Fruits and Vegetable By-Product Utilization as a Novel Approach for Value Addition

5

Maysam Sarafrazy and Urba Shafiq Sidiqi

Abstract

Among the various food processing industries, fruit and vegetable processing industry is the second prime generator of wastes into the environment only after the domestic sewage. An enormous amount of wastes in form of solids and liquids generated through fruit and vegetable processing industries contains certain reusable substances of high value with huge financial prospective. Processing of fruits and vegetables generates higher amounts of wastes which include skin, seeds, stones, and unused flesh produced during the various steps of the processing chains. Thus leading into various pollution problems due to the reason of not being utilized or disposed-of properly. A disposal of these waste materials frequently signifies a problem that is additionally provoked by different legal restrictions. Howbeit, the waste product, which is discarded into the environment, is loaded with valuable compounds. They are new, innate, and monetary sources of colorants, protein, dietary fiber, flavoring, antimicrobials, and antioxidants, which can be utilized in the food industry as a basis of natural food additives. Therefore, novel aspects concerning to the use of these by-products for advance utilization on the production of food additives or supplements with high nutritional value have gained immense interest because of their characterization among high-value products; therefore, their recovery and improvement may be economically attractive and beneficial.

M. Sarafrazy
Horticultural Research in Urdu Khan Agricultural Research Station, Herat, Afganistan

U. S. Sidiqi (✉)
Islamic University of Science and Technology, Pulwama Kashmir, Jammu & Kashmir, India

Collection and Conservation of Horticultural Germplasm, Urdokhan Agricultural Research Station, Herat, Afganistan

M. Thakur et al. (eds.), *Sustainable Food Waste Management*,
https://doi.org/10.1007/978-981-15-8967-6_5

Keywords

Antimicrobials · Flavorings · Colorants · Fruit and vegetable wastes (FVW)

5.1 Introduction

India is a largely populated country which exists as the major reason for massive waste generation created frequently out of domestic & industrial actions which includes removal of peel followed by cutting of raw fruits and vegetables former to processing, eating, and cooking. FAO revealed that every year, about one-third of all food produced for the purpose of human consumption globally is lost or wasted. This food wastage generation predicts a huge missed opportunity to enhance global food security, but also to alleviate environmental impacts and exhaustive resource use from food chains. Globally, the various quantitative food losses and waste estimations per year are roughly 40–50% for root crops, fruits, and vegetables; 20% for oil seeds, meat and dairy plus; 35% for fish, and 30% for cereals (Schieber et al. 2001).

Referring to the individual supplement, fruit processing industries contribute more than 0.5 billion tons of waste. Thus globally providing the accessibility of this feedstock and its intact potent alien encouraging researchers and other authorities to exercise comprehensive studies on the various value-added potential of fruit processing waste (FPW). On the other hand, vegetables are essential but uneconomical, i.e., they produce ample waste concentration. Around twenty peculiar kinds of plants are generally developed for vegetables in the United States (US). Including this in each State these plants are grown on commercial basis out of which maximum population resides in New York, Texas, California, and Wisconsin. The profits from them are approximately 300 million dollars annually despite of the fact not more than 20–30% of the crops consumed. Out of the total wastes 4 million tons of them are generally leaves. Several wastes are left as such on the soil to be plowed underneath. Few of them are fed, some are discarded in dumps and some are a simple nuisance; a small portion is synthetically dehydrated for feed. The most prominent component of the wastes is water which accounts nearly about 75 to 90% (Willaman and Eskew 1948). On a comparison fruit processing wastes are originated to be selective and concentrated in nature as compared to other biomass derived waste. Besides, the greatest contribution provided is the utilization of peels, pomace, and seed fractions as an excellent feedstock for recovery of bioactive compounds which include flavonoids, lipids, dietary fibers, pectin, etc. (Kowalska et al. 2017; Banerjee et al. 2017). A novel bio-refinery method would aim to manufacture a wider variety of important chemicals from fruit and vegetable processing waste. The wastes from bulk of the withdrawal processes may supplementary be used as recycle sources for creation of biofuels. These all benefits will open up as a scope for future utilization of fruit and vegetable waste for therapeutic and nutraceuticals purpose as well as a great source for value addition of the end products (Table 5.1).

