INTERNATIONAL IBERIAN NANOTECHNOLOGY LABORATORY

Microalgae encapsulation for food applications

EnhanceMicroAlgae - High added-value industrial opportunities for microalgae in the Atlantic Area

Marta Vinha Vieira

Research Fellow- Food Processing Research Group

ENHANCE MICROALGAE

Interreg Atlantic Area European Regional Development Fund

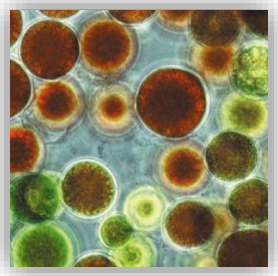
EUROPEAN UNION

Presentation topics

Microalgae encapsulation for food applications

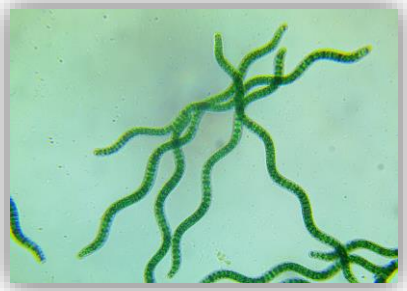
- Introduction to microalgae
- Challenges of microalgae incorporation into products
- Encapsulation/Advantages of microalgae encapsulation
- Practical example/Paper results

- Microalgae are a **heterogeneous** group of **photosynthetic microorganisms**, whose evolutionary and phylogenetic diversity have provided a **vast assortment in their biochemical composition.**

