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Review Article

Importance of *Arthrospira* [*Spirulina*] in Sustainable Development

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Abstract

Arthrospira are gram negative, a blue-green photolithoautotroph, filamentous cyanobacterium. The typical morphology of *Arthrospira* is characterized by its regularly helical coiling or spirals. There is food and dietary supplement made from two species of *Arthrospira*, *Arthrospira platensis* and *Arthrospira maxima*, known as spirulina. These and other *Arthrospira* species were once classified in the genus *Spirulina*. *Arthrospira* has been has been shown to be an excellent source of proteins, vitamins, lipids, minerals, carbohydrates, nucleic acids, enzymes and pigments. *Arthrospira* is useful in human nutrition, due to the high quality and quantity of its protein (60%-70% of its dry weight). The nutritive value of a protein is related to the quality of amino acids, digestibility coefficient, as well as by its biological value. *Arthrospira* contains essential amino acids; the highest values are leucine (10.9% of total amino acids), valine (7.5%), and isoleucine (6.8%). Arthrospira is the only food priority where the country facing a serious loss of cropland and higher food imports. *Arthrospira* require less land and water than other and can grow in climates where other crops cannot in the country. Mainly *Arthrospira* production will help to improve food security and sustainability within the country. It will also create more employment opportunities for local community members. High priority will be given to local community members through increased support for small scale *Arthrospira* cultivation with demonstration on how individuals can manage cultivation with minimal training and technical supervision.

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Introduction

Arthrospira is a genus of free-floating filamentous cyanobacteria characterized by cylindrical, multicellular trichomes in an open left-hand helix. There is food and dietary supplement made from two species of *Arthrospira*, *Arthrospira platensis* and *Arthrospira maxima*, known as spirulina. These and other *Arthrospira* species were once classified in the genus *Spirulina*. There is now an agreement that they are distinct genera, and that the food species belong to *Arthrospira*; nonetheless, the inaccurate term "Spirulina" remains the popular name. *Spirulina* is also the scientific name of a cyanobacteria genus rather distant to the *Arthrospira*. Both phylogenetic and morphological analysis illustrate that these microbes are definitely bacteria not being an algae. Therefore, the *Arthrospira* genus is the whole group of edible cyanobacteria sold under the name of spirulina (Garrity et al., 2004). Because it's nutritional value and health benefits, *Spirulina* was claimed to be an ideal food and dietary supplement in the 21st century by Food and Agriculture Organization of the United Nations and

World Health Organization. Recently, Arthrospira attracts more interests on its potential medical and biodiesel application (Tokusoglu and Unal, 2003; Khan et al., 2005; Bermejo-Bescos et al., 2008; Bachstetter et al., 2010; Cheong et al., 2010; Zang et al., 2010; Khola and Ghazala, 2012).

History

Arthrospira is understood to have a longer history in Chad, as far back as the 9th century Kanem Empire. It is still in daily use today, dried into cakes called "Dihe" or "Die" which are new to make broths for meals, and in addition sold in markets. The *Arthrospira* is harvested from small lakes and ponds around Lake Chad. *Arthrospira* is also thought to have been a food source for the Aztecs in 16th century Mexico, as it's harvesting from Lake Texcoco and sale as cakes is described by one of Cortés' soldiers. The Aztecs called it Tecuitlatl, which means the stone's excrement. *Arthrospira* was found in abundance at the lake by French researchers within the 1960s, but there is no reference to its use there as a daily food source after the 16th century. The first large-scale Spirulina production plant was established in the early 1970s and drew attention worldwide. Today *Arthrospira* is consumed by millions of people all over the world and they are discovering lots of health benefits apart from its nutritive value (Ciferri, 1983; Mosulishvili et al., 2002; Reid et al., 2006; Slonczewski and Foster, 2009; Singh et al., 2011).

