

CARRAGEENAN INFORMATION AND ISSUES

Sensitive supplier information blanked out

Carrageenan is a collective term for a family of natural carbohydrate linear sulfated polysaccharides obtained by extraction from red seaweed (*Rhodophyceae*), mostly of genus *Chondrus*, *Euचेuma*, *Gigartina* and *Iridaea*. Carrageenan is a hydrocolloid consisting mainly of the ammonium, calcium, magnesium, potassium and sodium sulfate esters of galactose and 3,6-anhydrogalactose polysaccharides. These hexoses (a monosaccharide with six carbon atoms having the chemical formula $C_6H_{12}O_6$) are alternately linked α -1,3 and β -1,4 in the cell walls of red algae. The number of sulfate groups determines carrageenan type: zero (agarose), one (kappa-), two (iota-), or three (lambda-) sulfate groups per disaccharidic monomer. The different seaweeds produce different carrageenans.

Carrageenan is obtained by extraction from seaweed into water or aqueous dilute alkali. Carrageenan may be recovered by alcohol precipitation, drum drying, or by precipitation in aqueous potassium chloride and subsequent freezing. The alcohols used are methanol, ethanol, and isopropanol. The processing technique is important because it influences the gelling characteristics.

The term or name carrageenan originated from a coastal town in southern Ireland, called Carragheen. Gelatinous extracts of carrageen seaweed (also known as Irish moss) have been used as food additives for hundreds of years. Carrageenan is a water-soluble polymer, also known as a gum or gel that can improve the texture of foods and is used as binding, emulsifying, thickening, suspending, and stabilizing agents.

Synonyms for Carrageenan

3,6-Anhydro-D-galactan, Aubygel GS, Aubygum DM, Burtonite, Carageenan gum, Carastay, Carrageen, Carrageenan, Carrageenan gum, Carrageenan degraded, Carrageenan native, Carrageenan degraded, Carrageenin, Carragheanin, Carragheen, Carragheen gum, Carragheenan, Carragheenin, Carraguard, Chondrus, Chondrus extract, Colloid 775, Coreine, EINECS 232-524-2, Euचेuma spinosum gum, FEMA No. 2596, Flanogen, Galozone, Gelcarin, Gelozone, Genu, Genugel, Genugol, Genuvisco J, Gum carrageenan, Gum chon 2, Gum chond, Gum ChronD, Irish moss, Irish moss extract, Irish moss gelose, Killeen, Lygomme, Marine Colloids, Norsk gelatan, Pearlpuss, Pellugel, Pencogel, Pig-Wrack, Satiagel, Satiagum, Seakem carrageenin, Seaweed, Seaweed extract, Self rock moss, Viscarin.

Carrageenans are large highly flexible molecules which form helical structures. This structure enables them to become a hydrocolloid, which can form a gel. And like

gelatin, they are thixotropic (except for Kappa carrageenan) — being thinned under shear stresses and thickens, increasing viscosity once the stress is lessened or removed. Carrageenan is a thermo-reversible gelling agent. Gel formation is obtained only in the presence of potassium ions (kappa and iota carrageenan) or calcium ions (iota carrageenan). They also exhibit the solubility characteristics similarity shown by other hydrophilic colloids – being water soluble and insoluble in most organic solvents (i.e. ethanol). There are three primary native fractions of carrageenan that differ by structure and degree of sulfation: *kappa, iota, and lambda*.

- Carrageenan** CAS No.: 9000-07-1
- Kappa carrageenan** κ -Carrageenan CAS No.: 11114-20-8
forms a strong, firm, rigid gel.
- Iota carrageenan** ι -Carrageenan CAS No.: 9062-07-1
forms soft elastic and water retentive gels.
- Lambda carrageenan** λ -Carrageenan CAS No.: 9064-57-7
has no gelling properties by itself, but can form a gel when mixed with proteins (i.e. a thickener in dairy products).

