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Efficient green extraction of polyphenols from post-harvested agro-industry vegetal sources in Piedmont

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ABSTRACT

A study of the polyphenols content and antioxidant capacity of grapevine waste and hazelnut skins (roasted material) from post-harvest products that originate from Piedmont (Italy) has been carried out and the results herein presented. Ultrasound-assisted extraction (UAE) and microwave-assisted extraction (MAE) were used to achieve process intensification in shorter extraction times, with lower environmental impact and higher selectivity compared to classic maceration. Besides classic solvents, the aqueous β-cyclodextrin solution (1.5%) showed to be an excellent extraction medium for grapevine waste. Total phenolic content (TP) from grapevine waste ranged from 18.23 ± 2.4 to 198 ± 3 mg gallic acid equivalents (GAE)/g dry weight, while total antioxidant capacity (TAC) expressed as EC_{50} ranged from 0.0902 ± 0.08 mg/mL to 0.0041 ± 0.02 mg/mL. For hazelnut skins, TP ranged from 61.68 ± 0.8 to 200.79 ± 3.0 mg GAE/g dry weight, while TAC ranged from 0.0021 ± 0.0004 to 0.0002 ± 0.0001 mg/mL extract. We have shown that, compared to maceration, the use of UAE and MAE methods can enhance polyphenols recovery and antioxidant capacity.

1. Introduction

It is well known that all agro-industrial production generates waste. Many by-products of different vegetal sources are now routinely diverted from the waste stream and turned to beneficial use. Agricultural waste is still an ignored source of high-value phytochemicals that can contribute to sustainability objectives [1]. Plants and their products have always played a pivotal role in human health by satisfying various essential needs, ranging from foods to medicines [2].

Located in the northwestern most part of Italy, Piedmont is blessed with plenty of ingredients and a great culinary culture. Even if Piedmont is known as one of the top wine regions in the world, hazelnuts, another typical product, are also held in remarkable esteem. Italy is the second largest hazelnut producer in the world, behind Turkey [3]. Both the bulk of grapevine waste, such as vine pruning, grape stalks, marc (skins and seeds), and hazelnut skins are becoming more and more valued worldwide for their richness in active phytochemicals. Growing interest in the processing of grape seeds comes from cosmetic and food supplements industry. The viability of using solid wastes in animal feed is also being explored. Hitherto, studies were mainly conducted on the phenolic profile of grapevine waste [4], mainly focused on *trans*-resveratrol, *trans*-viniferin and ferulic acid [5,6]. Some of these resveratrol derivatives are known to be of high bioactivity. They are hepatoprotective [7] and posses antioxidant properties [8], induce apoptosis of leukemia B cells [9,10] and inhibit human cytochrome P450 enzymes [11], noradrenaline and 5-hydroxytryptamine uptake, and monoamine oxidase activity [12].

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Hazelnut skins and other hazelnut processing by-products have mainly been used for livestock feed, but in the past few years, several studies have confirmed that they are a valuable source of natural antioxidants for nutraceutical, cosmeceutical and pharmaceutical applications [13–18].

Power ultrasound (18–40 kHz) is a green and efficient technique that greatly accelerates the extraction process and may reduce energy consumption. The final extract is more concentrated in soluble material which makes it easier to handle and reduces the need for additional process steps. Ultrasound-assisted extraction (UAE) is a clean procedure, and thanks to the low bulk temperature and the rapid execution, usually it does not degrade the extract. It leaves no residue in the extract and uses no moving mechanical parts inside the extract, thus preventing the occurrence of any pollution. It also offers advantages in terms of productivity, yield and selectivity, improves processing time, enhances quality, reduces chemical and physical hazards and is environmentally friendly [19]. Microwave-assisted extraction (MAE) can be carried out in a few minutes with high reproducibility, reducing the consumption of solvent, simplifying manipulation, giving higher final product purity and consuming only a fraction of the energy normally needed for conventional extraction. The volumetric heating generated by microwaves has several advantages which are caused by faster energy transfer, reduced thermal gradients and unique heating selectivity [20,21].