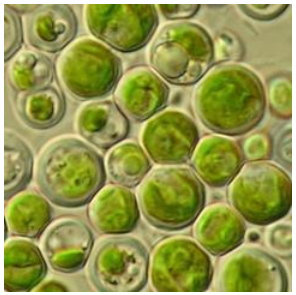


Haematococcus pluvialis

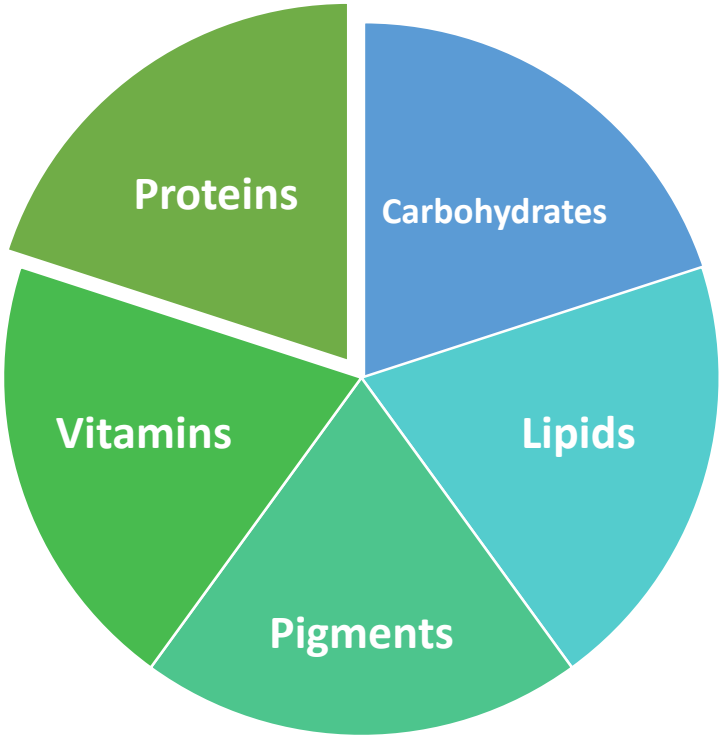
Dunaliella salina



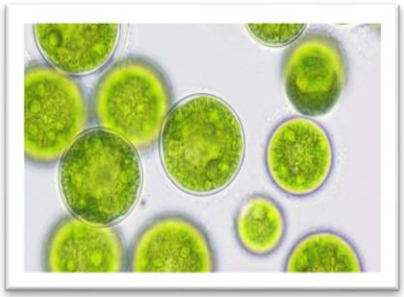
Arthrospira platensis



Chlorella vulgaris



Stress factors

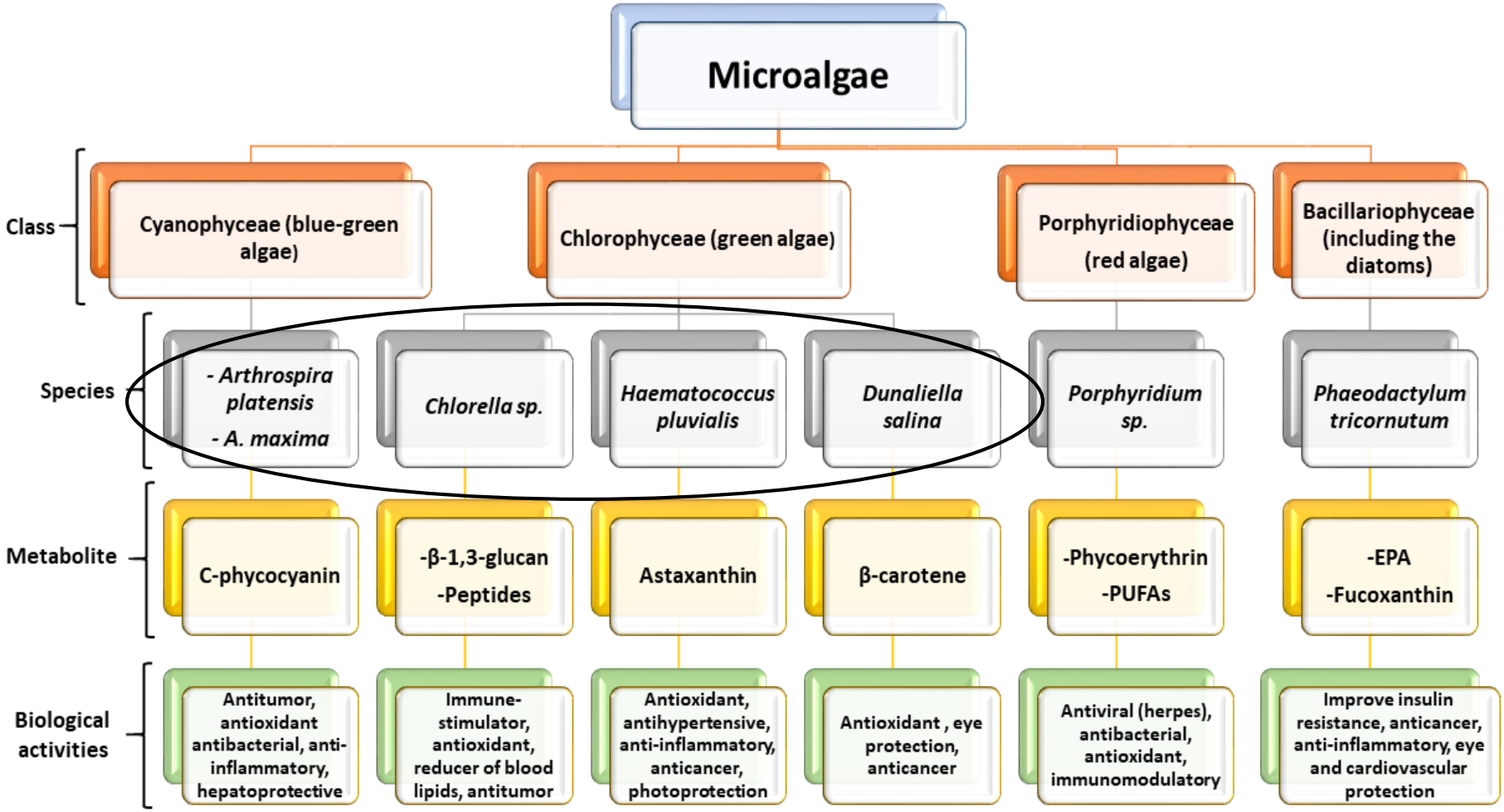


- Light intensity
- Temperature
- Growth phase
- Nutrients
- Salinity

Highly valuable substances with industrial applications and health benefits.

