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Grape pomace as an innovative functional ingredient to design value-added food products: A review

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Abstract

The purpose of this work was to review several studies about the valorisation of grape pomace as an innovative functional ingredient to develop food products with health benefits. The idea to exploit the potential of this wine industry by-product has been focused on its high content of dietary fiber and polyphenolic compounds. Several food classes have been successfully enriched in polyphenols by incorporating of grape pomace products. Cereal products, mainly bread, cookies, biscuits and pasta are the category with the highest number of applications of wine pomace flours. The dairy products are the second class of foods in which the grape pomace products have been incorporated for a significant increasing in the content of dietary fiber and polyphenols. The wine pomace products have been also used in the meat and fish products industry. Other food products, such as marmalade and candies, tomato puree and seafood sausage have been also improved by addition of grape pomace products. The red skin extracts were incorporated into tea infusions to increase their phenolic profile and antioxidant activity. Also, the grape seed extracts have been used as natural antioxidants in edible oils or to preserve the extruded cereal chips during storage. The reviewed studies prove that it is possible to exploit the grape pomace to design innovative value-added foods.

Keywords: grape pomace, functional ingredients, value-added food products, high dietary fiber and polyphenols content

1. Introduction

Approximately 20% of the grapes weight constitutes the main winemaking by-product, called grape or wine pomace [1]. Thus, every year, the wine making leads to the generation of huge quantities of grape pomace, around 7-9 million of tons worldwide [2-4]. Wine pomace has been for a long time an undervalued product due to the lack of alternative uses with economic benefits. The grape pomace valorization has become a growing problem in the world not only in terms of ecology but also because it can be used as a cheap source of high-quality polyphenolic compounds [2].

In the last years, the health promoting potential of phenolic compounds from grape pomace has been explored in many studies. The studies done so far have shown that the phenols within grape pomace have exhibited powerful antioxidant properties, antimicrobial activity against bacteria, fungus and virus, have inhibited the oxidation of human low-density lipoproteins, and have also acted as free radical scavengers [5-7]. Skins and seeds represent about 13% of the amount of processed grapes for winemaking and are especially a rich source of health-promoting polyphenols because they are poorly extracted upon vinification [8,9].

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Traditionally, the wine pomace has been used to produce different types of "*wine alcohol*" which are used to manufacture well-appreciated distilled spirits and liquors, to produce food colorings by recovering of anthocyanin pigments, to obtain grape seed oil and also, as soil fertilizer or animal feed [10].

Winemaking by-products have revealed numerous health benefits and multifunctional effects such as natural coloring agents, antioxidant and antimicrobial properties and texturizing properties. Nowadays, there are many studies focused on the valorizing of this by-product in the following directions: to obtain dietary supplements, as a valuable ingredient into pharmaceutical or cosmetic products, as antibacterial and antioxidant agents, to obtain value-added products such as natural extracts rich in bioactive compounds with antioxidant properties, especially polyphenolic compounds and also, for the recovery of tartaric acid [2, 8, 9, 11]. Due to the potential health benefits of dietary antioxidant fiber and polyphenolic compounds of this wine industry by-product, the grape pomace has been suggested as a valuable functional ingredient to develop healthy foods for the prevention of diet related diseases such as obesity, cardiovascular disorders, and certain types of cancer [10, 12].

Taking into account the above mentioned considerations, the purpose of this work was to review several studies carried out to demonstrate the potential of grape pomace as an innovative functional ingredient to successfully develop new food products with health benefits.

2.The applications of grape pomace products in food industry

The addition of grape pomace products in various food formulas represents a valuable strategy to increase their content of dietary fiber and phenolic compounds and also to improve their antioxidant properties [2].

Several food classes have been successfully enriched in phenols by incorporating of grape pomace products [10]. Cereal products, mainly bread, cookies, biscuits and pasta are the category with the highest number of applications of grape pomace flour. The grape pomace has been incorporated into bakery products as the partial replacement of wheat flour because the grape pomace flour is gluten-free and has a high content of dietary fiber [13-15]. So far, on the international market there are very few products containing grape pomace as a replacement for conventional wheat flour. Moreover, there are no this kind of products on the Romanian market.

