Management of apple and grape processing by-products. A review

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Abstract

Introduction. The by-products from the processing of apples and grapes can be excellent materials for the production of functional foods. In this case, the environment is preserved, and food products are enriched with important nutrients.

Materials and methods. A systematization of the latest scientific research in terms of management of the waste from the production of apple juice and grape wine.

Results and discussion. By-products of apple and grape processing contain important nutrients such as fibers, minerals, vitamins, polyphenols, and possess high antioxidant activity. In recent years, a lot of research has been conducted to study the application of this type of waste in preparation of different food products (biscuits, cookies, cakes, bread, pasta, noodles, yogurt, cheese, kefir, salami, sausages, patties, and burgers). Regarding the percentages of substitution of conventional flours with by-products of apple and grape processing, variations are observed. For cereal products, the minimum percentage of substitution was 1% and the maximum was 100%. For meat products, the percentages of added by-products of apple and grape processing varied from 1 to 20%, while for dairy products, these contents were between the values of 0.2 and 10%. An improvement in nutrient quality with the addition of by-products of apple and grape processing was observed, such as increase of fiber, total polyphenol, flavonoids, anthocyanins and mineral contents and antioxidant activity. Incorporation of apple and grape processing by-products leads to changes of the volume or height of the products (biscuits, cookies, cakes, and bread), and changes in texture (hardness, crunchiness), appearance (surface properties, color, density), and intensity of smell and taste. It was found that the optimum cooking time of pasta/noodles/spaghetti decreased and cooking loss increased with the increasing amount of incorporated apple and grape processing waste. Addition of these by-products reduced fermentation time and syneresis during yogurt storage. It was found that the addition of by-products of apple and grape processing in the meat products increased cooking yield, emulsion stability, radical scavenging activity, and decreased pH.

Conclusions. Use of waste from the processing of apples and grapes in the food industry is an opportunity to reduce environmental pollution, to create new functional and innovative food products, which will be enriched with important nutrients and biologically active substances.

Introduction

The by-products of fruit processing are rich with nutrients and bioactive compounds and can be used as ingredients for functional food production (Stabnikova et al., 2021). In recent decades, the demand for functional food with bioactive compounds has increased, and the food industry is constantly improving and reaching new sustainable solutions for the production of food using the by-products of plant origin (Colantuono, 2019; Ivanov et al., 2021).

During processing of fruits for production of juices, wine, jams, canned fruits and others, various fruit by-products are created, which are belonging to so called "food waste", which can be considered as additional sources of valuable raw materials to be used in manufacturing of new products (Galanakis et al., 2012).

By-products released in the processing of apples are presented by skins, peels, seeds, stems, flesh, pulps, and pomace (Figure 1), and skins, stalks, pulp, seeds and pomace are accumulated during grape processing (Figure 2).

Skins or peels are one of the by-products most often thrown away during fruit processing. Pomace is the remaining solid after juice extraction and usually consists from remaining seeds, skins, pulp and stems of the fruit (Lau et al., 2021). For example, apple pomace is a heterogeneous mixture composed mainly of skin and flesh, 95%, while the seeds and stems are represented by a smaller percentage, 2-4% and 1%, respectively (Lyu et al., 2020).

Grape pomace is composed of seeds, 22.5%, skins, 42.5%, stalks, 24.9%, and other minor constituents (e.g., water) (Spinei et al., 2021).The amount of by-products that are created from processed fruit varies depending on the type of product to be obtained, the type of fruit, its variety, the size and the stage of maturity (Larrosa et al., 2021).

Grape pomace, the main by-product of wine production, consists up to 20-25% of the weight of grapes crushed used for wine production (Yu et al., 2013). Apple pomace, the main by-product of apple juice production, accounts for 25-30% of all fresh apple fruit processed (Lyu et al., 2020). It is well known that fruit by-products are an important source of carbohydrates, minerals, vitamins, organic acids, raw proteins, dietary fiber, carotenoids, polyphenolic compounds, and other nutritionally significant components (Fierascu et al., 2020) and possess antioxidant, antimicrobial, anti-carcinogenic, antiviral, and antibacterial activities (Leyva-López et al., 2020).

The amount and composition of biological useful components in fruit by-products vary depending on the type of fruit, its variety, the climatic conditions in which it is grown and the way it is processed (Erinle et al., 2022). The composition of dry apple pomace includes carbohydrates: 18–31% fructose, 3.4-24% sucrose, and 2.5-12.4% glucose (Waldbauer et al., 2017), dietary fiber, 35-60%, with a high amount of insoluble fiber, 36.5%, as well as soluble fiber, 14.6% (Dhillon et al., 2013), small amounts of protein, fat, and ash, high content of phytochemicals primarily phenolic acids and flavonoids. Some of the phenolic compounds identified in apple pomace possess antioxidant capacities (Reis et al., 2014). Grape pomace is known to be a source of proteins, mean value of 10% on DW, as well as minerals, especially iron (18 mg/100 g DW), dietary fiber (approx. 50% on dry weight (DW)), and phenolic compounds such as flavonols, catechins, anthocyanins, and phenolic acids (Balli et al., 2021). However, apple and grape processing by-products contain a large amount of water, which makes them susceptible to rapid spoilage. In order to obtain stable products with a long shelf life, most often they are dried. Various drying techniques can be used to prolong shelf life, to avoid microbiological contamination, and to preserve nutrients, bioactive compounds, and antioxidant activity. In addition, dry by-products are ground to reduce particle size, and standardization of grain size is recommended (Larrosa et al., 2021).

Potentially valuable compounds of the by-products of apple and grape processing can be used as nutrients in people's diets. Using by-products is one option to avoid environmental problems and help the economy and society. This review summarizes some of the available literature related to the use of the by-products from apple and grape processing in human nutrition.

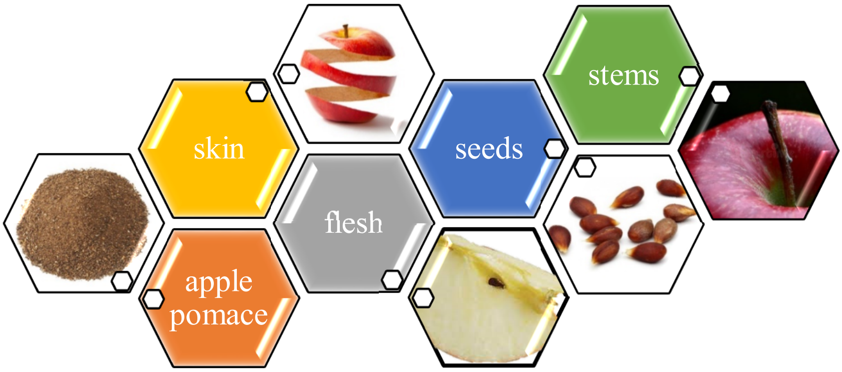

Figure 1. By-products from apple processing

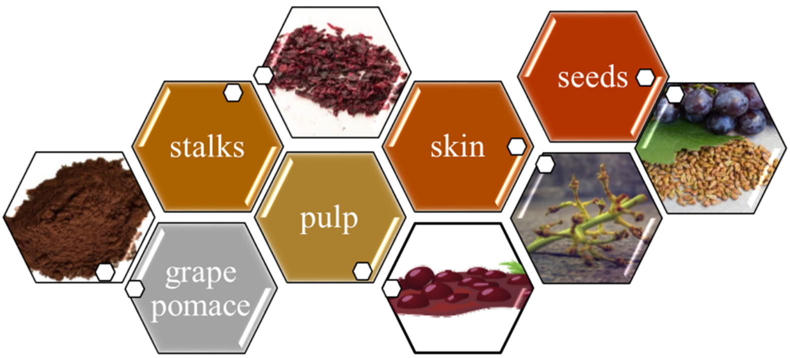

Figure 2. By-products from grape processing

Materials and methods

The materials used in this review cover information from the authors who focus on the most recent trends in the management of waste (fruit by-products). Material for the research served as literary sources in which the current food applications of by-products of apple and grape processing and the influence of their addition on the characteristics of food products are exposed. Literature referenced in this review article was obtained from bibliographic information in Google Scholar, Web of Science, Science Direct, Scopus, Springer Link, EBSCO host, Wiley online library, and PubMed.

Results and discussion

Utilization of fruit processing by-products

Fruit by-products have gained importance as a functional ingredient due to their superior nutritional properties (Bora et al., 2019). There have been numerous reports of the use of by-products derived from the processing of various types of fruit in the food industry. The authors design foods with different applications of fruit by-products as a supplement. Usually, fruit processing by-products are dried, ground and added to products prepared from flour or in yogurt, milk, and cheese (Larrosa et al., 2021). The advantages of adding fruit processing by-products include improved nutritional properties of the products, increasing of total phenolic content, total flavonoid content, antioxidant activity and dietary fiber content. In addition, some qualitative, technological and sensory properties of those food products can be improved (Piasecka et al., 2020). The dried fruit pomace can be used in bakery products as a substitute for flour, sugar or fat, increasing the amount of fiber and antioxidants and reducing energy consumption (Djeghim et al., 2021).The most studied products enriched with fruit by-products are: bread, muffins, cakes, cookies, biscuits, snack products, and pasta (Piasecka et al., 2020).

