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Proceeding Paper

Benefits and Drawbacks of Incorporating Grape Seeds into Bakery Products: Is It Worth It? †

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Abstract: Grapes are the third most produced fruit in the world, owing to their taste and use as raw materials for winemaking. Due to this fact, large volumes of waste biomass are generated as a result of grape juice and wine production, mainly grape seeds (GS) and peels. In recent decades, scientific research has highlighted the high content of polyphenols in GS, especially condensed tannins, and resveratrol. These compounds have been associated to various potential benefits to human health, such as antioxidant, hypoglycemic, hypolipidemic or anti-inflammatory bioactivities, among others. GS polyphenols may be incorporated into functional foods. Flour in wheat-based bakery products especially appears to be an attractive option. Two strategies may be followed. On one hand, the incorporation of GS flour increases the fiber, mineral, and protein content of bakery products, as well as their hardness and phenolic content. However, it seems that consumers may accept up to 10% of GS flour, since higher doses strongly diminish the organoleptic properties of the product. The other alternative involves the incorporation of polyphenol-rich GS extracts into bakery formulations, which would transfer their beneficial bioactivities to the final product. Nonetheless, this method is more laborious since it requires a prior chemical extraction of GS, and the control and addition of a safe, food-grade extract into the flour. Both strategies have been reported to increase the phenolic content and antioxidant capacity of bakery products. The direct incorporation of GS flour is affordable for industries, while the incorporation of polyphenol-rich extracts leads to the development of functional products with additional beneficial properties. This work discusses the benefits and potential hurdles of functional bakery products with incorporated GS flour and extracts, based on up-to-date evidence.

Keywords: grape seeds; bakery products; polyphenols; functional foods; circular economy

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1. Introduction

Winemaking generates waste in the form of grape pomace, seeds, and skins that remain after the wine has been pressed. Based on some estimates, approximately 20% of the total grape weight is disposed as waste in the form of seeds, stems, and skins, which can represent over 8 million tons of grape pomace waste worldwide [1]. Of this, grape seeds (GS) constitute the most environmentally persistent waste. Removal of this waste is costly and if it is not treated effectively, it may pose an environmental issue, since these seeds contain high levels of condensed tannins (CT) and other phenolic compounds (PC), that if concentrated, may have negative impacts on soil [1]. PC, however, have attracted a great deal of interest both by the industry and academia, since they have been reported to exert antioxidant, hypoglycemic, anti-obesity, anti-inflammatory, or cardioprotective effects, among many others [2]. Grape seeds have a high content of PC such as phenolic acids, monomeric PC (e.g., flavanols such as catechin or epicatechin), polymeric CT, and in the case of red grape varieties, several anthocyanins [3]. In addition, GS are one of the richest natural sources of resveratrol, a stilbene associated with highly promising anti-obesity effects [4]. On the other hand, there is an increasing demand of healthier foods prepared with natural ingredients, and this has given rise to functional foods which have potential health benefits besides their nutritional ones [5]. Therefore, one possible alternative for the management of GS as organic waste has been their application toward the fortification of several foodstuff, of which bakery products have emerged as the most feasible to produce, attractive to consumers, and easy to commercialize. Moreover, bakery products made with refined wheat flour generally lack a great quantity of nutrients and are often described as highly glycemic foods, since their only value is as highly energetic foods [6].

Non-conventional flours have been studied to increase the nutritional value of traditional flours, such as wheat, and compensate for the loss of nutrients that occurs after the refining process, for example, a mixture of flours from other options that are considered in baking, for which GS are a promising candidate [7]. Improvements in technological and nutritional characteristics have already been observed, without compromising the final acceptance of bakery products, resulting in potential health benefits [8]. As such, GS as part of flour appear to be a promising alternative to develop fortified foods. Nonetheless, PC-rich extracts may be obtained from GS and applied to flour formulations as a functional alternative to enrich these products (Figure 1).