SOLUBILITY

MEDIUM	Kappa	Iota	Lambda
Hot water	<i>Soluble above 60°C</i>	<i>Soluble above 60°C</i>	<i>Soluble</i>
Cold water	<i>Sodium salt soluble. Potassium and calcium salt, insoluble</i>	<i>Sodium salt soluble Calcium salts gives thixotropic dispersions</i>	<i>Soluble</i>
Hot milk	<i>Soluble</i>	<i>Soluble</i>	<i>Soluble</i>
Cold Milk	<i>Sodium, calcium and potassium salts insoluble, but swells markedly</i>	<i>Insoluble</i>	<i>Soluble</i>
Concentrated Sugar solutions	<i>Soluble hot</i>	<i>Not easily soluble</i>	<i>Soluble hot</i>
Concentrated Salt solutions	<i>Insoluble</i>	<i>Soluble hot</i>	<i>Soluble hot</i>
Effect of cations	<i>Gels most strongly with potassium ions</i>	<i>Gels most strongly with calcium ions</i>	<i>Non-gelling</i>
Type of Gel	<i>Strong and brittle with syneresis</i>	<i>Elastic and cohesive without syneresis</i>	<i>None</i>

<http://www.cpkelco.com/carrageenan/solubility.html>

SAFETY CONCERNS

There are two sides on the issue of how safe carrageenans are to use or ingest: *pro* and *con*. There are studies and opinions that exist supporting both points of view. Below are both current arguments.

NOTE: There two kinds of carrageenans being discussed here. The "degraded" type is distinguished from the "undegraded" type by its molecular weight. Degraded carrageenan has a molecular weight of 40,000 or lower, whereas undegraded carrageenan has a molecular weight of 100,000 or higher.

Chemical:	Carrageenan, degraded (acid) - Also known as <i>poligeenan</i> or <i>polygeenan</i>
CAS #:	53973-98-1
Chemical:	Carrageenan, undegraded (native)
CAS #:	9000-07-1

CON:

Dr. Joanne K. Tobacman, an assistant professor of clinical internal medicine at the University of Iowa College of Medicine, in a report disclosed that rats fed with degraded carrageenan (also called Poligeenan, which is an acid, peroxide hydrolyzed carrageenan) developed inflammatory bowel disease (IBD) and eventually neoplasms or uclers. Monkeys given the same food developed liver cancer. Tobacman's report fueled doubts on the safety of carrageenan in human health. The results of her study was published in October 2001 in an issue of *Environmental Health Perspectives*, a publication of the National Institute for Environmental Health Sciences (NIEHS), a branch of the National Institutes of Health. Her findings were from a review of 45 animal studies and from scientific literature that showed *degraded* forms of carrageenan can cause ulcerations and cancers of the gastrointestinal tract.

Dr. Tobacman also postulates that *undegraded* carrageenan, the kind most widely used as a food additive, might also be associated with malignancies and other stomach problems. She suggests that the reason for this association may be attributed to possible contamination of undegraded carrageenan by components of low molecular weight, spontaneous metabolism of undegraded carrageenan by acid hydrolysis under conditions of normal digestion, or the interactions with intestinal bacteria. She suggests that these activities may transform *undegraded* carrageenan into the more dangerous *degraded* type - converting high weight carrageenans into low molecular weight carrageenans and poligeenans in the human gut. So far, no government action has been taken as a result of Dr. Tobacman's findings. She is

currently looking into the possibility of an association between carrageenan and breast cancer risk.

In 1972 the FDA determined there was sufficient evidence from animal experiments to propose limiting the type of carrageenan that could be used in food products. In 1979 the FDA rescinded the proposal yet at the same time indicated there would be a more comprehensive regulation in the future. But no restriction has since been proposed, so there is no substantive regulation of carrageenan in food. In its native form, it has not been classified as a carcinogen, but in its degraded or broken down form it has been classified as a possible human carcinogen in 1982 by the International Agency for Research on Cancer (IARC) – designated as Group 2B.

