

RESEARCH

USES OF ALGAE IN THE CONTEXT OF PROBLEMS OF THE ENVIRONMENT AND OF PUBLIC HEALTH

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5th part

INTRODUCTION TO THE USES OF ALGAE

Since time immemorial, algae have been considered a precious asset by all the maritime countries in the world, although with varying degrees of appreciation according to the type of civilization. Especially in South-East Asian countries (Japan, China and Korea) they were used directly as food for human consumption, traditionally representing the staple diet for various groups of coastal populations, in particular in Japan. This was justified by the scientifically confirmed nutritional composition, which includes significant quantities of a variety of nutrients, including principally proteins, polysaccharides, vitamins and mineral substances. On the other hand, macroscopic algae represent an important source of chemically defined derivatives (for example hydrocolloids such as alginic acid and alginates, agar and carrageenans) or other complex raw materials and preparations that have important uses in various sectors, such as pharmaceuticals, the food and cosmetic industries. A general picture of the various current and potential uses in the various countries can be summarized as follows:

- current uses:
- edible uses consumed as such by man
- used as dry fodder in animal husbandry
- extraction of hydrocolloids to be used as food additives, ingredients of cosmetics or pharmaceutical excipients
- production of fertilisers
- paper manufacturing
- potential uses
- sources of chemical production of fine chemistry by means of pyrolysis
- sources of energetic compounds for digestion
- treatment of drain water
- sources of biologically active substances
- integral part of self-sufficient ecosystems in an experimental phase.

On this last point, apart from the aspects nurtured by some research projects aimed at meeting requirements which are for the time being somewhat futuristic (Vigna, 2000), it is curious to note hermetically sealed glass globes on sale which contain miniature living ecosystems simulating marine or freshwater microenvironments in equilibrium (Anonymous, 2001); from the exterior these only receive energy in the form of artificial light or indirect natural light. A species of red shrimp (which is found only in some islands of the Pacific) lives in this marine microenvironment in cooperation with some types of macro and microscopic algae. The freshwater environment is more complex: aquatic plants, floating plants (tiny plants called Star Chians) or plants (Ceratophyllum demersum) resting on the bottom (made up of animal and plant debris recycled by microbes), algae and other unicellular orga-



Cladophora aegagropila



Scinaia latifrons

nisms, amphipods similar to small shrimp, snails of various types (Ramshorn and trumpet), aquatic worms and tiny invertebrates: copepods, daphnia, ostracods interact, maintaining a delicate balance of life. The duration of the life cycles is nevertheless limited to a period of about three years; afterwards the biospheres lose the fascination of the spectacle of life (which could be observed in a variety of ways) whilst maintaining the characteristic of a curious, instructive piece of furniture and, for the readers of this article, a further reason for reflection on the role that those algae had had in maintaining those miniature ecosystems vital for as long as possible.

Another curiosity is that of the use of algae in paper manufacturing. The lagoon of Venice was the first to benefit from this innovative technology. Here, the phenomenon of eutrophication and the abnormal development of macroalgae has taken on worrying dimensions due to the continuous supply in the waters of nutrients from industrial waste and the urban settlements of the mainland and the islands. On the other hand, the situation tends to remain somewhat stationary due to the fact that a complete change of the waters by the Adriatic Sea takes place only every 2 or 3 weeks. As a consequence, in order to keep the lagoon's ecosystem in acceptable conditions as far as its vital capacity to sustain all the animal species that live in it are concerned, it is periodically indispensable to mechanically remove huge amounts of macroalgae. As tens of thousands of tons of algae are collected each year in the Venice Lagoon, their disposal poses further problems linked to the unrelenting phenomena of putrefaction of this biomass, which becomes fetid and a repository of insects if it is not rapidly removed and/or re-used in agricul-