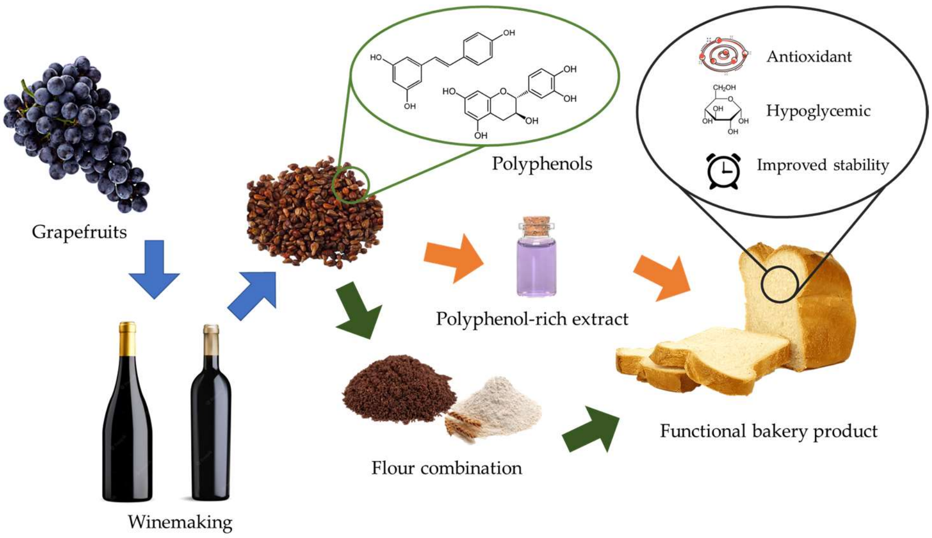

Figure 1. Grape seed revalorization as a functional ingredient in bakery products.

2. Incorporation into Bakery Products

2.1. Incorporation of Grape Seed Flour

GS are composed of approximately 40% fiber and 7% complex phenols, including CT, in addition to about 10% protein and other constituents, such as fatty acids, sterols, or minerals [9]. This means that, although the PC and fiber contents of GS are the main reason for their health benefits, the organoleptic properties of the final bakery products will be heavily altered. In particular, it has been consistently observed that combining GS flour with other flours, and particularly wheat, generally produces much denser doughs, at least upon using combinations of up to 10% of the flour weight [9]. This generally leads to a poorer gasification of the dough during fermentation and oven-baking, positively correlated with increasing GS flours concentrations making denser doughs [10]. GS flour concentration may be increased up to 20%, but rheological and organoleptic properties are negatively affected to the point the product may be unacceptable [9]. In addition, although the addition of GS may negatively alter the textural properties of the dough, it has been observed that elasticity and stability are positively improved [5]. This is probably due to their increased water absorption capacity, which impacts the moisture of the final product [11]. Moreover, there is a significant alteration of taste, as with increased GS concentrations, PC (and especially CT) provide the bread with a strongly bitter/sour taste, a common feature which can be more nuanced in complex PC [3].

However, considering the GS composition, this provides the end-product with additional fiber and mineral content. This also results in increased antioxidant properties, as the incorporated GS flour retains PC embedded in the seed tissue. It has been reported that white grape pomace flour addition (10%) can increase the fiber content of fortified breads by 88% and the levels of phenolic acids from 0.1 mg/g to 0.3 mg/g [12]. However, as the GS flour is kept at relatively low proportions, this antioxidant effect is much lower than that of GS alone [13]. For example, it was reported that following an in vitro ferric reducing power (FRAP) assay, bread made with 6% GS flour achieved an antioxidant effect more than 10 times higher than the control bread, with 590 mg Trolox equivalents (TE)/100 g vs. 45 mg TE/100 g, but was much lower than the unmixed GS (2775 mg TE/ 100 g) [13]. Similar results were obtained in other recent studies, with 6% GS addition reaching 346 mg TE/100 g, while the control bread showed 70 mg TE/100 g [14]. This evidences that GS flour incorporation may prove beneficial to some extent, considering its very low economic cost and antioxidant properties. However, such effects are also limited, since the resulting bakery product will not be accepted if more than 10% of GS is added due to the resulting poor texture and flavor [15].

