REVIEW

RECOVERY OF WINEMAKING BY-PRODUCTS FOR INNOVATIVE FOOD APPLICATIONS

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ABSTRACT

Winemaking by-products are potential resources for second-generation biorefineries, i.e., biorefineries fed with biowaste to produce added-value products, particularly for the food sector. In fact, winemaking by-products are outstanding sources of oil, phenolic compounds and dietary fibre and possess numerous health benefits and multifunctional characteristics, such as antioxidant, colouring, antimicrobial and texturizing properties. The present review highlights promising developments for the conversion of winemaking by-products into novel food ingredients, as well as their use in innovative foods, focusing on the type of recovered ingredients, dosage, formulation and processing. In addition, the primary benefits of winemaking by-products to new foods are described.

Keywords: by-products, dietary fibre, grape phenolics, grape seed oil, winemaking

1. INTRODUCTION

Food supply chains have significant environmental impacts due to their use of resources and production of emissions, effluents and wastes. According to the European Union (EU) Commission Council Directive 2008/98/EC, "waste" is defined as "any substance or object, which the holder discards or intends or is required to discard". The importance of food waste stretches from environmental pressures to economic and social impacts, including negative effects on food and nutrition security (OTLES *et al.*, 2015).

To meet the overall objective of increasing the sustainability of production chains, waste prevention/minimization is the main priority and best option, followed by reuse, recycling and energy recovery. Alternatively, disposal (the use of landfills or incineration with low energy recovery) must be considered the worst environmental option. Reuse and recycling strategies have drawn attention on the valorisation of by-products. A "by-product" is defined as a product that must originate from a production process without being the main goal of production, be usable in the same production process or in a subsequent production or utilization process and be directly re-usable without further treatment outside normal industrial practices. Moreover, a by-product must have a market value, and the final use should be integral without negatively impacting human health or the environment (GALANAKIS, 2015).

Like all agro-food productions, the winemaking process generates a series of by-products that are important from both a quantitative and qualitative point of view and have been considered potential resources for second-generation biorefineries, i.e., biorefineries fed with biowaste to produce added-value products (SCOMA *et al.*, 2016). In fact, grapes are one of the most cultivated fruits worldwide. According to the FAO (www.faostat3.fao.org), 77 Mt of grapes were produced throughout the world in 2013 (most of which were used in winemaking), along with 3.4 Mt of grape pomace (otherwise referred to as grape marc). The latter represents, by weight, the primary winemaking solid by-product (60% on average), followed by lees (approximately 25%) and stalks (approximately 14%). Minor solid by-products mainly include wine filtration residues. On average, depending on the grape variety and winemaking process, 100 kg of processed grapes generates 20-25 kg of pomace, a mixture of skins and seeds, 3-5 kg of stalks and 8-10 kg of lees (SPIGNO, 2015).

All of the aforementioned by-products pose serious environmental concerns because their production is typically concentrated in a limited time frame, and their high organic matter content prevents direct disposal into the soil, except for limited and regulated amounts. Although these materials are re-used for other applications, being correctly considered as by-products, landfill additions and incineration are also conducted, depending on the country. Conventional applications for winemaking by-products include: agronomic use, animal feed production and compost production for all residues; distillation for pomace and lees; tartaric acid manufacturing and the production of colouring additives and nutritional supplements from pomace, lees and filtration residues; oil recovery from seeds. Agronomic use, animal feed production, composting and distillation, a relatively new approach, are not considered remunerative strategies (SPIGNO, 2015).

If properly recovered, winemaking by-products show a wide range of potential and remunerative applications in many industrial sectors, including cosmetics, pharmaceuticals, biomaterials and food (BORDIGA, 2015; YU and AHMEDNA, 2013). In fact, grape pomace is a rich source of both dietary fibre and various phenolic compounds (TEXEIRA *et al.*, 2014). The amount of phenolic compounds that remain in the pomace depends on the initial, genetically dependent content of grapes, as well as the processing conditions and skin thickness, which is another genetically dependent parameter that is crucial for the maceration phase (BATTISTA *et al.*, 2015). A study of various cultivars of

Vitis vinifera L. has revealed that the content of soluble proanthocyanidins in the skin ranges between 1.16 and 44.6 g/kg d. w., while the content of soluble proanthocyanidins in seeds ranges between 23.1 and 68.5g/kg d. w. (TRAVAGLIA *et al*., 2011). The total anthocyanin content of red grape skins is in the range of 2.5-132 g/kg d. w. (KAMMERER *et al*., 2004; SRI HARSHA *et al.,* 2013). The presence of anthocyanins in the red grape seed fraction, due to mash constituents adhering to the seeds, is generally neglected or reported to be low (KAMMERER *et al*., 2004; LAVELLI *et al*., 2015a). However, a recent patent was focused on the extraction of anthocyanins from grape seeds, suggesting that their content deserves attention in a full recovery strategy (BI and RUI, 2014). The total flavonol content of grape skins is in the range of 0.3-2.6 g/kg d. w. (SRI HARSHA *et al*., 2013; SRI HARSHA *et al*., 2014), whereas these compounds are generally less than 0.1 g/kg d. w. in grape seeds (MAIER *et al*., 2009b). Compared to the above-mentioned phenolic compounds, phenolic acids and stilbenes are present in considerably lower amounts in winemaking by-products (KAMMERER *et al*., 2004). Grape seeds contain oil with a high nutritional value. Among various vegetable oils, grape seed oil shows the largest percentage of linoleic acid (C18:2 ≈70%). Other major fatty acids present in grape seed oil include oleic acid (C18:1 ≈15%), palmitic acid (C16:0 ≈7%) and stearic acid (C18:0 ≈3%) (HANGANU *et al*., 2012; FERNANDES *et al*., 2013; FIORI *et al*., 2014). In addition to the interesting fatty acid profile, grape seed oil contains significant amounts of bioactive compounds such as tocopherols and tocotrienols, presenting a total tocol content up to 1208 mg/kg (BEVERIGE *et al*., 2005; CREWS *et al*., 2006; FIORI *et al*., 2014).

Winemaking by-products are of particular interest for food uses when they are obtained via organic production because consumer preference is positively influenced by information on sustainable production practices (LAUREATI *et al*., 2013). In particular, a great deal of interest in sustainability issues has been expressed for winemaking (LAUREATI *et al*., 2014). The purpose of using winemaking by-products in foods may be fortification or enrichment. The distinction between these terms is not always recognized in scientific studies but has been clarified as follows: a fortified product is defined as a food containing additional nutrients, while an enriched product is defined as a food with additional novel nutrients or components not normally found in a particular food (SIRO' *et al*., 2008).

Tartaric acid, enocyanine (E163) and grape seed oil are classical examples of successful commercial products obtained from winemaking by-products. Additionally, in the last several years, grape seed and grape skin powders have been commercialized by different companies and promoted as highly nutritional ingredients to enrich conventional cereal flours and baked products with fibre, minerals, antioxidants, colour and aroma. The concept of antioxidant dietary fibre was first proposed by SAURA-CALIXTO (1998), who set the criteria that 1 g of antioxidant dietary fibre should possess a free radical scavenging capacity equivalent to at least 50 mg of vitamin E and should contain more than 50% dry matter of dietary fibre from the natural constituents of the material. Whole grape pomace, grape seeds and grape skin generally meet these criteria and are often referred to as antioxidant dietary fibre. Enocyanine and grape antioxidant dietary fibre represent the two basic solutions for the reintroduction of grape pomace into the food chain, including indirect and partial use as concentrated extracts, or direct use as ground, dehydrated and micronized antioxidant dietary fibre. In both of the above-mentioned cases, a new production process must be implemented.

Fig. 1 shows a schematic depiction of the basic conventional process for antioxidant dietary fraction production.

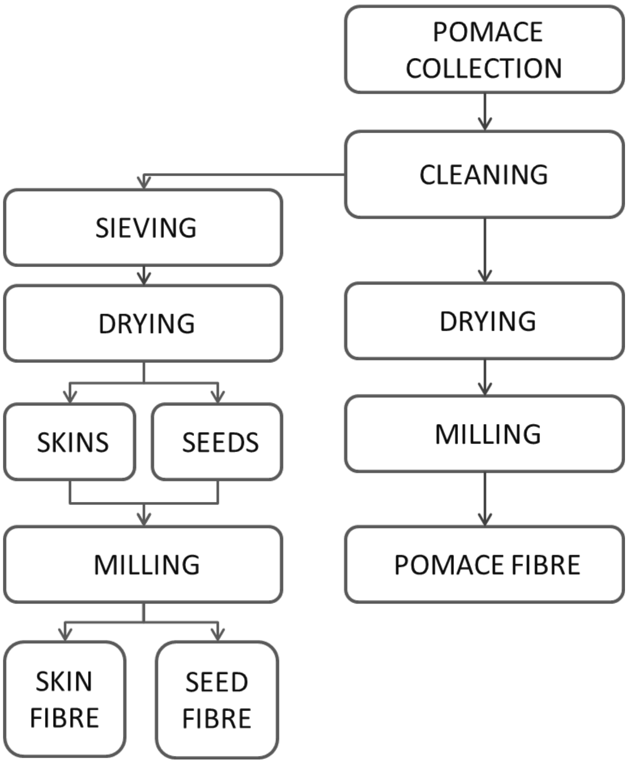

Figure 1: Scheme of the basic process for the production of grape pomace, skin or seed antioxidant dietary fibre.