In the research performed by Mildner-Szkudlarz *et al*. [13] it was evaluated the effect of grape pomace addition in sourdough rye bread at four different levels of 4, 6, 8 and 10% on soluble and insoluble dietary fiber content, phenolic compounds, antioxidant activity and organoleptic characteristics of the obtained bread. The results of this study reveal that the addition of grape pomace at a level of 10% significantly improves the dietary fraction contents. Also, the addition of grape pomace greatly enhanced the antioxidant properties of the mixed rye bread. Polyphenolic compounds contribute to the major antioxidant activity and improve the color, aroma and taste. With an increase in the level of grape pomace used in the bread recipe, the hardness and gumminess significantly increased. The sensory evaluation of the enhanced bread samples revealed that the grape pomace could be incorporated at a maximum level of 6% to prepare acceptable products.

According to Rosales Soto *et al.* [14], the grape seed flour coming out from Merlot and Cabernet Sauvignon pomace waste was included in the pancakes, noodles and cereal bars. The effect of this addition was evaluated in terms of antioxidant activity and consumer acceptance. The highest antioxidant activity was recorded in the pancakes with Cabernet Sauvignon grape seed flour to a level of 25 and 30%, noodles containing Cabernet Sauvignon grape seed flour to a level of 20% and cereal bars with addition of Merlot grape seed flour to a concentration of 5%. The products with lowest consumer acceptance included pancakes with 25% Cabernet Sauvignon grape seed flour and noodles with 20% Cabernet Sauvignon grape seed flour. The cereal bar samples with 5% Merlot grape seed flour have shown a good balance of high antioxidant activity with consumer acceptability, making from this food product a promising innovative formula with grape seed flour addition.

In agreement with the research performed by Sant'Anna *et al.* [15], the grape marc powder was incorporated at a level of 25, 50 and 75 g/kg in the fettuccini pasta. The final products were evaluated over its cooking, nutraceutical and sensory properties. The addition of grape marc powder in

the recipe did not interfere in the water absorption and in the solid losses of fettuccini pasta after cooking. The addition of grape marc powder increased the content of total phenolic, condensed tannins, monomeric anthocyanin and antioxidant capacity of the cooked pasta due to the incorporation of polyphenols resulted from grape. Generally, the grape marc incorporation had a negative impact on the sensory attributes.

Thus, the best sensory acceptance of the products was obtained for a level of 25 g/kg grape marc powder.

In the study carried out by Marinelli *et al.* [16] it was obtained spaghetti enriched with grape marc extract resulted by ultrasound-assisted extraction using water as solvent. The characteristics of spaghetti were compared to control samples. In particular, the total phenolic, the flavonoids contents, the antioxidant activity, the cooking quality and the sensory acceptability were evaluated at various steps of spaghetti production. The results of this study reveal that it was possible to use grape marc extract instead of simple water to produce pasta, without to alter the sensory characteristics of the products. Also, no significant differences have been found in sensory properties of the samples. The enriched samples by grape marc extract addition have shown a higher content of phenolic compounds, flavonoids, and antioxidant activity compared to the control sample. In addition, low cooking losses have been recorded.

In the research carried out by Manner *et al.* [17] a part of wheat flour from the cookies recipe was replaced by wine grape pomace powder to a level of 5, 10, 15 and 20%. The registered results proved that the addition of wine grape pomace powder increased the antioxidant properties, total phenol content, flavonoids and anthocyanins. Also, the addition of grape pomace powder imparts brown colour to cookies compared to the control sample. The colour intensity increased with the level of grape pomace powder added in the cookies recipe. The maximum score of the sensory properties was registered at a level of 5% grape pomace powder.

According to Baiano *et al.* [18] it has been investigated the production of functional bread by replacing of water with phenolic aqueous extracts from vegetable wastes which include also the grape marc wastes. The microwave-assisted extraction was applied to obtain the phenolic extracts.

