

# ESSENTIAL AND NON-ESSENTIAL ELEMENTS IN *CHLORELLA* AND *SPIRULINA* FOOD SUPPLEMENTS

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**Abstract.** This study aimed to determine the essential elements (Ca, Mg, K, Na, Co, Cu, Cr, Mn, Mo, Se, Fe, Zn) and non-essential elements (Al, Cd, Ni, Pb, As) in some commercial *Chlorella* and *Spirulina* products available in Romania. The Pb content in the analyzed food supplements did not exceed the maximum content of 3.0 mg/kg set by the European Commission. Also, the Cd content in all studied supplements was below the limit of detection (0.1 mg/kg) and did not exceed the maximum level of 1.0 mg/kg. The Ni and As were found in small amounts in the supplements. Al content in *Spirulina* supplements was 21.67 and 65.73 mg/kg, respectively, higher than in *Chlorella* supplements (1.69 mg/kg and <0.1 mg/kg). The analyzed food supplements can be considered safe for human consumption, based on the element content.

**Keywords:** *Chlorella*, essential elements, microalgae, *Spirulina*

## INTRODUCTION

The demand for food supplements increased in recent years in Europe, USA and Asia. The food supplements, typically supplied in tablets or capsules, are intended to provide sufficient nutrients to support the physiological functions (Augustsson et al., 2021, Rzymiski et al., 2019; Puścion-Jakubik et al., 2021). Supplements based on microalgal biomass are gaining worldwide attention due to their bioactive properties. *Spirulina* and *Chlorella* are the most widely used microalgae in supplements owing to their richness in proteins, fatty acids, pigments, minerals, digestive and restriction enzymes, and vitamins (Galasso et al., 2019; Rzymiski et al., 2019; González-Pérez et al., 2022). The potential presence of As, Hg, Pb, Cd, Ni in food supplements has raised concerns regarding the safety of these products (Wong et al., 2022; Augustsson et al., 2021, Koch et al., 2022). Hg, Cd, Pb and As are the most likely to cause the adulteration of *Spirulina*-based food products (Al-Dhabi et al., 2013). The intake of food supplements containing high amounts of metals (Mn, Co, Cu, Fe, K, Mg and Ca) can lead to various health effects, such as organ damage, developmental alterations, cancer, neurotoxic responses, cardiotoxicity, gastrointestinal symptoms, altered immune function, or unwanted cardiovascular events (Wong et al., 2022; Rzymiski et al., 2019). It has been reported a high discrepancy between the actual nutritional value of various food supplements and that declared on the product label (Rzymiski et al., 2019). Poniedziałek et al., determined the content of essential elements in 168 multi-ingredient food supplements distributed in Poland and found that the majority of the tested products displayed mineral content below the accepted margin (70 - 130 %) compared to the value declared on the product label. Moreover, the mineral content was below the value presented on the product label (Poniedziałek et al., 2018). Masten Rutar et al., investigated the nutritional quality and safety of 46 *Spirulina* supplements

on the Slovenian market and observed a high proportion of 86.7 % of inappropriate declarations regarding the content of Fe, Mn, Ca, Zn, P, K and Se, taking into account that a deviation of more than 45 % could be dangerous to human health (Masten Rutar et al., 2022).

The present study aimed to assess the content of non-essential elements (Al, Cd, Ni, Pb, As) and essential macro- and trace elements (Ca, Mg, K, Na, Co, Cu, Cr, Mn, Mo, Se, Fe, Zn) in *Chlorella* and *Spirulina* food supplements products.

## MATERIALS AND METHODS

### 1. Food supplements

A total of 4 microalgal food supplements denoted S1, S2, C1 and C2 were purchased from the Romanian market. The general characteristics of the studied food supplements are presented in Table 1.

Table 1

General characteristics of the studied microalgal food supplements			
Supplement	SPECIES	Form	Daily dose recommendation
S1	<i>Spirulina</i> sp.	powder	1 - 2 teaspoons
S2	<i>Spirulina platensis</i>	capsules	1.5 - 3.0 g adults 1.0 - 1.5 g children over 12 years
C1	<i>Chlorella</i> sp.	powder	2.0 - 4.0 g
C2	<i>Chlorella pyrenoidosa</i>	capsules	2.0 g

### 2. Metal content analysis

An amount of 200 mg of sample was digested in 5 mL HNO<sub>3</sub> 65 % and 2 mL H<sub>2</sub>O<sub>2</sub> 30 % in polytetrafluoroethylene digestion vessels using a closed-vessel microwave digestion system (Speedwave MWS-3+, Berghof, Germany) using a four-step digestion program (120 °C and 190 °C-heating; 100 °C and 25 °C-cooling) for 35 min (Neag et al., 2019). After digestion, the solution was diluted with ultrapure water and analyzed using an inductively coupled plasma quadrupole mass spectrometer, ICP-MS (ELAN DRC II, Perkin-Elmer, Waltham, MA, USA). Each sample was prepared in triplicate.