Systematics

Arthrospira belongs to the oxygenic photosynthetic bacteria that cover the groups *Cyanobacteria* and *Prochlorales*. They are filamentous, non-heterocystous cyanobacteria that are generally found in tropical and subtropical regions in warm bodies of water with high carbonate/bicarbonate content, elevated pH, and salinity. Current taxonomic classification of Arthrospira is as follows (Vonshak, 1997; Mosulishvili et al., 2002; Garrity et al., 2004).

Kingdom:	*Bacteria*
Phylum:	*Cyanobacteria*
Class:	*Cyanophyceae*
Order:	*Oscillatoriales*
Family:	*Phormidiaceae*
Genus:	*Arthrospira*
Species	*Arthrospira platensis, Arthrospira jenneri, Arthrospira maxima*

Morphology

Arthrospira are gram negative, a blue-green photolithoautotroph, filamentous cyanobacterium. The typical morphology of *Arthrospira* is characterized by its regularly helical coiling or spirals. It containing one or multiples of ten cells aligned together in a straight line or more or less in spirals, which have been used as important taxonomic criteria and in the rank of product quality. These filaments have a variable length (typically 100-200 microns) and a diameter close to 8-10 microns. Individual cells multiply in the usual manner via cell fission. The superstructure is the helical multicellular trichome. When the trichome is mature, it breaks up into short cellular chains of 2-4 cells, or hormogonia. These glide away and begin new trichomes systems (Belay, 1997; Wang et al., 2005).

Some common features have been found for the present commercial strains of *Arthrospira* (*A. platensis* and *A. maxima*), like the regular coiled helix, the blue-green color, high growth rate, and high adaptability to the shift of circumstances (Muhling et al., 2006).

Life cycle

There are three fundamental stages: Trichomes fragmentation, hormogonia cells enlargement and maturation processes, and trichome elongation. Then this mature trichomes get divided into filaments or hormogonia, cells in the hormogonias gets increased by binary fission, grows lengthwise and takes their helical form **.** In its natural environment, *Arthrospira* filaments grow to high cell densities, leading to thick mats at the surface of saline alkaline lakes. At night, cells respire oxygen at high rates to generate energy for osmotic balance, thereby regularly encountering microoxic or anoxic conditions (Kebede and Ahlgren, 1996; Ali and Saleh, 2012).

Ecology

Arthrospira has been on the planet over 3 billion years. It still grows wild and abundantly around the world in very alkaline, mineral-rich, largely pollution-free, soda lakes. *Arthrospira* is not sea bacteria. However, the fresh-water ponds and lakes *Arthrospira* favors are notably more alkaline, in the range of 8 to 11 pH, than ordinary lakes and cannot sustain any other forms of microorganisms. This water is too salty (up to pH 11) to support fish, to use for growing terrestrial crops or for drinking. But it is perfect for growing *Arthrospira*. *Arthrospira* thrives in very warm waters of 32 to 45 ^{0}C (approximately 85 to 112 ^{0}F), and has even survived in temperatures of 60 ^{0}C (140 ^{0}F). Certain desert-adapted species will survive when their pond habitats evaporate in the intense sun, drying to a dormant state on rocks as hot as 70^{0}C (160^{0}F). In this dormant condition, the naturally blue-green bacteria turn a frosted white and develop a sweet flavor as its 71% protein structure is transformed into polysaccharide sugars by the heat. In fact, the hotter it gets and the more the mineral salts concentrate as water evaporates the faster and more prolifically *Arthrospira* grows (Abdulqader et al., 2000; Gao and Zengling, 2007).

Ironically and significantly, the most fertile valley of soda lakes with heavy *Arthrospira* growth today lies in Africa. In East Africa, the Great Rift Valley begins in Ethiopia and runs vertically through desert wastelands for hundreds of miles linking Ethiopia, Kenya, Tanzania, and Botswana. This valley floor is lined with several large soda lakes. These lakes are large basins concentrating huge quantities of mineral salts leached from the volcanic soils by rainwater runoff over millennia. Along with the intense heat and sunlight of the area, these lakes provide the perfect growing conditions for *Arthrospira [Spirulina]* (Kebede and Ahlgren, 1996; Genene Tefera, 2008).

