

# Fucose Complexes, Fucoxanthin, Fucooid and Fat Storage

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## INTRODUCTION

The versatile medicinal benefits of certain types of seaweed and their derivatives<sup>1,2</sup> have been highlighted recently in the weight control arena.<sup>3-7</sup> While the value of seaweed-derived fucoxanthin has attracted much attention as a thermogenic agent, seaweed contains several other functional components that could benefit an individual with excessive body weight.<sup>7-9</sup>

The objective of this article is to sort science from speculation on the value of certain types of seaweed and their extracts as natural medicines, with special reference to their use in weight control.

## SEAWEED: A BRIEF OVERVIEW

Seaweed has been used in the food chain from time immemorial, and there is a colorful history of its application for medicinal purposes.<sup>9</sup> Seaweed belongs to a large group of plant life called algae.<sup>9</sup> There are two major categories of algae: unicellular and macroalgae.<sup>1,2,9</sup> Unicellular algae include spirulina, chlorella and plankton. These single-cell algae have been widely applied in dietary supplements because of their content of vital nutrients. In contrast, macroalgae are much bigger organisms and are commonly known as seaweed or “kelp.”<sup>9</sup> These sea plants have some physiological resemblances to plants on land, and they can range in size from centimeters to up to 200 meters or more in width or length.<sup>9</sup> Seaweeds come in shades of yellow, brown, blue, green and red, and there are more than 3,000 species of algae in the oceans worldwide (Table 1).<sup>9</sup>

Understanding the “botanical” classification of marine algae is a monumental task.<sup>1,2,9</sup> There are essentially four major groups of algae that can be classified by color, namely green (Chlorophyta), brown/yellow (Phaeophyta), red (Rhodophyta) and blue green (Cyanophyta) (Table 1).<sup>9</sup> The color of algae is deter-

BLUE-GREEN	Spirulina Chlorella
GREEN	Ulva spp. Monostroma spp. Enteromorpha spp.
RED	Porphyra spp. Chondrus spp. Palmaria spp.
BROWN	Laminaria spp. Fucus spp. Undaria spp.

Table 1. Examples of the genus of algae (seaweeds) classified by color.

mined by mixtures of pigments that play a variable role in photosynthesis. These pigments include chlorophylls, carotenoids and phycobillins.<sup>1,2,9</sup>

Pigments in seaweeds have important nutraceutical properties including antioxidant and biological response-modifying qualities.<sup>9</sup> Most relevant to the present discussions are the carotenoids found in seaweeds.<sup>9-13</sup> These red, orange or yellow compounds are composed of short, carbon chain-connected 6-carbon rings that are hydrophobic (e.g., combinations of mevalonic acid and lycopene or related compounds). Carotenoids cannot transmit sunlight into photosynthetic pathways, but they function as accessory pigments. A prominent accessory or “helper” pigment is fucoxanthin, which is responsible for the “brownish” appearance of kelp.<sup>9</sup>

Seaweed has been used in several traditional medical systems for many medical purposes including: nutritional support, cancer therapy, immune stimulation, body detoxification, weight control, treatment of viral disease, etc.<sup>9</sup> The ability of many types of seaweed to be adjunctive to weight control has been known for many years.<sup>11-13</sup> Recent interests involve

the ability of antioxidant compounds in seaweed, specifically fucoxanthin,<sup>3,11-13</sup> to promote weight loss.<sup>9,11-13</sup> While fucoxanthin has some support for its role as an enhancer of body metabolism (thermogenic effect), with direct effect on fat stores,<sup>11-13</sup> other components of seaweed may be of benefit in weight control.<sup>7</sup>

Many types of seaweed are excellent sources of dietary iodine, which is an essential element for normal function of the thyroid gland.<sup>5</sup> Deficiencies in the function of the thyroid gland may promote weight gain, and optimal thyroid function supports lean body mass. Some seaweeds contain a variety of trace minerals and vitamins, which provide general nutritional support for individuals who may be engaged in calorie-restricted diets.<sup>9</sup> The presence of certain poorly absorbed polysaccharides (or types of “fiber”) in seaweed may assist in providing “bulk” in the diet.<sup>9</sup> This bulking effect enhances a sensation of fullness in the stomach or regular bowel habits. Some of the complex sugars in seaweed are referred to as fucoids (glucans), which may stimulate immune function.<sup>9</sup> Overall, there is a large amount of scientific literature