Pomace collection should follow preliminary care selection to identify the best pomace for the production of food grade ingredients, based on the content of functional constituents (fibre, polyphenols and minerals), as well as possible contaminants (heavy metals, pesticides residuals and mycotoxins) (CORRALES *et al.*, 2010; SOLFRIZZO *et al.*, 2012). Washing and cleaning operations should be required, while the recovery of phenolic compounds would be reduced. If needed, skins and seeds can be separated by sieving, before or after drying. Of course, drying is necessary to obtain a final powder but is also the most common stabilisation treatment. Grape pomace has a high moisture content (greater than 60%) and undergoes rapid fermentation if not properly treated. Low temperature preservation may precede the drying step for logistic and timing reasons. Drying, which is an energy consuming process, should be reduced to a minimum because the thermal degradation of antioxidant compounds is detrimental to the nutritional profile. However, drying allows for the inhibition of enzymatic activity and can be considered a mild sanitization process. The operating temperature should not exceed 60°C to limit the degradation of phenolic compounds (AMENDOLA *et al.*, 2010). In the production of antioxidant dietary fibre from skins and seeds, the seeds can be defatted in a previous step to recover the oil and produce a fibre-rich ingredient with limited rancidity issues. The final milling step must set the ideal particle size, depending on the expected application. If dried skins and seeds are destined for the production of an extract, a particle size range of 0.5 to 2 mm is acceptable. As outlined in the following paragraphs, the particle size should be less than 0.5 mm for use in bakery products or pasta. For applications into fruit-based and dairy products, an even lower particle size is required, which leads to additional energy consumption.

Fig. 2 shows the basic process for the production of grape pomace, skin or seed extracts (SPIGNO, 2015).

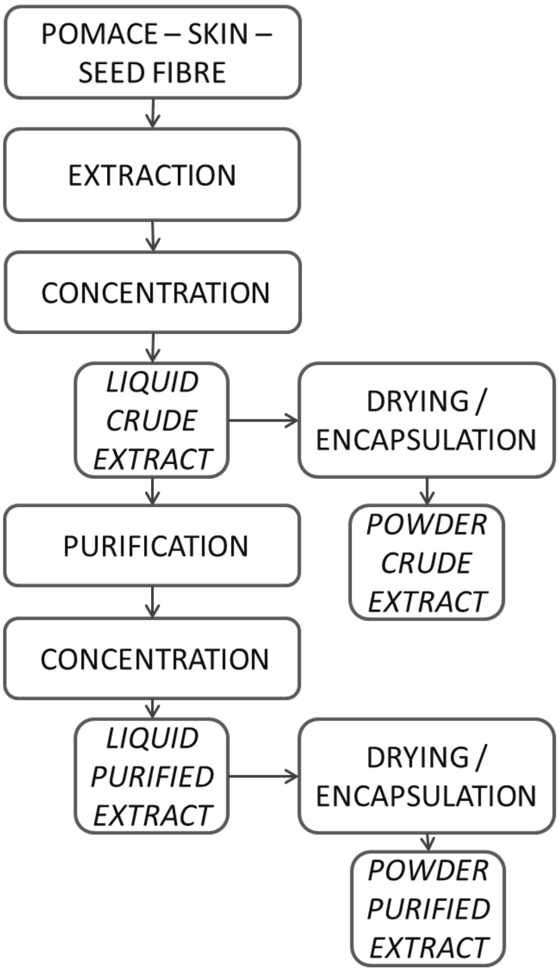

Figure 2: Scheme of the basic process for the production of extracts from grape pomace, skins or seeds.

As indicated in the production of antioxidant dietary fibre, the operating temperature should be less than 60°C. Different extraction techniques can be applied, such as conventional solvent extraction using food-grade solvents (AMENDOLA *et al.*, 2010), or non-conventional solvents and systems for the development of sustainable and environmentally friendly processes. The ultrasound-assisted extraction has been successfully applied for the extraction of grape pomace phenolics, using water as a solvent and achieving high extraction yield with a short extraction time (MARINELLI *et al.*, 2015). Microwave-assisted solvent extraction using ethanol/water (PEDROZA *et al.*, 2015) and high-pressure extraction using ethanol/water (PAINI *et al.*, 2016), as well as the use of aqueous solutions of organic acids (TZIMA *et al.*, 2015) have also been proposed. In general, all of these systems are characterized by low selectivity, and other compounds (such as sugars, minerals and organic acids) are co-extracted with the phenolic compounds, producing a crude extract. For food applications, the purification of extracts may be omitted without further increasing the production costs. The crude extract can then be simply concentrated to give a liquid extract or dried to give a powder extract. In this case, using a tailored approach (that takes into account the food category of the final target), the addition of suitable carrier materials (e.g., maltodextrins) can be exploited to increase and modify the stability and solubility of phenolic compounds (SPIGNO *et al.*, 2013; LAVELLI *et al*., 2016b). To obtain an extract with a higher purity in total phenolic compounds or within a selected class of phenolic compounds, a purification step is required. Adsorption resins (SOTO *et al*., 2011) and membranes (ZAGKLIS and PARASKEVA, 2015) are the most commonly investigated purification systems, along with other non-conventional approaches, such as the use of colloidal gas aphrons (SPIGNO *et al*., 2015). In any case, microfiltration is also suggested as a non-thermal technology to produce crude extracts while promoting microbiological stability.

Independent of the production process used to obtain grape pomace antioxidant dietary fibre, phenolic extracts or seed oil, this review describes literature examples of innovative food applications into meat, fish, cereal, fruit-based and dairy products, with a focus on the type of recovered ingredient, dosage level and primary results achieved by the application.

2. PHENOLIC EXTRACTS AND ANTIOXIDANT DIETARY FIBRE FROM GRAPE SKINS AND SEEDS AS INGREDIENTS IN INNOVATIVE FOODS

2.1. Functional effects

New ingredients recovered from winemaking by-products have the potential to provide a wide range of food products with numerous health benefits (SAURA-CALIXTO, 1998; TEXEIRA *et al*., 2014). Moreover, as outlined in the following sections, these by-products possess multifunctional properties and could be used as natural antioxidants, colorants, antimicrobial agents and texturizers.

2.1.1 Meat products

Due to the growing interest in convenience foods, ready-to-eat products such as dehydrated meat, frozen and precooked hamburgers, patties and meatballs have become a major category in the meat industry. The quality and shelf-life of these products is primarily dependent on the inhibition of lipid oxidation, which affects the colour, flavour, odour, texture and nutritional value of foods (FERNANDEZ *et al*., 1997). Consequently, research efforts have been devoted to the application of winemaking by-products in various meat products to prevent lipid oxidation during precooking and storage under refrigerated or frozen conditions, representing natural alternatives to the use of synthetic antioxidants (Table 1). In addition to auto-oxidation, microbial contamination is another serious factor that affects the quality and shelf-life of ready-to-eat meat products. However, only a few studies have investigated the antimicrobial properties of winemaking by-products in meat products (AHN *et al*., 2007). Regarding chicken meat, when red grape skin extract powder was added to the dehydrated product at a level of 1 g/kg_{meat}, the content of hexanal and thiobarbituric acid reactive substances (TBARS) formed during processing and storage at 22°C under air decreased. However, the efficacy was lower than those of rosemary extract and synthetic antioxidants, such as butylated hydroxyanisole and butylated hydroxytoluene (NISSEN *et al*., 2000). The antioxidant dietary fibre obtained from red grape pomace with particle sizes < 0.5 mm (total dietary fibre: 782 g/kg; soluble phenolics: 49.3 g/kg) has been applied to chicken hamburger, delivering fibre and imparting antioxidant effects during processing and refrigerated storage under air (SAYAGO-AYERDI *et al*., 2009). Alternatively, the extract obtained from the entire pomace (skins and seeds) has been proven to act as an antioxidant in uncooked and cooked chicken meat at a concentration corresponding to 60 mg $phenolics/kg_{meat}$ during processing and frozen storage under vacuum (SELANI *et al*., 2011).

Table 1: Applications of winemaking by-products as new food ingredients in meat products.

Food product	Recovered ingredient	Main results and references
Chicken meat (dehydrated)	Red grape skin extract powder (soluble TP: 1.60 mmol phenol Eq./g) Integration: 1 g/kg_{meat}	Decrease in hexanal and TBARS content during processing and storage at 22°C in aluminized sachets sealed in air. Lower efficacy than rosemary extract. NISSEN *et al.*, 2000
Chicken hamburger (uncooked and pre-cooked)	Red grape pomace antioxidant dietary fibre (particle size < 0.5 mm; TDF: 782 g/kg; soluble TP: 49.3 g GAE/kg) Integration: 5-20 g/kg_{meat}	Decrease in TBARS content during processing and storage in polyvinyl chloride bags (OTR: 13.500 cm^3/m^2d) at 4°C. High antioxidant activity and fibre content. SÁYAGO-AYERDI *et al.*, 2009
Chicken meatballs (uncooked and pre-cooked)	Red and white grape pomace extract (soluble TP: 7.8-9.4 g GAE/kg) Integration: 60 mg TP/kg_{meat}	Decrease in TBARS content during processing and storage at -18°C under vacuum. SELANI *et al.*, 2011
Pork patties (pre-cooked)	Red grape skin extract powder (soluble TP: 1.60 mmol phenol Eq./g) Integration: 0.2 g/kg_{meat}	Decrease in hexanal and TBARS content during processing and storage at 4°C in polyethylene bags (OTR > 2000 cm^3/m^2d). Lower efficacy than rosemary extract. NISSEN *et al.*, 2004
Beef and pork patties (pre-cooked)	Grape seed extract powder (TP: 980 g/kg) Integration: 0.1-0.2 g/kg_{meat}	Decrease in TBARS content during processing and storage in polyvinyl chloride bags (OTR: 880 cm^3/m^2d) at 4°C. ROJAS and BREWER, 2007
Pork patties (pre-cooked)	Grape seed extract powder (TP: 865 g/kg) Integration: 0.05-1 g/kg_{meat}	Decrease in TBARS content during processing and storage in barrier film packs (OTR: 3 cm^3/m^2d) under 75% O_2 and 25% CO_2, at 4°C. CARPENTER *et al.*, 2007
Beef ground meat (pre-cooked)	Grape seed extract powder (TP: not specified) Integration: 10 g/kg_{meat}	Reduced numbers of *Escherichia coli* O157:H7, *Salmonella typhimurium*, *Listeria monocytogenes* and *Aeromonas hydrophila* during storage in bags (OTR: not specified) at 4°C. AHN *et al.*, 2007
Beef sausage (pre-cooked)	Grape seed extract powder (TP: 800 - 990 g/kg) Integration: 0.1-0.5 g/kg_{meat}	Decrease in TBARS content during processing and storage in polyvinyl chloride bags (OTR: 880 cm^3/m^2d) at -20°C. Higher efficacy than ascorbate. KULKARNI *et al.*, 2011

OTR: oxygen transmission rate; TBARS: thiobarbituric acid reactive substances; TDF: total dietary fibre; TP: total phenolics (expressed as GAE: gallic acid equivalents or phenol Eq: phenol equivalents or PAs: proanthocyanidins).

