STRUCTURAL EFFECTS OF THERMAL PROCESSING ON RED SEAWEEDS FOR THE PRODUCTION OF BIO-BASED FOOD PACKAGING MATERIALS

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INTRODUCTION

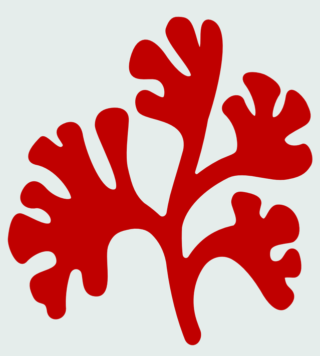
The use of biomass from **four different agarophyte species** is being explored as an alternative source for biopolymer production due to their high polysaccharide content (mainly agar and cellulose).

OBJECTIVES

- To obtain **biopolymeric materials** for food packaging applications in a more **environmentally-friendly** way
- To study the effect of the **composition** and **cell wall structure** of each seaweed species on the final performance of the films

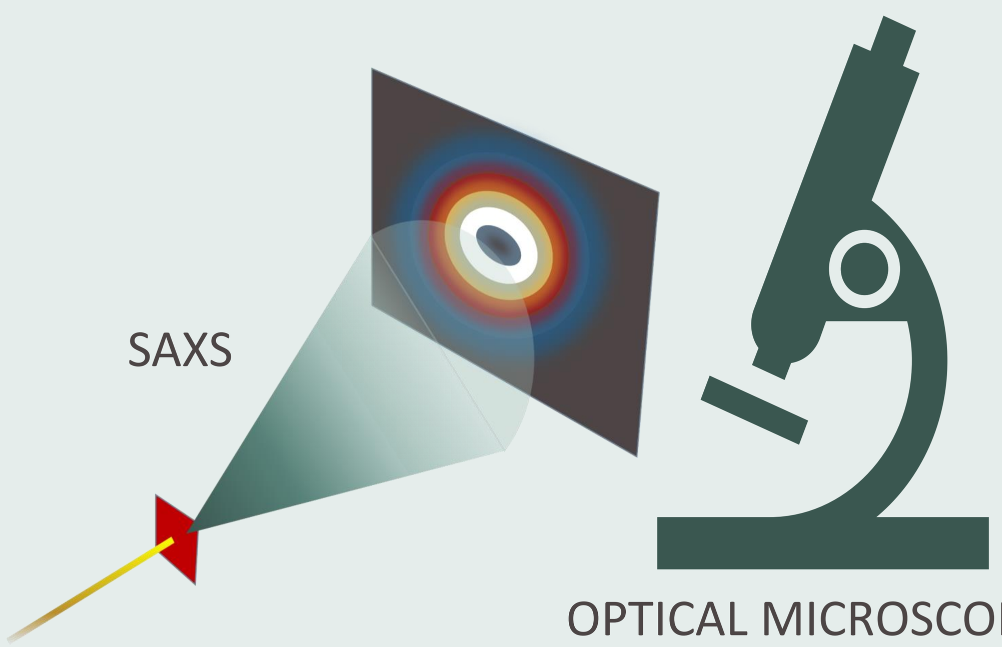
METHODOLOGY

SEAWEED BIOMASS CHARACTERIZATION



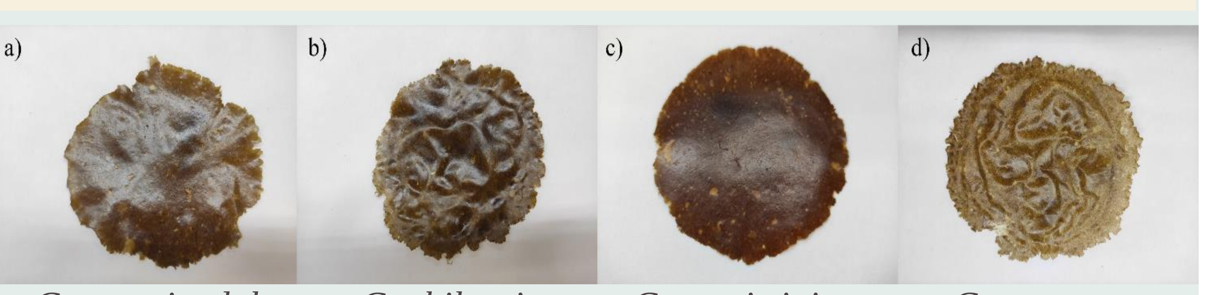
Gelidium sesquipedale
Gracilaria chilensis
Gracilaria tenuistipitata
Gracilaria verrucosa

