Electrostatic separation of grape stalk powder obtained from grape-wine chain waste

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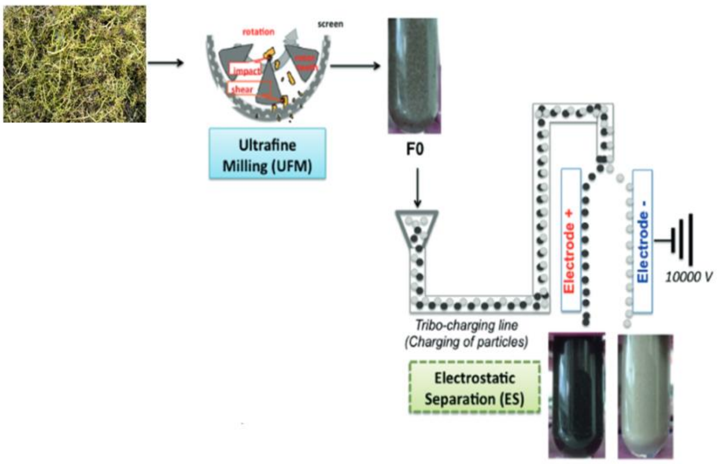
Grape stalks are made of lignocellulosic biomass, which represents a source of biopolymers, rich in simple sugars and phenolic compounds (Brandt *et al*, 2013; Guerriero *et al*, 2016). Since lignocellulose is a very complex material, a fractionation of its components that leads to the breakdown of their interactions is required. Pretreatment methods allow the lignocellulose to be broken down into its basic units, thus increasing accessibility for subsequent treatments on these biopolymers.

Grape stalks were subjected to drying, grinding, and electrostatic separation, a cutting-edge technique already successfully applied to separate proteins from polysaccharides, lignin, and polyphenol. In electrostatic separation (Fig. 1), grape stalk fine particles were conveyed, through a jet of compressed air, towards a device called "tribo-charging line" where they were charged through the triboelectric effect (Mayer-Laigle et al., 2018). The charged particles were then let run through a line equipped that ended with two high voltage electrodes and during this run the positively charged particles were separated from the negatively charged ones.

Figure 1: Electrostatic separation scheme of the grape stalk fine powder

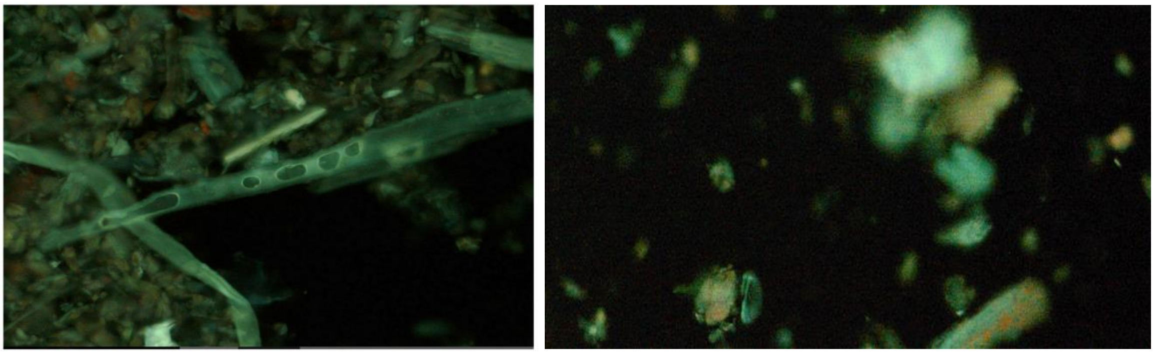


The electrostatic separation allowed to obtain 9 fractions in two runs: 1 control, 4 fractions from the first separation (electrode +, electrode -, and samples collected in jars placed under the electrodes a called jar + and jar -), and 4 fractions from a second separation using the pooled samples contained in the two jars (electrode +, electrode -, jar + and jar -). All the samples were extracted with water and sulfuric acid 2% and the extracts were subjected to HPLC analyses to determine the concentration of sugars, phenolics, and possible furanic artefacts (Spigno *et al*, 2013; Spigno *et al*, 2014).

