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Analysis of the characteristics of the residues of the wine production chain finalized to their industrial and energy recovery

*G. Toscano, G. Riva, D. Duca, E. Foppa Pedretti, F. Corinaldesi, G. Rossini**

Dipartimento di Scienze Agrarie, Alimentari e Ambientali dell'Università Politecnica delle Marche, Via Brecce Bianche, Monte Dago, 60131 Ancona, AN, Italy

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ABSTRACT

In Italy 1.5 Tg dry matter of residues are estimated to be produced by the agri-food sector. Approximately 30% of them are represented by residues of wine industry sector: grape marc. Referring to its production, it is possible to evaluate about 10 Mg of grapes from each vineyard hectare that generate, as wine industry residue, 2.7 Mg of grape marc, corresponding to about 19 GJ in terms of energy content. This kind of biomass is heterogenous and composed of stalks, grape skins and seeds. In this paper, in order to investigate the possibility of an energy and industrial utilization, the physical-chemical characteristics of each single component of grape marc are examined. In addition, a mechanical extraction test on the seed was performed to evaluate the vegetable oil production and the characteristics of the cake. Results on grape marc components put in evidence some difference in terms of ash and chemical elements content, which represent, specifically for these materials, the most critical aspects to take into account in combustion heating systems.

1. Introduction

Residues from agriculture, forestry and agri-food industry amount to about 21 Tg of dry matter every year in Italy; among them, 1.5 Tg are estimated to be produced by the agri-food sector [1].

Wine industry is significant in Italy. An estimated surface of 670 000 ha produces 6.5 Tg of wine grapes and, from these, 4.7 hm^3 of wine are produced every year [2]. It is estimated that the residue factors are 270 kg m^{-3} of wine with a moisture mass fraction of 60%, comprising 165–180 kg of marc, 40 kg of stalks, and 60 kg of lees and solids [3,4]. At a National level, the annual potential production of residues is about 0.5 Tg dry matter, more than 60% deriving from grape marc. Grape marc can be divided into three different parts: skins, seeds and stalks, respectively about the 72%, 17% and 11% of total dry matter [5].

The vineyard's average yield in Italy is about 10 000 kg ha^{-1} [2]; the correspondent fresh grape marc yield is 2700 kg ha^{-1} [5]:

- fresh skins – 1950 kg (≈730 kg of dried skins);
- fresh stalks – 300 kg (≈120 kg of dried stalks);
- fresh seeds – 450 kg (≈280 kg of dried seeds) [5].

Abbreviations and symbols: hhv, higher heating value; NHV, net heating value; LHV, lower heating value; DT, ash deformation temperatures; FT, ash flow temperatures; LSD, least significant difference; SCR, selective catalytic reduction; SNCR, selective non-catalytic reduction; PCDD, polychlorinated dibenzodioxins.

* *Corresponding author*. Tel.: +39 71 2204297; fax: +39 71 2204167.
E-mail address: g.rossini@univpm.it (G. Rossini).

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The mass balance is reported in Fig. 1.

Residues quantities are very high so different methods for their use have been developed. Worldwide the most common are: agronomic utilization, livestock feed, treatments for pharmaceutical and cosmetic productions or food. In particular, some authors evaluated agrochemical parameters of winery and distillery industry residues in order to verify the possibility of using them for agricultural purposes. Results showed that prior conditioning treatments are necessary for a possible use of these residues [6]. Another work specifically addresses the study of the composting process of winery and distillery wastes [7]. Other authors presented a more comprehensive technical, economic and environmental analyzes of the composting process [8]. Some researchers also studied the influence that adding grapeseed extract to porcine diets exercises on quality attributes of raw and cooked pork [9]. A research showed that health functional components of grape skin and seed powders from the tested by-products of grape/wine industry are comparable to those of fruits and vegetables [10]. The results of other studies confirm the press residues of grapeseed oil production still to be a rich source of polyphenolics with strong antioxidant activity [11,12]. Some researches highlight the nutritional properties of oil extracted from grapeseeds: a peculiar fatty acid composition, high concentration of polyphenols and a high smoke point (about 190–230 °C) make it suitable for cooking [13].

