Grape crop waste biomass as feedstock for a lignocellulosic biorefinery: effect of Deep Eutectic Solvent on biomass fractionation

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1. Introduction

Vine shoots (VS) is a grape crop waste resulting from the pruning of grapevines, with no industrial use at present. VS could be used in a biorefinery strategy, provided that their main components can be recovered and used separately.

Deep Eutectic Solvents (DES) are considered green solvents, able to fractionate biomass[1]. Among them, Choline Chloride : Lactic acid (ChCl:LA) has shown promising delignifications results[2].

The present work explores the fractionation of vine shoot biomass by ChCl:LA.

2. Objectives

- Assess the performance of the pre-treatment of vine shoots using a DES made of choline chloride and lactic acid.
- Quantify the amount of lignin extracted by DES pre-treatment.
- Evaluate sugar released from pre-treated vine shoots by enzymatic hydrolysis (EH).
- Compare the results obtained for grape crop waste to wheat straw.

3. Materials and Methods

Compositional Analysis[3]

- Ash quantification
- Water & etanol extraction
- 2-step hydrolysis:

- Filtrate → sugars, acetic acid, soluble lignin
- Solid residue → insoluble lignin

DES pre-treatment

5% wt. solids load

- Orbital shaker, 60ºC, 14 h, 120 rpm
- Oven, 120ºC, 6 h, no agitation

Vacuum filtration (0.45 µm)

Solid
- Washed with hot water until neutral pH
- Dried at 40ºC

→ Enzymatic hydrolysis

Filtrate
- Addition of water
- Refrigeration
- Centrifugation (9,000 rpm, 15 min)
- Pellet washed twice

→ Compositional analysis

DES preparation

Choline chloride + Lactic acid
1:5 molar ratio
Synthesis at 60ºC and 100 rpm, 40 min

Enzymatic hydrolysis

5% wt. solids load
Cellulase blend, 15 FPU/g substrate
50ºC, 150 rpm, 72 h

$$OY_i = \frac{(Sugar\ released by EH - Sugar\ in\ enzyme)}{Sugar\ in\ the\ raw\ biomass} \times 100$$

4. Results

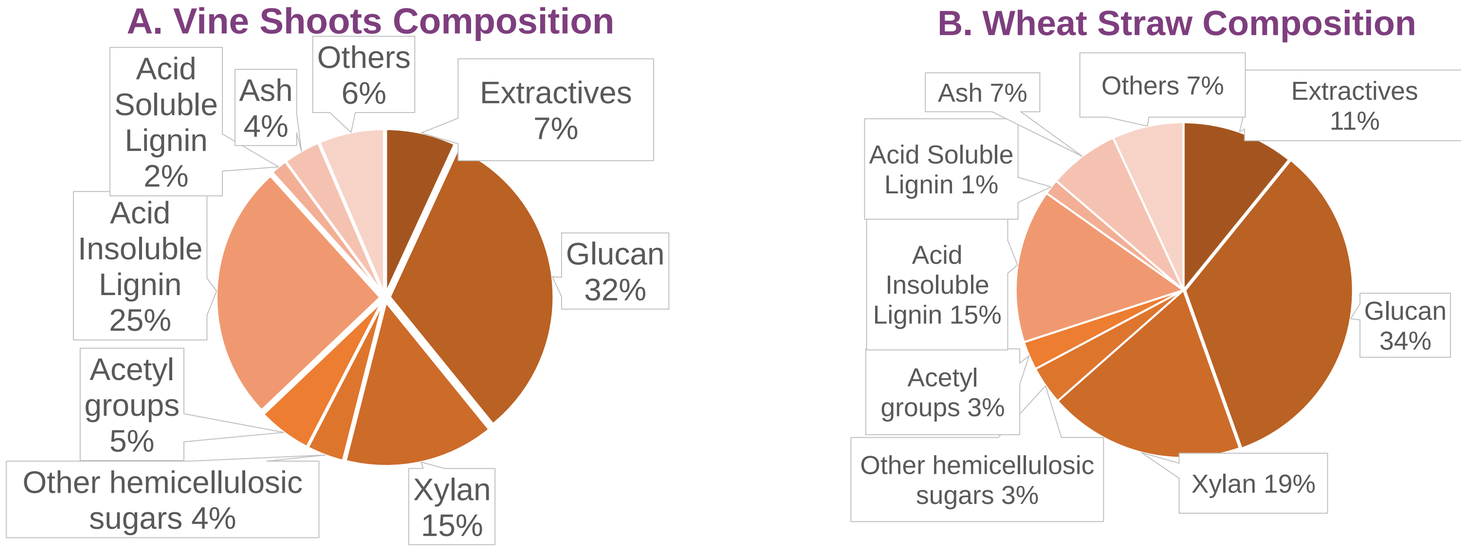

Figure 1. Main components of vine shoot (pannel A) and wheat straw (panel B) in % of dry weight basis

