Different pretreatment strategies to enhance fermentable sugar production from olive stone in the context of an olive-derived biomass biorefinery

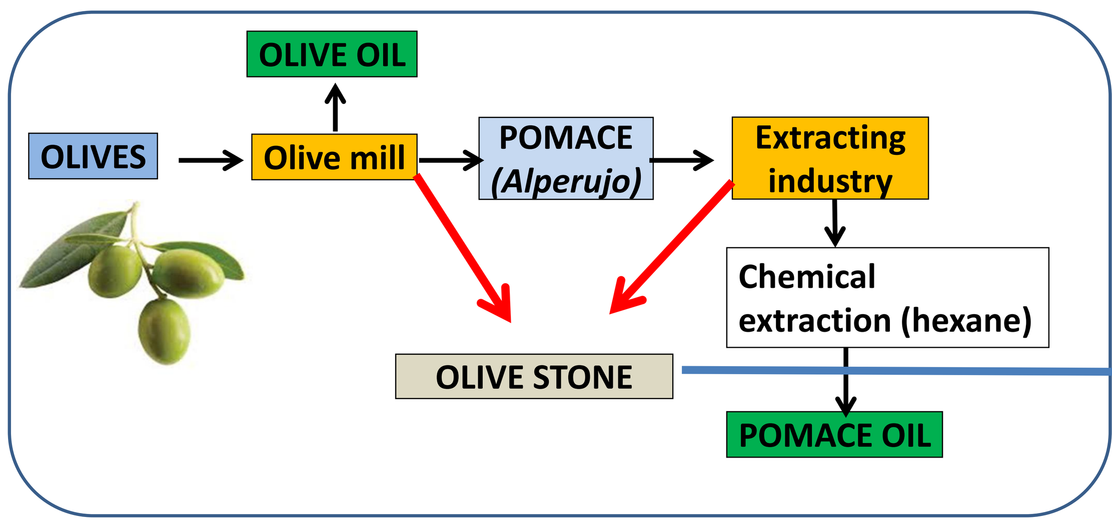
P. Manzanares[1], I. Ballesteros[1], A. Duque[1], P. Doménech[1], I. Higueras[1], I. Romero[2], J.M. Oliva[1]
[1]Biofuels Unit, Renewable Energy Department, CIEMAT. Madrid, Spain
[2]Department of Chemical Engineering, Environment and Materials, University of Jaén, Spain
E-mail presenting author: p.manzanares@ciemat.es

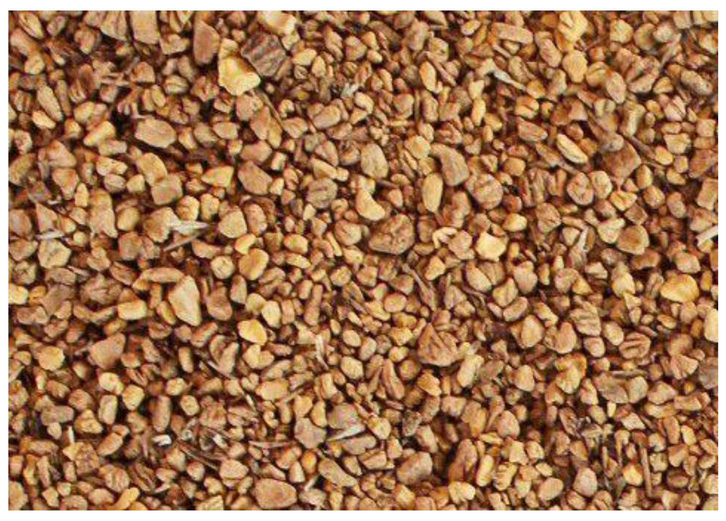
OBJECTIVE

To evaluate the effect of different pretreatment techniques for olive stone biomass fractionation, particularly extrusion technology or steam explosion (SE) in a two-step pretreatment strategy that includes a previous treatment with dilute acid, in the sugar release yield by enzymatic hydrolysis.

