1

Algae in Traditional Medicine

1.1. Traditional Asian medicines

1.1.1. *Chinese medicine*

Traditional Chinese medicine, or TCM, is an ancient medicinal practice. It is one of the three great traditional medicines along with Galenism (Arab world) and Ayurveda (India). Its origins date back to 3,000 BCE (Nestler 2002). It is best known worldwide for the practice of acupuncture. However, this medicine is not limited to this particular technique and its use is based on a set of prescriptions, some of which can be likened to a lifestyle (see Table 1.1).

Traditional Chinese medicine is based on a set of initially oral traditions, originating in the community, family or religious traditions. Depending on the ethnic group, they may also be based on magical beliefs. Some of these traditions are rooted in Shamanism, Buddhism or Taoism. The diversity of the origins and practices employed has led ethnologist Paul Unschuld to write that "there is not a traditional Chinese medicine, but traditional Chinese medicines" (Unschuld 2018).

Initially based on oral tradition, traditional Chinese medicine has developed over time into a written practice. The oldest text, *Yi Jing* ("Book of Changes"), was written by the Chinese emperor Fuxi.

One of his successors, Emperor Shennong, was the pioneer of herbal medicine, and the source of the *Bencao*, or "Treatise on Medicinal Matters".

Finally, in the 3rd century BCE, the knowledge acquired through traditional Chinese medicine was compiled in a medical encyclopedia known as *Huangdi Nei Jing*, or "The Yellow Emperor's Classics of Internal Medicine". This work, which covers almost 2,000 years of medicinal practice, was written by Emperor Huang Di, better known as the "Yellow Emperor".

Traditional Chinese medicine is based on a curative as well as preventive approach. This medicine is based on various precepts, such as nutrition, exercise and body manipulation (see Table 1.1).

Acupuncture	**Healthy nutrition**	**Consumption of medicinal plants***	**Therapeutic massages**	**Movement exercises (Qi Gong, Tai Chi)**
Common (preventive-curative)	Daily (preventive)	Quite frequent (curative)	Quite frequent (curative)	Daily (preventive)

* Including algae.

Table 1.1. *Precepts of traditional Chinese medicine for the prevention or treatment of disease (according to Nestler (2002))*

Today, traditional medicine coexists with modern Western-style medicine in Chinese hospitals. Algae, marine plants par excellence, are used in traditional Chinese medicine for both preventive (healthy food) and curative purposes.

Traditional Chinese medicine often uses the brown alga *Sargassum* in the treatment of various pathologies, as well as in the treatment of pain resulting from inflammatory mechanisms (Chatterji et al. 2010; Liu et al. 2018).

There are approximately 400 species in the genus *Sargassum*, and only a limited number of species are used in traditional Chinese medicine (see Table 1.2). Most of them are included in the Chinese pharmacopoeia and are associated with pain relief treatments or chronic pathologies, such as goiters, bronchitis or edemas (see Table 1.2).

Latin name	Chinese common name	Therapeutic applications
Sargassum pallidum ***Sargassum confusum*** ***Sargassum fusiforme***	Hai Zao	Treatment: – goiters – scrofula – testicular swelling and pain – edema – chronic bronchitis – angina pectoris – acute esophagitis – arteriosclerosis
Sargassum fulvellum ***Sargassum henslowianum*** ***Sargassum thunbergii*** ***Sargassum horneri***	Hai Qian	Treatment: – goiters – sore throat – cough – angina pectoris – edema – dysuria – boils – fever – pain
Sargassum siliquastrum ***Sargassum muticum*** ***Sargassum hemiphyllum*** ***Sargassum polycystum*** ***Sargassum vachellianum***	Species used in China, but not officially referenced under a common name	Same uses as for Hai Zao and Hai Qian

Table 1.2. *Examples of the use of* Sargassum *species (*Sargassum *spp.) in traditional Chinese medicine in the treatment of various pathologies (according to Liu et al. (2012))*

Sargassum algae, listed under the common name of “Hai Zao”, have been recognized in the Chinese pharmacopoeia since 1953. In the modern pharmacopoeia, in addition to the treatments listed in Table 1.2, sargassum is also recommended for the treatment of high blood pressure (Liu et al. 2012). According to the pharmacopoeia, the dose of seaweed should be between 6 and 12 g (expressed as dry matter). The method of administration is varied and depends on the nature of the ailment being treated. For dermal conditions, the product is administered as a powder spread topically over the lesion. However, for the treatment of certain internal dermal lesions, the product can be administered *per os* through the use of an extract. Algal decoction is one of the main ways in which an alga is administered in traditional therapeutic practice.

Algae can also be provided in the form of a food as an accompanying dish (sea vegetable). This is the case, for example, with the species *Sargassum fusiforme*, known as the “vegetable of longevity”. Traditional Chinese medicine, through this method of dietary administration of a drug, has appropriated the famous concept of “functional food”, little recognized in the Western world.

The species of sargassum known as “Hai Qiang” is part of folk medicine, especially in southeast China.

In addition to sargassum, other species belonging to the Chlorophyte (green algae) or Rhodophyte (red algae) phyla are also used in traditional Chinese medicine (see Table 1.3). These algae are recommended for the treatment of chronic conditions such as hypertension and hypercholesterolemia.

Chronic oral abscesses can also be treated by ingesting a seaweed decoction called “Long-shu-tsai”, which is prepared from the red alga *Gracilaria lemaneiformis* (Vonthron-Sénécheau 2016).

In traditional Chinese medicine, seaweed is also combined with other plants. They are used in complex preparations to achieve synergistic therapeutic effects. Sargassum is used in 226 herbal preparations.

Some, recognized by the Chinese pharmacopoeia, are highly complex preparations involving a multitude of ingredients (see Table 1.4). Such is the case with the medicinal preparation “Ru Jin Ling Ke” (乳疾灵颗粒), which

combines more than a dozen ingredients that also include an animal organism (oyster or *Concha ostreae*).