Table 1. Total solids, glucan, and xylan recovery and delignification, expressed in % of the wáter (W) pre-treated and DES pre-treated vineshoot (VS and wheat Straw (WS)

Substrate	Solids recovery	Glucan recovery	Xylan recovery	Delignification
VS- W 60ºC	91.4	94.2	90.1	1.0
VS- DES 60ºC	94.6	91.8	91.0	22.8
VS- W 120ºC	84.3	98.0	98.0	2.8
VS- DES 120ºC	59.7	79.7	18.6	52.9
WS- W 60ºC	91.2	91.4	87.1	0.0
WS- DES 60ºC	92.0	94.0	91.6	3.1
WS- W 120ºC	78.4	82.8	80.2	8.1
WS- DES 120ºC	61.1	89.4	13.4	41.7

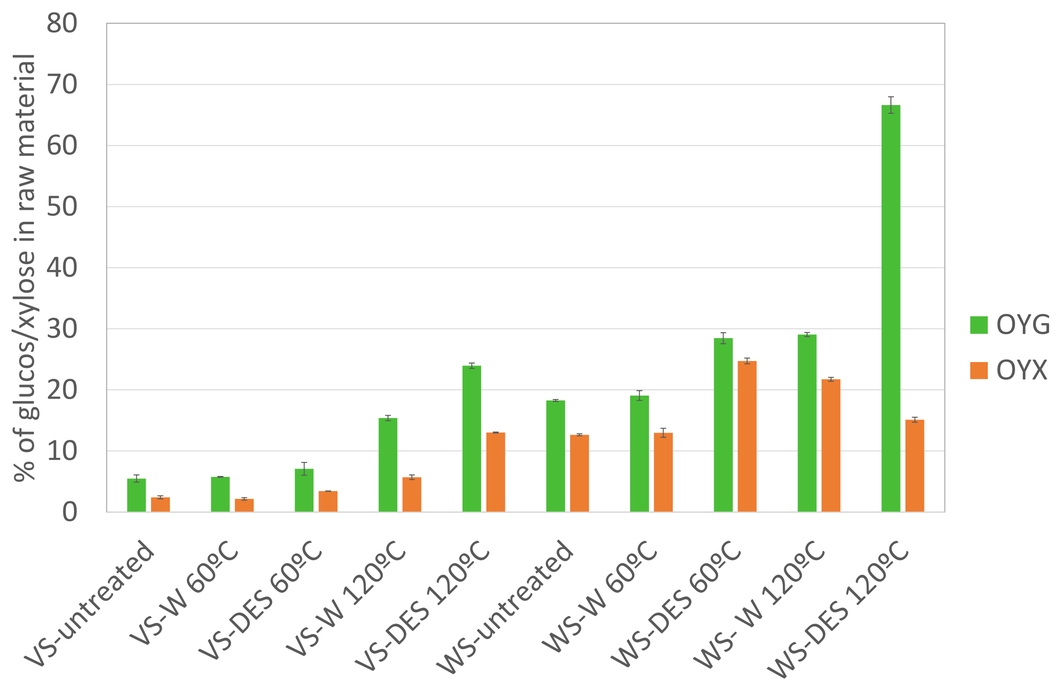

Figure 2. Overall glucose and xylose yield in % with respect to the raw material, for untreated, water (W) pre-treated, and DES pre-treated vine shoot (VS) and wheat straw (WS)

5. Conclusions

- Vine shoot is an agricultural residue with a greater lignin content compared to wheat straw, which results in a greater recalcitrance against the hydrolysis.
- Pre-treatment with the DES choline chloride and lactic acid, is a selective method able to partially solubilize the lignin of the biomass.
- The DES pre-treatment is more effective at 120ºC tan at 60ºC, even though the pre-treatment time was shorter at the highest temperature.
- The highest delignification rate was achieved under 120ºC and it correlates with a higher enzymatic digestibility of the pre-treated biomasses .
- Under the most severe condiitions, xylan solubilization is high and less than 20% of the initial carbohydrate is recovered after the pre-treatment with DES:

Acknowledgements

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6. References

1. Chen, Y. and Mu, T. (2019), Green Energy & Environment 4, 95-115
2. Kumar, A.K. et al. (2016), Environ Sci Pollut Res 23, 9265-9275
3. Slutier, JB, et al.(2010), Journal of AgricFood Chem 58, 9043-9053.