Table 5.1 Production percentage of food wastes and their by-products in fruit and vegetable sector

Production process	% of wastes and by-products
White wine production	20–30
Red wine production	20–30
Fruit and vegetable juice production	30–50
Fruit and vegetable processing and preservation	5–30
Vegetable oil production	40–70
Corn starch production	41–43
Potato starch production	80
Wheat starch production	50
Sugar production from sugar beet	85

Source: Agro food wastes minimization and reduction network, 2004

According to the global trend for fruits and vegetable production, the total sum of residues after processing has been anticipated in millions of tons every year. This demands the use of different forms of energy, water, and other factors providing a by-product potential as the cardinal significance. This comes into being due to the presence of bio-components, which may be utilized for novel food production. This demands an appropriate measure to convert conventional products into value-added ones for the reason of their calculus natural components (Fig. 5.1).

5.2 Functional Characteristics

Presently, consumers are becoming progressively more concerned in maintaining a healthy diet and standard of living (Schieber et al. 2003a, 2001). The by-products of fruit and vegetable processing wastes always give emphasis on the most important functional bioactive constituents such as tocopherols, carotenoids, polyphones etc. Various other components are present which stipulate the producers to generate products which hold a value-added feature, such as dietary fiber or in more modern epoch, phytochemicals. The invention and accumulation of such nutrients can be fairly costly for the manufacturer. In the fruit and vegetable industry, the preparation and dispensation measures can lead to one-third of the product being useless and hence discarded. This can be expensive for the producer and also may have a depressing impact on the surroundings. Researches have revealed that these by-products can have an elevated nutritional significance. It has also been recommended that they may possibly be used as a food component. This is mainly due to their purposeful and practical abilities such as water holding capacity and gelling. Several of their widely pronounced applications are proved as such.