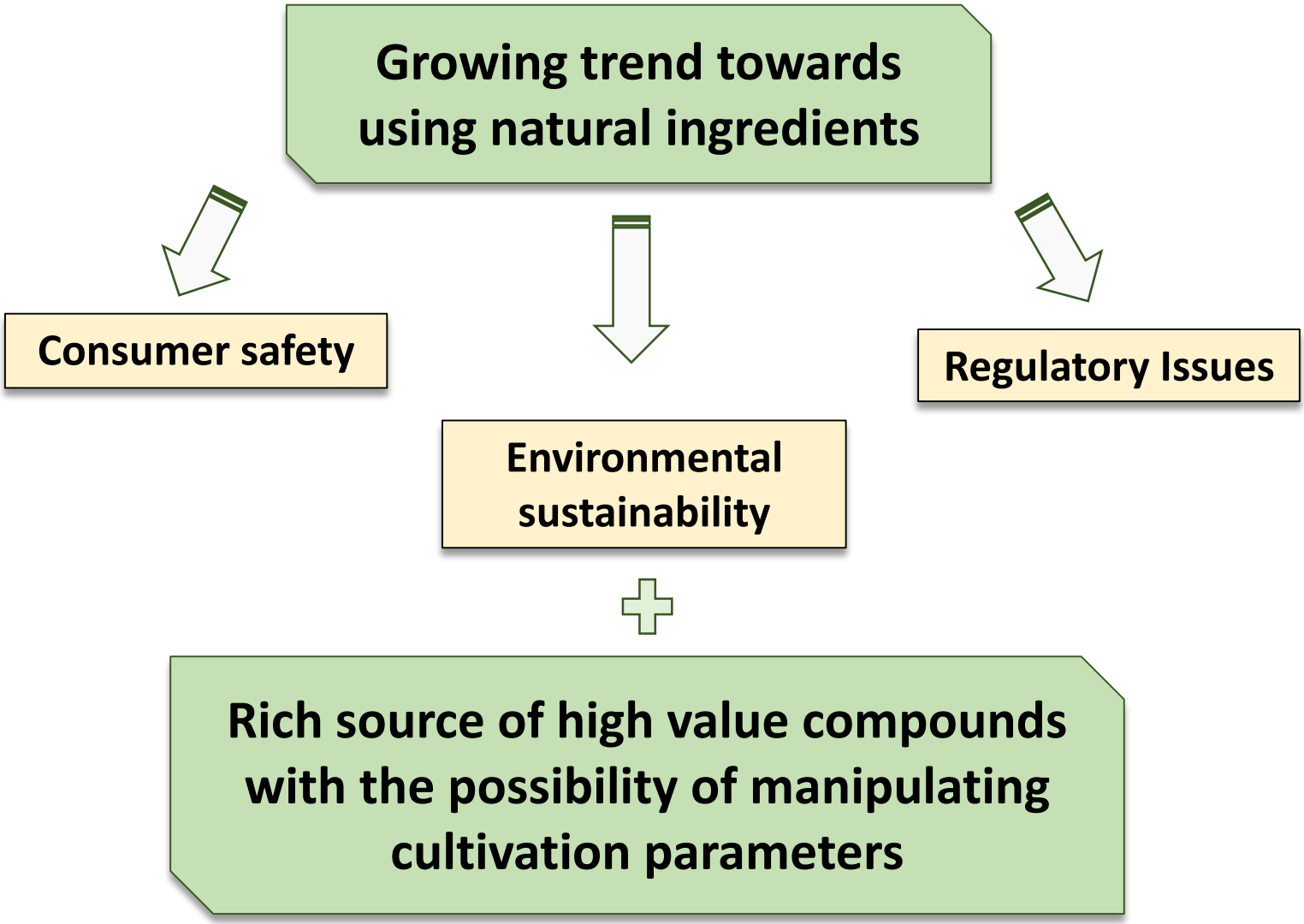
Main microalgae species and metabolites

Introduction



Interest in microalgae

Introduction

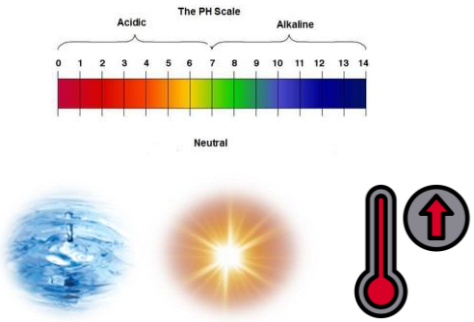


Challenges of microalgae applications

General aspects

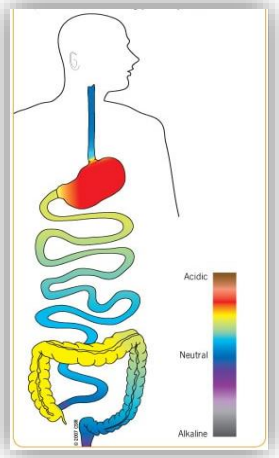
➢ Target

- **Commodities**
- **Whole cell**
- **Purified compound**



Oxidative degradation

Unpleasant taste/off-odours



Bioavailability and poor water solubility

Sensorial characteristics and consumer acceptability

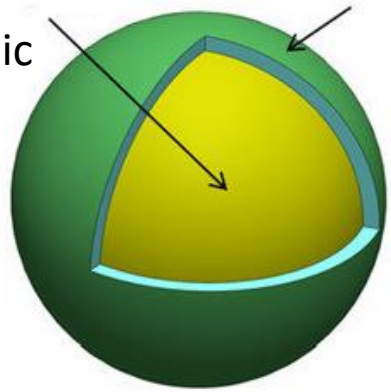
Absorption by GIT conditions/ product development

- It may be defined as a **process** in which a **substance (active agent)** is **entrapped or coated** by a carrier material, in order to form a **particulate system**.

- Substances can be in the solid, liquid, or gaseous state.

Core/active agent

- Lipophilic
- Hydrophilic



Coating/wall material

- Food-grade status
- Bio-based
- Synthetic

Nanoparticles: 1 nm to 100 nm
Microparticles: 100 nm to 1000 µm

Advantages of encapsulation for food applications

Microalgae compounds

Protection from adverse environmental and processing conditions

- Maintain the biological, functional, and physicochemical properties of the active agent
- Increase in stability and extended shelf-life

Solubility improvement of a compound into a dissimilar medium

- Allow compatibility and uniformity with the food matrix

