beverages

MDPI

Review

Grape Pomace as a Renewable Natural Biosource of Value-Added Compounds with Potential Food Industrial Applications

Teresa Abreu [1], Patrícia Sousa [1], Jéssica Gonçalves [1], Nance Hontman [1], Juan Teixeira [2], José S. Câmara [1,3] and Rosa Perestrelo [1,*]

[1] CQM—Centro de Química da Madeira, Universidade da Madeira, Campus da Penteada, 9020-105 Funchal, Portugal; teresa.abreu@staff.uma.pt (T.A.); patricia.sousa@staff.uma.pt (P.S.); jmariana4699@hotmail.com (J.G.); nance.8@hotmail.com (N.H.); jsc@staff.uma.pt (J.S.C.)

[2] Justino's Madeira Wines, S.A., Parque Industrial Da Cancela, Caniço, 9125-042 Santa Cruz, Portugal; juan.teixeira@justinosmadeira.com

[3] Departamento de Química, Faculdade de Ciências Exatas e Engenharia, Universidade da Madeira, Campus da Penteada, 9020-105 Funchal, Portugal

* Correspondence: rmp@staff.uma.pt; Tel.: +351-291705254

Abstract: Growing consumer demand for environmentally conscious, sustainable, and helpful products has prompted scientists and industry experts worldwide to look for inventive approaches to mitigate the environmental impact, particularly concerning agricultural and industrial waste. Among the by-products of winemaking, grape pomace (skins, seeds, stems) has the potential to be economically valuable as it is rich in value-added compounds (e.g., phenolic compounds, fibers, flavonoids, anthocyanins, terpenoids) related to health (e.g., antioxidant, antimicrobial, anti-inflammatory, cardioprotective effects) and technological issues (e.g., extraction of value-added compounds). These value-added compounds can be extracted using emerging green extraction techniques and then used in the food industry as preservatives, colorants, and for the formulation of functional foods, as well as in the development of smart food packaging. This review provides an overview of the value-added compounds identified in grape pomace, the emerging green extraction, and integrated approaches to extract value-added compounds based on the literature published in the last five years. The potential applications of these value-added compounds have been extensively researched for the food industry.

Keywords: grape pomace; value-added compounds; advanced and emerging extraction techniques; valorization; food industrial applications

check for updates

Citation: Abreu, T.; Sousa, P.; Gonçalves, J.; Hontman, N.; Teixeira, J.; Câmara, J.S.; Perestrelo, R. Grape Pomace as a Renewable Natural Biosource of Value-Added Compounds with Potential Food Industrial Applications. *Beverages* **2024**, *10*, 45. https://doi.org/10.3390/beverages10020045

Received: 7 May 2024
Revised: 4 June 2024
Accepted: 12 June 2024
Published: 17 June 2024

1. Introduction

According to the United Nations Organization (UNO) estimates, the world population will reach around 10 billion people in 2050. This fact, associated with constant and increasing climate changes and the decline in agricultural production areas due essentially to desertification, constitutes a problem on a global scale that challenges the food sector. In this context, and to minimize and prevent these outcomes and restrict the depletion of resources, the European Union (EU) plans to attain climate neutrality by 2050. The implementation of the circular economy's doctrines is vital to achieving this goal, since the reuse, recycle, and reduce concepts are adopted to create a closed-loop ecosystem for efficient resource consumption and usage [1,2]. The wine industry is one of the agri-food sectors responsible for the elevated expenditure of natural resources (e.g., water) and for the generation of substantial volumes of residues (solid or liquid) around the world [3,4].

According to Oliveira et al. [5], 1000 kg of processed grapes results in approximately 750 L of wine, 130 kg of grape pomace, 60 kg of lees, and 1650 L of wastewater (Figure 1). Grape pomace, also known as grape marc, is degradable biomass that represents around 20–25% of the total mass of grapes [6] and thus comes out to around 8.49 million tons a year worldwide [7]. This winemaking by-product includes a mixture of peels (representing 43%

of total grape pomace residue), seeds (23%), and stalks (25%) [8,9]. The management of this by-product is one of the main concerns of the wine industry, as the discard of grape pomace directly into landfills causes serious environmental issues, such as soil and groundwater contamination, the generation of unpleasant odors, the attraction of plant disease vectors (insects and flies), microbial contamination, and severe health risks to the aquatic and human populations due to its high chemical oxygen demand and biodegradable organic contents (e.g., tannins), among other parameters [9].

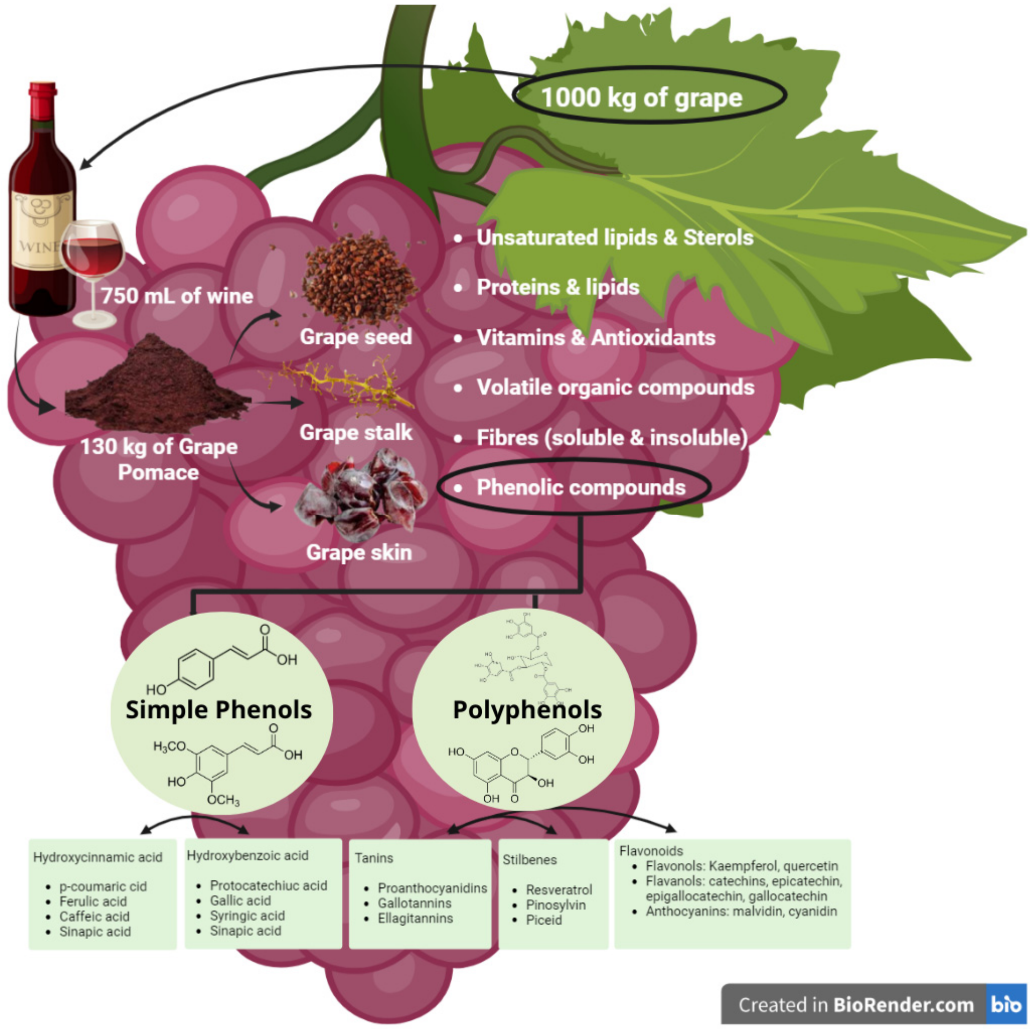

Figure 1. Value-added compounds are presented in grape pomace.

The chemical oxygen demand of nine different varieties of deseeded grape pomace was determined by El Achkar et al. [10], and the values ranged from 268 g to 591 g of O_2/kg. In this sense, several studies have been carried out in the last decade to valorize grape pomace as a sustainable approach, which includes the extraction of value-added compounds (since only 30% to 40% of phenolic compounds from grapes were transferred to wine), energy production, animal feed, cosmetics, organic building components by destroying the biological substances in a rather severe way, among others [2,6,11]. It is an economical raw material that represents a rich source of bioactive compounds (Figure 1) such as phenolic compounds, anthocyanins, volatile organic compounds, fibers, proteins, minerals (e.g., potassium, iron), vitamins, tannins, lipids, lignocellulosic compounds, among others, suitable for human health-promoting effects as well as for industrial applications (e.g., pharmaceutical, cosmetic, food) [12].

Several studies have shown that these value-added compounds have antioxidant, antibacterial, anti-inflammatory, antifungal, antimicrobial, and anti-aging activities and can be used as potential candidates for the prevention of cardiovascular diseases and cancer, as well as the regulation of bile acid and lipid homeostasis [6,13]. The concentration of these phytochemicals is significantly influenced by the ripening stage, cultivation procedures, genetic factors, grape varieties, and climatic and geographical conditions [14,15]. However, grape pomace may also contain mycotoxins (e.g., ochratoxin A) and other health-damaging substances in addition to health-beneficial molecules [14]. For this reason, suitable, more environmentally friendly, and efficient extraction procedures can be optimized and developed to recover the maximum yield of value-added compounds without compromising the biological and physicochemical characteristics of the exhausted grape pomace [16].

This comprehensive literature review intends to explore recent achievements related to efficient and suitable approaches for the valorization of grape pomace and to report on its volatile and phenolic compounds with potential added value. The diversity of potential industrial applications to minimize waste and enhance the valorization of this by-product of the wine industry will be discussed. Although numerous reviews have been published related to the valorization of grape pomace, the current review distinguishes itself by providing a comprehensive review of value-added compounds identified in grape pomace, emerging green extraction technologies used in their extraction, and integrated valorization approaches, with a specific focus on potential food industrial applications. Unlike previous reviews that may have focused narrowly on either the extraction methods or the end products, this manuscript integrates these aspects to present a holistic view of the entire valorization process. Furthermore, this review highlights integrated strategies like cascade biorefineries and zero-waste processes, providing practical case studies such as the approaches proposed by Farru et al. [17] and Monari et al. [16]. By addressing gaps in the existing literature and offering a comprehensive framework for the valorization of grape pomace, this manuscript aims to provide valuable insights for researchers and industry professionals looking to implement sustainable and economically viable practices in the food industry.

2. Review Design

The design employed in this scientific study is based on a retrospective examination of research publications published between 2020 and 2024 that explored efficient suitable approaches for grape pomace valorization and prospective uses of value-added compounds in the food industry. For this purpose, the bibliographic databases Scopus, PubMed, and ScienceDirect were used to identify and select publications. These platforms were chosen because of their extensive coverage of journals. The criteria used to select the articles were the title, abstract, keywords, and the year of publication reflecting the most recent advancements in the industrial application of grape pomace. The following keywords were considered in the current research: “grape pomace”, “grape marc”, “grape byproduct”, “added-value compounds”, “phenolic compounds”, “Volatiles”, “emerging extraction techniques”, “food industrial applications”. Wildcards (*, $, among others), operators, and Boolean (OR, AND) were also applied to obtain more exact results.

