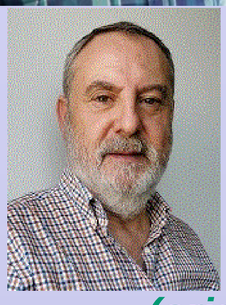
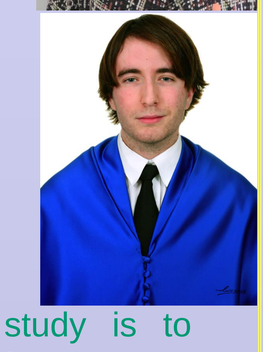


Added-value biorefinery products from invasive brown seaweed *Rugulopteryx okamuare*. A kinetic comparison



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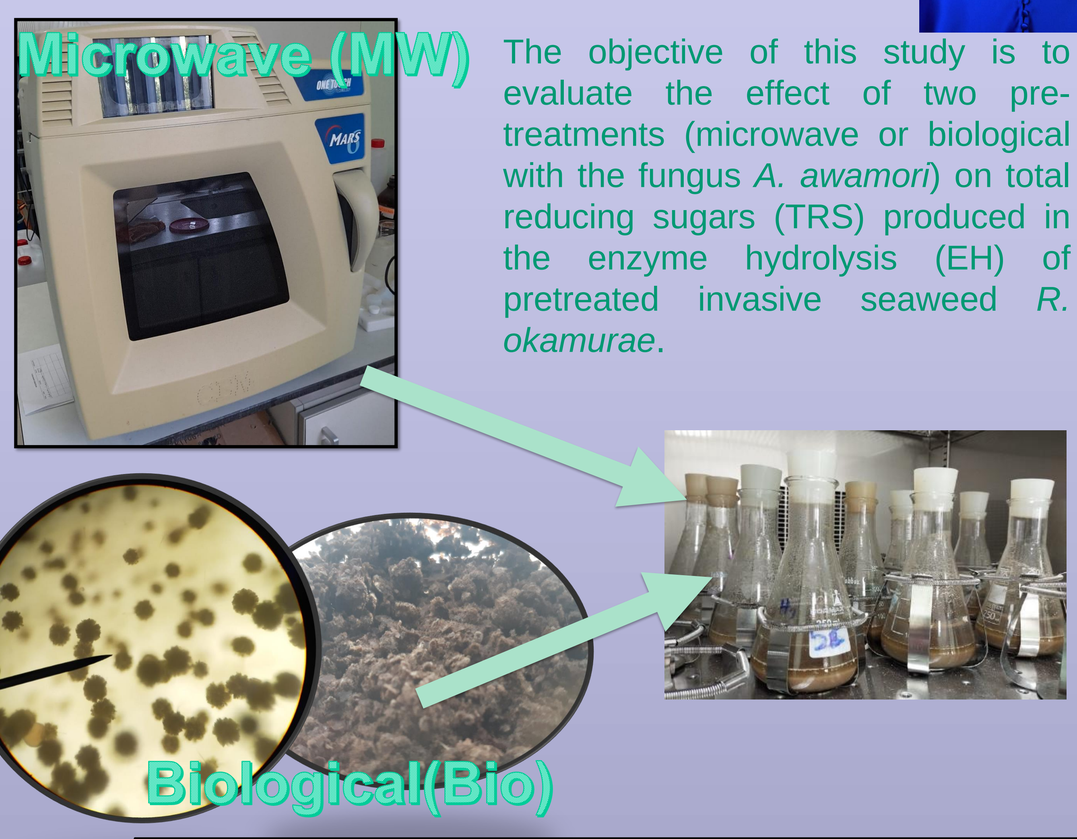
Introduction

Since 2015, the coastal area of the Strait of Gibraltar has been colonised by the Asiatic seaweed *Rugulopteryx Okamurae*. affecting the economy of the regional fishing and tourist sectors. This environmental problem is, in fact, an opportunity to apply the circular economy approach. On the other hand, between 19 and 23 million tonnes of plastic waste are dumped into the sea every year due to its low biodegradability (Bergmann et al., 2022). In this context, bioplastic production through biological processes may provide an opportinity of valorisation.

Enzyme hydrolysis is one of the most well-known processes used to obtain fermentable sugars for bioplastics (polyhydroxyalkanoates) synthesis (Heng et al., 2017; Serafim et al., 2008). However, the macroalgae cell structure is hard to fully degrade without pre-treatments.

Figure 1. Conditioning macroalgae: above: washing system; below: drying system



The objective of this study is to evaluate the effect of two pre-treatments (microwave or biological with the fungus *A. awamori*) on total reducing sugars (TRS) produced in the enzyme hydrolysis (EH) of pretreated invasive seaweed *R. okamurae*.