ture or as a raw material for possible industrial transformation. On this last point, it is the merit of a historic paper works, built in a mill in Rossano Veneto in 1736, then called Favini after the entrepreneur who took it over, that was the first in the world to industrially manufacture paper containing pure algae, using Swiss green algae (*Ulva* spp.) in the lagoon of Venice (Casonni, 2004). The technological procedure begins with the gradual desiccation of the algal biomass before the biological phenomenon of putrefaction takes place; this is followed by grinding and the transformation into a very stable flour with a slightly salty-sea odour. The algae flour obtained replaces the cellulose fibres of trees, the general usage and starch in the paper pulp. Lastly, an intermediate product passes through the traditional machine for the final production of the paper to take on the usual forms. The manufacturing process of paper from algae, compared to the traditional procedure, does not use toxic substances, does not cause polluted waste water and globally allows energy saving. In addition, the procedure solves important environmental and ecological problems, of the type already seen, and conservation of trees as 50,000 tons/year of algae removed from the lagoon of Venice saves 30,000 tons of live trees.

The paper thus obtained can rightly be defined ecological and has first-class physical-mechanical, aesthetic and performance characteristics; the colour if light despite the presence of chlorophyll, tends in any case to lighten with time; a slight and characteristic presence of dots can be noted in the mass due to the presence of algae particles. This example is also a reason to reflect, in consideration of the scarcity of resources of cellulose fibres that can be obtained from trees, on

Table 1 – Presence of phycocolloids in brown algae (Pheophyceae) and in red algae (Rhodophyceae).

PHYCOCOLLOIDS	GENUS AND SPECIES	FAMILY	CLASS
Alginic acid and alginates (1)	<i>Laminaria digitata</i>	Laminariaceae	Pheophyceae or Brown algae
	<i>Laminaria hyperborea</i>	Laminariaceae	
	<i>Laminaria saccharina</i> <i>Ascophyllum nodosum</i>		
Carrageenans	<i>Macrocystis pyrifera</i> (2)	Lessoniaceae	Idem
	<i>Durvillaea antarctica</i> (3)	Durvillaeales	Idem
	<i>Fucus vesiculosus</i>	Fucaceae	Idem
	<i>Fucus serratus</i>	Fucaceae	Idem
Furcellaria gum	<i>Chondrus crispus</i>	Gigartiniaceae	Rhodophyceae or Red algae
	<i>Gicartina stellata</i>		
	<i>Gicartina</i> spp.		
Agar	<i>Mastocarpus stellatus</i>	Furcellariaceae	Idem
	<i>Furcellaria fastigiata</i>		Idem
	<i>Gelidium</i> spp.	Gelidiaceae	Idem
	<i>Gracilaria</i> spp.	Gracilariaceae	Idem
	<i>Ceramium</i> spp.	Ceramiales	Idem

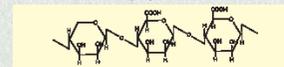
(1) The alginates in algae carry out the same support function as cellulose in terrestrial plants. Algin was discovered in 1813 by the English chemist E.C. Standford (Proserpio, 2000; Anzalone and Consonni, 1997).

(2) This is the most important industrial source of alginic acid and alginates.

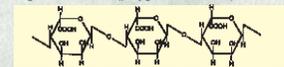
(3) *Durvillaea antarctica* has an alginic acid content of about 48%. The sample of Chilean origin (kindly offered by Madam Nathalie Gueneau), in the photo has been estimated as having a length of about 8-9 metres (36 folds of about 21 cm in length and 3 ligations of about 15 cm in diameter).

and/or L-glucuronic acid (G) linked with β -(1 \rightarrow 4) or α -(1 \rightarrow 4) glucoside bonds (Proserpio, 2000);

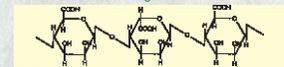
- the -M-M-M-M- segment is wholly made up of D-mannuronic acid (polymannuronic acid);



- the -G-G-G-G- segment is wholly made up of L-glucuronic acid (polyglucuronic acid);



- the -M-G-M-G- segment, on the other hand, is a casual alternation of molecules of D-mannuronic acid and of L-glucuronic acid;



The relative proportions of these units vary with the botanical source and the degree of maturation of the algae (The Merck Index, 2001). The table shows the percentages of these units or segments that are alternated in the molecule of alginic acid according to the type of algae from which the polysaccharide is extracted (Proserpio, 2000);

Structural differences between the two M and G acids and their contents in alginates are at the basis of the different gelling power observed for these polysaccharides. The struc-

tural units of polymannuronic acid are linked by an equatorial ligand, showing as a whole more extended linear conformation than that of polyglucuronic acid; the latter is characterized by structural units which are linked by two axial ligands and therefore by a more contracted linear conformation (Proserpio, 2000).

