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Review Article

An Overview of Fruit by-products Valorization: A step towards Sustainable Utilization

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ABSTRACT

Among the horticulture crops, fruits are the most utilized commodities. Processed, minimally processed, and raw forms are consumed because of their nutrients and bioactive compounds. Increased population has significantly increased the demand for the production and processing of fruits and their products. This over-production by processing industries leads to the production of a large amount of waste and by-products, which has created serious economic, environmental, and economic issues. To overcome these issues the utilization of waste and by-products is highly considered by researchers and scientists. The peels, unused flesh, seeds, pomace, and albedo are the major by-product, rich in many valuable compounds. These compounds are used by many industries as economical, low-cost, and natural sources of antioxidants, dietary fiber, enzymes, pectin, organic acids essential oils, food additives, etc. This paper aims to highlight the utilization of by-products from various fruits.

Keywords: *Fruits by-product; Biomolecules; Extraction techniques; Valorization.*

INTRODUCTION

In 2011, Food and Agriculture Organization (FAO) estimated that about one-third of all the food produced in the world is either wasted or lost, which amounts to 1.3 billion tons per year (Swaminathan & Swaminathan, & Swaminathan, 2015). For awareness regarding food waste and losses, 29 September 2020 was celebrated as the International Day of awareness of Food Loss and Waste. With the increase in urbanization and industrialization, demand for fruits and their processed products has raised. In a recent survey by FAO in developing countries, around 50% of fruits produced are lost in supply chain between their harvest and consumption. The processing industries, on the other hand, are the chief sources of by-products and waste generation in huge amounts (Blakeney, 2019). This has made fruit safety and management the major concern, globally. Since these materials are prone to microbial spoilage it may cause high level of environmental contamination.

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Hence, different management techniques are required to be explored to resolve this problem (Banerjee et al., 2017). According to FAO and the World Health Organization (WHO) recommendation, at least 400 grams of fruit and vegetables should be consumed by an adult, daily. Being the main reservoir of vitamins, minerals, dietary fiber, and other phytochemicals it aids human health by preventing several chronic diseases and the deficiency of micronutrients (Blakeney, 2019). In this context, an event entitled "International year of fruits and Vegetables" was observed on the 15th of December 2020, discussing food safety and security in a way to decrease the food loss as waste and the importance of fruits and vegetables in human health.

A promising alternative to overcome these issue is the valorization of fruit by-products into high-value-added compounds. Consequently, by-products of processed fruits such as peels, unused flesh, and seeds are used for the production of functional food products of high nutritional value with several health benefits. This makes it applicable in different industries like nutraceutical, cosmetic, agriculture, pharmaceutical, etc (Dimou et al., 2019). Keeping in view these aspects, this article is written with the pretext to discuss different by-products of fruits, the valuable products extracted from them and their potential applications.

2. FRUIT BY-PRODUCTS

Fruits are the most utilized commodities among the horticulture crops. Fruit by-products can be defined as unused or unconsumed parts of fruit which is an outcome of improper handling or discarding of it. The quantity and the type of fruit by-products vary from its commodities and morphological components which include seeds, pomace, pulp, skin, leaves, tuber, etc (Panouille et al., 2007). It is observed that peel, seeds, and other non-consumable components of fruits have ample amount of essential nutrients and phytochemicals (Rudra et al., 2015). A schematic representation of the fruit waste and by-products utilization in different sectors is shown in **Fig 1.**