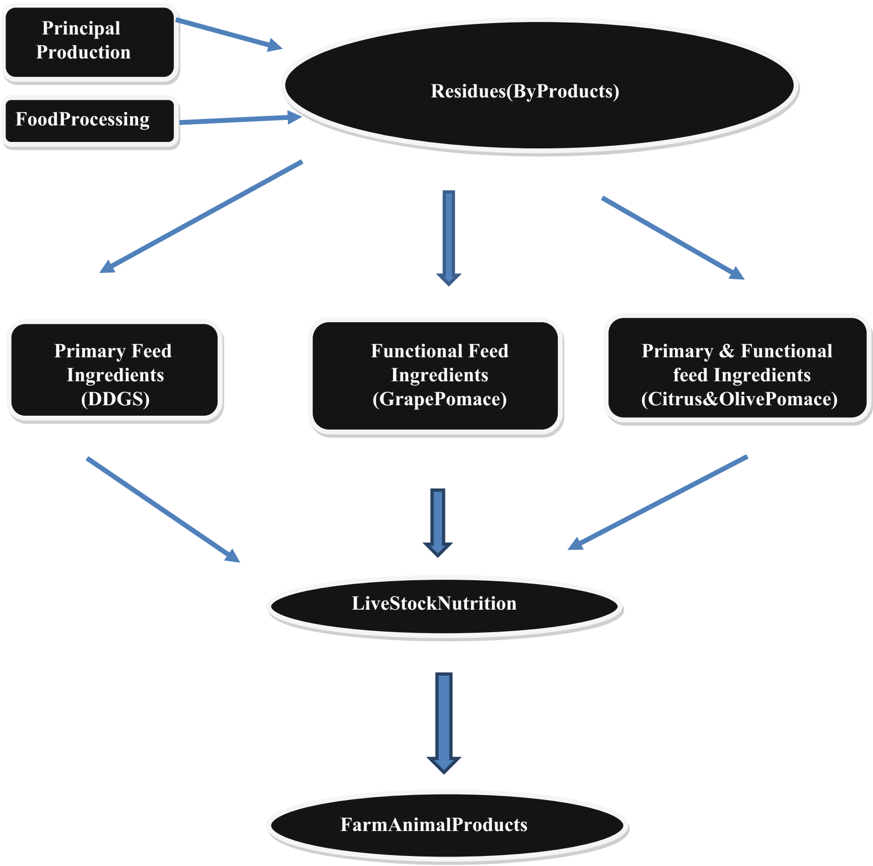

Fig. 5.1 Fruit & Vegetable by-product utilization in Food Processing Chain

5.3 Source of Dietary Fiber

One of the most important nutrients incorporated in diet is dietary fiber. Over the past years, dietary fiber has acknowledged much affirmative concentration with regard to its prospective as a pharma food. This is because of its ability to lessen coronary heart disease, diabetes, cholesterol and it also has ability to ease constipation (Telrandhe et al. 2012). In recent epoch, fiber has also been considered as a constituent with particular and specific functions in food fabrication. Due to the nature of fiber accounting both insoluble as well as soluble properties, it has a wide array of technical and scientific attributes. These properties mainly include water holding capacity, structure building, and gelling. In addition, it can be used as a fat replacer. It was elaborated that the "ideal fiber" is having the certain uniqueness such as exempting any such constituents that are nutritionally odious or increasing its use.

It must be of elevated concentrate in a minute quantity. The ideal fiber should be tasteless and no depressing odor, color, or any such texture properties. It requires maintaining equilibrium among soluble and insoluble fiber with an adequate existence of bioactive compounds. Its accumulation must not alter the food as is being used supplementary. Further, the ideal fiber must also have an extended shelf life. It should work cordially with food processing and it must have a constructive buyer reflection (Larrauri 1999; Kunzek et al. 2002).

5.4 Utilization of Dietary Fiber

Characteristically, fibers such as corn, wheat, and rice have been utilized for food production in the past for their health as well as technical functions. Howbeit, recently novel discovery and utilization of fiber sources came into existence. Among the discovery one of the sources discovered and utilized is the by-product fraction obtained from various types of food processing. In particular, the by-products obtained from any such fruit and vegetable processing unit (e.g., juices, drinks etc.) are seeking great attention as being a novel and economic and cardinal sources of a healthy functional ingredient (Ayala-Zavala et al. 2011). Such by-products can be explained as the remnants or residues left after the manufacturing of fruit and vegetable-based product processing. These residues include pips, peel, stems, skins, and cores. Presently these by-products are disposed of and wasted at a specific cost to the producer for the production of animal feed, landfill, or incineration (Angulo et al. 2012).

5.5 Source of Phytochemicals

Phytochemicals are bioactive component derived from plants (Thakur et al. 2020) and from various by-products also we extract them. The major product produced from apple processing is apple juice. The whole fruit is typically hard-pressed in a cold press to remove the juice as of the fruit. This can result in a large amount of waste, which is termed as Apple pomace. Apple pomace consists of around 25% of fresh apple weight (Angulo et al. 2012). In broad-spectrum, producers typically dispose tones of pomace at a cost to themselves.

On the other hand, it is used as animal feed. Contrasting cereals, there is an elevated proportion of the soluble fiber portion in apple fiber, thus giving rise to the accessibility of the polymer pectin. Pectin has such distinctiveness as it can be used as gelling, thickening stabilizing agent in foods. It is also a health-promoting polymer, considered to lower cholesterol and setback gastric emptying (Hwang et al. 1998; Royer et al. 2006). It was considered that the phytochemicals which was a part of apple pomace produced throughout cider processing (Garcia et al. 2009). The phytochemicals during various researches came into being were polyphenols such as flavonoids, e.g., flavanols and phenolic acids such as caffeic acid, chlorogenic acid, and protocatechuic acid.