STUDY OF PROCESSING TEMPERATURE EFFECT

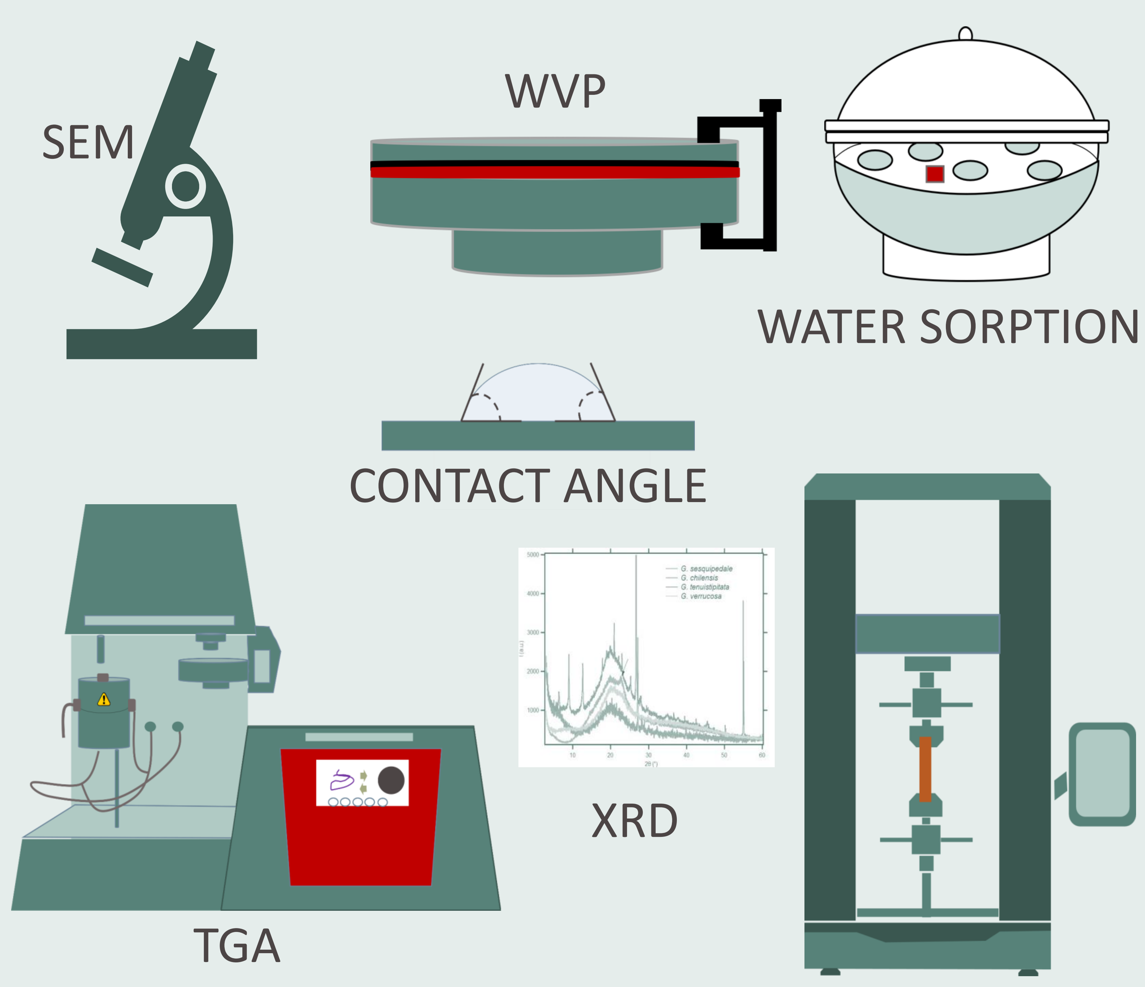


Optimum processing T=130°C

PRODUCTION OF SEAWEED-BASED FILMS



CHARACTERIZATION OF THE FILMS



RESULTS

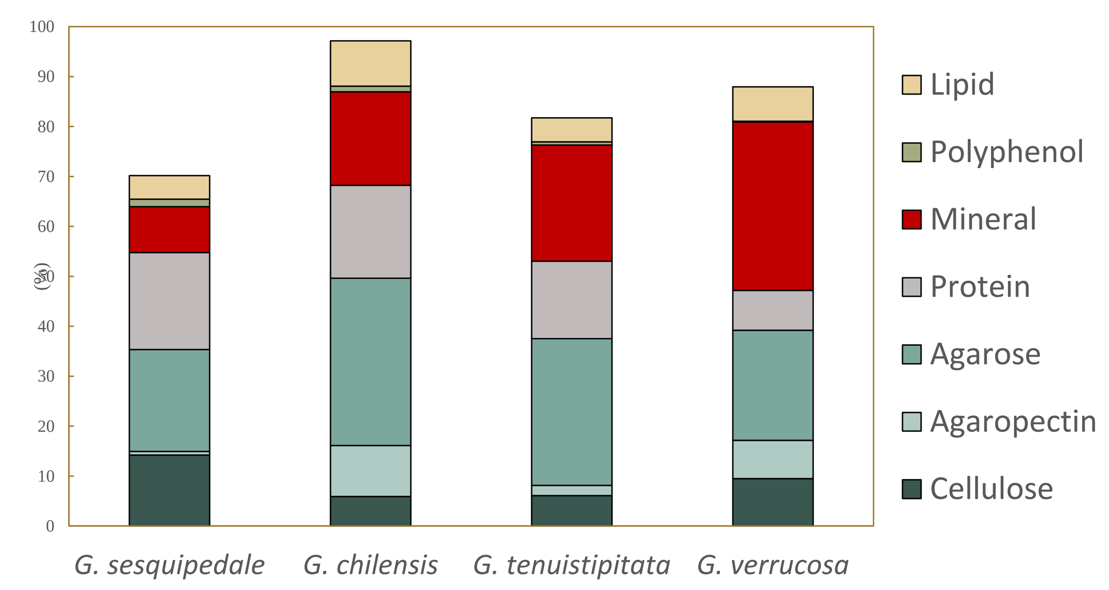


Figure 1. Gross composition of the dried seaweeds

- *G. sesquipedale* presented the highest protein and cellulose content. Although the agar content was the lowest, almost 97% of it consisted of agarose.
- *G. verrucosa* presented a higher cellulose content and a lower agar content, with almost 26% of it constituted by agaropectin.
- *G. chilensis* and *G. tenuistipitata* exhibited very similar cellulose and protein contents, but differed significantly in their agar concentration. *G. chilensis* was the species with the highest agar content, although its agaropectin fraction was also quite high. *G. tenuistipitata,* showed a lower agar content but consisted of almost 93% agarose.

