SEAWEEDS AS ALTERNATIVE PROTEIN SOURCES: DIGESTIBILITY AND NANOSTRUCTURAL EVOLUTION UPON DIGESTION

FOOD PROTEINS

Marta Martínez-Sanz, Vera Cebrián-Lloret, Cynthia Fontes-Candia, Laura Díaz-Piñero, Isidra Recio

CIAL INSTITUTO DE INVESTIGACIÓN EN CIENCIAS DE LA ALIMENTACIÓN

MOTIVATION

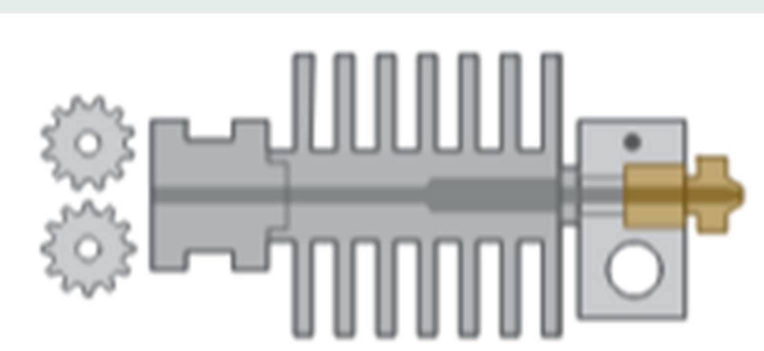
- ✓ **Seaweeds** are a potential source of **alternative proteins**, with interesting composition and many advantages over land-based biomass. However, they are still largely unexplored as food ingredients, mainly due to the lack of knowledge on their techno-functional and nutritional properties.
- ✓ The aim of this study was to investigate the potential of two different red seaweed species, typically used in the food industry for the extraction of agar, as dietary protein sources. The impact of **their distinct cell wall structure** and different **processing methods** on the digestibility were also evaluated.

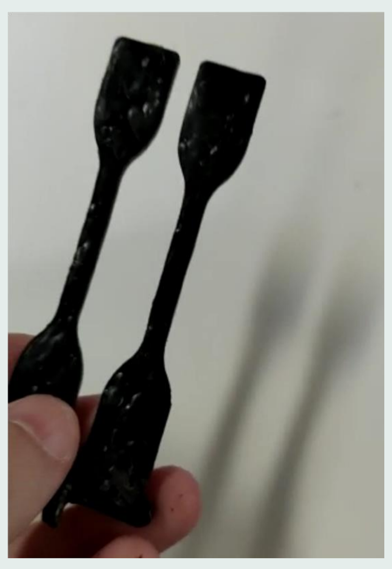
METHODOLOGY

SEAWEEDS PROCESSING

RED SEAWEEDS
Gelidium corneum (GC_S)
Gracilaropsis longissima (GL_S)