Moreover, investigations reported the phenolic compound content of apple pomace and similar findings in their result (Schieber et al. 2003b; Garcia et al. 2009). A number of quercetin glycosides with quercetin 3-galactoside being the principal, flavonol chlorogenic acid, phloridzin were also found. Derivatives of flavanols, i.e., catechins and procyanidin were also obtainable in huge amounts. Phloridzin was revealed to be the most abundant multiple components present, while chlorogenic acid also existed. Procyanidins and flavonol glycosides were either seen in lesser quantities or missing on the whole. The phytochemicals there in apples have been linked with many health-promoting benefits, e.g., cancer cell propagation, decreased lipid oxidation, and lesser cholesterol. In turn these valuable phytochemicals have peripheral dropping effects on chronic diseases there in the western world, e.g., obesity, cancer, and heart disease. Various conclusions highlighted the accessibility of phenolic acids, e.g., chlorogenic acid which has an elevated alkyl peroxyl radical scavenging accomplishment; hence, apples have a self-protective outcome against cancer. Procyanidins have an elevated antioxidant action and restrain low density lipoprotein oxidation (Rice-Evans et al. 1997; Henriquez et al. 2010).

Quercetin is one of the major flavonoids originated in apple, mainly in apple peel. It has been connected with compact incidences of breast cancer and leukemia (Rice-Evans et al. 1997; Henriquez et al. 2010). This information illustrates the accessibility of phytochemicals in apple pomace. It is also suggested that the addition of apple pomace as a bioactive component in food products. This addition could noticeably advance the nutritive properties of such products and conceivably the vigor of the buyer. It has many functional properties like water holding capacity, gelling ability, thickening as well as stabilizing abilities), nutrients and availability of phytochemicals also.

Apple pomace has been utilized by researchers in a wide range of food products such as sausages, jams, and baked goods (Rupasinghe et al. 2008). An apple skin powder (ASP) was supplementary to muffins to develop their phenolic substance. It was brought into being to improve the flavor while rising the phenolic and antioxidant contents accomplished that ASP from the producers could be used as a substitute for wheat flour and in muffins (Rupasinghe et al. 2009; Sudha et al. 2016). The substitution of wheat with 16% (weight basis [w/w]) ASP still acknowledged favorable sensory scores. Apple pomace (AP) was also supplemented to cakes; however, it was originated that as the pomace level augmented ahead of a particular level, the volume of the cake decreased. Additionally, it was exposed that due to the water binding capacity of AP, extra water was requisite to fully hydrate the dough. Also it was perceived that the color of the cake became darker as the quantity of AP decreased. The addition of AP resulted in some favorable qualities such as a fruit aroma and taste, thus permitting the level of sugar added to be concentrated (Masoodi et al. 2002; Ayala-Zavala et al. 2011).

5.6 Antioxidant

Fruit peels such as skins are loaded with nutrients and include many phytochemicals that may be competently used as drugs or as food supplements or replacers (Bobinaite et al. 2016). Antioxidants are excellent compounds as additives in foodstuffs in order to enhance their nutritional value or in manufacture of fruit purees (Chacko and Estherlydia 2014). In addition to their sensory properties they also act as a raw material for the creation of food dyes. Very essential is the prospect of preserved and improved quality as a consequence of avoiding food oxidation (Ayala-Zavala et al. 2011). The probable antioxidative position and bioavailability of by-products from creation of nectar of the pomegranate fruit were examined under a study (Surek and Nilufer-Erdil 2016). Pomegranate seeds and the impulsive obtained by sedimentation of nectar comprise a good supply of anthocyanins. Filter cake, sediment peel contained extra phenolic compounds and were characterized by elevated antioxidant action than those extracted from the pomegranate nectar. In the certain studies the antioxidant activity and overall content of polyphenols of tomato skin were found to be 38.2 and 66.5% elevated, correspondingly, in comparison to the seeds of tomatoes (Sarkar and Kaul 2014).

5.7 Antimicrobial Activity

Recent studies have shown that natural extracts have high antimicrobial prospective. Besides, it has to be taken into description that the fruit and vegetables by-products may supply as probable natural antimicrobial agents. Principally due to the antioxidants radical chelating and scavenging activities can hinder or inhibit the oxidation of DNA and proteins as well as lipids. The components have shown various effects and at the same time playing a cardinal role in food protection against pathogenic agents (Ayala-Zavala et al. 2011; Bobinaite et al. 2010).