3. Efficient and Sustainable Approaches for Grape Pomace Valorization

3.1. Biological Conversion

In the case of grape pomace, biological conversions such as enzymatic hydrolysis, fermentation, and anaerobic digestion appear to be suitable approaches for the production of biofertilizers and/or bioenergy (Figure 2). Enzymatic hydrolysis is the breakdown of macromolecules (e.g., carbohydrates, proteins, lipids) of grape pomace in the presence of enzymes (e.g., cellulase, pectinase, tanninase, glucoamylase, protease) that promote their cleavage of bonds following its reaction with water to generate reducing sugar hydrolysate, which can be used as a substrate by fermentation organisms or converted into biofuels by microorganisms [3]. Filippi et al. [18] proposed a new process to convert grape pomace and stalks into a highly antioxidant extract and bio-based succinic acid. The substrates were enzymatically hydrolyzed to a high-sugar hydrolysate after pre-treatment with acidic and alkaline solutions. *Actinobacillus succinogenes* can effectively utilize the free sugars in the hydrolysate as a substrate for the synthesis of succinic acid, which has various applications in the food, pharmaceutical, and agricultural industries. On the other hand, the highest carbohydrate content in grape pomace represents a suitable renewable lignocellulosic biomass source for biofuel production [2]. A new and integrated process to fully explore grape pomace for biochemical production and recovery of oil and phenolic compounds using pressurized liquid extraction (PLE) has been proposed by Jin et al. [19]. In the context of biochemical production, the reducing sugars obtained from the enzymatic hydrolysis of cellulose and hemicellulose were fermented to acetone, butanol, and ethanol by *Clostridium beijerinckii* after pre-treatment with an alkaline solution. Martínez-Avila et al. [20] proposed an integrated enzymatic hydrolysis and fermentation for polyhydroxyalkanoates from agro-industrial residues, including grape pomace. The findings demonstrated that the use of hydrolyzed residues in fermentation significantly increases the production of polyhydroxyalkanoates compared to the residues alone.

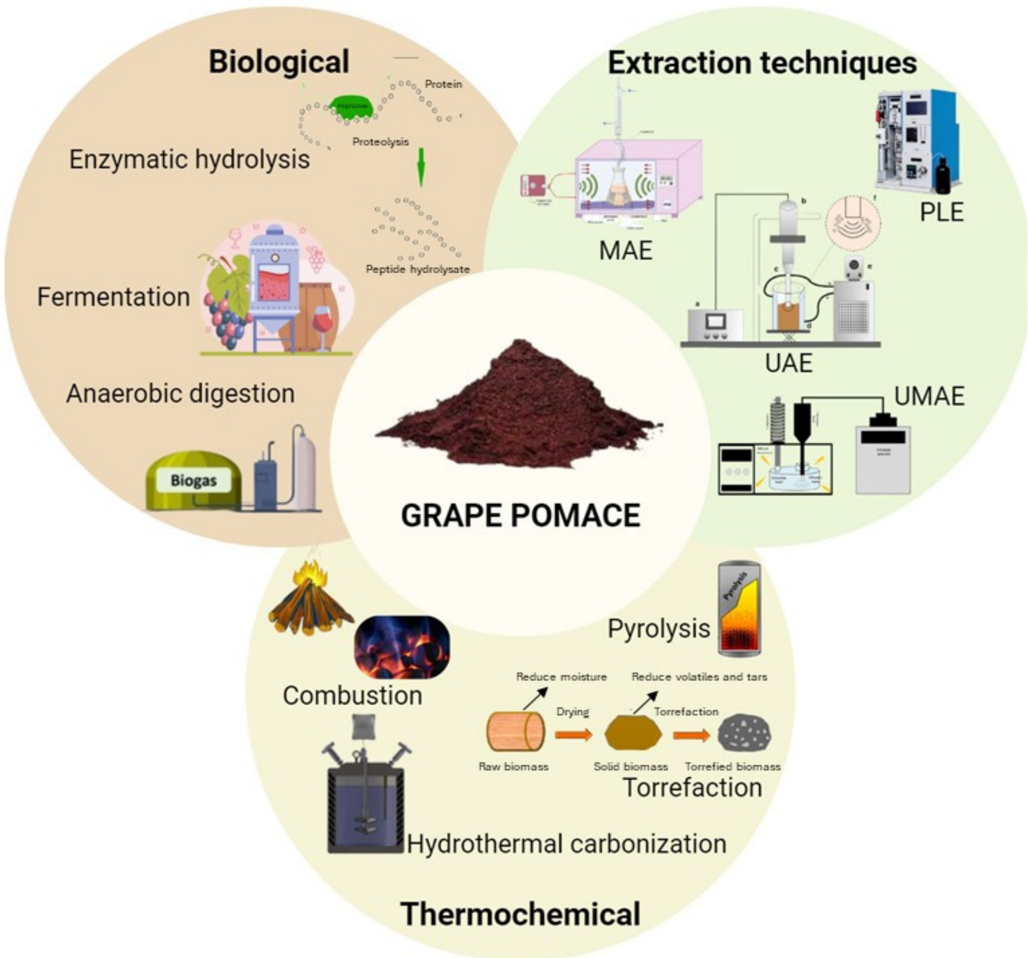

Figure 2. Efficient and sustainable approaches for grape pomace valorization. MAE—microwave-assisted extraction; PLE—pressurized liquid extraction; UAE—ultrasound-assisted extraction; UMAE—ultrasound-microwave-assisted extraction.

On the other hand, to operate in an ecologically favorable and economical manner, lignocellulosic wastes, such as those found in grape pomace, appear to be important feedstocks for methane (CH_4) generation through anaerobic digestion, supporting the transition to renewable green energy sources [21]. Nevertheless, this biological conversion represents the worst environmental outline in terms of carbon footprint (450 kg CO_2 eq per ton of biowaste) due to CH_4 emissions. On the other hand, considering the advantages of biogas (around 70% CH_4 and 30% CO_2), the carbon footprint of this alternative is almost equal to that of incineration [22]. At the laboratory scale, the anaerobic digestion of grape pomace from the Pedro Ximénez variety was evaluated under mesophilic conditions by Javier et al. [23]. The result showed that the maximum yield of the CH_4 coefficient obtained was 65.55 L of CH_4 per ton of grape pomace (ton_{gp}), with a biodegradability of 51%. Burning the biogas produced can provide 3.63 kW/ton_{gp} of electricity, which, depending on the price of energy, can be converted into EUR 0.43/ton_{gp}.

3.2. Thermochemical Conversion

Through a sequence of physicochemical reactions in a controlled environment, thermochemical conversion employs heat to break down biomass into low molecular weight molecules to produce desired outputs [24]. Thermochemical conversion, in contrast to biochemical conversion, utilizes whole biomass to generate value-added compounds with high energy efficiency, high yields, and shorter processing times. In this sense, grape pomace represents a suitable source for thermochemical conversions, namely, pyrolysis, torrefaction, hydrothermal carbonization, and combustion.

Pyrolysis is the process of the thermal decomposition of biomass at high temperatures (300 and 800 °C) in an inert environment to prevent combustion. It is the most frequent process for the production of biochar, the most common carbonaceous substance obtained from biomass, and it allows the production of exceptional structures with detailed surfaces and high porosity [2,25]. On the other hand, torrefaction, also known as mild pyrolysis, takes place at 200–300 °C and produces a primary solid fraction and, to a lesser extent, a torrefaction liquid mainly composed of hemicellulose degradation products [26]. A comparative study between the efficiency of pyrolysis and torrefaction to convert grape pomace into a source of value-added compound source (e.g., oils, acetic acid, phenols) was conducted by del Pozo et al. [26]. The data demonstrated that with pyrolysis the phenolic compounds were separated in the bio-oil, resulting from lignin degradation, whereas with torrefaction most of the phenolic compounds were not volatilized and remained in the biochar. On the other hand, Yoon et al. [27] used pyrolysis at different temperatures to produce biochar from grape pomace as an adsorbent for cymoxanil pesticide removal. The data obtained showed that the biochar obtained at 350 °C had the highest cymoxanil pesticide adsorption capacity (161 mg cymozanil/g biochar) and the lowest surface area (0.25 m^2/g) at pH 7. Zabaniotou et al. [28] investigated the efficiency of the pyrolysis of grape pomace and observed the production of 0.52 t of biochar, 0.80 t of bio-oil, and 0.630 MWh of energy. The energy produced can replace 1t of lignite, resulting in an additional economic value of EUR 4470/ha and avoiding 355 kg CO_2/t on a dry pomace basis. In this sense, hydrothermal carbonization appeared as a sustainable approach for the valorization of grape pomace since it requires water, lower temperatures (150–350 °C), and can be directly applied in residues characterized by high water levels, leading to the production of gases and carbonaceous materials, called hydrochar. Salaudeen et al. [29] evaluated the influence of hydrothermal carbonization on the steam gasification of grape pomace, which can theoretically reduce tar formation by eliminating minimum quality volatiles with the process water, although further research is required.

3.3. Extraction of Value-Added Compounds

Extraction is considered the most important step in the recovery, isolation, and subsequent identification of compounds present in extracts, and there is no standard method [30]. Conventional techniques such as solid–liquid, maceration, and Soxhlet extractions, have been used for many years; however, they require large quantities of solvent, are time-consuming, and can result in losses of value-added compounds due to the numerous steps in the process (Figure 3). In addition, the choice of extraction solvent and even the sample/solvent ratio are important in achieving good recovery of the compounds.

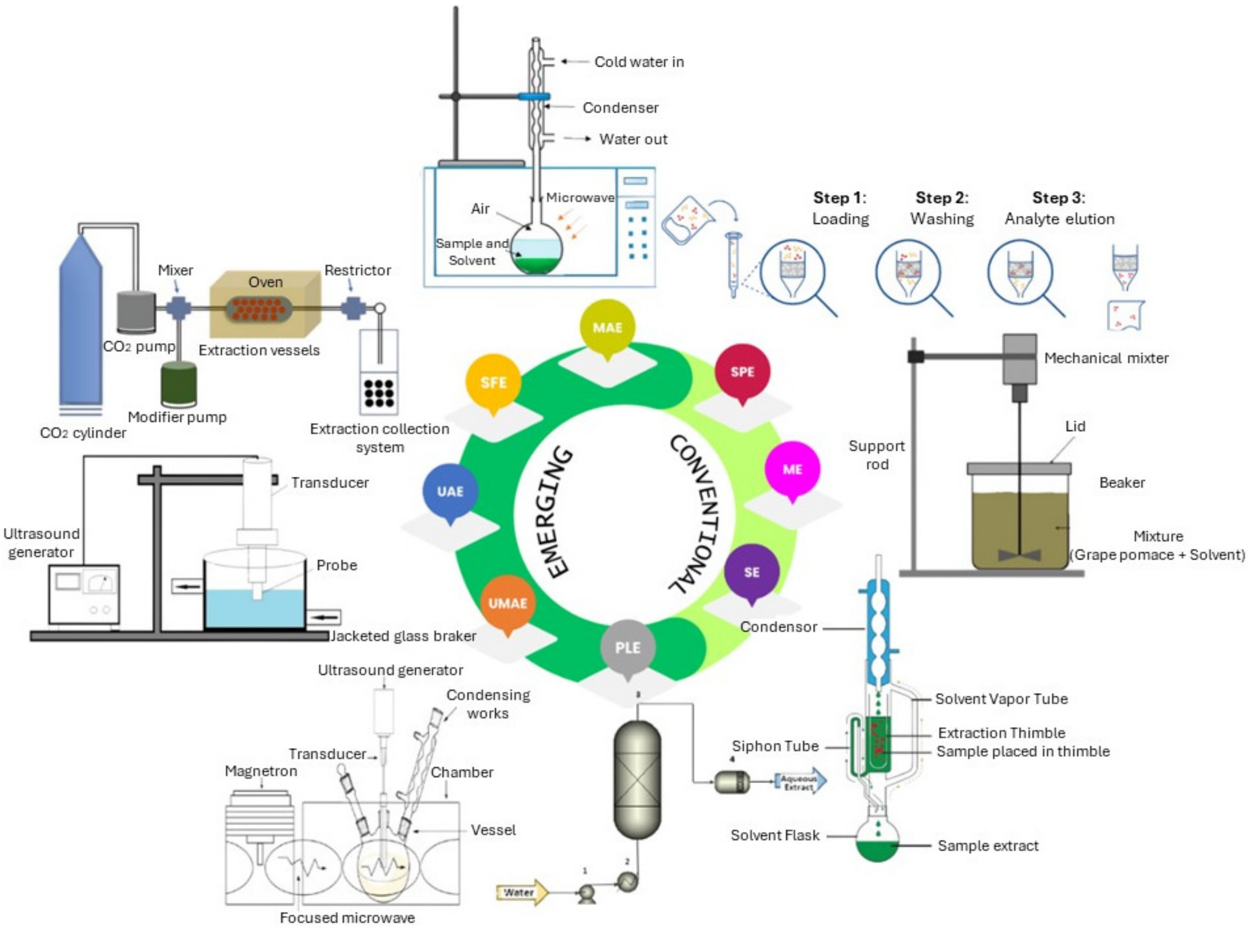

Figure 3. Conventional and emerging extraction techniques are used to recover value-added compounds from grape pomace. MAE—microwave-assisted extraction; ME—maceration; SE—Sohxlet; PLE—pressurized liquid extraction; SPE—solid phase extraction; SFE—supercritical fluid extraction; UAE—ultrasound-assisted extraction; UMAE—ultrasound–microwave-assisted extraction.

