EDIBLE FILMS WITH PROTEIN AND BIOACTIVE COMPOUNDS FROM *ARTHROSPIRA* SP. MICROALGA

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Introduction

Arthrospira sp., known as Spirulina, is a microalga rich in natural nutrients and it consists of 60–70% protein, including essential amino acids, vitamins (B-complex, vitamin E), minerals (Fe, Ca), and fatty acids (γ-linolenic acid). Its bioactive compounds are associated with therapeutical properties [1].
Antioxidant and antimicrobial properties of Spirulina are essential to produce edible films that can be used to increase the shelf life of perishable foods.
The nutritional content of edible films may also be increased by adding protein extract from an alternative source, such as Spirulina.

Objectives

- To extract bioactive compounds with antioxidant properties from *Arthrospira* sp. microalga
- To extract protein from *Arthrospira* sp.
- To produce edible films by adding bioactive compounds and protein extracts from *Arthrospira* sp. to alginate
- To test the antioxidant and physical properties of the produced edible films

Methods

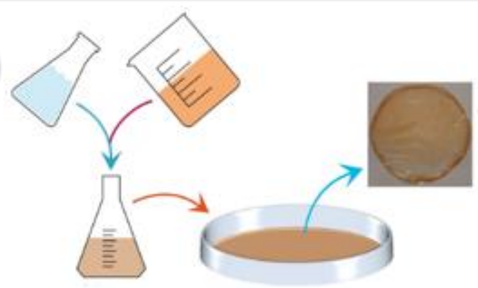
Freeze-dried Spirulina

Bioactive compounds extraction: hydroethanolic maceration (10:90 v:v, 2h, 50 °C) assisted by ultrasounds [2]

Total phenolic content (TPC) and antioxidant activity (ABTS, DPPH, ORAC) [2]

Protein extraction: water (50 ° C, 2 h), cellulase and protease at adequate pH and temperature (40 °C, 2 h), centrifugation, and freeze-drying [3]

Edible film production: "casting" method [4]



Edible film antioxidant activity (ABTS, DPPH) [5]

Edible film physical properties: thickness [6], Color [7], water vapor permeability [8], solubility [9]

Results

- **The yield of extraction** was 12.99±0.90% for the bioactive compounds and 46.07±4.22% for the protein.

Table 1. TPC and antioxidant activity (ABTS, DPPH, ORAC) of the bioactive-rich extract

TPC (mg GAE/100 mg DW)	ABTS (µmol TE/100 mg DW)	DPPH (µmol TE/100 mg DW)	ORAC (µmol TE/100 mg DW)
0.973±0.061	2.846±0.452	2.284±0.064	18.378±1.004

- **Edible films:**

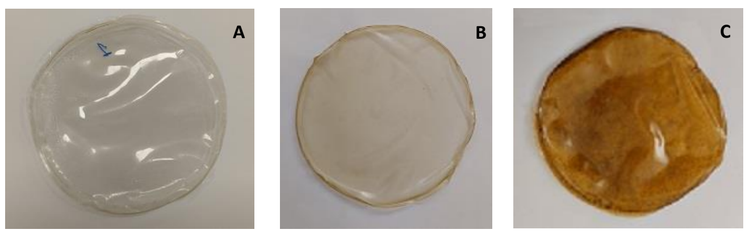


Figure 1. (A) alginate; (B) alginate + protein extract; (C) alginate + protein extract + bioactive-rich extract

Table 2. Edible films antioxidant activity (ABTS, DPPH)

Edible film	ABTS (µM TE/mg film)	DPPH (µM TE/mg film)
Alginate (3%)	120.15±6.81 ^{c}	85.97±3.19 ^{b}
Alginate (2%) + Protein extract (0.5%)	922.36±129.06 ^{b}	95.93±15.91 ^{b}
Alginate (2%) + Protein extract (0.5%) + Bioactive-rich extract (0.25%)	1537.50±191.87 ^{a}	190.75±15.53 ^{a}

Different letters in each column mean significant differences ($p < 0.05$).

The thickness of the edible film with alginate was 0.058±0.002 mm; with alginate + protein extract it was 0.063±0.005 mm, and with alginate + protein extract + bioactive-rich extract it was 0.076±0.006 mm.

Table 3. Edible films color parameters

Edible film	L*	a*	b*	Hue (°)	Chroma
Alginate (3%)	51.79±3.77 ^{a}	2.30±0.15 ^{a}	0.93±0.11 ^{b}	21.85±1.32 ^{c}	2.48±0.18 ^{b}
Alginate (2%) + Protein extract (0.5%)	61.16±9.54 ^{a}	1.76±0.24 ^{b}	6.80±0.48 ^{a}	75.50±1.90 ^{a}	7.02±0.49 ^{a}
Alginate (2%) + Protein extract (0.5%)+Bioactive-rich extract (0.25%)	20.66±1.21 ^{b}	2.58±0.32 ^{a}	6.90±0.45 ^{a}	69.46±2.79 ^{b}	7.38±0.42 ^{a}

Different letters in each column mean significant differences ($p < 0.05$).

The water vapor permeability ($g.mm.m^{-2}.day^{-1}.kPa^{-1}$) of the edible film with alginate was 22.080±0.594; with alginate + protein extract it was 14.388±3.636; and with alginate + protein extract + bioactive-rich extract it was 12.276±3.014.

Table 4. Edible films solubility

Edible film	H_20	Acetic acid 3%	EtOH 10%	EtOH 20%	EtOH 50%
Alginate (3%)	100	16.93±1.65 ^{b}	100	100	100
Alginate (2%) + Protein extract (0.5%)	100	27.34±6.77 ^{a}	100	100	100
Alginate (2%) + Protein extract (0.5%) + Bioactive-rich extract (0.25%)	100	20.49±2.33 ^{ab}	100	100	100

Different letters in each column mean significant differences ($p < 0.05$).

Conclusions

It was possible to extract bioactive compounds and protein hydrolysates from Spirulina, which presented antioxidant properties.
It was possible to produce edible films with the protein extract and bioactive compounds extract, the films presenting a high antioxidant activity, especially using both extracts.
The edible films containing protein had lower water vapor permeabilities than the one with only alginate.
All the edible films are soluble in water and hydroethanolic solutions, and the alginate (3%) film presented the lower value of solubility in acetic acid (3%).

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