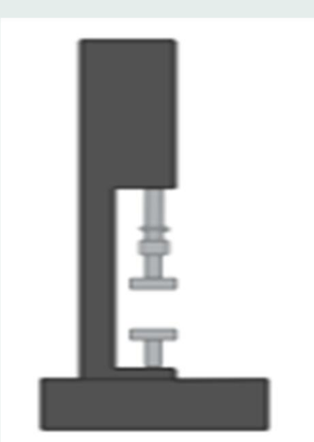
1 **EXTRUSION**





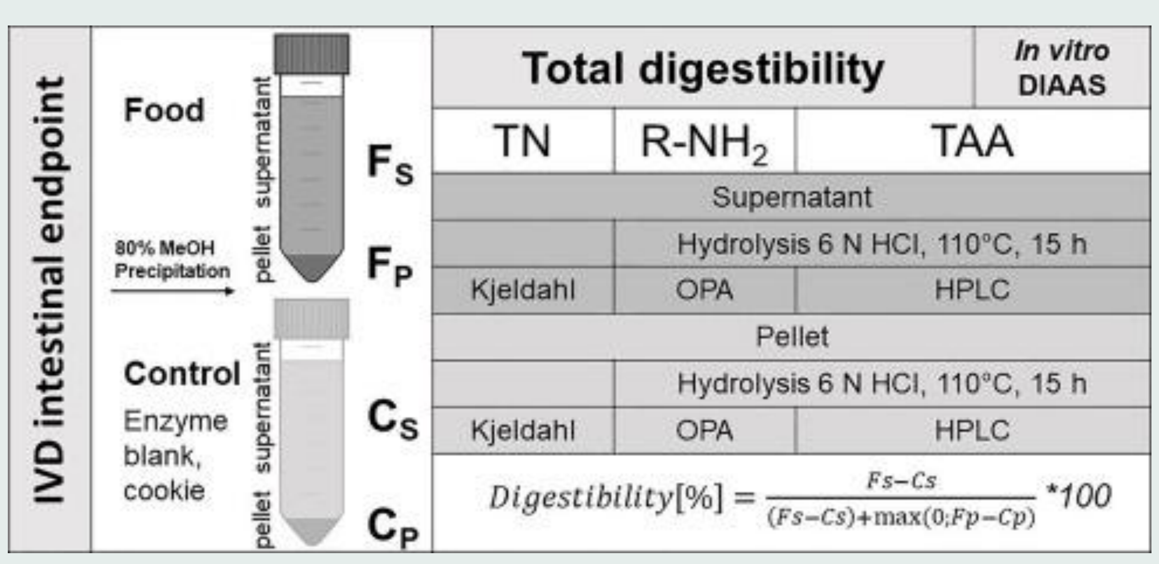
Extrudates (GC_E, GL_E)

2 **HOT PRESSING**



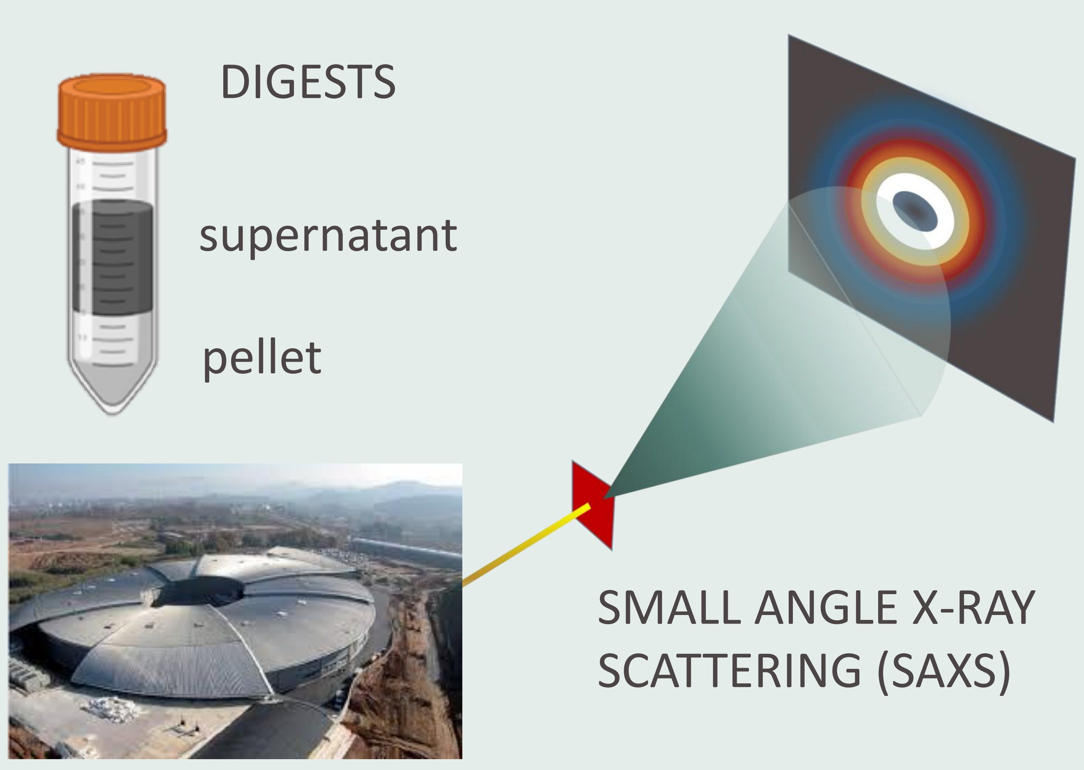
Films (GC_F, GL_F)

IN VITRO PROTEIN DIGESTIBILITY



Sousa, R. *et al.* Food Chemistry, 404, 134720 (2023)