Several researchers have reported the design and optimization of emerging extraction procedures, such as supercritical fluid extraction (SFE) [31,32], microwave-assisted extraction (MAE) [33–35], PLE [16,36], ultrasound-assisted extraction (UAE) [35,37], enzymatic extraction [38], among others, to maximize the yield of value-added compounds (e.g., phenolic compounds, anthocyanins, fibers, proteins) from grape pomace for various applications in food, agriculture, pharmaceuticals, and cosmetics [12,39–42]. These emerging extraction techniques have been proposed for the recovery of phenolic compounds from grape pomace with the main objective of reducing extraction time, solvent volume, and cost, as well as increasing sustainability [30,43]. Solid–liquid extractions (e.g., PLE) use high temperatures and pressures and are considered a more efficient extraction procedure compared to solvent extraction and SFE, which use high solvent power and the distinctive physicochemical properties of supercritical fluids [16,30,44]. Aresta et al. [31] compared the extraction efficiency of traditional solid–liquid extraction (SLE) and SFE, in terms of extraction yield, total phenolic content (TPC), and antioxidant activity from Merlot grape pomace. The data obtained showed that SLE allowed to obtain higher extraction yield, TPC, and antioxidant activity compared to SFE, as can be observed in Table 1.

Table 1. Phenolic compounds identified in grape pomace from different grape varieties.

Grape Pomace	Extraction Procedure	Analytical Approach	Outcome	Ref
Cabernet Sauvignon	PLE: 40% (*v*/*v*) ethanol, 9 min, 5 cycles, 130 °C Sonification: acetone/H_2O/acetic acid 70/28/2%*v*/*v*	HPLC	EY: 0.11 (sonification), 0.32 (PLE) g/g dw TPC: 10.4–72.6 mg(GAE)/g dw TA: 0.80–0.90 mg(C3GE)/g dw TPCA: 7.68–11.30 mg(PB2E/g dw TF: 10.5–50.3 mg(CAE)/g dw DPPH: 36.2–76.1 mg(TE)g dw ABTS: 66.9–109.3 mg(TE)g dw	[19]
Merlot	LLE: S/L 1:50, 100:0, 80:20, 60:40, 40:60, 20:80, and 0:100% of ethanol: H_2O *v*/*v*)	HPLC-DAD	The best TPC, TFC, and TA were attained with ethanol: H_2O (40:60 *v*/*v*). TPC: 649–2915 mg(GAE)/100 g dw TFC: 254–1793 mg(CAE)/100 g dw TA: 7.24–66.2 mg(C3GE)/100 g dw PC: syringic acid (46.1 mg/100 g dw), quercetin (31.2), vanillic acid (35.4), gallic acid (36.0)	[45]
Garganega	SE: 75% acetone, S/L 1:5, 50 °C, 2 h PLE: 10.6 g GP, 100 bar, 1 h, 80 °C, 75% (ethanol:H_2O 50:50 *v*/*v*), 25% CO_2, 8 g/min	HPLC-DAD	EY: 51.1 (SE), 60.8 (PLE) g/kg TPC: 60.8–77.9 g(GAE)/kg dw PC: catechin, epicatechin gallate, epicatechin, epigallocatechin, rutin	[16]
Feteasca Neagra, *Merlot*, *Burgundy*, *Cabernet Sauvignon*, *Pinot Noir*	MAE: ethanol:H_2O 50% g/g, S/S 1:3 g/g, 100 °C, 5 min, 13 psi	UHPLC–ESI/HRMS	TPC: 17.1–25.6 mg(GAE)/g dw CAT: 17.7–20.7 mg(CAE)/g dw TAN: 179–448 mg/g dw TA: 26.8–156.6 mg(C3GE)/g dw DPPH: 41.7–85.1 µM(TE)/g dw PC: Quercetin (355–1445.7 mg/100 g dw), catechin (79.2–185.7), epicatechin (79.9–142.8), syringic acid (18.3–94.3), gallic acid (6.44–14.1), pinocembrin (0.81–45.4)	[34]
White	MAE: 10% (m/m) of GP, 10 min, 100 °C, 2.7 g of ChCl:LacA: H_2O (36:39:25% *v*/*v*)	HPLC-ESI-MS/MS	EY: 135 mg proanthocyanidins/g dw (MAE), 126 mg/g dw (conventional maceration) The extraction time was reduced from 1 h to 3.56 min.	[33]
Grape pomace	NADES-UMAE: ChCl:citric acid (2:1) with 30% H_2O/DES (*v*/*v*) 50 °C, 2 h, 300 W (MAE), 50 W (US)	HPLC	EY: 1.77 mg/g dw TPC: 2892 mg(GAE)/kg dw ORAC: 2190 mM(TE)/g dw PC: Malvidin-3-(6-O-p-coumaroyl) monoglucosides (1116 mg/kg dw), Malvidin-3-O-monoglucoside (556.8), catehin (266.6)	[46]
Tannat	UAE: 3 g of GP, 60 mL ethanol/H_2O 1:1 *v*/*v*	HPLC	UAE extracts were 50% richer in TPC and TMAC than conventional extractions. TPC: 7.8–77.6 mg(GAE)/g dw TMAC:1.29–5.46 mg(C3GE)/g dw TAC: 32.4–200.7 mg(TE)/g dw	[44]
Lacrima Di Morro d'Alba and *Verdicchio*	UAE: 1 g of GP, 15 mL ethanol:H_2O 70:30, *v*/*v* acidified HCl (0.1%), 40 KHz, 60 min, 25 °C	HPLC-ESI-MS/MS	TPC: 41.2–106.5 mg(GAE)/g dw TFC: 27.7–38.2 mg(RE)/g dw TA: 0.38–8.02 mg(C3GE)/g dw DPPH: 82.9–303.4 mg(TRE)/g dw PC: gallic acid (117.3–605.2 mg/kg dw), vanillic acid (200.4–713.6), quercetin (6–262.0), rutin (3.4–46.1), kaempferol (1.9–9), isorhamnetin (0.1–0.8)	[37]

Table 1. *Cont.*

Grape Pomace	Extraction Procedure	Analytical Approach	Outcome	Ref
Monastrell	UAE: 100 mg of GP, 1 mL of methanol/formic acid/H_2O (50:2:48, *v/v/v*), 60 min	HPLC-DAD-ESI-MS/MS	PC: Catechin (96.15 mg/kg dw), proanthocyanidin dimer (B-type) (84.60), proanthocyanidin dimer monogallate (45.04), epicatechin (42.0), proanthocyanidin dimer digallate (8.61), gallocatechin (7.99), catechin-gallocatechin (7.83)	[47]
Red and white	SE: 150 g of GP, 300 mL of ethanol/H_2O 50:50 *v/v*, 40 °C, 15 min	HPLC-DAD-ESI-MS/MS	Σflavonols: nd–204.5 µM/g dw Σanthocyanins: nd–57.7 µM/g dw Σflavan-3-ols: 245–826 µM/g dw Σ stilbenes: nd–1.06 µM/g dw	[48]
Aresta White	SFE: 0.1 kg GP, 8 MPa, 40 °C, 10% (*w/w*) ethanol/240 min	HPLC-DAD-MS	EY: 2.3 g/100 g dw TPC: 2245 mg(GAE)/100 g dw DPPH: 5154 mg(α-tocopherol)/100 g dw TPCA: 0.994 g (CAE)/100 g dw PC: *cis*-resveratrol glucoside (2297 µg/100 g dw), *cis*-coutaric acid (1841), *trans*-p-coumaric acid (897), and quercetin (659)	[32]
Merlot	SFE: 3 g GP, 60°C 250 bar, flow rate 2 mL/min. SLE: 5 g GP, 5 mL of 70% ethanol, 20 min	-	SFE obtains a higher EY of all analytes compared to SLE, except for β-sitosterol and α-tocopherol TPC: 570 µg(GAE)/g dw SFE, 650 µg(GAE)/g dw (SLE) DPPH: 0.118 mM (TE)/g dw (SFE), 0.141 mM (TE)/g dw (SLE)	[31]
Syrah, *Cabernet Sauvignon*, *Malbec Pinot-Noir and Marselan*	Enzymatic extraction: pectinase, cellulase, tannase, 50 mM acetate buffer at S/L 1:10 (*w/v*)	HPLC-DAD	Both fungi increased the antioxidant activity of the extracts, reaching maximum values of 73.7 (*A. niger*) and 109 (*A. oryzae*) mM (TE)/100 g dw TPC: 0.49 to 0.81 g (GAE)/100 g dw TAC: 3.1 to 5.6 mM (TE)/100 g dw PC: syringic acid (0.13–0.17 g/100 g dw, gallic acid (0.03–0.16), (+)-catechin (0.018–0.028)	[38]

Abbreviations: ABTS: 2,2′-azino-bis-3-ethylbenzthiazoline-6-sulphonic acid assay; C3GE: cyanidin-3-glucoside equivalent; CAE: catechin equivalent; CAT: catechins; ChCl: choline chloride; LacA: lactic acid; NADES: natural deep eutectic solvents; DPPH: 2,2-diphenyl-1-picrylhydrazyl assay; dw: dry weight; EY: extraction yield; GAE: gallic acid equivalent; GP: grape pomace; HPLC: high-performance liquid chromatography; HPLC-DAD-ESI-MS/MS: high-performance liquid chromatography equipped with photodiode array detection-electrospray ionization tandem mass spectrometry; HPLC-ESI-MS/MS: high-performance liquid chromatography-electrospray ionization tandem mass spectrometry; LLE: liquid–liquid extraction; MAE: microwave-assisted extraction; nd: not detected; PB2E: procyanidin B2 equivalent; PC: main phenolic compounds identified; PLE: pressurized liquid extraction; RE: rutin equivalent; ORAC: oxygen radical absorbance capacity; S/L: ratio solid/liquid (g/mL); SLE: solid–liquid extraction; S/S: ratio solid/solid (g/g); SE—solid-based extraction; TA: total anthocyanins; TAC: total antioxidant capacity; TAN: tannins; TE: trolox equivalent; TFC: total flavonoid content; TMAC: total monomeric anthocyanin content; TPC: total phenolic content; UAE: ultrasound-assisted extraction; UHPLC–ESI/HRMS: ultra-high-performance liquid chromatography–electrospray ionization high-resolution mass spectrometry.

Another extraction procedure for recovering value-added compounds from grape pomace is MAE, which promotes the separation by using a heated solvent and microwave radiation. This extraction process has many advantages, including high efficiency, low energy consumption, fast processing times, economical, clean, easy to control, and lower solvent volumes [34,49]. Spinei and Oroian [49] optimized MAE in terms of microwave power, irradiation time, and pH to obtain pectin from grape pomace, and this wine by-product represents a suitable source of pectin with high galacturonic acid content, degree of esterification, and molecular weight. More recently, Spinei and Oroian [50] compared the properties of pectin extracted using conventional and emerging techniques (MAE, UAE), including emulsifying activity and emulsion stability, among others, from grape pomace. The data obtained showed that MAE had the highest yield, and the extracted pectin showed potential for various applications such as emulsification, thickening, and stabilization in food products.

