international network of spirulina growers for food sovereignty

practical manual for growing spirulina at home

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Getting to know spirulina

Appearance, classification and origin

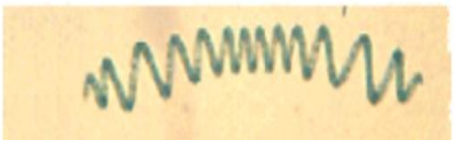
Spirulina is a cyanobacterium that lives in saline and alkaline lakes and is also cultivated artificially. Its scientific name is Arthrospira platensis (Arthro=joint, spira=spiral). It is commonly known as a micro-algae or blue-green algae.

It is an aquatic being capable of photosynthesis that does not have a nucleus (prokaryote). It reproduces by cell division: a filament divides into 2 filaments when it reaches a suitable length, every 24-72 hours.

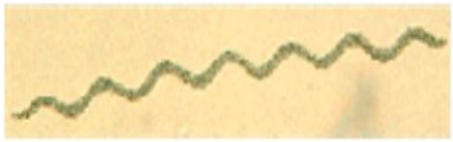
Spirulina filaments (called trichomes) are multicellular (that is, made up of several cells) and have an average length of 0.3mm and a width of 0.008mm; so it is necessary to use a microscope to see them.

Kingdom: **Bacterium**
Edge: ***Cyanobacteria***
Class: ***Cyanobacteria***
Order: ***Oscillatorial***
Family: ***Phormidiaceae***
Gender: ***Arthrospira***
Species: ***Platensis***
Variety: ***Lonar, Paracas***

The spiral shape characterizes its various species that have given it the name of spirulina (spira=spiral, lina=small). The best known varieties of spirulina are Lonar (very spiral) and Paracas (very wavy).



lonar variety



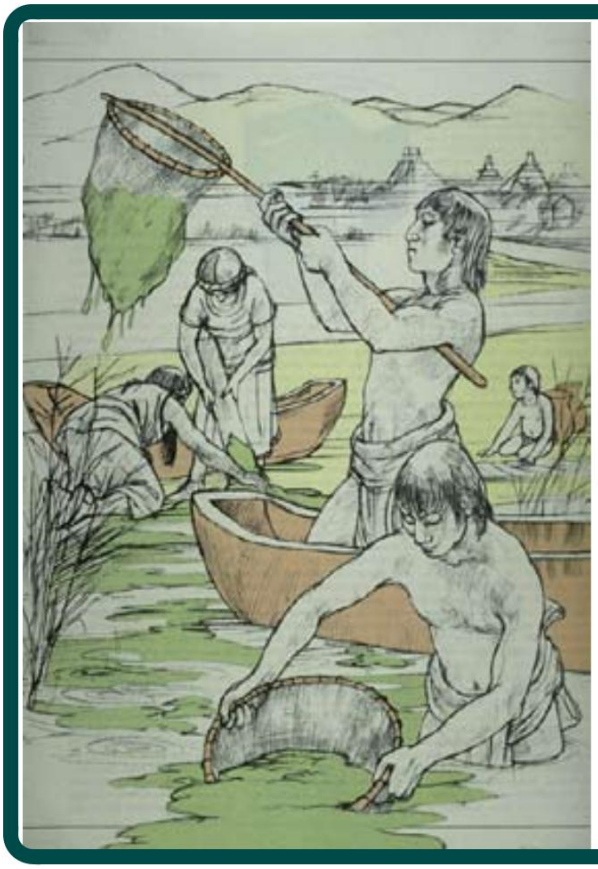
paracas variety

In the mists of time, approximately 3.5 billion years ago, microorganisms called cyanobacteria appeared. They were the first living beings capable of fixing carbon from CO_2 and release oxygen through the process of photosynthesis. Thanks to this process continued for thousands and thousands of years, the ozone layer was created, which today allows life on Earth for beings like us who need oxygen to live.

The cell walls of spirulina are not made of cellulose like those of most vegetables, but of murein (a mucopolymer) and polysaccharides (complex sugars), compounds that are more fragile than cellulose and easily digestible by the body.