In Ethiopia, three soda lakes, Lake Arenguade (Hadho) (approx. 3 km south of Bishoftu), Lake Kilole (approx.14 km East of Bishoftu) and Lake Chitu (approx. 37 Km west of Shashemene near by Senbete Shala) were known as lakes rich with *Arthrospira*. But Kenya and Chad are the spirulina "bread baskets". In Kenya- Lake Bogoria (11+ square miles), Lake Elementita (7+ square miles), Lake Magadi (29+ square miles), Lake Nakuru (30 square miles), and Lake Turkana (2,325 square miles) contain quantities of *Arthrospira* (Kebede and Ahlgren, 1996; Genene Tefera, 2008).

Huge Lake Chad, which is situated both in Chad and Nigeria, contains *Arthrospira* in one section of the lake that comprises approximately one-fourth of its surface area, or 1,600 square miles. Based on observed growth rates of 10 grams per square meter per day, Scientists of the Microalgae International Union calculate that Lake Bogoria alone is capable of producing continuously over 290 tons of dry spirulina per day (Kebede and Ahlgren, 1996; Mosulishvili et al., 2002; Genene Tefera, 2008).

Chemical composition and nutritional value

Since 1970, *Arthrospira* has been analyzed chemically. It has been shown to be an excellent source of proteins, vitamins, lipids, minerals, carbohydrates, nucleic acids, enzymes and pigments. *Arthrospira* is useful in human nutrition, due to the high quality and quantity of its protein (60%-70% of its dry weight). The nutritive value of a protein is related to the quality of amino acids, digestibility coefficient, as well as by its biological value. *Arthrospira* contains essential amino acids; the highest values are leucine (10.9% of total amino acids), valine (7.5%), and isoleucine (6.8%). Denaturation of *Arthrospira* protein is observed when it is heated above 67^{0}C, at neutral aqueous solution. Hydrophobic regions interaction during heating and hydrogen bonds formation during cooling are aggregation and gelation factors of *Arthrospira* protein (Ciferri, 1983; Dagnelie et al., 1991; Belay and Ota 1993; Dillon et al., 1995; Hayashi et al., 1996; Genene Tefera, 2008).

Among food, *Arthrospira* has a relative high provitamin-A concentration. An excessive dose of β-carotene may be toxic, but when the β-carotene is ingested from the *Arthrospira*, it is usually harmless since the human organism only converts into vitamin A the quantity it needs. *Arthrospira a* is a very rich source in vitamin B_{12}, and that is a reason why these *Cyanobacteria* are of great value for people needing supplements in the treatment of pernicious anemia. Also contains 4-7% lipids. It has essential fatty acids: linoleic acid (LA) and g-linolenic acid (GLA). The latter is claimed to have medicinal properties and is required for arachidonic acid and prostaglandin synthesis. GLA lowers low-density lipoprotein, being 170-fold more effective than LA. Iron in some nutritional complements is not appropriately absorbed. Iron in *Arthrospira* is 60% better absorbed than ferrous sulfate and other complements. Consequently, it could represent an adequate source of iron in anemic pregnant women (Iwata et al., 1990; Dagnelie et al., 1991; Hayashi et al., 1994; Dillon et al., 1995; Hayashi et al., 1996; Genene Tefera, 2008).

Arthrospira contains about 13.6% carbohydrates; some of these are glucose, rhamnose, mannose, xylose and galactose. *Arthrospira* does not have cellulose in its cell wall, a feature that makes it an appropriate and important foodstuff for people with problems of poor intestinal absorption, and geriatric patients. A new high molecular weight polysaccharide, with immunostimulatory activity has been isolated from *Arthrospira* and is called "Immulina". This highly water-soluble polysaccharide represents between 0.5% and 2.0% (w/w) of the dry mass (Dillon et al., 1995; Hayashi et al., 1996; Genene Tefera, 2008).

