

**ADVERSE REACTIONS**

Occasionally, gastrointestinal side effects, such as nausea and diarrhea have been reported.

**INTERACTIONS****DRUGS**

No interactions are known. However, chitosan might bind to certain drugs, especially lipophilic drugs.

**NUTRITIONAL SUPPLEMENTS**

Vitamin C is believed to enhance the putative benefits of chitosan. Chitosan might bind to the fat soluble vitamins A, D, E and K, as well as carotenoids and flavonoids. It might also bind to some minerals such as zinc.

**FOODS**

Chitosan might bind some dietary lipids. It may also bind the fat-soluble vitamins A, D, E and K, as well as flavonoids, carotenoids and some minerals, such as zinc, found in foods.

**OVERDOSAGE**

There are no reports of overdosage.

**DOSAGE AND ADMINISTRATION**

There are several chitosan supplements available. Those who use chitosan for cholesterol-lowering effects typically use 1000 to 1200 milligrams twice a day, taken before or after meals and with a glass of water. Chitosan can be contaminated with such metals as lead, mercury, iron, copper and arsenic.

Chitosan supplements should not be consumed within two hours of taking the fat-soluble vitamins A, D, E and K, carotenoids (e.g., lycopene, lutein), flavonoids (e.g., genistein, quercetin, ipriflavone) or prescription medication.

**LITERATURE**

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## Chlorella

**DESCRIPTION**

Chlorella is a genus of unicellular green algae belonging to the Phylum *Chlorophyta*. Chlorophytes comprise a major component of the phytoplankton. Chlorella is a popular food supplement in Japan and is marketed as a nutritional supplement in the United States. Chlorella, along with wheat grass, barley grass and spirulina, are sometimes referred to as "green foods." There are several species of chlorella. Those most commonly used in nutritional supplements are *Chlorella vulgaris* and *Chlorella pyrenoidosa*.

Chlorella is rich in protein. In addition, it is rich in chlorophyll, carotenoids, such as astaxanthin, canthaxanthin, flavoxanthin, loraxanthin, neoxanthin and violaxanthin. Chlorella also contains the xanthophyll, echinenone.

**ACTIONS AND PHARMACOLOGY****ACTIONS**

Chlorella has putative anticarcinogenic, immunomodulatory, hypolipidemic, gastric mucosal-protective and detoxification activities.



**MECHANISM OF ACTION**

Glycoprotein-rich extracts of *Chlorella vulgaris* have been found to have antitumor activity against both spontaneous and experimentally induced metastasis in mice. The antitumor activity is thought to be mediated by an immunopotential mechanism. The glycoprotein-rich extracts may enhance the migration of T cells to the tumor sites.

The mechanism of the putative hypolipidemic and gastric mucosal-protective activities of chlorella, which again have only been found in animal studies, is unknown.

In rats, chlorella was found to promote the excretion of dioxin in the feces. The mechanism of this action is unknown.

**PHARMACOKINETICS**

The pharmacokinetics of chlorella in humans have not been studied. However, the proteins, lipids and carbohydrates in chlorella should be digested, absorbed and metabolized by normal physiological processes.

**INDICATIONS AND USAGE**

A chlorella extract has demonstrated antitumor and antimetastatic effects in animal experiments. Chlorella has shown some experimental antiatherogenic activity and some radio-protective and chemo-detoxifying effects. It has shown some preliminary benefit in immune function and in some with fibromyalgia.

**RESEARCH SUMMARY**

An extract of chlorella markedly increased survival time in mice injected with Meth-a tumor cells. A glycoprotein constituent of chlorella demonstrated antitumor properties *in vitro*. Recently, a glycoprotein extract exerted a pronounced antitumor effect against spontaneous and experimentally induced metastasis in mice. Immune-enhancement appeared to play a central role, particularly T cell activation in the peripheral lymph nodes of the tumor-bearing mice.

Chlorella has demonstrated an ability to protect against gamma-radiation, as well as against a number of drugs and various toxic chemicals. In one animal experiment, it alleviated some of the side effects of 5-fluorouracil. In another study, chlorella helped prevent gastrointestinal absorption and promoted the excretion of dioxin already present in tissues in rats.

Chlorella has exhibited hypolipidemic and antiatherogenic effects in some animal experiments. Aortic atheromatous lesions were significantly inhibited by chlorella in rabbits on a high-cholesterol diet.

In one animal model of peptic ulcer, oral administration of dry powder chlorella helped protect gastric mucosa.

In a recent clinical trial of chlorella, some patients with moderately severe symptoms of fibromyalgia syndrome were said to derive significant benefit from consumption, over a two-month period, of 10 grams daily of Sun chlorella tablets and 100 ml of liquid Wakasa Gold, two commercial chlorella products. Evaluation of improvement was largely subjective.

**CONTRAINDICATIONS, PRECAUTIONS, ADVERSE REACTIONS****CONTRAINDICATIONS**

Chlorella is contraindicated in those who are hypersensitive to any component of a chlorella-containing nutritional supplement.