Considering pork meat, red grape skin extract powder added at a level of 0.2 g/kg_{meat} enhanced the oxidative stability of cooked patties during processing and refrigerated storage under air but showed lower efficacy than rosemary extract, as observed for chicken meat (NISSEN *et al.*, 2004). Grape seed extract appears to be more effective than grape skin extract. In fact, grape seed extract powder added at a level of 0.1-0.2 g/kg_{meat} had better antioxidant effects compared to rosemary oleoresin and oregano water extract during the processing and refrigerated storage under air of cooked beef and pork patties (ROJAS and BREWER, 2007). Grape seed extract powder is also an effective antioxidant in cooked pork patties during processing and frozen storage under a high-oxygen atmosphere, when added at a concentration as low as 0.05 g/kg_{meat} (CARPENTER *et al.*, 2007).

In ground beef, grape seed extract powder has been demonstrated to inhibit the growth of *Escherichia coli* O157:H7, *Salmonella typhimurium*, *Listeria monocytogenes* and *Aeromonas hydrophila* (AHN *et al.*, 2007) at a level of 10 g/kg_{meat} during refrigerated storage. However, the required addition of grape seed extract is higher than the effective amount for the inhibition of meat oxidation. In fact, at an extract concentration of 0.5-1 g/kg_{meat}, grape seed extract powder prevented the oxidation of beef sausage during processing and frozen storage under air, more effectively than ascorbic acid (KULKARNI *et al.*, 2011).

2.1.2 Fish products

Fish tissues have a high content of polyunsaturated fatty acids (PUFA), which undergo degradation via auto-oxidation. The use of natural antioxidants has become as an effective strategy for controlling the stability of these products, either during the frozen storage of minced tissue or during the processing and refrigerated storage of pre-cooked fish-based products. For this purpose, winemaking by-products have also been considered (Table 2).

Table 2: Applications of winemaking by-products as new food ingredients in fish products.

Food product	Recovered ingredient	Main results and references
Atlantic mackerel minced muscle (uncooked)	Phenolic fractions of white grape pomace. Integration: 0.1 g monomeric flavonoids or PAs/kg_{fish}	Longer induction period for the formation of peroxides and aldehydes during storage in Erlenmeyer flasks under air at -10°C. Maximum protection by PAs with high degree of polymerization and percentage of galloylation. PAZOS *et al.*, 2005
Horse mackerel minced muscle (uncooked)	White grape pomace antioxidant dietary fibre (particle size < 0.25 mm; TDF: 760 g/kg; soluble TP: 78 g GAE/kg) Integration: 20 - 40 g/kg_{fish}	Inhibition of formation of conjugated dienes and trienes and TBARS during storage in Cryovac BB4L bags (OTR: 30 cm^3/m^2d) at -20°C. Significant antioxidant activity and high fibre content. SANCHEZ-ALONSO *et al.*, 2008
Chub mackerel minced muscle (uncooked)	Red grape seed extract (soluble TP: 66 g GAE/kg) Integration: 20 g/kg_{fish}	Inhibition of lipid hydroperoxides and TBARS formation during storage in cartoon trays under air at -20°C. OZEN *et al.*, 2011
Meagre sausage (pre-cooked)	White grape skin antioxidant dietary fibre (particle size < 1 mm; TDF: 820 g/kg; soluble TP: 42 g GAE/kg) Integration: 30 g/kg_{fish}	Inhibition of TBARS formation and oxidation during storage in barrier bags (OTR: < 2.1 cm^3/m^2d) at 2°C. Significant antioxidant activity and high fibre content. Antimicrobial effect on H_2S producers and a reduction in total viable counts. RIBEIRO *et al.*, 2013

OTR: oxygen transmission rate; TBARS: thiobarbituric acid reactive substances; TDF: total dietary fibre; TP: total phenolics (expressed as GAE: gallic acid equivalents or sum of monomeric flavonoids or PAs: proanthocyanidins).

Fractionated grape pomace phenolic compounds at a concentration of 0.1 g/kg_{fish} have been proposed as inhibitors for fatty fish species, such as the muscle of Atlantic mackerel (*Scomber scombrus*) during frozen storage under air. The induction period for the formation of peroxides and aldehydes was significantly increased in samples treated with grape phenolic fractions, and the maximum protection was achieved using procyanidins with a high degree of polymerization and percentage of galloylation (PAZOS *et al*., 2005). Non-fractionated grape seed phenolics also increased the oxidative stability of minced fish during frozen storage under air (OZEN *et al*., 2011).

The antioxidant dietary fibre obtained from white grape pomace with a particle size < 0.25 mm (total dietary fibre: 760 g/kg; soluble phenolics: 78 g/kg) at a concentration of 20-40 g/kg$_{fish}$ can also increase the oxidative stability of the minced muscle of horse mackerel (*Trachurus trachurus*) during frozen storage under a low oxygen atmosphere (SANCHEZ-ALONSO *et al*., 2008). Similarly, white grape skin antioxidant dietary fibre with a particle size < 1 mm (total dietary fibre: 820 g/kg; soluble phenolics: 42 g/kg), which was used at a concentration of 30 g/kg$_{fish}$ in precooked meagre (*Argyrosomus regius*) sausage, showed antioxidant effects as well as antimicrobial effects on H_2S producer counts and total viable counts, during refrigerated storage under a low oxygen atmosphere (RIBEIRO *et al*., 2013).

2.1.3 Bakery products and pasta

Bread is a staple food, and fortification with polyphenols and dietary fibre derived from winemaking by-products has been investigated to improve the diet of consumers (Table 3).

Grape seed extract powder added at a level of 0.6-2 g/kg$_{bread}$ greatly increased the antioxidant activity of the final product, despite the loss of phenolic compounds during processing due to either thermal treatment or interaction with the food matrix. Interestingly, a decreased amount of N-(carboxymethyl) lysine, an advanced glycation end-product associated with health risks, was observed in bread containing grape seed extract. Moreover, the addition of grape seed extract powder did not significantly affect the hardness of bread but did increase the darkness (PENG *et al*., 2010). To obtain another vehicle for grape seed phenolics, the entire grape seed can be milled to fine particle sizes (< 0.150 mm). However, upon the addition of this ingredient (total dietary fibre and total phenolic contents not specified) to dough at a level of 25-100 g/kg$_{flour,}$ a decrease in loaf brightness and volume, along with an increase in hardness and porosity, was observed (HOYE and ROSS, 2011). These effects were likely due to the inhibition of yeast activity, which reduced the gassing power. Moreover, phenolics can inhibit the activity of endogenous amylases in dough, leading to inadequate maltose release for yeast activity during proofing (MILDNER-SZKUDLARZ *et al*., 2011). Because grape phenolics also inhibit mammalian α-glucosidase and α-amylase, white grape skin antioxidant dietary fibre with particle sizes < 0.250 mm (soluble phenolics: 20.0 g/kg) at a level of 100 g/kg$_{flour}$ has been used in functional flat bread for diabetic people (LAVELLI *et al*., 2016a). Sourdough fermentation improves the textural properties of wheat and rye breads. Hence, the fortification of mixed wheat-rye bread with red grape pomace dietary fibre (total dietary fibre: 593 g/kg; soluble phenolics: 58.9 g/kg) has been investigated (MILDNER-SZKUDLARZ *et al*., 2011). An increase in hardness, gumminess and springiness was once again observed in wheat-rye mixed sourdough bread, but the cohesiveness and resilience did not change (MILDNER-SZKUDLARZ *et al*., 2011).

To increase the fibre and/or phenolic content, the fortification of brownies and biscuits with winemaking by-products has been achieved. In brownies, upon addition of 150-250 g/kg$_{flour}$ of red grape pomace antioxidant dietary fibre with particle size < 0.589 mm (total dietary fibre and total phenolic contents not specified), hardness and chewiness decreased, while springiness increased. Hence, the fortification of brownies showed an opposite trend compared to bread fortification, likely due to the presence of fat (WALKER *et al*., 2014).

Table 3. Application of winemaking by-products as new food ingredients in bakery products and pasta.

