, C172/00 C07 v29/0., Publ.-Chemistry, 1985,№7,7R,182P.

Patent 5531107 (Japan). Tableted foods from Undaria pinnatifida. /Inventor I.Takao,-Filed 25.09.78.,Publ. 18,07.81, Cl A23L1/337, Ascar A. Alginate Herstellung, Eigenschaft und Verwendung in der Lebensmitelindustrie.-Alimenta, 1982, 21, N 6, p.195-199.

Chapman V.J. Seaweeds and their uses. London, 1970, 304 p.

Chapman V.J., Chapman D.J. Seaweeds and their uses. L:N-Y.: Chapman and Hall, 1980, 334 p.

Christeller J.T., Furneaux R., Gordon B.E., Laing N.A., Miller J., Nelson W., Shaw B.E. The potential for mariculture of seaweeds in New Zealand. Techn.Rep., No 18, 1983, p.21.

Cooper M.E, Windsor M.L. Seaweeds - promise in marine plants research - Fishing News Intern., 1977, v.16, No 7, p. 41-45.

Dano J.H. Alginates et carraghenans, ressemblances et dissemblances, -Revista italiana (mensile tecnico scientifico), 1976, an.58, N 6, p.318-321.

El-Dashlouty M.S., Askar A., El-Baki M.M., Abd-El-Ebzary M.M. Food prepared from brown algae. -Alimenta, 1982, 21, No 4, p. 101-105.

Duville C.A., Duville J.L., Pansarasa E.H. Basic studies of alginic acids of brown algae from the Patagon coast.-Contrib. Tec. Cent. Invest. Biol. Mar., Buenos Aires, 1974, 16, p.1-13.

Edwards P, Tam D.M. The potential for Gracilaria farming in Thailand. II Int. Seaweeds Symp., Qungdao, China, 1983, p.63.

Fiszman S.M., Costell E., Duran L. Rev. agroquim. y technol. alim., 1982, 22, N. 2, p 245-256.

Freeman K. Fish of the mouth-nori. Pacific Fishing, July, 1935,p.21

Gellenbeck K.W., Chapman D.J. Seaweed uses: the outlook for mariculture. Endeavour. New Series, 1983, v.7, No 1, p.31-37.

Gfan M. Seaweed resources of the ocean. FAO Fisheries Technocal Pap Rome, 1975, No 138, 127 p.

Hardihorst C.V. Continuous process for quality alginate gum.-Food Eng., 1977, 2, 41, p. 46-48.

Harger B.W., Neushul M. Macroalgal mariculture. Proc. 2-d Int. Workshop, La Paz, 16-20 Nov.1980, N-Y, London, 1982, p.393-404.

Horstman H. Cultivation of the green algae, Gaulerpa rasemosa, in tropical waters and some aspects of its physiological ecology. Aquaculture, 1983, v.32, No. 3-4, p. 361-371.

Kuhnert Peter. Hydrokolloide als Lebensmittel zusatzstoffe. - "Gordian" 1980, 80, N 7-8, p. 172, 174-180.

Lapointe B.E., Ryther J.H. Some aspects of the growth and yield of Cracilaria tikvahiae in culture, Aquaculture, 1978, v.15, No 3, p. 185-193.

Li S.Y. The ecological characteristics of monospores of Porphyra yezoensis Ueda and their use in cultivation. "Hydrobiologia",1984, p.116-117.

Li R.Z., Chong R.Y., Meng Z.C. A preliminary study of raft cultivation of Gracilaria varrucosa and Gracilaria ajoestedtii. Hydrobiologia, 116/117, 1984, p. 252-254.

Liu S., Zhuang P. The commercial cultivation of Eucheuma. II Intern. Seaweed Symp., Qingdao, China, 1983, p.47.

Martin G. Evaluation toxicologique de carraghenancs. -2. Définition, structure, fabrication, proprietés et applications. - Sciences de aliments, 1984,,N 4, p. 335-346.

Mateus H., Regenstain G.M., Baker R. Studies to improve the extraction of mannitol, alginic acid from Macrocystis pyrifera of marine brown algae. -Econ.Bot., 1977, 31, p. 24-27.

Van der Meer J.P. The domestication of seaweeds. Bioscience, v. 33, No 3, 1983, p. 172-176.

Miura A., Merril J.E. Genetic studies and improvement of Porphyra in Japan. First Internat. Phycological Congress. Aug. 8th to 14th, 1982, St.Jon's, Newfoundland, Canada.

Moeller H.W., Garber S.M., Griffin G.P. Biology and economics of growing seaweeds on lens in a film culture. Hydrobiologia, 116/117, 1984, p.299-302.

