SUBCRITICAL WATER EXTRACTION SCALE-UP FROM LABORATORY TO PILOT SYSTEM FOR RED ALGAE RESIDUE VALORIZATION

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Gelidium sesquipedale

This algae is used for agar extraction

Solid residue after extraction

Solid residue after industrial agar extraction contains high amounts of:

- **Proteins with all essential amino acids**
- **Carbohydrates such as glucans, galactans or arabinans**[1].

Reincorporation in the industry as a value-added product.

SUBCRITICAL WATER EXTRACTION (SWE)

Hot pressurized water above its boiling point, 100 °C, and **below its critical point, 374 °C,** in its **liquid state**[2].

Water dielectric constant decreases with increasing temperature, being **similar to organic solvents, at 200 - 250 °C.**

SWE is able to **selectively extract polar or non-polar compounds**[4].

SWE was proved to be effective in previous studies in a laboratory-scale system for the **extraction of the protein and carbohydrate fraction** of dried macroalgae residue (DMR)[5].

Would this process be feasible in an industrial-scale SWE system?

1. LABORATORY SCALE SWE SYSTEM

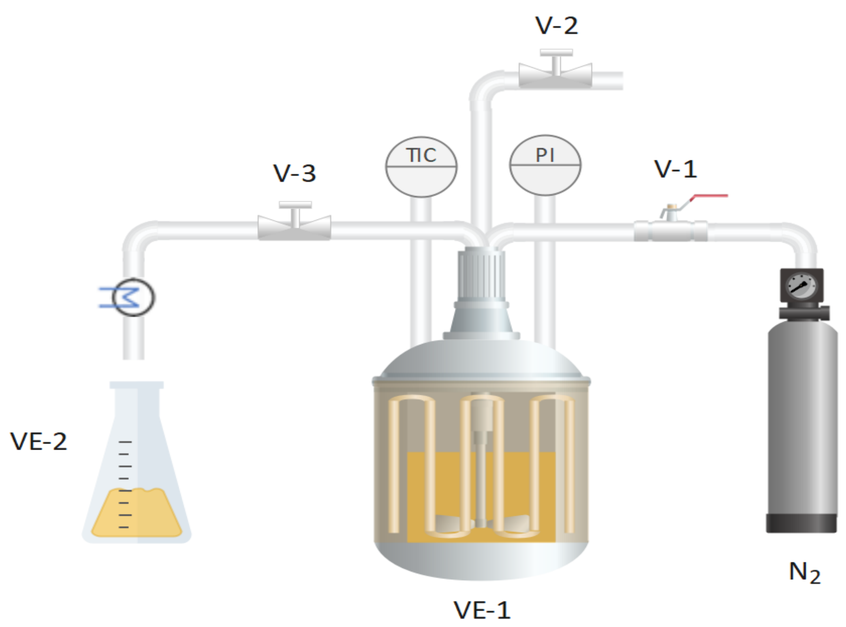


Figure 2. Diagram of the laboratory-scale subcritical water equipment. VE-1: extractor; VE-2: sample collector; V-1: pressurization valve; V-2: pressure relief valve; V-3: needle valve.