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on the use of seaweeds as health food, soil fertilizers and sources of medicinal compounds.<sup>9</sup>

### SEAWEED IN “NATURAL MEDICINE”

Several types of seaweed are used topically in facial treatments, body wraps and baths, with claims of improvements in blood circulation, detoxification, treatment of acne and rosacea and skin moisturizing, purification, exfoliation or rejuvenating effects.<sup>10</sup> The use of marine algae in this manner constitutes one aspect of *thalassotherapy* (Greek: *thalassa* = ocean and *therapeion* = treat), a discipline based on the belief that “The Sea washes away all of the ills of mankind.” (Euripides, 480 B.C.)

Many medical or “destination” spas are using topical seaweed body therapies to promote skin beauty and health. Seaweed body treatments are believed to provide surface minerals that can diffuse into the skin; and they provide pleasurable and relaxing experiences when applied in the correct context. Cosmetic therapists believe marine algae can enhance skin circulation, increase local metabolism in the skin and supporting structures, flush out toxins and assist in improving skin tone and smoothness, perhaps by inducing a mild dermabrasion.<sup>10</sup>

Certain seaweed applications are believed to be moisturizing and toning for the skin.<sup>10</sup> Specific applications of seaweed body treatments include attempts to detoxify the body, treat cellulite, enhance lymphatic drainage, clear limb swelling (edema) and even provide rejuvenating qualities.<sup>10</sup> Seaweed “scrubs” are excellent for skin exfoliation. The evidence base for these beneficial effects of the topical application of seaweed remains arguable in the medical literature.<sup>10</sup>

### SEAWEED-BASED NUTRACEUTICALS

In addition to the extensive topical use of seaweed, many types of macroalgae (kelp or seaweed) are treasured as dietary inclusions, dietary supplements or sources of pharmaceuticals.<sup>9</sup> Several textbooks and Internet resources give extensive botanical profiles of different types of seaweed, with discussions of their nutritional or potential medicinal value.<sup>9</sup> Examples of particularly valuable types of seaweed used in oral

supplements include Irish moss (*Chondrus crispus*), Fucose or *Fucus vesiculosus* (Bladderwrack), species of *Laminaria*, (especially *Laminaria japonica*), *Sargassum muticum* (Hondawara, Japan and Limu-Lala, Hawaii) and *Undaria pinnatifida* (Wakame).<sup>9</sup>

*Chondrus crispus*, or Irish moss, is an important source of mixed amino acids, magnesium and sulfur.<sup>9</sup> There is some evidence that oral intake of Irish moss can reduce blood cholesterol levels, and it may have antiviral properties.<sup>9</sup> Other proposed properties of Irish moss include neutralization of gastric acid secretion and possible exertion of a protective effect on the lining of the stomach and upper intestines.<sup>9</sup> The sulfur-containing mucopolysaccharides in Irish moss form a gel when mixed with water and they are able to retain water up to 20 times their own weight.<sup>9</sup> These gels, in sufficient dosages, may cause a sensation of stomach fullness, which is part of the simple, but valuable “feel-full, weight-loss trick.”

*Fucus (Fucose) vesiculosus* is a brownish green seaweed which is in common use in medicines.<sup>9</sup> It is rich in minerals, trace elements, iodine and vitamin C. It has found application as a dietary source of iodine and a promoter of immune function.<sup>9</sup> Fucoxanthins are abundant in Fucose or *Fucus* types of seaweed.<sup>4</sup> Independent laboratory studies suggest this antioxidant can exert significant thermogenic effects and assist directly in weight loss.<sup>7,11-13</sup> These effects have been noted to be additive with exercise.<sup>7</sup>

Several species of *Laminaria* are prized types of medicinal seaweed that have been used often in traditional Japanese medicine and by alternative physicians in Europe.<sup>9</sup> *Laminaria* seaweeds are a popular dietary inclusion in Japan and Korea. These species are rich in iodine, trace elements, polysaccharides (fucoidan) and antioxidants with the structure of fucoxanthin.<sup>9</sup>