Nutritional aspects

Spirulina provides vitality and energy as well as numerous micronutrients for humans. Many properties are attributed to it, for example: anticancer properties, strengthens the immune system, acts as an antioxidant, controls diabetes, cholesterol, anemia, promotes the elimination of heavy metals and radioactivity, helps to recover from physical exertion, combat fatigue, stress, etc. If you want to know more about the nutritional benefits of spirulina, there are more than 500 scientific publications on the effects of consuming spirulina. Not in vain has it been attributed the label of "one of the best foods in the world."



From ancestral use, to space

The Aztecs called it tecuitlalt and Kanembous dihé, some in Central America and others in Africa consumed "the green stone" appreciated for its nutritional contributions. Today, the European Space Agency) is also studying the cultivation and consumption of spirulina for space missions.

A food with these nutritional properties could easily be used to eradicate hunger in the world, and there are already many humanitarian projects for this purpose. However, in developed countries, spirulina arrives as one more nutritional supplement to be fashionable and/or keep the line; Against this we apply the maxim of Hippocrates:

> “Let your food be your medicine, let your medicine be your food”
>
> hippocrates

natural spirulina

Today spirulina in its natural state is found in shallow lakes, slightly saline, alkaline and with an abundance of minerals.
In Europe, spirulina has been documented in the Doñana park (Spain), and in the Camargue park (France). An indication to detect natural spirulina is the appearance of the lesser pink flamingos; they can consume up to 60g of spirulina per day.

Composition per 10g of spirulina

VITAMINS		MINERALS	
Pro A(Beta-Carotene)	14mg	Calcium	100mg
B1 (Thiamine)	0.35mg	Iron	18mg
B2 (Riboflavin)	0.4mg	Magnesium	40mg
B3 (Niacin)	1.4mg	Match	80mg
B5 (pantothenic acid)	0.01mg	Potassium	140mg
B6 (pyridoxine)	0.06mg	Zinc	0.3mg
B8 (Biotin)	5µg	Copper	0.12mg
B9 (folic acid)	0.01mg	Manganese	0.5mg
B12(Cyanocobalamin)	3.2µg	Sodium	9mg
AND(α-tocopherol)	1mg	Chrome	28µg
K(phytomenadione)	244 µg	Selenium	2 µg

PIGMENTS AND ENZYMES		FATTY ACIDS	
Chlorophyll a	79mg	Saturated fats	100mg
carotenoids	37mg	unsaturated fats	210mg
Beta-Carotene	7-20mg	linolenic acid	120mg
Phycocyanin	1500-2000mg	Linoleic acid	80mg
SuperOxide Dismutase	10-35,000 IU	Oleic acid	11mg

ESSENTIAL AMINO ACIDS		AMINO ACIDS NOT ESSENTIALS	
Phenylalanine	280mg	Alanin	470mg
histidine	100mg	Arginine	430mg
isoleucine	350mg	Aspartic acid	610mg
Leucine	540mg	Cysteine	600mg
lysine	290mg	Glutamic acid	910mg
methionine	140mg	glycine	320mg
threonine	320mg	Proline	270mg
tryptophan	90mg	serine	320mg
valine	400mg	tyrosine	300mg

Knowing the crop

If we talk about tomatoes, lettuce, or other vegetables, fruits or vegetables, we will surely know how to respond to the most basic needs of their crops. However, in the case of spirulina, since it is a cyanobacterium, we are usually a bit confused about what the basic parameters of the culture are, so they are presented below.

Spirulina concentration:

The concentration of spirulina present in the medium is a key parameter, which is very easy to observe with the spirulimeter (Secchi disk). Every spirulina fan quickly becomes familiar with the spirulimeter, since it indicates the amount of spirulina we have.

Spirulimeter operation

The spirulimeter is what is known in laboratories as a Secchi disk. This consists of a graduated scale and at the beginning of it a white background. It works by submerging it in water and noting the cm that it has descended until the white background is no longer visible. The cm that has descended indicates the turbidity of the water, and in this case it also indicates the concentration of spirulina.