Certain studies showed that by-product extracts of raspberry exhibited antibacterial activity adjacent to a range of Gram-positive and Gram-negative bacteria (Bobinaite et al. 2010).

A study carried with the aim of preparation and processing of jams from certain fruits peels such as pineapple, pomegranate, orange, and banana evaluates the antimicrobial properties. Among all pomegranate peel jam was observed to possess the maximum activity against Shigella (Bobinaite et al. 2010). Moreover, avocado fruit seeds are highly rich not only in fiber but also in certain antimicrobials, colorants, flavorings, antioxidants, and thickening agents (Vodnar et al. 2017; Barbosa-Martín et al. 2016). Further, their seeds hold various components such as furanoic acids, flavonoid terpenes, fatty acids, and saponin, phytosterols, proanthocyanidins among which some of them are connected to possess certain antifungal activities, antimicrobial activities, and larvicidal activities (Vodnar et al. 2017; Rodríguez-Carpena et al. 2011). A study showed that quercetin and rutin possess certain antifungal effects against Cryptococcus spp. specifically. This arises due to the polyphenolic components. Cauliflower and mandarin by-product mixture of vegetables particularly in aggregation with process of pasteurization by application of highly hydrostatic pressure (HHP) technology presented a result of strong antimicrobial effect against S. Typhimurium (Oliveira et al. 2015; Sanz-Puig et al. 2017). Consequently, these techniques could be used as a supplementary control measure to assure the food safety.

5.8 By-Products Used as a Global Trend

5.8.1 Innovative Foods

The by-product as the innovative food provides a novel approach in every aspect globally. It further extends its contribution towards the attractiveness and the production of high quality food with every essential predominant characteristic. The innovative foods are highly connected towards the growing environmental concern as the waste from fruit and vegetable processing industry is drastically produced. Thus, the innovation comes into existence when the majority of plant waste is converted and recovered into high value and setting a bench mark of novelty.

However, the process demands more reproducibility and wide use. There exist certain berry fruits which pertain to an essential role in maintaining the healthy diet (Aura et al. 2015). The addition of raspberry extract (2%) to certain mix fruit purees showed a cardinal increase of total phenolic content up to 3 folds. Therefore, this addition provided with an enhanced and improved functional properties of the products (Bobinaite et al. 2010).

Further, pumpkin varieties of Muscovy produce a by-product constituting a source of specific bioactive compounds providing antimicrobial, antioxidant pro-health properties (Saavedra et al. 2015). The addition of oligofructose, apple fiber, and inulin, as the source of prebiotic fiber provided a cardinal increase in the antioxidant characteristics. It also signifies a flourishing preservation of sensory attributes of strawberry juice (Cassani et al. 2016). The novelty of fruit pomace used as an ingredient in the functional food processing commonly known for bakery industry may provide a part effectively to promote health benefits. They impart an essential role against various disorders which include ulcer, diabetes, atherosclerosis, and cancer (Sudha et al. 2016). A marked remark of increased bioactivity has been observed by addition of apple pomace. Blueberry bagasse flour may be added for the formation of fermented beverages (Goldmeyer et al. 2014). The flour imparts very good microbiological stability during storage and enhancing various characteristics such as lipid and ash content, pH and soluble solids, moisture, protein, which makes its use possible for the production of novel products. Flour extracted out of guava skin is used for the fortification of wheat flour which then improves the nutritional quality of products manufactured out of it without affecting the sensory quality of the respective product.

Among fruit and vegetable by-products, waste out of salads reveals high water content. On the other hand, various waste management techniques could be efficaciously implemented. Certain important compounds like fibers, polyphenols, and water are the major components out of salad wastes (Plazzotta et al. 2017). Further, in order to reduce the salad waste, certain traditional techniques like composting and anaerobic digestion may be used in combination with various other novel technologies together with those based ultrasound and pressure. By-products out of apple are thought to be considered as one of the most feasible strategies for pectin extraction. Gluten free formulation can be produced out of apple pomaces (Parra et al. 2015). Because of the increased water binding capacity of all the polysaccharides, apple fiber being polysaccharide can be used for preparation of low calorie products (Sharma et al. 2016).