*Sargassum* species have been used as stimulants for plant growth in liquid plant foods and as a traditional Chinese remedy to deal with excessive mucus production in the body.<sup>9</sup> *Sargassum muticum* originates most often from Japan and can grow to a length of several meters.<sup>9</sup> This seaweed contains fucoidans and fucoxanthin-like antioxidants. It serves as an important source of alginates, which have widespread use in the pharmaceuti-

cal industry.<sup>9</sup>

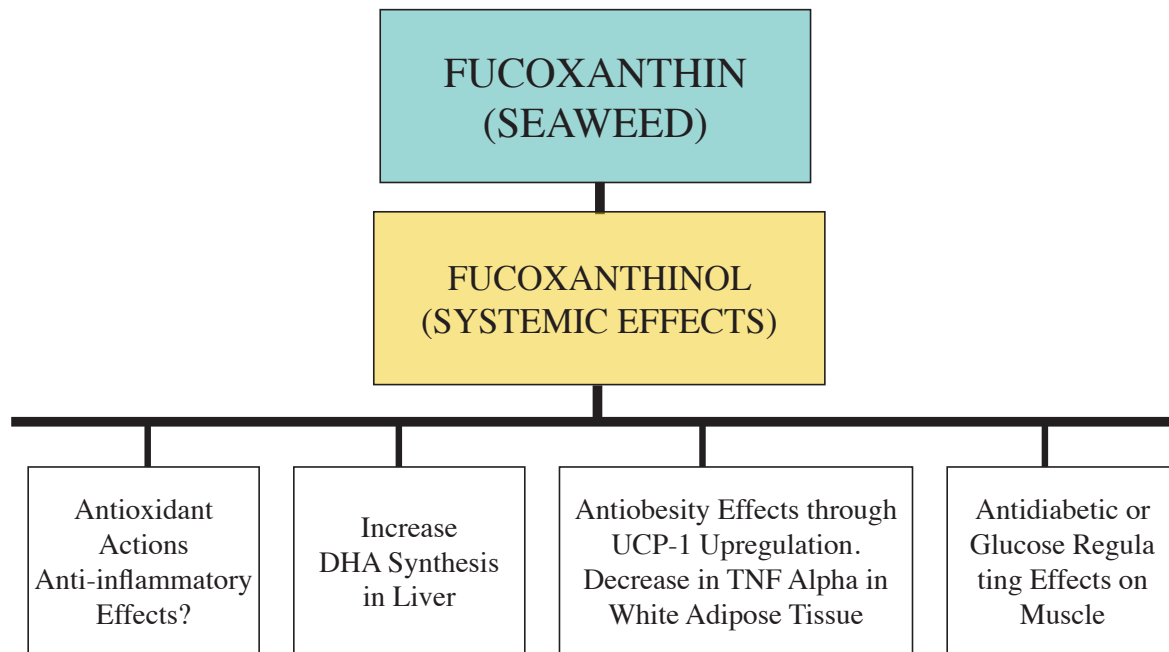
*Undaria pinnatifida* (Wakame) is a large brown algae and it is related to the *Laminaria* types of seaweed.<sup>9</sup> In common with other types of brown algae, it contains trace elements and antioxidants including fucoxanthin. *Undaria* species are rich sources of minerals and trace elements and they contain “glucans” (fucoid-like molecules) that may stimulate immunity.<sup>9</sup> This group of seaweeds is rich in calcium, niacin and vitamin C.<sup>9</sup>

### FUCOXANTHINS

Fucoxanthins “crop up” in the scientific literature in several contexts.<sup>9</sup> These compounds are strong antioxidants, related to well-known nutraceuticals such as canthaxanthins, astaxanthins, lycopene, violaxanthin and neoxanthin.<sup>9</sup> The potent and versatile antioxidant actions of carotenoids are implicated in cancer protection, immune function and anti-aging.<sup>9</sup> The anti-aging benefits of seaweed have been “touted” for years.<sup>9</sup>

Japanese researchers have shown that the fucoxanthin components of *Undaria* (Wakame) may cause up to a 10% weight loss in experimental animals by direct effects on shrinking abdominal fat stores.<sup>11-13</sup> Fucoxanthin appears to stimulate proteins (Uncoupling protein-1) that cause the oxidation of fat and its conversion to energy or heat (thermogenesis).<sup>13</sup> Uncoupling protein-1 (UCP-1) appears to be present in white adipose tissue (belly fat) and acts on mitochondria in a direct manner that promotes the oxidation of free fatty acids, thereby reducing fat tissue stores.<sup>13</sup> The preponderance of white fat in abdominal fat stores leads to the inference that this upregulating activity of UCP-1 may be valuable in reducing the size of a “pot belly.”<sup>11-13</sup> Pot bellies are a hallmark physical sign of insulin resistance and Syndrome X.