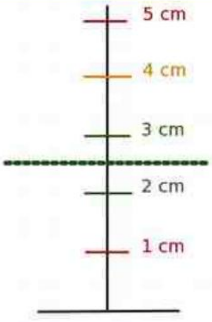
This table indicates the equivalence in grams of dry spirulina for each centimeter that the spirulimeter descends.

centimeters descended	1	2	3	4
Spirulina concentration (dry g/L)	1	0.45	0.28	0.20

These data vary depending on the variety (lonar, paracas, toliara, etc) and also depending on how clear/cloudy the culture medium is.

The concentration of spirulina directly affects several parameters of the crop, such as its productivity, stability and quality.

It is recommended to keep the spirulimeter between the values of 2 and 3 cm. The more we move away from these values, the more the previous parameters are affected.

Spirulimeter	Speed of production	Stability	Quality	To do?
	Fast	Short	little phycocyanin	need more shadow and more agitation
	Slow	Hi	High Content in phycocyanin	Collect / add medium cultivation

Culture medium:

Spirulina lives in a saline and alkaline aquatic environment.

The water must be of potable origin and without chlorine, in rainwater a heterotrophic bacteriological control is interesting. Chlorine evaporates in contact with the atmosphere after 24h.

Although the salinity can range between 5g/L and 45g/L, it is not recommended that it exceeds 10g/l. It can be achieved either by using seawater (1 part seawater, 9 parts freshwater) or by using the purest and least treated salt possible; however, seawater contains more trace elements than salt.

The pH of a crop ranges between 8.5 and 11.3, the usual value being 10. To achieve alkalinity, sodium bicarbonate can be added, and other methods such as ash water or soda can also be used.

Toxicological safety: The exhaustive toxicological studies, its ancestral consumption in Mexico and Chad, and the more than 30 years of industrial and artisanal cultivation without incident, prove that this food is completely harmless. There is a great genetic uniformity of spirulina cultivated around the world; the environment of a high pH means that very few organisms can coexist, and finally the collection process where only particles between 40 and 100 microns are retained. An "immediate" consumption is the best guarantee of bacteriological safety.

multiplication speed

Spirulina in laboratory conditions can double every 16 hours, however, an optimal speed in artisanal cultures is that it doubles every 36 hours. The speed of multiplication, or productivity, depends mainly on:

- **Lightning:** it is necessary to ensure that spirulina can carry out photosynthesis. Spirulina likes to alternate between light and shadow, that's why it turns on itself. Due to the large number of pigments it has, it can absorb a very wide range of wavelengths; solar lighting is the one he likes the most, but it can also work with led bulbs. They are optimal between 40,000 and 50,000 lux.

- **Temperature:** from 20ºC spirulina begins to multiply. When it multiplies more quickly it is at 37ºC; but it must be taken into account that if it exceeds 41º C it begins to die. For spirulina, around 30ºC is usually a very comfortable temperature.

- **Agitation:** It is necessary to distribute lighting, temperature and nutrients in the crop, as well as to prevent spirulina from accumulating on the surface. It can be done by air pump, water pump or manually. The use of a timed switch is highly recommended, which starts the agitation at the moments of maximum irradiation, and stops it at night. At sunrise and sunset it can work at intervals of 15 or 30 minutes.

- **Shading:** Shading is basically used to improve the quality of the spirulina (with more shade, more phycocyanin), while preventing its death (from possible photolysis). And it is also used to reduce evaporation, 50% shading is optimal.

- **Nutrient Availability:** when spirulina runs out of nutrients (be it carbon, nitrogen, phosphorus or iron) the multiplication of spirulina stops.

If there is little agitation... increase the shading
If there is a lot of agitation...fragmentation of the spirulina.
Danger of death: Cold cultivation (less than 12ºC) and direct sunlight.

Crop nutrition

Spirulina needs a source of carbon, nitrogen and minerals.