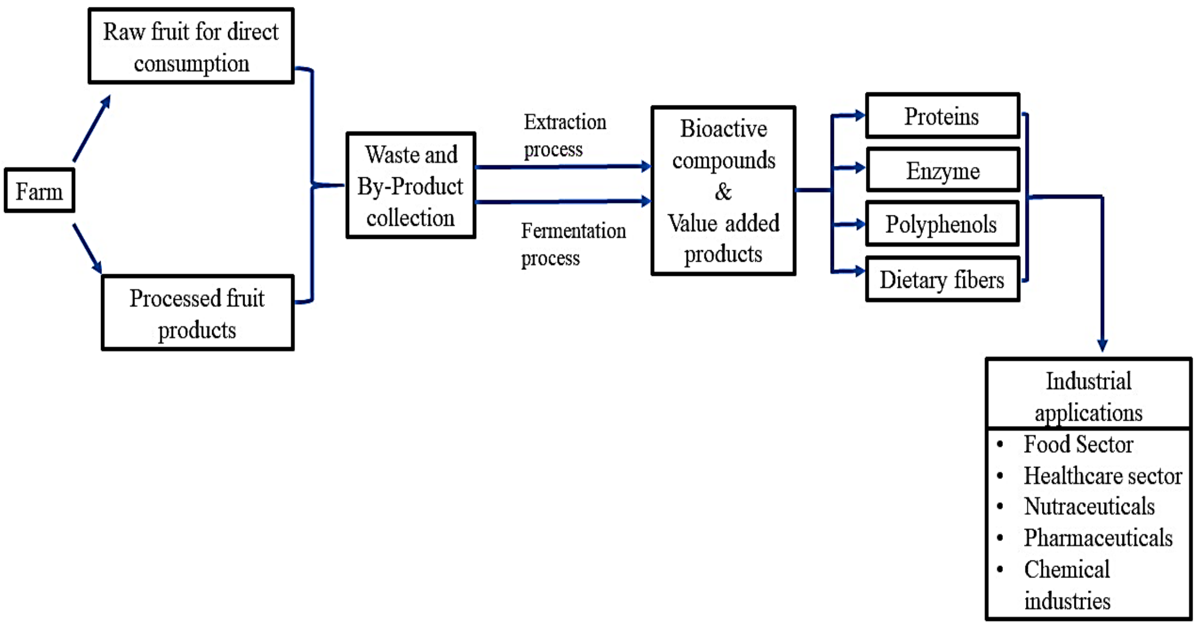

Fig. 1: Schematic representation of fruit waste and by-products Utilization.

Several fruit by-products are found to be a rich source of phenolic compounds which are considered as one of the largest group of bioactive and value-added compounds (Ignat et al., 2011). For example, seeds of jackfruits, mangoes, avocados, and skins of grapes, oranges, lemons, encompass 15% higher concentrations of phenols than that of fruit pulp (Soong & Barlow, 2004). Annually, about 6 MMT of solid waste is generated from canning and frozen fruit industries. 5 to 9 MMT of solid waste is generated from grape wine processing yearly, which accounts to 20 to 30% of processed materials (Schieber, 2019). In Apple, 10.91% of pulp and seed are generated as by-products and 89.09% of the final product. The utilization of major fruit by-products like banana, pineapple, sugarcane, orange, and mango in terms of their high bio-active compounds in processing industries are discussed below.

2.1 Pineapple (*Ananas comosus*)

Pineapple (*Ananas comosus*) is one of the most utilized fruits of the family *Bromeliaceae*. Pineapple juice is the third most preferred juice after orange and apple (Cabrera et al., 2000). The by-products of pineapple mainly comprise peels, pulp, leaves, and stems, which ranges between 45-65% of total fruit used for processing This indicates that if disposal management is not done properly, it will result in serious environmental pollution (Deliza et al., 2005). Pineapple peel is the chief by-product rich in sugars and acts as a nutrient in the fermentation process. It acts as a potential substrate for the production of ethanol, hydrogen, and methane generation (Choonut et al., 2014). Second major by-product of pineapple is the core that can be used for the production of non-alcoholic, alcoholic, vinegar, or beverages (Kodagoda & Marapana, 2017). A commercially available enzyme Bromelain is extracted from pineapple stem which has a proteolytic activity that makes it applicable in many industrial applications like, bread dough improver, meat tenderizer, tooth whitening agent, anti-browning agent, cosmetic substance, and animal feed (Arshad et al., 2014). Fibers from pineapple by-products have high quality of insoluble and soluble fibers that makes them a potential source for the development of less caloric food and dietary fiber-enriched food products (Huang et al., 2011).

2.2 Banana (*Musa acuminata*)

Banana (*Musa acuminata*) is one of the most popular fruit worldwide. Peel represents 30% of the total fruit and is considered as the main by-product (González-Montelongo et al., 2010). The Peel is a reservoir of various phytochemicals such as carotenoids, anthocyanin, phenolic compounds, triterpenes, sterols, and catecholamines which are known for their antioxidant property (Someya et al., 2002). A study resulted in a low-calorie food product having a high dietary fiber content when banana peel (10% concentration) was added to it and showed no significant change in the overall aroma, taste, and color (Kodagoda & Marapana, 2017). Banana peels are also a rich source of polymers such as hemicellulose, lignin, and pectin that makes them suitable for synthesizing silver nanoparticles which are known for the antimicrobial activity towards many tested bacterial and fungal cultures (Bankar et al., 2010). Banana peel also possess a pigment, anthocyanin, which is proved to be a good food colorant (Schieber, 2019). Other by-products of banana like pseudostem, peels, leaves, inflorescence, and stalks have been used in various food and non-food products as flavor, thickening and coloring agent, fibers, bioactive compounds and nutraceuticals (Padam et al., 2014).