Algal species	Therapeutic use
Ulva clathrata (green alga) *Gracilaria arcuata* (red alga) *Porphyra* spp. (red alga)	Treatment of goiters Treatment of inflammation of the lymphatic system
Chondrus ocellatus (red alga) *Gelidiella acerosa* (red alga) *Gelidium* spp. (red algae) *Gracilaria* spp. (red alga) *Hypnea* spp. (red alga)	Treatment of chronic constipation
Gracilaria verrucosa (red alga) *Ulva linza* (green algae)	Diuretic
Porphyra spp. (red alga) *Ulva* spp. (green alga)	Treatment of hypertension Treatment of hypercholesterolemia

Table 1.3. *Examples of green, red and brown algae used in traditional Chinese medicine for the treatment of chronic pathologies*

Another, less complex preparation combines brown algae of the *Laminaria* or *Sargassum* with a more limited number of terrestrial plants (7) and is also recognized by Chinese pharmacopoeia. This preparation, called "Xiao Ying Wu Hai Wan" (消瘿五海丸), is administered as an oral expectorant in pill form. Its therapeutic indications are associated with the treatment of goiters, tuberculosis of the lymph nodes or cancer[1].

1 See: http://www.tcmip.cn/ETCM/index.php/Home/Index/fj_details.html?id=3176.

Name of medicinal preparation	Composition	Therapeutic use	Mode of administration	Reference
Ru Ji Ling Ke Li (乳疾灵颗粒)	*Radix bupleuri* *Rhizoma cyperi* *Radix paeoniae rubra* *Salviae miltiorrhizae radix* *Salviae miltiorrhizae rhizoma* *Concha ostreae* *Citri reticulatae pericarpium* *Sargassum* *Laminaria* *Semen cuscutae* *Semen vaccariae* *Caulis spatholobi* *Herba epimedii*	Treatment: – liver stagnation syndrome – breast hyperplasia – pulmonary nodules	Oral (granules)	Chinese Pharmacopoeia Encyclopedia of Traditional Chinese Medicine

Table 1.4. *Example of a medicinal preparation incorporating the brown algae* Sargassum *and* Laminaria *(Ru Ji Ling Ke Li) (according to Liu et al. (2012), Chinese pharmacopoeia (see: http://www.tcmip.cn/ETCM/index.php/Home/Index/fj_details.html?id=2324))*

Algal species	Traditional use	Pharmacopoeia
Digenea simplex (red alga)	Antihelminthic	Chinese
Grateloupia livida (red alga)	Antihelminthic	Chinese
Corallina pilulifera (red alga)	Antihelminthic	Chinese
Gracilaria caudata (red alga)	Pest control	Chinese
Codium fragile (green alga)	Antihelminthic	Chinese
***Enteromorpha* spp.** (green alga)	Antihelminthic	Chinese
Udotea flabellum (green alga)	Antimicrobial	Chinese
Sargassum fluitans (brown alga)	Antihelminthic, antiprotozoal	Chinese
Sargassum thunbergii (brown alga)	Antimicrobial	Chinese
Sargassum horneri (brown alga)	Antimicrobial	Chinese

Table 1.5. *Examples of green, red and brown seaweed used as antiparasitic agents in traditional Chinese medicine (according to Vonthron-Sénécheau (2016))*

In traditional Chinese medicine, the use of seaweed is not restricted to the treatment of pain, goiters or certain chronic pathologies. Various species belonging to the red (Rhodophytes), green (Chlorophytes) or brown (Phaeophytes) algae groups are used in parasitic treatments of helminthic or protozoan origin (Vonthron-Sénécheau 2016). These uses are well known and listed in the Chinese pharmacopoeia (see Tables 1.4 and 1.5).

In Asia, other traditional medicines also use algae for therapeutic purposes. Traditional Japanese medicine is one such example.

1.1.2. *Japanese medicine*

Traditional Japanese medicine, or Kampo, is more recent than traditional Chinese medicine. It first appeared on the Japanese peninsula around the 5th century AD. It was introduced via Korea, which had itself received it from China. This medicinal practice is therefore derived from Chinese folk medicine. Kampo is a traditional medical approach used by over 80% of Japanese doctors (Motoo et al. 2011).

In Japanese clinical practice guidelines, 10% of prescriptions are associated with the use of Kampo. By comparison, only 7% of traditional Chinese medicine practices are listed in Chinese clinical practice guidelines.

In 2001, the Japanese government introduced the teaching of Kampo in medical studies. In this way, Japan has encouraged the fusion of two types of medicine: traditional and Western. This close association between the two types of medicine also exists in China but in a more limited way (see Figure 1.1). However, it is absent in Korea, where traditional medicine and Western medicine represent two separate branches of medicine (see Figure 1.1).

Kampo medicine is based on the use of therapeutic herbal formulas. The Japanese pharmacopoeia recognizes 165 herbal ingredients that can be used in Kampo preparations. The main manufacturer of Kampo medicines (the Tsumura firm) commonly uses licorice (*Glycyrrhizae radix*) and ginger rhizome (*Zingibiris siccatum rhizoma*) in its formulations. Seaweed is used less frequently, except in certain cases where the aim is to reinforce the effectiveness of Kampo medical practice.

In the case of digestive disorders or chronic pathologies relating to the digestive system, the Kampo approach is known as “Daikenchuto”. It is based on the use of plant preparations of various compositions.

The preparation consisting of *Zanthoxylum fructus* (Japanese pepper), *Zingibiris siccatum rhizoma* (ginger), *Ginseng radix* (ginseng) and maltose powder can be recommended to relieve the effects of colitis (Shi et al. 2022). The “Daikenchuto” approach is also recommended in the treatment of post-operative gastrointestinal ileus (Endo et al. 2017).