Utilization of apple processing by-products

The by-products obtained in the processing of apples have a significant potential for application in the production of nutritionally enriched food prepared from flour, because of its favorable nutritional profile due to the presence of phenolic compounds and dietary fiber and good sensory characteristics, namely pleasant fruity aroma. Their addition to food products increases in the amount of dietary fiber and polyphenols and prevents undesirable oxidation reactions caused by the action of free radicals, which affects the quality and sustainability of the product itself, as well as consumer health (Sudha et al., 2016). Different applications of apple pomace are shown in Figure 3.

Multiple reports of studies are available on the enrichment of flour products by adding apple processing by-products. Karkle et al. (2012) prepared corn-based extrudates in which they added 17%, 22%, and 28% apple pomace. The added pomace did not adversely affect the mechanical properties and structure of the products and contributed to a fruity aroma and a greater share of dietary fiber and polyphenols.

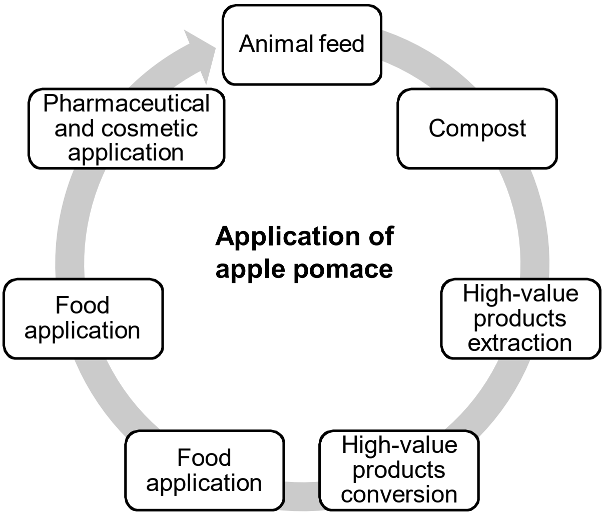

Figure 3. Application of apple pomace

Jung et al. (2015) prepared cookies and muffins replacing 10% and 20% of wheat flour with apple pomace. The partial substitution of wheat flour with apple pomace (up to 20%) had a positive effect on the physical-chemical and sensory characteristics of cookies and muffins. The addition of apple pomace to brown rice flour in the formulation of gluten free crackers in a proportion of 3, 6, and 9% resulted in better antioxidant properties, higher polyphenol content, total dietary fiber and minerals, and sensory acceptability (Mir et al., 2017). A higher value for total dietary fiber content compared to a control wheat sponge cake was determined by Torbica et al. (2018), who substituted wheat flour in the formulation for a sponge cake with apple pomace coextruded with corn grit in a ratio of 45:55.

The use of the apple pomace can affect the reduction of the glycemic index of the products to which it is added, while not affecting sensory descriptors, such as taste, sweetness, acidity, hardness and crunchiness. Alongi et al. (2019) produced biscuits replacing wheat flour (10 and 20%) with apple pomace powder and found a decrease in the glycemic index, from a glycemic index of 70 to a glycemic index of 65 and 60 respectively, and were ranked as products with a mean glycemic index.

Apple skin powder replaced with wheat flour in the production of muffins in an amount of up to 16% increased the share of dietary fiber and polyphenolic compounds, while not worsening sensory characteristics (Rupasinghe et al., 2008; 2009). Research conducted by Nakov et al. (2020) found that apple peel powder-enriched cookies (4, 8, 16, 24 and 32%) had significantly higher moisture, ash, lipid, fiber, total polyphenols, and antioxidant capacity than control cookies. The addition of apple peel powder did not worsen the physical characteristics of the products but helped to improve their sensory quality. Cookies with 24% apple peel powder proved to be the best in terms of appearance, internal structure, texture, and taste.

Several studies have focused on noodles and bread enriched with apple pomace. Apple pomace powder is incorporated into noodles at three different levels (10, 15 and 20%). Noodles enriched with apple pomace had a higher total dietary fiber and protein content, and showed improved antioxidant activity compared to control noodles. Analyses of cooking characteristics, such as texture, quality, color, and sensory evaluation, found that noodles enriched with 10% apple pomace powder were the most acceptable product in terms of both taste and nutritional composition (Suman et al., 2015). The addition of a 5% to 10% of apple pomace has been shown to be best when enriching Chinese raw pasta (Xu, 2020). Bchir et al. (2022) studied the impact of incorporating the by-products of pear, date, and apples processing on the properties of pasta. From the overall results, it was concluded that the by-products have a positive impact on the physical-chemical properties and quality attributes of pasta. Pasta with a 2.5% share of by-products proved to be the most acceptable.

Jannati et al. (2018) rated the quality of traditional Iranian bread that had apple pomace powder added to it (1, 3, 5 and 7% w/w of flour). The results showed that adding the apple pomace powder can reduce the hardness of the bread, and the color of the crust of the bread added with apple pomace was darker compared to the bread without pomace powder. Sensory analysis showed that adding up to 3% of the pomace can improve the aroma, texture, and overall acceptability of bread. Bread formulated with gluten-free raw materials has low nutritional properties, poor taste, and is of poorer quality, and due to the absence of gluten, the dough has poor rheological properties and is unable to develop a protein network, which affects the final quality of the resulting bread. Adding fruit by-products such as apple processing by-products to a gluten-free bread formulation can improve the texture, mouth feel, acceptability, shelf life, and nutritional properties of gluten-free bread (Djeghim et al., 2021). Apple pomace also has a high potential to be used as a natural stabilizer and texturizer in the fermentation of yogurt, while enriching the final product with dietary fiber and phytochemicals (Wang et al., 2019). Studies of the sensory and textural characteristics of probiotic yogurts indicate that apple pomace flour can be added in the optimal amount of 3% (Jovanović et al., 2020).

Most studies to date have emphasized the use of apple pomace in meat products such as salami (Grispoldi et al., 2022), chicken sausages (Choi et al., 2016), beef burgers (Pollini et al., 2022), chicken patties (Junget al., 2015), buffalo meat patties (Younis and Ahmad, 2018), and buffalo meat sausages (Younis and Ahmad, 2015) to improve nutritional properties, reduce fat content and energy value, increase the content of dietary fiber and antioxidants. The obtained results confirm an increased content of dietary fiber and phenols, along with lower values for fat and calories in enriched meat products with apple pomace. The summary of the various studies on application of apple pomace in food product preparation is presented in Table 1.

Table 1

Application of apple pomace in food product preparation

Food product	Apple pomace	Results	References
Extruded products	Added, 10-30% on a dry weight basis	Increased fiber and phenolic content, antioxidant capacity.	Reis et al.,2014
	Added, 5-20% w/w	Increased bulk density, total phenolic content, and antioxidant activity.	Singha et al., 2018
	Added, up to 30 %	Increased total contents of phenols and antioxidant activity.	León et al.,2022
Gluten-free cakes	Replacement of rice flour, 5–15%.	Increased elastic modulus, viscosity, specific gravity, and crumb hardness. Decreased specific volume.	Kırbaș et al., 2019

Food product	Apple pomace	Results	References
Muffins	Replacement of wheat flour, 10% and 20%	No detrimental effects on the physicochemical and textural properties.	Junget al.,2015
	Addition of apple pomace powder, 5, 10, and 15%.	Increased ash, fiber, and phenolic contents. Decreased protein and moisture contents. Muffins with 10% of apple pomace had higher sensory evaluation.	Younas et al.,2015
Cookies	Replacement apple pomace flour, 10 and 20%	No detrimental effects on the physicochemical and textural properties.	Junget al.,2015
	Replacement of flour, 5, 10, and 15% with hydrated apple pomace powder.	Reduced physical properties (volume, diameter, porosity). Increased the rheological properties of dough (water absorption, stability). Prolonged dough development time and reduced the mixing tolerance index. High overall acceptance.	Lauková et al.,2016
	Addition of apple pomace powder, 5, 10, 15, 20, and 25% to wheat flour	Increased water absorption, dough development time, dough stability, and falling number. Decreased width, and thickness, and increased spread factor. Reduced color. Increased moisture, ash, crude fat, and crude fiber contents. Good quality cookies with improved organoleptic properties can be prepared using 10%.	Usmanet al.,2020
Bread	Addition of apple pomace, 1, 2, 3, and 4% (60-mesh and 100-mesh).	Reduced the whiteness and specific volume. French bread with 1% apple pomace (100-mesh) had highest sensory score.	He and Lu, 2015
	Addition of whole apple pomace, 5, 10, and 15% to wheat bread.	Increased in total polyphenol content, flavonoids, and anthocyanins by 55, 200 and 160% as compared to control, respectively. Reduced volume. Recorded baking loss. The bread with 5% whole pomace received the best scores (good volume, small baking loss, low crumb hardness).	Gumul et al.,2019
	Addition of apple pomace powder, 1, 2, 5, and 10%.	Increased ash, total carbohydrate, total polyphenols contents, and antioxidant activity. Decrease protein and fat contents, and loaf volume. Sensory evaluation – no significant differences in all tested attributes. The addition of 10% can be recommended.	Valková et al., 2022
Pasta/ Noodles	Replacement of durum semolina with 10 and 15% of apple peel powder.	Increased cooking loss and the amount of absorbed water. Hardness and adhesiveness have decreased. Increased total antioxidant activity and total phenolic content.	Lončarić et al.,2014