Controlling and targeting release

- Response to external conditions

Enhancing the bioavailability and bioactivity

- Sustaining sufficient time of gastric residence without degradation
- Appropriate gut permeability

Masking unpleasant flavors

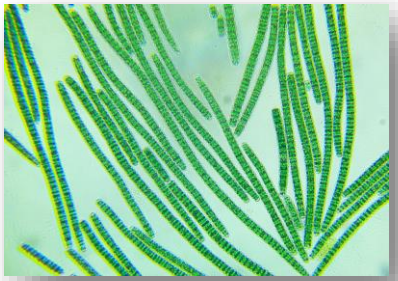
INTERNATIONAL IBERIAN NANOTECHNOLOGY LABORATORY

Practical example

Vieira, M. V.; Oliveira, S.M.; Amado, I.R.; Fasolin, L.H.; Vicente, A.A.; Pastrana, L.M.; Fuciños, P. 3D printed functional cookies fortified with *Arthrospira platensis*: Evaluation of its antioxidant potential and physical-chemical characterization. *Food Hydrocoll.* 2020, *107*.

Aim:

Fortify 3D-printed cookies with the microalga *Arthrospira platensis*, aiming to develop a new functional food with antioxidant properties.



Physicochemical evaluation:

Assessed 24 h after baking and with 30 days of storage at room temperature, protected from light.

- Colour
- Texture
- Antioxidant activity
- Water activity

3D printed functional cookies fortified with *A. platensis*

Antioxidants extraction optimization

Table 1 Design of Experiments for *A. platensis* antioxidant recovery. Real values in parentheses.

Run	Ethanol/Total solvent (%)	Microalga mass/Volume of solvent (%)
1	1 (100 %)	1 (12 %)
2	1 (100 %)	-1 (2 %)
3	-1 (0 %)	1 (12 %)
4	-1 (0 %)	-1 (2 %)
5	0 (50 %)	0 (7 %)
6	0 (50 %)	0 (7 %)