2.3 Pomegranate (*Punica granatum)*

Pomegranate (*Punica granatum)* belongs to the family *Lythraceae*, is the oldest consumed fruit with high biological activities. The major pomegranate by-products are rind and peels which are found to have a good concentration of anthocyanins, tannins, and flavonoids. A study shows an inhibitory effect for lipid oxidation in cooked chicken patties by powdered extracts of pomegranate rind more than that of vitamin C (Aziz & Karboune, 2018). In food industry, it is used in the preparation of different products like juices, jams, and marmalades (Andrade et al., 2019). Extracts from pomegranate peel have their application in the meat industry during the time of low-temperature storage that will increase the shelf life of meat products due to their antimicrobial activity against the Staphylococcus aureus and Bacillus cereus (Gowe, 2015). In addition to the antimicrobial activity, pomegranate juices, oils and extracts have shown anticancer activity against breast cancer (Shirode et al., 2014).

2.4 Mango (*Mangifera indica*)

Mango (*Mangifera indica*) belongs to the Anacardiaceae family and is grown in many parts of India. In processed form, mangoes are consumed in various products such as juices, pickles, puree, canned slices, and concentrates along with their economical importance. The processing produces high amounts of by-products that are not fully approached (Ajila, Bhat, et al., 2007). It has been found that mango peel is a good source of phytochemicals, such as carotenoids, vitamins, polyphenols and exhibited good antioxidant properties which play an important role in the prevention of diseases (Ajila, Naidu, et al., 2007). Polyphenol content in mango peel is reported to be more than its flesh (Kim et al., 2010). Mango seed and peel could be used as a cost effective and natural alternative to synthetic food additives.

2.5 Oranges (*Citrus sinensis*)

Orange is a citrus species fruit that belongs to the *Rutaceae* family**.** In the gloal citrus fruit production, over 61% share is of the orange. Pigmented or blood oranges, common oranges, and navel oranges are some of the varieties (Stinco et al., 2016). In oranges, the peel, and seed is the major contributor of the waste part which account for about 50-60% of the total harvest (Negro et al., 2017). Orange peels have a great significance due to the presence of highly valuable products, such as polyphenols (including naringin and hesperidin), polymers such as cellulose, hemicellulose, pectin, and essential oils, mostly d-limonene (Satari & Karimi, 2018). Some advanced extraction techniques (microwave and ultrasound), that are free from solvent have been applied to obtain bio-products derived from waste (Boukroufa et al., 2015)**.** Apart from the above discussion some other fruit by-products and Biomolecule extracted from them are discussed in **Table 1.**

Table1: Fruits By-Product Valorisation By Utilizing Different Extractable Biomolecules

Extracts	Fruit by-product	Extraction method	References
Pectin	Lemon peel	Ethanol extraction, Acid-assisted extraction, centrifugation, freeze-drying.	(Masmoudi et al., 2008)
	Apple Pomace	Solid-liquid extraction	(Wang & Lü, 2014)
	Orange peel	Microwave-assisted extraction Ultrasound-assisted extraction.	(Yousuf et al., 2019)
Flavanones	Orange peels	Solid-liquid extraction	(Lachos-Perez et al., 2018)
Dietary fibers	Apple Pomace	Solid-liquid extraction	(Schieber et al., 2003)
Phenolic Compounds	Mango peel	Methanol elution, Acid assisted extraction, ethanol precipitation, Freeze-drying, resin adsorption, evaporation.	(Berardini et al., 2005)
	Apple pomace	Solid-liquid extraction	(Schieber et al., 2003)
	Grape pomace	High voltage electrical discharge, Water extraction.	(Boussetta et al., 2009)
Carotenoids,	Mango peel	Supercritical CO2 extraction.	(Garcia-Mendoza et al., 2015)
	Tomato pomace	Ultrasound-assisted extraction. (Hexane/ethanol as solvent)	(Luengo et al., 2014)
Lycopene	Tomato pomace	Supercritical CO2 extraction.	(Baysal et al., 2000)
Anthocyanin	Grape skin	Pulsed electric fields, Ultrasonics, High hydrostatic pressure	(Corrales et al., 2008)
Essential oils	Orange peel	Microwave and ultrasound extraction, solid-liquid extraction.	(Boukroufa et al., 2015)