NANOSTRUCTURAL CHARACTERISATION OF THE DIGESTION PRODUCTS



RESULTS

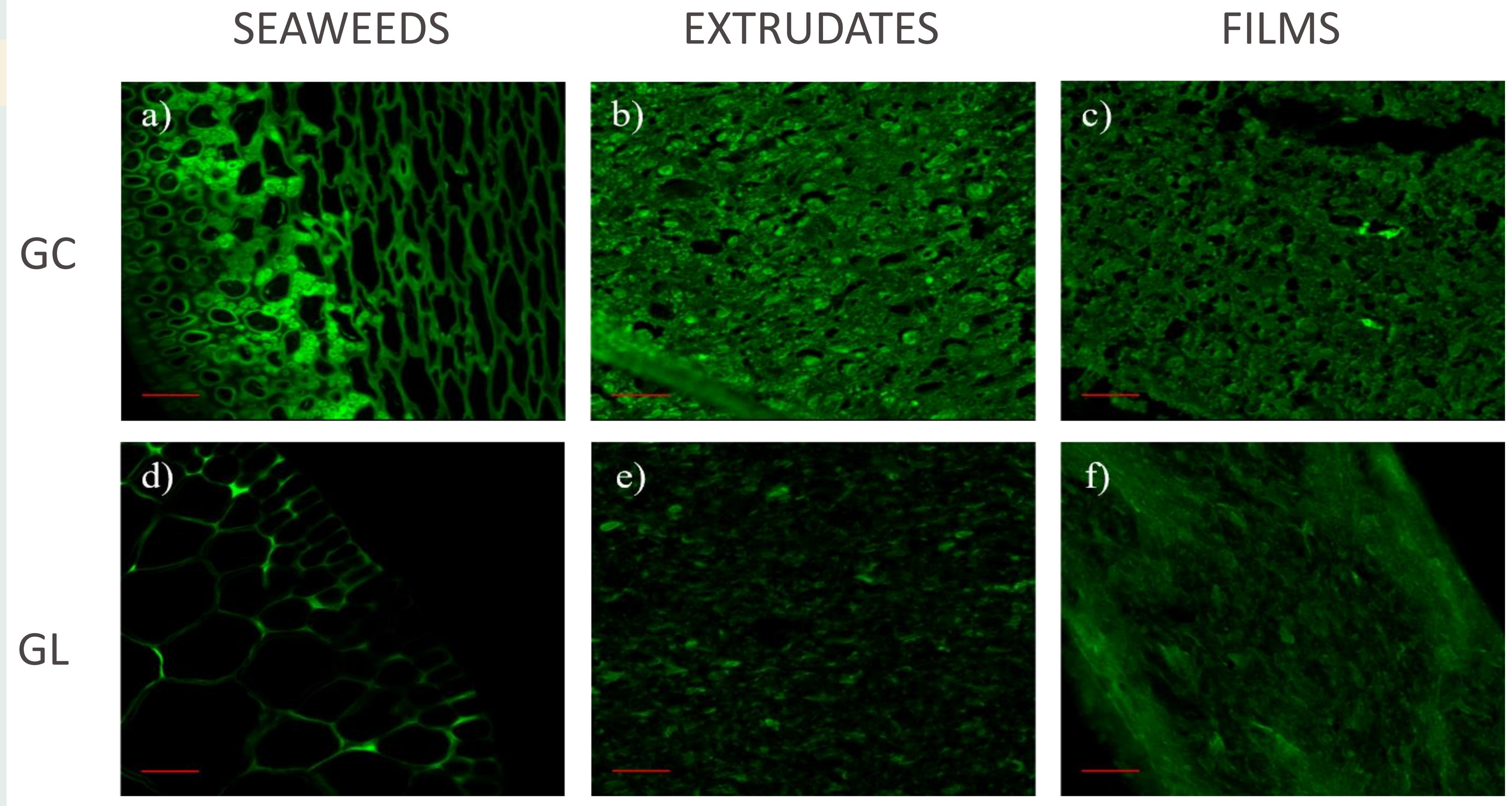


Figure 1. Confocal microscopy images of the native seaweeds and their processed products. Proteins were stained with Fast Green.

- *G. corneum* presented smaller and more compacted cell structures.
- Processing leads to cell wall distortion and outward migration of proteins.