2.2. Incorporation of Grape Seed Extracts

Another strategy, involves the processing of GS to obtain chemical extracts with high concentrations of polyphenols, which may be added to the flour, thus working as a natural additive. This fortification may provide the end product with natural antioxidants, thus furthering their range of action and effectiveness [16]. The application of GS extracts on breads has been associated with greatly ameliorating acrylamide production during baking (66 µg/kg vs. 296 µg/kg in the control), as well with improved antioxidant capacity [17]. In contrast to the incorporation of GS flour, the addition of GS extracts is accounted to not significantly alter the texture of the produced breads [17]. Thus, the incorporation of GS extracts not only adds beneficial phytochemicals to the end-product, but also prevents negative alterations that the flour incorporation may involve. Indeed, it appears that PC are better retained in the form of extracts than in the form of flour. For example, following measurements via total phenolic content (TPC) analyses, GS flour breads displayed up to 45 mg gallic acid equivalents (GAE)/100 g [18], with a 5% substitution, while 1.5% addition of GS extracts increased this value more than 10 times, up to 580 mg GAE/100 g [17].

GS extracts have been applied to other foods such as mackerel, showing improved storage stability and delay of degradation [19]. In this sense, GS extracts have showed an improved delay of spoilage by microorganisms [16]. Moreover, the anti-obesity and antioxidant effects of GS extracts are well established [20]. Indeed, the intake of GS extracts has been reported to inhibit postprandial glycemia in small-scale clinical trials. It was showed that even when subjects had high-calorie meals, a daily intake of 100 mg of GS extract could ameliorate glucose levels (5.63 mmol/L vs. 6.99 mmol/L) [21]. Therefore, given that PC from GS are retained in the bakery product even after baking and at high concentrations, it is suggested that they can exert these anti-glycemic and anti-obesity effects more effectively as added extracts [17]. This was demonstrated in an in vivo study on the breads fortified with grape skin extracts (1.4%), which significantly reducing the fat and protein digestion in treated rats. Being fed a high-fat diet, supplementation with the fortified bread powder resulted in decreased low-density lipoprotein (LDL) cholesterol levels, decreased leptin secretion, and glycemia, among other markers. This suggested that grape waste-derived extracts were effective in ameliorating diet-induced obesity symptoms [22]. Notably, in the same study, flour supplementation resulted in slightly better results, but this was coupled with a more negative impact on organoleptic properties that the extract addition eliminated [22]. However, there is a lack of more accurate and concise studies directly assessing the effect of GS extract addition on critical quality parameters such as storage time, organoleptic properties alterations, and direct potential health benefits from the intake of the formulated bakery products. On the other hand, many studies assess whole pomace or skins, making it difficult to discern the effect of seeds alone [12].

3. Conclusions

The valorization of winemaking wastes such as GS can be easily and beneficially reintegrated into the food industry. This waste represents natural sources of antioxidants, of which reutilization enables the reduction in synthetic analogues related to negative side effects. The incorporation of these antioxidants as preservatives maintains the stability of the final product, while potential health benefits may be added. Moreover, this reutilization of GS can be an effective strategy to produce added-value products, while reducing volumes of this biomass destined for landfilling, thus promoting a circular economy model. This fact can contribute to the higher perceived value by consumers that would balance the cost of the development of new formulations and optimization of food-making processes. Considering both strategies of GS incorporation and their derived extracts into the final product, it can be suggested that GS flour appears as the most feasible and economic practice, at concentrations of up to 10% of the total flour weight. However, this limitation is accompanied by a proportional limitation of the antioxidant activity of the fortified bakery products, but if such limit is exceeded, acceptability of the product may be compromised. In this sense, the inclusion of GS extracts as natural additives results in higher antioxidant properties of the product, with reduced alteration of organoleptic properties. Altogether, considering available reports, it would seem that the current best strategy to develop bakery products valorizing GS would be to apply PC-rich extracts. Nevertheless, this could lead to additional costs of the end-product that could act as deterrents to its consumer acceptability. Further research could unveil alternative optimized methods to compensate the current shortcomings in valorizing GS for functional bakery products.

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