Carbon can be obtained from the air, fixing CO_2 in the process of photosynthesis, feeding and contributing at the same time to fix greenhouse gases.

Spirulina cannot fix nitrogen from the air, so it has to be provided. Macronutrients can be based on urea or nitrates (synthetic origin), or through urine (organic origin).

Spirulina fixes the minerals so that they can later be assimilated by the human body. Micronutrients refer to iron and traces of other minerals:

- To obtain iron, it can be done using iron syrup (based on iron sulfate) or rusty nails.
- To obtain the rest of the minerals, it can be obtained from unrefined sea salt, directly from seawater, or with trace elements.

The urine it is the perfect food for spirulina, since it is the most local, economical and is absorbed more quickly since it has an optimal ratio of macronutrients (urea, nitrogen, phosphorus, chlorides, etc.); however, some specifications must be taken into account:

- The urine must be from a healthy person, who is not taking drugs, alcohol, tobacco or antibiotics or contraceptives.
- Add 10% vinegar to urine. Although it is not necessary, it is recommended for hygienic reasons. It also helps prevent nitrogen from being wasted.
- Dilute the urine with a little water before being added to the culture. It may be the water needed to compensate for evaporation.
- Cultivating with urine requires a more attentive spirulina grower, since the culture becomes a little more organic and unstable since the exact composition of each urine is not known.
- Add the urine during the morning and only the amount that the spirulina can absorb during that day, since at night the urine can ferment.
- Cultivating with urine is the most eco-logical, local and sustainable way and what makes spirulina more than just a food.

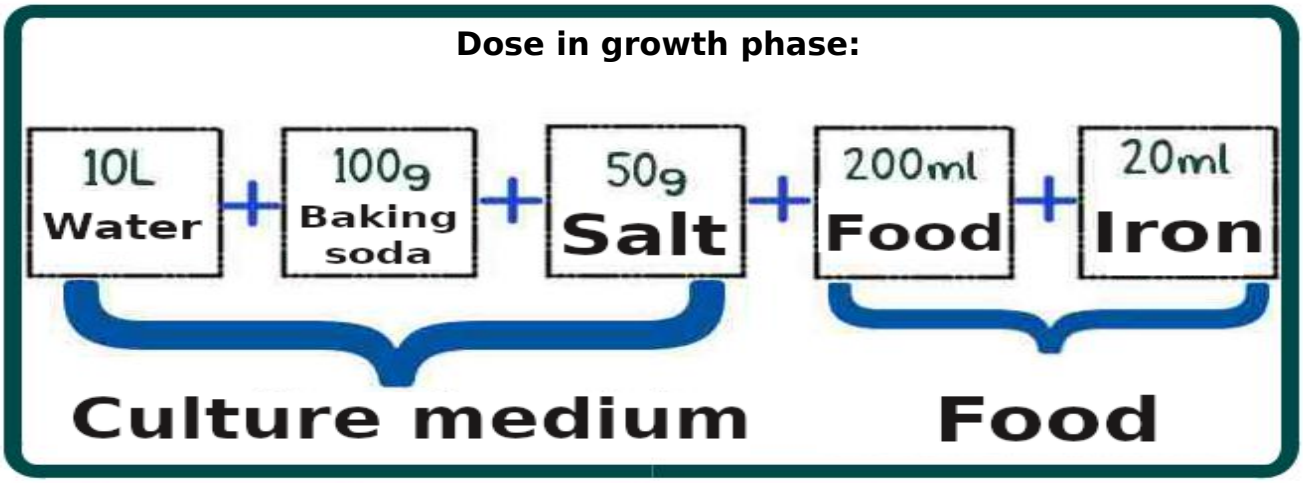
Recipe and dose to cultivate

10L of culture medium:
• 10L of water without chlorine • 100g of baking soda • 50gr of salt • 200ml of food (macronutrients) • 10ml of iron syrup (micronutrients)

