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Perspective of applications of wine pomace in flour-containing foods: a mini-review †

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Abstract: Wine pomace, also mentioned as grape pomace (GP), is a by-product of the wine industry, containing about 50% grape skins, 25% grape seeds and 25% stems. These wastes are of great value and great potential as a source of biologically active compounds. This opens up new prospects for the rational use of GP in the food industry. It is no coincidence that numerous new technologies for processing these by-products have recently emerged to create a wide range of diverse new food products by enriching traditional foods with antioxidants, dietary fiber and mineral compounds. The most popular GP processing products are extracts and powders. Powders do not require special storage conditions, they are highly adaptable, mixing well with other types of food raw materials, especially loose ones. Therefore, they are widely used in such products as bread, cookies, pasta, muffins, etc. Grape powders improve the structure of the dough, slow down the oxidation of fats, for example, in cookies, and increase the nutritional value of flour products. Finally, we will discuss these perspectives on the use of grape pomace as an ingredient in the formulation of flour-containing food products.

Keywords: grape pomace; grape seeds; grape skin; polyphenols; flour-containing foods; bioactive compounds

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1. Introduction

A large number of publications, including reviews, are currently devoted to the use of grape pomace in food production, for example [1–6]. This attention is based on the special composition and properties of grape pomace. The composition of this by-product depends on many factors - the place and conditions of growing the grape, its variety, harvesting conditions, methods of processing but in general, the wine pomace is the source of the following compounds. The main component of wine pomace is dietary fiber. In dried pomace, the content of dietary fiber ranges from 43% to 75%. Dietary fiber is mainly composed of cell wall polysaccharides and lignin, and also contains a considerable proportion of tannins and proteins. The protein content of wine pomace may range between 6% and 15%. It has an amino acid profile similar to that of cereals. Lipids are concentrated in grape seeds; lipid content varies from 14% to 17%. The main minerals of grape pomace are potassium, calcium, phosphorus, sulfur and magnesium [1]. Their amount varies widely. The most important component of grape pomace are polyphenolic compounds. The total extractable phenolics in grapes are present 60–70% in the seeds, and 28–35% in the skin [7]. Total polyphenol content (TPC) can vary over a wide range of 0.28–8.70 g/100g of the sample [3]. The main of the polyphenolic compounds are:

hydroxybenzoic (gallic, ellagic, vanillic, syringic, p-hydroxybenzoic) and hydroxycinnamic (ferulic, caffeic, p-coumaric, syringic) acids; flavonols (kaempferol, myricetin, quercetin and their derivatives); flavanols (catechin, epicatechin, gallocatechin, epigallocatechin, and epicatechin 3-O-gallate); anthocyanidins; tanins; proanthocyanidins; stilbenes (resveratrol tetramer and hexoside) [2]. These compounds have the potential to exert antioxidant, anti-inflammatory, antimicrobial, anticancer and antithrombotic effects, and antidepressant activity [2].

So, wine pomace has great value and great potential as a source of biologically active compounds. Numerous studies have found that, thanks to the rich chemical composition, pomace not only serves as a fortifying agent but is also capable of slowing down oxidative processes in the product and regulating its rheological properties**.** This makes the use of this by-product from wine production in food technology, and specifically in the technology of flour products, promising. Grape pomace is a perishable product, so extracts or powders are prepared from it, including separately, powder from grape seeds and powder from grape skins. A mini-review of the results of using such products from the processing of grape marc in the technology of flour products is presented below.

2. The perspective of applications of wine pomace in formulation foods

Earlier in [4], it was noted that the perspective of using grape pomace in food technologies is relevant, first of all, from the point of view of their use as a fairly valuable source of bioactive substances. From the point of view of practical use, the value of biologically active components lies in the three most important features, highlighted in [1]:

- Powerful (strong) antioxidant properties due to the high content of polyphenol compounds;
- Enriching (fortifying) properties due to the presence of minerals, dietary fiber, vitamins;
- Antimicrobial activity due to polyphenols.

The addition of processed grape pomace products as a fortifying agent for traditional flour-containing foods allows us to solve some dietary problems associated with insufficient intake of antioxidants, dietary fiber and mineral compounds. This strategy of increasing their nutritional value is in line with the current trends in the development of food technologies for functional foods. It should be noted that this strategy is not without its drawbacks. Thus, the review [1] notes both positive trends in successful fortification with improved organoleptic characteristics and technological properties of foods, and negative ones in the form of side effects. These effects are associated with color changes caused by polyphenol compounds and undesirable texture changes.

3. The applications of grape pomace products in flour-containing foods

These facts are confirmed by a mini-review of publications devoted to the effect of grape pomace processing products on the properties and quality indicators of flour-containing food products (Table 1). The most popular product for enrichment with grape pomace is bread. There are also technologies known for other products with grape powders, such as cereal bars, pancakes, waffles, biscuits, cookies, muffins, pasta and others. Our goal in this review was not to cover all possible publications in this topic. The task was to highlight the prospects of using grape pomace to enrich this type of food with some studies. The technological implementation of food fortification involves partial replacement of one or more main components of the traditional formulation. Typically, this ingredient is wheat flour, but in the cereal bars, grape pomace was introduced instead of part of the sultanas. Usually, grape pomace is used in the form of flour or powder. Grape seeds and skin flour or powders do not require special storage conditions and have such high technological properties as good miscibility with other types of food raw

materials, especially bulk ones. This feature allows them to be widely used in flour-based food.