Alginic acid and alginates appear in the form of powders of white-beige granules. Alginic acid is insoluble in water, but absorbs it in quantities of about 200 – 300 times its own weight; it dissolves in glycerine, basic solutions and organic solvents; it is resistant to acids, oxidants and reducers (Proserpio, 2000).

The salification and the esterification of alginic acid form alginates of Na (known as algins, which are obtained by boiling the algae in the presence of Na₂CO₃), K, Ca, NH₄, and propylene glycol. The solutions of alginate are highly viscous even at low concentrations (a 1% solution has a viscosity of 2500 mPa.s). The viscosity is a function of the degree of polymerisation of the alginate and of its concentration in the solution; a gradual increase of the temperature decreases the viscosity reversibly, which returns to its original values with the cooling of the gel (Proserpio, 2000).

The solvation of alginates is complete in hot or cold water and the gels can be of variable consistency (soft, compact or elastic) by means of adding soluble salts of Ca, phosphates and carbonates (these at low concentrations of about 0.5% decrease the viscosity). These gels of immediate formation, very compact and with excellent textures, are technologically obtained by the reaction of soluble salts of alginic acid with the calcium ions (Ca²⁺). It is curious to observe the rapid formation of a "bowel" which is formed by pouring a thread of

Table 2 - Percentage of D-mannuronic acid (M) and of L-glucuronic acid (G) and of the relative sequences (Proserpio, 2000).

SPECIES OF ALGAE	M %	G %	M/G RATIO %	-M-M-M-M- %	-G-G-G-G- %	-M-G-M-G- %
<i>Macrocystis pyrifera</i>	61	39	1.56	40.6	17.7	41.7
<i>Ascophyllum nodosum</i>	65	35	1.84	38.4	20.7	41.0
<i>Laminaria digitata</i>	59	41	1.45	12.7	60.5	26.8
<i>Laminaria hyperborea</i>	31	69	0.45	-	-	-

the fires that each year destroy many hectares of forests and on the fact that Italy imports scrap paper to be recycled to make up for the growing needs for paper.

PRODUCTION OF PHYCOCOLLOIDS

Algae, however, are the object of greater interest in all industrialised nations as a raw material for the extractive industry of the phycocolloids which are widely needed, due to their gelling, thickening and stabilizing properties, in the manufacture of a variety of products of wide human consumption. The term phycocolloid is linked with phycology, i.e. the science that studies algae and the great gelling or thickening power of these substances in aqueous media generally at low dosages (0.01 – 0.5%). These hydrocolloids derive from few species of brown (Pheophyceae) and red (Rhodophyceae) algae which are collected and transformed using modern technologies and then variously destined to the textile, paper, electrode, paint, glue, pharmaceutical, food and cosmetics industries. The table shows a summary of their botanical origin.

The polysaccharides deriving from algae are normally ingested (unconsciously and due to the consumers' ignorance of the meaning of the abbreviations of the food additives shown on product labels) with ice creams, creams, cakes, jams, milk-based products, chocolate, tinned foods, fruit juices, infants' foods or are consumed with a variety of pharmaceutical and cosmetic products.

From the structural point of view, hydrocolloids are biopolymers made up of polysaccharides, which will be described individually below by their structure and most important characteristics. The substantial difference between hydrocolloids (alginic acid and alginates) obtained from brown algae (Pheophyceae) and those obtained from red algae (Rhodophyceae) is that in the latter there is a presence of sulphate groups, -OSO₃-; in addition, the different content of sulphate groups also represents a criterion of differentiation of the phycocolloids derived from red algae (Proserpio, 2000):

- agar: < 6% of sulphates;
- Danish agar or furcellaria gum: 3 - 18% of sulphates;
- carrageenans: up to 20% and sometimes even up to 35% of sulphates.