1L of food for spirulina: (macronutrients)	
Organic:	Synthetic:
• 1000ml of urine (multiply by 0.75 in case of very carnivorous diets; multiply by 1.5 in case of diets vegans).	• 1L of water • 100gr Potassium Nitrate • 10gr monoammonium phosphate • 5gr potassium sulfate • 5gr Magnesium Sulfate

1 L of iron syrup for spirulina: (micronutrients)		
Organic:	Chelated Sulfate:	Sulfate + Lemon:
• 100gr of nails/oxidized iron • 1L of vinegar • juice of 2 lemons (Let macerate 15 days)	• 10gr of sulfate of iron chelated.	• 10gr of iron sulfate • juice of 2 lemons • 900ml of water (Let macerate 15 days)

Dose in growth phase:



Dose in harvesting phase:

10g of fresh spirulina = 20 ml of food + 2 ml of iron syrup

Preparing to farm

To start growing spirulina you need two essential things:

1. Desire and time to cultivate this small organism:
2. A strain to start growing:

The strain can be obtained through the webpage www.sunspiru.com

Once we have made sure that we can meet the two requirements, it is convenient to answer the following questions:

Who is the crop intended for?

One square meter can provide a daily ration of 5 grams of dry spirulina on average per year. The spirulina ration can range from 1 g to as much as we want since there are no overdose problems.

The first months it is proposed to focus until you get between 100-200L of culture.

What is the best location?

To obtain a good location, a series of conditions must be met:

- The air/water pump of the spirulina and the bubbling produce noise, therefore it is better not to have it located in a place where you want to appreciate the silence.
- Spirulina needs a sunny spot; the afternoon sun is the one that suits you best.
- Normally there must be an electrical outlet in the place.
- It must be a place that can be visited easily, since especially at the beginning it has to be controlled.
- It can be in a fixed or transportable place, but it must be taken into account that it is common to have crops of more than 100 L.

Materials

There are many ways to grow spirulina, and each method requires specific materials. In this case, a basic form is proposed, which can serve as a basis for you to develop the type of crop that best suits your local needs.

SunSpiru Grow Kit:

- cultivation manual
- Air pump
- connecting tube
- Analog timer.
- Thermometer
- Air difusor
- spirulina strain
- Nutrients for the crop
- 40 and 100 micron filter cloth

SunSpiru

info@sunspiru.com
+34 642 000 927
www.sunspiru.com

Other things you will need:

- Kitchen scale
- Growth phase containers
- Collection phase container
- Sodium bicarbonate
- Salt
- chlorine-free water
- shade cloth

To become an expert:

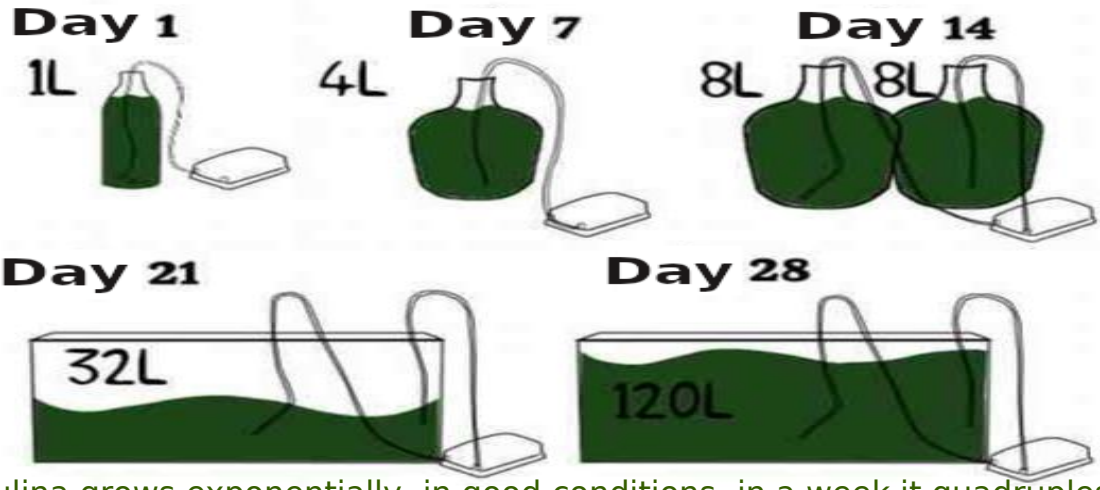
- PH meter
- Microscope
- nitrate meter
- nitrite meter