One of the main concerns about the consumption of microorganisms is their high content of nucleic acids that may cause disease such as gout. *Arthrospira* contains 2.2%-3.5% of RNA and 0.6 %-1% of DNA, which represents less than 5% of these acids, based on dry weight. These values are smaller than those of other microalgae like *Chlorella* and *Scenedesmus* (Dillon et al., 1995; Hayashi et al., 1996; Genene Tefera, 2008). Some natural pigments are found in *Arthrospira*. These pigments are responsible for the characteristic colors of certain flamingo species that consume these *Cyanobacteria* in the African Valley (Kebede et al., 1994; Genene Tefera, 2008) (For detailed information, see Tables 1 and 2).

Table 1. Nutritional composition of the world's best complete food-*Spirulina* (Dillon et al., 1995; Kebede et al., 1994; Tokusoglu and Unal, 2003; Khan et al.; 2005; Genene Tefera, 2008).

Nutrients	By dry weight
Protein	50-77 %
Carbohydrates	15-25 %
Lipids (fats)	6- 8 %
Fiber	8-10 %
Vitamins	**per 10 g**
A	23000 IU
B1	0.35 mg
B2	0.40 mg
B3	1.4 mg
B6	80 mcg
B12	20 mcg
C	90 mcg
D	1200 IU
E	1.9 mg
K	200 mcg
Beta Carotene	14 mg
Biotin	0.5 mcg
Inositol	6.4 mg
Folic acid	1 mcg
Nicotinic acid	1.18mg
Pantothenic acid	10 mcg
Mineral	**per 10 g**
Calcium	70 mg
Iron	15 mg
Phosphorus	80 mg
Magnesium	40 mg
Zinc	0.3 mg
Selenium	10 mcg
Copper	120 mcg
Manganese	0.5 mg
Chromium	25 mcg
Sodium	90 mg
Potassium	140 mg
Germanium	60 mcg
Natural pigment phytonutrients	**per 10 g**
Phycocyanin (blue)	1400 mg
Chlorophyll (green)	100 mg
Carotenoids (orange)	47 mg
Natural phytonutrients	**per 10 g**
Gama Linolenic Acid (essential fatty acid)	130 mg
Palmitic acid	210 mg
Linoleic acid	138 mg
Alpha Linolenic acid	70 mg
Chlorophyll-a	76 mg
Beta Sitosterol	1 mg
Glycolipids	200 mg
Sulfolipids	10 mg
Polysaccharides	460 mg
Natural pigments (carotenoids)	**per 10 g**
Carotenes (orange)	25 mg
Beta Carotene	21 mg
Other Carotenes	4 mg
Xanthophylls (yellow)	22 mg
Myxoxanthophyll	9 mg
Zeaxanthin	8 mg
Crytoxanthin	1 mg
Echinenone	3 mg
Other Xanthophyll's	3 mg
Amino acids	**per 10 g**
Essential Amino Acids	
Isoleucine	350 mg
Leucine	540 mg
Lysine	290 mg
Methionine	140 mg
Phenylalanine	280 mg
Threonine	320 mg
Tryptophan	90 mg
Valine	400 mg
Non-Essential Amino Acids	
Alanine	470 mg
Arginine	430 mg
Aspartic acid	610 mg
Cystine	60 mg
Glutamic acid	910 mg
Glycine	320 mg
Histidine	100 mg
Proline	270 mg
Serine	320 mg
Tyrosine	300 mg

Table 2. Some of comparative nutritional values (Genene Tefera, 2008; Ashraf, 2014)

Protein	**g/100g**
Eggs	13.3
Milk	4.3
Soya bean	43.2
Pulses (black gram)	24.0
Spirulina	55-77
Beta-Carotene	**mcg/100g**
Carrots	1890
Spinach	5580
Mango	2740
Spirulina	190000
Vitamin B_{12}	**mcg/100g**
Milk	0.60
Spirulina	5
Iron	**g/100g**
Soya bean	11.5
Spinach	10.9
Spirulina	32

When we see to health benefits of spirulina, studies are showing that it may exhibit antiviral, anticancer, antimicrobial, and anti-inflammatory activity. It has also been shown to have beneficial effects on controlling cholesterol, diabetes, coronary artery disease, weight loss and wound healing.