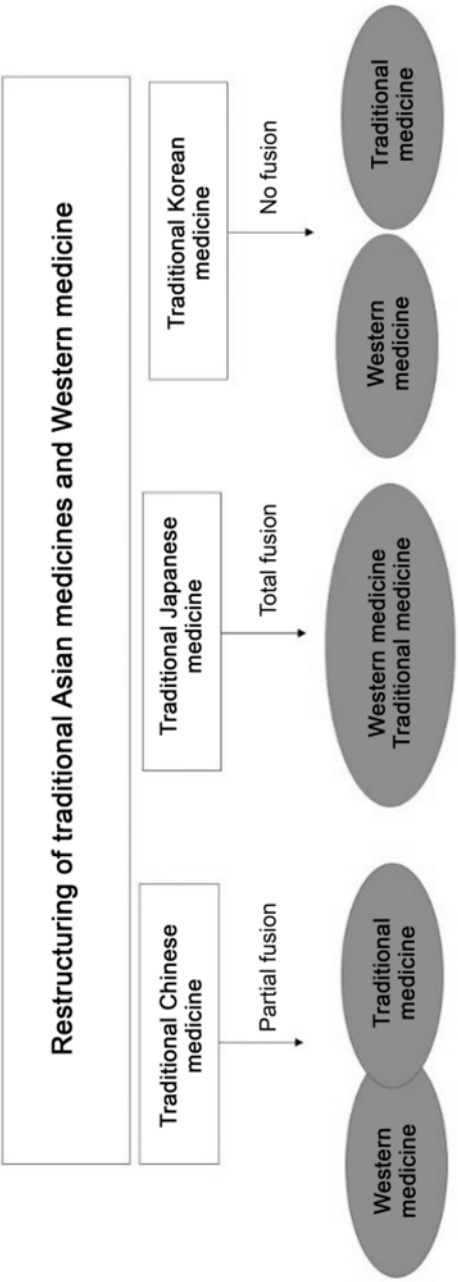

Figure 1.1. *Association or integration of traditional Asian medicines and Western medicine according to Motoo et al. (2011))*

In the case of stomach cancer, the use of Kampo medicine is recommended to reduce the pain and side effects of chemotherapy. The inclusion of algae in the basic formula of the "Daikenchuto" preparation is recommended during palliative care related to stomach cancer (Kobayashi 2016). The species concerned are mainly brown algae rich in fucoidanes and sulfated polysaccharides known for their immunostimulant and anticancer properties. These algae can be administered as extracts or as part of the patient's diet (see Table 1.6) (Kobayashi 2016). In the latter case, the term "Yakuzen", or "healthy medicinal cuisine", is used to describe the use of "vegetable seaweed" as a functional food.

Algal species	Common name
Laminaria japonica (*Saccharina japonica*) (brown alga)	Kombu
Undaria pinnatifida (brown alga)	Wakame
Hizikia fusiformis (brown alga)	Hijiki
Cladosiphon okamuranus (brown alga) *Nemacystus decipiens* (brown alga)	Okinawa – Mozuku Mozuku
Undaria pinnatifida (lower part of the thallus) (brown alga)	Mekabu
Gelidium elegans (red alga)	Tengusa
Sargassum horneri (brown alga)	Akamoku
Ulva lactuca (green alga)	Aosa
Porphyra yezoensis (red alga)	Nori

Table 1.6. *Algal species used in traditional Japanese Kempo medicine for the preparation of the enriched therapeutic preparation "Daikenchuto" or for healthy medicinal cooking (according to Kobayashi (2016))*

Apart from the classic field of Kampo medicine, certain species of algae are used in their own right in local traditional medicine practices. For example, in the Amami Islands, in the south of the Japanese archipelago (see Figure 1.2), certain red algae are used to produce deworming medicines.

Figure 1.2. *Geographical location of the Amami Islands (according to Google Maps (2023)). For a color version of this figure, see www.iste.co.uk/fleurence/health.zip*

This is the case for *Digenea simplex* (see Figure 1.3) and *Chondria armata*, known as "Makuri" or "Hana-Yanagi", respectively (Arasaki and Arasaki 1985; Terada and Watanabe 2016).

In particular, these algae produce kainic (see Figure 1.4) and domoic acids, which are powerful antihelminthics (Maeno et al. 2019).

Algae from the family *Laminariacea* are also used in traditional Japanese medicine for their hypotensive effects. This activity is linked to the presence in these brown algae, and more specifically in the species *Laminaria angustata,* of a peptide called laminin (Girard et al. 1988). This hypotensive agent has also given rise to a drug known today under the generic name of Laminin (Arasaki and Arasaki 1985).

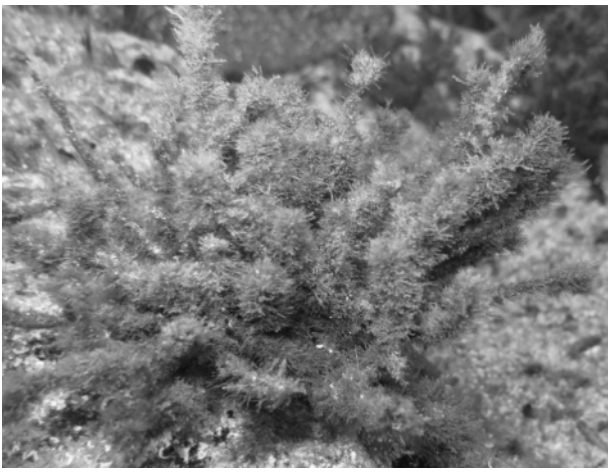

Figure 1.3. Digenea simplex *(photo credit © Lerissel et al. 2021). For a color version of this figure, see www.iste.co.uk/fleurence/health.zip*

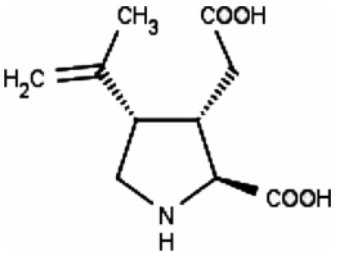

Figure 1.4. *Structure of kainic acid*

Kampo is also associated with the treatment of neurodegenerative pathologies such as dementia and Alzheimer's disease. The practice is based on a phytotherapeutic approach known as "Yokukansan". The associated preparation is essentially composed of the roots or rhizomes of terrestrial plants.

"Yokukansan" is recommended for reducing the severity of behavioral disorders associated with neurodegenerative diseases. In the case of dementia, it is recommended to alleviate certain symptoms, such as excitement, aggressiveness and hallucinations. Stemming from the Sino-Japanese tradition, this preparation has often been used in China to treat aggression in children.

Animal studies show the presence, in the preparation, of bioactive substances with neuroprotective and anti-stress effects (Czelusta et al. 2018). Such compounds also exist in brown algae. They are mainly polysaccharides (laminarinfucoidanes) (Pereira and Valado 2021). The addition of brown algae of the genus *Laminaria* (*Saccharina*) in the preparation "Yokukansan" may therefore be justified for the treatment of neurodegenerative diseases. Despite this, the scientific literature does not mention the association of algae with the basic "Yokukansan" preparation. It is likely that such a practice exists, but its application is surely local and must be based on an oral tradition not easily identifiable outside the regional context.