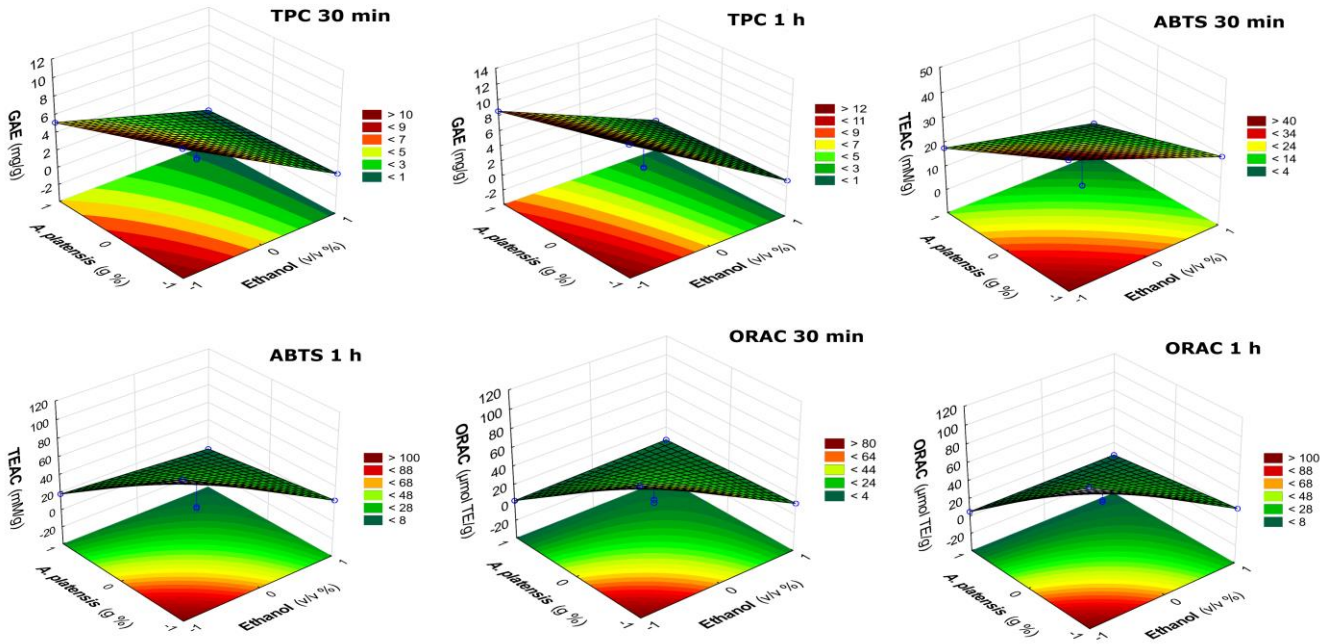


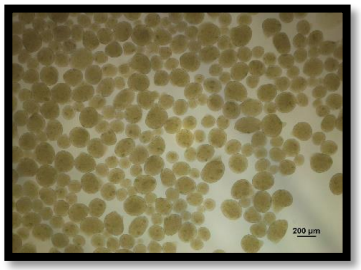
Fig. 1 Response surfaces of the biomass and ethanol concentrations combined effect in *A. platensis*' antioxidant activity and TPC. ORAC (Oxygen Radical Absorbance Capacity); ABTS (2,2'-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid radical scavenging activity). GAE= Gallic Acid Equivalent; TE=Trolox Equivalent; TEAC= Trolox Equivalent Antioxidant Capacity.

3D printed functional cookies fortified with *A. platensis*

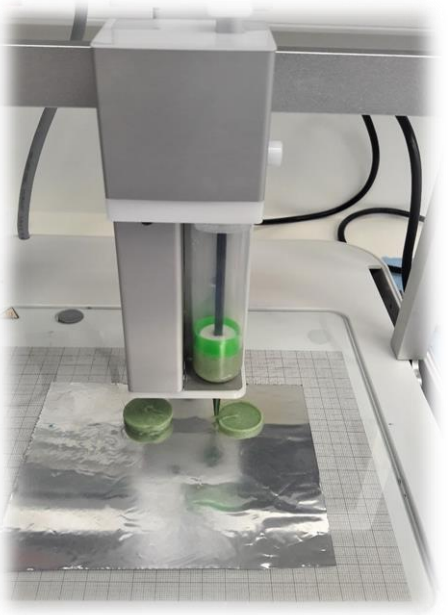
Dough preparation and 3D printing

2% of *A. platensis* biomass

Direct incorporation of the freeze-dried highest antioxidant extract



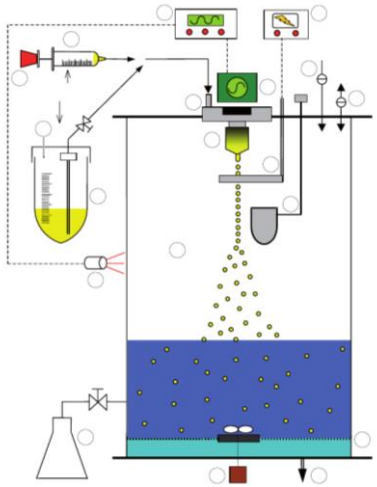
Antioxidant extract encapsulated into alginate microbeads