PRO:

There are two forms of carrageenan: *undegraded (food-grade)* and *degraded (poligeenan)*. The food grade carrageenan we use is a natural substance and is used as a binder and thickener in foods like ice cream, puddings, etc. Degraded carrageenan is a different ingredient—it is a chemically treated form (hydrolyzed by acid) of the lower molecular weight (used in France as a treatment for peptic ulcers) and is not absorbed by the human stomach. Degraded carrageenan is not approved for use in food products. However, a majority of the reported studies used degraded carrageenan, which has shown unfavorable health effects in animal studies.

Some have expressed concern that, during the process of digestion, carrageenan is degraded into a harmful form. This possibility seems to be of limited toxicological significance for, if native carrageenan were sufficiently degraded in the gut to cause ulceration or tumor growth, then other feeding studies would have shown this. So, at this point, there is no evidence that this occurs. Current studies have shown that food-grade carrageenan in the digestive tract is either not degraded or degraded in a different way as the poligeenan form of carrageenan is (this disputed by some). Food-grade carrageenan does not have the same effects as degraded carrageenan – one reason is they are not the same chemical compound. Poligeenan lacks the thickening or stabilizing properties of undegraded carrageenan; it was and still is confused with the food-grade carrageenan. Due to this confusion, the U.S. Adopted Names Council determined that “*poligeenan*” was a more accurate, descriptive name for this chemical (degraded carrageenan). Food-grade carrageenan has no known toxicity or carcinogenicity and has Generally Recognized As Safe (GRAS) status by the U.S. Food and Drug Administration.

Contrary to Dr. Tobacman's conclusion (*referred to in the above Con section*), many authorities agree that undegraded form carrageenan may be used safely in food.

The safety of carrageenan for use in foods was confirmed at the 57th meeting of the Joint FAO/WHO (United Nations Food and Agriculture Organization and the World Health Organization) Expert Committee on Food Additives (the JECFA) in Rome in June of 2001 (JECFA; is an independent international panel of expert scientists and government authorities). They concluded a multiple year review of all of the relevant safety data on carrageenan. This included a specific analysis of the potential for promotion of colon cancer by carrageenan. The JECFA affirmed their earlier conclusion on the safety of carrageenan – that it may be used safely in the diet at amounts only limited by the amount necessary to achieve its technical function. Overall, the carrageenan sold as a food, drug, and cosmetic additive has been tested extensively, and regulatory authorities worldwide have uniformly found carrageenan to be essentially nontoxic and agreed that it may be used safely in food. The JECFA recommended an Acceptable Daily Intake of "*not specified*" the most favorable ADI a food additive can get. This is significant since the JECFA review was based on extensive safety studies, some of which were not addressed in Dr. Tobaman's article questioning the safety of carrageenan.

Below is the quoted EU's conclusion and opinion on carrageenan use:

EUROPEAN COMMISSION HEALTH & CONSUMER PROTECTION DIRECTORATE-GENERAL
Scientific Committee on Food SCF/CS/ADD/EMU/199 Final 21 February 2003
Opinion of the Scientific Committee on Food on Carrageenan (expressed on 5 March 2003)

The Committee noted that the toxicological issues discussed by Tobacman not new, that much of the data cited in the paper had been published review and had been considered at that time by the Committee.

On the issue of degraded carrageenan, while there is no evidence of any adverse effects in humans from exposure to food-grade carrageenan, or that exposure to degraded carrageenan from use of food-grade carrageenan is occurring, the Committee nevertheless proposes the specification for food-grade carrageenan to be tightened in order to ensure that the presence of any degraded carrageenan is kept to a minimum.

Conclusion

The Committee concluded that the information available since its last review of carrageenan as an additive for general food use did not provide any reason to alter the ADI of 0 - 75 mg/kg bw established previously. The Committee notes that normal dietary intakes are considerably below the ADI.

The Committee does however consider that, if feasible, a molecular weight limit of not >5% below 50 kDa should be introduced into the specification, in order to ensure that the presence of any degraded carrageenan is kept to a minimum. In the absence of any further information on possible absorption of carrageenan by the immature gut in the very young infant, the Committee

reaffirms its earlier view (SCF, 1998) that it remains inadvisable to use carrageenan in infant formulae that are fed from birth, including those in the category of foods for special medical purposes. The Committee has no objection to the use of carrageenan in foods for older infants, such as follow-on milks (SCF, 1983) and weaning foods.