Figure 1.5. *Donguibogam Encyclopedia, on display at the National Museum of Korea (photo credit © Durrey J.)*[2]

1.1.3. *Korean medicine*

Korean traditional medicine is as old as Chinese traditional medicine. Its origins are generally estimated at 3,000 BCE. Like other traditional Asian medicines, it is based on the use of herbal beverages and the consumption of foods considered to be healthy. The practices of traditional Korean medicine have been recorded in an encyclopedia called *Donguibogam* (see Figure 1.5). This 25-volume medical encyclopedia was written in the 16th century by a physician at the court of King Seonjo of Joseon. This document, preserved in the National Library of Korea, is listed by UNESCO

2 See: https://commons.wikimedia.org/w/index.php?curid=47255719.

in the Memory of the World Register. It is the first medical work to be included in this prestigious register[3].

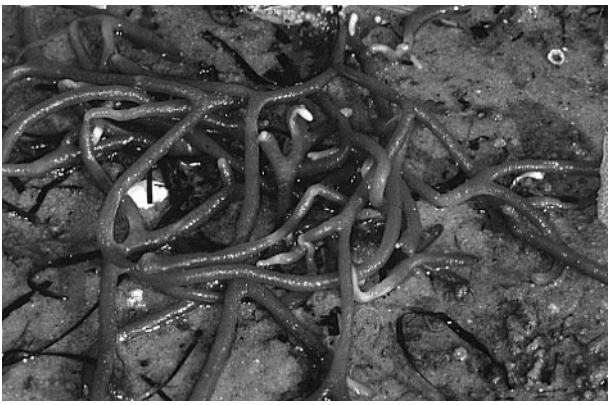

Figure 1.6. Codium fragile *(Cheong-kag), a green alga used in traditional Korean medicine (photo credit © Barbaroux O. 2016). For a color version of this figure, see www.iste.co.uk/fleurence/health.zip*

The links between traditional Chinese and Korean medicines are numerous, and certain prescriptions based on the use of algae to treat goiters in particular are shared between the two types of medicine. Traditional Korean medicine, however, presents a number of particularities. It specifically employs several species of green algae in extract form. The species *Codium fragile* and *Caulerpa lentillifera* (see Figures 1.6 and 1.7) are used to treat chronic or specific pathologies (see Table 1.7). *C. lentillifera*, commonly known as "Ba-da-po-do", is associated with the treatment of hypertension. The presence of hypotensive peptides recently characterized in this alga explains its empirical use in traditional Korean medicine (Joel et al. 2018).

The practices of traditional Korean medicine are largely based on those of traditional Chinese medicine. This is mainly due to the geographical, cultural and historical proximity between the two countries. Korea's adoption of the Chinese script (Kugyol) has made it possible to read the writings developed by traditional Chinese medicine and thus ensured their application in Korean medicine. Apart from this historical dimension, China and Korea share a

3 See: https://fr.unesco.org/courier/novembre-2009/donguibogam-book-precieux-medicine-coreenne.

common algal resource and similar practices in terms of both food and therapeutic uses.

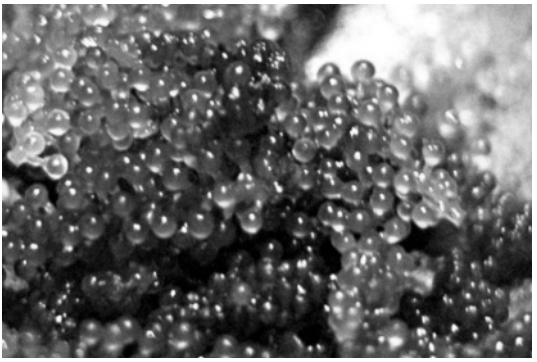

Figure 1.7. Caulerpa lentillifera*, a green alga used in traditional Korean medicine (photo credit © Jpatokal 2009)*[4]*. For a color version of this figure, see www.iste.co.uk/fleurence/health.zip*

Algal species	Korean name	Use in traditional medicine
Capsosiphon fulvescens (green alga)	Mae-saeng-i	Treatment of stomach disorders Treatment of hangovers
Caulerpa lentillifera (green alga)	Ba-da-po-do	Treatment of hypertension Treatment of rheumatism Diabetes treatment Treatment of bacterial and fungal infections
Codium fragile (green alga)	Cheong-gak	Treatment of dysuria Treatment of edema Treatment of enterobiosis
Gloiopeltis tenax (red alga)	Pul-ga-sa-ri	Treatment of diarrhea Treatment of colitis

Table 1.7. *Examples of green and red algae used in traditional Korean medicine (according to Sanjewa et al. (2018))*

1.1.4. *Vietnamese medicine*

Like other Asian folk medicines, traditional Vietnamese medicine is inspired by traditional Chinese medicine. It is also based on the use of

4 See: https://commons.wikimedia.org/w/index.php?curid=6913523.

medicinal plants. Unlike the Chinese tradition, however, it does not rely on the use of complex mixtures. Instead, it relies on the use of simple preparations made from fresh or dried local plant ingredients. This medicine is also referred to as "southern herbal", in contrast to Chinese phytotherapeutic practice, which comes from the north.

In addition to ingestible preparations, traditional Vietnamese medicine also makes use of ointments and poultices.

Unlike the previous examples, seaweed is not widely used in this traditional medicine. This is mainly due to the recent nature of seaweed use in Vietnam. This resource has only been exploited by local populations for the past hundred years (Nang and Dinh 1998), and its use outside coastal areas is far from widespread. Despite this, the scientific literature mentions a few examples of the use of seaweed in Vietnamese medicine. These are mainly red algae (*Gracilaria* spp., *Kappaphycus cottonii*, *Caloglossa leprieurii*, and brown algae (*Sargassum* spp.) (Zemke-White and Ohno 1999). The fields of therapeutic application are not always well explained.

1.1.5. *Filipino medicine*

Algae are often used in traditional Filipino medicine, particularly in certain northern regions of the archipelago. Such is the case of the Ilocos Norte region, located to the far north of Manila (see Figure 1.8).