Alginic acid and alginates

Alginic acid is a hydrophilic colloidal polysaccharide, that in the forms of mixed salts with calcium, magnesium and other bases, is a structural component of the cell wall of brown algae (mainly of *Laminaria* spp., *Ascophyllum nodosum*, *Macrocystis pyrifera* and *Durvillaea antarctica*). Structurally it is a linear polymer, with a molecular weight of about 240,000, made up of units of β -D-mannuronic acid and α -L-glucuronic acid (The Merck Index, 2001). Three types of segments are alternated in the alginic molecule, made up differently of units of D-mannuronic acid (M)

a 1% solution of alginate of Na into a 5% solution of CaCl₂: the bowel, made up of insoluble Ca alginate and containing a solution of sodium alginate which has not come into contact with the salt of Ca, can be extracted from the recipient and manipulated (Proserpio, 2000). The solutions of alginates are stable up to approximately pH 4.5; at lower pHs the solutions of salts of Na, K and NH₄ thicken and gel and at pH 3 precipitate the alginic acid; the alginate of propylene glycol, on the other hand, is acid resistant (Proserpio, 2000).

The presence of preservatives in the solutions of alginates is necessary to prevent attack by micro organisms.

Due to their viscosity and film-forming properties, they are widely used in the food, pharmaceutical, cosmetic industries and in the manufacture of adhesives and paints.

The general pattern of the preparation of alginates from algae includes the following phases:

- desiccation of the algae;
- washing to eliminate the soluble sugars, mineral salts and alkaline iodides;
- treatment of alginic acid with NaOH or Na₂CO₃ and elimination after dilution of the insoluble cellulose and pigments;
- separation of the soluble alginate and clarification with hypochlorite or hydrogen peroxide;
- release of the alginic acid;
- transformation into salts of Na, K, NH₄ and propylene glycol (Proserpio, 2000).

Alginic acid is thus described in the special monograph of the 4th Edition of the European Pharmacopoeia (Alginic acid - Acidum alginicum; synonym E 400; Ph. Eur., 2004).

It is a mixture of polyuronic acids [(C₆H₈O₆)_n] made up of residues of D-mannuronic acid and of L-glucuronic acid; it comes mainly from algae belonging to the Pheophyceae. A small part of the carboxylic groups may be salified. It contains not less than 19.0% and not more than 25.0% of carboxylic groups (-COOH), calculated on the basis of the dehydrated substance.

It is a crystalline or amorphous powder from white to whitish-grey, poorly soluble or practically insoluble in alcohol and practically insoluble in organic solvents. It swells in water but does not dissolve. It dissolves in solutions of alkaline hydroxides. The dispersion at 3% in water has a pH of between 1.5 and 3.5 (Martindale, 2002; The United States' National Formulary 20, USNF 20, 2002). The monograph, as well as the definition and the characteristics shown above, contains 3 tests for identification, 5 assays (chlorides, heavy metals, loss on desiccation, sulphated ashes, microbial contamination) and the determination of the content of carbonyl groups by means of volumetric titling. As far as heavy metals in particular are concerned, these are ascertained on 1.0 g of product by means of a limit assay (20 ppm) carried out according to the F method and preparing the standard with 2 ml of standard solution of lead (10 ppm of Pb).

In Martindale (2002) alginic acid, the alginates (ammonium alginate, calcium alginate, potassium alginate, propylene glycol alginate, sodium alginate), the carrageenans and agar are

described amongst the stabilizing suspension agents having, the property to increase the viscosity of water when they are dissolved or dispersed in it. They have the capacity to stabilize oil in water emulsions. The rheological properties of the suspensions can vary widely from fine liquids to thick gels. Sterilisation in an autoclave decreases the viscosity of the solutions of sodium alginate.

SODIUM ALGINATE

This is the sodium salt of alginic acid (Sodium alginate - Natrii alginas; synonyms algin and E 401; Ph. Eur., 2004). It appears as a white or pale yellow-brown powder, slowly soluble in water forming a viscous and colloidal solution, practically insoluble in alcohol and ether. The monograph, as well as the definition and the characteristics shown above, contains four identification tests and 8 assays (S solution, appearance of the solution, chlorides, heavy metals, loss on desiccation, sulphated ashes, microbial contamination). As far as heavy metals in particular are concerned, these are ascertained on 1.0 g of product by means of a limit assay (20 ppm) carried out according to the F method and preparing the standard with 2 ml of standard solution of lead (10 ppm of Pb).