Figure 2. Scheme of the p**rocesses**: pre-treatments + EH

Results & Discussion

Table 1. Characterization of liquid extract after pre-treatments

Parameters	MW-160ºC	MW-220ºC	Bio-56 FPU	Bio-37 FPU
TOC (mg/L)	781	4775	1003	998
IC(mg/L)	42.8	64.6	12	74
TN(mg/L)	60	353	58	59
C/N	13.7	13.7	22.5	18.2
TRS(mg/L)	410	1730	338	338
$COD_{potential}$ (g/L)	0.438	1.85	0.361	0.361

The highest solubilisation rates and reducing sugars concentrations were obtained by using microwave pretreatment at 220ºC as it can be seen in TOC, TRS and $COD_{potential}$ values shown in Table 1.

Table 2. TRS yields of EH. A comparison between microwave and biological pretreatment

PT	Condition	RS Yield
MW-1day	160 °C	1.28
	220 °C	2.19
BIO-5 days	56FPU	1.33
	37 FPU	2.02

As it can be seen the optimal TRS yield was due to at 220ºC MW treatment, too. However, when the temperature decreases to 160ºC the results are similar to biological pre-treatment at 56 FPU. So, we could find similar results using an ecological and economical process.

If the time evolution is considered, approximately 90% of the final TRS obtained was produced in the first 10 hours. In this way, performing a kinetic adjustment to compare the main kinetic parameters associated with the effect of each pre-treatment is highly interesting, especially in view of an industrial scale-up of the process. Finally, the first-order kinetic model was applied using Origin Pro8® software according to the following equation:

$$P = \beta \cdot S_o\left(1 - e^{-kt}\right) = P_{max}\left(1 - e^{-kt}\right)$$

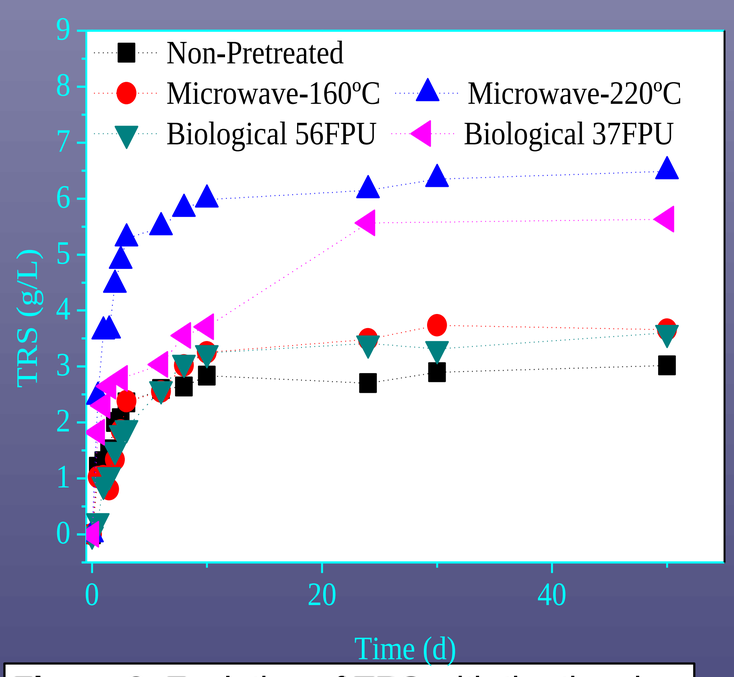


Figure 3. Evolution of TRS with the time in the hydrolysis with CellictCTec2® of pretreated seaweed

As it is shown in Table 3, the first-order kinetic model finely fits the process behaviour ($R^2 > 0.95$ in all cases except for Bio- 37FPU $R^2 = 0.83$).

Table 3. TRS yields a comparison between microwave and biological pretreatment

Kinetic parameter	NP	MW-160 °C	MW-220 °C	Bio-56FPU
βS_0	2.60	3.34	5.69	3.47
k	0.56	0.23	0.68	0.28
P_0	0.20	0.25	0.35	-0.04
P_{max}	2.80	3.59	6.04	3.43
R^2	0.96	0.96	0.97	0.99

It is noteworthy to highlight the kinetic constant (k) value, which is directly proportional to the reaction rate, and the maximum production (Pmax). Although the highest reaction rate and maximum yield are obtained by MW at 220 °C, it can be seen that BIO pretreatment achieves the same parameters values as MW pretreatment at 160 °C

Conclusions

- ✓ MW pretreatment at 220°C gave the highest TRS yields and reaction rate.
- ✓ In the first 10 hours, enzyme hydrolysis produces almost 90% of the total RS.
- ✓ BIO-56 pre-treatment reached the TRS yields obtained by MW pretreatment at 160 °C more economically and sustainably.
- ✓ BIO-37 pre-treatment increased the TRS to 5.6 g/L but it does not fit with first order equation.

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