On its coastline, 34 species of algae are frequently used by the local population for the treatment of various pathologies, such as digestive, thyroid or respiratory disorders (see Table 1.8). These algae belong to the red, brown and green algae families.

The green alga *Caulerpa racemosa* (see Figure 1.9) is one of the species most frequently used under the local name of "Ar-arusip" (see Table 1.8). It is particularly recommended for the treatment of respiratory ailments, such as coughs and asthma (Dumilag and Javier 2022).

Other caulerps, such as *C. serrulata* or *C. sertularioides*, are also recommended in the treatment of these respiratory ailments (see Table 1.8). As in the case of traditional Japanese medicine, Filipino folk medicine recommends the use of the red algae *Digenea simplex* for its vermifuge properties.

Figure 1.8. *Ilocos Norte region in the Philippine archipelago (from Google Maps (2023)). For a color version of this figure, see www.iste.co.uk/fleurence/health.zip*

Figure 1.9. *Caulerpa racemosa (photo credit © Hobgood N. 2007)*[5]*. For a color version of this figure, see www.iste.co.uk/fleurence/health.zip*

5 See: https://commons.wikimedia.org/w/index.php?curid=5704057.

Algal species	Common name	Therapeutic use
Caulerpa racemosa (green alga)	Ar-arusip	Cough Asthma
Codium arabicum (green alga)	Pok-poklo	Goiters
Halimeda incrassata (green alga)	Sal-salamu-gui	Goiters
Ulva lactuca (green alga)	Gam-gamet	Dermal infection
Digenea simplex (red alga)	Bodo-bodo	Parasitic infection
Halymenia durvillei (red alga)	Gayong-gay-ong	Indigestion
Gracilaria edulis (red alga)	Cao-caoy-an	Abdominal pain Antidiarrheal Asthma treatment
Palisada perforata (red alga)	Tar-tariptip	Antidiarrheal
Scinaia hormoides (red alga)	Garganatis	Sexual impotence
Padina minor (brown alga)	Lap-lapayag	Antidiarrheal
Sargassum aquifolium (brown alga)	Aragan	Indigestion

Table 1.8. *Examples of algal species used by traditional Filipino medicine (according to Dumilag and Javier (2022))*

Gastrointestinal disorders, such as indigestion or abdominal pain, can also be treated using various species belonging to the genera *Sargassum* or

Gracilaria (see Table 1.8). Symptoms of digestive disorders, such as diarrhea, are also treated with algae. The species concerned by this particular application belong to the genus *Padina* (see Figure 1.10). Traditional Filipino medicine also uses algae to treat thyroid dysfunction, the cause of goiters. For this therapeutic application, it relies mainly on green algae of the genera *Codium* and *Halimeda* (Dumilag and Javier 2022). More anecdotally, this medicine sometimes recommends the use of certain species to treat sexual impotence. These are mainly red algae belonging to the species *Phycocalidia acanthophora* and *Scinaia hormoides.*

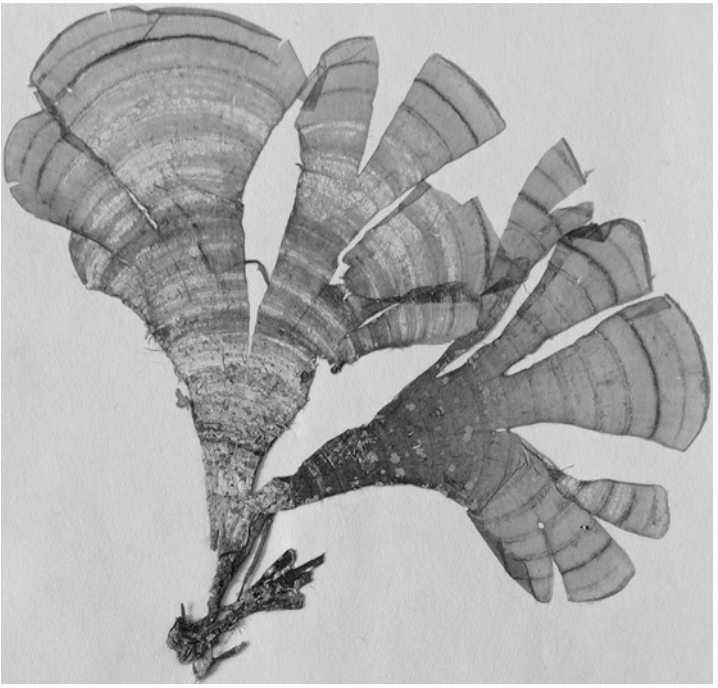

Figure 1.10. Padina *sp. (Lap-lapayag), a brown alga used in traditional Filipino medicine for the treatment of diarrhea (photo credit © Fleurence J. 2023). For a color version of this figure, see www.iste.co.uk/fleurence/health.zip*

Seaweed can be administered in a variety of ways. For *per os* use, decoction remains the most widespread method. Next come infusions, alcoholic extracts and syrups. For topical use, an alga is applied to lesions in the form of creams or poultices.

Figure 1.11. *Location of the island of Sumba in the Indonesian archipelago (from Google Maps (2023)). For a color version of this figure, see www.iste.co.uk/fleurence/health.zip*

Folk medicine in the Philippines differs from other traditional Asian medicines by the use of a large number of algal species and by the diversity of pathologies or ailments treated. It is based on local, ancient practices that are now well documented in the recent literature. Unlike traditional Chinese or Korean medicine, it is not based on a thousand-year-old medical encyclopedia, but rather on the oral traditions of coastal populations. The familiarity of these populations with the use of algae as a food resource probably explains the interest they have developed for algae in folk medicine.

1.1.6. *Indonesian medicine*

Indonesian folk medicine includes algae in its therapeutic practices. These practices are often localized to certain islands in the archipelago. This is the case of the island of Sumba, located between the main island of Java and Timor (see Figure 1.11).

An ethnobotanical study carried out on the island reveals that 38 species of algae belonging to 18 different genera are used in local traditional medicine (Anggadiredja 2009). Of the algal species listed as "medicinal plants", the majority are brown algae (see Figure 1.12).