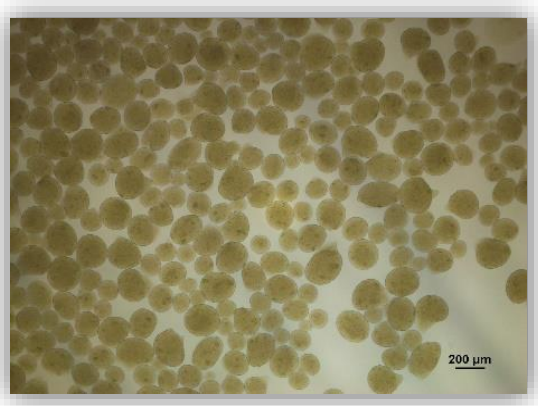


3D printed functional cookies fortified with *A. platensis*

Encapsulation of the antioxidant extract

Technique: Wet "Prilling by Vibration"





Composition

Matrix: 2% sodium alginate +
8% freeze-dried extract
Gelling solution: 100 mM $CaCl_2$

Process parameters

Flow rate = 1.5 mL/min
Frequency = 2000 Hz
Airflow = 0.8 mbar
Amplitude = 2
Charge = 1200 V
Inner nozzle: 150 µm; outer nozzle: 600 µm

3D printed functional cookies fortified with *A. platensis*

Cookies physicochemical characterization

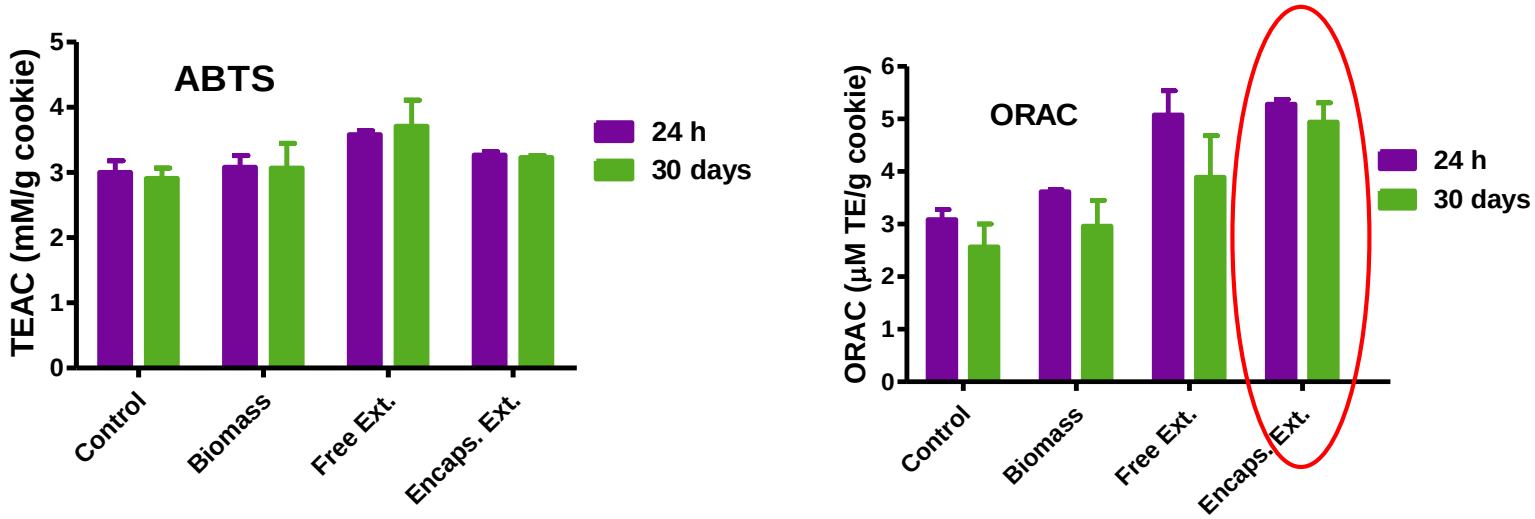


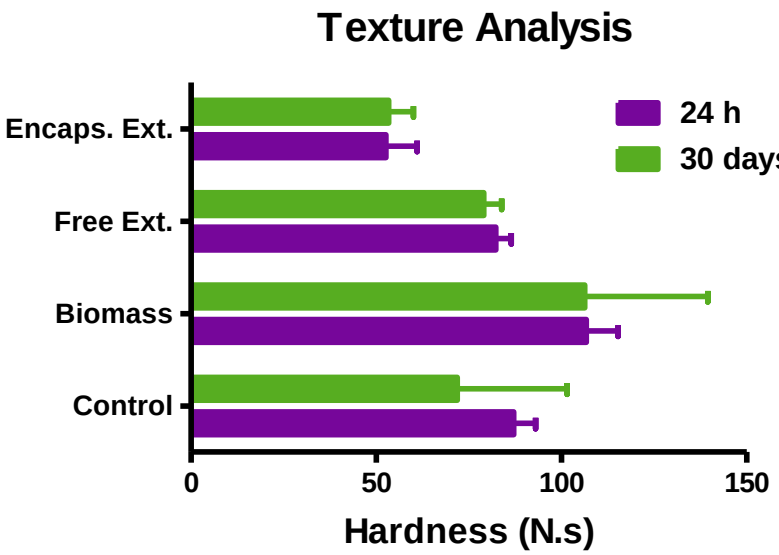
Fig. 2 Antioxidant activity of the 3D-printed cookies over 30 days of storage time.

Table 2. Total color variation (ΔE*) between baked and raw cookie samples and color stability along conservation time.

Total colour difference (ΔE*)	Raw x Baked	24 h x 30 days
Control	9.71	2.85
Biomass	25.50	2.43
Free Extract	25.29	2.12
Encapsulated Extract	17.47	1.30