Food product	Recovered ingredient	Main results and references
Wheat bread	Grape seed extract powder TP: not specified Integration: 0.6-2 g/kg$_{bread}$	Decreased level of N-(carboxymethyl)lysine, an advanced glycated end-product related to health risk. No significant difference in hardness. Increase in darkness. PENG *et al.*, 2010
Wheat bread	Grape seed antioxidant dietary fibre (particle size < 0.150 mm; TDF and TP: not specified) Integration: 25-100 g/kg$_{flour}$	Decrease in loaf volume, and increase in hardness and porosity. HOYE and ROSS, 2011
Wheat bread	White grape skin antioxidant dietary fibre (particle size < 0.25 mm; soluble TP: 1.5 g monomeric flavonoids/kg and 18.5 g PAs/kg) Integration: 100 g/kg$_{flour}$	Inhibition of mammalian α-glucosidase and α-amylase. LAVELLI *et al.*, 2016a
Wheat-rye bread (sourdough)	Red grape pomace antioxidant dietary fibre (particle size not specified; TDF: 593 g/kg; soluble TP: 58.9 g GAE/kg). Integration: 40-100 /kg$_{flour}$	Significant increase in TDF and TP. Increase in hardness, gumminess and springiness. No change in cohesiveness and resilience. MILDNER-SZKUDLARZ *et al.*, 2011
Brownies	Red grape pomace antioxidant dietary fibre (particle size < 0.589 mm; TDF and TP: not specified). Integration: 150-250 g/kg$_{flour}$	Decrease in firmness and chewiness and increase in springiness. WALKER *et al.*, 2014
Biscuits	Grape seed extract encapsulated in mesquite gum, zein and maltodextrin (soluble TP: 21 g GAE/kg) Integration: 0.6 g TP/kg$_{dough}$	Increase in TP content and thermal stability Partial masking of darkness DAVIDOV-PARDO *et al.*, 2012
Biscuits	White grape pomace antioxidant dietary fibre (particle size < 0.150 mm; TDF: 509 g/kg; soluble TP: 31 g GAE/kg) Integration: 100 - 300 g/kg$_{flour}$	Significant increase in TDF and TP. Decrease in hardness, brightness and yellowness MILDNER-SZKUDLARZ *et al.*, 2013
Biscuits	Red grape marc extract (soluble TP: 2.1 g GAE/L) Integration: 450 mL/kg$_{semolina}$	Increase in TP and antioxidant activity Increase in compounds derived from the Maillard reaction, except pyrazines, and lipid oxidation PASQUALONE *et al.*, 2014
Pasta	Red grape pomace antioxidant dietary fibre (particle size < 0.811 mm; TDF: 689.5 g/kg; TP: not specified). Integration: 25-75 g/kg$_{flour}$	Increase in TP and antioxidant activity Increase in cooking loss SANT'ANNA *et al.*, 2014
Pasta	Red grape marc (soluble TP: 4.43 g GAE/kg) Integration: 300 g/kg$_{semolina}$	Increase in TP and antioxidant activity Decrease in cooking loss MARINELLI *et al.*, 2015

TDF: total dietary fibre content; TP: total phenolic content (expressed as GAE: gallic acid equivalents or sum of monomeric flavonoids or PAs: proanthocyanidins).

Regarding biscuits, the addition of white grape pomace antioxidant dietary fibre with particle size < 0.150 mm (total dietary fibre: 509 g/kg; soluble phenolics: 31 g/kg) up to 300 g/kg$_{flour}$ led to a decrease in hardness, brightness and yellowness (MILDNER-

SZKUDLARZ *et al.*, 2013). In contrast, the incorporation of grape seed phenolics encapsulated with mesquite gum, zein and maltodextrin (soluble phenolics: 21 g/kg) partially masked the dark colour (DAVIDOV-PARDO *et al.*, 2012). Alternatively, biscuits containing red grape extract (soluble phenolics: 2.1 g/L) at a level of 450 mL/kg$_{\text{semolina}}$ displayed a particular red colour and aromatic profile and possessed greater contents of Maillard-reaction compounds, except pyrazines, as well as higher amounts of compounds derived from lipid peroxidation than the control biscuits (PASQUALONE *et al.*, 2014).

The fortification of pasta with winemaking by-products is also promising. Grape pomace antioxidant dietary fibre with particle size < 0.811 mm (total dietary fibre: 689.5 g/kg; total phenolic content not specified) formulated into pasta (25-75 g/kg$_{\text{flour}}$) increased the total phenolic content and antioxidant activity but also caused a slight increase in the cooking loss at high levels of addition. This effect could be attributed to changes in the gluten protein network due to the interference of grape pomace fibre, which reduces the gluten strength and interrupts the overall structure of pasta (SANT'ANNA *et al.*, 2014). However, the incorporation of red grape marc extract (soluble phenolics: 4.43 g/kg) into pasta at a ratio of 1:10, w/v, led to an increase in the phenolic content and antioxidant activity, as well as improved cooking performance. In fact, the cooking loss decreased due to the presence of grape pomace phenolics, which were complexed with proteins around starch granules, encapsulating phenolic compounds during cooking and restricting excessive swelling and amylose diffusion. The fortified sample was also characterized by a low adhesiveness value due to the formation of a stronger gluten network in the presence of phenolics, which entrapped the starch granules, slowing down amylose release during cooking. However, the hardness of fortified pasta was similar to that of the control pasta (MARINELLI *et al.*, 2015).

2.1.4 Fruit-based products

The replacement of synthetic additives with natural compounds such as winemaking by-products and the development of functional foods are emerging trends in the fruit processing industry (Table 4). When the phenolic extract of red grape pomace (soluble phenolics: 30 g/kg) was added to a model fruit gel at a concentration of 8.2 g/kg$_{\text{mixture}}$ (prior to concentration), a stable red colour and a marked increase in the antioxidant capacity were observed. These effects were maintained, even after storage for 24 weeks at room temperature, likely due to intermolecular associations between pectins and anthocyanins (MAIER *et al.*, 2009a). The formulation of 0.01 g/kg$_{\text{juice}}$ of white grape skin extract (phenolic content not specified) in model fruit juice containing *Lactobacillus rhamnosus*, *Bifidobacterium lactis* and *Lactobacillus paracasei* improved the stability of probiotic bacteria during storage due to the presence of a more stable anaerobic environment (SHAH *et al.*, 2010). Red and white pomace extracts (soluble phenolics: 75-280 g/kg) were added to apple and orange juice to achieve a concentration of 20-100 g/kg$_{\text{juice}}$ of phenolics, and antimicrobial effects toward microbial contaminants were observed, including *Zygosaccharomyces rouxii* and *Z. bailii* (SAGDIC *et al.*, 2011). Alternatively, the use of antioxidant dietary fibre with particle size in the range of 0.125-0.5 mm obtained from white grape pomace (total dietary fibre: 505 g/kg; soluble phenolics: 30 g/kg; insoluble phenolics: 139 g/kg) imparted multiple functional effects. When this antioxidant- and fibre-rich ingredient was added to tomato puree at a level of 30 g/kg$_{\text{puree}}$, the reducing capacity and inhibitory effect of hyperglycaemia-induced damage increased due to the ability of grape phenolics to act as both oxygen-radical and carbonyl-radical scavengers (LAVELLI *et al.*, 2014; TORRI *et al.*, 2015).

Table 4: Application of winemaking by-products as new food ingredients in fruit-based products.

Food product	Recovered ingredient	Main results and references
Model fruit gel	Red grape pomace extract soluble TP: 30 g GAE/kg Integration: 8.2 g /$kg_{mixture}$ (before concentration)	Brilliant red colour and strong antioxidant capacity during storage at room temperature. MAIER *et al.*, 2009a
Model fruit juice containing probiotic bacteria	White grape skin extract TP: not specified Integration: 0.01 g/$kg_{mixture}$	Improved stability of the probiotic bacteria *Lactobacillus rhamnosus*, *Bifidobacterium lactis*, and *Lactobacillus paracasei* during storage. SHAH *et al.*, 2010
Orange and apple juices	Red and white pomace extracts (soluble TP: 75-280 g GAE/kg) Integration: 20-100 g/kg_{juice}	Antifungal activity towards *Zygosaccharomyces rouxii* and *Z. bailii* with variety-dependent efficacy. SAGDIC *et al.*, 2011
Tomato puree	White grape skin antioxidant dietary fibre (particle size in the range of: 0.125-0.5 mm; TDF: 505 g/kg; soluble TP: 30 g flavonoids/kg; insoluble TP: 139 g PAs/kg). Integration: 30 g/kg_{puree}	Increase in reducing capacity and potential ability to inhibit hyperglycaemia-induced damage. LAVELLI *et al.*,2014; TORRI *et al.*, 2015
Tomato puree	White grape skin antioxidant dietary fibre (particle size in the range of 0.125-0.5 mm; TDF: 505 g/kg; soluble TP: 22 g GAE/kg). Integration: 30 g/kg_{puree}	Increase in Bostwick consistency, storage (G) and loss (G) moduli, and complex viscosity (η*). LAVELLI *et al.*, 2015b
Apple-based fruit jelly	Red grape skin antioxidant dietary fibre (particle size in the range: 0.125 - 0.5 mm; TDF: 600 g/kg; soluble TP: 26 g flavonoids/kg). Integration: 63 g/$kg_{mixture}$ (before concentration)	Increase in puncture energy, i.e., stronger texture. Requires less dehydration. High antioxidant and fibre content. CAPPA *et al.*, 2015

TDF: total dietary fibre content; TP: total phenolic content (expressed as GAE: gallic acid equivalents or sum of flavonoids or PAs: proanthocyanidins).

In addition, the fibre content increased, which improved the Bostwick consistency, storage and loss moduli and complex viscosity, providing a means to modulate the textural properties of puree (LAVELLI *et al.*, 2015b). A similar antioxidant- and fibre-rich ingredient obtained from red pomace with particle size in the range of 0.125-0.5 mm (total dietary fibre: 600 g/kg; soluble phenolics: 26 g/kg) added at a level of 63 g/$kg_{mixture}$ to apple-based candy modified the textural properties, resulting in a stronger structure that required greater puncture and penetration energy. As a result, during candy processing, the dehydration step could be reduced (CAPPA *et al.*, 2015).

2.1.5 Dairy products

The addition of fruit phenolics into food products has increased due to the emerging popularity of functional foods, including phenolic addition in the dairy sector (O'CONNELL and FOX, 2001). The fortification of phenolics into dairy products may increase the heat and foam stability of milk and enhance nutritional benefits (O'CONNELL and FOX, 2001). However, many phenolics are bitter and astringent (VIDAL *et al.*, 2004), and humans instinctively reject bitter substances (DREWNOWSKI and GOMEZ-CARNEROS, 2000). Although phenolic compounds interact with proteins during the cheesemaking process, these interactions are dependent on the pH and molar ratio and molecular properties of the polyphenols and involve both hydrophobic and hydrophilic bonds (FELIX DA SILVA *et al.,* 2015). The application of winemaking by-products to the dairy sector is shown in Table 5.

Table 5: Application of winemaking by-products as new food ingredients in dairy products.