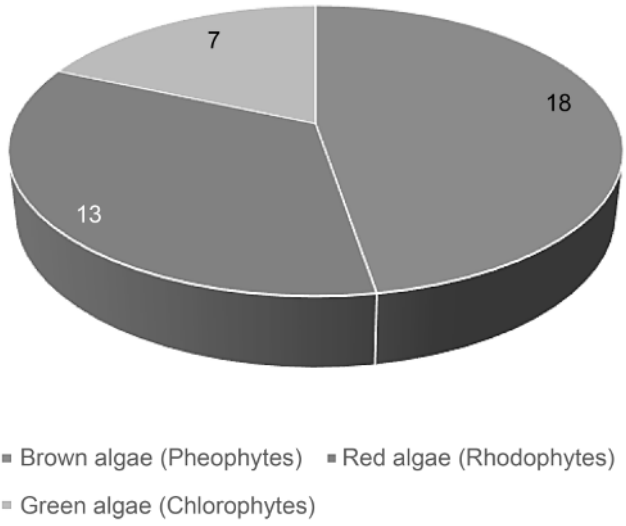

Figure 1.12. *Distribution of the different taxonomic groups of algae used in traditional medicine on the island of Sumba (Indonesia) from Anggadiredja (2009). For a color version of this figure, see www.iste.co.uk/fleurence/health.zip*

The main therapeutic application of algae on the island of Sumba is the treatment of goiters. For this type of treatment, brown algae are still the most popular (see Figure 1.13). This is partly due to the high iodine content of Pheophytes, compared with species belonging to the other two groups (personal communication, Fleurence J.).

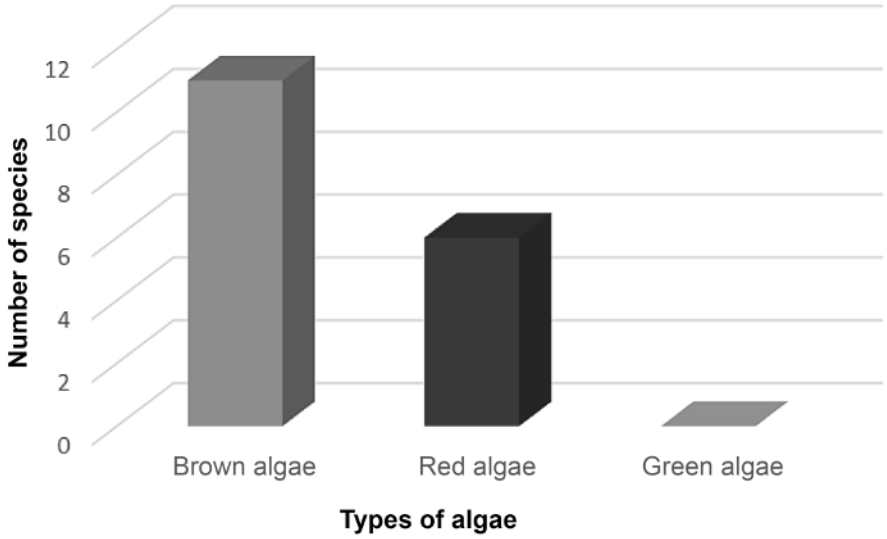

Figure 1.13. *Distribution by the algal group of species used for the treatment of thyroid dysfunctions by traditional Indonesian medicine (goiters) (according to Anggadiredja (2009))*

As with other traditional Asian medicines, Indonesian folk medicine uses algae to treat a wide range of respiratory, digestive and dermal pathologies (see Table 1.9).

The species *Codium arabicum* is used in traditional Indonesian and Filipino medicine, but for very different therapeutic applications (goiters or vermifuge) (see Tables 1.8 and 1.9).

This highlights the local nature of traditional medicine in the Philippines and Indonesia. This is in stark contrast to Chinese traditional medicine, which has disseminated and fed into Korean and Japanese traditional medicines.

Algal species	Therapeutic use
Codium arabicum (green alga)	Deworming Treatment of urinary diseases
Chaetomorpha linum (green alga)	Cough suppressant Antipyretic Antiseptic
Ulva lactuca (green alga)	Antipyretic Nasal antihemorrhagic Treatment of urinary diseases
Eucheuma serra (red alga)	Treatment of goiters Treatment of scrofula Stomach upset treatment
Gracilaria arcuata (red alga)	Treatment of goiters Treatment of scrofula Stomach upset treatment
Gracilaria gigas (red alga)	Treatment of goiter Treatment of scrofula Treatment of urinary diseases
Laurencia obtusa (red alga)	Antiseptic Stomach upset treatment
Hypnea musciformis (red alga)	Antipyretic Antiseptic
Ascophyllum sp. (brown alga)	Deworming Laxative Treatment of goiters
Sargassum ilicifolium (brown alga)	Treatment of goiters Treatment of scrofula
Padina japonica (brown alga)	Treatment of goiters Treatment of scrofula

Table 1.9. *Examples of algal species used by traditional Indonesian medicine (according to Anggadiredja (2009))*

1.2. Other traditional medicines

1.2.1. *African medicine*

Like all folk medicines, traditional African medicine relies on the use of plants in its therapeutic practice. It draws not only on herbalism, but also on

spirituality. Some of these uses are now well documented in ethnopharmaceutical publications (Van Wyck 2008). Some of this work has focused on the medicinal practices of two African communities, the Koikhoi and San ethnic groups. The first, also known as the Khoi, is a nomadic, pastoral population living in South Africa. The San ethnic group is a group of hunter-gatherer populations also living in southern Africa.

Figure 1.14. Ecklonia maxima *(photo credit © Derekkeats 2010, uploaded by JoJan)*[6]*. For a color version of this figure, see www.iste.co.uk/fleurence/health.zip*

These ethnic groups practice a traditional medicine based on the use of a large number of plant species, mainly from the terrestrial environment. However, their medicinal practice also includes the use of algae. The most widely used species is the brown alga *Ecklonia maxima* (see Figure 1.14), better known as "sea bamboo" and very common on the coasts of South Africa and Namibia.

This alga is recommended for treating iodine deficiency, glandular swelling and syphilis. It is administered in the form of hot poultices or infusions.