The combination of eutectic solvents (ESs) with MAE to extract proanthocyanidins from white grape pomace with a higher extraction yield (EY) and mean degree of polymerization (mDP) was studied by Neto et al. [33]. The best ES (36% of choline chloride, 39% of lactic acid, 25% of water) in combination with MAE at 100 °C allowed to reduce the extraction time from 1 h to 3.56 min, with slightly higher EY (135 vs. 126 mg proanthocyanidins/g of grape pomace) and mDP (7.2 vs. 6.5). UAE using high-frequency sound waves has also been used [30,44]. This technique is an efficient extraction method for the isolation of phenolic compounds from grape pomace, especially when applied to grape seed oil, allowing a reduction in extraction time with relevant results in the recovery of phenolic compounds. However, caution should be exercised with the UAE as may lead to the degradation of the phenolic compounds of interest [30]. González et al. [44] confirmed that UAE produced extracts that were, on average, 50% richer in TPC and total monomeric anthocyanins compared to traditional extractions. Recently, natural deep eutectic solvents (NADESs) combined with simultaneous ultrasound/microwave-assisted extraction (UMAE) have emerged as suitable green solvents for the recovery of value-added compounds from grape pomace. Hydrogen bond acceptors (e.g., quaternary ammonium, phosphonium salts), hydrogen bond donors (e.g., sugars, alcohols, amino acids, organic acids), and occasionally up to 50% (v/v) of water are the two or three components that constitute NADESs, a combination that forms intramolecular hydrogen bonds [46,51]. Regarding the importance of an integrated approach to the valorization of grape pomace, there have been few studies related to this topic available in the literature. For example, Farru et al. [17] proposed a cascade biorefinery for grape pomace starting with the recovery of the phenolic compound using an eco-friendly and economical SLE, followed by the production of value-added products and energy through thermochemical conversion, and the production of CH_4-rich biogas through anaerobic digestion. Monari et al. [16] also proposed a two-step cascading process aiming at a complete zero waste valorization of grape pomace, starting with the recovery of phenolic compounds through two extraction procedures, SLE and PLE, then using the solid fiber extraction residue to produce fully bio-based composite formulations by melt blending with the renewable and biodegradable poly(hydroxybutyrate-co-hydroxyvalerate) matrix.

4. Potential Food Industrial Applications

The growing attention to grape pomace, the most important by-product of wineries, is mainly due to the bioactivity of the high-value-added compounds, including phenolic compounds, flavonoids, anthocyanins, volatile organic compounds (VOCs), minerals, fibers, hemicellulose, as well as their potential application various industrial sectors, such as pharmaceuticals, cosmetics, nutraceuticals, agriculture, livestock, and in energy recovery systems, Figure 4 [12,39–42]. However, in the current review, only industrial food applications will be discussed.

The nutritional content of a product, food quality, and consumer acceptance of the food are gradually reduced by this process in combination with auto-oxidation and microbial contamination [12]. In this context, the use of grape pomace as a source of new foods or components/ingredients with nutritional and functional properties is a growing trend due to its phenolic content (70% phenolic compounds), which persists after the vinification process. Together with dietary fiber, these beneficial substances offer health advantages including the prevention of cancer or chronic diseases [52], and they can be used for food preservation by preventing lipid oxidation and through their antimicrobial effects [15].

Grape pomace can serve as a source of natural food additives due to its rich content of bioactive compounds, including phenolic compounds, anthocyanins, dietary fibers, terpenoids, among others [47,53–56]. These additives can be used for various purposes in food formulations, such as antioxidants, dietary fibers, flavor enhancers, and natural colorants, among others. By incorporating grape pomace-derived additives into food formulations, manufacturers can meet consumer demand for clean-label products while benefiting from the functional properties and health-promoting effects of these natural ingredients.

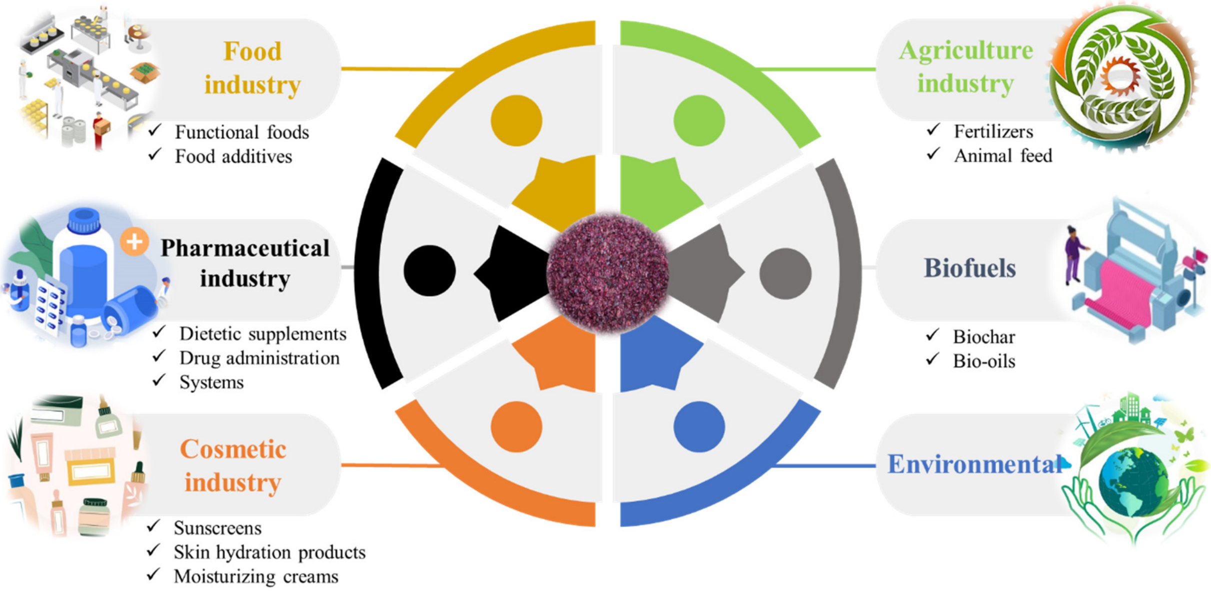

Figure 4. Potential industrial application of grape pomace.

4.1. Antioxidant and Antimicrobial Agents

Phenolic compounds extracted from grape pomace can act as natural antioxidants and antimicrobial agents, preventing lipid oxidation and extending the shelf life of food products (e.g., meat, dairy products, and baked products), thereby preserving their quality and nutritional value [57,58]. Some studies show that grape pomace contains high levels of phenolic compounds, with different qualitative and quantitative distributions, depending on different factors such as the type of grape variety, the location, and the wine-making process used [16,45,46]. Table 1 shows the main phenolic compounds that have already been identified in grape pomace from different grape varieties using different extraction processes and analytical methods, as well as TPC, total anthocyanins (TA), total flavonoid content (TFC), and antioxidant activity (DPPH, ABTS).

Antioxidant packaging is a sort of active packaging created by incorporating antioxidants into the packaging material to enhance food preservation and shelf life [59]. Although synthetic antioxidants (e.g., butylated hydroxyanisole, butylated hydroxytoluene) and/or natural antioxidants from food waste and by-products have been used to develop more sustainable and environmentally friendly packaging solutions [60]. In a study conducted by Cejudo-Bastante et al. [61], a new active food packaging material was developed using natural jute fibers impregnated with grape pomace extract (90 mg/mL) at 50 MPa and 55 °C. The results showed that the antioxidant and antibacterial (against *Escherichia coli*, *Staphylococcus aureus*, and *Pseudomonas aeruginosa*) properties of grape pomace extract were successfully transferred to jute natural fibers. Mugnaini et al. [59] also evaluated the incorporation of natural phenolic compounds found in grape pomace into biopolymer films intended for food preservation. The active edible biopolymeric films showed improved mechanical, antioxidant, and antibacterial properties, demonstrating their potential for significant effects under real conditions. Silva et al. [62] observed that the addition of grape pomace extract increased the relaxation time of the polypropylene film melt and reduced the initial thermal decomposition temperature of the film. The antimicrobial polypropylene film prepared with grape pomace extract showed significant antibacterial activity, making it suitable for food packaging applications. In a published study, different amounts of grape pomace were incorporated to enhance the preservation of pork burgers [63]. This incorporation significantly inhibited coliform growth during storage and prevented the development of protein and lipid oxidation during storage. Interestingly, grape pomace extract has been touted as a replacement for sulfite; however, the effectiveness of this approach appears to depend on the assay used, as the formation of complexes between phenols and proteins can interfere with some protein assays. However, the promising outlook for the development of active food packaging using grape pomace as an active agent provides opportunities for the valorization of these by-products. Incorporating bioactive compounds from grape pomace into packaging materials can not only improve food quality and safety through antioxidant and antimicrobial properties but also promote economic and environmental sustainability through the use of agricultural residues.

4.2. Dietary Fibers

Grape pomace contains insoluble (e.g., cellulose, hemicellulose, lignin) and soluble (e.g., pectin) dietary fibers that can improve the texture, stability, and nutritional profile of foods, such as baked products, cereals, and meat products. Insoluble fibers have high porosity and low density, which helps the digestive tract function more efficiently. Some dietary fiber components in grape pomace form chemical bonds with phenolic chemicals, resulting in antioxidant dietary fibers, giving grape pomace a higher radical scavenging capacity. This gives them a better nutritional value than the dietary fiber found in cereals. Studies have shown that these complex chemicals combined with dietary fibers have a greater impact on human health [14,64].

As has been extensively researched, grape pomace can be used to increase the fiber content of foods. Recently, leavened bakery products with high nutritional value, such as pizza bases, have been produced using grape pomace flour. In the study conducted by Difonzo et al. [52], grape pomace flour was used in proportions of 15%, 20%, and 25% in place of wheat flour. Experimental products with the addition of grape pomace flour showed a higher phenolic content and antioxidant activity and high dietary fiber content (6 g/100 g) already with 15% flour substitution, allowing the nutritional claim "enriched in fiber". An equivalent technological application was the use of grape pomace flour to produce muffins with higher fiber and lower fat content. The muffins produced had suitable properties in terms of phenolic content, fiber content, and antioxidant activity [65]. The use of grape pomace flour in unleavened bakery products, such as breadsticks has been the subject of scientific research [66]. In this study, technical methods were used to produce fortified breadsticks by substituting 0.5 g and 10 g of grape pomace flour per 100 g of wheat flour. Nutritionally, the fortified breadsticks contained more dietary fiber and phenolic compounds. The outcomes of these studies indicated the potential of grape pomace flour for the production of fiber-rich and bioactive breadsticks, with reasonable sensory acceptance [67]. In this sense, food enriched in fiber can aid in digestive health, promote regular bowel movements, and potentially reduce the risk of chronic diseases such as heart disease and diabetes by helping to maintain healthy blood sugar and cholesterol levels.

4.3. Flavor Enhancers

Grape pomace extracts are recognized for their ability to impart distinctive flavors and aromas to food products, enriching their sensory attributes and increasing consumer acceptance. This potential is attributed to the presence of various VOCs within the pomace in grape pomace, which contribute to its flavor profile; moreover, due to their low odor threshold, they may offer new opportunities for flavor modulation in the food industry, thus contributing to the sustainable use of resource utilization [50,68]. Table 2 summarizes the VOCs identified in grape pomace obtained from different *Vitis vinifera* L. grapes using headspace solid-phase microextraction combined with gas chromatography (HS-SPME/GC-MS).

For instance, the VOCs identified in wine by-products by Câmara et al. [68] can be used as additives to enhance the organoleptic characteristics of fish feed. In addition, specific VOMs such as benzyl alcohol and 2-phenyl ethanol are often utilized as flavoring agents in different beverages and food products (e.g., bakery products and sweets) [50], due to their low odor threshold.