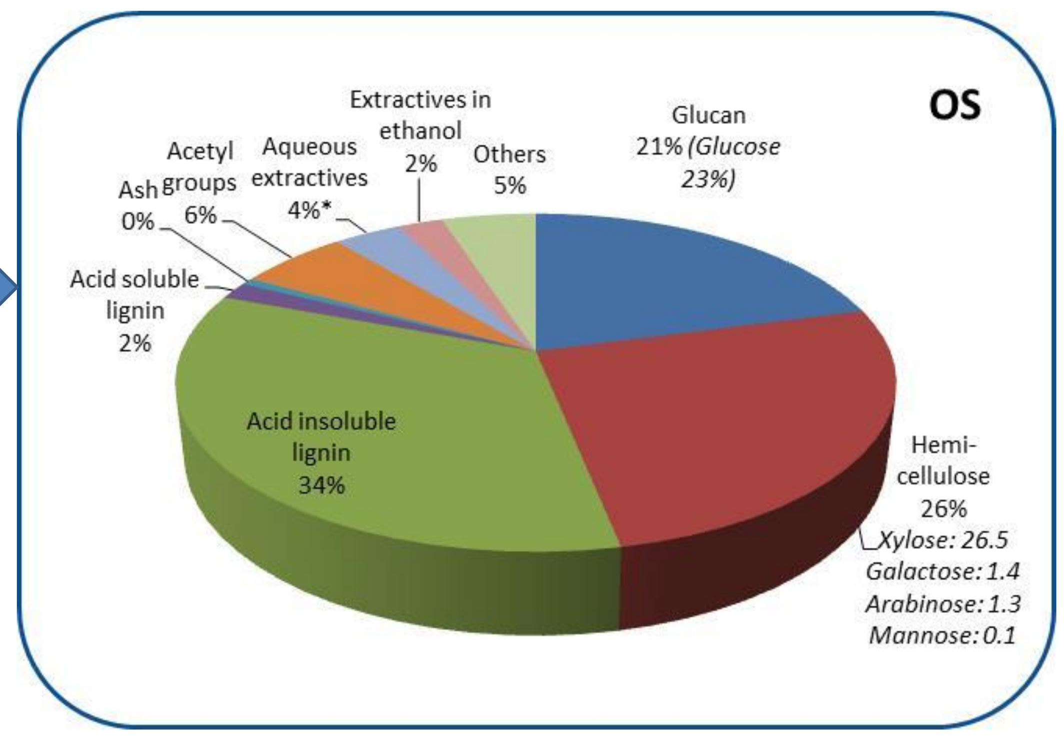
BACKGROUND

Olive industry generates several residues or by-products, such as **olive stones (OS),** that could be used to produce high-added value products in energy and food markets, within a biorefinery concept associated to olive oil production sector. OS is separated from the olive fruit either in the olive mill, the olive-oil pomace industry or in both, depending on the local process operation. The valorization of OS as a feedstock to obtain chemicals or fuels such as bioethanol implies the study of an adequate conversion process. To this end, a first step is the selection of an adequate **fractionation/pretreatment technology** to facilitate the release of sugars by enzymatic hydrolysis of the carbohydrates contained in OS. In this work, a sequential pretreatment of acid and steam explosion (strategy A), with the acid pretreatment conditions having been previously optimized and alkaline extrusion (Strategy B), are tested.



