

Grape pomace: a challenging renewable resource of bioactive phenolic compounds with diversified health benefits

Abstract

A pillar of high significance for human health is adequate nutrition, rich in compounds with biological action. Many epidemiologic studies have shown protective effect of plant based diets rich in phenolic compounds on cardiovascular disease, cancer, diabetes, osteoporosis and other chronic diseases. Thus, consumption of functional foods enriched with bioactive phenolic compounds and subsequent nutraceuticals has become a very interesting field of research. Recently, suppliers have turned their interest to the re-use of by-products and wastes originated by agricultural sector. The vinification process generates a large amount of solid wastes. Pomace, accounting for about 20-25% (w/w, on dry basis) of the total grape used for the winemaking process, is a promising source of nutrients and compounds with functional properties such as phenolics, indicating the potential use of this sustainable resource as food ingredient in daily diet or as nutritional supplement. This review focuses on recent studies revealing the phenolic profile of grape pomace, their potential health benefits and their possible applications, aiming to highlight the significance of integrating agro waste not only for promoting health but also sustainable development concept.

Keywords: pomace, bioactive compounds, chronic diseases, wine seeds, wine skins, phenolic compounds, phytochemicals, nutrition rich in phenolics, health promoting phytochemical compounds

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Introduction

Grape is one of the largest and most significant fruit crops cultivated all over around the world. Grapes and other products-originated from them (grape juices, raisins, jams), form a sector with high economic importance. Wine world production in 2015, reached 275.7million hectolitres.¹ The wine making process produces, each year, millions of tons of residues, such as grape pomace. Since the vast majority of wineries, world widely, are small or medium sized, waste management may become a real burden to wine producers. Re-use of grape pomace, which accounts for 20-25% (w/w) of the grape crushed for wine making, as nutritional dietary supplement or functional ingredients, would provide a sustainable alternative of post-winemaking waste treatment, providing several health benefits, promoting sustainable development.²

Grape pomace is considered a biodegradable solid by-product of winemaking process, formed after the pressing of grapes, comprised mainly of peels (skins), seeds and some part of stems, depending on both the technological process followed and the targeted product (red wine, white wine, etc.). Seeds, skins and stems are sources rich in a diversified spectrum of phenolic groups.

The aim of the present work is to report which phenolic compounds exist in grape pomace and their beneficial health benefits. Bioactive phenolic compounds extracted from wine pomace may provide great opportunities for adding value to wine residues, contributing to the development of novel functional foods and supplements, helping prevent the development of serious chronic diseases, besides promoting sustainable development through revalorization of waste residues² and decreasing environmental impact.

Grape pomace phenolic compounds and its possible health benefits

Bioactive phenolic compounds in grape pomace

Fruits, such as grape, are a basic source of bioactive phenolic compounds.³ Phenolic compounds existing in winery wastes and by-products belong to different classes. More specifically, the main groups of phenolic compounds found in winery residues are:

- i. Phenolic acids (hydroxybenzoic acids and hydroxycinnamic acids),
- ii. Simple flavonoids (flavanols or flavan-3-ols, proanthocyanidins, flavones, and flavonols),
- iii. Stilbenes,
- iv. Tannins and proanthocyanidins.

The most common phenolic compounds identified in grape pomace are presented in Table 1. Grape pomace as a whole but also its constituents, skins, seeds and stems contains a wide spectrum of phenolic compounds. The high content of grape pomace is attributed to partial and not complete extraction throughout wine making process. Total phenolic content determined in different varieties in seed extracts ranged from 88.11 to 667.98mg gallic acid/g, on dry basis, indicating a wide variation in phenolic composition among different varieties.^{4,5} This probably might be attributed either to different agro-climatic conditions or to the stage of maturation that samples were collected or to diverse genetically presented potential of phenolic biosynthesis in different grape varieties. On the contrary,

total phenolic characterization of grape skins demonstrated that there were only slight variations among the tested varieties and all tested samples contained approximately up to 112mg gallic acid/g, on dry basis.⁶ Chemical composition analyses of total phenolics in grape stems, estimated by colorimetric assays, have revealed great variations between cultivars ranging from 26.88 to 35.99mg gallic acid/g.⁷