PROPYLENE GLYCOL ALGINATE

This is a fibrous or granular powder, white to yellowish in colour and practically odourless. Soluble in water, in solutions of diluted organic acids and, according to the degree of esterification, in hydro-alcoholic mixtures containing up to 60% in weight of alcohol to give stable viscose colloidal solutions with a pH of 3 (Propylene Glycol Alginate; E 405; propane-1,2-diol alginate; USNF 20; Martindale, 2002).

CARRAGEENAN

These are obtained by extraction with water or alkaline solutions from red algae of the genus *Chondrus* (Rhodophyceae), mainly *Chondrus crispus* (L.) Stackhouse and *Gigartina stellata* J. Agardh, which are abundantly found in the coastal regions of the North Atlantic, from Norway to North Africa. The name carrageenan derives from the name of the Irish town Carrageen. They consist mainly of a mixture of sulphate polysaccharides, i.e. esters between copolymers of galactose and 3,6-anhydrogalactose and sulphates of ammonium, calcium, magnesium, potassium and sodium (Carrageenan; E 407; Chondrus Extract; Irish Moss Extract; Martindale, 2002). The main copolymers are K carrageenan, I-carrageenan, which are the only gelling carrageenans; gelation takes place in the presence of some cations: potassium, ammonium, rubidium and caesium. The viscosity of a 1% solution at 25 °C is comprised between 250 and 500 mPa.s; with the increase of the temperature there is a reversible decrease of the viscosity (Proserpio, 2000).

The two families of K and I carrageenan structures are identified according to the position of the sulphate group, -OSO₃-, and by the presence/absence of anhydrogalactose. All car-



Sample of *Durvillaea antarctica* from Chile. Kindly given by Madam Nathalie Gueneau. Photo by Giuseppe Salvatore.

	SULPHATE GROUPS	3,6-AHYDROGALACTOSE GROUPINGS	CHARACTERISTICS OF SOLUBILITY
K carrageenan	25 %	28 %	Soluble cold only in the form of sodium salt; in association with other cations there is swelling to a greater or lesser extent.
i carrageenan	32 %	-	Intermediate behaviour.
λ carrageenan	35 %	absent	Very soluble in water, whatever the cation that salifies the sulphate group.

rageenans are sulphated galactans, i.e. polymers of esterified D-galactose, in different positions depending on the carrageenan, with sulphuric acid and alternatively linked with (1→3) and (1→4) linkages.

The K family (K) consists of K, K₁, K₂, K₃, K₄, K₅, K₆, K₇, K₈, K₉, K₁₀, K₁₁, K₁₂, K₁₃, K₁₄, K₁₅, K₁₆, K₁₇, K₁₈, K₁₉, K₂₀, K₂₁, K₂₂, K₂₃, K₂₄, K₂₅, K₂₆, K₂₇, K₂₈, K₂₉, K₃₀, K₃₁, K₃₂, K₃₃, K₃₄, K₃₅, K₃₆, K₃₇, K₃₈, K₃₉, K₄₀, K₄₁, K₄₂, K₄₃, K₄₄, K₄₅, K₄₆, K₄₇, K₄₈, K₄₉, K₅₀, K₅₁, K₅₂, K₅₃, K₅₄, K₅₅, K₅₆, K₅₇, K₅₈, K₅₉, K₆₀, K₆₁, K₆₂, K₆₃, K₆₄, K₆₅, K₆₆, K₆₇, K₆₈, K₆₉, K₇₀, K₇₁, K₇₂, K₇₃, K₇₄, K₇₅, K₇₆, K₇₇, K₇₈, K₇₉, K₈₀, K₈₁, K₈₂, K₈₃, K₈₄, K₈₅, K₈₆, K₈₇, K₈₈, K₈₉, K₉₀, K₉₁, K₉₂, K₉₃, K₉₄, K₉₅, K₉₆, K₉₇, K₉₈, K₉₉, K₁₀₀.