5.8.2 By-Products as a Source of Flavorings

Because of the importance gained by potential flavorings they are being widely used. They are extensively used in various dishes as seasoning. Besides, most of them are utilized by traditional medicine, e.g., certain essential oils that are rich in terpene compounds are acknowledged for supporting in the treatment and curability of enormous health problems. An important purpose of some of them leads to various activities such as antifungal, antiviral, anti-inflammatory, antimutagenic, antibacterial, vermicide, and anticancer activities (Raut and Karuppayil 2014; Felipe et al. 2017). At the present epoch flavor companies are concerned with the aromas and flavors which are more stable and do not escape openly besides under specifically defined conditions, i.e., they are mostly microscopically encapsulated (Arvanitoyannis and Varzakas 2008).

Sometimes, various factors affect the existence or availability of specific flavoring extracts such as their existence being uneconomical due to high cost or its unavailability. This leads to a great switch towards the commercial flavoring adoption. These trendy flavorings are nothing but an equal or adjacent chemical substitutes or equivalents of the existing natural flavors commonly known as the "nature-identical" (Mantzouridou et al. 2015). The production of the specific enzymatic as well as the whole-cell biocatalysts has gained a cardinal attention as well as a novelty. Their approach has been greatly observed as a substitute for the better development of several esters when compared to any naturally or chemically synthesized enzymes (Zhuang et al. 2015). These extractions of the enzymes from the particular organisms serve various vital benefits which mainly include superior productivity with respect to the elevated catalyst concentration, as well as the simpler product refinement. Some researches provide three main methods exercised for the process of aroma compounds production (Felipe et al. 2017). These processes include the method of chemical synthesis, extraction from natural sources, and some of the biotechnological production processes resulting in the development of the bio-aromas.

However, among all the above-mentioned techniques majority advantages are contributed by the biotechnological process. The importance can be approved or confirmed by its natural product development as a versatile resultant. Furthermore, the most novel advantage offered is the development of the better, suitable, and sustainable preservation approach towards the environment. Bio-aroma production extends its approach towards the most unique renewable processing characteristics. This imparts requirement of very simple operation conditions responsible for non-toxic waste generation, thus sometimes availing the agro-industrial residues. The vital substitute is a by-product of fruit and vegetable waste which is a prospective resource off-flavor production.

5.9 Conclusion

There have been growing remarks and evidences of various value-added food products developed from the by-production of the fruit and vegetable residues. Among which the majority have been significantly implemented for the various cardinal purposes such that their value is unhampered and not being adversely affected. However, their production can itself be a challenge to the manufacturer for the reason of imparting additional cost to the processing value and adding to the economical values or the overall cost. Howbeit, in the meantime these value-added product development may also lead to a remarkable growth in terms of the profit, but the identification, selection, manufacturing itself pertains to a major challenge. This depends on the production practices, utilization on the agro-economic level, and the least threats imparted to the global environment.

References

Angulo J, Mahecha L, Yepesi SA, Yepesi AM, Bustamante G, Jaramillo H (2012) Nutritional evaluation of fruit and vegetable waste as feedstuff for diets of lactating Holstein cows. J Environ Manage 95:S210–S214

Arvanitoyannis IS, Varzakas TH (2008) Vegetable waste treatment, comparison and critical presentation of methodologies. Crit Rev Food Sci Nutr 48(3):205–247

Aura AM, Holopainen Mantila U, Sibakov J, Kössö T, Mokkila M, Kaisa P (2015) Bilberry and bilberry press cake as sources of dietary fibre. J Food Nutr Res 59(1):28367

Ayala-Zavala JF, Vega-Vega V, Rosas-Domínguezi C, Palafox-Carlo H, Villa-Rodriguez JA, Siddiqui MW (2011) Agro-industrial potential of exotic fruit byproducts as a source of food additives. Food Res Int 44(7):1866–1874

Banerjee JN, Singh R, Vijayaraghavan R, MacFarlane D, Patti AF, Arora A (2017) Bioactives from fruit processing wastes: green approaches to valuable chemicals. Food Chem 225:10–22