Until 2010 in Italy fresh and fermented grape marc had to be compulsorily used only for distillation; Italian laws about by-products of wine industry have recently changed and now different uses are permitted: agronomic, pharmaceutical/cosmetic and also energy use. This latter is particularly interesting from many points of view:

- logistic: by-products originated in industry as concentrated residues; the incidence during the collection and transportation is almost negligible [14];
- energy-environmental: wine production requires high energy consumptions and has great environmental costs in terms of CO_2 emissions [15,16]. The use of residues for energy could, therefore, reduce these problems;
- economic: an energy utilization of residues could contribute to a better economic balance through the lower energy costs or by selling the produced energy.

Furthermore, the energy use of residues comply with the aims of EU Directives that promote a global target of 20% of renewable energy in the final energy consumption by 2020 [17].

The whole process of thermal utilization of solid biofuels (fuel supply, combustion system, solid and gaseous emissions) is influenced by the type of solid biofuel used, its physical characteristics (e.g. particle size, bulk density, moisture content, HHV) and its chemical composition [18]. A study evaluated the potentials of food wastes for power generation and energy conservation [19]. Another work suggests that methane can be produced very efficiently by co-digesting wine-grape residues and other wastes [20]. A research showed that a grate firing plus steam turbine system is a good option for the employment of grape by-products for power production [21]. A study about the production of biodiesel from winery waste highlights that chemical extraction and transesterification of refined oil produces a biodiesel of good quality [22]. In every work the characterization analyzes were conducted on winery residues as produced by the industry and there are no information about energy characteristics of their single components nor about the possibility to separate them in order to destine each of them to a specific valorization. A study on grape marc produced in Central Italy has observed a high amount of ashes, with a wide range of values: this highlights a large variability in these products. The thermal behavior of ashes, on the contrary, seems to be more homogenous, as a consequence of the high fusion temperatures [3,23,24]. Another study focused the attention on different kind of experiments (scanning electron microscope and particle size distribution, energy-dispersive X-ray spectroscopy elemental analysis, thermogravimetric profiles and emitted gases analysis) carried

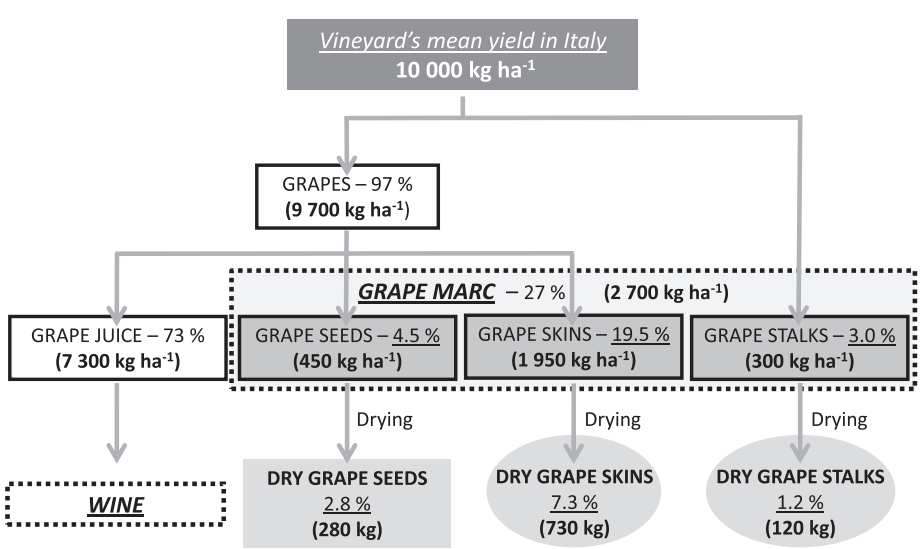

Fig. 1 – Mass balance referring to 1 ha of vineyard for wine production (ISTAT data processing [2] and bibliographic sources [5]).