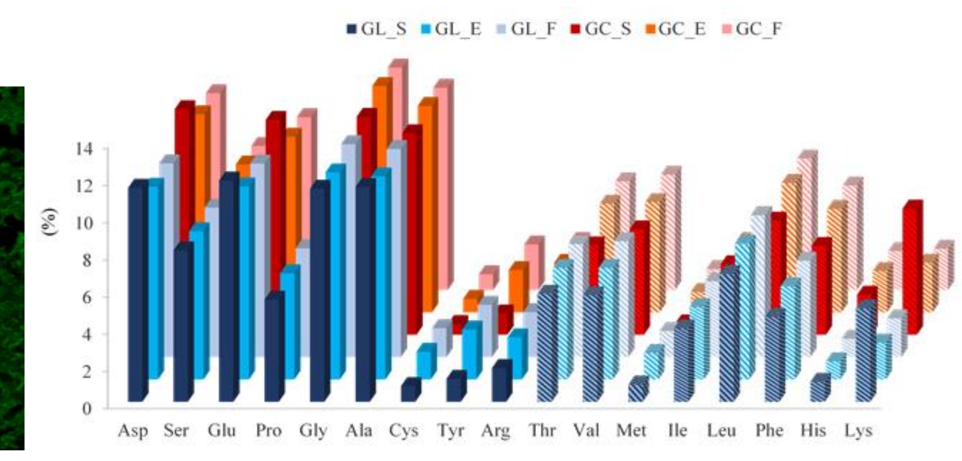


Figure 2. AA profile of the native seaweeds and their processed products.

- The **protein content** was 15.5% for *G. corneum* and 15.6% for *G. longissima*.
- The proportion of **essential AAs** was 36% for *G. corneum* and 35% for *G. longissima*.
- The most abundant AAs in both seaweeds were Asp, Glu, Gly and Ala.
- Processing affected the **AA profile**, with the proportion of more labile AAs, such as Lys, decreasing.

