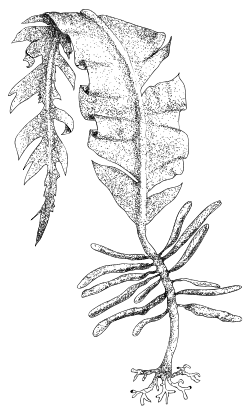
marginata, which is found in the Pacific from California to Alaska. To complicate matters, the former also goes by the name of Atlantic *wakame* or wild *wakame*, even though it belongs to a completely different genus. On occasion, winged kelp is also just called kelp, using the umbrella term for large brown algae, which is reasonable given that it belongs to the order Laminariales. It has thinner, softer blades than other types of kelp and its color tends toward yellowish and olive green with a golden midrib. Winged kelp has very characteristic long spore-bearing blades (sporophylls), which branch out from the stipe above the holdfast. They resemble small wings, hence, the Latin name derived from *ala*, meaning wing, and the common English name of the seaweed. The main blade, which can attain a length of 1–3 meters, has irregular segments, especially toward the tip, which look a little like a fringe.

In many cases, dried winged kelp can be substituted for Japanese *wakame* in recipes, but it requires a longer soaking time (ca. 20 minutes). After it has been rehydrated in cold water, dried winged kelp is almost as good as fresh. It has a mild taste and can be used as a salad. The midrib is edible if it is toasted and deep frying the sporophylls brings out a taste that is reminiscent of peanuts.

Winged kelp is one of the seaweed species with the highest vitamin A content, comparable to that of spinach and parsley. It also contains a significant amount of calcium, almost equivalent to that in sesame seeds, and potassium is present in greater quantities than sodium.

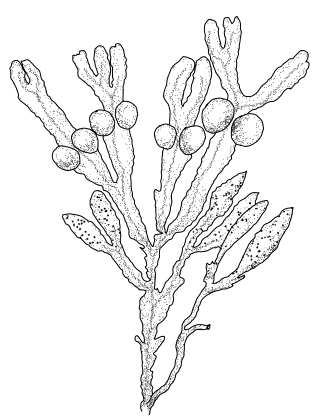


▲ Winged kelp (*Alaria esculenta*).

Bladder wrack—abundant everywhere

Bladder wrack is a brown alga from the genus *Fucus*, the best known example of which is *Fucus vesiculosus.* Although it is widespread along the coastlines in virtually every part of the world and is possibly one of the more valuable of all the species of seaweeds, it is held in relatively low esteem. Some varieties of bladder wrack have traditionally been used to make a tea and it can be used in the same way as *konbu*. It is not very often utilized as food for humans, which is a shame, as the youngest and outermost shoots of the seaweed are extremely tasty.

Fucus is commonly dried and sold in two forms: as granules or as small branches, which are a beautiful deep green or brownish color and have their dehydrated air bladders attached. It has a strong taste of iodine and is generally very salty, both indicators that bladder wrack has a chemical composition that mirrors that of *konbu*. It is good in cooked dishes, soups, or sprinkled on salads.



▲ Bladder wrack (*Fucus vesiculosus*).

Seaweeds and *umami*

Seaweeds & human nutrition

The taste of seaweeds is closely tied to what is known as the fifth taste or *umami*. In Asia, one has for many years talked about five different types of taste. In addition to the four well-known ones—sour, sweet, salt, and bitter—there is a fifth taste, *umami*, which in Japanese means something along the lines of savory or delectable.

That *umami* is a distinct taste in the sensory physiological sense was established scientifically in 2000, when the first specific taste receptor that is able to recognize the key substance imparting the *umami* taste was identified. This substance is monosodium glutamate, MSG, the sodium salt of glutamic acid, an amino acid found in great abundance in seaweeds. MSG is sometimes referred to as the third spice, the first two being salt and pepper. It is used widely as a taste enhancer in Chinese cuisine. MSG is also found in cured ham, Parmesan cheese, mature tomatoes, as well as fish and soy sauce. Hence, terms often used in English to characterize *umami* taste are brothy and meaty.