## RESULTS AND DISCUSSION

### 1. Macroelements

The content of macroelements, express in mg/kg, in the studied food supplements is presented in Figure 1.

The content of macroelements decreased in the order Ca > K > Na > Mg for *Spirulina* supplements and K > Mg > Ca > Na for *Chlorella* supplements. High K content was observed for S2 sample compared with S1 and both *Chlorella* samples. The highest contents of Ca (9640 mg/kg), Mg (1325 mg/kg) K (5956 mg/kg) and Na (2286 mg/kg) were in S2, a sample containing *Spirulina*, while the lowest contents were in the samples containing *Chlorella*.

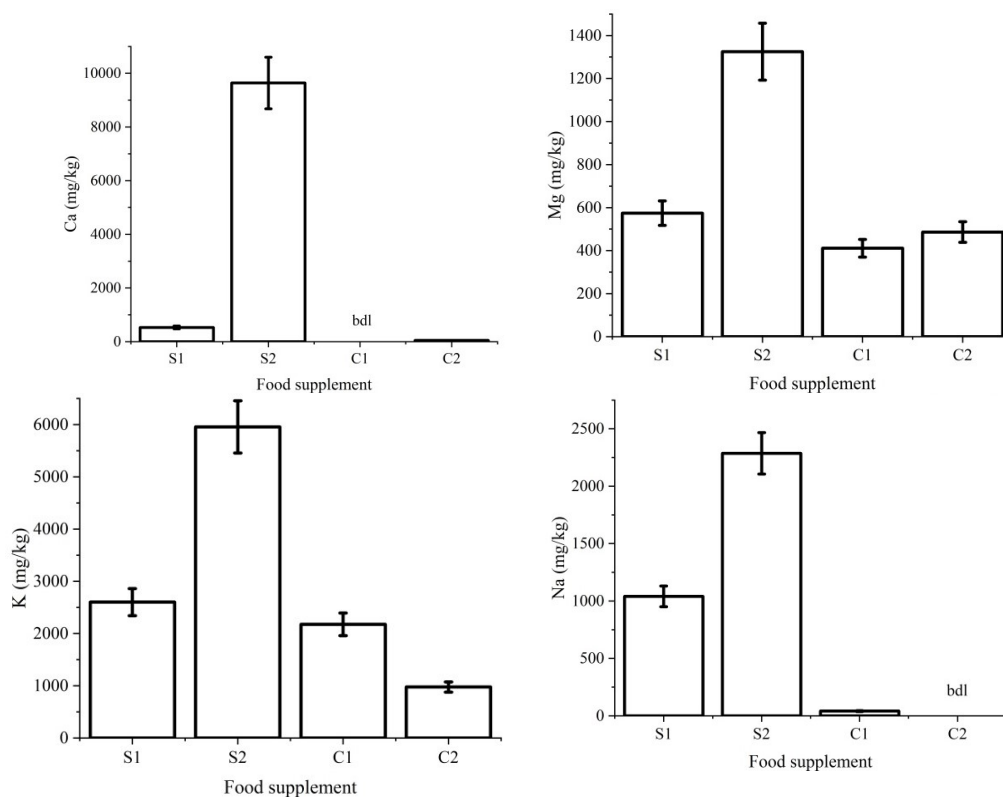


Figure 1. The content of Ca, Mg, K and Na in *Chlorella* and *Spirulina* food supplements

## 2. Trace elements

The content of trace elements, express in mg/kg, in the studied food supplements is presented in Figure 2.

The content of trace elements decreased in the following order: Fe > Mn > Zn > Cu > Cr > Co > Mo > Se in *Spirulina* supplements and Fe > Mn > Zn > Mo > Cr > Co = Cu = Se in *Chlorella* supplements. Rzymiski et al., reported a similar order for the content of trace elements in 13 *Spirulina* food supplements and the following order Fe > Mn > Zn > Cu > Cr > Mo > Se > Co in 10 *Chlorella* food supplements (Rzymiski et al., 2019). Small amounts of Co, Cr, Cu, Mo and Zn were found in the analyzed food supplements. The Mn and Cr content in *Spirulina* and *Chlorella* supplements were comparable. The Fe content in *Spirulina* supplements was 186 (S1) and 378 mg/kg (S2), while in *Chlorella* supplements was 126 (C1) and 72.4 mg/kg (C2). The Se content was below the limit of detection (0.1 mg/kg) in all studied food supplements.