Barbosa-Martín E, Chel-Guerrero L, Gonzalez-Mondrag-on E, Betancur-Ancona D (2016) Chemical and technological properties of avocado (Persea Americana Mill.) seed fibrous residues. Food Bioprod Process 100:457–463

Bobinaite R, Viskelis P, Buskienee L (2010) Extraction of phenolic compounds from raspberry press cake Scientific Works of the Institute of Horticulture, Lithuanian Research Centre for Agriculture and Forestry and Lithuanian University of Agriculture: SODININKYSTĖ IR DARŽININKYSTĖ:29(2)

Bobinaite R, Viskelis P, Bobinas C, Miezeliene A, Alencikiene G, Venskutonis PV (2016) Raspberry marc extracts increase antioxidative potential, ellagic acid, ellagitannin and anthocyanin concentrations in fruit purees. Food Sci Technol 66:460–467

Cassani L, Tomadoni B, Viacava G, Ponce A, Moreira MR (2016) Enhancing quality attributes of fibre-enriched strawberry juice by application of vanillin or geraniol. LWT Int J Food Sci Technol 72:90–98

Chacko CM, Estherlydia D (2014) Antimicrobial evaluation of jams made from indigenous fruit peels. Int J Curr Adv Res 2(1):202–207

Felipe LO, de Oliveira AM, Bicas JL (2017) Bioaromas—perspectives for sustainable development. Trends Food Sci Technol:141–153

Garcia YD, Valles BS, Lobo AP (2009) Phenolic and antioxidant composition of by-products from the cider industry apple pomace. Food Chem 4:731–738

Goldmeyer B, Pena NG, Melo A, da Rosa CS (2014) Physicochemical characteristics and technological functional properties of fermented blue berry pomace and their flours. Revista Brasileira De Fruti cultura 36(4):980–987

Henriquez C, Speisky H, Chiffelle I, Valenzuela T, Araya M, Simpson R (2010) Development of an ingredient containing apple peel as a source of polyphenols and dietary fiber. J. Food Sci 75(6): H172–H181

Hwang JK, Kim CJ, Kim CJ (1998) Extrusion of apple pomace facilitates pectin extraction. J Food Sci 63(5):841–844

Kowalska H, Czajkowska K, Cichowska J, Lenart A (2017) What's new in biopotential of fruit and vegetable by-products applied in the food processing industry Faculty of Food Sciences, Department of Food Engineering and Process Management. S GGW 159c Nowoursynowska St:02-776 Warsaw Poland

Kunzek H, Müller S, Vetter S, Godeck R (2002) The significance of physico chemical properties of plant cell wall materials for the development of innovative food products. Eur Food Res Technol 214(5):361–376

Larrauri JA (1999) New approaches in the preparation of high dietary fibre powders from fruit by-products. Trends Food Sci Technol 10(1):3–8

Mantzouridou FT, Paraskevopoulou A, Lalou S (2015) Yeast flavour production by solid state fermentation of orange peel waste. Biochem Eng J 101:1–8

Masoodi FA, Sharma B, Chauhan GS (2002) Use of apple pomace as a source of dietary fiber in cakes. Plant Food Hum Nutr 57(2):121–128

Oliveira VM, Carraro E, Auler ME, Khalilc NM (2015) Quercetin and rutin as potential agents antifungal against Cryptococcus spp. Braz J Biol 76(4):1029–1034

Parra AF, Ribotta PD, Ferrero C (2015) Apple pomace in gluten-free formulations: Effect on rheology and product quality. Int J Food Sci Technol 50(3):682–690

Plazzotta S, Manzocco L, Nicoli MC (2017) Fruit and vegetable waste management and the challenge of fresh-cut salad. Trends Food Sci Technol 63:51–59

Raut JS, Karuppayil SM (2014) A status review on the medicinal properties of essential oils. Ind Crops Prod 62:250–264

Rice-Evans C, Miller N, Pagang G (1997) Antioxidant properties of phenolic compounds. Trends Plant Sci 2(4):152–159

