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Sustainable wineries through waste valorisation: A review of grape marc utilisation for value-added products

Richard A. Muhlack, Ravichandra Potumarthi, David W. Jeffery *

The Australian Research Council Training Centre for Innovative Wine Production, and Department of Wine and Food Science, The University of Adelaide, PMB 1, Glen Osmond, South Australia 5064, Australia

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ABSTRACT

Grapes are one of the most cultivated fruits worldwide, with one third of total production used in winemaking. Both red and white winemaking processes result in substantial quantities of solid organic waste, such as grape marc (pomace) and stalks, which requires suitable disposal. Grape marc accounts for approximately 10–30% of the mass of grapes crushed and contains unfermented sugars, alcohol, polyphenols, tannins, pigments, and other valuable products. Being a natural plant product rich in lignocellulosic compounds, grape marc is also a promising feedstock for renewable energy production. However, despite grape marc having such potential, advanced technologies to exploit this have not been widely adopted in wineries and allied industries. This review covers opportunities beyond traditional composting and animal feed, and examines value-added uses via the extraction of useful components from grape marc, as well as thermochemical and biological treatments for energy recovery, fuel or beverage alcohol production, and specialty novel products and applications such as biosurfactants and environmental remediation. New advances in relevant technology for each of these processes are discussed, and future directions proposed at both individual producer and regional facility scales, including advanced processing techniques for integrated ethanol production followed by bioenergy generation from the spent marc.

Contents

* Corresponding author.
E-mail address: david.jeffery@adelaide.edu.au (D.W. Jeffery).

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1. Introduction

Grapes consistently rank in the top five among all fruits in terms of total global production (Food and Agriculture Organization of the United Nations, 2017). According to data from the Organisation Internationale de la Vigne et du Vin (OIV), in 2012 this equated to around 70 million t of grapes, with almost 60% being used for "pressed grapes" (i.e., mainly wine and grape juice): in turn, almost 26 billion litres of wine were produced globally. During the winemaking process, solid waste known as grape marc or grape pomace is generated after extracting the juice to ferment white wine, and after fermentation and pressing for red wine (Fig. 1).

Grape marc typically consists of skins, stalks, seeds and moisture, as well as other components: among primary constituents such as organic acids and polyphenols, unfermented white marc contains residual sugars, whereas red marc has both residual sugars and some quantities of alcohol (ethanol) (Devesa-Rey et al., 2011; Hixson et al., 2014). The concentration of residual sugars and alcohol in the marc varies greatly according to the source of the fruit and the processes, practices and logistics involved during grape crushing and winemaking (Hixson et al., 2014; Zheng et al., 2012). The quality and quantity of grape marc produced will also vary, largely based on the size of the winery and the methods used during winemaking. Small wineries may only crush several tonnes of fruit, whereas large operations can process tens of thousands of tonnes. Among these different scales of operation, the varying nature of the grapes and equipment used for pressing contribute to diverse data on grape marc generation per ton of fruit crushed. In the case of residual sugars, one technical report (Hixson et al., 2014) revealed fresh white marc had up to 38% (based on dry weight, DW) glucose and fructose. Contrasting this, residual sugar content in red marc varied based on wine type; red sparkling winemaking yielded marc with 18–30% whereas still red winemaking had as low as around 1% glucose and fructose on a DW basis (Hixson et al., 2014). Along with residual sugars, grape marc has

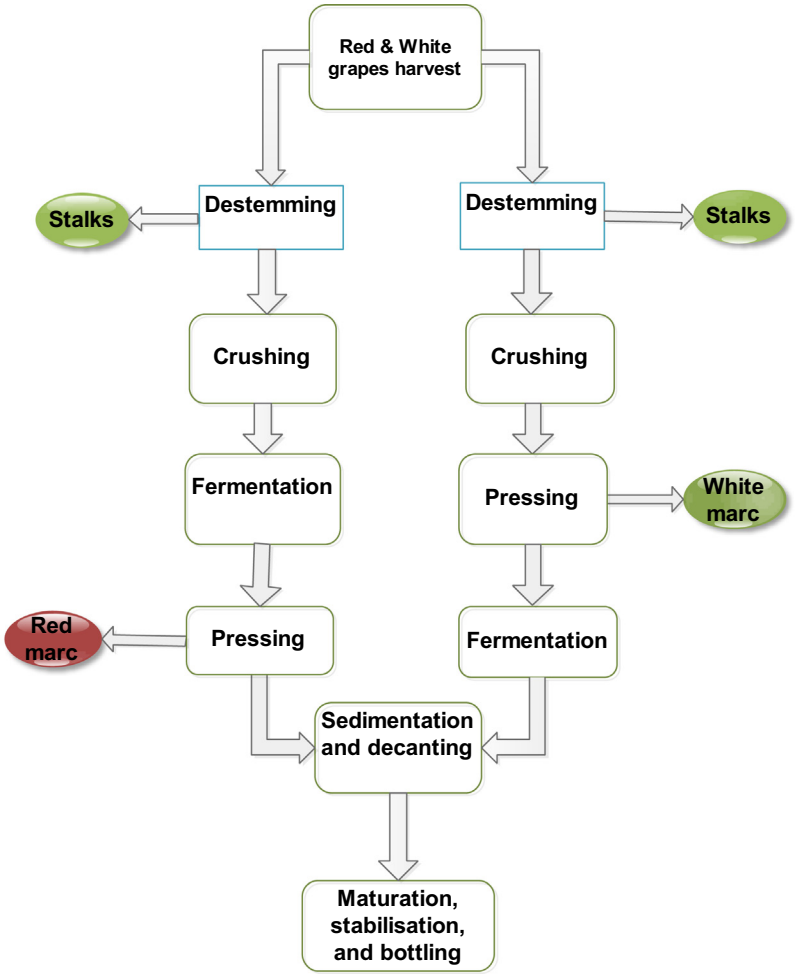

Fig. 1. White and red grape marc generation during winemaking.

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