The results of this research have revealed that the highest phenolic level was found in the grape marc extract and in the fortified bread by addition of this extract. The highest antioxidant activity was registered in the crust of bread produced with the addition of grape marc extract. Generally, the replacement of water has resulted in significant decreases of the specific volume, the shift of the crumb color towards redder and yellow tones, and some changes in the sensory properties.

In the study performed by Karnopp *et al.* [19] it was evaluated the impact of organic Bordeaux grape pomace addition to a level of 20, 25, 30 g/100 g on the sensory attributes as well as physico-chemical and functional properties of cookies. This study has proved that the development of cookies with grape pomace addition is feasible and the products have shown a high dietary fiber content and significant antioxidant activity. Also, no significant differences were observed in the sensory attributes of cookie samples.

The purpose of the research carried out by Samohvalova *et al.* [20] was to determine the rational dosage of grape seed powder to obtain butter biscuits enriched with biologically active compounds. It was found that the addition of grape seed powder to wheat flour decreased the output gluten and increased the elasticity of the butter biscuits. Also, it was noticed that a level of 15% grape seed powder added in the recipe of butter biscuits represent the rational dosage for improving their physico-chemical and organoleptic properties. The increasing of grape seed powder concentration to a level of 20% slightly deteriorated the sensory properties of butter biscuits.

The results reported by Mildner-Szkudlarz *et al.* [21] proved that using of grape pomace powder in the production of wheat biscuit reduced the hardness and color deterioration. Thus, the grape pomace might be utilized to develop innovative formulation of biscuits as an alternative source of dietary fiber and phenolic compounds. The addition of grape pomace in the wheat biscuits brings along the following benefits: additional fiber content and bioactive compounds, represents a substitute for the modified food starches, decreases the gluten content and increases the amount of natural ingredients in the products.

The dairy products are the second foods category in which the wine pomace products can be incorporated for a significant enrichment of the

fiber and polyphenols content [10]. The effectiveness has been lower than in cereal products due to the instability and losses in phenolic compounds during processing and storage, as well as to other technological issues.

The study performed by Tseng & Zhao [22] has been focused on investigation of antioxidant properties and sensory attributes as a result of grape pomace products addition in the yogurt. It is known that the yogurt represents the dairy product with a high nutritional value and a low content of polyphenolic compounds and dietary fiber. Therefore, the grape pomace was used as an alternative source of antioxidant dietary fiber for enhancing the nutritional value and improving the storability of the yogurt. Different forms of wine grape pomace such as dried whole grape pomace, liquid pomace extract and freeze dried pomace extract were evaluated. The addition of grape pomace flour to milk produced excessive syneresis of yogurt at a level higher than 3%, and no coagulation was noticed at a level higher than 5%. The storage time for lesser than a week resulted in a significant decrease in the total phenolic content and antioxidant activity of yogurt. These results were assigned to polyphenols degradation at yogurt pH and also to phenol–casein interactions. The products fortified by addition of dried whole pomace powder have revealed higher dietary fiber content than samples obtained with liquid and freeze dried pomace extracts. Unfortunately, the total phenolic content and radical scavenging activity of fortified samples decreased during storage time. The fortified products have shown acceptable sensory attributes for consumers.

In the study performed by Marchiani *et al.* [23], the powders from different grape pomaces were added at two concentration levels (0.8 and 1.6% w/w) into semi-hard and hard cheeses. The obtained results revealed that the grape pomace powder can be a functional ingredient to increase the total phenolic content and radical scavenging activity in cheese. This idea can be an environmentally friendly way to manage the winemaking wastes.

The wine pomace products are also used to prepare meat and fish products as well as during storage of refrigerated and frozen meat and meat products [24, 25]. The reported data have revealed that the grape pomace products have shown antioxidant effect by inhibition of lipid oxidation, help to the microbial shelf life extension of the food products, inhibit the food pathogens and have role as fortifying and coloring agents.