The Lambda family (λ) consists of λ and ε (xi) carrageenans; these are characterised by the repetition of linked disaccharides (1→3) of 2-sulphate-β-D-galactopyranosyl(1→4)-α-D-galactose. The residual galactose is 2,6-sulphate for the I form and 2-sulphate for the ε form. These carrageenans are not gelling (The Merck Index, 2001).

The aspect is that of a coarse or fine white, yellowish or reddish brown powder, practically odourless and tasteless; it is soluble in water at 80 °C forming a clear or slightly opalescent viscous solution. Dispersion is more rapid if it is mixed first with alcohol, glycerol or syrup.

The most important properties are: - the aqueous solutions are viscous; - they form gels in water; - they are reactive to proteins in particular with that of milk which gels (particular advantage is taken of this property in the food sector for the preparation of milk-based products: creams for the table, flavoured and condensed milks, milk puddings and countless products in the confectionery industry); - solubility depends on the content of soluble sulphate groups and 3,6-anhydrogalactose groupings with poor solubility. With regard to this last point, it is useful to consider the percentages in which the sulphate groups and 3,6-anhydrogalactose in K, I and λ carrageenan and the consequent variations of solubility (Proserpio, 2000).

AGAR - AGAR

This is made up of polysaccharides obtained from various species of Rhodophyceae, belonging in particular to the Gelidium genus. It is prepared by treating the algae with boiling water; the extract is filtered whilst hot, concentrated and dehydrated (Ph. Eur., 2004).

Agar has a mucilaginous taste. It appears in the form of powder or wrinkled strips, 2, to 5 mm wide or at times in flakes, from colourless to light yellow, translucent, fairly resistant and difficult to break; dehydration makes them more fragile.

The monograph, as well as the definition and the characteristics shown above, contains 4 identification tests (of which one is identification under the microscope) and 6 assays (swelling index, insoluble material, gelatine, loss on desiccation, total ashes and microbial contamination). The swelling index, established on the powdered drug (335), must not be less than 10 and not differ by more than 10 % of the value shown on the label.

To a lesser degree agar is also extracted from other Rhodophyceae, Gracilaria, Acanthopeltis, Ceramium and Pterocladia which are found in the Pacific Ocean, in the Indian Ocean and in the Sea of Japan. It may be separated in a neutral "gelling" fraction (agarose) and in a "non-gelling" fraction (agaropectin). Structurally it is a variable complex of chains of polysaccharides with alternate linkages α-(1→3) and β-(1→4); three limit structures are known: neutral agarose, poorly sulphated pyruvate agarose and sulphated galactan (The Merck Index, 2001).

Depending on the sources of collection of the algae, agarose is present in a variable degree between 50 % and 90 %; the percentage of sulphated groups varies, according to the origin, between 5 % and 10 % (Proserpio, 2000). The algae of the *Gelidium* genus are dark red in colour and grow on rocks in unpolluted waters of the ocean between the 30th and 40th northern and southern parallels of the hemisphere. Collection takes place between May

and October; the algae are also transported on to the coast by tides or fished by equipped boats. The treatment of the algae for the artisanal extraction of polysaccharides is called the "natural method" and comprises the following phases: - desiccation of the algae on the beach where it is also bleached by the action of the sun; - prolonged washing to eliminate foreign materials; - boiling for one or two days to extract the gelatinous part of the algae, i.e. agar-agar; - passage of the gel through threaders; - dehydration of the threads, grinding and selection of the various types of agar. Industrial procedures use solvents and more refined techniques (Proserpio, 2000).

The most interesting chemical and physical properties are: - the aqueous solution gels at 30 °C (even at concentrations of 0.5 %) forming a stable gel up to a temperature of 80 °C; - low freezing point of the solutions; - high melting point; - capacity to absorb large amounts of water; - high density; - great gel strength; - high stability; - innocuousness. The preparation of agar having a low gelling temperature and a high melting point is taken advantage of in the food sector for those products that require sterilisation in an autoclave at high temperatures. Other uses: in the pharmaceutical and cosmetic field and as a culture medium in microbiological techniques. It is not nutritionally significant, it is not digestible and passes practically unchanged through the intestine.