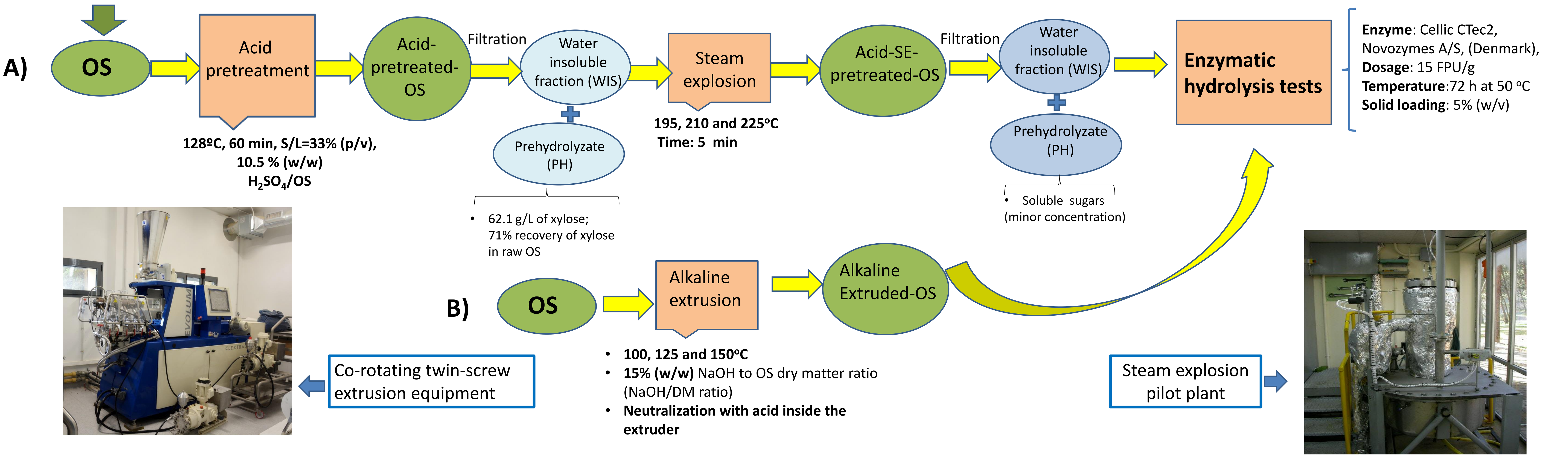


Chemical composition



METHODOLOGY

Raw material:
Olive stones from a local company in Jaen, Spain



Analytical methods:

- Raw and pretreated OS **biomass analysis** by Laboratory Analytical Procedures (LAP) of NREL (National Renewable Energy Department), Colorado, USA.
- **Sugars** by high-performance liquid chromatography (HPLC) in a Waters 2695 liquid chromatograph with refractive index detector and CARBOSep CHO-782 LEAD column (Transgenomic, USA).

Process yields calculation:

Pretreatment

- **Glucan and xylan release yield** (%) = (g glucose or xylose by EH)/(100 g glucose or xylose in acid-SE or extrusion pretreated OS)
- **Glucose and xylose production yield** (%) = (g glucose and xylose/100 g of dry raw biomass), considering solid recovery after pretreatment and conversion yields in EH

RESULTS

Table 1. Pretreated OS materials composition in % dry weight basis

Component	Extrusion [NaOH ratio-T (ºC)]			Steam explosion (T-ºC)		
	15-100	15-125	15-150	195	210	225
Cellulose	18.3 ± 0.4	18.1 ± 0.3	17.8 ± 0.3	35.4 ± 0.2	33.7 ± 0.2	31.3 ± 0.2
Hemicellulose	21.1 ± 0.4	19.5 ± 1.3	22.4 ± 0.6	2.6 ± 0.1	3.4 ± 0.2	3.4 ± 0.1
Xylan	19.2 ± 0.3	18.9 ± 0.2	20.6 ± 0.5	2.9 ± 0.1	3.3 ± 0.1	3.4 ± 0.1
Lignin	41.9 ± 0.3	34.3 ± 0.2	36.5 ± 0.3	57.8 ± 2.1	56.6 ± 1.8	58.6 ± 0.6
Acetyl group	0.6 ± 0.02	1.9 ± 0.02	2.1 ± 0.1	0.7 ± 0.0	0.8 ± 0.0	0.7 ± 0.1