Therapeutic value of *Arthrospira*

Many toxicological studies have proven *Arthrospira* as *safe* food for human consumption. It currently belongs to the substances that are listed by the US Food and Drug Administration under the category Generally Recognized as Safe (GRAS) (Salazar et al., 1996) and it now, can be found in health food stores and is sold mainly as a dietary supplement in the form of health drinks or tablets. *Arthrospira* increases healthy *Lactobacillus* in the intestine, enabling the production of Vitamin B_6 that also helps in energy release. It has also been well documented that *Arthrospira* exhibits anti-inflammatory properties by inhibiting the release of histamine from mast cells (Yang et al., 1997; Kim, et al., 1998). Ishii and his colleagues (1999) studied the influence of *Arthrospira* on IgA levels in human saliva and demonstrated that it enhances IgA production, suggesting a pivotal role of microalga in mucosal immunity. Hirahashi and his coworkers (2002) identified the molecular mechanism of the human immune capacity of *Arthrospira* by analyzing blood cells of volunteers with pre- and post-oral administration of hot water extract of *Arthrospira platensis*. IFN-γ production and Natural Killer (NK) cell damage were increased after administration of the *Arthrospira* extracts to male volunteers.

Now days it is well understood that deficiency of nutrients is responsible for changes in immunity, which manifests as changes in production of T-cells, secretory IgA antibody response, cytokines and NK-cell activity. The nutritional constitute of *Arthrospira* may modulate the immune system by its role in covering nutritional deficiencies. On the other hand, Hayashi and his coworkers (1996) reported that the active component of the water extract of *A. platensis* is a sulfated polysaccharide and calcium spirulan (Ca-Sp). They also described that Ca-Sp inhibits the in vitro replication of several enveloped viruses including Herpes simplex type I, human cytomegalovirus, measles and mumps virus, influenza A virus and human immunodeficiency virus-1 virus (HIV-1). In other in vitro experiment (Ayehunie et al., 1998) showed that an aqueous extract of *A. platensis* inhibited HIV-1 replication in human T-cells, peripheral blood mononuclear cells and Langerhan cells.

The hypolipidemic effect of *Arthrospira* and its extracts have been demonstrated in various animal models including mouse, rat, hamster and rabbit. The cholesterol lowering activity of *Arthrospira* was first reported in albino rats (Devi et al., 1983), followed by in mice (Kato et al., 1984). In the mouse study, supplementation of 16% *Arthrospira* in a high fat and cholesterol diet resulted in a significant reduction in total serum cholesterol, LDL, VLDL cholesterol and phospholipids whereas serum HDL cholesterol was concurrently increased. In addition, high hepatic lipids induced by the high fat and cholesterol diet were markedly reduced by *Arthrospira* consumption.

Iwata and his coworkers (1990) evaluated effects of *Arthrospira platensis* on plasma lipoprotein lipase activity in fructose-induced hyperlipidemic rats. They reported that increasing percentages of *Arthrospira* (5, 10, and 15%) in the diet significantly improved the hyperlipidemic profiles. Correlating with such improvement in lipid profiles, *Arthrospira* feeding resulted in a significant increase in lipoprotein lipase and hepatic triglyceride lipase activity. Such increased lipase activity by *Arthrospira* was suggested as a mechanism for improving the hyperlipidemia induced by high fructose diet. Ramamoorthy and Premakumari (1996) also assessed effect of administered *Arthrospira* supplements in ischemic heart disease patients and found a significant reduction in blood cholesterol, triglycerides and LDL cholesterol and an increase in HDL cholesterol. Similarly, Mani and his coworkers (2000) in a clinical study, found a significant reduction in LDL: HDL ratio in 15 diabetic patients who were given *Arthrospira*.