Food product	Apple pomace	Results	References
	Replacement of 10, 15, and 20% of wheat flour with apple pomace powder.	The total dietary fiber and protein content of the noodles increased from 6.0 to 13.28% and 10.20 to 11.80%, respectively, as compared to the control noodles. Increased ash content, cooking loss, swelling index, and antioxidant activity. The most acceptable product is noodles with 10% substitution.	Yadav and Gupta, 2015
	Addition of milled apple pomace, 10, 20, 30, and 50%.	Increased total polyphenols, phenolic acids, quercetin derivatives, flavon-3-ols, dihydrochalcones, dietary fiber, and minerals contents. Decreased protein and fat contents, hardness and maximum cutting energy. Water absorption capacity is not influenced up to a level of 50% apple pomace rep.	Gumul et al., 2023
Buffalo meat sausages	Replacement of 2, 4, 6, and 8% lean meat by apple pomace powder.	Increased the dietary content, cooking yield and emulsion stability, firmness, toughness, hardness, springiness, and gumminess, while the cohesiveness and chewiness decreased.	Younis and Ahmad, 2015
Chicken patties	Replacement of chicken with 10 and 20% (w/w) of wet apple pomace	Meat products with apple pomace had higher dietary fiber content (0.7–1.8 % vs. 0.1–0.2 % in control) and radical scavenging activity.	Jung et al.,2015
Beef jerky	Replacement of ground beef with 10 and 20% (w/w) of wet apple pomace		
Chicken sausages	Replacement of pork fat by incorporation of apple pomace fiber, 1 and 2%.	Lower cooking loss, total expressible fluid separation, fat separation, pH, and redness. Reduction of pork fat from 30 to 25 and 20%.	Choi et al.,2016
Beef jerky	Replacement of ground beef with 10 and 20% (w/w) of wet apple pomace	Meat products with apple pomace had higher dietary fiber content (0.7–1.8 % vs. 0.1–0.2 % in control) and radical scavenging activity.	Junget al.,2015
Buffalo meat patties	Replacement of 2, 4, 6, 8% of meat by apple pomace powder.	Increased cooking yield, emulsion stability, water holding capacity, diameter, and thickness. The texture like firmness, toughness, hardness, and cohesiveness has increased. Sensory evaluation showed acceptability up to 6% level of incorporation.	Younis and Ahmad, 2018

Food product	Apple pomace	Results	References
Fish fingers	Replacement of 2.5, 4.5, 6.5 of fish meat by apple pomace powder.	Decreased pH, crude protein, moisture, crude fat, and total ash and increased crude fiber content. Increased emulsion stability and cooking yield. Sensory evaluation showed decreasing trend.	Akhtar et al.,2019
Italian salami	Addition of dried apple pomace, 7 and 14%.	Increased fiber and phenol content, together with the lower fat and energy value.	Grispoldi et al.,2022
Beef burger	Addition of freeze-dried apple pomace, 4 and 8%.	Increased fiber and phenol content. The colour and sensory analysis of beef burger with apple pomace were graded better than the control.	Pollini et al., 2022
Yogurt	Addition of freeze-dried apple powder, 0.1, 0.5 and 1%.	Increased gelation pH and shortened fermentation time. The most stable structure over a 28-day storage period – the yogurt fortified with 0.5% apple pomace.	Wang et al., 2019
	Addition of freeze-dried apple pomace powder, 1, 2, and 3%.	Increased dietary fiber content, viscosity, firmness, and cohesiveness. Decreased whey release during cold storage.	Wang et al., 2020
	Addition of apple pomace flour, 1, 3, and 5%.	Increased total phenolic content, radical scavenging and reducing activity. The highest firmness, cohesiveness, and viscosity index values, and the highest scores for color and taste, were obtained for yogurt with 3% of apple pomace.	Jovanović et al., 2020
	Addition of apple pomace powder, 0.2–1.0%.	Reduced fermentation time. Increased total dietary fiber content and antioxidant activity. Improved the textural properties and significant reduction in syneresis during the 20 days of storage. Sensory evaluation found that that sample with 0.6–0.8% of apple pomace had the highest score.	Popescuet al., 2022

Utilization of grape processing by-products

It has been shown that by-products obtained in the processing of grapes due to their chemical composition including proteins, ash, lipids, carbohydrates, vitamins, and substances with important biological properties such as phenolic compounds, can be used as potential ingredients for enrichment of various cereal products (Boff et al., 2022). The resulting enriched bakery products are distinguished by improved nutritional characteristics, without causing significant changes in the sensory profile. However, the incorporation of by-products of grape processing requires adjustment of recipes and technological parameters to preserve the quality of baked products (García-Lomillo, 2017). Different applications of grape pomace, the main by-product of grape processing, are shown in Figure 4.

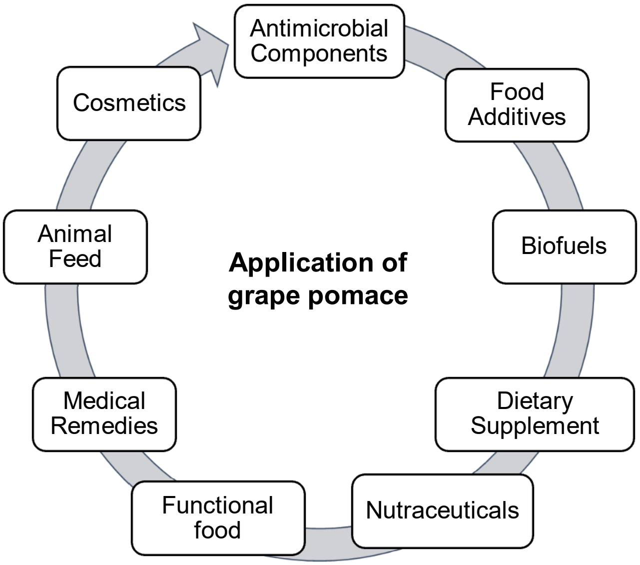

Figure 4. Application of grape pomace

Grape processing by-products can be used in the production of cereal products after drying and the formation of powder or flour, according to the relevant specifications. Thus, when using flours from grape pomace up to a maximum of 10%, cookies with a high content of phenolic compounds, antioxidants, and dietary fiber are produced, from which consumers can be satisfied (Acun et al., 2014).

Pasqualone et al. (2014) studying functional biscuits with the addition of grape pomace extract found that enriched biscuits have a strong antioxidant activity and contain a greater amount of total phenolic compounds, flavonoids, anthocyanins, and proanthocyanidins in terms of control. The intense color, fruity smell, and sour taste of enriched biscuits did not affect the product's acceptability.

Walker et al. (2014) prepared cereal products, namely bread, muffins, and brownies with 5-25% grape pomace, finding that the dietary fiber and total phenol content increased compared to the control. It has been found that enriching muffins with 20% grape by-products improve their nutritional value without showing significant changes in the sensory profile (Mildner-Szkudlarz et al., 2015). No significant changes in the sensory profile were also determined by Kuchtová et al., 2016, who replaced up to 15% composite flour in the formula for cookies, with a grape skin pomace.

In this context, Bender et al. (2017) did a study to evaluate the effects that Riesling and Tannat grape skin flour had on muffins and their taste, appearance, and texture. The inclusion of ratios 5, 7.5, and 10% of these flours affected the texture, mainly hardness, which increased as the level of addition increased, as well as the color and content of total dietary fiber. This study showed that Tannat and Riesling grape skin flour could be used as an alternative to increasing the dietary fiber content of muffins without having a negative effect on the sensory properties of the products.

In functional biscuits prepared with grape pomace powder, it was found that the addition of grape pomace does not affect the physical parameters of the cookies, but significantly affects the increase in protein and dietary fiber content. Biscuits with 4% and 6% grape pomace (w/w) tasted better, and cookies with 6% grape pomace showed higher antioxidant potency, lower anthocyanin losses, and greater hardness retention during the shelf life study (Theagarajan et al., 2019).

Nakov et al. (2020) prepared cakes by replacing wheat flour with 4%, 6%, 8 %, and 10% grape pomace powder, and it was found that as the share of pomace powder increased, the ash, fat, protein, fiber, free phenols, anthocyanins, and total polyphenol content, as well as the antioxidant capacity gradually increased, and the moisture and pH value decreased. Cakes containing 4% pomace powder had the best sensory characteristics. Studies for adding fruit by-products to different types of bread include the use of by-products ofgrape processing.

Mildner-Szkudlarz et al. (2011) developed a new formulation for mixed rye bread produced with grape pomace as an alternative source of dietary fiber, ash and dietary polyphenols. New formulations have been shown to have a significantly higher total dietary fiber content and have been characterized by significantly higher antioxidant activity associated with their phenolic compound content.