FURCELLARIA GUM

This is a colloidal gum (Furcellaria gum; Danish Agar), obtained from the red algae *Furcellaria fastigiala* (Rhodophyceae), which is mainly to be found in the waters of Northern Europe between Sweden and Denmark. The gum is the potassium salt of acid sulphuric esters of polysaccharides with a high molecular weight. It consists mainly of D-galactose, 3,6-anhydro-D-galactose and sulphate esters of these sugars; each sulphate group is found every 3 or 4 monomer units in an alternated sequence of

Table 3. Medicinal substances of algal nature currently present in medicines (L'Informatore Farmaceutico, 2003).

MEDICINAL SUBSTANCE OR ASSOCIATION	ANATOMICAL, THERAPEUTIC CHEMICAL CLASSIFICATION ATC*	THERAPEUTIC GROUP	SPECIAL GROUP	PRESENCE IN MEDICINES
alginate acid		metabolic: various catabolizing anti-acids	excipients	
alginate acid + aluminium hydrate + magnesium trisilicate + sodium bicarbonate	A02BX13	anti-acids	excipients	Digerall cpr Gaviscon cpr
alginate acid + sodium bicarbonate	A02BX13	acids		Gaviscon os sosp
agar		laxatives - purgatives	ecipients	
fucus		metabolic: various catabolizing laxatives - purgatives	phytotherapies	
cascara + frangula bark + fucus	A06AB20	laxatives - purgatives	Fave di Fuca conf	
sodium alginate		anti-acids	excipients	
sodium alginate + potassium bicarbonate	A02BX13	anti-acids	Advance os fl	Gaviscon

* A02 Drugs for disorders correlated with acid secretion
A02BX Other drugs for the treatment of peptic ulcer and gastro-esophageal reflux (GORO)
13 Alginic acid; A06 Laxatives; A06AB Contact laxatives; 20 Contact laxatives in association

linked units (1→3) and (1→4). The uses shown as a gelling and viscosity agent concern food and pharmaceutical products, products for diabetic, products to reduce excess body weight and toothpastes (The Merck Index, 2001).

THE PHARMACOLOGICAL USES OF PHYCOCOLLOIDS

Some alginates are used in the treatment of gastro-intestinal disorders. Alginic acid and the alginates, magnesium alginate and sodium alginate, are used as anti-acids and as antagonists of the histaminergic receptors (histamine H2-receptor) in problems of gastro-esophageal reflux. Alginic acid and alginates react with gastric acid forming a viscous gel (called a "raft") which floats on the gastric contents and which forms a mechanical barrier against the reflux (Martindale, 2002).

Sodium alginate (which in the presence of calcium ions forms insoluble calcium alginate) and calcium alginate have haemostatic properties and therefore are used in particular pharmaceutical forms which stop bleeding and foster coagulation of the blood. Sodium alginate is also used in cooling solutions for hyperthermia and in dentistry in products for dental moulds (Martindale, 2002).

Carrageenans belong to the category of mechanical laxatives (bulk-forming laxatives) as does agar because they encourage peristalsis and intestinal evacuation, increasing the content of water and the volume of faeces.

They are used in topical preparations for the Anore (USNF 20). These laxatives are amongst the safest, but they may also have undesired effects because they are solid in a dry or incompletely hydrated form and are in fact contraindicated in the cases of intestinal obstruction and have to be taken with an adequate quantity of fluid to avoid constipation and intestinal and esophageal obstruction. In this regard, some authors (McGuffin et al) recommend the following:

"Warning: Taking this product without adequate fluid may cause it to swell and block your throat or oesophagus and may cause choking. Do not take this product if you have difficulty in swallowing. If you experience chest pain, vomiting or difficulty in swallowing or breathing after taking this product, seek immediate medical attention."

"Directions: Take (or mix) this product (child or adult dose) with at least 8 ounces (a full glass) of water or other fluid. Taking this product without enough liquid may cause choking see warning."