In the aqueous extracts, the concentrations of glucose and fructose were in the range of 9.4-13.5 g/100 g d.w. and 7.46-11.6 g/100 g d.w. respectively. In the acid extracts, the concentration of xylose, deriving from the cleavage of hemicellulose structures, was in the range of 8.26-17.53 g/100 g d.w., while those of furfural and HMF were 1996.19-260.24 mg/kg d.w. and 290.58-144.41 mg/kg d.w., respectively.

All the fractions were also investigated using a fluorescence microscope to obtain information on the morphology. Microscopic analysis allowed to highlight a prevalence of fluorescent lignified structures in the samples selectively collected at the positive electrode (Fig. 2, left). As some authors had already observed (Barakat *et al*, 2014; Chuetor *et al*, 2015), it can be argued that particles with higher amount of lignin selectively moved towards the positive electrode. This phenomenon was due to a higher presence of phenolic substances, which are characterized by the presence of electronic clouds in the aromatic rings. In the control sample, the presence of these elements was fair limited (Fig. 2, right), while they were not found at all in the samples collected at the negative electrode. A similar behavior has been already described in a study on the electrostatic separation of sunflower oil cake (Barakat *et al*, 2015), in which the authors showed that protein structures selectively migrated toward the positive electrode, while the lignocellulosic material was massively directed to the negative one.

Figure 2: on the left - fluorescence-microscopy image of grape stalk powder collected at the positive electrode. Lignified structures, such as trachea and fibers can be noted; on the right - fluorescence-microscopy image of the grape stalk control sample.



The aqueous extraction of the obtained fractions showed appreciable concentration of simple sugars that are likely lost during the grape pressing. A quite high rate of simple sugars (in particular pentoses) was also obtained through the acid hydrolysis of the residual pellet. This is a source of sugars that can find applications in the microbial fermentations for the production of various metabolites. The extraction in acid condition led to the formation of furanic compounds derived from the sugars. A proper modulation of the acid-extraction condition is necessary to lead the reaction towards either the highest yield in simple sugars or in furanic compounds. Indeed, these latter represent useful building blocks, which find employment in the fine chemistry. For this reason, other strategies, such as pyrolysis and electrochemical should be taken into account for an extensive production of these compounds.

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References

Barakat, A., & Rouau, X. (2014). New dry technology of environmentally friendly biomass refinery: glucose yield and energy efficiency. *Biotechnology for biofuels*, *7*(1), 138.

Barakat, A., Jérôme, F., & Rouau, X. (2015). A dry platform for separation of proteins from biomass-containing polysaccharides, lignin, and polyphenols. *ChemSusChem*, *8*(7), 1161-1166.

Brandt, A., Gräsvik, J., Hallett, J. P., & Welton, T. (2013). Deconstruction of lignocellulosic biomass with ionic liquids. *Green chemistry*, *15*(3), 550-583.

Chuetor, S., Luque, R., Barron, C., Solhy, A., Rouau, X., & Barakat, A. (2015). Innovative combined dry fractionation technologies for rice straw valorization to biofuels. *Green Chemistry*, *17*(2), 926-936.

Guerriero, G., Hausman, J. F., Strauss, J., Ertan, H., & Siddiqui, K. S. (2016). Lignocellulosic biomass: biosynthesis, degradation, and industrial utilization. *Engineering in life sciences*, *16*(1), 1-16.

Mayer-Laigle, C., Barakat, A., Barron, C., Delenne, J. Y., Frank, X., Mabille, F., ... & Lullien-Pellerin, V. (2018). Dry biorefineries: Multiscale modeling studies and innovative processing. *Innovative Food Science & Emerging Technologies*, 46, 131-139.

Spigno, G., Maggi, L., Amendola, D., Dragoni, M., & De Faveri, D. M. (2013). Influence of cultivar on the lignocellulosic fractionation of grape stalks. *Industrial crops and products*, *46*, 283-289.

Spigno, G., Moncalvo, A., De Faveri, D. M., & Silva, A. (2014). Valorisation of stalks from different grape cultivars for sugars recovery. *Chemical Engineering Transactions*, *37*, 475-450.