Table 2. Volatile organic compounds (VOCs) identified in grape pomace using headspace solid-phase microextraction combined with gas chromatography (HS-SPME/GC-MS).

Grape Pomace	HS-SPME Extraction	Analytical Approach	Main VOCs	Ref.
Tinta negra, Complexa, Verdelho, Malvasia roxa, Boal, Malvasia, Sercial, Terrantez,	2 g GP, 0.5 g NaCl, 5 mL of H_2O, 40 °C, 45 min, DVB/CAR/PDMS fiber	GC-MS	Ethyl acetate (0.23–47.3 µg/L) Hexan-1-ol (1.33–25.5 µg/L) (*E*)-2-hexenal (n.d.–8.60 µg/L) 3-Methyl butan-2-ol (0.02–8.18 µg/L) Isoamyl acetate (0.02–6.32 µg/L) Hexanal (0.64–6.16 µg/L) Menthol (n.d.–3.64 µg/L)	[50]
Tinta Negra	4 g GP, 2 g NaCl, 5 mL of H_2O, 40 °C, 45 min, DVB/CAR/PDMS fiber	GC-MS	Methyl acetate (8.03 µg/L) 3-Hydroxy-2-butanone (5.97 µg/L) Acetic acid (4.48 µg/L) Methyl hexanoate (3.09 µg/L)	[68]
Chardonnay	1 mL GP extract, 9 mL H_2O, 2 g NaCl, 35 °C, 30 min, PDMS/DVB fiber	GC-MS	1-Butanol (0.81–0.96 µg/L) 1-Hexanol (1.58–9.25 µg/L) (*E*)-2-hexen-1-ol (0.38–2.01 µg/L) (*E*)-2-octen-1-ol (2.14–5.15 µg/L) Benzyl alcohol (0.17–0.92 µg/L) 2-Phenyl ethanol (0.16–0.76 µg/L) Geraniol (0.21–0.22 µg/L)	[69]

Abbreviations: HS-SPME—headspace-solid phase microextraction; GC-MS—gas chromatography-mass spectrometry; GP—grape pomace.

4.4. Natural Colorants

Anthocyanins, tocopherols, carotenoids, and other pigments present in grape pomace can be used as natural colorants in food and beverage applications, replacing synthetic additives, and their color can change depending on the pH of the medium. Nevertheless, the main studies reported in the literature have focused on the extraction of anthocyanins from grape pomace (84.4–131 mg anthocyanins/100 g) [4]. The use of anthocyanins as food colors in beverages, jams, sweets, ice creams, and medicines is now permitted by the European Food Safety Authority (EFSA) [12]. Because of this characteristic, several food manufacturers have started to use natural anthocyanins instead of synthetic dyes to color food ingredients [53]. It is known that the color of anthocyanins can change depending on the pH of the medium and that their colors can remain stable after acetylation, polymerization, and condensation processes [70]. Nogueira et al. [71] proposed arrowroot starch films containing anthocyanin-rich grape pomace extract for several applications, including color migration for food simulants and fish meat freshness testing. The developed film changes color in different pH buffer solutions, from pink at pH 2 to light blue at pH 7 and slightly yellowish green at pH 10. After 96 h of storage at 25 °C, the composite films changed color from reddish pink to slightly green, indicating fish meat freshness. Moreover, Souza Mesquita et al. [72] used eutectic solvents with potential health benefits, such as those based on vitamins, to recover anthocyanins from grape pomace, and the extracted anthocyanins were loaded onto silicon dioxide (SiO_2) and tested for thermal stability at different temperatures. The data showed that this strategy also enhanced the stability of the pigments at high temperatures, thus contributing to the valorization of grape pomace by extracting natural pigments. On the other hand, Romanini et al. [73] microencapsulate anthocyanins from grape pomace extract in a combination of maltodextrin and xanthan gum and use gelatin to assess the effect of this process on color stability. The results showed that encapsulation maintained the stability of anthocyanins in grape pomace extract under different conditions (e.g., temperature, absence, presence of light), resulting in a longer half-life compared to the control (isolated extract). In this sense, EFSA's approval of anthocyanins as food colors has significant implications for the wider use of encapsulated natural colors across the food industry and the promotion of innovation.

4.5. Functional Ingredients in Foods

In addition to its nutritional importance, grape pomace extract can certainly be utilized as a functional component in foods and beverages to provide health benefits [65,74–76], as can be observed in Table 3. The influence of grape pomace powder on the chemical, technological, and sensory characteristics of muffins was assessed by Troilo et al. [65], Baldán et al. [74], and Antoniolli et al. [77]. These studies concluded that grape pomace powder added to muffins can enhance their nutritional value by increasing the content of bioactive compounds (e.g., phenolic compounds, anthocyanins), as evidenced by the positive results obtained in the analysis of muffins and the acceptance of products containing grape pomace by consumers [65,74,77]. Milinčić et al. [76] investigated the physical and functional qualities of goat milk powders enhanced with grape pomace seed extract, and the results demonstrated that thermally treated enriched goat milk powders exhibited improved emulsifying properties and stability, making them promising ingredients for the formulation of functional food that require good emulsifying activity and stability. This research also revealed phenolic–protein interactions and changes in the secondary structure of milk proteins due to the presence of phenolic compounds and thermal treatment. On the other hand, Difonzo et al. [52] evaluated the influence of the addition of three different percentages of grape pomace in the formulation of pizza bases. These authors found that the addition of grape skins and seed flours to pizza bases resulted in increased fiber content and antioxidant activity, as well as significant differences were found in texture and volatile compounds depending on the type and percentage of grape flour added. For instance, Tolve et al. [78] fortified wheat bread with grape pomace powder, and the results demonstrated that this incorporation improved water absorption and quality score, reduced the softening degree of doughs, and modified the chemical composition and sensory attributes of the bread. In addition, the potential of grape pomace for the development of functional biscuits is demonstrated in another study by Olt et al. [79], in which the level of grape pomace powder was varied (10–20% *w*/*w* total wet dough). The data showed that this incorporation potentially improved oxidative stress, glucose, and fatty acid levels while maintaining good sensory quality. Nevertheless, most of them try to increase the antioxidant activity of the system or the total dietary fiber content, which will strengthen the protection of the different forms of fat that may be present in the food matrix from oxidation [8].

Table 3. Grape pomace as a valuable resource in the development of functional foods.

Food Product	**Amount of Grape Pomace**	**Main Outcome**	**Ref**
Biscuits	10% to 20% (*w*/*w*) grape pomace powder (GPP)	The integration of GPP on biscuits appeared to be an encouraging functional meal with the facility to alleviate oxidative stress and hyperglycemia.	[79]
Bread	5% (*w*/*w*) of GPP	The incorporation of GPP indicated a decrease in moisture content and a rise in anthocyanin levels.	[80]
Bread	2% (*w*/*w*) of GPP	Bread formulation with the incorporation of GPP produces the greatest results, as it allows for a product with a homogenous structure and improved volume.	[81]
Bread	5% and 10% (*w*/*w*) GPP	Fortification with GPP resulted in a significant increase in anthocyanins, lower starch hydrolysis, and predicted glycemic index.	[82]
Breadsticks	5 g and 10 g/100 g of GPP	Fortification of breadsticks with GPP improved TPC and antioxidant activity, as well as affected the rheological properties of doughs.	[66]

Table 3. *Cont.*

Food Product	Amount of Grape Pomace	Main Outcome	Ref
Breadsticks	5 g and 10 g/100 g of GPP	Antioxidant capacity within breadsticks declined over time, revealing that oxidation initiated and decreased antioxidant activities.	[67]
Cereal bars	10 g and 20 g of GPP	The fortified bars demonstrated alterations in properties, namely increased moisture, and soluble dietary fiber level.	[83]
Gluten-free muffins	108 g to 180 g	The addition of GPP improved the nutritional composition of the muffins as their content increased, emphasizing protein and crude fiber levels.	[74]
Goat milk powders	0.2 mg to 0.6 mg grape pomace seed extract (GPSE)	Functionally enhanced GPSE powders, exhibited remarkable emulsifying properties, positioning them as promising candidates for formulating new food products that need ideal emulsifying activity and stability.	[76]
Jelly candy	1 g of grape pomace	The incorporation of grape pomace enhanced phenolic content, oil-binding capacity, antioxidant activity, color, and textural parameters.	[84]
Muffins	15 g of GPP	The particle size of the GPP was found to affect the texture, color, antioxidant activity, and sensory properties of the muffins.	[65]
Pasta	25% and 50% of GPP	The pasta with 50% GPF demonstrated an excellent mix of antioxidant activity, nutritional value, consumer appeal, and promise as a new functional food.	[85]
Pasta	25% of GPP	The addition of GPP raised the amount of dietary fiber in the finished product by nearly 45 times.	[86]
Pasta	5% and 10% (*w*/*w*) GPP	Polyphenol concentration varied amongst GP-fresh pasta samples and rose proportionately with the quantity of GPP applied. The antioxidant activity of raw GP-fresh pasta samples did not differ but increased during cooking due to interactions between polyphenols in GPP and gluten proteins.	[87]
Pasta	3, 6 and 9% (*w*/*w*) GPP	The inclusion of GPS into pasta formulations of up to 6% resulted in products with better organoleptic and functional qualities. A 9% GPS level is not suggested in the pasta recipe because of the challenges that might develop in the pasta processing, in the reduction of the dough elasticity.	[88]
Pizza bases	Grape pomace (mix of skin/seed flour 70:30 (*w*/*w*)) to replace 15–25% of wheat flour	The addition of grape pomace to pizza bases enhanced fiber content and antioxidant activity. Significant differences were observed in texture based on the type and percentage of grape pomace added.	[52]
Savory crackers	5%, 10% and 15% (*w*/*w*) GPP	The incorporation of GPP in savory crackers showed potential as a functional food, with novel colors and enhanced fiber amount.	[75]
Wheat bread	5 g and 10 g/100 g GPP	The incorporation of GPP in wheat bread changed the taste, color, and flavor of the bread.	[78]
Wheat pasta	4% (*w*/*w*) GPP	The incorporation of GPP improved phenolic content, antioxidant activity, carotenoids, tocochromanols, and fiber content.	[89]
Wheat pasta	5 g and 10 g grape pomace/100 g	Pasta fortified with grape pomace increased TPC, antioxidant activity, and fiber content in cooked products.	[90]

4.6. Prebiotic Potential

Numerous studies on the use of grape pomace in functional foods have led researchers to focus on the prebiotic potential of grape pomace and its components [8,91]. It is known that the encapsulation of phenolic compounds is a practical alternative to increase their bioaccessibility and bioavailability. A recent study evaluated the effects of a micro-encapsulated pomace extract added to coconut water on the growth of probiotic bacteria [92]. At a concentration of 2% (w/v), the extract appeared to have prebiotic potential, acting as both an antioxidant and an antibacterial agent. The findings showed a beneficial effect on the development of bifidobacteria and lactobacilli, with no adverse effects on the sensory aspect in terms of aroma and flavor. In another investigation, maltodextrin and a grape pomace extract rich in value-added compounds were combined to form vesicles for intestinal transport [1]. The ability of these vesicles to produce *Lactobacillus reuteri* biofilm in vitro was demonstrated by their apparent ability to reduce hydrogen peroxide-induced damage to intestinal epithelial cells. Anghel et al. [93] investigated the effects of different drying methods on grape pomace and evaluated the potential antidiabetic effect of the extracts obtained. The data obtained demonstrated that anthocyanins from grape pomace have the potential to act as antidiabetic molecules and that the infrared drying method can be employed to protect the quality of GP puree inoculated with probiotic (*Lactobacillus casei ssp. paracasei* (*L. casei* 431®). Bordiga et al. [94] also showed the in vitro prebiotic potential of grape seed extracts; however, the results of the study showed that *Lactobacillus acidophilus* P18806 displayed different sensitivity to phenolic compounds; therefore, the purification of such extracts is considered crucial. However, the extraction of these bioactive compounds could also be valuable as they can be utilized to enhance the quality of food items or to replace synthetic commercial additives. A step in the right direction was taken when Meini et al. [38] investigated the solid-state fermentation of grape pomace using filamentous fungi, such as *Aspergillus niger* and *Aspergillus oryzae*, and, in particular, the effect of the process on the antioxidant and prebiotic activities of the extracts produced. The idea was based on the discovery that filamentous fungi can secrete hydrolytic enzymes that facilitate the release and extraction of phenolic compounds. The extracts obtained appeared to promote the development of probiotic *Lactobacillus casei* species. The simultaneous synthesis of enzymes such as cellulase, pectinase, and tannase, which may be recovered and used in industrial applications, is another benefit of this system, in addition to the production of grape pomace extracts with prebiotic and antioxidant activity.