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International Agency for Research on Cancer ((ARC)

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The available data do not provide evidence that native (undegraded) carrageenan is carcinogenic to experimental animals. In the absence of epidemiological data, no evaluation of the carcinogenicity of native carrageenans in humans could be made.

California Proposition 65 (Prop 65) states (quoted):

Polygeenan NSRL May 2001 OEHHA -6 (degraded)

The Proposition 65 “no significant risk level” (NSRL) is defined in regulation as the daily intake level posing a 10^{-5} lifetime risk of cancer.

This report describes the derivation of a cancer potency value and NSRL for polygeenan (CAS number 53973-98-1, commonly called degraded carrageenan, average molecular weight 20,000 to 40,000). Polygeenan was listed on January 1, 1988 as a chemical known to the State to cause cancer under Proposition 65 (California Health and Safety Code 25249.5 et seq.). Polygeenan is formed by heated, strong-acid hydrolysis of native carrageenan (obtained from seaweed) (IARC, 1983; Kolbye et al., 1987). Polygeenan is not in the U.S. food supply but is used to suspend barium sulfate in medical diagnostic procedures to aid x-ray visualization of the gastrointestinal tract (Kolbye et al., 1987).

There is some uncertainty about selecting a cancer potency for polygeenan based on low-dose extrapolation. First, humans are potentially exposed at high dose rates. Polygeenan is used to suspend barium sulfate for medical imaging and may result in high, short-term exposures. As discussed above, there is clearly a dose-rate effect for polygeenan-induced metaplasia and likely to be one for cancer. As observed in the Oohashi et al. (1981) study, a short (two month) exposure to a high dose (ten percent polygeenan) resulted in 100 percent metaplasia which progresses irreversibly in some rats to cancer (Table 3). Studies in animals given polygeenan and other sulfated polysaccharides observed squamous metaplasia "as early as 2 weeks after the start of administration" (Ishioka et al., 1987). It is unknown if current use of polygeenan in humans induces metaplasia. The number of potential medical procedures for affected individuals was not evaluated here. It is noteworthy that medical conditions precipitating the use of medical imaging may include hyperplastic and metaplastic lesions. It is unknown whether the extent to which exposures to polygeenan through the use of barium sulfate medical imaging may interact or otherwise increase risks to these individuals with pre-existing medical conditions.

NO SIGNIFICANT RISK LEVEL

The NSRL for Proposition 65 is the intake associated with a lifetime cancer risk of 10^{-5} . The cancer potency estimate of $6.0 \times 10^{-4} \text{ (mg/kg-d)}^{-1}$ was used to calculate the NSRL for polygeenan (1200 $\mu\text{g/day}$).

CONCLUSIONS

The conclusion can only be one of opinion or of risk assessment. Almost every ingested compound has or offers some kind of risk. Assessing a risk factor (risk or benefit) is really a personal choice. Simply stated, a benefit is something good or helpful and a risk is the possibility of harm. Most of us make decisions like this every day, since daily life has much potential for both benefit and risk. You will need to decide for yourself if the benefit is worth the risk. There are scientists on both sides regarding the issue of safety, something that is really not unusual these days.

Several websites have been proclaiming carrageenan as being dangerous, stating it can cause cancer in humans. These reports, as mentioned earlier, are based on studies that used degraded carrageenan, which is chemically different than food-grade material. Degraded carrageenan is not approved for use in food products, only undegraded material is. These adverse studies were mainly conducted on animals, although some have used cells from humans. The food grade carrageenans are generally of high relative molecular mass and are not broken down to very small molecules in the gastrointestinal tract. Especially in light that the normal dosage amounts ingested are low, the FAO/WHO and JECFA), FDA, EU, and California have all have acknowledged that the acceptable daily intake (ADI) is not thought to be dangerous at this time. In this particular case, (in our opinion) the current evidence appears to support carrageenan (undegraded) use is safe and acceptable.