In 1908, a Japanese chemist, Kikunae Ikeda (1864–1936), identified MSG as the chemical compound that is responsible for the savory taste of the traditional Japanese soup stock, *dashi*. This broth is made from a warm aqueous extract of *konbu* and a conserved fish product called *katsuobushi*. *Konbu* turned out to be very rich in MSG, which makes up about 2–3% of its dry weight. Ikeda coined the term *umami* to describe the taste of MSG, from the Japanese *umai* (delicious taste) and *mi* (essence).

Brown algae such as *konbu* have a particularly high MSG content. This substance is released when the seaweeds are softened and heated gently in water. Normally one should not wash dried seaweeds before using them, as tasty minerals and amino acids have often seeped out onto their surfaces. Their taste can, however, also depend on how they are treated. When making soups, for example, the seaweeds should not be boiled for very long or, better yet, not at all, as prolonged cooking can bring out a taste that is too strong and fish-like.

Of the many different variants of Japanese *konbu*, *ma-konbu*, *rausu-konbu*, and *rishiri-konbu* are considered to be the best bases for *dashi* and they yield a very light *dashi* with a mild and somewhat complex taste. *Ma-konbu* is the *konbu* with the largest amount of free MSG, 3200mg/100g, whereas *rausu-konbu* has 2200mg/100g, and *rishiri-konbu* has 2000mg/100g. The lower quality *hidaka-konbu* has 1300mg/100g.

Other substances, which are derived from nucleic acids that are dissolved within the cells of some seaweeds, in particular *nori*, are also sources of the *umami* taste. These nucleic acids, especially inosine monophosphate and guanosine monophosphate, are formed when the cells break down ATP (adenosine triphosphate), the energy storing molecule, in order to obtain the energy they require to do their work. Nucleic acids impart a sweetish taste to seaweeds and these taste substances can be transferred to the animals that eat the algae. Sea urchin roe is sought out for its sweetness and *umami* taste, which is due to the inosine monophosphate that sea urchins ingest when they graze in kelp forests.

The reason why seaweeds contain many of these substances that draw out the *umami* taste is that they help to maintain the correct osmotic balance in the seaweed cells so that they do not burst when they are exposed to the surrounding, often very salty, seawater. Consequently, seaweed species from more saline oceans have a stronger *umami* taste. Another substance that

►► Dried *arame* and bladder wrack.

Seaweeds, wellness, and nutrition

Folk traditions and the health movement

For many millennia, the original inhabitants of all continents, especially those in coastal areas, have availed themselves of seaweeds for food and medicine. In the last few decades, numerous health movements have embraced seaweeds and marine algae and touted their beneficial aspects. Some of these claims are well founded, at least from a scientific point of view. In other cases, probably the majority, the supposed positive effects are supported by references to tradition and experience. There is a real need for research in this field.

Nevertheless, there are some interesting observations that are hard to avoid. It is well-known that people who inhabit places where consumption of substantial quantities of seaweeds and other marine foodstuffs is the norm have a lower incidence of cardiovascular disease and high blood pressure. They also tend to live longer. This latter fact was already pointed out in 1927 by the Japanese professor Shoji Kondo of Tohoku University, who was investigating the correlation between lifespan and diet in various areas of Japan. His findings, later corroborated by more recent studies, were that on those islands of southern Japan where the consumption of seaweeds is high, life expectancy, especially that of women, is generally longer. These population groups also had a low calorie intake, ate less rice, and used less salt in their food than those in other parts of Japan.

Throughout the ages, and increasingly in connection with a variety of modern health movements, beneficial properties and the ability to cure all sorts of ailments, from digestive problems to cancer, have been ascribed to seaweeds, algae, and products made from them.

What have we already learned?

In general terms, it can be said that a varied diet that includes a proportion of seaweed products, for example, up to 10% as in Japan, promotes wellness. This is due principally to the high concentration in marine algae of important minerals and vitamins. These minerals in seaweeds are in what are known as chelated and colloidal forms, which enhance their bioavailability in the body. Seaweeds are also a good source of proteins and essential amino acids.