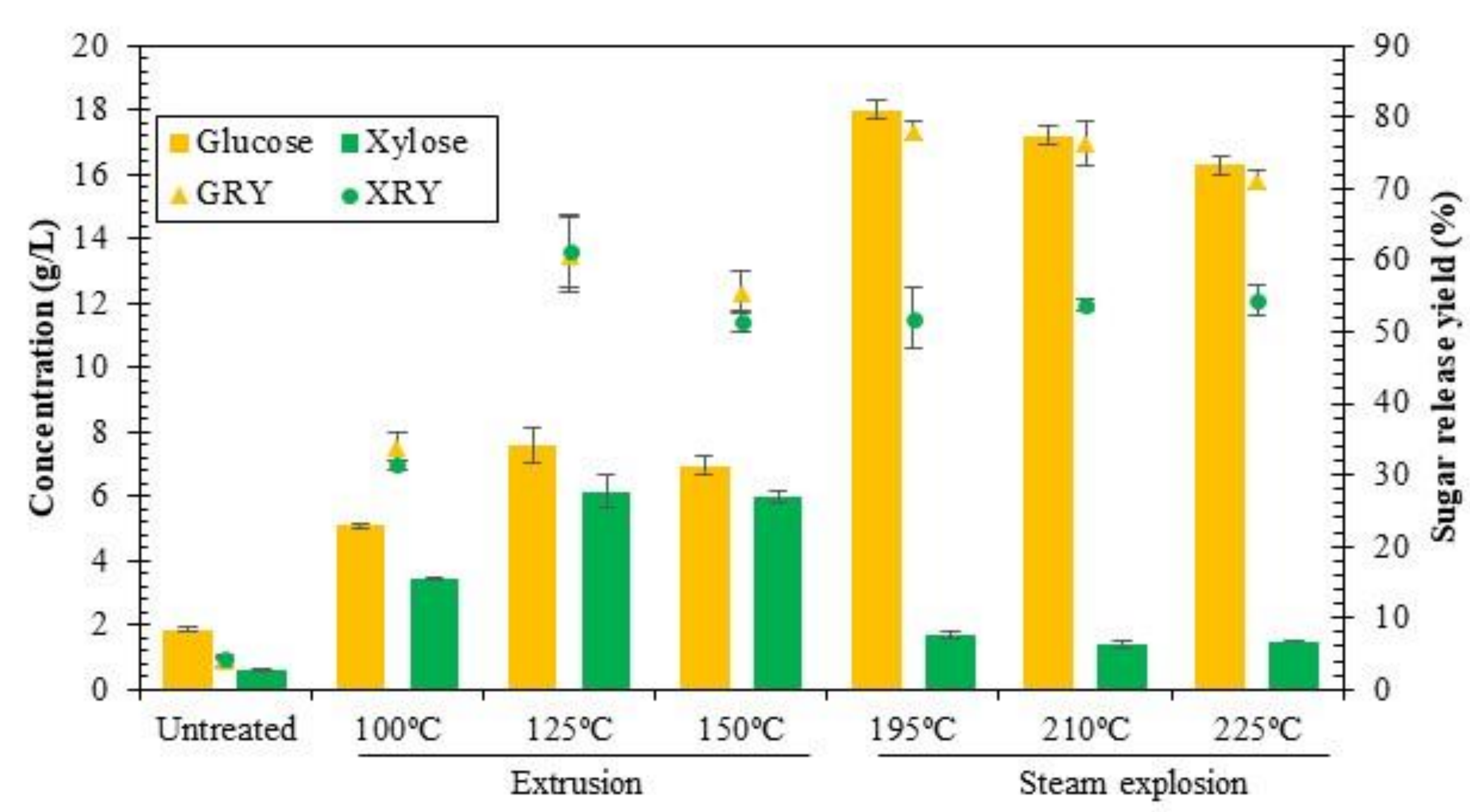


Figure 1. Glucan and xylan release (GRY, XRY) in % of theoretical (spare marks, right) and glucose and xylose concentration in the media in g/L (plain bars, left), after enzymatic hydrolysis of raw OS and OS biomass pretreated by acid + SE or extrusion under different conditions

Table 2. Overall glucose, xylose and total sugars production in pretreatment and EH steps (g per 100 g of raw OS)

Experiment	Glucose	Xylose	Total G+Xy	% of content in raw OS
Extrusion				
15% NaOH ratio-100ºC	11.7	7.9	19.6	39.5
15% NaOH ratio-125ºC	17.4	14.1	31.6	63.8
15% NaOH ratio-150ºC	16.0	13.8	29.8	60.2
Acid +Steam explosion at				
195ºC, 5 min	17.8	23.9	41.7	84.2
210ºC, 5 min	14.1	21.8	35.9	72.5
225ºC, 5 min	12.5	22.7	35.2	71.1

CONCLUSIONS

- **The sequential pretreatment of acid plus steam explosion results in the best process strategy to fractionate and recover carbohydrates in form of sugars during pretreatment and enzymatic hydrolysis. This is mostly due to the effcient extraction of xylose during the first step of consecutive pretreatment; acid pretreatment step.**
- **The application of alkaline extrusion, although showing the advantage of a more integrated pretreatment, still needs of further optimization to reach satisfactory levels of sugar production yield.**

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