Single cell protein from grape pomace: Sustainability in the winery to value-added food- Review

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Keywords: winery by products, single cell protein, grape pomace, waste management
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ABSTRACT.

Grapes and the obtained products (wine, grape juice and raisins) constitute an economically important factor [16]. Grape production in Greece is estimated in 990.289 tons [10]. About 80% is used in wine making and 20% of the weight of grapes processed remains as pomace [16]. A large volume (200.000 tons) of winery wastes are produced with most of them remaining unexploited every year on an international level [10].

Grape pomace is the main waste in the wine industry and it consists of skin residues, broken cells with pulp remains, stalks, and seeds [30]. According to various analyses, grape pomace could be competitive with other typical agroindustrial wastes used as substrates in solid state fermentation processes [18, 19].

In this respect, the major aim of this research work is to look for the usages of the winery wastes and more precisely the grape pomace. The objective is to develop single cell protein through solid state fermentation, a promising microbial technology for primary and secondary metabolite production [29]. This can be a way to reduce the winery waste generation and disposal, provide further alternatives to diminish the environmental impact of winery's activity and introduce additional sources of income for the winemakers.

Another important aspect to be considered is the facts of malnutrition of a huge population especially in the third world, nutritious related diseases, death starvation [17] as long as the doubled food requirements [2]. Thus, single cell protein can be an alternative and innovative way to solve the global food problem [21], apart from the high protein content, it contains fats, carbohydrates, nucleic acids, vitamins and mineral [2, 15].

This research focuses on the utilization of grape pomace and on the production of single cell protein. The results of the study reveal a potential use of winery by products in the food and animal feed industry.

Introduction

Grapes are one of the most important fruit crop with global annual production during the year 2016 almost 75, 8 million of tons [23] with 47% of the global grape production used as wine grapes [23].

Vinification as a process includes several different stages where waste can be produced (stemming, pressing, fermentation, maceration, decanting).

During the wine making process, there are produced several by-products that are rich in biodegradable organic matter that can cause, if not treated correctly, potential environmental hazards. More precisely, inappropriate grape pomace disposal can attract flies and pests and can easily create unwanted hazards [8].

Moreover, utilization of wine by-products in combination with the production of sustainable wine can provide

enough advantages in order to differentiate.

Vineyard and winemaking by-products contain valuable chemical compounds that are not extracted during wine making process.

The nutritional concentrations vary on the different type of each by-product (marc, pomace, grape seeds) and also on the different wine making process (white or red vinification). The starting point of the research is that all the by-products are rich in organic and they are able to provide the fermentation's necessary nutrient substrate.

Single Cell Protein (SCP)/microbial protein is one of the alternative protein sources that can supplement the conventional protein sources [20]. SCP refers to dead, dry microbial cells or total proteins that are extracted from pure microbial cell culture and is produced using a number of different microorganisms (fungus, algae and bacterium). SCP contains high protein, fats, carbohydrates, nucleic acids, vitamins and minerals [2, 15] and also essential amino acids like lysine and methionine that are not found in most plants and animals.

Greek legislation enforce small wineries, with up to 2000 tons wine production, to transfer their waste in collecting wells with scratch- solids retention then to septic - α-a pre-it is made available for irrigation. Only the larger wineries are obliged by relevant legislation to implement biological processing. Despite this legislation, most of the wineries reject their waste without the basic processing processes and as a result polluting polls water resources areas or small wineries generate grape marc and wine lees together with grape stalk as organic waste.

According to the European Council Regulation (EC) 479/2008 grape marc and lees must be sent to alcohol distilleries in order to produce exhausted grape marc and a liquid waste known as vinasse [28].

Grape by-products

There are two main categories of by-products that can be used: the by-products that derived from grape and the by-products from wine. In the first category stems, grape pomace and grace seeds are included whereas in the second one wine lees, soluble components of lees, tartaric acid, carbon dioxide and wastewater are included.

Stalks and grape pomace are the left-over from pressing grapes and wine lees (dead yeasts, yeast residue and other particles) is a material derived throughout the whole wine making process.

These materials are rich in biodegradable organic ingredients and can support microbial growth and emission of environmentally undesirable odors and compounds. In that case, if not treated efficiently, they can cause environmental hazards ranging from surface and groundwater pollution to foul odors [5].