6 See: https://commons.wikimedia.org/w/index.php?curid=12225732.

1.2.2. *European medicine*

In Europe, some countries have incorporated algae into their traditional medicinal practices. This is the case in Bulgaria, a country on the Balkan Peninsula with a long coastline on the Black Sea. On this coast, the main species is the brown alga *Cystoseira barbata*. In traditional Bulgarian medicine, this species is used in the form of decoctions and for the treatment of chronic pathologies such as hypertension and diabetes (Stoyneva-Gärtner and Uzunov 2017). In addition to this species, which is common on the Black Sea coast, traditional Bulgarian medicine also makes use of other algal species that are rarely or never found on the country's coastline. These include *Fucus vesiculosus* and *Chondrus crispus*, algae usually found on Atlantic coasts. Like *Cystoseira barbata*, these species are used for the treatment of various chronic or transient pathologies (see Table 1.10).

Algal species	Form of administration	Pathology treated
Cystoseira barbata (brown alga)	Decoctions	Hypertension Obesity Diabetes Atherosclerosis
Chondrus crispus (red alga)	Decoctions	Chronic bronchitis Cough Graying hair Pyrosis (acid reflux) Hyperthyroidism
Fucus vesiculosus (brown alga)	Baths Massages	Rheumatism Tendonitis Muscular tetany Poliomyelitis

Table 1.10. *Examples of treatments using algae in Bulgarian traditional medicine (according to Stoyneva-Gärtner and Uzunov (2017))*

Apart from Bulgaria, other European countries have used algae in their traditional therapeutic practices. These are often brown algae belonging to the genera *Laminaria* or *Fucus*. Within the genus *Fucus*, the species *Fucus serratus* (see Figure 1.15) and *Fucus vesiculosus* (see Figure 1.16) are the

main fucals used in traditional European medicine. These two species are still listed as traditional medicinal plants in the French pharmacopoeia[7].

Figure 1.15. Fucus serratus *(photo credit © Fleurence J. 2023). For a color version of this figure, see www.iste.co.uk/fleurence/health.zip*

For traditional homeopathic preparations, however, only the species *F. vesiculosus* is recommended by the same pharmacopoeia[8].

In the United Kingdom, Ireland and France, algae were often recommended as a dietary supplement for sick children and the elderly (Pérez-Lloréns et al. 2023). A poster by the famous Italian illustrator

7 See: https://ansm.sante.fr/uploads/2023/01/10/liste-a-des-plantes-medicinales-utilisees-traditionally-january-2023-v2.pdf.

8 See: https://ansm.sante.fr/uploads/2020/10/22/fucus-vesiculosus-pph.pdf.

Leonetto Cappiello (1875–1942) perfectly sums up the recommendations of the time (see Figure 1.17). In particular, it extols the benefits of a marine food cure based on the consumption of a super-food, or "Maraliment", made from algae. But algae were also incorporated into traditional therapeutic practice, to treat a variety of chronic or temporary ailments (see Table 1.10).

Figure 1.16. Fucus vesiculosus*, a brown alga used in traditional homeopathic preparations (photo credit © Fleurence J. 2023). For a color version of this figure, see www.iste.co.uk/fleurence/health.zip*

In addition to brown algae, traditional European medicine also involves other algae, such as the Rhodophyte *Palmaria palmata*, which is commonly known as dulse or dillisk. Found on Europe's Atlantic coasts, this alga was traditionally used in Ireland and Scotland for its purifying, antipyretic and anti-scorbus properties. A Scottish saying went: "He who eats the Dulse of

Guerdie and drinks from the well of Kildinguie will escape all diseases except the Black Death".

In European Mediterranean countries, the red alga *Corallina officinalis*, or Coralline officinale, was also used in traditional medicine. Taken internally in the form of decoctions, infusions or syrups, this alga was mainly used as a vermifuge (Pérez-Llorens et al. 2023).

Figure 1.17. *Poster promoting the benefits of the Maraliment seaweed cure (according to Leonetto Cappiello (1875–1942)). For a color version of this figure, see www.iste.co.uk/fleurence/health.zip*

In France, a laxative based on agar or agar-agar was also recommended to restore proper intestinal function. This product, marketed at the beginning of

the 20th century under the name Jubol, met with considerable popular success, not least thanks to numerous advertising campaigns for the time (see Figure 1.18). In addition to its functional and laxative properties, the drug was also recommended for the treatment of hemorrhoids and migraines. During World War I, Jubol was often recommended to French soldiers in the trenches, to combat constipation and hemorrhoids caused by precarious, stressful living conditions. In 1916, the French newspaper *Le Petit Provençal* published an advertisement in which Jubol was equated with the French soldier in the trenches dislodging the related German soldier, a microbe, who must be driven away (see Figure 1.19). This was one of the rare occasions when a traditional algae-based pharmaceutical product was associated with an act of war propaganda.

Algal species	Therapeutic application	Country
Laminaria spp. (brown alga)	Treatment of goiters	United Kingdom Ireland France
Laminaria stipes **(L. digitata, L. clouston)** (brown alga)	Surgery	Ireland
Fucus spp. (brown alga)	Treatment of goiters Treatment of scrofula	United Kingdom Ireland France
Alaria esculenta (brown alga)	Treatment of pica disease Stomach fortification Restoring normal appetite	Denmark (Faroe Islands)
Chondrus crispus (red alga)	Treatment of bronchitis Cough treatment Treatment of dysentery Treatment of diarrhea Treatment of scrofula	Ireland
Palmaria palmata (red alga)	Scurvy treatment Blood purification treatment Antipyretic	Scotland (Orkney Islands) Ireland

Table 1.11. *Examples of the use of algae in traditional Northern European medicine (according to Sauvageau 1920; Pérez-Llorens et al. 2023)*

Jubol, a traditional French medicine, has now been replaced by Gaviscon, a pharmaceutical preparation composed mainly of sodium alginate (47.5% of

content). This contemporary medicine, based on phycocolloids, is mainly used in the treatment of acid reflux.