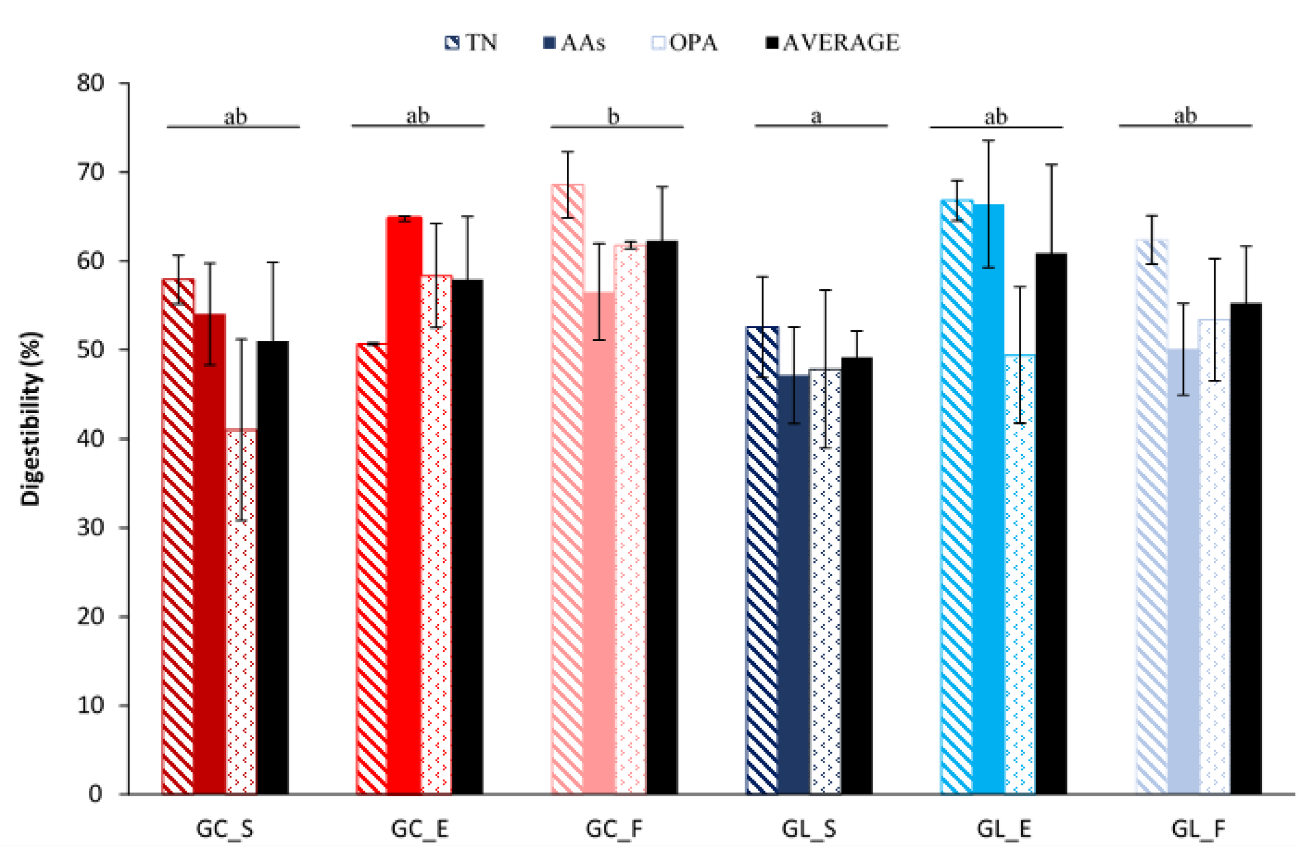


Figure 3. Protein digestibility obtained from TN, TAA and OPA and the average values from the three methods.

- ***In vitro* protein digestibility** was low (<58%) for both seaweed species, compared to other plant sources, such as pigeon peas (96%), black beans (82%) and peanuts (96%).
- In the case of *G. corneum*, the digestibility increased after each processing step, up to 62% for the films.
- In the case of *G. longissima*, the digestibility reached a maximum after the extrusion step (61%), being slightly reduced after further processing to obtain films (55%).
- The OPA method provided the largest errors, probably due to interference of coloured compounds from the seaweeds.

	GC_S	GC_E	GC_F	GL_S	GL_E	GL_F
Lowest DIAAS	25.03	23.94	20.12	68.67	20.87	25.49
Limiting AA	SAA	LYS	LYS	HIS	LYS	LYS

- The highly resistant cell walls from *G. corneum* require successive processing steps to be permeabilized and promote the release of proteins.
- *G. longissima* cell walls are highly permeable, facilitating the release of proteins upon extrusion. Further processing leads to thermal degradation of some AAs, having a negative impact on the digestibility.
- Lysine is highly susceptible to thermal processing, becoming the limiting AA in the processed materials.