Food product	Recovered ingredient	Main results and references
Cheese	Single phenolic compounds and whole grape extract Integration: 0.5 mg single phenolic or GAE/mL$_{milk}$	Slightly reduced hydration capacity of cheese curd network. No variation in gel strength. Less smooth and less dense internal structure of cheese curds. More granular outer surfaces than control cheese by SEM microstructure analysis. HAN *et al.*, 2011a
Cheese	Single phenolic compounds and whole grape extract Integration: 0.5 mg single phenolic or GAE/mL$_{milk}$	High retention of grape phenolics in the curd. High radical scavenging activity. Increase in gel-formation rate due to a slight decrease in pH. HAN *et al.*, 2011b
Cheese	Red and white grape pomace antioxidant dietary fibre before and after distillation (particle size < 0.25 mm; TP: 3.64-16.0 g GAE/kg). Integration: 8 and 16 g/kg$_{curd}$	Highest radical scavenging activity and TP content, yielding 16 g/kg of grape powder after distillation. No effect on lactic bacteria or proteolysis. MARCHIANI *et al.*, 2015
Yogurt and salad dressing	Red grape pomace antioxidant dietary fibre (particle size < 0.18 mm; TDF: 613.2 g/kg, TP: 67 g GAE/kg). Integration: 10-30 g/kg$_{yogurt}$; 5-10 g/kg$_{salad\ dressing}$	Increase in TDF, TP and radical scavenging activity (but slight decrease in TP during storage at 4 °C). Decrease in peroxide values for both yogurt and salad dressing. Stable value for lactic acid percentage and syneresis during 3 weeks of storage at 4 °C for yogurt. TSENG and ZHAO, 2013
Yogurt	Grape seed extract TP: 76 - 150 g GAE/kg Integration: 50-100 mg TP/kg$_{yogurt}$	Increase in TP (slight decrease in TP during storage at 4 °C). No change in pH or Lactobacilli counts. CHOUCHOULI *et al.*, 2013
Yogurt	Red and white grape skin antioxidant dietary fibre (particle size < 0.25 mm; TDF: 345-481 g/kg). Integration: 60 g/kg$_{yogurt}$	Increase in acidity, total phenolic content and antioxidant activity with respect to control, but lower pH, syneresis and fat. Lactic acid bacteria, phenolic content and antioxidant activity were stable during 3 weeks of storage. MARCHIANI *et al.*, 2016
Milk	Grape seed extract powder TP: 842-927 g/kg Integration: 2 g/L$_{milk}$	Phenolic content equal to that of one serving of fresh apple. Increase in potential health benefit. AXTEN *et al.,* 2008

TDF: total dietary fibre content; TP: total phenolic content (expressed as GAE: gallic acid equivalents).

HAN *et al.* (2011a,b) studied the effect of single phenolic compounds (catechin, epigallocatechingallate, tannic acid, homovanillic acid, hesperetine and flavone) and natural extracts, such as whole grape extract, green tea extract and dehydrated cranberry powder as functional ingredients in cheese at a level of 0.5 mg of total phenolics/mL$_{milk}$. Three gel-forming parameters were evaluated, including T_{lag} (the lag-time before the beginning of milk coagulation), V_{max} (the maximum rate of gel formation) and TV_{max}(the time required to reach the maximum rate of gel formation). The results demonstrated that the addition of phenolic compounds to milk affected all of the gel-forming parameters. In fact, the change in pH due to the addition of phenolics resulted in faster gel formation in cheese samples fortified with single phenolic compounds than those fortified with natural extracts. In addition, several phenolic sources improved the antioxidant properties of cheese products. Among the tested single phenolic compounds and natural extracts, the greatest radical scavenging activity was achieved using whole grape extracts, likely due to the improved retention of grape phenolics in the curd, representing a promising utilization of winemaking by-products.

MARCHIANI *et al.* (2015) used antioxidant dietary fibre obtained from three grape pomaces (Barbera, Chardonnay prior to distillation and Chardonnay after distillation) with particle size < 0.25 mm (soluble phenolics: 3.64-16.0 g/kg) in semi-hard and hard cheeses (Italian Toma-like and Cheddar) to increase the content of phenolic compounds. Powders were added at two different concentrations (8 and 16 g/kg$_{cheese}$), and the results showed that the amount and type of powder did not significantly affect the physicochemical parameters of cheese, except the pH. Cheeses containing Chardonnay powder after distillation showed the highest phenolic content and radical scavenging activity at the end of ripening. Proteolysis and microbial counts did not show significant differences between fortified and control cheeses.

TSENG and ZHAO (2013) applied grape pomace antioxidant dietary fibre with particle size < 0.18 mm (total dietary fibre: 613.2 g/kg; soluble phenolics: 67 g/kg) at a level of 10-30 g/kg to yogurt and 5-10 g/kg to salad dressing to enhance the nutritional value and improve the storability. The authors demonstrated that this ingredient can be used as an alternative source of antioxidants and dietary fibre to delay the oxidation of lipids during refrigerated storage. However, the total phenolic content and radical scavenging activity of fortified yogurts decreased slightly during storage, likely due to interactions between proteins and phenolic compounds. Consequently, further research is necessary to determine the mechanism of the long-term retention of grape phenolics and radical scavenging activity of the aforementioned products.

CHOUCHOULI *et al.* (2013) used grape seed extracts from two grape varieties (50-100 mg of phenolics/kg$_{yogurt}$) to fortify full-fat and non-fat yogurt. The addition of the extract did not affect the pH or *Lactobacilli* count, while fortified yogurts showed higher antioxidant and antiradical activity than control samples, even after 3-4 weeks of cold storage. However, the phenolic content and radical scavenging activity decreased during storage.

The fortification of yogurt with up to 60 g/kg$_{yogurt}$ of red and white grape skin antioxidant dietary fibre with particle size < 0.25 mm (total dietary fibre: 345-481 g/kg) was performed by MARCHIANI *et al.* (2016). In this case, a reduction in the total phenolic content did not occur during refrigerated storage, but the radical scavenging activity decreased. Grape addition did not affect the growth of lactic acid bacteria.

Moreover, UHT low fat milk was fortified with different grape seed extract powders to obtain a concentration of 2 g/L$_{milk}$ of phenolics in the final product, representing the amount of phenolics ingested when consuming one serving of fresh apple (AXTEN *et al.*, 2008).

2.2. Sensory effects

Understanding the impact of new ingredients on consumers' perception is considered a key step in new product development (VERBEKE, 2006; TUORILA, 2007). Therefore, including a sensory- and consumer-based approach in product innovation is strategic for determining the properties that have the greatest effect on consumer preference, as well as relevant attributes that drive product optimization (TORRI *et al.,* 2016).

2.2.1 Meat products

The sensory effects of grape by-products on meat products have been thoroughly analysed in the literature. For chicken meat, grape skin extract added to dehydrated products (1 g/kg$_{meat}$) prevented changes in sensory attributes due to oxidation (hot wash, boiled chicken, subcutaneous fat and rancidity), with comparable efficacy to synthetic antioxidants and other natural antioxidants, such as rosemary, coffee and tea (NISSEN *et al.*, 2000). In chicken hamburger, the use of grape antioxidant fibre (5-20 g/kg$_{meat}$) increased the lipid stability without affecting the desirability of the odour, flavour, and tenderness during 5 days of storage. Only the colour was modified by the addition of grape skin extract (15-20 g/kg$_{meat}$), which did not affect the acceptability of samples. The sensory test comparing the effect of four different addition levels revealed that hamburgers preferred by consumers had the highest extract content (15-20 g/kg$_{meat}$) (SÀYAGO-AYERDI *et al.*, 2009). The incorporation of grape pomace extracts in raw and cooked chicken meatballs (60 mg of phenolics/kg$_{meat}$) also provided satisfactory results in terms of odour and flavour properties during frozen storage, which were not different from those observed using synthetic antioxidants (SELANI *et al.,* 2011).

Regarding pork meat, the addition of grape skin extract (0.2 g/kg$_{meat}$) to cooked patties was not sufficient to reduce the intensity of rancid and linseed odours and flavours correlated to lipid oxidation indexes (TBARS and hexanal content); thus, acceptable sensory properties for consumption could not be guaranteed (NISSEN *et al.*, 2004). Nevertheless, grape seed extract (0.1-0.2 g/kg$_{meat}$) has been proven to have a positive effect on both cooked pork and beef patties and was even more effective than rosemary oleoresin and oregano water-extracts. In fact, sensory evaluation performed over eight days of storage at 4°C demonstrated the efficiency of grape seed extract at controlling several negative sensory characteristics associated with a warmed-over flavour, such as rancidity, wet cardboard (for beef patties) and grassy (for beef and pork patties) odour descriptors (ROJAS and BREWER, 2007). Accordingly, the addition of grape seed extract (0.05-1 g/kg$_{meat}$) did not significantly affect the average scores obtained for cooked pork patties for any of the quality parameters evaluated (colour, flavour, texture, juiciness and off-flavour) over four days of storage at 4°C under a modified atmosphere (CARPENTER *et al.*, 2007).

In beef patties, grape seed extract (0.1-0.2 g/kg$_{meat}$) led to visual green discoloration (ROJAS and BREWER, 2007). This effect was also observed in precooked beef sausage containing grape seed extract (0.3-0.5 g/kg$_{meat}$). Moreover, grape seed extract improved the persistence of fresh cooked beef odour and flavour during the storage of fortified products with respect to the control group and prevented the formation of a rancid odour (KULKARNI *et al.,* 2011).

2.2.2 Fish products

Very little information is available on the sensory effects of grape by-products in fortified fish products. In fact, only one paper out of those cited in the present review included a sensory evaluation of fortified fish sausage. The sensory description of this product showed that samples containing grape skin antioxidant dietary fibre (30 g/kg_{fish}) were significantly darker, less elastic, cohesive, succulent and oily and possessed a more unpleasant texture and flavour than the control product. The unpleasant odour and flavour has been described as a sour note, but a rancid aroma or flavour did not develop after 98 days of storage at refrigerated temperatures (RIBEIRO *et al.*, 2013).