Uncoupling protein-1 is expressed in brown adipose tissue and plays a major role in whole-body energy expenditure. Dysfunction of this regulatory mechanism promotes obesity. Fucoxanthin exerts its effects through protein gene expression in UCP-1 in white adipose tissue, but not brown adipose tissue (Table 2). Animal experiments show that feeding concentrates



**Table 2.** Fucoxanthin is absorbed and converted into fucoxanthinol, which is further metabolized to amarouciaxanthin A and fucoxanthinol. The end results are antioxidant effects, increased synthesis of DHA in the liver, UCP-1 upregulation in white adipose tissue and glucose-regulating effects in muscle tissue. These combined metabolic effects of fucoxanthin have implications for the management of Syndrome X, and it appears that anti-inflammatory actions are present, as a predictable consequence of powerful antioxidant effects that have value in “obesitis” (see text).

of fucoxanthin results in significant weight reduction in rodents.<sup>11-13</sup>

When rodents are fed fucoxanthin, the expression of messenger RNA that controls UCP-1 was found to be amplified in amount in white adipose tissue, but much lower expression of this mRNA was found in mice who did not receive fucoxanthin.<sup>11-13</sup> Fucoxanthin has been found to reduce blood glucose in animals with diabetes and in normal mice that are fed high-fat diets (Table 2). It appears that fucoxanthin is capable of upregulating glucose transporter 4 mRNA expression of L-6 myotubes,<sup>11-13</sup> which are responsible for glucose transport in adult muscle tissue (Table 2). An interesting additional metabolic benefit of fucoxanthin administration in rodents is the promotion of the synthesis of docosahexanoic acid (DHA) in the liver.<sup>11-13</sup> The versatile effects of fucoxanthin on intermediary metabolism make this carotenoid of great potential value in the prevention or management of metabolic syndrome X (Table 2).

The animal experiments with fucoxanthin stimulated researchers to recommend

human clinical trials with fucoxanthin. Studies in Russia and the U.S. (not fully reported in the literature), seem to show notable thermogenic effects of seaweed antioxidants (fucoxanthin) in humans.<sup>14</sup> In placebo-controlled trials, a supplement containing a 5% fucoxanthin concentrate (daily dosage: 10 mg), combined with calorie restriction to 1,800 calories per day, resulted in an average of 14.5 lbs lost over a 16-week period. In the placebo group in this study, individuals lost an average of 3 lbs in body weight (almost a fivefold difference).<sup>14</sup>

In a second clinical experience using the same supplement formulation, increases in measurements of metabolic rate were recorded, without evidence of significant central nervous system stimulation (average 18% increase in metabolic rate).<sup>14</sup> In open-label observations of a different formula containing fucoxanthin (10% extract) enhanced with green tea and chromium, similar weight-loss results were obtained.<sup>15</sup> These weight-loss outcomes<sup>15</sup> were similar to those experienced with the previously mentioned formulation.<sup>14</sup>

### WEIGHT CONTROL

While one can accept the beneficial effects of seaweed ingredients on body metabolism in the overweight individual, the thermogenic effects of fucoxanthin<sup>11-14</sup> are best complemented by other natural substances that can provide valuable metabolic enhancement.<sup>15</sup> Thermogenesis induced by fucoxanthin can be complemented by metabolic promoters such as chromium, green tea polyphenols, chlorogenic acid and hydroxycitrate (*Garcinia cambogia*).<sup>16,17</sup> The limitation of the use of single dietary supplements for weight control has become increasingly apparent in recent times, especially given the complex pathophysiology of obesity.<sup>17,18</sup>

Chromium has several advantages for weight control supplements, largely because of its insulin sensitizing effects and ability to promote healthy blood cholesterol.<sup>16-18</sup> Green tea polyphenols exert anti-inflammatory actions and alter glucose metabolism in a favorable manner.<sup>16-19</sup> In a similar manner,

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chlorogenic acid and other “coffee polyphenols” may favorably alter lipid and sugar metabolism and afford protection against the development of type II diabetes mellitus.<sup>16-18</sup> Hydroxycitric acid (*Garcinia cambogia*) may inhibit fat storage by promoting sugar storage as glycogen and may suppress appetite, thereby decreasing body weight.<sup>17</sup> This supplement has enjoyed great individual popularity for many years, but its stand-alone use may be limited in benefits.