Rodríguez-Carpena JG, Morcuende D, Andrade J, Kylli P, Estevez M (2011) Avocado (Persea Americana Mill) phenolics in vitro antioxidant and antimicrobial activities and inhibition of lipid and protein oxidation in porcine patties. J Agric Food Chem 59(10):5625–5635

Royer G, Madieta E, Symoneaux R, Jourjo F (2006) Preliminary study of the production of apple pomace and quince jelly LWT. Int J Food Sci Technol 39(9):1022–1025

Rupasinghe HP, Wang LX, Huber GM, Pitts NL (2008) Effect of baking on dietary fibre and phenolics of muffins incorporated with apple skin powder. Food Chem 107(3):1217–1224

Rupasinghe HPV, Wang LX, Pitts NL, Astatkie T (2009) Baking and sensory characteristics of muffins incorporated with apple skin powder. J. Food Qual 32(6):685–694

Saavedra MJ, Aires A, Dias C, Almeida JA, De Vasconcelos M, Santos P (2015) Evaluation of the potential of squash pumpkin by-products (seeds and shell) as sources of antioxidant and bioactive compounds. J Food Sci Technol Mys 52(2):1008–1015

Sanz-Puig M, Moreno PM, Pina-Perez C, Rodrigo D, Martínez A (2017) Combined effect of high hydrostatic pressure (HHP) and antimicrobial from agro-industrial by-products against S Typhimurium. LWT Int J Food Sci Technol 77:126–133

Sarkar A, Kaul P (2014) Evaluation of tomato processing by-products A comparative study in a pilot scale setup. J. Food Process Eng 37(3):299–307

Schieber A, Stintzing FC, Carle R (2001) By-products of plant food processing as a source of functional compounds — recent developments. Trends Food Sci Technol 12:401–413

Schieber A, Berardini N, Carle R (2003a) Identification of flavonol and xanthone glycosides from mango (Mangifera indica L. Cv. "Tommy Atkins") peels by high-performance liquid chromatography-electrospray ionization mass spectrometry. J Agric Food Chem 51 (17):5006–5011

Schieber A, Hilt P, Streker P, Endress H, Rentschler C, Carle R (2003b) A new process for the combined recovery of pectin and phenolic compounds from apple pomace. Innov Food Sci Emerg 4:99–107

Sharma PC, Gupta A, Issar K (2016) Effect of packaging and storage on dried apple pomace and fiber extracted from pomace. J Food Process Preserv 12913:1745–4549

Sudha ML, Dharmesh SM, Pynam H, Bhimangoude SV, Eipson SW, Somasundaram R (2016) Antioxidant and cyto/DNA protective properties of apple pomace enriched bakery products. Int J Food Sci Technol 53(4):1909–1918

Surek E, Nilufer-Erdil D (2016) Phenolic contents antioxidant activities and potential bio accessibilities of industrial pomegranate nectar processing wastes. Int J Food Sci Technol 51 (1):231–239

Telrandhe UB, Kurmi R, Uplanchiwar V, Mansoori MH, Raj VJ, Jain K (2012) Nutraceuticals — a phenomenal resource in modern medicine. J Pharm Clin 2(1):179–195

Thakur M Singh K, Khedkar R (2020) Phytochemicals: extraction process, safety assessment, toxicological evaluations, and regulatory issues. In: Prakash B (ed) Functional and preservative properties of phytochemicals. Elsevier, pp 34–356

Vodnar DC, Calinoiu LF, Dulf FV, Stefanescu BE, Crisan D, Socaciu D (2017) Identification of the bioactive compounds and antioxidant antimutagenic and antimicrobial activities of thermally processed agro-industrial waste. Food Chem 231:131–140

Willaman JJ, Eskew RK (1948) Uses for vegetable wastes. United States Department of Agriculture, p 739

Zhuang S, Fu J, Powell C, Huang J, Xia Y, Yan R (2015) Production of medium chain volatile flavor esters in *Pichia pastoris* whole-cell biocatalysts with extracellular expression of *Saccharomyces cerevisiae* acyl-CoA: ethanol O-acyltransferase Eht1 or Eeb1. Springer plus https://doi.org/10.1186/s40064-015-1195-0