In the study carried out by Sagdic *et al.* [26], the crude grape pomace extracts obtained from different grape varieties were incorporated into beef patties at different levels (1, 2, 5, and 10% w/w) to evaluate their antimicrobial effects during storage for 12, 24 and 48 h. Based on the reported it can be noticed that the numbers of microorganisms were generally decreased by the extract level during the storage time. All microorganisms tested were inhibited to a level of 10% extract in all investigated storage periods. A level of 5% extract added in the beef patties induced the inhibition of food-borne pathogens including *Enterobacteriaceae* and coliform bacteria, and the spoilage microorganisms including yeasts, moulds and lipolytic bacteria.

The study undertaken by Riazi *et al*. [27] has been focused on the effect of two levels of red grape pomace powder (1 and 2% w/w) on the color changes, total phenol content, antioxidant activity, lipid oxidation, microbial counts and sensory characteristics of the sausages. The reported results have shown that the addition of grape pomace to a level of 1% reduced the degree of lipid oxidation. Total phenol content was significantly increased with the grape pomace level. Also, oxidative stability and radical scavenging activity were significantly increased in the samples with addition of grape pomace powder. As regard the color changes, it was noted a significant reduction in lightness and yellowness of samples with grape pomace. The redness of sausages was significantly decreased by grape pomace level. The addition of grape pomace not significantly impacted on the acceptability of beef sausages. The sausages fortified with grape pomace had higher scores for taste and odor than the control sample.

In agreement with the data available on this topic, other food products have also been improved by addition of grape pomace products, such as marmalade and candies [28], tomato puree [29], seafood functional sausage [30]. The addition of dried pomace powders in these food products led to the increasing of dietary fiber content and the level of bioactive compounds.

As regards the grape pomace extracts, there is a wide diversity in the types of the grape seed or skin extracts on the basis of the total phenolics content. This variation is mainly due to the cultivar selection, the processing methods and handling.

According to the research work carried out by Bekhit *et al*. [31] the red skin extracts were incorporated at different levels ranging between 50% and 100% into tea infusions in order to increase their phenolic profile and the antioxidant activity. In other studies, the grape seed extracts have been used as natural antioxidants in edible oils to enhance their oxidative stability [32, 33] or to preserve the extruded cereal chips during storage [34].

With respect to the grape seed oil recovered from the grape pomace, it can be said that it contains high levels of unsaturated fatty acids. Actually, it is known as a product with high linoleic acid content, able to raise high-density lipoprotein (HDL) cholesterol and decrease the level of low-density lipoprotein (LDL) cholesterol. Grape seed oil is rich in tocopherols and contains higher tannins levels than other edible oils and this is the reason for its high stability against oxidative degradation of lipids [35]. Moreover, grape seed oil has shown interesting properties for the food industry due to its high smoking point. From these reasons, grape seed oil was proposed as an innovative food ingredient in various food formulations. It has been used to reduce the animal fat content in meat products, to improve the nutritional properties as well as to reduce the cooking loss, and to increase the protein solubility [36]. The incorporation of grape seed oil at a level up to 10% has been also proposed to replace the beef fat and to improve the fatty acids profile of frankfurters and beef steak [37].

3.Conclusions

The results of the studies performed so far reveal that, the grape pomace represents a valuable source of phenolic compounds, a low-cost raw material for extraction of value-added compounds used as potential functional food ingredients, especially food additives or nutraceuticals. The phenolic compounds coming out from grape pomace have the ability to enhance the antioxidant capacity and promote the health benefits. The addition of grape pomace as flour or various extracts into food formulas represents both an interesting market opportunity for wine producers that could lead to sustainable growth and development of this sector and also a strategy to increase the dietary ingestion of fiber and phenolic compounds. The presented information suggested that the grape pomace can be included as antioxidant dietary fiber to fortify the food products for promoting the nutritional benefits and extending the products shelf-life.

Thus, it can be said that it is possible to reuse the grape pomace to design new food formulas with health promoting properties and to satisfy the consumer demand for healthy products in a more sustainable perspective. Moreover, it can be managed the environmental issues due to huge amounts of grape pomace generated every year from the wine industry.

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