5. Conclusions and Future Trends

The disposal or management of winemaking by-products (e.g., grape pomace, lees) is a serious concern for the wine industry. To overcome and/or mitigate environmental concerns, academics and industry experts worldwide have been investigating sustainable approaches to valorize this by-product by employing emerging techniques to isolate value-added phytochemicals and/or by applying biotechnological, mechanical, and chemical conversion.

Regarding the isolation and recovery of value-added compounds, emerging extraction procedures, such as SFE and ASE, appear to be sustainable approaches to reducing processing time, reducing environmental damage caused by toxic solvents and energy consumption, and increasing extraction yields compared to conventional techniques (Soxhlet, SLE). Nevertheless, these approaches to grape pomace management have generally been carried out individually, and, in this context, future investigations should be performed to integrate strategies to valorize the bulk organic matter after the extraction of valuable phytochemicals with promising benefits in the food, cosmetic, and pharmaceutical industries. To the best of our knowledge, there are few studies in the literature on integrated strategies for the valorization of grape pomace, but this represents an important approach for enhancing environmental sustainability, economic viability, and resource efficiency. They support the transition towards a circular economy by turning waste into valuable products and energy, fostering innovation, and creating new economic opportunities. Nevertheless, to fully implement these integrated approaches and enhance the economic competitiveness and resilience of the winemaking sector, it is important to enhance our understanding of each process, maybe by implementing them at a pilot scale.

Author Contributions: Conceptualization, R.P. and J.S.C.; investigation, T.A., P.S., J.G. and N.H.; writing original draft preparation T.A., P.S., J.G. and R.P.; review and editing, R.P. and J.S.C.; visualization, T.A., R.P. and J.S.C.; supervision, J.T. and R.P.; funding acquisition J.S.C., J.T. and R.P. All authors have read and agreed to the published version of the manuscript.

Funding: This work was supported by the Fundação para a Ciência e a Tecnologia (FCT) with Portuguese Government funds through the CQM Base Fund—UIDB/00674/2020 (DOI: 10.54499/UIDB/00674/2020) and Programmatic Fund—UIDP/00674/2020 (DOI 10.54499/UIDP/00674/2020), and by ARDITI-Agência Regional para o Desenvolvimento da Investigação Tecnologia e Inovação through funds from Região Autónoma da Madeira-Governo Regional. The authors also acknowledge the financial support from Fundação para a Ciência e Tecnologia and Madeira 14-2020 program to the Portuguese Mass Spectrometry Network through PROEQUIPRAM program, M14-20 M1420-01-0145-FEDER-000008. Teresa Abreu thanks PhD fellowships FCT 2022.11323. BDANA is supported by FCT.

Data Availability Statement: No new data were created or analyzed in this study. Data sharing is not applicable to this article.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Manca, M.L.; Casula, E.; Marongiu, F.; Bacchetta, G.; Sarais, G.; Zaru, M.; Escribano-Ferrer, E.; Peris, J.E.; Usach, I.; Fais, S.; et al. From Waste to Health: Sustainable Exploitation of Grape Pomace Seed Extract to Manufacture Antioxidant, Regenerative and Prebiotic Nanovesicles within Circular Economy. *Sci. Rep.* **2020**, *10*, 14184–14197. [CrossRef]
2. Perra, M.; Bacchetta, G.; Muntoni, A.; De Gioannis, G.; Castangia, I.; Rajha, H.N.; Manca, M.L.; Manconi, M. An Outlook on Modern and Sustainable Approaches to the Management of Grape Pomace by Integrating Green Processes, Biotechnologies and Advanced Biomedical Approaches. *J. Funct. Foods* **2022**, *98*, 105276–105285. [CrossRef]
3. Rodrigues, R.P.; Gando-Ferreira, L.M.; Quina, M.J. Increasing Value of Winery Residues through Integrated Biorefinery Processes: A Review. *Molecules* **2022**, *27*, 4709. [CrossRef]
4. Sirohi, R.; Tarafdar, A.; Singh, S.; Negi, T.; Gaur, V.K.; Gnansounou, E.; Bharathiraja, B. Green Processing and Biotechnological Potential of Grape Pomace: Current Trends and Opportunities for Sustainable Biorefinery. *Bioresour. Technol.* **2020**, *314*, 123771. [CrossRef]
5. Oliveira, M.; Duarte, E. Integrated Approach to Winery Waste: Waste Generation and Data Consolidation. *Front. Environ. Sci. Eng.* **2016**, *10*, 168–176. [CrossRef]
6. Yang, C.; Han, Y.; Tian, X.; Sajid, M.; Mehmood, S.; Wang, H.; Li, H. Phenolic Composition of Grape Pomace and Its Metabolism. *Crit. Rev. Food Sci. Nutr.* **2022**, *64*, 1–18. [CrossRef]
7. Castellanos-Gallo, L.; Ballinas-Casarrubias, L.; Espinoza-Hicks, J.C.; Hernández-Ochoa, L.R.; Muñoz-Castellanos, L.N.; Zermeño-Ortega, M.R.; Borrego-Loya, A.; Salas, E. Grape Pomace Valorization by Extraction of Phenolic Polymeric Pigments: A Review. *Processes* **2022**, *10*, 469. [CrossRef]
8. Kokkinomagoulos, E.; Kandylis, P. Grape Pomace, an Undervalued by-Product: Industrial Reutilization within a Circular Economy Vision. *Rev. Environ. Sci. Biotechnol.* **2023**, *22*, 739–773. [CrossRef]
9. Iqbal, A.; Schulz, P.; Rizvi, S.S.H. Valorization of Bioactive Compounds in Fruit Pomace from Agro-Fruit Industries: Present Insights and Future Challenges. *Food Biosci.* **2021**, *44*, 101384–101399. [CrossRef]
10. El Achkar, J.H.; Lendormi, T.; Hobaika, Z.; Salameh, D.; Louka, N.; Maroun, R.G.; Lanoisellé, J.L. Anaerobic Digestion of Nine Varieties of Grape Pomace: Correlation between Biochemical Composition and Methane Production. *Biomass Bioenergy* **2017**, *107*, 335–344. [CrossRef]
11. Barakat, N.; Bouajila, J.; Beaufort, S.; Rizk, Z.; Taillandier, P.; El Rayess, Y. Development of a New Kombucha from Grape Pomace: The Impact of Fermentation Conditions on Composition and Biological Activities. *Beverages* **2024**, *10*, 29. [CrossRef]
12. Kalli, E.; Lappa, I.; Bouchagier, P.; Tarantilis, P.A.; Skotti, E. Novel Application and Industrial Exploitation of Winery By-Products. *Bioresour. Bioprocess.* **2018**, *5*, 46–66. [CrossRef]
13. Ilyas, T.; Chowdhary, P.; Chaurasia, D.; Gnansounou, E.; Pandey, A.; Chaturvedi, P. Sustainable Green Processing of Grape Pomace for the Production of Value-Added Products: An Overview. *Environ. Technol. Innov.* **2021**, *23*, 101592–101616. [CrossRef]
14. Antonić, B.; Jančíková, S.; Dordević, D.; Tremlová, B. Grape Pomace Valorization: A Systematic Review and Meta-Analysis. *Foods* **2020**, *9*, 1627. [CrossRef]
15. Peixoto, C.M.; Dias, M.I.; Alves, M.J.; Calhelha, R.C.; Barros, L.; Pinho, S.P.; Ferreira, I.C.F.R. Grape Pomace as a Source of Phenolic Compounds and Diverse Bioactive Properties. *Food Chem.* **2018**, *253*, 132–138. [CrossRef]

