3D-printed functional cookies fortified with *A. platensis*: evaluation of its antioxidant potential and physical-chemical characterisation

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In the last decades, consumers' growing attention to the close relationship between health and nutrition is emerging as a new trend, mostly regarding the incorporation of natural resources into food. Among those resources, microalgae may be considered as an innovative and promising food ingredient, rich in nutrients such as high-value proteins, carotenoids, phenolic compounds and other bioactive molecules. In the present work, 3D-printed cookies were fortified with the microalga *A. platensis* aiming to develop a new functional food with antioxidant properties. *A. platensis* antioxidants were recovered using ultrasound-assisted extraction in hydroalcoholic solutions. Ethanol/water and biomass/solvent ratios were optimised through a Design of Experiments (DOE) approach, using the antioxidant activity (ORAC and ABTS) and total phenolic content (TPC) as response variables. The higher ORAC, ABTS and TPC values were observed in the extract obtained with 0 % ethanol and 2 % biomass. This extract was chosen to be incorporated into a printable cookie dough. Two different approaches were followed: (1) direct incorporation of the freeze-dried antioxidant extract and (2) incorporation of the antioxidant extract encapsulated into alginate microbeads to enhance the stability to heat, light, and oxygen during baking and further storage. Control cookies (without microalgae) and cookies prepared with whole *A. platensis* biomass were also investigated for comparative purposes.

The cookies were shaped using extrusion-based 3D printing. Flow rate and the Z-offset were optimised to obtain the ideal dough weight and shape (diameter and thickness) according to the 3D model. Under optimal conditions (10 mm/s), all dough formulations were successfully extruded forming a homogenous filament with a diameter close to the nozzle aperture (1.6 mm). Disk-shaped cookies were prepared consisting of 6 layers, each one with a thickness of 1.12 mm. Cookies were characterised for antioxidant activity, texture, water activity and colour. Results showed that all formulations presented water activity below 0.3, indicating high microbiological stability; colour tonality varied significantly between the different types of cookies and a significant reduction in the cookie hardness was observed when alginate microbeads were added. After the baking process, cookies incorporated with free and encapsulated extract presented significantly higher TPC (0.39 mg and 0.33 mg GAE/g cookie, respectively) and ABTS value (3.58 mM and 3.27 mM TEAC/g cookie, respectively), than those found for the control (0.22 mg GAE and 3.00 mM TEAC/g cookie) and the whole biomass cookie (0.28 mg GAE and 3.08 mM TEAC/g cookie). These results revealed the potential of *A. platensis* for the development of functional, 3D-printable, food-ink.

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