3. VALORIZATION AND APPLICATION OF EXTRACTS

Valorization of fruits by-products is done by utilization of extracts via different techniques. Application of these extracts is observed in different sectors like nutraceuticals, packaging material, preservation, etc. By-products are mainly obtained and then discarded due to lack of management by food processing industries. The by-product that is produced unintentionally governs the major part of processing cost of the product. Hence, the idea for the utilization of by-products within the same industry will ensure an eco-sustainability of the food processing industry (Tremocoldi et al., 2018). To overcome these challenges, components extracted from fruit by-products are utilized by many sectors for different applications. The increased market demand of consumers for natural fragrance and flavors has triggered the utilization of vanillin (4-hydroxy-3-methoxy benzaldehyde) for the vanilla flavor in the cosmetic, detergent, food, and pharmaceutical industries (Ashwini et al., 2008). Ferulic acid, a precursor of vanillic acid is found in pineapple peels which are used in the synthesis of vanillin (Ong et al., 2014). Pomegranate peel is a rich source of phenolic compounds that includes a high concentration of anthocyanin. In a study, fish gelatin active film was incorporated with pomegranate peel powder of 5% and shows an inhibitory effect for Escherichia coli, Staphylococcus aureus, and Listeria monocytogenes (Hanani et al., 2019). Pectin is another product that plays an important role in the preparation of food products such as jam, jellies, sweets because of its high gelling property. It is found in by-products of fruits such as apple, orange, carrot, peach, etc. (Nawirska & Kwaśniewska, 2005). It has been found that polyphenols extracted from orange peel and flesh are known to have a therapeutic aspect. It protects human HepG2 cells against peroxyl radical-induced oxidation and leukocytes from oxidative DNA damage (Park et al., 2014). An overview of components obtained from different fruit by-products having different applications are shown in **Table 2.**

Table 2: List of fruit by-product and their application in different sectors

Fruits	Type of By-products	Component	Application	References
Grape	Skin, marc, seeds	Polyphenols	Food industry	(Andrade et al., 2019)
	Pomace	Phenolic Compounds	Beverage industry	(Fierascu et al., 2020)
Mango	Peels	Phenolics, Carotenoids, flavonoids	Food and pharmaceutical industry	(Ruiz-Montañez et al., 2014)
Orange	Peels	Essential oil, polyphenols, and pectin	Fructo-oligosaccharides production	(de la Rosa et al., 2019)
Apple	Pomace	Phenolic compounds	Production of microbial oils, biofuel, Bioethanol production cosmetic industry	(Liu et al., 2019)
Pineapple	Peels	Ferulic acid	Synthesis of Vaznillin	(Ong et al., 2014)

CONCLUSION

An enormous amount of waste is generated during the industrial processing of fruits. This waste has become a serious challenge as it affects the environment and needs to be either managed or valorized. Being a source of functional ingredients, extensive research is required for the utilization of the fruits by-products from processing industries. Besides this, increased environmental concern has also made the valorization of these by-products a promising field and a global requirement for sustainable development. Fruit by-products, which are treated as waste are known to have an enormous potential for the extraction of valuable components like pectin, bioactive compounds, and other useful phytochemical compounds. There is thus a need to search for alternative scientific technologies in place of the conventional extraction techniques to extract out these compounds from the fruit waste. These extracted valuable compounds can then be utilized in pharmaceutical, food, chemical, and cosmetic industries, and can furthermore be used in the development of functional food products which in turn will be an effective and sustainable solution for the fruit by-products valorization.

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REFERENCES

Ajila, C. M., Bhat, S. G., & Prasada Rao, U. J. S. (2007). Valuable components of raw and ripe peels from two Indian mango varieties. *Food Chemistry*, *102*(4), 1006–1011. https://doi.org/10.1016/j.foodchem.2006.06.036.

Ajila, C. M., Naidu, K. A., Bhat, S. G., & Rao, U. J. S. P. (2007). Bioactive compounds and antioxidant potential of mango peel extract. *Food Chemistry*, *105*(3), 982–988. https://doi.org/10.1016/j.foodchem.2007.04.052.

Andrade, M. A., Lima, V., Sanches Silva, A., Vilarinho, F., Castilho, M. C., Khwaldia, K., & Ramos, F. (2019). Pomegranate and grape by-products and their active compounds: Are they a valuable source for food applications? *Trends in Food Science and Technology*, *86*, 68–84. https://doi.org/10.1016/j.tifs.2019.02.010.