16. Monari, S.; Ferri, M.; Vannini, M.; Sisti, L.; Marchese, P.; Ehrnell, M.; Xanthakis, E.; Celli, A.; Tassoni, A. Cascade Strategies for the Full Valorisation of Garganega White Grape Pomace towards Bioactive Extracts and Bio-Based Materials. *PLoS ONE* **2020**, *15*, e0239629. [CrossRef]
17. Farru, G.; Cappai, G.; Carucci, A.; De Gioannis, G.; Asunis, F.; Milia, S.; Muntoni, A.; Perra, M.; Serpe, A. A Cascade Biorefinery for Grape Marc: Recovery of Materials and Energy through Thermochemical and Biochemical Processes. *Sci. Total Environ.* **2022**, *846*, 157464–157473. [CrossRef]
18. Filippi, K.; Georgaka, N.; Alexandri, M.; Papapostolou, H.; Koutinas, A. Valorisation of Grape Stalks and Pomace for the Production of Bio-Based Succinic Acid by Actinobacillus Succinogenes. *Ind. Crops Prod.* **2021**, *168*, 113578–113587. [CrossRef]
19. Jin, Q.; Neilson, A.P.; Stewart, A.C.; O'Keefe, S.F.; Kim, Y.T.; McGuire, M.; Wilder, G.; Huang, H. Integrated Approach for the Valorization of Red Grape Pomace: Production of Oil, Polyphenols, and Acetone-Butanol-Ethanol. *ACS Sustain. Chem. Eng.* **2018**, *6*, 16279–16286. [CrossRef]
20. Martínez-Avila, O.; Llimós, J.; Ponsá, S. Integrated Solid-State Enzymatic Hydrolysis and Solid-State Fermentation for Producing Sustainable Polyhydroxyalkanoates from Low-Cost Agro-Industrial Residues. *Food Bioprod. Process.* **2021**, *126*, 334–344. [CrossRef]
21. Bordiga, M.; Travaglia, F.; Locatelli, M. Valorisation of Grape Pomace: An Approach That Is Increasingly Reaching Its Maturity—A Review. *Int. J. Food Sci. Technol.* **2019**, *54*, 933–942. [CrossRef]
22. Cortés, A.; Moreira, M.T.; Domínguez, J.; Lores, M.; Feijoo, G. Unraveling the Environmental Impacts of Bioactive Compounds and Organic Amendment from Grape Marc. *J. Environ. Manag.* **2020**, *272*, 111066–111074. [CrossRef] [PubMed]
23. Javier, H.; Siles, J.Á.; Aida, G.; del Carmen, G.M.; de los Ángeles, M.M. Revalorization of Grape Marc Waste from Liqueur Wine: Biomethanization. *J. Chem. Technol. Biotechnol.* **2019**, *94*, 1499–1508. [CrossRef]
24. Perera, S.M.H.D.; Wickramasinghe, C.; Samarasiri, B.K.T.; Narayana, M. Modeling of Thermochemical Conversion of Waste Biomass—A Comprehensive Review. *Biofuel Res. J.* **2021**, *8*, 1481–1528. [CrossRef]
25. Perra, M.; Cuena-Lombraña, A.; Bacchetta, G.; Manca, M.L.; Manconi, M.; Maroun, R.G.; Muntoni, A.; Tuberoso, C.I.G.; Gil, K.A.; De Gioannis, G. Combining Different Approaches for Grape Pomace Valorization: Polyphenols Extraction and Composting of the Exhausted Biomass. *Sustainability* **2022**, *14*, 10690. [CrossRef]
26. del Pozo, C.; Bartrolí, J.; Alier, S.; Puy, N.; Fàbregas, E. Production, Identification, and Quantification of Antioxidants from Torrefaction and Pyrolysis of Grape Pomace. *Fuel Process. Technol.* **2021**, *211*, 106602–106611. [CrossRef]
27. Yoon, J.Y.; Kim, J.E.; Song, H.J.; Oh, K.B.; Jo, J.W.; Yang, Y.H.; Lee, S.H.; Kang, G.; Kim, H.J.; Choi, Y.K. Assessment of Adsorptive Behaviors and Properties of Grape Pomace-Derived Biochar as Adsorbent for Removal of Cymoxanil Pesticide. *Environ. Technol. Innov.* **2021**, *21*, 101242–101250. [CrossRef]
28. Zabaniotou, A.; Kamaterou, P.; Pavlou, A.; Panayiotou, C. Sustainable Bioeconomy Transitions: Targeting Value Capture by Integrating Pyrolysis in a Winery Waste Biorefinery. *J. Clean. Prod.* **2018**, *172*, 3387–3397. [CrossRef]
29. Salaudeen, S.A.; Acharya, B.; Dutta, A. Steam Gasification of Hydrochar Derived from Hydrothermal Carbonization of Fruit Wastes. *Renew. Energy* **2021**, *171*, 582–591. [CrossRef]
30. Moro, K.I.B.; Bender, A.B.B.; da Silva, L.P.; Penna, N.G. Green Extraction Methods and Microencapsulation Technologies of Phenolic Compounds from Grape Pomace: A Review. *Food Bioprocess Technol.* **2021**, *14*, 1407–1431. [CrossRef]
31. Aresta, A.; Cotugno, P.; De Vietro, N.; Massari, F.; Zambonin, C. Determination of Polyphenols and Vitamins in Wine-Making by-Products by Supercritical Fluid Extraction (SFE). *Anal. Lett.* **2020**, *53*, 2585–2595. [CrossRef]
32. Da Porto, C.; Natolino, A.; Scalet, M. Improved Sustainability in Wine Industry Byproducts: A Scale-up and Economical Feasibility Study for High-Value Compounds Extraction Using Modified SC-CO2. *ACS Omega* **2022**, *7*, 33845–33857. [CrossRef] [PubMed]
33. Neto, R.T.; Santos, S.A.O.; Oliveira, J.; Silvestre, A.J.D. Impact of Eutectic Solvents Utilization in the Microwave Assisted Extraction of Proanthocyanidins from Grape Pomace. *Molecules* **2022**, *27*, 246. [CrossRef]
34. Onache, P.A.; Geana, E.I.; Ciucure, C.T.; Florea, A.; Sumedrea, D.I.; Ionete, R.E.; Tița, O. Bioactive Phytochemical Composition of Grape Pomace Resulted from Different White and Red Grape Cultivars. *Separations* **2022**, *9*, 395. [CrossRef]
35. Marianne, L.-C.; Lucía, A.-G.; de Jesús, M.-S.M.; Eric Leonardo, H.-M.; Mendoza-Sánchez, M. Optimization of the Green Extraction Process of Antioxidants Derived from Grape Pomace. *Sustain. Chem. Pharm.* **2024**, *37*, 101396. [CrossRef]
36. Silva, J.T.P.; Borges, M.H.; de Souza, C.A.C.; Fávaro-Trindade, C.S.; Sobral, P.A.; de Oliveira, A.L.; Martelli-Tosi, M. Grape Pomace Rich-Phenolics and Anthocyanins Extract: Production by Pressurized Liquid Extraction in Intermittent Process and Encapsulation by Spray-Drying. *Foods* **2024**, *13*, 279. [CrossRef]
37. Abouelenein, D.; Mustafa, A.M.; Caprioli, G.; Ricciutelli, M.; Sagratini, G.; Vittori, S. Phenolic and Nuntritional Profiles, and Antioxidant Activity of Grape Pomaces and Seeds from Lacrima Di Morro d'Alba and Verdicchio Varieties. *Food Biosci.* **2023**, *53*, 102808. [CrossRef]
38. Meini, M.R.; Cabezudo, I.; Galetto, C.S.; Romanini, D. Production of Grape Pomace Extracts with Enhanced Antioxidant and Prebiotic Activities through Solid-State Fermentation by Aspergillus Niger and Aspergillus Oryzae. *Food Biosci.* **2021**, *42*. [CrossRef]
39. Iacono, E.; Di Marzo, C.; Di Stasi, M.; Cioni, E.; Gambineri, F.; Luminare, A.G.; De Leo, M.; Braca, A.; Quaranta, P.; Lai, M.; et al. Broad-Spectrum Virucidal Activity of a Hydroalcoholic Extract of Grape Pomace. *Bioresour. Technol. Rep.* **2024**, *25*, 101745. [CrossRef]
40. Ranganathan, A.; Tripathi, J.; Iftikhar, S.; Paroha, S. Production of Wine from Red Grapes & Study the Effect of Pomace on Seed Germination. *Int. J. Agric. Ext. Soc. Dev.* **2024**, *7*, 38–44. [CrossRef]

41. Thema, K.K.; Mlambo, V.; Egbu, C.F.; Mnisi, C.M. Use of Red Grape Pomace and Aloe Vera Gel as Nutraceuticals to Ameliorate Stocking Density-Induced Stress in Commercial Male Broilers. *Trop. Anim. Health Prod.* **2024**, *56*, 107. [CrossRef] [PubMed]
42. Tsantila, E.M.; Esslinger, N.; Christou, M.; Papageorgis, P.; Neophytou, C.M. Antioxidant and Anticancer Activity of Vitis Vinifera Extracts in Breast Cell Lines. *Life* **2024**, *14*, 228. [CrossRef] [PubMed]
43. Cañadas, R.; Díaz, I.; Sánchez-Monedero, A.; González, E.J.; González-Miquel, M. Green Extraction of Natural Antioxidants from White Grape Waste Using Bio-Renewable Solvents and Ultrasonic Process Intensification. *Chem. Eng. Process.-Process Intensif.* **2024**, *196*, 109644. [CrossRef]
44. González, M.; Barrios, S.; Budelli, E.; Pérez, N.; Lema, P.; Heinzen, H. Ultrasound Assisted Extraction of Bioactive Compounds in Fresh and Freeze-Dried Vitis Vinifera Cv Tannat Grape Pomace. *Food Bioprod. Process.* **2020**, *124*, 378–386. [CrossRef]
45. Ribeiro, L.F.; Ribani, R.H.; Stafussa, A.P.; Makara, C.N.; Branco, I.G.; Maciel, G.M.; Haminiuk, C.W.I. Exploratory Analysis of Bioactive Compounds and Antioxidant Potential of Grape (*Vitis vinifera*) Pomace. *Acta Sci.-Technol.* **2022**, *44*, e56934–e56944. [CrossRef]
46. Panić, M.; Gunjević, V.; Cravotto, G.; Radojčić Redovniković, I. Enabling Technologies for the Extraction of Grape-Pomace Anthocyanins Using Natural Deep Eutectic Solvents in up-to-Half-Litre Batches Extraction of Grape-Pomace Anthocyanins Using NADES. *Food Chem.* **2019**, *300*, 125185–125193. [CrossRef]
47. Costa-Pérez, A.; Medina, S.; Sánchez-Bravo, P.; Domínguez-Perles, R.; García-Viguera, C. The (Poly)Phenolic Profile of Separate Winery by-Products Reveals Potential Antioxidant Synergies. *Molecules* **2023**, *28*, 2081. [CrossRef]
48. Pérez-Ortiz, J.M.; Alguacil, L.F.; Salas, E.; Hermosín-Gutiérrez, I.; Gómez-Alonso, S.; González-Martín, C. Antiproliferative and Cytotoxic Effects of Grape Pomace and Grape Seed Extracts on Colorectal Cancer Cell Lines. *Food Sci. Nutr.* **2019**, *7*, 2948–2957. [CrossRef] [PubMed]
49. Spinei, M.; Oroian, M. Microwave-Assisted Extraction of Pectin from Grape Pomace. *Sci. Rep.* **2022**, *12*, 12722–12738. [CrossRef]
50. Spinei, M.; Oroian, M. Structural, Functional and Physicochemical Properties of Pectin from Grape Pomace as Affected by Different Extraction Techniques. *Int. J. Biol. Macromol.* **2023**, *224*, 739–753. [CrossRef]
51. Punzo, A.; Porru, E.; Silla, A.; Simoni, P.; Galletti, P.; Roda, A.; Tagliavini, E.; Samorì, C.; Caliceti, C. Grape Pomace for Topical Application: Green Nades Sustainable Extraction, Skin Permeation Studies, Antioxidant and Anti-Inflammatory Activities Characterization in 3d Human Keratinocytes. *Biomolecules* **2021**, *11*, 1181. [CrossRef] [PubMed]
52. Bender, A.B.B.; Speroni, C.S.; Moro, K.I.B.; Morisso, F.D.P.; dos Santos, D.R.; da Silva, L.P.; Penna, N.G. Effects of Micronization on Dietary Fiber Composition, Physicochemical Properties, Phenolic Compounds, and Antioxidant Capacity of Grape Pomace and Its Dietary Fiber Concentrate. *LWT* **2020**, *117*, 108652. [CrossRef]
53. Abreu, T.; Jasmins, G.; Bettencourt, C.; Teixeira, J.; Câmara, J.S.; Perestrelo, R. Tracing the Volatilomic Fingerprint of Grape Pomace as a Powerful Approach for Its Valorization. *Curr. Res. Food Sci.* **2023**, *7*, 100608. [CrossRef] [PubMed]
54. Difonzo, G.; Troilo, M.; Allegretta, I.; Pasqualone, A.; Caponio, F. Grape Skin and Seed Flours as Functional Ingredients of Pizza: Potential and Drawbacks Related to Nutritional, Physicochemical and Sensory Attributes. *LWT* **2023**, *175*, 114494. [CrossRef]
55. Ferrer-Gallego, R.; Silva, P. The Wine Industry By-Products: Applications for Food Industry and Health Benefits. *Antioxidants* **2022**, *11*, 2025. [CrossRef]
56. Ferreira-Santos, P.; Nobre, C.; Rodrigues, R.M.; Genisheva, Z.; Botelho, C.; Teixeira, J.A. Extraction of Phenolic Compounds from Grape Pomace Using Ohmic Heating: Chemical Composition, Bioactivity and Bioaccessibility. *Food Chem.* **2024**, *436*, 137780. [CrossRef]
57. Almanza-Oliveros, A.; Bautista-Hernández, I.; Castro-López, C.; Aguilar-Zárate, P.; Meza-Carranco, Z.; Rojas, R.; Michel, M.R.; Martínez-Ávila, G.C.G. Grape Pomace—Advances in Its Bioactivity, Health Benefits, and Food Applications. *Foods* **2024**, *13*, 580. [CrossRef]
58. Sateriale, D.; Forgione, G.; Di Rosario, M.; Pagliuca, C.; Colicchio, R.; Salvatore, P.; Paolucci, M.; Pagliarulo, C. Vine-Winery Byproducts as Precious Resource of Natural Antimicrobials: In Vitro Antibacterial and Antibiofilm Activity of Grape Pomace Extracts against Foodborne Pathogens. *Microorganisms* **2024**, *12*, 437. [CrossRef]
59. Mugnaini, G.; Bonini, M.; Gentile, L.; Panza, O.; Del Nobile, M.A.; Conte, A.; Esposito, R.; D'Errico, G.; Moccia, F.; Panzella, L. Effect of Design and Molecular Interactions on the Food Preserving Properties of Alginate/Pullulan Edible Films Loaded with Grape Pomace Extract. *J. Food Eng.* **2024**, *361*, 111761. [CrossRef]
60. Zainal Arifin, M.A.; Mohd Adzahan, N.; Zainal Abedin, N.H.; Lasik-Kurdyś, M. Utilization of Food Waste and By-Products in the Fabrication of Active and Intelligent Packaging for Seafood and Meat Products. *Foods* **2023**, *12*, 456. [CrossRef]
61. Cejudo-Bastante, C.; Arjona-Mudarra, P.; Fernández-Ponce, M.T.; Casas, L.; Mantell, C.; Martínez de la Ossa, E.J.; Pereyra, C. Application of a Natural Antioxidant from Grape Pomace Extract in the Development of Bioactive Jute Fibers for Food Packaging. *Antioxidants* **2021**, *10*, 216. [CrossRef] [PubMed]
62. da Silva, D.J.; de Oliveira, M.M.; Wang, S.H.; Carastan, D.J.; Rosa, D.S. Designing Antimicrobial Polypropylene Films with Grape Pomace Extract for Food Packaging. *Food Packag. Shelf Life* **2022**, *34*, 100929. [CrossRef]
63. Martín-Mateos, M.J.; Delgado-Adámez, J.; Moreno-Cardona, D.; Valdés-Sánchez, M.E.; Ramírez-Bernabé, M.R. Application of White-Wine-Pomace-Derived Ingredients in Extending Storage Stability of Fresh Pork Burgers. *Foods* **2023**, *12*, 4468. [CrossRef] [PubMed]
64. Megías-Pérez, R.; Ferreira-Lazarte, A.; Villamiel, M. Valorization of Grape Pomace as a Renewable Source of Techno-Functional and Antioxidant Pectins. *Antioxidants* **2023**, *12*, 957. [CrossRef] [PubMed]