Nanostructure of the digestion products

- *Sample before digestion*
- *Digest Pellet*
- *Digest Supernatant*

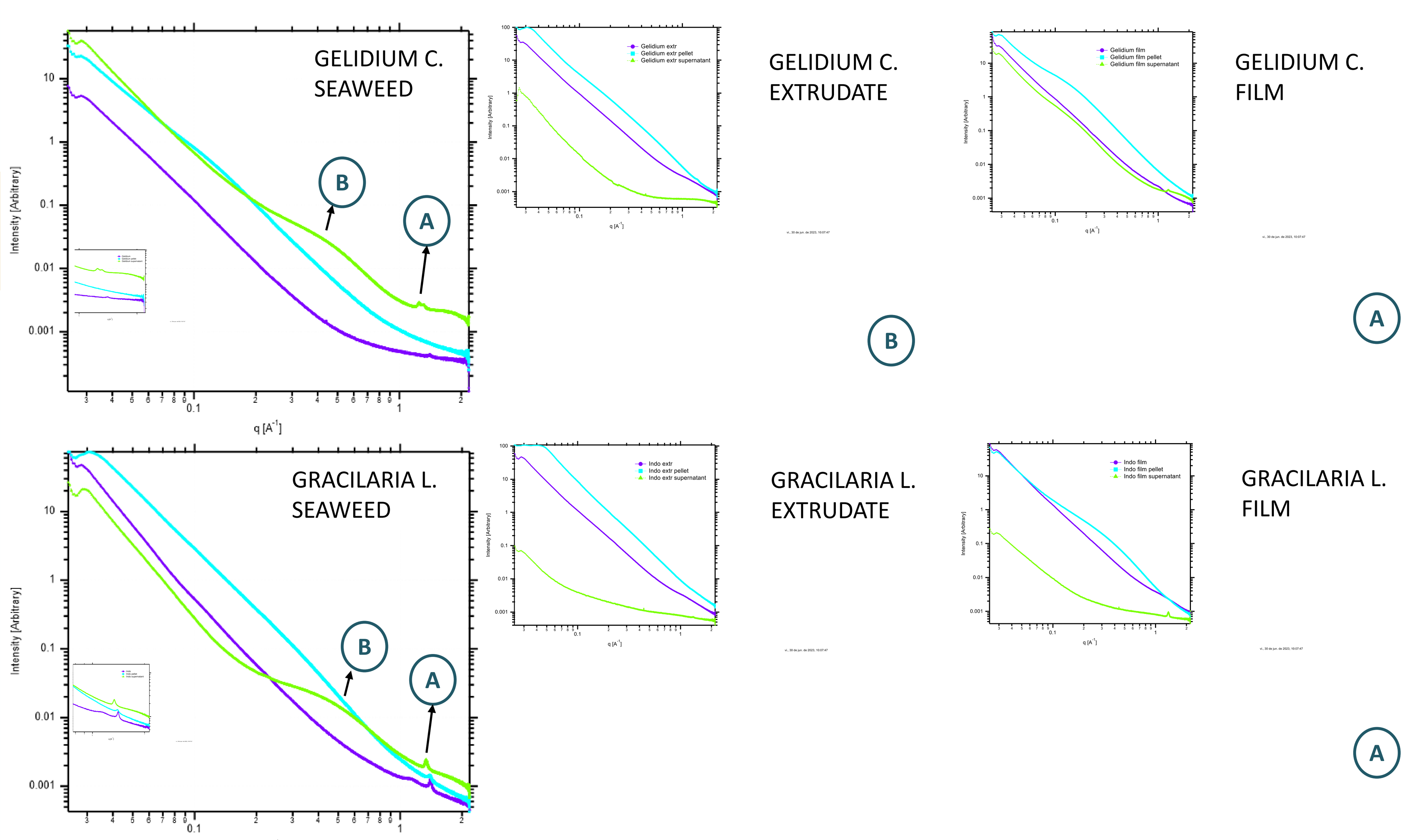
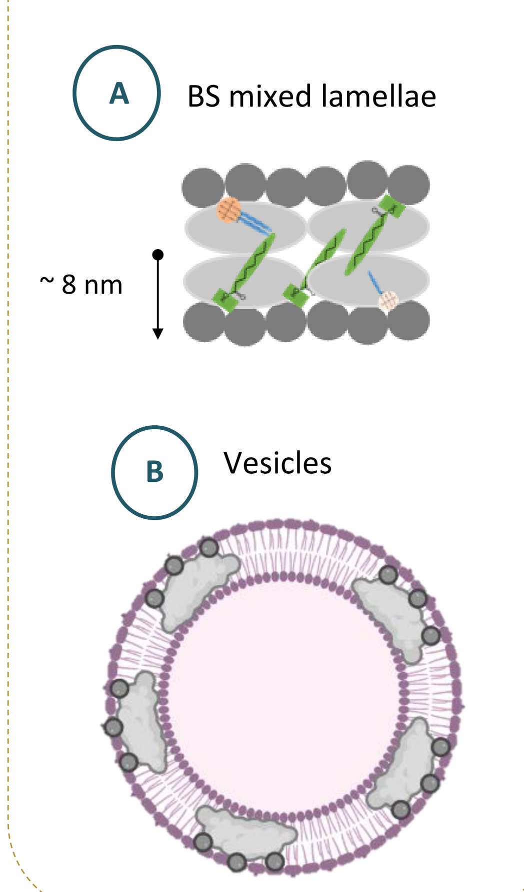


Figure 4. SAXS patterns of the digests from the seaweeds and their processed products.

- Pellets → non-digested material
- Nanostructural changes occur only after extrusion+hot pressing

Two types of structures detected in supernatants:



CONCLUSIONS

- The two studied red seaweed species contain relatively high protein contents and high proportion of EAAs. However, their **tough cell walls** limit protein diffusion. This, together with the presence of **gelling polysaccharides** such as agar, hinder protein digestibility. Thus, native seaweeds present lower protein digestibility than other plant sources.
- **Processing** through conventional methods such as extrusion and hot pressing induces **cell wall distortion and permeabilization**, hence **increasing protein digestibility**.
- Cell wall structure and composition are key to determine protein digestibility of native seaweeds and the effect of processing.
- Protein digestion products can interact with components from the physiological medium to form different types of nanostructures. This is expected to have a strong impact on intestinal transport.

ALBA

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