METHODOLOGIES FOR CAPITALIZING ON WINE BY-PRODUCTS AND THEIR ROLE IN ENVIRONMENTAL PROTECTION

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Abstract. *Climate change, environmental degradation, and biodiversity loss have driven Europe to alter its industrial system away from a fossil-based and linear economy and toward a biodiversity-based circular economy paradigm. Because winemaking is the Republic of Moldova's largest economic sector, implementing the concepts of the circular bioeconomy in wineries is of significant practical relevance, both in terms of corporate sustainability and environmental preservation, which has a direct impact on food safety.*

Reducing non-recyclable wastes is a promising emerging trend in today's world. Because the wine industry generates a huge quantity of biological waste and is also one of the most important industries in the Republic of Moldova, it is crucial to grow this field and conduct additional research into the opportunities of utilizing vinification waste.

In the present article, there are compiled several waste-valorization perspectives, applicable to the Moldovan wine sector.

Keywords*: grape pomace, waste valorization, circular economy, agri-food waste,*

Introduction

Wine by-products are waste from the processing of grapes and the manufacture of wine products in the Republic of Moldova and Romania, according to the Law on Vine and Wine. Must bunches, grape pomaces, piquette, diffusion juice, wine yeast, wine stone, vinasse, and marc are all considered to be winemaking waste [1].

Grape pomace is the main organic solid waste generated from the winery industry. 75% of grape harvest has been used for wine production. Over the years, wine consumption has increased and also the concomitant increase in the production of grape pomace has drawn attention [2].

Winemaking waste

In addition to the basic products (must and wine), grape processing and wine conditioning produce a significant amount of other materials, which are classified under the generic term "by-products." The term "by-product" refers to something that is extracted from a material during processing but cannot be used in the same technological process. By-products account for 18-20% of the total volume of processed grapes in winemaking [1, 3, 4].

Grappa production is a traditional approach to reprocessing pomace, that originated in Italy [3]. Modern processes for processing grape pomace include the following operations: separation of pomace and seeds, drying the pomace, drying the seeds, separation of seeds and skins, drying wine yeasts, obtaining tartaric acid [4].

Separation and drying of grape seeds

Because the oil in grape seeds is nutrient-rich, the seeds are sorted from the pomace and the oil is extracted by pressing [3]. The seed oil content (recalculated on the dry matter) varies from 9.5 % to 20.0 % depending on the grape variety and area of cultivation. As a result, around 190-512 t of grapeseed oil can be produced annually from winemaking waste, which is demanded on the western market at a price of around $50 per kg [4].

Landspreading the grape pomace

Fresh pomace medium is acidic, which might change the pH of the soil. Because of the high polyphenol content, the one derived from red grapes may have a phytotoxic effect. If the pomace is spread in large quantities close to the trunk, special care should be taken because the pomace can quickly heat up and injure the vine [4].

After going through a particular fermentation procedure, the pomace can also be used as fertilizer [3]. Composting is usually done in piles, and the compost can be used after composting in the platform. The advantage is that the compost is already fermented at the time of application [4]. Vermicomposting is an alternative solution for the management of winemaking wastes. The resulting vermicomposts had lower carbon to nitrogen ratio, conductivity, and phenolic-compound concentration than the starting substrates. At the same time, they demonstrated greater pH, humic acids, and nutritional content (excluding potassium), as well as lower phytotoxicity [5].

Biotechnology applications

The aqueous white grape skins extract is primarily made up of hexoses, making it ideal for high-yield bioethanol production at a high specific cell growth rate [6].

By employing grape must as a nutrition material, it was established the growth and citric acid production capabilities of two *Yarrowia lipolytica* strains. It was found to be a good alternative substrate for the synthesis of citric acid [7].

For the generation of microbial polysaccharides, grape pomace substrate can be utilized as a medium for *A. pullulans*, *Sclerotium glucanicum*, and *Xantomonas sp*. *Aspergillus awamori* produces pectinases, cellulases, and xylanases during grape pomace fermentation. *Lactobacillus pentosus* and *Lactobacillus rhamnosus*, both employed in bioprocessing, favor grape vine lees as a lactic acid fermentation medium [8].

Grape stalk hydrolysis is used to produce liquors with varying concentrations of fermentable sugars, which *Debaryomyces nepalensis* utilized to produce industrial metabolites (ethanol, lactic acid, and xylitol in the presence of xylose) [9].