Spirulina cultivation

In the growth phase synthetic feeding is recommended, in the harvesting phase organic feeding is recommended.

growth phase

The growth phase begins from the moment we receive the spirulina strain, until we start harvesting. It is the phase in which you go from an initial volume of spirulina in its culture medium, usually between 1 and 2 liters, to the desired final volume (between 100 and 200L).



Spirulina grows exponentially, in good conditions, in a week it quadruples its initial content!

This phase can last between 15 days and 2 months, depending on the conditions (temperature, lighting, agitation) and it is the phase in which the spirulina is weakest. In addition, it is the initial phase, in which the spirulina is more inexperienced, therefore it is the phase in which extreme precautions must be taken and observations must be sharpened.

In the growth phase, the container will change, adapting to the total amount of spirulina. The container can be plastic or glass. They can be, for example, 5 or 8 L containers, or basins, fish tanks, etc.

The main parameter to take into account in the growth phase is the height of the crop. The height of the crop must be between 10 and 40cm.

More height: more stable, easier agitation, slower cultivation.
Less height: less stable, more difficult to shake, faster cultivation.

Example of a spirulina day in the growth phase:

0. Get spirulina, materials and spirulimeter.
1. Have food, iron and culture solution ready.
2. Measure the concentration of spirulina.
3. Add culture solution with the ratio of food and iron.
4. Record the activity of the culture in the table.

The first few days we can be guided by the following table to check that everything is progressing as planned.

Day	Hour	Sun, foggy	Temp. (ºC)	Spirulimeter before (cm)	Solution added (L)	Spirulimeter after (cm)	Quantity overall (L)	Observations
Jun 10	*10am*	*Sun*	*30*	*2.2*	*30*	*3.1*	*150*	*Good aspect*

Spirulina in growth phase

Harvest phase

The harvesting phase begins when we have already achieved the necessary crop volume. This varies according to what we have decided. Normally it will be around 200 L.

For the harvesting phase, the same routine is followed as in the growth phase, but the difference is that once it is verified that the spirulimeter is less than 3cm; instead of adding culture medium to decrease the concentration of spirulina, a part of the culture (a maximum of 1/3 of the culture) is filtered to obtain fresh spirulina.

1 gr of dry spirulina = 5 gr of fresh spirulina
The amounts are always expressed in grams of dry spirulina unless otherwise stated.

Example of a spirulina day in the harvest phase:

1. Control the concentration of spirulina with the spirulimeter.
2. Filter the crop.
3. Press the collected spirulina.
4. To weigh.
5. Add macronutrients and micronutrients.
6. Compensate for evaporation.
7. Record the operations in the table.

The first days we can help ourselves from the following table to see that everything evolves as planned:

Day	Hour	Sun, foggy	tempe rature (ºC)	Spirulimeter before (cm)	Epirulina fresh(g)	Food added (ml)	Water added (L)	Spirulimeter after	Observations
17Jul	*7 am*	*Sun*	*31*	*2.6*	*200*	*400*	*--*	*2.9*	*Bluish appearance.*

Spirulina harvest

Dr. Spiral

What has become khaki yellow? does it accumulate on the surface?

Yes, spirulina is a living being, it responds to surrounding conditions, especially light, temperature, agitation, food and also the affection that one can give it.

As such, its response is often unpredictable, however, after several years of study and observation, the following tables have been prepared that explain a little what may be happening to spirulina.