According to a study conducted by Hayta et al. (2014), incorporating about 5% (w/w, flour basis) grape pomace powder into bread formulation positively affects the total phenol content and anti-radical activity. It has been found that the addition of grape trop powder contributes to the bread to improve its functional properties.

Tolve et al. (2021) prepared wheat bread in which a portion of wheat flour, 5, and 10 g/100 g have been replaced by grape pomace powder. The inclusion of a higher level of grape pomace powder caused a decrease in the total starch content (from 85.5 to 75.3 g/100 g DM) and an increase in the total dietary fiber content (2.8 to 6.3 g/100 g DM). As the proportion of pomace in bread increased, total phenolic compounds and antioxidant capacity increased. The total phenolic compounds increased 3.5-fold and 7-fold as GPP replacement increased from 0% to 5% and from 0% to 10%, respectively. The grape pomace powder addition did not have a significant impact on the overall acceptability of the product.

Rainero et al. (2022), in their study with breadsticks, replaced wheat flour with 5 and 10 g 100 g^{-1} of powdered grape pomace, and they observed that the total phenolic compounds, dietary fiber, and antioxidant capacity increased. The content of total phenolic compounds increased from 72.21 to 171.83 mg GAE 100 g^{-1} DM, the dietary fiber from 3.47 to 5.81 and 8.55 g 100 g^{-1} DM and antioxidant capacity evaluated by FRAP (ferric reducing ability of plasma) increased from 360.60 to 2801.00 µM TE 100 g^{-1} DM. Breadsticks with 5 g 100 g^{-1} of powdered grape pomace flour showed lower overall acceptability.

When foods are enriched with fiber, it is necessary to evaluate the effects that added fiber has on consumers' perceptions of color, texture, and acceptability. For example, the baking properties of some products can be significantly affected when a portion of wheat flour is replaced by ingredients that are rich in fiber. Such effects include a decrease in the volume or height of the bread and changes in texture (increases the hardness of the crumb, loss of crunchiness), appearance (surface properties, color, density), and intensity of smell and taste (Bender et al., 2017; Šporin et al., 2018). Sensory assessment of bread with added pomace suggests that a maximum of 6% grape pomace can be incorporated to prepare acceptable products (Mildner-Szkudlarz et al., 2011).

Smith et al. (2015) used grape pomace of four grape varieties to substitute 5 and 10% flour in a white bread formulation. The results showed that bread with 5% grape pomace has a similar volume of bread, but a darker color compared to the control, while bread with 10% grape pomace became denser. Dietary fiber, polyphenols, and antioxidant activity of bread increased with increasing content of grape pomace in the formulation. Grapes can also be used in the production of pasta. Choosing this by-product as a functional ingredient for pasta production can improve the nutritional profile of this widely consumed food, increase the daily intake of phenols and fiber, and add economic value to wine production (Balli et al., 2021).

Namely, Tolve et al. (2020) performed enrichment of pasta by replacing 5 and 10 % of semolina with grape pomace. By incorporating grape pomace in pasta optimal cooking time and the swelling index were significantly reduced, the firmness and adhesiveness of the pasta were improved, the total phenolic content and antioxidant activity increased, and sensory analysis showed that enriched spaghetti had good overall acceptability.

Balli et al. (2021) conducted a study in order to assess the possibility of using dry grape pomace as a source of phenolic compounds and fibers in tagliatelle pasta, which are usually characterized by a negligible amount of phenolic compounds and fibers. The profile of pasta enriched with 7% dry grape pomace was studied, focusing on phenolic compounds after cooking. The enriched tagliatelle was characterized by improved organoleptic and nutritional characteristics, retained phenolic compounds after cooking, and an increased amount of fiber. The enriched tagliatelle retained the same monoglycolized and acetylated anthocyanins found in grapes. In enriched tagliatelle, the fiber content increased by ≈ 3%, while the added phenols retained after cooking the enriched tagliatelle amounted to 6.21 mg/100 g.

Grape by-products have been added to various dairy products (Antonić et al., 2020), such as yogurt, kefir, cheese, and salad dressing. Some studies have shown that the effectiveness is lower than in cereal products due to instability and loss of nutritional components in the processing and storage of dairy products, as well as other technological problems (García-Lomillo et al., 2017).

In addition, several studies have reported the use of grape pomace in meat products such as chicken nuggets and chevon nuggets. The summary of the various studies on application of grape by-products in food product preparation is presented in Table 2.

Table 2

Application of grape by-products in food product preparation

Product	**Grape by-products**	Results	References
Biscuits	Addition of white grape pomace powder, 10, 20 and 30% (w/w)	Increased total dietary fiber from 0.85 mg GAE g^{-1} DM to 4.45 mg GAE g^{-1} DM, total phenolic compound content from 0.11 mg g^{-1} DM to 1.07 mg g^{-1} DM, and significantly higher antioxidant activities. Sensory profile analysis showed acceptability up to 10% level of incorporation.	Mildner-Szkudlarz et al., 2013

Product	**Grape by-products**	Results	References
	Adding grape seed powder, 5, 10, 15 and, 20% of the weight of flour	Adding grape seed powder to wheat flour lowers the output gluten reduces its sensibility and increases elasticity. Adding 15.0 % of grape seed powder to butter biscuits improves their physicochemical (specific volume and wetting ability) as well as organoleptic quality indices.	Samohvalova et al., 2016
	Replacing cocoa powder with grape pomace powder in ratios of 50 and 100%.	The grape powder does not significantly affect the height, spread ratio, hardness, flexibility, toughness, appearance, and odor of biscuits. A positive impact on biscuits flavor, despite fruity taste.	Molnar et al., 2020
	Wheat flour substitution by Tannat grape pomace flour, 10 and 20% (w/w) in the total wet biscuit mass.	Increased the content of total polyphenols and antioxidant capacity. Greater α-glucosidase and pancreatic lipase inhibition capacity compared to the biscuits without grape pomace flour.	Olt et al., 2022
Cookies	Addition of whole grape pomace flour and pomace flour without seeds at levels of 5, 10, and 15%, and seed flour at levels of 5, 7.5, and 10%.	Not significantly affected on the width, thickness, and spread ratio of cookies. Total dietary fiber and total phenolics increased as compared to the control. Cookies with 10% seed flour had higher total dietary fiber and total phenolics (153.10 g/kg GAE and 5.61 mg/mL, respectively) than others. The best acceptable product is cookies with 5% seed flour.	Acun and Gü, 2014
	Replacing wheat flour with wine grape pomace powder at levels of 5, 10, 15, and 20 %.	Increased colour intensity, antioxidant properties, total phenol content, flavonoid, and anthocyanin. Samples with 5 % of wine grape pomace powder had the maximum score.	Maner et al., 2017
	Replacing wheat flour with grape pomace powder at levels of 2.5, 5.0, 7.5, and 10.0 % with 3 different granulations (0.25, 0.50, 1.00 mm)	Well accepted due to their good appearance, likable colour, pleasant aroma, and taste. Those that contain grape pomace powder in granulation 1.00 mm are the best.	Temkov et al., 2021
Muffins	Replacing whole-wheat flour with white and red grape pomace at levels of 10 and 20%	The high content of fiber. Decreased elasticity, cohesion, resilience, and color parameters of the muffins with white and red grape pomace. Increased chewiness and firmness. High levels of acceptability of the muffins that incorporated white and red grape pomace products at concentrations of 10%.	Ortega-Heras et al., 2019

Product	**Grape by-products**	Results	References
	Replacing rice flour with grape pomace powder at levels of 15, and 25%.	Improved nutritional composition of the gluten-free muffins. Increased protein from 5.00 g/100 g dwb to 5.72 g/100 g dwb and 6.64 g/100 g dwb, crude fiber content from 0.05 g/100 g dwb to 1.47 g/100 g dwb and 2.19 g/100 g dwb. Good level of acceptability.	Baldánet al., 2021
	Addition of 7.5% and 15% grape seed flour substituting whole wheat, whole siyez wheat, and whole oat flour.	Increased protein, lipid, moisture, phenolic contents, and antioxidant capacity with an increased amount of grape seed flour addition. Decreased hardness and chewiness of the muffins with whole wheat flour and whole siyez wheat flour, and increased of the muffins with whole oat flour.	Yalcin et al., 2021
	Addition of 15% grape pomace powder with different particle size fractions (600-425, 425-300, 300-212 and 212-150 µm)	Thinner granulometry -higher values of antioxidant activity, anthocyanin, and phenol content. From a textural and sensorial point of view, the smaller particle sizes negatively affected the hardness and color in terms of lightness, as well as the homogeneity of the pores.	Troilo et al., 2022
Bread	Addition of 'Merlot' and 'Zelen'grape pomace flour, 6, 10, and 15%.	Positive correlation with phenolic content and antioxidant activity, and negative correlation with brightness and firmness. The variety 'Zelen' is suggested for use.	Šporin et al., 2018
	Replacement of wheat flour with 1%, 2%, 5%, and 8% (w/w) of grape seeds micropowder (GSMP) with nanosized particles (10 µm).	Positive effect on dough manifesting with rheology by increased dough stability. Significantly decreased bread volume was observed in the bread supplemented with ≥ 2%. The bread supplemented with 1% had the highest scores for all the quality attributes.	Valková et al., 2020
	Replacement of wheat flour with 3%, 5%, 7%, and 9% (w/w) of grape seeds flour.	Increased fiber, protein, and minerals. Declined rheological parameters and technological performance. The samples with 3% and 5% can be considered a fiber source and Cu source, respectively, and are rich in Zn. The samples containing 7% and 9% – unsatisfactory from rheological and sensorial points of view.	Oprea et al., 2022
Panettones	Incorporation of powdered compound produced from grape bark and arrowroot in the proportions of 10%, 15%, and 20% (m/m) in place of wheat flour.	Not differ statistically from the traditional formulation in terms of moisture content, lipids, proteins, and water activity. Increased color intensity, flavonoids (1.58 mg QE g^{-1}; 1.71 mg QE g^{-1}; 1.83mg QE g^{-1}), and anthocyanins content (1.20 mg.g^{-1}; 1.34mg.g^{-1}; 1.41 mg.g^{-1}) in contrast to traditional panettone (0.03 for both).	Souza et al., 2023