Grape stalks can also be used to make cellulolytic enzymes. [10]

Extraction of bioactive compounds from agro-industrial waste

Grape pomace extract can be used in food, pharmaceutical, cosmetics, and edible packaging as liquid extracts, concentrates, or powders [2].

Wastes with a high content of biologically active compounds are very unstable due to the high redox potential of BAC and their decomposition in oxygen or in contact with metal ions at moderate heating or under the action of light [4]. BAC extraction from agri-food waste can be carried out with a limited number of solvents, as the finished product will be used in food, cosmetics, and pharmaceuticals, thus, must not be contaminated.

Depending on the cellulose and lignin content, the remaining matrix can be turned into various profitable products: artificial soil structuring agents, fuel briquettes, adsorbents (activated carbon), cellulose production, and its further hydrolysis [4].

Dietary supplement potential

The strained lees of wines are a good source of natural antioxidants, angiotensin I-converting enzyme, and hyaluronidase inhibitors to prevent and cure allergy and lifestyle-related diseases [11].

The antioxidant effects of grape marc on intestinal cells could be increased through lactic fermentation, and grape marc works as a carrier protecting lactic acid bacteria and bifidobacteria strains during stomach passage. It may be employed as functional foods, dietary supplements, or pharmaceutical preparations in aqueous or freeze-dried forms [12].

Vine shoot extracts inhibited the enzymes α-amylase and acetylcholinesterase, indicating their potential for use in the treatment of Alzheimer's and diabetes [13].

Data showed that grape seeds' oligosaccharidic fractions obtained in some combinations could be considered a novel functional ingredient with potential prebiotic activity primarily toward *L. acidophilus* [14].

Grape peel extract was found to diminish UVB-induced epidermal thickening of the skin in mice by 63%. Furthermore, the extract stimulated the activation of the Nrf2/HO-1 signaling pathway, which helped to reduce UVB-induced damage [15].

Applications in food production

Grape pomace flour has been used as a natural preservative, stabilizer, thickener, and antioxidant agent in the food processing and packaging industries. It was also successfully used in developing a chitosan-based edible film with grape pomace as reinforcing agents to improve antioxidant properties and provide a longer shelf-life for food products [2].

At the same time, grape pomace extracts showed antibacterial capacity against food pathogenic bacterial spectrums such as *S. aureus, B. cereus, Campylobacter*, *E. coli,* and *Salmonella typhimurium* strains [2, 10].

Manufacturing of sorbents from winemaking waste

The conversion of Merlot and Sauvignon Blanc grape marc into sorbents, capable of lowering heavy metals concentration in wastewater is offered as a new technique to profit on agri-food waste. Activated carbon is a carbonaceous material with a high porosity that may selectively trap gases, liquids, or contaminants inside its pores, resulting in superior liquids purifying ability. It can be obtained by a variety of methods, although it has a fairly high production cost. Biochar is a carbon-rich solid material made from the processing of various source materials. It is less expensive to manufacture than activated carbon and has a similar adsorption capacity [4].

Biorefinery

The integrated use of all winery by-products, such as grape stalks, grape pomace, and wine lees, could lead to the creation of integrated biorefineries capable of producing a wide range of goods with multiple market outlets [16].

Designing a biorefinery process to fully recover and/or utilize these components will be relevant in the future. Furthermore, developing more efficient technologies and methods to improve the separation and/or recovery efficiency of valuable components is important. Before scaling up the above-mentioned processes to an industrial scale, economic and environmental assessments are required [17].

To build profitable refining schemes with wine lees processing capacities of 500 to 5000 kg/h and 120 days of yearly working time, the lowest selling prices of the antioxidant-rich extract in the range of 11.06-122 $/kg are expected [16].

Other possible applications

Because grape skin contains a high concentration of soluble sugars, it can be used to create innovative, highly flexible, biodegradable packaging materials [2]. Extracted grape skins are a viable raw material for the manufacture of low-density insulating boards [6].

Conclusions

The inappropriate wine waste handling may endanger the local ecosystem microbiologically (as growth media for pathogens) and chemically (demonstrate phytotoxicity).

Multiple modern developments and studies give an opportunity to the producers to recycle and moreover, to capitalize on this waste.

The ideal outcome is to develop a complex biorefinery to allow the production of the majority of possible goods, starting from bioethanol production and composting to extraction and processing of the valuable bioactive compounds from the winemaking wastes.

This work shows that it can be made use of all kinds of organic waste from wineries, demonstrating a novel and sustainable approach to the industry, and avoiding discarding on landfills, causing ecological issues.

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