In addition to this, these laxatives, especially when taken over a long period, have the capacity of inhibiting the absorption of other drugs (for example aspirin, digitalis and other cardiac glycosides, antibiotics and anti-coagulants), as well as various nutrients, such as calcium, iron, zinc, sodium and potassium. The pharmacotherapeutic categories that above all characterize the medicinal products, in the composition of which algal derivatives and preparations are to be found (L'Informatore Farmaceutico, 2003), are:

- Anti-reflux
Sodium alginate is the active ingredient present (for example, 1 g/10 ml of oral suspension in

Table. Algal ingredients in the European Inventory of Cosmetic Ingredients (1996).

INCI NAME OF THE ALGAL INGREDIENT	COMMON NAME AND/OR DESCRIPTION	FUNCTION IN COSMETICS (1)
Agar		binder - rheology modifier
Algae		vegetable derived
Algin	Alginic acid, sodium salt	binder - rheology modifier
Alginic acid	Alginic acid	binder - rheology modifier
Ammonium alginate	Ammonium alginate	binder - film former - rheology modifier
Calcium alginate	Calcium alginate	rheology modifier
Carrageenan	Carrageenan	binder stabilize rheology modifier
Chondrus crispus	Extracts and their derivatives physically modified such as tinctures, concretes, absolutes, essential oils, oleoresins, terpenes, terpene-free fractions, distillates, residues, etc., obtained from Chondrus crispus, Gigartinales.	rheology modifier
Euglena gracilis	Extracts and their physically modified derivatives such as tinctures, concretes, absolutes, essential oils, oleoresins, terpenes, terpene-free fractions, distillates, residues, etc., obtained from Euglena gracilis, Euglenaceae.	vegetable derived
Fucus crispus, extract (2)	Extracts and their physically modified derivatives such as tinctures, concretes, absolutes, essential oils, oleoresins, terpenes, terpene-free fractions, distillates, residues, etc., obtained from Fucus crispus, Fucales.	perfume - aromatic raw materials (2)
Fucus vesiculosus	Extracts and their physically modified derivatives such as tinctures, concretes, absolutes, essential oils, oleoresins, terpenes, terpene-free fractions, distillates, residues, etc., obtained from Fucus vesiculosus, Fucales.	vegetable derivative
Fucus vesiculosus, extract (2)	Extracts and their physically modified derivatives such as tinctures, concretes, absolutes, essential oils, oleoresins, terpenes, terpene-free fractions, distillates, residues, etc., obtained from Fucus vesiculosus, Fucales.	perfume- aromatic raw materials (2)
Glyceryl alginate		film former
Macrocystis pyrifera	Extracts and their physically modified derivatives such as tinctures, concretes, absolutes, essential oils, oleoresins, terpenes, terpene-free fractions, distillates, residues, etc., obtained from Macrocystis pyrifera, Laminariales.	rheology modifier
Macrocystis pyrifera	Extracts and their physically modified derivatives such as tinctures, concretes, absolutes, essential oils, oleoresins, terpenes, terpene-free fractions, distillates, residues, etc., obtained from Macrocystis pyrifera, Laminariales.	rheology modifier
Plankton extract	Plankton, marine, extract. Extracts and their physically modified derivatives such as tinctures, concretes, absolutes, essential oils, oleoresins, terpenes, terpene-free fractions, distillates, residues, etc., obtained from marine plankton.	rheology modifier
Potassium alginate	Potassium alginate	binder - stabilizer - rheology modifier
Propylene glycol alginate	Alginic acid, ester with 1,2-propanediol	binder - rheology modifier
Spirulina maxima	Extracts and their physically modified derivatives such as tinctures, concretes, absolutes, essential oils, oleoresins, terpenes, terpene-free fractions, distillates, residues, etc., obtained from Spirulina maxima, Oscillatoriales.	vegetable derivatives

(1) Definition of the functions shown in the last column of the table.

- Rheology modifier: substances that increase or decrease the viscosity of the finished product.

- Vegetable derivatives: substances of plant origin, generally extracted with physical means, that are added to the cosmetic products to give specific characteristics to the product.

- Film-former: substances that produce, spreading it, a continuous film over the skin, hair or nails.

- Binders: substances that added to solid cosmetic mixtures make them cohesive.

- Stabilizers: encourage the emulsifying process and improve the stability and preservation of the product.

(2) Ingredients of Section Two of the Inventory to show on the label under the general name of "perfume" or "aromatic raw materials".