## 3. Non-essential elements

The content of non-essential elements, expressed in mg/kg, is presented in Figure 3. Al content in *Spirulina* supplements (21.67 and 65.73 mg/kg in S1 and S2 samples, respectively) was higher than in *Chlorella* supplements (1.69 mg/kg in C1 sample, while in C2 sample was below the detection limit of 0.1 mg/kg). The Ni content was present in small amount in S1 and in both *Chlorella* supplements, while in S2 samples was slightly higher (1.33 mg/kg). The Pb content was below the limit of detection (0.1 mg/kg) in *Chlorella* samples and slightly higher in *Spirulina* samples (0.31 and 0.27 mg/kg in S1 and S2, respectively), but did not exceed the maximum

content of 3.0 mg/kg set by the European Commission (Rzyski et al., 2019). As content was below the detection limit (< 0.1 mg/kg) in S1, C1 and C2 samples and in S2 sample was present in small amount (0.13 mg/kg). The Cd content was below the limit of detection (0.1 mg/kg) in all studied supplements and did not exceed the maximum level of 1.0 mg/kg set for food supplements by the European Commission (Rzyski et al., 2019).

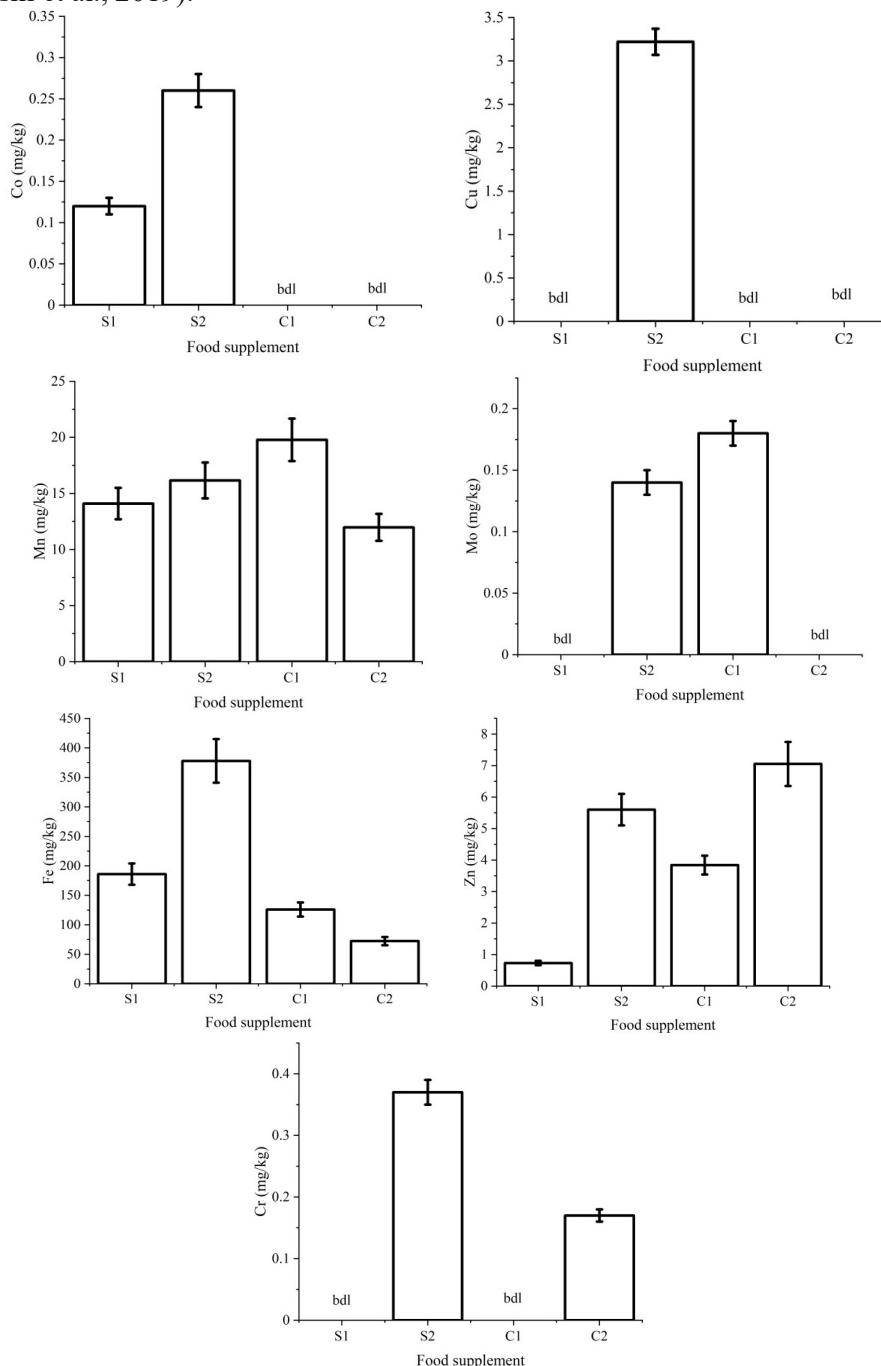


Figure 2. The content of Co, Cr, Cu, Mn, Mo, Fe and Zn in *Chlorella* and *Spirulina* food supplements

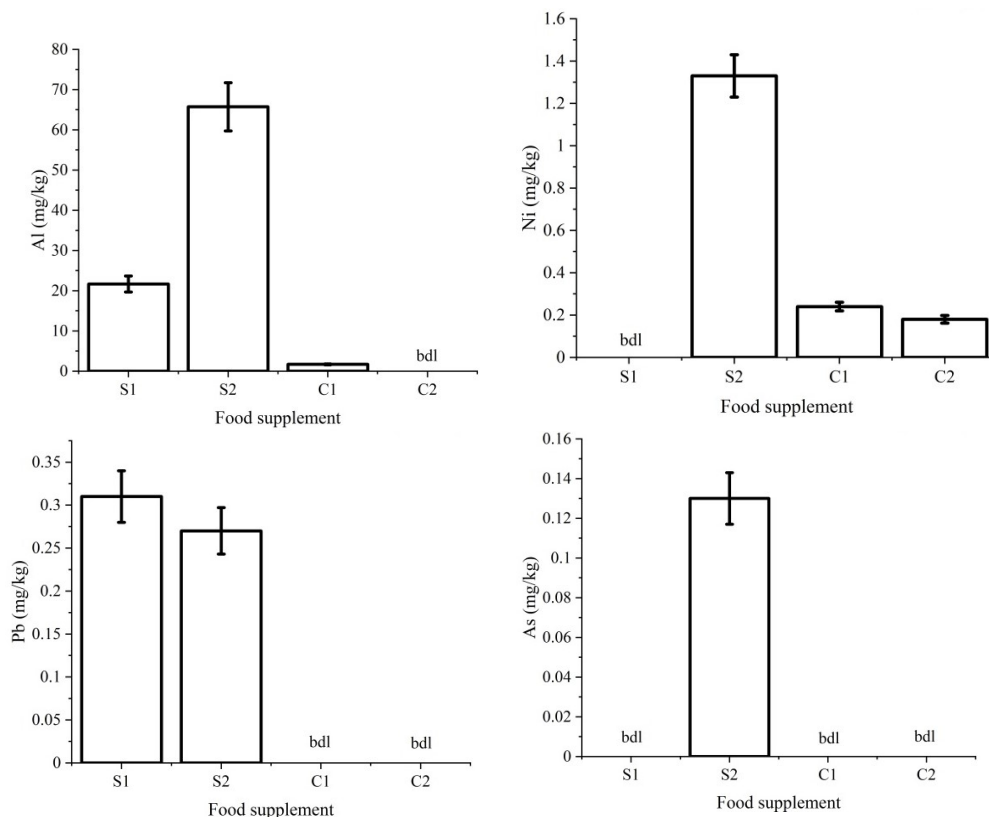


Figure 3. The content of Al, Ni, Pb and As in *Chlorella* and *Spirulina* food supplements

## CONCLUSIONS

In summary, the content of minerals and non-essential elements in four commercial *Spirulina* and *Chlorella* food supplements available on the Romanian market was determined. The analyzed *Spirulina* and *Chlorella* supplements contain essential elements. The content of elements, such as Pb and Cd did not exceed the maximum content of 3.0 mg/kg and 1.0 mg/kg, respectively set by the European Commission. The metal content from food supplements should be monitored regularly in order to avoid a potential human health risk.

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