2. PILOT-PLANT SWE SYSTEM

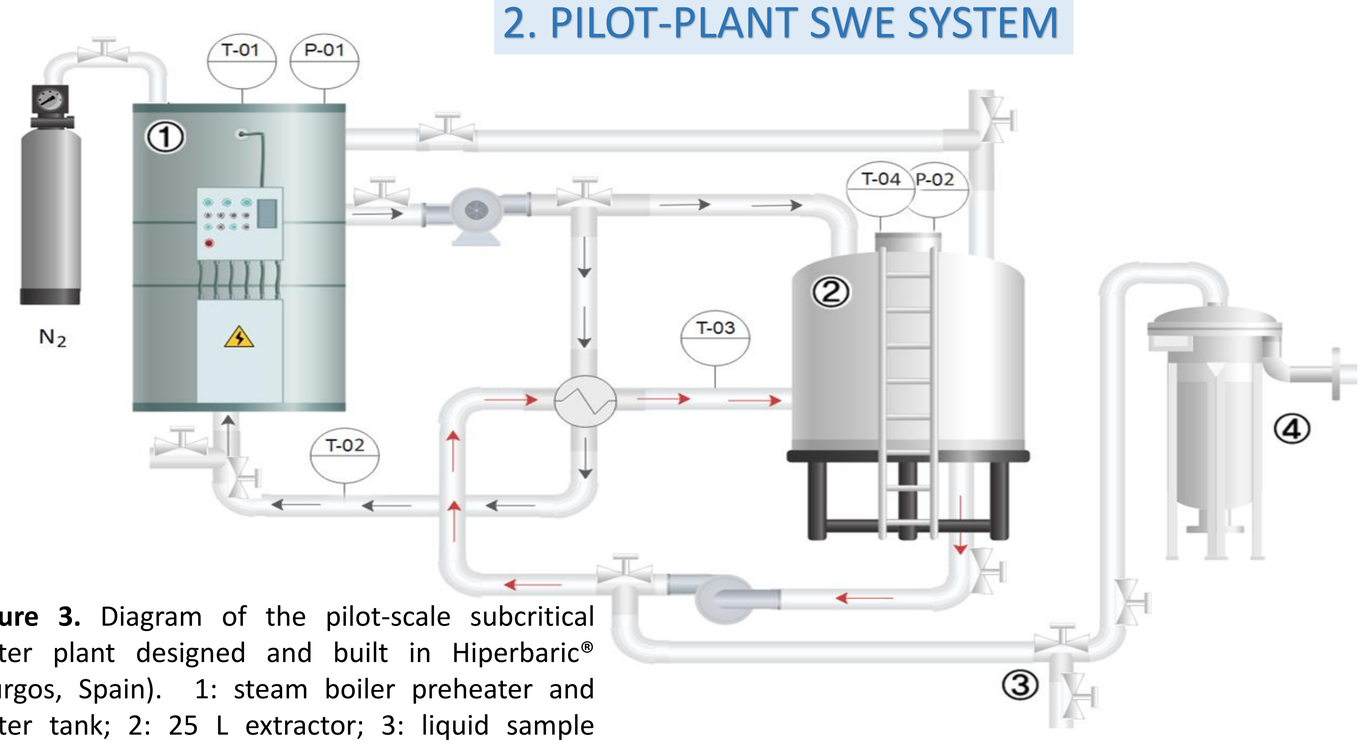


Figure 3. Diagram of the pilot-scale subcritical water plant designed and built in Hiperbaric® (Burgos, Spain). 1: steam boiler preheater and water tank; 2: 25 L extractor; 3: liquid sample collector; 4: filtration tank.

SCALE-UP STUDY

Comparison between both systems for:

- **Polysaccharides** fraction extraction
- **Protein** fraction extraction
- **Total phenolic content** of extracts

SWE SYSTEM	LABORATORY SCALE	PILOT PLANT
Reactor volume	**500 ml**	**25 L**
Pressure	**50 bar**	**20 bar**
Temperature	**130 °C and 175 °C**	
Time	**140 minutes**	

POLYSACCHARIDES FRACTION EXTRACTION

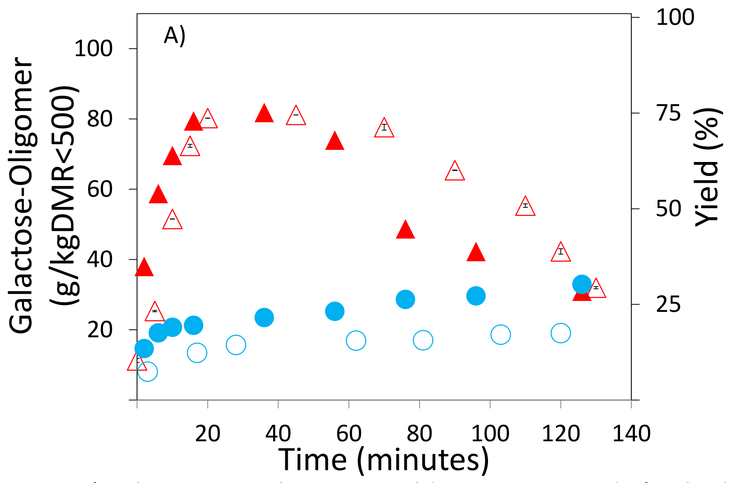
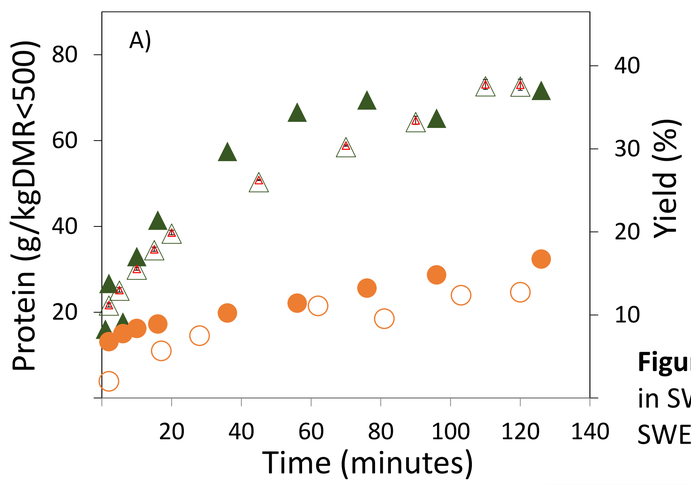


Figure 4. A)Galactose as oligomer yield extraction and B) 5-hydroxy methylfurfural content in SWE from DMR<500 at lab-scale: 130 (○) and 175 °C (△), and pilot-scale SWE system: 130 (●) and 175 °C (▲).

- **Galactose** showed the highest extraction yields in both systems.
- **Acetic acid** was the **main degradation product.**
- Generation of **furfural and HMF** was **low.**

PROTEIN FRACTION EXTRACTION



The **greatest extraction yield** was accounted for the **smallest amino acids.**

	Macroalgae residue (mg/g)	Laboratory-scale SWE yield	Pilot plant SWE yield
Glycine	8.6 ± 0.5 %	9.6 ± 0.9 %	4.7 ± 0.2 %
Aspartic acid	20.4 ± 0.8	6.1 ± 0.5 %	6.4 ± 0.6 %
Alanine	19.8 ± 0.7	2.6 ± 0.2 %	1.4 ± 0.1 %

Figure 5. A) Protein yield extraction and B) free amino acids per gram of protein in SWE extracts collected at lab-scale: 130 (○) and 175 ºC (△), and pilot-scale SWE system: 130 (●) and 175 °C (▲)

CONCLUSIONS

- ✓ **SWE is an efficient technology for bioactive compounds recovery** such as carbohydrates, protein and amino acids from algae residue.
- ✓ **Scaling up** of subcritical water system from laboratory to pilot scale resulted in **good and reproducible results.**
- ✓ Feasibility of industrial-scale subcritical water system through scaling-up from lab to pilot system has been showed.

References

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