Product	**Grape by-products**	Results	References
Pasta / Spaghetti	Incorporation of 25, 50 and 75 g/kg of grape marc powder.	Increased total phenolic content, condensed tannins, monomeric anthocyanin and compounds antioxidant capacity. The sensory analysis found that the incorporation reduced the acceptance of aroma, aftertaste, flavor, and appearance. The best overall acceptance, with lower changes of color is fettuccini pasta with 25 g/kg incorporation.	Sant'Anna et al., 2014
	Replacement of wheat flour in proportions of 3, 6 and 9% (w/w) with grape pomace skins.	Improvements in the polyphenolic content. Increased antioxidant capacity. Improved sensory and functional properties up to a level of 6%.	Gaita et al., 2020
	Grape marc extracts (grape marc suspended in water at a ratio of 1: 10 (w/v)).	Higher content of phenolic compounds, flavonoids, and antioxidant activity. No difference in optimum cooking time (around 10 min.). Low cooking losses. Without altering sensory characteristics..	Marinelli et al., 2015
	Addition of 15% (w/w) red grape marc flour with a different particle size (500 µm; 125µm) to durum wheat semolina.	Increased total polyphenol, anthocyanin content, and antioxidant activity. Decreased bioaccessible glucose.	Marinelli et al., 2018
"Vegan" sausages	Addition of the grape seed flour with different concentra-tions 0,1,3,7,10,20%.	Increased antioxidant capacity and polyphenol content. Decreased protein. The most acceptable product is vegan sausages with 1% and 3% addition.	Tremlova et al., 2022
Chicken nuggets	Replacement of flour mix (wheat flour, corn flour, leavening agent, salt) with grape seed flour amounts of 1, 2, 5, 8, and 10%.	Higher antioxidant activity. Reduced lipid oxidation. Decreased thiobarbituric acid reactive substance, para-anisidine values, and conjugated diene concentration values.	Cagdas and Kumcuoglu, 2015
Chevon nuggets	Addition of grape seed extract, 5% stock solution (0.5g of dried extract /10 mL).	Lower thiobarbituric acid reactive substance and free fatty acid, %. Reduced total plate, total psychrophilic, and yeast and mold count. A superior score of flavor, juiciness, and overall acceptability.	Meena et al., 2021
Semi-hard and hard cheeses	Added grape pomace powder (Barbera, Chardonnay before distillation, Chardonnay after distillation)/ at two concentration levels 0.8 and 1.6 % (w/w).	Higher antioxidant activity and phenolic content in all fortified cheeses, but to obtain a significant increase in cheese antioxidant activity it is necessary to add at least 1.6 % of grape pomace powder. The highest total phenolic content and radical scavenging activity values at the end of ripening (30 days and 120 days respectively) showed cheeses fortified with Chardonnay after distillation powder.	Marchiani et al., 2015

Product	Grape by-products	Results	References
Spreadable cheese	Addition of white and red grape pomace powders at a concentration of 5% (w/w).	Increased total phenolic content (2.74 ± 0.04 and 2.34 ± 0.15 mg GAEs/g dw, respectively) compared to the control (0.66 mg GAEs/g dw). Increased flavonoids, and antioxidant activity. Decrease of pH.	Luceraet al., 2018
Fresh ovine “primosale” cheese	Addition of 1% (w/w) grape pomace powder with four selected Lactococcus lactis strains.	Reduced fat content and increased protein and secondary lipid oxidation. Increased antioxidant activity of the cheese after that the dairy matrix was degraded by the simulated digestive process.	Gaglio et al., 2021
Ovine Vastedda-like stretched cheese	Incorporation of 1% (w/w) red grape pomace powder Nero d’Avola Cultivar into ovine stretched cheese.	Higher protein, polyphenols content, and lower fat content. Favorable influence on sensory traits.	Barbaccia et al., 2022
Kefir	Addition of Sangiovese skins and seeds extracts at a concentration of 1, 5, and 10 mg.	Better antioxidant activity. Good performance in the inhibition of key enzymes linked to metabolic syndrome (α-amylase, α-glucosidase, and lipase).	Carullo et al., 2020
Yogurt, Italian and Thousand Island salad dressing	Addition of 1%, 2%, and 3% (w/w yogurt) grape pomace powder; 0.5 and 1% grape pomace powder (w/w Italian salad dressing); 1 and 2% grape pomace powder (w/w Thousand Island salad dressing).	Higher dietary fiber content. Decreased total phenolic content and DPPH radical scavenging activity during storage. Best received products are 1% (w/w) fortified yogurt, 0.5% (w/w) fortified Italian dressing, and 1% (w/w) fortified Thousand Island dressing.	Tseng et al., 2013
Yogurt	Addition of grape skin flours (Chardonnay, Moscato, and Pinot noir varieties) in a proportion of 60 g/kg in yogurt.	Yogurt containing grape skin flour presented significantly higher total phenolic content (+55%), antioxidant activity (+80%), and acidity (+25%) whereas lower pH, syneresis (−10%), and fat (−20%) than control. Retained total phenolic content and radical scavenging activity during yogurt storage (no significant changes observed).	Marchiani et al., 2016
	Addition of Tannat grape skin powder in a proportion of 0.5% (w/w) in yogurt.	Increased α-glucosidase inhibition capacity. The antioxidant capacity increased slightly with time until day 12 and then remained unchanged up to the end of the study (28 days). Higher overall acceptance.	Fernández-Fernández et al., 2022

Conclusion

The utilization of waste from the fruit processing industry to be used for preparation of new food products is an innovative and functional way for environmental protection. In addition to reducing environmental pollution, functional food products with better nutritional characteristics are created. It has been proven that waste from apple and grape processing contains biologically active substances such as polyphenols, dietary fibers, proteins, fats, minerals, has antioxidant, antimicrobial, anti-carcinogenic, antiviral and antibacterial characteristics and can be successfully incorporated into new functional food products.

References

Acun S., Gü H. (2014), Effects of grape pomace and grape seed flours on cookie quality, *Quality Assurance and Safety of Crops & Foods*, 6(1), pp. 81–88, DOI: 10.3920/QAS2013.0264

Akhtar S., Gani M., Hakeem H.R., Ganie S. A., Mir M.A., Dar A. H. (2019), Effect of apple pomace powder on the quality attributes of fish fingers, *Journal of Fisheries Research*, 3(1), pp. 26-34, DOI: 10.35841/fisheries-research.3.1.26-34

Alongi M., Melchior S., Anese M. (2019), Reducing the glycemic index of short dough biscuits by using apple pomace as a functional ingredient, *LWT,* 100, pp. 300–305, DOI: 10.1016/j.lwt.2018.10.068

Antonić B., Jančíková S., Dordević D., Tremlová B. (2020), Grape pomace valorization: a systematic review and meta-analysis, *Foods,* 9(11), 1627, DOI: 10.3390/foods9111627

Baldán Y., Riveros M., Fabani M.P., Rodriguez R. (2021), Grape pomace powder valorization: a novel ingredient to improve the nutritional quality of gluten-free muffins, *Biomass Conversion and Biorefinery,* DOI: 10.1007/s13399-021-01829-8

Balli D., Cecchi L., Innocenti M., Bellumori M., Mulinacci N. (2021), Food by-products valorisation: grape pomace and olive pomace (pâté) as sources of phenolic compounds and fiber for enrichment of tagliatelle pasta, *Food Chemistry*, 355, 129642, DOI: 10.1016/j.foodchem.2021.129642

Barbaccia P., Busetta G., Barbera M., Alfonzo A., Garofalo G., Francesca N., Moscarelli A., Moschetti G., Settanni L., Gaglio R. (2022), Effect of grape pomace from red cultivar 'Nero d'Avola' on the microbiological, physicochemical, phenolic profile and sensory aspects of ovine Vastedda-like stretched cheese, *Journal of Applied Microbiology,* 133(1), pp. 130–144, DOI: 10.1111/jam.15354

Bchir B., Karoui R., Danthine S., Blecker C., Besbes S., Attia H. (2022), Date, apple, and pear by-products as functional ingredients in pasta: cooking quality attributes and physicochemical, rheological, and sensorial properties, *Foods,* 11(10), 1393, DOI: 10.3390/foods11101393