2.2.3 Bakery products and pasta

Among the food categories considered in this review, cereal products have been the most commonly investigated from a sensory perspective. By adding different amounts of grape seed extract to white bread (0.6-2 g/kg_{bread}), significant alterations in quality attributes (sweetness, porosity, astringency and stickiness) were not detected (PENG *et al.*, 2010). The recommended replacement of hard red spring flour with grape seed antioxidant dietary fibre in bread was 50 g/kg_{flour}. Above this threshold, low sensory acceptance of astringency, sweetness, bitterness and overall liking was observed (HOYE and ROSS, 2011). Similarly, the overall acceptance for sourdough mixed rye bread decreased as the content of red grape pomace antioxidant dietary fibre increased from 40 to 100 g/kg_{flour}, indicating that a maximum of 60 g/kg_{flour} could be used to prepare acceptable products. Higher levels were associated with a decrease in the volume, porosity and typical aroma of freshly baked breads and an increase in hardness, acidity and alcoholic, sharp and fruity notes (MILDNER-SZKUDLARZ *et al.*, 2011).

Regarding brownies, fortification with red and white grape pomace antioxidant dietary fibre at levels higher than those acceptable for bread, up to 150 g/kg_{flour}, did not impact the sensory properties and acceptability of the products (WALKER *et al.*, 2014). The acceptance of biscuits enriched with white grape pomace antioxidant dietary fibre was also dependent on the level of addition: 100 g/kg_{flour} incorporation in wheat flour was adequate, while concentrations of 200 or 300 g/kg_{flour} induced a fruity-acidic note and an intense brown colour, which was undesirable to consumers (MILDNER-SZKUDLARZ *et al.*, 2013). However, microencapsulation of grape seed extracts prevented a decrease in the likeability ratings by consumers (DAVIDOV-PARDO *et al.*, 2012). Biscuits enriched with a red grape pomace extract (450 $mL/kg_{semolina}$) have been described by a trained panel of assessors as having a more intense colour, fruity odour and sour taste and lower friability than control samples. Moreover, consumers were able to discriminate among biscuits samples based on both colour and taste. However, neither the modifications in sensory profiles nor the differences perceived during the affective test influenced the acceptability or willingness of the subjects to buy anthocyanin-enriched biscuits. Regarding both the colour and taste, in a global evaluation, the number of consumers who preferred enriched biscuits was not significantly different than those who preferred control biscuits (PASQUALONE *et al.*, 2013).

In fettuccini pasta formulated with red grape pomace antioxidant dietary fibre (25-75 g/kg_{flour}), the overall liking and acceptance of aroma, aftertaste, flavour and appearance decreased, regardless of the concentration of the ingredient (SANT'ANNA *et al.*, 2014). However, upon addition of red grape pomace extract (300 $g/kg_{semolina}$), the sensory properties of fortified, fresh-extruded, fresh-pasteurized and dry spaghetti pasta were as acceptable as control products (MARINELLI *et al.*, 2015).

2.2.4 Fruit-based products

Information regarding the effect of grape by-products on the sensory properties of fruit-based products is scarce. The incorporation of different granulometric fractions of white grape skins into either smooth or rough tomato puree (30 g/kg_{puree}) induced a clear increase in the textural attributes (crispiness and granularity), a decrease in the perceived homogeneity and a change in the vegetable odour notes (spicy hay). The intensity of these effects depended on the fraction particle size, which also influenced consumers' preferences. A cluster of subjects was found to significantly prefer the smallest particle size fraction (< 0.125 mm), especially when combined with smooth tomato puree, while another group of consumers showed opposite preferences, preferring the largest particle size (0.250-0.500 mm) and rough tomato puree cells (LAVELLI *et al.*, 2014; TORRI *et al.*, 2015).

2.2.5 Dairy products

A limited number of applications of grape pomace have been investigated in dairy products, especially in terms of sensory effects; however, yogurt fortified with winemaking by-products has been investigated. Fortification with grape seed extract amounts corresponding to 50-100 mg of total phenolics/kg_{yogurt} did not result in any major defects in sensory properties (consistency, colour and flavour) compared to control samples (CHOUCHOULI *et al.*, 2013). On the contrary, higher levels of addition strongly modified the sensory properties of yogurt, which was perceived as too sour by consumers, possessing an unpleasant flavour and grainy/sandy texture. However, significantly different hedonic scores were observed using by-products from different grape varieties, suggesting that Chardonnay was more suitable than Pinot noir and Muscat (MARCHIANI *et al.*, 2016). The fortification of yogurt with red grape pomace in the range of 10 to 20 g/kg_{yogurt} provided satisfying overall likeability values. Nevertheless, lower likeability scores for flavour and texture were observed for the sample with the highest concentration of grape pomace (TSENG and ZHAO, 2013). In salad dressing, the addition of red grape pomace antioxidant dietary fibre at a level of 10 g/$kg_{mixture}$ was best received by consumers (TSENG and ZHAO, 2013). Fortification with grape skin antioxidant dietary fibre clearly influenced the sensory properties of soft cow milk cheeses, especially the appearance and texture. In particular, the marbling aspect, granularity, sandiness, sourness and astringency (due to the presence of fibre and polyphenols from grape skin) negatively impacted the overall likeability of the cheese when the amount of Barbera and Chardonnay grape was greater than 8 and 16 g/kg_{curd}, respectively (TORRI *et al.*, 2016). The addition of grape seed extracts to low fat UHT milk had a significant effect on the product sensory attributes, tending to suppress sweetness and UHT odour and flavour and to increase the perception of bitterness, sourness, astringency, odours and flavours (fresh raisin, honey, inka, ashy and tobacco), as well as chalkiness (AXTEN *et al.*, 2008).

3. GRAPE SEED OIL EXTRACTION BY GREEN TECNOLOGIES

Grape seed oil extraction can be applied in parallel with the recovery of both antioxidant dietary fibre and phenolic extracts from grape skins and defatted grape seeds, thus making the overall recovery strategy more sustainable. With the recent technological advancements, "green technologies" have been proposed to replace the traditional oil recovery process by solvents.

The recovery of grape seed oil requires the preliminary separation of seeds from other grape pomace constituents, including skins and stalks. Separation occurs by mechanical devices, usually after grape pomace drying.

The conventional "non-green" solvent extraction allows for nearly complete oil recovery. Non-polar solvents are used for oil extraction, including *n*-hexane and petroleum ether, which are the most common extracting solvents and have the lowest cost. After extraction, the oil must be separated from the solvent in which it is dissolved, and the solvent may be recycled. Separation is achieved by evaporating off the solvent. For *n*-hexane, evaporation occurs at 69 °C (the boiling point of *n*-hexane at ambient pressure).

High quality oil is obtained by mechanical extraction performed at ambient temperature. Unfortunately, mechanical extraction does not afford a high yield of oil, particularly for grape seeds, whose woody texture makes them mechanically resistant and, more importantly, whose oil content is reduced to the range of 4 to 17% (FERNANDES *et al.*, 2013; FIORI *et al.*, 2014). To increase the oil recovery, mechanical extraction can be performed at higher temperatures: however, at increased extraction temperatures, some of the noble oil constituents, which are thermally unstable, tend to degrade.

An emerging solvent for use in the food industry is high pressure CO_2, more precisely termed supercritical CO_2 (SC-CO_2) (DUBA and FIORI, 2015a). A fluid is in the supercritical state when the actual temperature and pressure are higher, respectively, than the critical temperature (T_c) and pressure (P_c) of the fluid. For CO_2, T_c and P_c are 31°C and 73 bar, respectively. Therefore, SC-CO_2 can be used while operating at temperatures only slightly higher than ambient temperature, making SC-CO_2 particularly interesting for thermally unstable compounds, which is often the case in the food sector.

An important advantage in the use of supercritical fluids as solvents is the extreme ease in separating the solvent and solute after extraction: separation occurs by simple depressurization. When using SC-CO_2 for extracting grape seed oil, after flowing SC-CO_2 is contacted with a static bed of milled grape seeds, the mono-phase stream consisting of SC-CO_2 and extracted and dissolved grape seed oil is expanded through a back-pressure valve. After expansion, low pressure gaseous CO_2 separates from grape seed oil, which is recovered solvent-free. Solvent-free defatted grape seeds can also be recovered and used for further food applications (LAVELLI *et al.*, 2015a). The process and corresponding equipment for an industrial-scale plant for SC-CO_2 extraction of grape seed oil have been fully explained in the literature (FIORI, 2010; FREITAS *et al.*, 2013). The effect of process parameters on the extraction kinetics and yield of the SC-CO_2 extraction of grape seed oil has been recently outlined (DUBA and FIORI, 2015b). Other obvious advantages of using SC-CO_2 in the food sector are represented by the peculiarities of CO_2, which is non-toxic, non-flammable and inexpensive.

Unfortunately, the proposed process includes drawbacks of an economic nature. The solubility of grape seed oil in SC-CO_2 is lower than 10 g_{oil}/kg_{CO2} for pressures lower than 350 bar (DUBA and FIORI, 2016). To achieve relatively high solubility values for oil in SC-CO_2, the equipment must be operated at not less than 400 bar, preferably at 500-600 bar, which translates into high investment costs for the facility, where the extractors must be employed at high pressure (FIORI, 2010).

4. CONCLUSIONS

The studies summarized in the present review demonstrate an increase in interest in potential food applications of winemaking by-products and provide a new production scenario for winemakers. Winemaking by-products can be processed into various food ingredients, including antioxidant dietary fibres, crude phenolic extracts or encapsulated extracts, and applied to produce new foods. Grape seed oil can be recovered using SC-CO_2 extraction. However, economic and regulatory factors prevent these applications from achieving large-scale application. First, the proposed applications imply new production cycles across winemaking and other food sectors. The establishment of these connections demand improved logistic organization, including appropriate technologies for the collection, storage, transportation and processing of grape pomace. Investment costs for new processes are sometimes high. Second, although food legislation strongly promotes the recycling of by-products, a recovery strategy based on value addition and by-product use in functional food production results in additional regulatory issues. Actually, the application of by-products in foods generally leads to novel foods, which opens the debate regarding safety. Fortification/enrichment with the appropriate amount of grape antioxidant dietary fibre only allows for the labelling of foods as fibre-rich, while other possible health claims must be substantiated by specific studies. Thus, further scientific research is necessary to surpass economic and regulatory barriers and achieve significant advance towards the establishment of a biorefinery fed with winemaking by-products.