The use of other metabolic enhancers combined with fucoxanthin has implications for the management of metabolic syndrome X.<sup>11-13</sup> This disorder affects up to 70 million Americans with its variable constellation of overweight status, abnormal blood cholesterol and/or triglycerides and hypertension, linked by resistance to the hormone insulin.<sup>16,18,20</sup> The amplification of the actions of fucoxanthin-containing seaweeds is a synergistic approach to dietary supplement formulation with more potent and versatile effects on weight control.<sup>21</sup> This modern nutraceutical technology introduces the concept of a clinical fucose or fucoxanthin complex formula.

There is no “perfect” or ideal weight and certainly there is no “perfect diet.” Weight control is a function of behavior modification, calorie-controlled diet, exercise and adjunctive care, along with the judicious use of dietary supplements (or drugs). Diet alone cannot be relied upon for sustained weight control and there is not a dietary approach described in the history of medicine that ensures long-term weight control.<sup>16,17</sup> The “low carb” dietary approach (popularized by Atkins and copied by others) is effective in the short term and I recommend it for its provision of early weight loss. This initial weight loss serves as a positive stimulus for compliance with complex regimens that are required for sustained weight balance.<sup>17-20</sup>

It is clear that the restriction of simple sugars in the diet is quite safe and it makes eminent sense for use in mature individuals who often have insulin resistance as part of the complex of syndrome X.<sup>18,20</sup> However, it must be recognized that carbohydrate restriction alone has not been shown to overcome insulin resistance in a consistent manner.<sup>17,18,21</sup> This

is a principal reason why an Atkins-like diet is doomed to failure in the intermediate- to long-term control of body weight. It is about time dietary fads were avoided in the professional management of obesity.<sup>17</sup> Managing obesity-related disease and the litany of disorders associated with metabolic syndrome X (Syndrome X, Y and Z...) are mandatory interventions.<sup>16,18</sup> I fail to understand why both conventional and alternative medicine have failed to recognize the global importance of managing Syndrome X! While 70 million people in the U.S. have syndrome X, this diagnosis is missing from many patient charts.<sup>17,20</sup>

The role of body cleansing or detoxification seems to have emerged in clinical practice with the increasing recognition of the role of body toxicity in weight gain.<sup>22</sup> Obesity (obesitis) and syndrome X are associated with a “pro-inflammatory body status” (obesitis).<sup>16</sup> This makes eicosapentanoic acid (EPA in enteric-coated fish oil supplements) an important adjunctive weight loss supplements.<sup>18,20</sup> EPA is both anti-inflammatory and sensitizes the action of insulin by effects on PPAR receptor complexes.<sup>18</sup> Seaweeds may contain variable amounts of marine omega-3 fatty acids.<sup>9</sup> An interesting amplification of the weight-loss effects of fucose complexes may occur with the use of nonstimulant appetite-suppressant supplements, such as *Hoodia gordonii* or *Caralluma fimbriata*.<sup>23,24</sup> Of course, combating overweight status, metabolic syndrome X and prediabetes are pivotal in the prevention of type II diabetes.<sup>16,18</sup>

### CONCLUSION

Overweight individuals and their caregivers have become desperate when fat storage in the body is recalcitrant. This circumstance precipitates a willingness to look for “easy ways out” and “quick fixes.” Desperate individuals may tend to accept “hyperbolic claims” of the effects of drugs or supplements. There is no quick fix for the nation’s obesity. While diets are not “stand-alone” interventions for weight control, nor are drugs or dietary supplements, the examination of groups of individuals who have controlled their weight over extended periods of time shows that such individuals have taken a multi-pronged approach to weight control.<sup>17,18</sup>

Weight management is a holistic medical venture.<sup>16,25</sup> ♦

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