Bender B. B. A., Speroni S. C., Salvador R. P., Loureiro B. B., Lovatto M. N., Goulart R.F., Lovatto T. M., Miranda Z. M., Silva P. L., Penna G .N. (2017), Grape pomace skins and the effects of its inclusion in the technological properties of muffins, *Journal of Culinary Science & Technology*, 15(2), pp. 143–157, DOI: 10.1080/15428052.2016.1225535

Boff J. M., Strasburg V. J., Ferrari G. T., de Oliveira Schmidt H., Manfroi V., de Oliveira V. R. (2022), Chemical, technological, and sensory quality of pasta and bakery products made with the addition of grape pomace flour, *Foods*, 11, pp. 3812, DOI: 10.3390/ foods11233812

Bora P., Ragaee S., Abdel-Aal E.-S. M. (2019), Effect of incorporation of goji berry by-product on biochemical, physical and sensory properties of selected bakery products, *LWT,* 112, 108225, DOI: 10.1016/j.lwt.2019.05.123

Cagdas E., Kumcuoglu S. (2015), Effect of grape seed powder on oxidative stability of precooked chicken nuggets during frozen storage, *Journal of Food Science and Technology*, 52(5), pp. 2918–2925, DOI: 10.1007/s13197-014-1333-7

Carullo G., Spizzirri U.G., Loizzo M.R., Leporini M., Sicari V., Aiello F., Restuccia D. (2020), Valorization of red grape (*Vitis vinifera cv. Sangiovese*) pomace as functional food ingredient, *Italian Journal of Food Science,* 32, pp. 367–385, DOI: 10.14674/IJFS-1758

Castro L. A., Lizi J.M., Chagas E.G.L.D., Carvalho R.A., Vanin F.M. (2020), From orange juice by-product in the food industry to a functional ingredient: application in the circular economy, *Foods,* 9(5), 593, DOI: 10.3390/foods9050593

Choi Y.S., Kim Y.B., Hwang K.E., Song D.H., Ham Y.K., Kim H.W., Sung J.M., Kim C.J. (2016), Effect of apple pomace fiber and pork fat levels on quality characteristics of uncured, reduced-fat chicken sausages, *Poultry Science,* 95(6), pp. 1465–1471, DOI: 10.3382/ps/pew096

Colantuono A. (2019), Vegetable by-products as a resource for the development of functional foods, In: Ferranti P., Berry E. M., Anderson J. R. (eds.), *Encyclopedia of Food Security and Sustainability,* Elsevier, pp. 360–363, DOI: 10.1016/b978-0-08-100596-5.22142-2

Dhillon G. S., Kaur S., Brar S. K. (2013), Perspective of apple processing wastes as low-cost substrates for bioproduction of high value products: A review, *Renewable and Sustainable Energy Reviews*, 27, pp. 789–805, DOI: 10.1016/j.rser.2013.06.046

Djeghim F., Bourekoua H., Różyło R., Bieńczak A., Tanaś W., Zidoune M.N. (2021), Effect of by-products from selected fruits and vegetables on gluten-free dough rheology and bread properties, *Applied Sciences,* 11(10), pp. 4605, DOI: 10.3390/app11104605

Erinle T. J., Adewole D. I. (2022), Fruit pomaces - their nutrient and bioactive components, effects on growth and health of poultry species, and possible optimization techniques, *Animal Nutrition*, 9, pp. 357–377, DOI: 10.1016/j.aninu.2021.11.011

Fernández-Fernández A. M., Dellacassa E., Nardin T., Larcher R., Ibañez C., Terán D., Gámbaro A., Medrano-Fernandez A., del Castillo M.D. (2022), Tannat grape skin: A feasible ingredient for the formulation of snacks with potential for reducing the risk of diabetes, *Nutrients,* 14(3), pp. 419, DOI: 10.3390/nu14030419

Fierascu R. C., Sieniawska E., Ortan A., Fierascu I., Xiao J. (2020), Fruits by-products – a source of valuable active principles. A short review, *Frontiers in Bioengineering and Biotechnology*, 8, 319, DOI: 10.3389/fbioe.2020.00319

Gaglio R., Barbaccia P., Barbera M., Restivo I., Attanzio A., Maniaci G., Di Grigoli A., Francesca N., Tesoriere L., Bonanno A., Moschetti G., Settanni L. (2021), The use of winery by-products to enhance the functional aspects of the fresh ovine “primosale” cheese, *Foods,* 10(2), 461, DOI: 10.3390/foods10020461

Gaita C., Alexa E., Moigradean D., Conforti F., Poiana M. A. (2020), Designing of high value-added pasta formulas by incorporation of grape pomace skins, *Romanian Biotechnological Letters*, 25(3), pp. 1607–1614, DOI: 10.25083/rbl/25.3/1607.1614

Galanakis C. M. (2012), Recovery of high added-value components from food wastes: Conventional, emerging technologies and commercialized applications, *Trends in Food Science & Technology*, 26(2), pp. 68–87, DOI: 10.1016/j.tifs.2012.03.003

García-Lomillo J., González-SanJosé M. L. (2017), Applications of wine pomace in the food industry: Approaches and functions, *Comprehensive Reviews in Food Science and Food Safety,* 16(1), pp. 3–22, DOI: 10.1111/1541-4337.12238

Grispoldi L., Ianni F., Blasi F., Pollini L., Crotti S., Cruciani D., Cenci-Goga B. T., Cossignani L. (2022), Apple pomace as valuable food ingredient for enhancing nutritional and antioxidant properties of Italian salami, *Antioxidants,* 11(7), pp. 1221, DOI: 10.3390/antiox11071221

Gumul D., Korus J., Ziobro R., Kruczek M. (2019), Enrichment of wheat bread with apple pomace as a way to increase pro-health constituents, *Quality Assurance and Safety of Crops & Foods*, 11(3), pp. 231–240, DOI: 10.3920/QAS2018.1374

Gumul D., Kruczek M., Ivanišová E., Słupski J., Kowalski S. (2023),Apple pomace as an ingredient enriching wheat pasta with health-promoting compounds, *Foods,* 12, pp. 804, DOI: 10.3390/foods12040804

Hayta M., Özuğur G., Etgü H., Şeker T. İ. (2014), Effect of grape (*Vitis vinifera* L.) pomace on the quality, total phenolic content and anti-radical activity of bread, *Journal of Food Processing and Preservation,* 38(3), pp. 980–986, DOI: 10.1111/jfpp.12054

He Y.Q., Lu Q. (2015), Impact of apple pomace on the property of French bread, *Advance Journal of Food Science and Technology,* 8, pp. 167–172, DOI: 10.19026/ajfst.8.1487

Ivanov V., Shevchenko O., Marynin A., Stabnikov V., Gubenia O., Stabnikova O., Shevchenko A., Gavva O., Saliuk A. Trends and expected benefits of the breaking edge food technologies in 2021–2030,*Ukrainian Food Journal*, 2021, 10(1), pp. 7-36, DOI: 10.24263/2304-974X-2021-10-1-3

Jannati N., Hojjatoleslamy Z, M., Hosseini E., Mozafari H.R., Siavoshi M. (2018), Effect of apple pomace powder on rheological properties of dough and sangak bread texture, *Carpathian Journal of Food Science and Technology*, 10(2), pp. 77–84.

Jovanović M., Petrović M., Miočinović J., Zlatanović S., Laličić Petronijević J., Mitić-Ćulafić D., Gorjanović S. (2020), Bioactivity and sensory properties of probiotic yogurt fortified with apple pomace flour, *Foods,* 9(6), 763, DOI: 10.3390/foods10081696

Jung J., Cavender G., Zhao Y. (2015), Impingement drying for preparing dried apple pomace flour and its fortification in bakery and meat products, *Journal of Food Science and Technology,* 52(9), pp. 5568–5578, DOI: 10.1007/s13197-014-1680-4

Karkle E. L., Alavi S., Dogan H. (2012), Cellular architecture and its relationship with mechanical properties in expanded extrudates containing apple pomace, *Food Research International,* 46(1), pp. 10–21, DOI: 10.1016/j.foodres.2011.11.003

Kırbaş Z., Kumcuoglu S., Tavman S. (2019), Effects of apple, orange and carrot pomace powders on gluten-free batter rheology and cake properties, *Journal of Food Science & Technology*, 56(2), pp. 914–926, DOI: 10.1007/s13197-018-03554-z

Kuchtová V., Karovičová J., Kohajdová Z., Minarovičová L., Kimličková V. (2016), Effects of white grape preparation on sensory quality of cookies, *Acta Chimica Slovaca,* 9(2), pp. 84–88, DOI:10.1515/acs-2016-0014

Larrosa Q. P., Otero M. D. (2021), Flour made from fruit by-products: characteristics, processing conditions, and applications, *Journal of Food Processing and Preservation*, 00, 15398, DOI:10.1111/jfpp.15398

Lau K. Q., Sabran M. R., Shafie S. R. (2021), Utilization of vegetable and fruit by-products as functional ingredient and food, *Frontiers in Nutrition,* 8, pp. 661693, DOI: 10.3389/fnut.2021.661693