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REFERENCES

Ahn J., Grun I.U. and Mustapha A. 2007. Effects of plant extracts on microbial growth, color change, and lipid oxidation in cooked beef. Food Microbiol. 24: 7.

Amendola D., De Faveri D.M. and Spigno G. 2010. Grape marc phenolics: extraction kinetics, quality and stability of extracts. J. Food Eng. 97:384.

Axten L.G., Wohlers M.W. and Wegrzyn T. 2008. Using phytochemicals to enhance health benefits of milk: Impact of polyphenols on flavor profile. J. Food Sci. 73: H122.

Battista F., Tomasi D., Porro D., Caicci F., Giacosa S. and Rolle L. 2015. Winegrape berry skin thickness determination: comparison between histological observation and texture analysis determination. Ital. J. Food Sci. 27: 136.

Beverige T.H.J., Girard B., Kopp T. and Drover J.C.G. 2005. Yield and composition of grape seed oil extracted by supercritical carbon dioxide and petroleum ether: varietal effects. J. Agric. Food. Chem. 53: 1799.

Bi N. and Rui D. 2014. Extracting anthocyanin from grape seed, comprises crushing the grape seed, adding modifying agent, soaking grape seed particle in an organic solvent, adding water to the degreased grape seed, and performing supercritical extraction. Patent number: CN103351370-A. Patent Assignee: Jurong Chuncheng Niansheng-Grapery.

Bordiga M. (Ed.) 2015. "Valorization of wine making by-products" CRC Press.

Cappa C., Lavelli V. and Mariotti M. 2015. Fruit candies enriched with grape skin powders: physicochemical properties. LWT - Food Sci. Technol. 62: 569.

Carpenter R., O'Grady M.N., O'Callaghan Y.C., O'Brien N.M. and Kerry, J.P. 2007. Evaluation of the antioxidant potential of grape seed and bearberry extracts in raw and cooked pork. Meat Sci. 76: 604.

Chouchouli V., Kalogeropoulos N., Konteles S.J., Karvela E., Makris D.P. and Karathanos V.T. 2013. Fortification of yoghurts with grape (*Vitis vinifera*) seed extracts. LWT - Food Sci. Technol. 53: 522.

Corrales M., Fernandez A., Vizoso Pinto M.G., Butz P., Franz C.M.A.P., Schuele E. and Tauscher B. 2010. Characterization of phenolic content, in vitro biological activity, and pesticide loads of extracts from white grape skins from organic and conventional cultivars. Food Chem. Toxicol. 48: 3476.

Crews C., Hough P., Godward J., Brereton P., Lees M., Guiet S. and Winkelmann W. 2006. Quantitation of the main constituents of some authentic grape seed oils of different origin. J. Agric. Food Chem. 54: 6261.

Davidov-Pardo G., Moreno M., Arozarena I., Marín-Arroyo M.R., Bleibaum R.N. and Bruhn C.M. 2012. Sensory and consumer perception of the addition of grape seed extracts in cookies. J. Food Sci. 77: S430.

Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain directives.

Drewnowski A. and Gomez-Carneros C. 2000. Bitter taste, phytonutrients and the consumer: a review. Am. J Clin. Nutr. 72: 1424.

Duba S.K. and Fiori L. 2015a. Extraction of bioactives from food processing residues using techniques performed at high pressure. Curr. Opin. Food Sci. 5: 14.

Duba S.K. and Fiori L. 2015b. Supercritical CO_2 extraction of grape seed oil: Effect of process parameters on the extraction kinetics. J. Supercrit. Fluids 98: 33.

Duba S.K. and Fiori L. 2016. Solubility of grape seed oil in supercritical CO_2: Experiments and modeling. J. Chem. Thermodynamics 100: 44.

Felix da Silva D., Matumoto-Pintro P.T., Bazinet L., Couillard C. and Britten M. 2015. Effect of commercial grape extracts on the cheese-making properties of milk. J. Dairy Sci. 98: 1552.

Fernandes L., Casal S., Cruz R., Pereira J.A. and Ramalhosa E. 2013. Seed oils of ten traditional Portuguese grape varieties with interesting chemicals and antioxidant properties. Food Res. Int. 50: 161.

Fernandez J., Perej-Alvarez J.A. and Fernandez–Lopez J.A. 1997. Thiobarbituric acid test for monitoring lipid oxidation in meat. Food Chem. 59: 345.

Fiori L. 2010. Supercritical extraction of grape seed oil at industrial-scale: Plant and process design, modeling, economic feasibility. Chem. Eng. Proc. 49: 866.

Fiori L., Lavelli V., Duba K.S., Sri Harsha P.S.C., Mohamed H. Ben and Guella G. 2014. Supercritical CO_2 extraction of oil from seeds of six grape cultivars: modeling of mass transfer kinetics and evaluation of lipid profiles and tocol contents. J. Supercrit. Fluids 94: 71.

Freitas L.D.S, Dariva C., Jacques R.A. and Caramao E.B. 2013. Effect of experimental parameters in the pressurized liquid extraction of Brazilian grape seed oil. Sep. Purif. Technol. 116: 313.

Galanakis C.M. (Ed.) 2015. "Food Waste Recovery: Processing Technologies and Industrial Techniques." Elsevier Inc., London, U.K.

Han J., Britten M., St-Gelais D., Champagne C. P., Fustier, P. Salmieri, S. and Lacroix M. 2011a. Effect of polyphenolic ingredients on physical characteristics of cheese. Food Res. Int. 44: 494.

Han J., Britten M., St-Gelais D., Champagne C.P., Fustier P., Salmieri S., and Lacroix M. 2011b.. Polyphenolic compounds as functional ingredients in cheese. Food Chem. 124: 1589.

Hanganu A., Todaşcă M.-C., Chira N.A., Maganu M. and Roşca S. 2012. The compositional characterization of Romanian grape seed oils using spectroscopic methods. Food Chem. 134: 2453.

Hoye C. and Ross C.F. 2011. Total phenolic content, consumer acceptance, and instrumental analysis of bread made with grape seed flour. J. Food Sci. 76: S428.

Kammerer D., Claus A., Carle R. and Schieber A. 2004. Polyphenol screening of pomace from red and white grape varieties (*Vitis vinifera* L.) by HPLC–DAD–MS/MS. J. Agric. Food Chem. 52: 4360.

Kulkarni S., De Santos F.A., Kattamuri S., Rossi S.J. and Brewer M.S. 2011. Effect of grape seed extract on oxidative, color and sensory stability of a pre-cooked, frozen, re-heated beef sausage model system. Meat Sci. 88: 139.

Laureati M., Gaeta D. and Pagliarini E. 2014. Qualitative and sensory evaluation of Sangiovese red wine obtained from organically and conventionally grown grapes. Ital. J. Food Sci. 26: 355.

Laureati M., Jabes D., Russo V. and Pagliarini E. 2013. Sustainability and organic production: how information influences consumer's expectation and preference for yogurt. Food Qual. Pref. 30: 1.

Lavelli V., Sri Harsha P.S.C. and Fiori L. 2015a. Screening grape seeds recovered from winemaking byproducts as sources of reducing agents and mammalian α-glucosidase and α-amylase inhibitors. Int. J. Food Sci. Technol. 50: 1182.

Lavelli V., Sri Harsha P.S.C. and Spigno G. 2016b. Modelling the stability of maltodextrin-encapsulated grape skin phenolics used as a new ingredient in apple puree. Food Chem. 209: 323.

Lavelli V., Sri Harsha P.S.C., Ferranti P., Scarafoni A. and Iametti S. 2016a. Grape skin phenolics as inhibitors of mammalian α-glucosidase and α-amylase – Effect of food matrix and processing on efficacy. Food Func. 7: 1655.

Lavelli V., Sri Harsha P.S.C., Torri L. and Zeppa G. 2014. Use of winemaking by-products as an ingredient for tomato puree: The effect of particle size on product quality. Food Chem. 152: 162.

Lavelli V., Sri Harsha, P.S.C., Mariotti, M., Marinoni, L. and Cabassi G. 2015b. Tuning physical properties of tomato puree by fortification with grape skin antioxidant dietary fibre. Food Bioprocess Technol. 8: 1668.

Maier T., Fromm M., Schieber A., Kammerer D.R. and Carle R. 2009a. Process and storage stability of anthocyanins and non-anthocyanin phenolics in pectin and gelatin gels enriched with grape pomace extracts. Eur. Food Res.Technol. 229: 949.

Maier T., Schieber A., Kammerer D.R. and Carle R. 2009b. Residues of grape (*Vitis vinifera*) seed oil production as a valuable source of phenolic antioxidants. Food Chem. 112: 551.

Marchiani R., Bertolino M., Belviso S., Giordano M., Ghirardello D., Torri L., Piochi M. and Zeppa G. 2016. Yogurt enrichment with grape pomace: effect of grape cultivar on physicochemical, microbiological and sensory properties. J. Food Qual. 39: 77.

Marchiani R., Bertolino M., Ghirardello D., McSweeney P.L.H. and Zeppa G. 2015. Physicochemical and nutritional qualities of grape pomace powder-fortified semi-hard cheeses. J. Food Sci. Technol. 53:1585.

Marinelli V., Padalino L., Nardiello D., Del Nobile M.A. and Conte A. 2015. New approach to enrich pasta with polyphenols from grape marc. J. Chem. 2015:1.