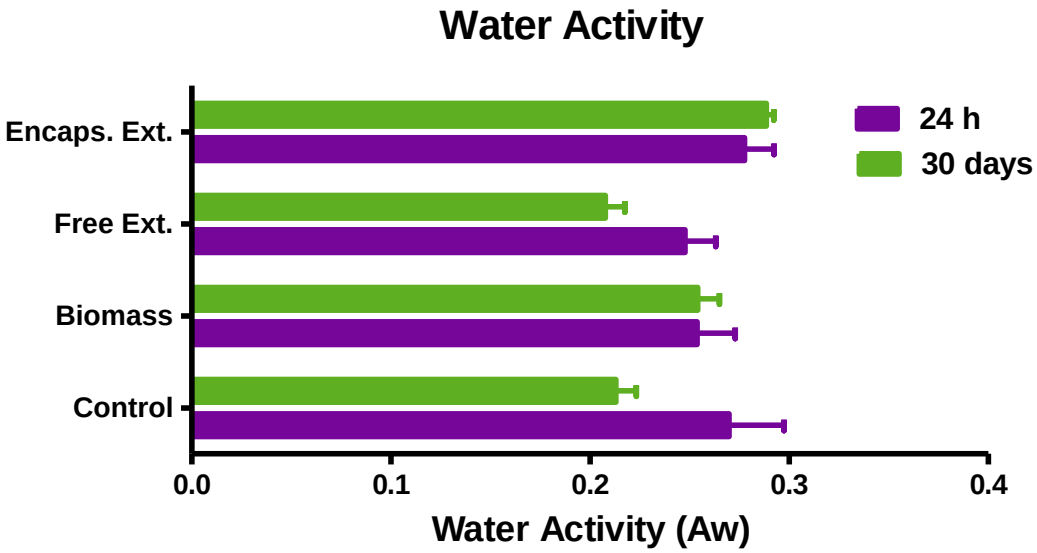
3D printed functional cookies fortified with *A. platensis*

Cookies physicochemical characterization



- The cookies texture, represented by the resistance to penetration or hardness, showed no significant difference over the storage time for all formulations.

- All cookies presented Aw values below 0.3, indicating high microbiological stability.



3D printed functional cookies fortified with *A. platensis*

Final remarks

- The incorporation of *A. platensis* as a natural ingredient resulted in 3D-printed cookies with an innovative appearance.

- The encapsulation of the antioxidant extract was capable to improve the antioxidant activity and colour stability along the storage time, when compared to all formulations.

- These results revealed the potential of *A. platensis* for the development of a functional, 3D-printable, food-ink.

INTERNATIONAL IBERIAN
NANOTECHNOLOGY
LABORATORY

Thank you for listening!

Marta Vinha Vieira

marta.vieira@inl.int

Food Processing Group