Lauková M., Kohajdová Z., Karovičová J. (2016), Effect of hydrated apple powder on dough rheology and cookies quality, *Potravinarstvo*, 10(1), pp. 506–511, DOI: 10.5219/597

León E. A. V., Aldapa C. A. G., Rojas J. A., Torres A. V., Uribe J. P. H., Rodríguez H. M. P., Cortez R. O. N. (2022), Phytochemical content and antioxidant activity of extruded products made from yellow corn supplemented with apple pomace powder, *Food Science and Technology*, 42, pp. 91221, DOI: 10.1590/fst.91221

Leyva-López N., Lizárraga-Velázquez C.E., Hernández C., Sánchez-Gutiérrez E. Y. (2020), Exploitation of agro-industrial waste as potential source of bioactive compounds for aquaculture, *Foods,* 9, pp. 843, DOI: 10.3390/foods9070843

Lončarić A., Kosović I., Jukić M., Ugarčić Ž., Piližota V. (2014), Effect of apple by-product as a supplement on antioxidant activity and quality parameters of pasta, *Croatian Journal of Food Science and Technology*, 6, pp. 97–103, DOI: 10.17508/CJFST.2014.6.2.05

Lucera A., Costa C., Marinelli V., Saccotelli M. A., Del Nobile M. A., Conte A. (2018), Fruit and vegetable by-products to fortify spreadable cheese, *Antioxidants*, 7(5), pp. 61, DOI: 10.3390/antiox7050061

Lyu F., Luiz S. F., Azeredo D. R. P., Cruz A. G., Ajlouni S., Ranadheera C. S. (2020), Apple pomace as a functional and healthy ingredient in food products: a review, *Processes,* 8, pp. 319, DOI: 10.3390/pr8030319

Majerska J., Michalska A., Figiel A. (2019), A review of new directions in managing fruit and vegetable processing by-products, *Trends in Food Science & Technology*, 88, pp. 207–219, DOI: 10.1016/j.tifs.2019.03.021

Maner S., Sharma A.K., Banerjee K. (2017), Wheat flour replacement by wine grape pomace powder positively affects physical, functional and sensory properties of cookies, *Proceedings of the National Academy of Sciences, India Section B: Biological Sciences*, 87, pp. 109–113, DOI: 10.1007/s40011-015-0570-5

Marchiani R., Bertolino M., Belviso S., Giordano M., Ghirardello D., Torri L., Piochi M., Zeppa G. (2016), Yogurt enrichment with grape pomace: effect of grape cultivar on physicochemical, microbiological and sensory properties, *Journal of Food Quality,* 39, pp. 77–89, DOI: 10.1111/jfq.12181

Marchiani R., Bertolino M., Ghirardello D., McSweeney P. L. H., Zeppa G. (2015). Physicochemical and nutritional qualities of grape pomace powder-fortified semi-hard cheeses, *Journal of Food Science and Technology,* 53, pp. 1585–1596, DOI: 10.1007/s13197-015-2105-8

Marinelli V., Padalino L., Conte A., Del Nobile M. A., Briviba K. (2018), Red grape marc flour as food ingredient in durum wheat spaghetti: nutritional evaluation and bioaccessibility of bioactive compounds, *Food Science and Technology Research*, 24 (6), pp. 1093–1100, DOI: 10.3136/fstr.24.1093

Marinelli V., Padalino L., Nardiello D., Del Nobile M. A., Conte A. (2015), New approach to enrich pasta with polyphenols from grape marc, *Journal of Chemistry*, 2015: 734578, DOI: 10.1155/2015/734578

Meena P., Pandey A., Saini A., Gurjar A.S., Raman R., Meel S.K., Chauhan V.K. (2021), Effect of grape (*Vitis vinifera*) seed extract on the physico-chemical, microbial and sensory characteristics of chevon nuggets, *Indian Journal of Animal Research*, 55(3), pp. 364–368, DOI: 10.18805/ijar.B-3958

Mildner-Szkudlarz S., Bajerska J., Zawirska-Wojtasiak R., 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, *Journal of the Science of Food and Agriculture*, 93(2), pp. 389–395, DOI: 10.1002/jsfa.5774

Mildner-Szkudlarz S., Siger A., Szwengiel A., Bajerska J. (2015), Natural compounds from grape by-products enhance nutritive value and reduce formation of CML in model muffins, *Food Chemistry,* 172, pp. 78–85, DOI: 10.1016/j.foodchem.2014.09.036

Mildner-Szkudlarz S., Zawirska-Wojtasiak R., Szwengiel A., Pacyński M. (2011), Use of grape by-product as a source of dietary fibre and phenolic compounds in sourdough mixed rye bread, *International Journal of Food Science and Technology*, 46, pp. 1485–1493, DOI: 10.1111/j.1365-2621.2011.02643.x

Mir S. A., Bosco S. J. D., Shah M. A., Santhalakshmy S., Mir M. M. (2017), Effect of apple pomace on quality characteristics of brown rice based cracker, *Journal of the Saudi Society of Agricultural Sciences,* 16(1), pp. 25–32, DOI: 10.1016/j.jssas.2015.01.001

Molnar D., Novotni D., Krisch J., Bosiljkov T., Ščetar M. (2020), The optimisation of biscuit formulation with grape and aronia pomace powders as cocoa substitutes, *Croatian Journal of Food Technology, Biotechnology and Nutrition*, 15, pp. 38–44, DOI: 10.31895/hcptbn.15.1-2.5

Nakov G., Andrea B., Hidalgo A., Ivanova N., Stamatovska V., Dimov I. (2020), Effect of grape pomace powder addition on chemical, nutritional and technological properties of cakes, *LWT – Food Science and Technology*, 134, 109950, DOI: 10.1016/j.lwt.2020.109950

Nakov G., Brandolini A., Hidalgo A., Ivanova N., Jukić M., Komlenić D. K., Lukinac J. (2020), Influence of apple peel powder addition on the physico-chemical characteristics and nutritional quality of bread wheat cookies, *Food Science and Technology International,* 26(7), pp. 574–582, DOI: 10.1177/1082013220917282

Olt V., Báez J., Curbelo R., Boido E., Dellacassa E., Fernández-Fernández A.M., Medrano A. (2022), Development of potential functional biscuits with the incorporation of tannat grape pomace and sweetener, *Biology and Life Sciences Forum*, 18(1), pp. 50, DOI: 10.3390/Foods2022-13067

Oprea O.B., Popa M.E., Apostol L., Gaceu L. (2022), Research on the potential use of grape seed flour in the bakery industry, *Foods*, 11, 1589, DOI: 10.3390/foods11111589

Ortega-Heras M., Gómez I., de Pablos-Alcalde S., González-Sanjosé M. L. (2019), Application of the just-about-right scales in the development of new healthy whole-wheat muffins by the addition of a product obtained from white and red grape pomace, *Foods*, 8(9), 419, DOI: 10.3390/foods8090419

Pasqualone A., Bianco A.M., Paradiso V.M., Summo C., Gambacorta G., Caponio F. (2014), Physico-chemical, sensory and volatile profiles of biscuits enriched with grape marc extract, *Food Research International,* 65, pp. 385–393, DOI: 10.1016/j.foodres.2014.07.014

Piasecka I., Górska A. (2020), Possible uses of fruit pomaces in food technology as a fortifying additive – a review, *Zeszyty Problemowe Postępów Nauk Rolniczych*, 600, pp. 43–54, DOI: 10.22630/ZPPNR.2020.600.5

Pollini L., Blasi F., Ianni F., Grispoldi L., Moretti S., Di Veroli A., Cossignani L., Cenci-Goga B. T. (2022), Ultrasound-assisted extraction and characterization of polyphenols from apple pomace, functional ingredients for beef burger fortification, *Molecules,* 27(6), 1933, DOI: 10.3390/molecules27061933

Popescu L., Ceșco T., Gurev A., Ghendov-Mosanu A., Sturza R., Tarna R. (2022), Impact of apple pomace powder on the bioactivity, and the sensory and textural characteristics of yogurt, *Foods*, 11(22), 3565, DOI: 10.3390/foods11223565

Rainero G., Bianchi F., Rizzi C., Cervini M., Giuberti G., Simonato B. (2022), Breadstick fortification with red grape pomace: effect on nutritional, technological and sensory properties, *Journal of the Science of Food and Agriculture,* 102(6), pp. 2545–2552, DOI: 10.1002/jsfa.11596

Reis S.F., Rai D.K., Abu-Ghannam N. (2014), Apple pomace as a potential ingredient for the development of new functional foods, *International Journal of Food Science,* 49(7), pp. 1743–1750, DOI: 10.1111/ijfs.12477

Rupasinghe V. H. P., Wang L., Huber M. G. Pitts L. N. (2008), Effect of baking on dietary fibre and phenolics of muffins incorporated with apple skin powder, *Food Chemistry,* 107, pp. 1217–1224, DOI: 10.1016/j.foodchem.2007.09.057

Rupasinghe V. H. P., Wang L., Pitts L. N., Astatkie T. (2009), Baking and sensory characteristics of muffins incorporated with apple skin powder, *Journal of Food Quality*, 32, pp. 685–694, DOI: 10.1111/j.1745-4557.2009.00275.x

Samohvalova O., Grevtseva N., Brykova T., Grigorenko A. (2016), The effect of grape seed powder on the quality of butter biscuits, *Eastern-European Journal of Enterprise Technologies*, 3(11), pp. 61–66, DOI: 10.15587/1729-4061.2016.69838

Sant'Anna V., Christiano F.D.P., Marczak L.D.F., Tessaro I.C., Thys R.C.S. (2014), The effect of the incorporation of grape marc powder in fettuccini pasta properties, *LWT – Food Science and Technology*, 58, pp. 497–501, DOI: 10.1016/j.lwt.2014.04.008

Singha P., Muthukumarappan K. (2018), Single screw extrusion of apple pomace-enriched blends: Extrudate characteristics and determination of optimum processing conditions, *Food Science and Technology International*, 24(5), pp. 447–462, DOI: 10.1177/1082013218766981

Smith I. N., Yu J. (2015), Nutritional and sensory quality of bread containing different quantities of grape pomace from different grape cultivars, *EC Nutrition*, 2, pp. 291–301.