It has been argued that the combined antioxidant and immune modulation characteristics of *Arthrospira* may have a possible mechanism of tumor destruction and hence play a role in cancer prevention. With this regard several animal and human in vitro studies were conducted. Mathew and his colleagues (1995) conducted an experiment that looked specifically at the effects of *Arthrospira* on oral carcinogenesis in particular leukoplakia. This study was conducted on a cohort of 77 patients originates from previous trials on hamsters that showed tumor regression after topical application or enteral intake of *Arthrospira* extract. They reported that 45% of their study cohort showed complete regression of leukoplakia after taking *Arthrospira* supplements for one year. The authors also reported that there was no rise in the serum concentration of retinal β-carotene despite supplementation and concluded that other constituents within *Arthrospira* may have been responsible for the anticancer effects.

A number of animal studies have been carried out to evaluate the antioxidant and/or anti-inflammatory activities of *Arthrospira*. In one study with aged male rats (Gemma et al., 2002), *Arthrospira* reversed age-related increase in proinflammatory cytokines in cerebellum, such as tumor necrosis factor-alpha (TNF-α) and TNF-β. *Arthrospira* supplementation also significantly decreased the oxidative marker MDA whereas increased the cerebellar ß-adrenergic receptor function which was reduced by aging. The data thus demonstrated the antioxidant and anti-inflammatory activities of *Arthrospira* in aged rats. Doxorubicin (DOX) is an anthracycline antibiotic primarily used in the treatment of cancers. However, its application is limited due to its cardiac toxicity. The generation of ROS, lipid peroxidation, iron-dependent oxidative damage leading to mitochondrial dysfunction has been implicated in doxorubicin (DOX)-induced cardiotoxicity (Doroshow, 1991; Xu, et al., 2001). To determine whether *Arthrospira* has cardioprotective activity in DOX-induced cardiotoxicity, mice were treated with DOX alone or DOX with *Spirulina* (Khan, et al., 2005). As expected, mice administrated with DOX exhibited severe cardiac pathologies. However, feeding of *Arthrospira* at a dose of 250 mg/kg significantly decreased the mortality, ascites and lipid peroxidation; normalized the antioxidant enzymes levels; and minimized the microscopic damages to the heart. The data indicated that *Arthrospira* had a protective effect on cardiotoxicity induced by DOX, most likely through its antioxidant activity (Gemma et al., 2002).

In addition, a large number of animal studies were carried out to investigating the preventive or protective effects of *Arthrospira* intake on environmental toxicant, chemical, heavy metal or drug-induced oxidative stress and inflammation. Accumulative data from those studies concluded that *Arthrospira* ingestion significantly relieved or totally prevented the oxidative stress or inflammation, and their associated pathological damages induced by insulting compounds. Although those studies were not directly investigating Arthrospira’s effects on cardiovascular conditions, the findings clearly demonstrated the antioxidant and anti-inflammatory activities of *Arthrospira* (Gemma et al., 2002).

Arthrospira produce a diverse range of bioactive molecules, making them a rich source of different types of medicines. Vinay and his coworkers (2012) evaluated four different strains of *Arthrospira platensis* that were isolated from different habitats and tested with three different concentrations prepared in four different solvent extracts (N-hexane, Chloroform, Acetone, Methanol) to check the antimicrobial activity of microbes (*Microsporum canis* MTCC-3270, *M. fulvum* MTCC-7675, *Candida albicans* MTCC-227) and bacteria (*Salmonella typhimurium* MTCC-TA 98, *Staphylococcus aureus* MTCC-96) by using Agar-well diffusion method. Their research finding revealed that the *Arthrospira* extracts had antimicrobial activity of which effectiveness varied with strain and extion solvent. Mona and his colleagues (2014) showed that the total crude (70%) methanol extract and five successive extracts of *Arthrospira platensis* were tested against four types of viruses using cell viability assay and nine strains of Gram positive and Gram negative bacteria as well as *Candida albicans* using disc diffusion method. The results revealed that the total methanol and *n*-hexane extracts were significantly active against all tested viruses showing mean % inhibition of 56.7% and 66.7% against rotavirus Wa strain; 60% and 63.3% against adenovirus type 7; 53.3% and 50% against adenovirus type 40 respectively and 50% for both extracts against Coxsackievirus B4. The ethyl acetate extractive was active only against rotavirus Wa strain with 53.3% inhibition. Normal hexane extract was most potent against *Salmonella senftenberg* with 58.5% inhibition.