Observations on Spirulina

Color	What's happening?	To do?
blue dark green	• excellent health	• Possibility to reduce shading
Olive green	• Good health	
Light green-yellow	• Too much sun -> photolysis • lack of nitrates • If it has rained, possible pollution	• Shade and improve agitation. • Increase the dose of urine • Add culture medium and observe under the microscope.
green yellow (and ammonia smell)	• too much ammonia	• Check the amounts of urine. • Stop the intake of nitrates.
yellow + foam	• broken strands and release of exopolyscharides (spirulina sugars = EPS)	• Reduce pH; add baking soda or $CO_{two.}$ • Shade • Add nitrates and potassium
khaki green	• lack of nitrates • lack of carbon • Iron deficiency	• More food for spirulina • Shade
white spots and blues	• Insolation (surface layer decomposing)	• Remove stains. • Increase shading • Improve agitation.
Colorless (or light brown)	• The culture has precipitated or well he's dead.	• Look under a microscope to see if the Spirulina is alive.

microscopic observations

Spirulina long (more than 10 turns).	• Iron deficiency	• Add iron syrup.
Spirulina in small pieces (1 to 2 turns).	• shaking too much strong • lack of potassium	• reduce agitation • Add potassium (if they persist reducing agitation)

Observations on the smell:

odor type	What's happening?
Nice	Sweet characteristic, synonymous with good health
ammonia	Too much urea or urine.
Strong	Unsightly, animal carcass type: • Lots of dead spirulina • Crop in poor condition • Hole in the container
sulphurous	Fermentation... purge the bottom especially from the less agitated.

Crop aspect

Appearance	What's happening?	To do?
Spirulina in lumps	• Stress or strong dissolution	• Shade and shake
Spirulina in the background	• light shock stress or temperature. • lack of nitrates	• Undo lumps. • Improve agitation • increase nitrate
The surface layer is not undo.	• Low temperature • lack of nitrates	• Shake and shade if the Temp. of the water container <10ºC
Spirulina is gathered in thick and compact layers		• add nitrates
Gelatinous culture, little bright white, translucent	• Many EPS due to lack of nitrates and sulfur	• Add urine and wait 3 days.
Foam: whitish layer like egg white	• Spirulina Proteins dead • Insolation	• reduce agitation • Shade and remove foam.
brown balls	• balls of calcareous salts, magnesium, phosphorous, etc. • If only balls are seen, the spirulina is dead.	• Purge your lots of spirulina dead. • Treat the water if too calcareous.
Many small balls to the surface at night and day	• strong growth during the day • Fermentation by night.	• Increase shading. • reduce sugar • Remove the bottom deposit.
Soapy liquid to the touch.	• Very high alkalinity pH greater than 10.8.	• Shade • add carbon • Renew the culture medium

how to eat it

In order to take full advantage of the properties of fresh spirulina, it is best not to cook it. From 42ºC, some fragile nutrients begin to be denatured by heat. This is the case of vitamins, for example, enzymes, antioxidant pigments, etc.

Don't cook the spirulina!

Vitamin C allows the body to assimilate iron from food. Therefore, ingesting spirulina together with a source of vitamin C ensures optimal assimilation of the iron contained in spirulina. A good way to consume spirulina can be on an empty stomach together with a fruit juice such as lemon, orange or kiwi.

In general, spirulina can accompany any type of dish. If we have fresh spirulina, the number of recipes
possible is infinite: simply spread on a slice of bread and with a drop of olive oil, we can enjoy an extraordinary nutritional treasure. To this slice we can add fresh cheese, it will be simply wonderful. You can mix fresh spirulina in yogurt, fruit and vegetable juice, etc. Properly drained fresh spirulina has hardly any taste: it can be assimilated to the taste of fresh hazelnuts or spinach.

quantities

The amount of recommended daily intake of spirulina will vary depending on the benefits sought. An athlete in a training or competition phase can easily consume 10 to 12g of dry spirulina per day, while a person consuming spirulina for their well-being and to reinforce their vitality will consume between 2 and 5g of dry spirulina per day.

It is important to know that there are no problems with overdose in the consumption of spirulina. The only problem that it could cause in some people is the cleansing effect that spirulina has on the human body.

Fresh spirulina is the most sustainable and the one with the most properties