Mildner-Szkudlarz S., Bajerska J., Zawirska-Wojtasiak R. and Górecka D. 2013. White grape pomace as a source of dietary fibre and polyphenols and its effect on physical and nutraceutical characteristics of wheat biscuits. J. Sci. Food Agric. 93: 389.

Mildner-Szkudlarz S., Zawirska-Wojtasiak R., Szwengiel A. and Pacyński M. 2011. Use of grape by-product as a source of dietary fibre and phenolic compounds in sourdough mixed rye bread. Int. J. Food Sci. Technol. 46: 1485.

Nissen L.R., Byrne D. V., Bertelsen G. and Skibsted L.H. 2004. The antioxidative activity of plant extracts in cooked pork patties as evaluated by descriptive sensory profiling and chemical analysis. Meat Sci. 68: 485.

Nissen L.R., Månsson L., Bertelsen G., Huynh-Ba T. and Skibsted L.H. 2000. Protection of dehydrated chicken meat by natural antioxidants as evaluated by electron spin resonance spectrometry. J. Agric. Food Chem. 48: 5548.

O'Connell J.E. and Fox P.F. 2001. Significance and applications of phenolic compounds in the production and quality of milk and dairy products: a review. Int. Dairy J. 11: 103.

Otles, S., Despoudi, S., Bucatariu, C., and Kartal, C. 2015. Food waste management, valorization, and sustainability in the food industry. In: "Food Waste Recovery -Processing Technologies and Industrial Techniques". C. M. Galanakis (Ed.), p. 3. Academic Press, Elsevier, London.

Ozen B.O., Eren M., Pala A., Ozmen I. and Soyer A. 2011. Effect of plant extracts on lipid oxidation during frozen storage of minced fish muscle. Int. J. Food Sci. Technol. 46: 724.

Paini M., Casazza A.A., Aliakbarian B., Perego P., Binello A. and Cravotto G. 2016. Influence of ethanol/water ratio in ultrasound and high-pressure/high-temperature phenolic compound extraction from agri-food waste. Int. J. Food Sci. Technol. 51: 349.

Pasqualone A., Bianco A.M. and Paradiso V.M. 2013. Production trials to improve the nutritional quality of biscuits and to enrich them with natural anthocyanins. CyTA - J. Food 11: 301.

Pasqualone A., Bianco A.M., Paradiso V.M., Summo C., Gambacorta G. and Caponio F. 2014. Physico-chemical, sensory and volatile profiles of biscuits enriched with grape marc extract. Food Res. Int. 65: 385.

Pazos M., Gallardo J.M., Torres J.L. and Medina I. 2005. Activity of grape polyphenols as inhibitors of the oxidation of fish lipids and frozen fish muscle. Food Chem. 92: 547.

Pedroza M.A., Amendola D., Maggi L., Zalacain A., De Faveri D.M. and Spigno G. 2015. Microwave-assisted extraction of phenolic compounds from dried waste grape skins. Int. J. Food Eng. 11: 359.

Peng X., Ma J., Cheng K.-W., Jiang Y., Chen F. and Wang M. 2010. The effects of grape seed extract fortification on the antioxidant activity and quality attributes of bread. Food Chem. 119: 49.

Ribeiro B., Cardoso C., Silva H.A., Serrano C., Ramos C., Santos P.C. Santos P. C. and Mendes R. 2013. Effect of grape dietary fibre on the storage stability of innovative functional seafood products made from farmed meagre (*Argyrosomus regius*). Int. J. Food Sci. Technol. 48: 10.

Rojas M.C. and Brewer M.S. 2007. Effect of natural antioxidants on oxidative stability of cooked, refrigerated beef and pork. J. Food Sci. 72: 282.

Sagdic O., Ozturk I., Ozkan G. Yetim H.,EkiciL. and Yilmaz M. T. 2011. RP-HPLC–DAD analysis of phenolic compounds in pomace extracts from five grape cultivars: Evaluation of their antioxidant, antiradical and antifungal activities in orange and apple juices. Food Chem. 126: 1749.

Sanchez-Alonso I., Jimenez-Escrig A., Saura-Calixto F. and Borderias A.J. 2008. Antioxidant protection of white grape pomace on restructured fish products during frozen storage. LWT - Food Sci. Technol. 41: 42.

Sant'Anna V., Christiano F.D.P., Marczak L.D.F., Tessaro I.C. and Thys R.C.S. 2014. The effect of the incorporation of grape marc powder in fettuccini pasta properties. LWT - Food Sci. Technol. 58: 497.

Saura-Calixto F. 1998. Antioxidant dietary fiber product: a new concept and a potential food ingredient. J Agric. Food Chem. 46: 4303.

Sáyago-Ayerdi S.G., Brenes A. and Goñi I. 2009. Effect of grape antioxidant dietary fiber on the lipid oxidation of raw and cooked chicken hamburgers. LWT - Food Sci. Technol. 42: 971.

Scoma A., Rebecchi S., Bertin L. and Fava F. 2016. High impact biowastes from South European agro industries as feedstock for second-generation biorefineries. Crit. Rev. Biotechnol. 36: 175.

Selani M.M., Contreras-Castillo C.J., Shirahigue L.D., Gallo C.R., Plata-Oviedo M. and Montes-Villanueva N.D. 2011. Wine industry residues extracts as natural antioxidants in raw and cooked chicken meat during frozen storage. Meat Sci. 88: 397.

Shah N.P., Ding W.K., Fallourd M.J., and Leyer G. 2010. Improving the stability of probiotic bacteria in model fruit juices using vitamins and antioxidants. J. Food Sci. 75: M278.

Siró I., Kápolna E., Kápolna B., and Lugasi A. 2008. Functional food. Product development, marketing and consumer acceptance - A review. Appetite 51: 456.

Solfrizzo M., Piemontese L., Gambacorta L., Zivoli R. and Longobardi F. 2012. Food coloring agents and plant food supplements derived from *Vitis vinifera*: a new source of human exposure to ochratoxin A. J. Agric. Food Chem. 63: 3614.

Soto M.L., Moure A., Domínguez H. and Parajó J.C. 2011. Recovery, concentration and purification of phenolic compounds by adsorption: A review. J. Food Eng. 105: 1.

Spigno G. 2015. Recupero ed utilizzazione dei sottoprodotti enologici. In: "La nuova viticoltura – Innovazioni tecniche per modelli produttivi efficienti e sostenibili". Palliotti A., Poni S. and Silvestroni O. (Eds.), p 393, Edagricole, Milano.

Spigno G., Amendola D., Dahmoune F. and Jauregi P. 2015. Colloidal gas aphrons based separation process for the purification and fractionation of natural phenolic extracts. Food Bioproducts Process. 94: 434.

Spigno G., Donsì F., Amendola D., Sessa M., Ferrari G. and De Faveri D.M. 2013. Nanoencapsulation systems to improve solubility and antioxidant efficiency of a grape marc extract into hazelnut paste. J. Food Eng. 114: 207.

Sri Harsha P.S.C., Gardana C., Simonetti, P., Spigno G. and Lavelli V. 2013. Characterization of phenolics, *in vitro* reducing capacity and anti-glycation activity of red grape skins recovered from winemaking by-products. Bioresource Technol. 140: 263.

Sri Harsha P.S.C., Lavelli V. and Scarafoni A. 2014. Protective ability of phenolics from white grape vinification by-products against structural damage of bovine serum albumin induced by glycation. Food Chem. 156: 220.

Teixeira A., Baenas N., Dominguez-Perles R., Barros A., Rosa E., Moreno D.A. and Garcia-Viguera C. 2014. Natural bioactive compounds from winery by-products as health promoters: A review. Int. J. Mol. Sci. 15: 15638.

Torri L., Piochi M., Lavelli V. and Monteleone E. 2015. Descriptive sensory analysis and consumers' preference for dietary fibre- and polyphenol-enriched tomato purees obtained using winery by-products. LWT - Food Sci. Technol. 62: 294.

Torri L., Piochi M., Marchiani R., Zeppa G., Dinnella C. and Monteleone E. 2016. A sensory- and consumer-based approach to optimize cheese enrichment with grape skin powders. J. Dairy Sci. 99: 194.

Travaglia F., Bordiga M., Locatelli M., Coïsson J.D. and Arlorio M. 2011. Polymeric proanthocyanidins in skins and seeds of 37 *Vitis vinifera* L. cultivars: A methodological comparative study. J. Food Sci. 76: C742.

Tseng A. and Zhao Y. 2013. Wine grape pomace as antioxidant dietary fibre for enhancing nutritional value and improving storability of yogurt and salad dressing. Food Chem. 138: 356.

Tuorila H. 2007. Sensory perception as a basis for food acceptance and consumption. In: "Consumer-led food product development" H.J.H. Mac Fie (Ed.), p. 34. Cambridge: Woodhead Publishing.

Tzima K., Kallithraka S., Kotseridis Y. and Makris D.P. 2015. A comparative evaluation of aqueous natural organic acid media for the efficient recovery of flavonoids from red grape (*Vitis vinifera*) pomace. Waste Biomass Valorization 6: 391.

Verbeke W. 2006. Functional foods: Consumer willingness to compromise on taste for health? Food Qual. Prefer. 17: 126.

Vidal S., Francis L., Noble A., Kwiatkowski M., Cheynier V. and Waters E. 2004. Taste and mouth-feel properties of different types of tannin-like polyphenolic compounds and anthocyanins in wine. Anal. Chim. Acta 513: 57.

Walker R., Tseng A., Cavender G., Ross A. and Zhao Y. 2014. Physicochemical, nutritional, and sensory qualities of wine grape pomace fortified baked goods. J. Food Sci. 79: S1811.

Yu J. and Ahmedna M. 2013. Functional components of grape pomace: Their composition, biological properties and potential applications. Int. J. Food Sci. Technol. 48: 221.

Zagklis, D.P. and Paraskeva C.A. 2015. Purification of grape marc phenolic compounds through solvent extraction, membrane filtration and resin adsorption/desorption. Sep. Purif. Technol. 156: 328.

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