Grape by-products contain a respectful amount of organic components (sugars, phenolics, lipids, pectins)

In the recent years, there are various attempts to use those by-products not only as a way to protect the environment by minimizing their unwanted effects arising from their disposal but also as a way to provide an extra income to the wine industry. Grape by-products can be used as nutraceuticals, antioxidants, colorants, antimicrobials, animal feed, fertilizers, in combustion process, biomass for biofuels, medical remedies, cosmetics and natural ingredients to improve nutritional value of food [5].

Grape pomace

Grape pomace is a major by-product of wine making, as it is equivalent to about 20% of the grapes used. It consists of pressed skins and pulp (10-12% of grapes), grape seeds (3-6%) and stems (2,5-7,5%) [34] and contributes to approximately 62% of the organic waste [23].

GP is a rich source of high value products including ethanol, tartates, malates, citric acid, grape seed oil, hydrocolloids and dietary fiber [34, 14, 7, 12].

Figure 1. The solid remain of grapes (stems, seeds, skins),
Source: Bordiga M., Valorization of wine making by-products.2016. CRC Press

Furthermore, GP has been found to be an excellent source of low-ash carbon whose extensive porosity [36]. The overall properties of GP has widen their utilization and supported the sustainable agricultural production [16] as long as the existence of phenolic phytochemicals, that are found in abundance in grapes, wines and wine by-products [5]. GP provides phenolic compounds as they share characteristics with anthocyanins in terms of solubility in waster and stability to temperature and oxygen [5].

GP is a good source of soluble fiber, with high antioxidant activity due to the natural presence of polyphenols and other bioactive compounds [32, 18, 9].Thus, GP and grape seeds extracts can be used in healthy food products such as yoghurt and salad dressing [33].

Sousa et al. [31] reported that the microbiological quality of GP can be consumed by humans due to its unfavorable conditions of low moisture and pH lower than 4.

According to Avantaggiato et al.[3], GP could remove in vitro a number of mycotoxins from liquid media, with the biosorbent efficacy in the order aflatoxin B1>zearalenone, ochratoxin A and fumonisin B1>>deoxynivalenol.

Microbial protein

Grape pomace can be useful substrate for production of microbial proteins. The utilization of grape by-products in the production of Single Cell Protein will help in controlling pollution and also in solving waste disposable problem to some extent in addition to satisfy the world shortage of protein rich food [4].

SCP has high protein content (about 60-82% of dry cell weight), fats, carbohydrates, nucleic acids, vitamins and

minerals. It is rich in certain essential amino acids like lysine, methionine which are limiting in most plant and animal foods [1]. This protein can be used as additive added to the main diet instead of sources known very expensive such as soya bean and fish [13].

Grape pomace waste with good nutrient content can be converted into food enriched with protein and feed and by properly utilizing them, will bring an end to the protein deficiency around the world. Furthermore, good nutritious food can be supplied with least expenditure of cost.

Sustainability in the winery

It is now recognized that environmental concern is leading consumers to demand for products which take environment issues into account, such as organic food, carbon neutral products or water-friendly products [24, 35, 25].

Nowadays, sustainability is not referred only in the vineyard but it refers also to energy conservation, solar and other renewable sources, efficient and recycled construction and winery's overall carbon footprint (Shannon Borg).

Research from New Zealand indicated that consumers are willing to pay more and to support wines produced from green production practices that leads to sustainably produced wines [11].

Other research findings revealed that in general consumers attached more importance to the issues of natural resources that to the water savings in wine production and that can be related to the fact that consumers are less familiar with the issue of water consumption in food production [27].

Conclusion- Discussion

There are many studies that justify positive health effects, basically associated with the known antioxidative properties of GP. The sustainable exploitation of GP can be one more useful strategy for wineries aiming towards reducing environmental contamination and as an alternative to reduce the carbon footprint in the wine production process (sustainability in the winery) as part of the seventeen Sustainable Development Goals (SDGs). In this sense, simplified processes will be the choice with the aim of an easier scale-up as well as achieving a cheaper production.

With further research elements, the present study aims to prove that grape pomace have compounds with beneficial effects when correctly used as a substrate allowing the valorization of winery by- products and produce value-added products that can be used as human or animal food.

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