Mshigeni K.E. The red algae genus Eucheuma (Gigartinales,Solieriaceae) in East Africa; Underexploited resource. Hydrobiologia, 116/117, 1984, 347-350.

North W.J. Biomass from marine macroscopic plants. Solar Energy, 1980, v.25, No 3, p. 387-395.

North W.J. Culturing and utilization of large brown seaweeds (kelps). Proc. Ocean483, San Francisco, 29 Aug.61 Sept?1983, v.2,1983, N.-Y., p. 884-889.

Ofstad B. Use of alginate as a gelformer in sterilized fishball type products. II Intern. Seaweed Symp., Qingdao, 1983, p. 191.

Okazaki A. Seaweeds and their uses in Japan.-Tokyo: Tokai Univ.Press 1971, 165 p.

De Oliveira F.E.C. Marine phycology and exploitation of seaweeds in South America. Xth Internat. Seaweed Symp., Berlin-New-York p.97-112.

Patent 3396158 (USA) Preparation of alginic acid by extraction of algae /Inventor A.Haug. 06.08.68; Nat. Cl.,260-290.6.

Patent 3849395 (USA) Degraded modified deaweed extractive and composition containing same and their production. -Marine colloids. Inv: Moriano A.L. Filed 25.08.71; Publ. 19.11.74. Int Cl C.07 G 3/00.

Patent 980261 (Canada) Process for the purification and concentration of solutions derived from marine algae. /Inventor C.H.G.Strong.- Filed 16.08.72; Publ. 23.12.75; Int.Cl. G 08 B 19/00.

Patent 3876628 (USA). Processing of Macrocystis help to clarified algin liquor (Inventor W.D. Wright.- Filed 09.04.73; Publ. 08.04.75 Int. Cl. C 08.B 19/10.

Patent 2370756 (France) Procédé perfectionné pour eliminer la pellicules exterieur des algues. /Deposant N.Hasebe- Depot 15.11.76; Publ. 09.06.78; Int. cl. C 08.B 37/04.

Patent 2538682 (France). Aliments à grande valeur nutritive, contenant certains extraits d'algues et additifs. Energêtiques correspondantes. Herve R.A., Labo Golmar S.A. - Depot. 30.12.82; Publ.06.07.8.

Phillips Glyn.O. Applications of hydrocolloids. -Gums and stab. for the Food Ind., vol.2. Proc. 2nd Int.Conf. Wrexham Wales, July, 1983, Oxford ed. Pergamon Press, 1984, 569 p.

Rhodes R.J. Status of world aquiculture. Aquiculture Mag., 1985,p4-

Pilnik W., Voragen A.G.J. Polisaccharides and food.-Gordian, 1984, 84, No 10, p.195-199; No 9, p. 166,171.

Rious G. Evaluation toxicologique des carraghenanes. 3-aspects reglementaires de leurs utilization.-Sciences des aliments, 1984,4,347-35

Rittenburg J.H., Smith C.J., Ghaffar A., Allen J.C. A new approach the assay of food gums and stabilizers. -Gums and stabilizers for the Food Industry. Food Ind., vol.2, 2nd Int. Conf. Clywl.,July, 1983. Oxford e.a., 1984, p.457-463.

Robinson P.K. Phycotechnology. Industrial biotechnology. Oct/Nov. 1985, p.73-78.

Seaweed resources of the ocean.- FAO Fish.Techn.Paper,1976,No 13

Selby H.H., Wynne W.H. Agar. - In: Industrial Gums. Polysaccarides and their derivatives. Academic Press,1973, p.29-48.

Smith A.H., Nichols K., McLachlan J. Cultivation of seamass (Gracilaria) in St.Lucia, West Indies, Hydrobiologia 116/117,1984,p.249-251.

Tseng C.K. Some remarks on the kelp cultivation industry of China. Internat. Gas.Research Conf., 1981, p.728-733.

Vard C. Regard sur l'aquaculture mondiale' Pêche mar.,1983,No 1269, p. 644-703.

Wheeler W.N., Neushul M., Haessner J.W. Marine agriculture: progress and problems. Experientia, 1979, v.35, No 4, p. 433-435.

Yang S., Wang C. Effect of environmental factors on Gracilaria cultivated in Taivan. Bull.Mar.Cci.,1983, v.33, p. 759-766.

Yamauchi K. The formation of Saragassum beds on artificial substrate by transplanting seedlings of S.horneri (Turner) C.AGazdh and S.muticum (Yendo) Fensholt.Bull.Jap.Soc.Sci. Fish.,50(7),1984, p. 1119-1123.

Yearbook of fishery statistics. FAO, 1984, v. 54, p. 220-223.