Figure 1.18. *Early 20th century advertisements for the laxative Jubol, made from agar or agar-agar red alga* (Gracilaria verrucosa) *(copyright © public domain)*

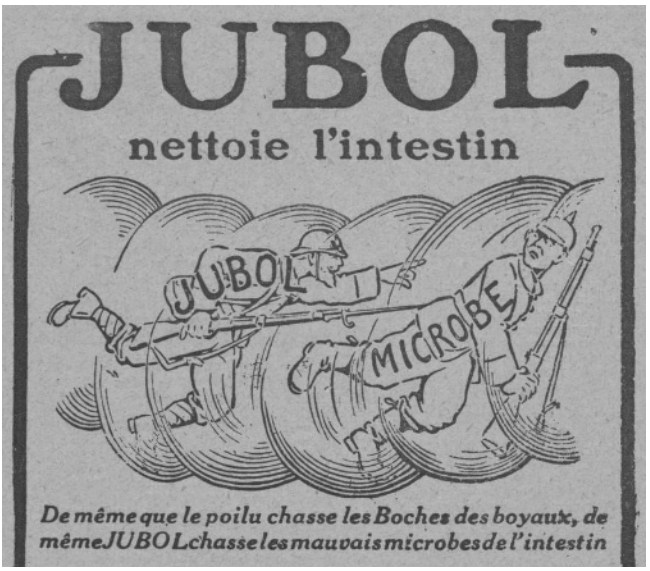

Figure 1.19. *War propaganda advertisement in* Le Petit Provençal *(1916): the qualities of the agar-based medicine Jubol (copyright © public domain)*

1.2.3. *Medicine on the American continent*

Type	Botanical group
Sargassum	Brown alga
Macrocystis	Brown alga
Durvillaea	Brown alga
Gigartina	Red alga
Mazzaella	Red alga
Sarcothalia	Red alga

Table 1.12. *Main seaweed genera used by prehistoric populations on the southern Chilean coast for food and medicinal purposes (according to Pérez-Lloréns et al. (2023))*

Evidence of the use of algae as a food and medicinal plant has been found at the Monte Verde archaeological site in southern Chile. These traces,

which date back to around 14,000 BCE, demonstrate the role played by algae in the daily lives of populations settled along the southern coasts of the Pacific Ocean (Dillehay et al. 2008). The species concerned belong to different genera, mainly associated with the groups of brown algae (Phaeophytes) or red algae (Rhodophytes) (see Table 1.12).

In his 1856 book *Elementos de farmacia applicada a la medicina*, Professor Vicente Bustillos cites the use of algae as a remedy for lung ailments (gels for poultices), diarrhea, chronic dysentery, scrofula and oral infections (Bustillos 1856).

Apart from coastal populations, the inhabitants of central Chile, and in particular the Mapuche Indians, have also used algae in their medicinal practices (Bustillos 1856; Pérez-Lloréns et al. 2023). The species used, *Durvillaea antartica*, known as "cochayuyo", has been used for the treatment of mumps and for making poultices.

This traditional product is still marketed in Chile under its original name (see Figure 1.20).

Figure 1.20. *Bales of cochayuyo about to be sold at a market in Chile (photo credit © drapeau picard A.P. 2012)*[9]*. For a color version of this figure, see www.iste.co.uk/fleurence/health.zip*

9 See: https://commons.wikimedia.org/w/index.php?curid=20160956.

1.2.4. *Polynesian medicine*

Polynesia, or "many islands" according to Greek etymology, comprises a large number of archipelagos in the Pacific Ocean. Algae are not widely used as food or medicine in the islands of French Polynesia. It is absent in Tahiti, but present in the Marquesas Islands (Conte and Payri 2002). In the Marquisian archipelago, algae are mainly consumed as a sea vegetable under the generic name of "imu". These are mainly six species belonging to the genera *Enteromorpha*, *Cladophora*, *Ulva, Caulerpa* and *Chnoospora*. However, there are no written examples of the use of these algae in traditional Marquesan medicine.

The situation is different in the Hawaiian archipelago, where algae are not only traditionally consumed, but also incorporated into folk medicine. More than 60 species are used by Hawaiians for these two applications (McDermid et al. 2019). These algae are known generically as "limu". However, less than half are identified by the scientific binominal nomenclature, i.e. their Latin name. Many species of limu are used in traditional Hawaiian medicine. They are used to treat a wide range of ailments, including minor wounds, asthma, oral thrush, miscarriages and dietary problems. More surprisingly, algae are also associated with the treatment of psychological ailments. This therapeutic contribution is achieved through traditional rituals and ceremonies.

A case in point is the ceremony of forgiveness (ho'oponopono), which aims to resolve personal conflicts. During this ancient practice, each participant consumes a blade of *Sargassum aquifolium,* an alga commonly known as "limu kala". Consumption of the blade during the Indian ceremonial marks the end of the ritual and the release of interpersonal tensions. Limu kala is also used in healing or purification rituals for those affected by psychological suffering following bereavement.

In Hawaii, algae play an important role in popular culture. They are an integral part of traditional dietary and therapeutic practices. They are also part of the legends of this archipelago, and certain species, such as Ulva, qualified as "limu palahalaha" (see Figure 1.21), enjoy sacred status.

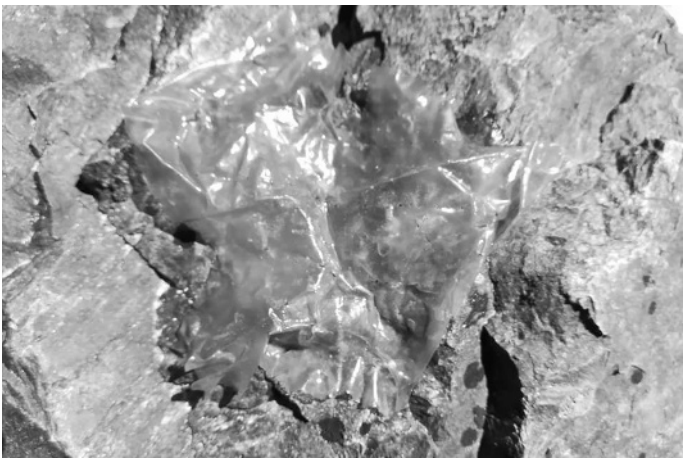

Figure 1.21. *Green alga* Ulva *sp. or* limu palahalaha*, considered sacred in traditional Hawaiian culture (photo credit © Fleurence J. 2019). For a color version of this figure, see www.iste.co.uk/fleurence/health.zip*