The status of *Arthrospira* in Lake Chitu

Arthrospira of Lake Chitu serves as the main food source for the large flocks of lesser flamingos inhabiting the lake. Strains of *Arthrospira* from this lake have also been used for various scientific studies and commercial cultures elsewhere (Li et al., 2001). Lake Chitu is a tropical creator lake located in the Ethiopian Rift Valley some 287 km south of Addis Ababa at a geographical position of 7023'N 38024'E and latitude of 1600masl. It is a small soda lake known for its natural monospecific population of *Arthrospira* and the associated unusually high primary productivity. The lake is characterized by environmental conditions, which are ideal for the growth of *Arthrospira*. The lake water has high pH, salinity alkalinity and frequently limiting levels of inorganic nitrogen compounds (Kebede, 1994). The lake is within the closed basin and lakes obvious surface outflow and inflows, and receives water from direct precipitation and a few hot springs located at its shores It experiences high evaporation concentration, which is the major factor for its saline-alkaline nature (Legesse et al., 2002; Gebremariam, 2002).

The Ethiopian Biodiversity Institute with other stakeholders is working on the restoration and rehabilitation of Chitu Lake as *In-situ* conservation site for *Arthrospira* and other microalgael biodiversity. The purpose is to preserve the species and populations in a natural state in the habitat where they naturally occur. This preserves both the population and the evolutionary processes that enable the population to adapt by managing biotic and abiotic factors in their natural state and within their normal range.

Conclusion

Arthrospira has no hidden environmental costs and offers more nutrition than any other products. It conserves land and soil and uses water and energy more efficiently than other foods. *Arthrospira* appears to have considerable potential for development, especially as a small-scale crop for nutritional enhancement, livelihood development and environmental mitigation. In many countries of Africa, it is used as human food as an important source of protein and is collected from natural water, dried and eaten. It has gained considerable popularity in the human health food industry and in many countries of Asia it is used as protein supplement and as human health food. Arthrospira has been used as a complementary dietary ingredient of feed for poultry and increasingly as a protein and vitamin supplement to aqua feeds (Habib et al., 2008).

Arthrospira is the only food priority where the country facing a serious loss of cropland and higher food imports. *Arthrospira* require less land and water than other and can grow in climates where other crops cannot in the country. Mainly *Arthrospira* production will help to improve food security and sustainability within the country. It will also create more employment opportunities for local community members. High priority will be given to local community members through increased support for small scale *Arthrospira* cultivation with demonstration on how individuals can manage cultivation with minimal training and technical supervision.

Recommendation

As it is well known, Ethiopia, with enormous natural resources, has been wounded by drought and famine. However, the country could have the potential to produce abundant food for its people. One of these natural resources is *Arthrospira platensis* after which Ethiopia is recognized as one of the home countries for the "food of the future", supplier of the best food. Even so, after 20 years, since harvesting of spirulina from lakes in Ethiopia was proposed, practically nothing has happened.

Currently, ending poverty and hunger is a primary goal of UN-Sustainable Development Goals No. **1** (End poverty in all its forms everywhere) and **2** (End hunger, achieve food security and improved nutrition and promote sustainable agriculture). We think, one of the oldest forms of life and the oldest food complement used by humanity which affirms itself as one of the best solutions against malnutrition and gives hope back to developing countries, including Ethiopia, to realize these goals.

What actions are to be undertaken to develop a healthy diet, where spirulina, the magic food, has its place. And say, there has increasingly free space in our countryside where install spirulina farms. And we strongly believe that spirulina will be a primary solution to combat malnutrition and hunger in our country!

Conflict of interest statement

Authors declare that they have no conflict of interest.

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