Structural effects of processing temperature studied by SAXS

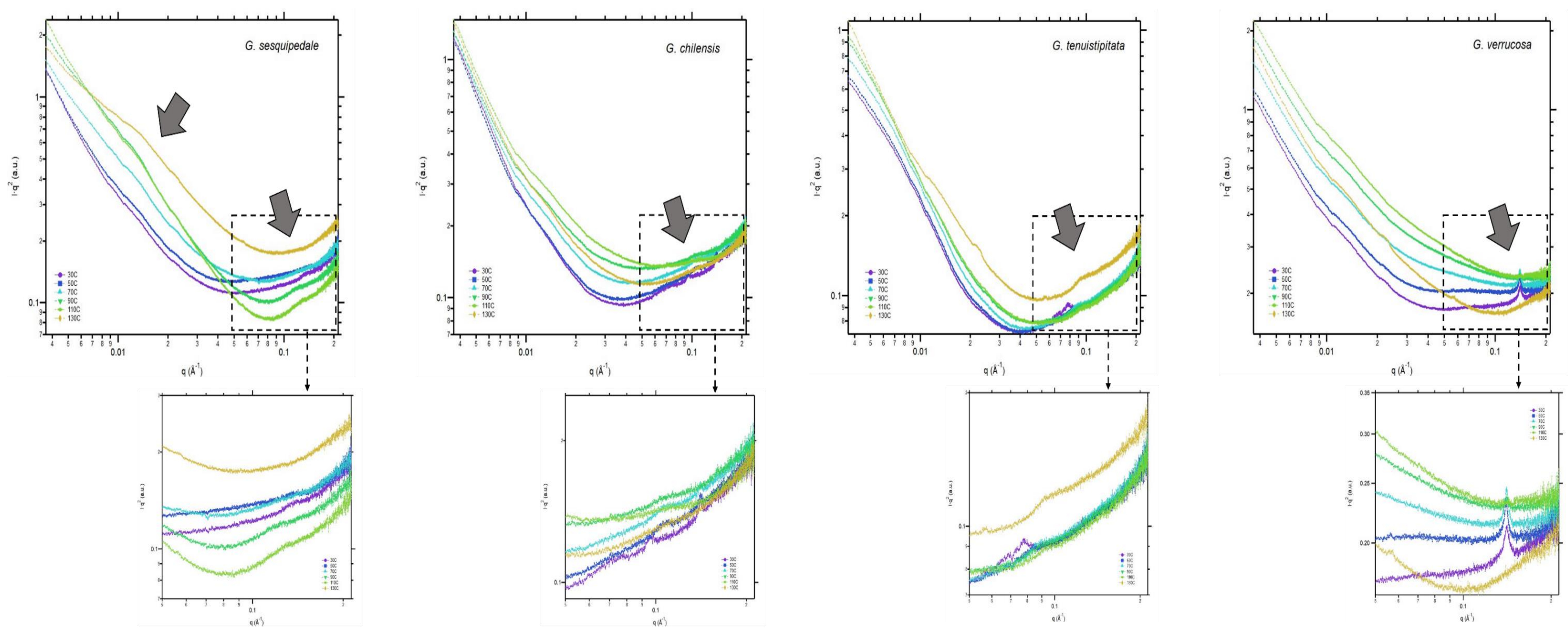


Figure 2. SAXS Kratky plots of seaweed aqueous dispersions processed at different temperatures from 30ºC to 130ºC. The arrows point towards structural peaks, which are more clearly visualized in the insets.

- The temperature had a clear effect on all seaweeds, with the scattering intensity generally increasing as the temperature was raised due to the diffusion of agar from the interior of the cell walls towards the liquid medium.
- In *G. chilensis* and *G. verrucosa*, the scattering intensity decreased when raising the temperature from 110ºC to 130ºC which may be due to the disruption of the double helical structure in the agarose fraction when reaching high temperatures.
- A weak peak centred at q~0.14 $Å^{-1}$, related to the centre-to-centre distance between the cellulose microfibrils, was more evident in *G. sesquipedale* and *G. verrucosa*.
- The appearance of this peak in the aqueous suspensions indicates a high degree of packing even in the hydrated state, in contrast to other cellulosic sources (e.g. cotton) in which water can easily penetrate the space between the microfibrils and increase the interspacing distance.
- While an interfibrillar distance of 4.5 nm corresponded to the species with the highest cellulose content (*G. sesquipedale* and *G. verrucosa*), greater distances were detected for the other species, which was presumably due to the presence of other polysaccharides interacting with cellulose and increasing the interfibrillar distance.