Table 1. Effect of incorporation of grape pomace by-products as value-added ingredients to the flour-containing foods.

Type of food	Fortifying agent	Particle replace level, %	The main result			Ref.
			Nutrition value	Functional and technological properties	Sensory characteristics	
Bread	Grape seeds flour	2.5-10.0	Increase the TPC* of the bread and dough	Decrease of bread brightness and bread volume; increase bread porosity and hardness	The replacement of no more than 5% for TPC-fortified bread with acceptable sensory properties	[8]
		2.5-7.5	Increase the TPC	Increase of AA***; improved rheological properties	Change in color	[9]
		2.0-10.0	Increase the TPC, DFC**	The highest moisture and digestibility	Higher additions of grape seed flour (8-10%) were unacceptable; the darkest color which is positive	[10]
		3.0-7.0	-	The microstructure was characterized by some disruption of the gluten and starch matrix; the best rheological properties of dough with a level of 4%	-	[11]
	Grape pomace powder	5.0-15.0	Increase the TPC, antioxidant DFC	Increase of radical scavenging activity	Acceptable level of replacement with a 5% or 10%	[12]
	Grape skin flour	3.0-9.0	Not studied	Improvement of rheological properties test, increasing the viscosity modulus and reducing the loss tangent	Pleasant, fruity-acidic and easily grape specific smell; pleasant, a little sweet, and specific to wheat flour taste with lights red grape notes; darker colour.	[13]
	Soluble and insoluble dietary fibers obtained from grape pomace	5.0	Increase the DFC	Close to the control samples of bread. The best results obtained with microwave processed dietary fibers	Close to the control samples of bread	[14]

Table 1. Continuance.

Biscuit	Defatted grape seeds powder	5.0	Increase of TPC** (Gallic acid and catechin)	Increase of AA**	Decreased darker color	[15]
Noodles	Grape seeds flour	1.0-10.0	The results for the TPC and the anti-oxidant activity, showed the highest effect with 10% grape seed flour fortification	Increase in hardness	Good sensory properties	[16]
Cookies	Grape pomace (leftover skin and seeds)	2.0-8.0	Increase DFC, TPC and its protein content;	Decrease lipid oxidation and textural stability during storage time	Significant change in sensory properties	[17]
	Grape seeds and skin flour	5.0-15.0	Increase of DFC	Addition of grape skins increases water absorption and reduces dough stability; addition of grape seeds has the opposite effect	The volume and thickness of cookies, their hardness decreased with increasing levels of grape skin and seed preparations	[18]
		5.0-10.0	Increase of DFC, mainly in the form of soluble fibers	Increase of hardness	Without changing the color, taste, flavor, texture	[19]
Muffin	Grape skin flour	10.0-20.0	Increase of DFC	Increase of hardness and chewiness; decrease of springiness, cohesiveness, resilience	Good sensory acceptability; decrease of color parameters	[20]
	Grape seeds flour	10.0	The antioxidant activity of noodles increases by 8 times	-	-	[21]
Cereal Bars	Grape pomace	1.9 and 3.8 of the total mass of raw materials instead of sultanas	Increase of DFC	Increase of the mechanical strength	Darkening the color	[22]

* TPC is acronym of total phenolic content,.

**DFC is acronym of dietary fibers content and.

***AA is acronym of antioxidant activity.

The replacement level depends on the type of product, but is typically 5-10%. A smaller dosage does not ensure sufficient enrichment of the product, and a larger dosage often impairs the structural-mechanical and organoleptic properties of the products, in particular, leads to darkening of color.

As can be seen from Table 1 almost all publications indicate an increase in the total content of polyphenol compounds and dietary fibers in end-products, as well as an increase in antioxidant activity. It should be noted that it is the use of grape pomace in the form of flour or powder that allows them to be used to their maximum as a source of polyphenols, including non-extractable polyphenol compounds.

Among the positive effects of including grape pomace, it is worth noting the improvement of some functional and technological properties of semi-products and the end-product:

- Improving the rheological properties of bread dough;
- Improvement of noodle textural characteristics such as firmness;
- Increase in antioxidant properties for muffins and cookies which reduced lipid oxidation during shelf life;
- Changes in muffin texture characteristics such as firmness, chewiness, firmness, cohesion, springiness, not all of which are positive.

The data presented in Table 1 confirms the changes in sensory characteristics noted above, in particular the darker color. Although, it should be noted that in general, researchers note an improvement in the organoleptic characteristics of flour products, since darkening is not a disadvantage for all of them. So, the use of grape pomace should be considered as a more effective way to utilize by-products to enrich foods with dietary fiber and polyphenols.

4. Conclusion

This mini-review presents the successful use of grape pomace as a valuable source of important nutrients in the formulation of various flour-based food products. Particular attention is paid to polyphenols as the most important components of grape pomace. Their addition resulted in an increase in the total polyphenol content and an increase in the oxidative stability of the fortified products. On the other hand, a negative effect on textural and organoleptic characteristics was noted. In general, the data presented confirm the prospect of using grape pomace as an ingredient for creating flour-based functional products.

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