Over the last decade, increasing demand for bioactive natural products for food supplement preparation has exploited the healthy properties of the large polyphenols family. Our investigation is focused on the feasibility of extracting these high-value phytocompounds while reducing the environmental impact and disposal costs of waste by using UAE and MAE techniques. With the aim to compare different methods with classic maceration, among several tests of MAE and UAE we selected in each case the operative conditions that gave the highest yields and highest polyphenols content.

2. Results and discussion

2.1. Extraction yields

The influence on yields of different solvents and their mixture with water as well as different extraction techniques were studied. In the present study, maceration was chosen for comparison with all the non-conventional techniques. For comparison sake, we selected the best conditions found in any extraction technique. Clearly the best results obtained with UAE have operative conditions that differ from the best MAE conditions. It is important to highlight that the experiment carried out at 60 °C under conventional heating (oil bath for 30 min) gave a slightly higher extraction yield compared with maceration at room temperature, but the total polyphenols content was not improved. The total percentage extraction yields for grapevine waste and hazelnut skins are shown in Figs. 1 and 2 respectively. The highest grapevine waste extraction yield was obtained by UAE using a 1.5% β-cyclodextrin solution, while the best yield of hazelnut skins was obtained with a mixture acetone/H_2O, under MAE (40 min). In fact, Contini et al. [15] reported that methanol

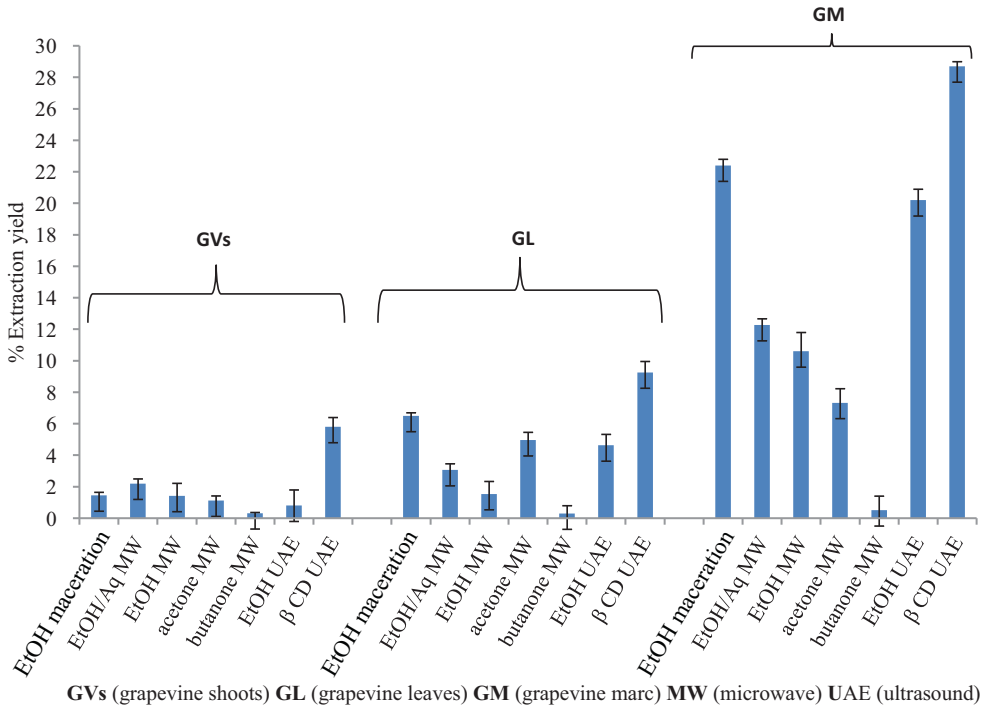

Fig. 1. Extraction yield % of grapevine waste under different conditions (statistical errors are presented in bars above columns). GVs: grapevine shoots; GL: grapevine leaves; GM: grapevine marc; MW: microwave; UAE: ultrasound.