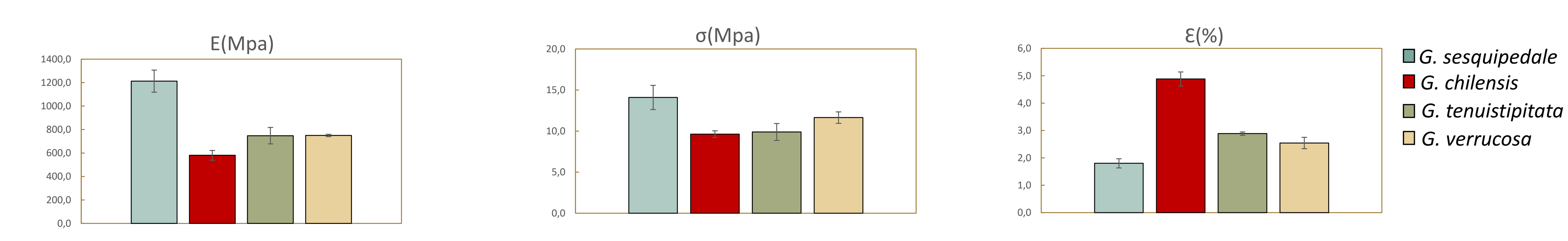


Figure 3. mechanical properties of the seaweed-based films.

- Due to its higher cellulose content, *G. sesquipedale* resulted in stiffer and more resistant films.
- The higher agar and lower cellulose content of *G. chilensis* significantly decreased the elastic modulus and tensile strength of the film, but improved its ductility.

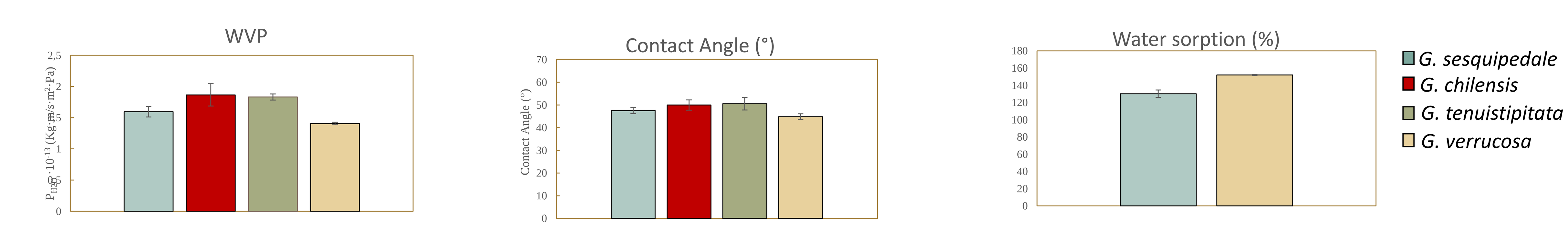


Figure 4. Water vapour permeability, contact angle and water sorption of the seaweed-based films.

- Seaweeds with the highest cellulose content (*G. verrucosa* and *G. sesquipedale*) produced films with a greater barrier capacity.
- The films made from *G. verrucosa* and *G. sesquipedale*, exhibited a slightly more hydrophilic surface.
- The films from *G. sesquipedale* and *G. verrucosa* maintained their structure, while the films made from *G. chilensis* and *G. tenuistipitata* disintegrated over time at high moisture conditions.

CONCLUSIONS

- The seaweed biomass was **mainly composed of carbohydrates** (35-50%), but significant amounts of **protein** and **ashes** were also detected in all the agarophytes.
- Increasing the **processing temperature** promoted a greater **release of agar** from the cell walls.
- The **higher cellulose** content of *G. sesquipedale* resulted in **stronger** films with **high water vapour barrier capacity**, while the **higher agar** content of *G. chilensis* improved its **elongation capacity.**
- The films made from ***G. verrucosa*** showed **interesting properties** offering an alternative for the production biopolymeric films **at lower cost** than *G. sesquipedale*.
- The results from this work evidence **the potential of red seaweed biomass to generate food packaging materials in a cost-effective and environmentally-friendly way.**

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