**PRECAUTIONS**

Pregnant women and nursing mothers should avoid chlorella-containing supplements.

Some chlorella-containing supplements may be rich in vitamin K. Therefore those on warfarin should be cautious in the use of chlorella supplements.

Allergic reactions have been reported in some using chlorella supplements. Therefore, those with allergic diatheses should exercise caution in the use of chlorella supplements.

**ADVERSE REACTIONS**

Allergic reactions and photosensitivity reactions have been reported in some using chlorella supplements.

**INTERACTIONS**

Some chlorella supplements may be rich in vitamin K and may affect the INR of those on warfarin. Animal studies suggest that certain substances in chlorella may ameliorate some of the side effects of 5-fluorouracil. There is no human documentation of this.

**OVERDOSAGE**

No reports of overdose.

**DOSAGE AND ADMINISTRATION**

There are various forms of chlorella, including capsules, tablets, softgels and granules. Most chlorella marketed in the U.S. is grown in Japan and Taiwan and is processed into the various supplemental forms. Chlorella is marketed as a stand-alone supplement or combined with other so-called "green foods," such as wheat grass, barley grass and spirulina. There is no typical dosage.

**LITERATURE**

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## Chlorophyll/Chlorophyllin

### DESCRIPTION

Chlorophyll is the green pigment found in higher plants, as well as algae. Chlorophyll is the principal photoreceptor in photosynthesis, the light-driven process in which carbon dioxide is "fixed" to yield carbohydrates and oxygen. Chlorophyll is a cyclic tetrapyrrole, similar in structure to the heme group of globins (hemoglobin, myoglobin) and cytochromes. Chlorophyll differs from heme in a few major respects, most notably that the central metal ion in chlorophyll is magnesium while that in heme is iron.

There are a few types of chlorophyll. Higher plants and green algae, such as *Chlorella* (see *Chlorella*) contain chlorophyll a and chlorophyll b in the approximate ratio of 3:1. The molecular formula of chlorophyll a is  $C_{55}H_{72}MgN_4O_5$ ; the molecular formula of chlorophyll b is  $C_{55}H_{70}MgN_4O_6$ . The difference between the two chlorophylls is that a methyl side-chain in chlorophyll a is replaced by a formyl group in chlorophyll b. Chlorophyll a is found with chlorophyll c in many types of marine algae. Red algae contain principally chlorophyll a and also chlorophyll d.

Chlorophyllin is a semi-synthetic sodium/copper derivative of chlorophyll. In contrast to chlorophyll, chlorophyllin is water-soluble. Chlorophyllin, like chlorophyll, has deodorizing activity. It is used as an aid to reduce odor from a colostomy or ileostomy and also as an aid to reduce fecal odor due to incontinence. A topical ointment of chlorophyllin is used to reduce malodors in wounds and surface ulcers.

Chlorophyll and chlorophyllin are available as nutritional supplements. Preliminary evidence from *in vitro* and animal studies suggests that these substances may have anticarcinogenic activity.

### ACTIONS AND PHARMACOLOGY

#### ACTIONS

Chlorophyll and chlorophyllin may have antimutagenic and anticarcinogenic activities.

#### MECHANISM OF ACTION

Chlorophyll and its metabolites pheophytin, pyropheophytin and pheophorbide, as well as chlorophyllin, have demonstrated antimutagenic effects *in vitro* against such mutagens as 3-methylcholanthrene, N-methyl-N'-nitro-N'-nitrosoguanidine (MNNG) and aflatoxin B1. Chlorophyll and chlorophyllin have also demonstrated anticarcinogenic effects in animal models against such carcinogens as aflatoxin B1, 1,2-dimethylhydrazine and dibenzo[*a,l*]pyrene.

The mechanism of the antimutagenic and anticarcinogenic activities of chlorophyll and chlorophyllin are unknown. It is speculated that antioxidant activity of chlorophyll/chlorophyllin may play a role in these activities. Another possible mechanism is the formation of complexes between the mutagen/carcinogen with chlorophyll/chlorophyllin through strong interactions between their planar unsaturated cyclic rings. The complexes would effectively inactivate the mutagens/carcinogens.

#### PHARMACOKINETICS

There is little on the pharmacokinetics of chlorophyll and its derivative chlorophyllin in humans. Some older studies showed that chlorophyll, following absorption, is converted into pheophytin, pyropheophytin and pheophorbide. These three derivatives of chlorophyll are tetrapyrroles.

#### INDICATIONS AND USAGE

Some experimental data suggests that chlorophyll and chlorophyllin may have some antimutagenic and anticarcinogenic potential, may help protect against some toxins, and may ameliorate some drug side effects. They are useful in reducing urinary and fecal odor in some circumstances. They may help ease constipation in some. There is some preliminary indication that they could be beneficial in the treatment of calcium oxalate stone disease and that they may have some anti-atherogenic activity.