65. Troilo, M.; Difonzo, G.; Paradiso, V.M.; Pasqualone, A.; Caponio, F. Grape Pomace as Innovative Flour for the Formulation of Functional Muffins: How Particle Size Affects the Nutritional, Textural and Sensory Properties. *Foods* **2022**, *11*, 1799. [CrossRef] [PubMed]
66. Rainero, G.; Bianchi, F.; Rizzi, C.; Cervini, M.; Giuberti, G.; Simonato, B. Breadstick Fortification with Red Grape Pomace: Effect on Nutritional, Technological and Sensory Properties. *J. Sci. Food Agric.* **2022**, *102*, 2545–2552. [CrossRef] [PubMed]
67. Bianchi, F.; Lomuscio, E.; Rizzi, C.; Simonato, B. Predicted Shelf-Life, Thermodynamic Study and Antioxidant Capacity of Breadsticks Fortified with Grape Pomace Powders. *Foods* **2021**, *10*, 2815. [CrossRef] [PubMed]
68. Câmara, J.S.; Lourenço, S.; Silva, C.; Lopes, A.; Andrade, C.; Perestrelo, R. Exploring the Potential of Wine Industry By-Products as Source of Additives to Improve the Quality of Aquafeed. *Microchem. J.* **2020**, *155*, 104758. [CrossRef]
69. Liang, Z.; Pai, A.; Liu, D.; Luo, J.; Wu, J.; Fang, Z.; Zhang, P. Optimizing Extraction Method of Aroma Compounds from Grape Pomace. *J. Food Sci.* **2020**, *85*, 4225–4240. [CrossRef]
70. Enaru, B.; Drețcanu, G.; Pop, T.D.; Stănilă, A.; Diaconeasa, Z. Anthocyanins: Factors Affecting Their Stability and Degradation. *Antioxidants* **2021**, *10*, 1967. [CrossRef]
71. Nogueira, G.F.; Meneghetti, B.B.; Soares, I.H.B.T.; Soares, C.T.; Bevilaqua, G.; Fakhouri, F.M.; de Oliveira, R.A. Multipurpose Arrowroot Starch Films with Anthocyanin-Rich Grape Pomace Extract: Color Migration for Food Simulants and Monitoring the Freshness of Fish Meat. *Int. J. Biol. Macromol.* **2024**, *265*, 130934. [CrossRef] [PubMed]
72. de Souza Mesquita, L.M.; Sosa, F.H.B.; Contieri, L.S.; Marques, P.R.; Viganó, J.; Coutinho, J.A.P.; Dias, A.C.R.V.; Ventura, S.P.M.; Rostagno, M.A. Combining Eutectic Solvents and Food-Grade Silica to Recover and Stabilize Anthocyanins from Grape Pomace. *Food Chem.* **2023**, *406*, 135093. [CrossRef] [PubMed]
73. Romanini, E.B.; Rodrigues, L.M.; Stafussa, A.P.; Cantuaria Chierrito, T.P.; Teixeira, A.F.; Corrêa, R.C.G.; Madrona, G.S. Bioactive Compounds from BRS Violet Grape Pomace: An Approach of Extraction and Microencapsulation, Stability Protection and Food Application. *Plants* **2023**, *12*, 3177. [CrossRef] [PubMed]
74. Baldán, Y.; Riveros, M.; Fabani, M.P.; Rodriguez, R. Grape Pomace Powder Valorization: A Novel Ingredient to Improve the Nutritional Quality of Gluten-Free Muffins. *Biomass Convers. Biorefinery* **2023**, *13*, 9997–10009. [CrossRef]
75. Marcos, J.; Carriço, R.; Sousa, M.J.; Palma, M.L.; Pereira, P.; Nunes, M.C.; Nicolai, M. Effect of Grape Pomace Flour in Savory Crackers: Technological, Nutritional and Sensory Properties. *Foods* **2023**, *12*, 1392. [CrossRef] [PubMed]
76. Milinčić, D.D.; Kostić, A.; Kolašinac, S.; Rac, V.; Banjac, N.; Lađarević, J.; Lević, S.; Pavlović, V.B.; Stanojević, S.P.; Nedović, V.A.; et al. Goat Milk Powders Enriched with Grape Pomace Seed Extract: Physical and Techno-Functional Properties. *Food Hydrocoll.* **2024**, *146*, 109293. [CrossRef]
77. Antoniolli, A.; Becerra, L.; Piccoli, P.; Fontana, A. Phenolic, Nutritional and Sensory Characteristics of Bakery Foods Formulated with Grape Pomace. *Plants* **2024**, *13*, 590. [CrossRef] [PubMed]
78. Tolve, R.; Simonato, B.; Rainero, G.; Bianchi, F.; Rizzi, C.; Cervini, M.; Giuberti, G. Wheat Bread Fortification by Grape Pomace Powder: Nutritional, Technological, Antioxidant, and Sensory Properties. *Foods* **2021**, *10*, 75. [CrossRef] [PubMed]
79. Olt, V.; Báez, J.; Curbelo, R.; Boido, E.; Amarillo, M.; Gámbaro, A.; Alborés, S.; Gerez García, N.; Cesio, M.V.; Heinzen, H.; et al. Tannat Grape Pomace as an Ingredient for Potential Functional Biscuits: Bioactive Compound Identification, in Vitro Bioactivity, Food Safety, and Sensory Evaluation. *Front. Nutr.* **2023**, *10*, 1241105. [CrossRef] [PubMed]
80. Rodríguez, M.; Bianchi, F.; Simonato, B.; Rizzi, C.; Fontana, A.; Tironi, V.A. Exploration of Grape Pomace Peels and Amaranth Flours as Functional Ingredients in the Elaboration of Breads: Phenolic Composition, Bioaccessibility, and Antioxidant Activity. *Food Funct.* **2024**, *15*, 608–624. [CrossRef]
81. Scappaticci, G.; Mercanti, N.; Pieracci, Y.; Ferrari, C.; Mangia, R.; Marianelli, A.; Macaluso, M.; Zinnai, A. Bread Improvement with Nutraceutical Ingredients Obtained from Food By-Products: Effect on Quality and Technological Aspects. *Foods* **2024**, *13*, 825. [CrossRef] [PubMed]
82. Rocchetti, G.; Rizzi, C.; Cervini, M.; Rainero, G.; Bianchi, F.; Giuberti, G.; Lucini, L.; Simonato, B. Impact of Grape Pomace Powder on the Phenolic Bioaccessibility and on In Vitro Starch Digestibility of Wheat Based Bread. *Foods* **2021**, *10*, 507. [CrossRef] [PubMed]
83. Blicharz-Kania, A.; Vasiukov, K.; Sagan, A.; Andrejko, D.; Fifowska, W.; Domin, M. Nutritional Value, Physical Properties, and Sensory Quality of Sugar-Free Cereal Bars Fortified with Grape and Apple Pomace. *Appl. Sci.* **2023**, *13*, 10531. [CrossRef]
84. Spinei, M.; Oroian, M. Characterization of Băbească Neagră Grape Pomace and Incorporation into Jelly Candy: Evaluation of Phytochemical, Sensory, and Textural Properties. *Foods* **2023**, *13*, 98. [CrossRef] [PubMed]
85. Oliveira, B.E.; Contini, L.; Garcia, V.A.d.S.; de Lima Cilli, L.P.; Chagas, E.G.L.; Andreo, M.A.; Vanin, F.M.; Carvalho, R.A.; Sinnecker, P.; Venturini, A.C.; et al. Valorization of Grape By-products as Functional and Nutritional Ingredients for Healthy Pasta Development. *J. Food Process. Preserv.* **2022**, *46*, e17245. [CrossRef]
86. Yavruyan, N.V.; Avetisyan, N.A. Food Powder Manufacture from Grape Pomace and Its Application as an Improver in the Macaroni Production. *Agrisci. Technol.* **2021**, *4*, 428–431. [CrossRef]
87. la Gatta, B.; Rutigliano, M.; Liberatore, M.T.; Dilucia, F.; Palmitessa, M.; Di Luccia, A.; Lamacchia, C. Effect of the Addition of Freeze-Dried Grape Pomace on Fresh Tagliatelle Gluten Network and Relationship to Sensory and Chemical Quality. *Foods* **2023**, *12*, 2699. [CrossRef]
88. Gaita, C.; Alexa, E.; Moigradean, D.; Conforti, F.; Poiana, M.-A. Designing of High Value-Added Pasta Formulas by Incorporation of Grape Pomace Skins. *Rom. Biotechnol. Lett.* **2020**, *25*, 1607–1614. [CrossRef]

89. Gerardi, C.; D'Amico, L.; Durante, M.; Tufariello, M.; Giovinazzo, G. Whole Grape Pomace Flour as Nutritive Ingredient for Enriched Durum Wheat Pasta with Bioactive Potential. *Foods* **2023**, *12*, 2593. [CrossRef]
90. Tolve, R.; Pasini, G.; Vignale, F.; Favati, F.; Simonato, B. Effect of Grape Pomace Addition on the Technological, Sensory, and Nutritional Properties of Durum Wheat Pasta. *Foods* **2020**, *9*, 354. [CrossRef]
91. Dinu, L.-D.; Vamanu, E. Gut Microbiota Modulators Based on Polyphenols Extracted from Winery By-Products and Their Applications in the Nutraceutical Industry. *Life* **2024**, *14*, 414. [CrossRef] [PubMed]
92. Caponio, G.R.; Minervini, F.; Tamma, G.; Gambacorta, G.; De Angelis, M. Promising Application of Grape Pomace and Its Agri-Food Valorization: Source of Bioactive Molecules with Beneficial Effects. *Sustainability* **2023**, *15*, 9075. [CrossRef]
93. Anghel, L.; Milea, A.Ș.; Constantin, O.E.; Barbu, V.; Chițescu, C.; Enachi, E.; Râpeanu, G.; Mocanu, G.-D.; Stănciuc, N. Dried Grape Pomace with Lactic Acid Bacteria as a Potential Source for Probiotic and Antidiabetic Value-Added Powders. *Food Chem. X* **2023**, *19*, 100777. [CrossRef] [PubMed]
94. Bordiga, M.; Montella, R.; Travaglia, F.; Arlorio, M.; Coïsson, J.D. Characterization of Polyphenolic and Oligosaccharidic Fractions Extracted from Grape Seeds Followed by the Evaluation of Prebiotic Activity Related to Oligosaccharides. *Int. J. Food Sci. Technol.* **2019**, *54*, 1283–1291. [CrossRef]