Souza E.L., Santos L.F.P., Barreto G. de A., Leal I.L., Oliveira F.O., dos Santos L. M. C., Ribeiro C. D. F., Rezende C. S. M., Machado B.A.S. (2023), Development and characterization of panettones enriched with bioactive compound powder produced from Shiraz grape by-product (*Vitis vinifera* L.) and arrowroot starch (*Maranta arundinaceae* L.), *Food Chemistry Advances*, 100220, DOI: 10.1016/j.focha.2023.100220

Spinei M., Oroian M. (2021), The potential of grape pomace varieties as a dietary source of pectic substances, *Foods*, 10, pp. 867, https://doi.org/10.3390/foods 10040867

Šporin M., Avbelj M., Kovač B., Možina S. S. (2018), Quality characteristics of wheat flour dough and bread containing grape pomace flour, *Food Science and Technology International*, 24(3), pp. 251–263, DOI: 10.1177/1082013217745398

Stabnikova O., Marinin A., Stabnikov V. (2021), Main trends in application of novel natural additives for food production, *Ukrainian Food Journal*, 10(3), pp. 524–551, DOI: 10.24263/2304-974X-2021-10-3-8

Sudha M. L., Dharmesh S. M., Pynam H., Bhimangouder S. V, Eipson S. W., Somasundaram R., Nanjarajurs S. M. (2016), Antioxidant and cyto/DNA protective properties of apple pomace enriched bakery products, *Journal of Food Science and Technology,* 53(4), pp. 1909–1918, DOI: 10.1007/s13197-015-2151-2

Suman Y., Gupta R. K. (2015), Formulation of noodles using apple pomace and evaluation of its phytochemicals and antioxidant activity, *Journal of Pharmacognosy and Phytochemistry*, 4(1), pp. 99–106.

Temkov M., Velickova E., Stamatovska V., Nakov G. (2021), Consumer perception on food waste management and incorporation of grape pomace powder in cookies, *Scientific Papers. Series "Management, Economic Engineering in Agriculture and Rural Development"*, 21(1), pp. 753–762.

Theagarajan R., Malur N. L., Dutta S., Moses J. A., Chinnaswamy A. (2019), Valorisation of grape pomace (cv. Muscat) for development of functional cookies, *International Journal of Food Science & Technology*, 54(4), pp. 1299–1305, DOI: 10.1111/ijfs.14119

Tolve R., Pasini G., Vignale F., Favati F., Simonato B. (2020), Effect of grape pomace addition on the technological, sensory, and nutritional properties of durum wheat pasta, *Foods,* 9(3), 354, DOI: 10.3390/foods9030354

Tolve R., Simonato B., Rainero G., Bianchi F., Rizzi C., Cervini M., Giuberti G. (2021), Wheat bread fortification by grape pomace powder: nutritional, technological, antioxidant, and sensory properties, *Foods,* 10(1), pp. 75, DOI: 10.3390/foods10010075

Torbica A. M., Tomić J. M., Savanović D. M., Pajin B. S., Petrović J. S., Lončarević I. S., Fišteš A. Z., Blažek K. A. M. (2018), Utilization of apple pomace coextruded with corn grits in sponge cake creation, *Food and Feed Research,* 45(2), pp. 149–157, DOI: 10.5937/ffr1802149t

Tremlova B., Havlova L., Benes P., Zemancova J., Buchtova H., Tesikova K., Dordevic S., Dordevic D. (2022), Vegetarian “sausages” with the sddition of grape flour, *Applied Sciences,* 12 (4), 2189, DOI:10.3390/app12042189

Troilo M., Difonzo G., Paradiso V. M., Pasqualone A., Caponio F. (2022), Grape pomace as innovative flour for the formulation of functional muffins: how particle size affects the nutritional, textural and sensory properties, *Foods,* 11, 1799, DOI: 10.3390/foods11121799

Tseng A., Zhao Y. (2013), Wine grape pomace as antioxidant dietary fibre for enhancing nutritional value and improving storability of yogurt and salad dressing. *Food Chemistry,* 138(1), pp. 356–365, DOI: 10.1016/j.foodchem.2012.09.148

Usman M., Ahmed S., Mehmood A., Bilal M., Patil P. J., Akram K., Farooq U. (2020), Effect of apple pomace on nutrition, rheology of dough and cookies quality, *Journal of Food Science and Technology*, 57(9), pp. 3244–3251, DOI: 10.1007/s13197-020-04355-z

Valková V., Ďúranová H., Štefániková J., Miškeje M., Tokár M., Gabríny L., Kowalczewski P., Kačániová M. (2020), Wheat bread with grape seeds micropowder: impact on dough rheology and bread properties, *Applied Rheology*, 30(1), pp. 138–150, DOI: 10.1515/arh-2020-0112

Valková V., Ďúranová H., Havrlentová M., Ivanišová E., Mezey J., Tóthová Z., Gabríny L., Kačániová M. (2022), Selected physico-chemical, nutritional, antioxidant and sensory properties of wheat bread supplemented with apple pomace powder as a by-product from juice production, *Plants*, 11(9), 1256, DOI: 10.3390/plants11091256

Waldbauer K., McKinnon R., Kopp B. (2017), Apple pomace as potential source of natural active compounds, *Planta Medica,* 83(12–13), pp. 994–1010, DOI: 10.1055/s-0043-111898

Walker R., Tseng A., Cavender G., Ross A., Zhao Y. (2014), Physicochemical, nutritional, and sensory qualities of wine grape pomace fortified baked goods, *Journal of Food Science,* 79(9), pp. S1811–S1822, DOI: 10.1111/1750-3841.12554

Wang X., Kristo E., La Pointe G. (2019), The effect of apple pomace on the texture, rheology and microstructure of set type yogurt, *Food Hydrocolloids,* 91, pp. 83–91, DOI: 10.1016/j.foodhyd.2019.01.004

Wang X., Kristo E., LaPointe G. (2020), Adding apple pomace as a functional ingredient in stirred-type yogurt and yogurt drinks, *Food Hydrocolloids*, 100, pp. 105453, DOI: 10.1016/j.foodhyd.2019.105453

Xu J., Bock J.E., Stone D. (2020), Quality and textural analysis of noodles enriched with apple pomace, *Journal Food Processing and Preservation*, 44(8), pp. 1–8, DOI: 10.1111/jfpp.14579

Yadav S.K., Gupta R. (2015), Formulation of noodles using apple pomace and evaluation of its phytochemicals and antioxidant activity, *Journal of Pharmacognosy and Phytochemistry, 4(1), pp.* 99–106.

Yadav S., Malik A., Sharma D, Islam R.U., Pathera A. (2016), Development of dietary fibre enriched chicken sausages by incorporating corn bran, dried apple pomace and dried tomato pomace, *Nutrition & Food Science,* 46, pp. 16–29, DOI: 10.1108/NFS-05-2015-0049

Yalcin E., Ozdal T., Gok I. (2021), Investigation of textural, functional, and sensory properties of muffins prepared by adding grape seeds to various flours, *Journal of Food Processing and Preservation*, 46(5), 15316, DOI: 10.1111/jfpp.15316

Younas M. B., Rakha A., Sohail M., Rashid S., Ishtiaq H. (2015), Physicochemical and sensory assessment of apple pomace enriched muffins, *Pakistan Journal of Food Sciences*, 25(4), pp. 224-234.

Younis K., Ahmad S. (2015), Waste utilization of apple pomaceas a source of functional ingredient in buffalo meat sausage, *Cogent Food & Agriculture*, 1(1), 1119397, DOI: 10.1080/23311932.2015.1119397

Younis K., Ahmad S. (2018), Quality evaluation of buffalo meat patties incorporated with apple pomace powder, *Buffalo Bulletin,* 37(3), pp. 389–401.

Yu J., Ahmedna M. (2013), Functional components of grape pomace: their composition, biological properties and potential applications, *International Journal of Food Science & Technology,* 48, pp. 221–237, DOI: 10.1111/j.1365-2621.2012.03197.x