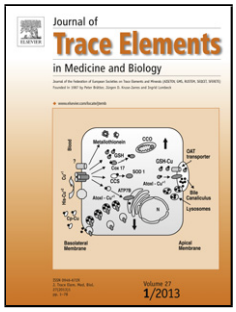
Accepted Manuscript



Title: Mössbauer spectroscopic study of transformations of iron species by the cyanobacterium *Arthrospira platensis* (formerly *Spirulina platensis*)

Authors: Yurii D. Perfiliev, Alexandr Kh. Tambiev, Maxim A. Konnychev, Anatoly V. Skalny, Elena S. Lobakova, Mikhail P. Kirpichnikov

PII: S0946-672X(17)30718-6
DOI: https://doi.org/10.1016/j.jtemb.2018.02.030
Reference: JTEMB 26079

To appear in:

Received date: 10-8-2017
Revised date: 20-2-2018
Accepted date: 28-2-2018

Please cite this article as: Perfiliev Yurii D, Tambiev Alexandr Kh, Konnychev Maxim A, Skalny Anatoly V, Lobakova Elena S, Kirpichnikov Mikhail P.Mössbauer spectroscopic study of transformations of iron species by the cyanobacterium Arthrospira platensis (formerly Spirulina platensis).*Journal of Trace Elements in Medicine and Biology* https://doi.org/10.1016/j.jtemb.2018.02.030

Mössbauer spectroscopic study of transformations of iron species by the cyanobacterium *Arthrospira platensis* (formerly *Spirulina platensis*)

Yurii D. Perfiliev[1], Alexandr Kh. Tambiev[2], Maxim A. Konnychev[2]*, Anatoly V. Skalny[3], Elena S. Lobakova[2], Mikhail P. Kirpichnikov[2]

[1] Faculty of Chemistry, Lomonosov Moscow State University, Leninskie gory, Moscow 119992, Russia
[2] Faculty of Biology, Lomonosov Moscow State University, Leninskie gory, Moscow 119992, Russia
[3] RUDN University, Miklukho-Maklay St., 10/2, Moscow 117198, Russia
Corresponding author at: Faculty of Biology, Lomonosov Moscow State University, Leninskie gory, Moscow 119992, Russia. Fax: +7 495 939 4309. E-mail address: maxim-kedr@mail.ru (Maxim A. Konnychev).

Mössbauer spectroscopic study of the iron state in cells of *Arthrospira platensis*

ABSTRACT: In the present paper, Mössbauer spectroscopic studies of dry biomass samples of the cyanobacterium *Arthrospira platensis* (formerly known as *Spirulina platensis*) were performed with regard to metabolic iron accumulation. ^{57}Fe Mössbauer parameters of iron in the biomass correspond to ferrihydrite. Spectra of iron hydroxides in *A. platensis* biomass differ from those of iron complexes with ethylenediaminetetraacetic acid injected to Zarrouk culture medium. The limit of saturation of *A. platensis* trichomes with iron in the form of ferrihydrite was found to be 5 μg/ml (0.09 μmol/ml) Fe in the culture medium. Conglomerates precipitated in the medium at higher iron concentrations also contain ferrihydrite but the ratio of the crystal lattice forms is different from that in the biomass.

Keywords: *Arthrospira platensis; Spirulina*; iron; Mössbauer spectroscopy; microscopic study; ferrihydrite

INTRODUCTION

Mössbauer spectroscopy is widely used to study the state and transformations of iron-containing biological objects [1, 2]. In the present work the subject of study was *Arthrospira platensis* (Nordstedt) Gomont. *A. platensis* is a microscopic filamentous cyanobacteria (blue-green algae). *Arthrospira* does not fix nitrogen and does not develop differentiated cells such as heterocysts or akinetes as a part of the filament [3].

A. platensis is one of the most common objects in photobiotechnology. *A. platensis* contains a large amount of protein (up to 60-70% of dry weight) which includes all essential amino acids and is similar to protein of many traditional foods. There is also a significant amount of B vitamins (B_1, B_2, B_3, B_6, B_{12}) and also folic acid, biotin and pantothenic acid in *A. platensis* biomass. Main pigments of *A. platensis* are chlorophyll A, beta-carotene (20-25 times more than in carrot), porphyrin, mixoxanthophyll and C-phycocyanin, which have immunomodulatory and antioxidant activity [4, 5]. Lipid content varies from 3% to 7% of dry cells weight. *A. platensis* has a high level of mono- and polyunsaturated fatty acids, especially rare gamma-linolenic acid (17.1–40.1 % of total fatty acids). Carbohydrates make up 14-19% of *A. platensis* dry weight [5].

A. platensis biomass contains a significant amount of potassium, magnesium, iron, phosphorus, calcium and such essential trace elements as zinc, manganese, copper. The minerals are present in chelated form, and therefore they have good (about 85-95%) bioavailability for human body. As opposed to most algae and cyanobacteria, the cell membrane of *A. platensis* is easily digested because it is composed not of cellulose but of sugars, which determines a high bioavailability coefficient of *A. platensis* biomass. Essential and conditionally essential trace elements along with vitamins and pigments are primary factors included to preventive nutrition providing normal functioning of all systems of the human body. Therefore *A. platensis* biomass is often used as a part of dietary supplements [6, 7].

Some species of *A. platensis* are cultivated worldwide. Biomass of *A. platensis* is used in different areas of human activity such as production of biologically active substances (enzymes, vitamins, fragrances, pigments, lipids and others), high-quality food protein for therapy-prophylactic purposes and animal feeds, as well as for bioconversion of sun energy, recycling wastes etc. [4, 6, 7].

Nowadays, open reservoirs with mixing and isolated photobioreactors of different design are employed for cultivating *A. platensis* [7, 8].

Influence of low intensity electromagnetic waves of millimeter range (EHF-emission) on *Arthrospira* species [7], as well as the ability of *A. platensis* and *A. maxima* cells to accumulate essential and conditionally essential trace elements (B, Mo, Se, Zn, Cu, V, Li, Co) were studied in our group previously. Novel descriptors (optimal concentration, optimal concentration criterion, coefficient of trace elements accumulation) based on the obtained results were introduced [6, 7, 9]. Some Mössbauer data presented in this work have been reported at a conference [10].

The parameters of cultivation and accumulation of iron in *A. platensis* can be applied to industrial biotechnology and the production of dietary supplements.

The aim of this work was to determine iron species in *A. platensis* biomass and also to determine the concentration limit up to which iron could be accumulated by *A. platensis* cells without a significant decline of the culture productivity.