Table I The most important phenolic compounds in grape pomace^{4,5,19,24,25,30}

Phenolic classes	Phenolic compounds in pomace
Hydroxycinnamic acids	Cafeic acid
	Ferulic acid
	Sinapic acid
	Caftaric acid
	Fertaric acid
	Coutaric acid
	p-coumaric acid
	Gallic acid
Hydroxybenzoic acids	Protocatechuic acid
	p-Hydroxybenzoic acid
	Syringic acid
Flavanols	Catechin
	Epicatechin
	Epicatechin gallate
	Kaempferol
	Quercetin
Flavonols	Isorhamnetin 3-O-glucoside
	Kaempferol 3-O-glucoside
	Quercetin 3-O-glucoside
	Quercetin 3-O-galactoside
	Quercetin 3-O-rhamnoside
	Rutin
Stilbenes	trans-Resveratrol
	trans-Polydatin

Table Continued

Phenolic classes	Phenolic compounds in pomace
Procyanidins	Procyanidin B1
	Procyanidin B2
	Cyanidin
	Cyanidin 3-O-glucoside
	Cyanidin 3-O-p-coumaroylglucoside delphinidin
	delphinidin 3-O-glucoside
Anthocyanins	delphinidin 3-O-acetylglucoside
	Malvidin
	Malvidin 3-O-p-coumaroylglucoside
	Peonidin
	Peonidin-3-O-p-coumaroylglucoside
	Peonidin 3-O-acetylglucoside
	Peonidin 3-O- p-coumaroylglucoside
	Petunidin
	Petunidin 3-O-glucoside
	Petunidin 3-O-acetylglucoside
Petunidin3-O- p-coumaroylglucoside	

Recent years, there is increased interest in the possible bioactivity of polyphenols in a variety of plant foods and products, such as wine by-products. Nevertheless, it has to be highlighted that the biological activity of polyphenols differs and is directly related to their bioavailability.⁸ Polyphenols are absorbed in small intestine and in some cases are extensively metabolized. In several situations, a part of dietary phenolic compounds are not absorbed in the small intestine and can interact with colonic microbiota, leading to possible health effects.⁹

The characterization of bioactive polyphenols derived from wine by-products is essential in order to establish ways for potential uses of pomace, after suitable processing, with aim to create functional foods and supplements.

Health related effects of grape pomace phenolic compounds

Epidemiological studies have revealed an inverse relationship between chronic diseases and phenolic compounds nutrition intake. In fact, phenolic groups are able of accepting an electron, forming phenoxyl radicals, rather stable, interrupting chain oxidative reactions in cellular components.¹⁰ Also, polyphenols possibly offer a significant protection against cancer, diabetes, cardiovascular diseases, asthma, hypertension, neurological disorders (such as Alzheimer's disease), psychiatric and in general cognitive diseases.¹¹⁻¹⁵ The possible

mechanisms of polyphenols bioactivity are based on their antioxidant activity, but plethora of studies concludes potential effect on metabolic pathways and on the expression of specific genes.¹⁶ For example, grape polyphenols seems to be able of activating specific kinase pathways in endothelial cells, such as p38 MARK (p38 Mitogen Activated Protein Kinase), ½ ERK1/2 (Extracellular Signal Regulation Kinase) and PI3-Kinase/Akt, resulting in relaxation of the arteries, through mobilization of EDHF (Endothelium Derived Hyperpolarizing Factor) and decreasing the risk for cardiovascular diseases.¹⁷

Depending on their structure, grape polyphenols exhibit a wide range of properties. Landbo et al.¹⁸ stated that malvidin-3,5-diglucoside and malvidin-glucosides, might be potent inhibitors of lipid peroxidation of human LDL.¹⁸ Catechin and epicatechin, regarding dietary importance have found several applications such as:

- i. Natural antioxidant compounds (preventing fats and oils lipid oxidation).
- ii. Nutritional supplements in animal feed, aiming to protect directly their health and their subsequent products as well as indirectly consumers through the consumption of animal products.
- iii. As functional ingredient in foods and supplements.¹⁹ Padmini et al.²⁰ stated that flavonoids consumption might increase antioxidant defense, hindering the development of degenerative diseases, caused by oxidative stress. Oxidative stress, initiated by reactive oxygen species (ROS), stimulates lipid peroxidation of phospholipids and lipoproteins in cell membranes by spreading and promoting reaction chain, thereof damaging cell membranes. Oxidative stress is considered the central risk factor for the development of diseases such atherosclerosis, alcoholic liver cirrhosis, cancer, pre-eclampsia etc. It seems that flavonoids counteract the oxidative damage of ROS, reducing the risk of development of chronic diseases.²⁰

Grape polyphenols has extensively been studied as possible functional cardioprotective agent.²¹ Proanthocyanidins in grape seeds may display anti-inflammatory action, due to their ability to scavenge free radicals, prevent lipid peroxidation and inhibit formation of pro-inflammatory cytokines.²² Chuang et al.²³ studying the effects of grape powder and its extract on glucose tolerance and chronic inflammation in high-fat-fed obese mice revealed that quercetin-3-O-glucoside, which was the compound with the highest bioavailability in grape powder extracts, can reduce several inflammatory markers in human adipocytes.²³ A one year triple-blind, placebo-controlled, clinical trial in patients with stable coronary artery disease revealed that regular intake of resveratrol-rich grape extract increased serum adiponectin, prevented incensement of plasminogen activator inhibitor type 1 (PAI-1) and inhibited atherothrombotic signals in peripheral blood mononuclear cells.²⁴

A variety of grape phenolic compounds, such as catechins, gallic acid and resveratrol, has studied in vitro as potential anticancer parameters; nevertheless, further clinical and epidemiological research is needed for safer results.²⁵ Zhou et al.²⁶ revealed that grape skin extract may protect from breast cancer with metastases in model system.²⁶ Recently, human pancreatic cancer cells treated with grape seed proanthocyanidins significantly reduced cell viability and induced apoptosis in a dose-and time-dependent manner, indicating that grape seed proanthocyanidins may inactivate NF-κB (Nuclear Factor κB), the inflammatory transcription factor thereby hindering

migration of human pancreatic cancer cell.²⁷ Also, the effects of dietary grape seed proanthocyanidins in the prevention of UVR-induced immunosuppression in animals has been clearly demonstrated, suggesting the potential usage of dietary grape seed products as chemo preventing natural sources to UV-radiation-induced melanoma and non melanoma skin cancers in humans.²⁸

Despite the scientific data of the potential polyphenols bioactivity, it has been confirmed through many studies, that only a small part of consumed phenolic compounds is normally absorbed. Throughout absorption via intestinal track, flavonols, flavonons and catechins are partially transformed in their glucuronides and sulphates. Then, liver enzymes metabolize the absorbed fraction, forming polar coconjugates excreted in the urine or go back to the duodenum. The remaining fraction of phenolics, indeed the largest proportion, is catabolized by intestinal microflora.²⁹ Thus, bioavailability of grape phenolic compounds is a parameter of high importance in order to understand its possible biological role.⁸ Further studies are required with aim to be fully explained the role of grape pomace phenolic compounds in the pathophysiology of chronic diseases and in health promotion.

Conclusion

Extraction of bioactive ingredients from grape pomace is a very interesting field not only for related scientists but also for the winemaking, food, pharmaceutical and cosmetic industrial sectors. Though characterized of high complexity scaling up the process without affecting the functionality of the phenolic compounds is very significant. Up to present, the benefits in health associated with consumption of foods and supplements enriched with phenolic compounds have been well established. On the other hand, the potential beneficial effects of consuming phenolic rich supplements derived from winery agro-wastes is a field of high interest affecting diversified markets. The phenolic profile of wine or grape pomace supports its usage as bioactive phytochemical ingredient. Research on novel extraction conditions and designing is of high significance so as to optimize phenolics release from grape pomace, maximizing its potential usage as functional ingredient with several health benefits, promoting both health and solving several waste management problems emerged by the open area discharge of wine or grape pomace by-product.

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Conflict of interest

The author declares no conflict of interest.

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