In addition, marine algae have a much greater fiber content than vegetables and fruits, as they are largely composed of both soluble and insoluble dietary fiber. Because dietary fiber is indigestible, it contributes no calories,

Doses of those orders would correspond to up to 2 grams pure kainic acid for an adult human being. There appears to be no published data regarding human safety values, neither are there there any published studies relating oral intake of food containing kainic acid to neuronal activity in humans. In order to reach the hazardous levels of kainic acid used in the mice and rat experiments, a total amount of about 30 kilograms dried dulse of the variety with the highest concentration of kainic acid is required. It is highly unlikely that a human being would consume such a large amount of dulse in one meal. Furthermore, the consumed dulse has to pass through the gastrointestinal system before possibly making it into the bloodstream and from there across the blood-brain barrier. It would appear, therefore, that consumption of most dulse species does not present any serious danger to human health.

How much seaweed should one eat?

There is no scientific evidence for dietary advice about how much or how little seaweed one should eat. As there is also no well-documented proof of the therapeutic effects of marine algae, there are no recommended dosages for seaweed products in a medicinal context.

Nevertheless, there are two relationships that need to be taken into account. One is the iodine content in seaweeds and the other is the content of salts. In both cases, the central issue is to eat neither too much nor too little. Not surprisingly, the well-known maxim of the Renaissance doctor and alchemist Paracelsus still applies: All substances are poisons; it is only the proper dose that differentiates a poison from a remedy.

In the normal Japanese diet, which typically includes about 4–10 grams of marine algae every day, the iodine content is about 1 mg. It has been estimated that the average daily Japanese iodine intake is 1–3mg and that some Japanese consume as much as 20mg of iodine in their daily food. In a single sheet of *nori*, used for sushi rolls, there are only about 40µg of iodine, but it is not unusual for a bowl of good *miso* soup made with *konbu* to have about 1mg.

Even though seaweeds contain potassium salts, and in the case of some species a greater quantity of potassium salt than of sodium salt, the overall salt content can pose a problem for persons with a tendency to high blood pressure. So the golden rule is the usual one: use salt sparingly.

Our intestinal flora and enzymes are not normally adapted for breaking down some of the carbohydrates found in seaweeds. Consequently, some people benefit from incorporating marine algae into their diet slowly to allow their systems to adjust. It is, therefore, sensible to eat small portions of seaweeds regularly, instead of big quantities once in a while. Also, one should not expect that any positive effects of seaweeds on overall health would be noticeable immediately; this can take several months.

Given all of the above, it seems reasonable to recommend that the average adult could eat about 5–10 grams dry weight of seaweeds on a daily basis.

nori industry. Here I could see with my own eyes her carefully mounted *Porphyra umbilicalis* and read annotations, in her own handwriting, about classification and where the specimen was found.

Then I was allowed to sit amongst the collections and make use of the library, where there are many interesting books about algae that I have found nowhere else. Sitting beside the old shelves and cupboards, I soaked up the congenial atmosphere of this place, where time seemed to stand still and the staff went quietly about their tasks.

When I was leaving, Jenny Bryant told me that it had been a good day for algae, as one of their former colleagues had dropped by. I had the impression that seaweed research is a low priority at the museum and that only a few phycologists work on the collections. I exited by the little side door and found myself back on the large main staircase. To think that one could pass by that modest entrance and have no idea about what lies behind it.

'Seaweed people' are friendly and they are possessed of a peculiar, quiet enthusiasm for that special alga to which much of their working life is devoted. And they love to share their passion for it with others who are interested in the subject.

I left the museum in a good mood, with my own seaweed obsession recharged. Better yet, an arrangement had been made for me to come back again and have photographs taken of some selected specimens from the collections.

▸ Dried specimen of the red alga sea beech (*Delesseria sanguinea*) from the collections of the Natural History Museum in London.

▸▸ The Natural History Museum in London and a peek into the Herbarium.