Arshad, Z. I. M., Amid, A., Yusof, F., Jaswir, I., Ahmad, K., & Loke, S. P. (2014). Bromelain: An overview of industrial application and purification strategies. *Applied Microbiology and Biotechnology*, *98*(17), 7283–7297. https://doi.org/10.1007/s00253-014-5889-y.

Ashwini, T., Mahesh, B., Jyoti, K., & Uday, A. (2008). Preparation of ferulic acid from agricultural wastes: its improved extraction and purification. *Journal of Agricultural and Food Chemistry*, *56*(17), 7644–7648. email: usa@udct.org http://pubs.acs.org/journals/jafcau/index.html. http://micro189.lib3.hawaii.edu:2048/login?url=http://search.ebscohost.com/login.aspx?.direct=true&db=lah&AN=20083281086&site=ehost-live.

Aziz, M., & Karboune, S. (2018). Natural antimicrobial/antioxidant agents in meat and poultry products as well as fruits and vegetables: A review. *Critical Reviews in Food Science and Nutrition*, *58*(3), 486–511. https://doi.org/10.1080/10408398.2016.1194256.

Banerjee, J., Singh, R., Vijayaraghavan, R., MacFarlane, D., Patti, A. F., & Arora, A. (2017). Bioactives from fruit processing wastes: Green approaches to valuable chemicals. *Food Chemistry*, *225*, 10–22. https://doi.org/10.1016/j.foodchem.2016.12.093.

Bankar, A., Joshi, B., Kumar, A. R., & Zinjarde, S. (2010). Banana peel extract mediated novel route for the synthesis of silver nanoparticles. *Colloids and Surfaces A: Physicochemical and Engineering Aspects*, *368*(1–3), 58–63. https://doi.org/10.1016/j.colsurfa.2010.07.024.

Baysal, T., Ersus, S., & Starmans, D. A. J. (2000). Supercritical CO2 extraction of β-carotene and lycopene from tomato paste waste. *Journal of Agricultural and Food Chemistry*, *48*(11), 5507–5511. https://doi.org/10.1021/jf000311t.

Berardini, N., Knödler, M., Schieber, A., & Carle, R. (2005). Utilization of mango peels as a source of pectin and polyphenolics. *Innovative Food Science and Emerging Technologies*, *6*(4), 442–452. https://doi.org/10.1016/j.ifset.2005.06.004.

Blakeney, M. (2019). Food loss and food waste: Causes and solutions. In *Food Loss and Food Waste: Causes and Solutions*. https://doi.org/10.4337/9781788975391.

Boukroufa, M., Boutekedjiret, C., Petigny, L., Rakotomanomana, N., & Chemat, F. (2015). Bio-refinery of orange peels waste: A new concept based on integrated green and solvent free extraction processes using ultrasound and microwave techniques to obtain essential oil, polyphenols and pectin. *Ultrasonics Sonochemistry*, *24*, 72–79. https://doi.org/10.1016/j.ultsonch.2014.11.015.

Boussetta, N., Lanoisellé, J. L., Bedel-Cloutour, C., & Vorobiev, E. (2009). Extraction of soluble matter from grape pomace by high voltage electrical discharges for polyphenol recovery: Effect of sulphur dioxide and thermal treatments. *Journal of Food Engineering*, *95*(1), 192–198. https://doi.org/10.1016/j.jfoodeng.2009.04.030.

Buttery, R. G., Garibaldi, J. A., Laboratory, W. R. R., & Service, A. R. (1976). Aroma Production by Cultures of. *East*, *24*(6), 1247–1250.

Cabrera, H. A. P., Menezes, H. C., Oliveira, J. V., & Batista, R. F. S. (2000). Evaluation of residual levels of benomyl, methyl parathion, diuron, and vamidothion in pineapple pulp and bagasse (smooth cayenne). *Journal of Agricultural and Food Chemistry*, *48*(11), 5750–5753. https://doi.org/10.1021/jf9911444.

Choonut, A., Saejong, M., & Sangkharak, K. (2014). The production of ethanol and hydrogen from pineapple peel by Saccharomyces cerevisiae and Enterobacter aerogenes. *Energy Procedia*, *52*, 242–249. https://doi.org/10.1016/j.egypro.2014.07.075.

Corrales, M., Toepfl, S., Butz, P., Knorr, D., & Tauscher, B. (2008). Extraction of anthocyanins from grape by-products assisted by ultrasonics, high hydrostatic pressure or pulsed electric fields: A comparison. *Innovative Food Science and Emerging Technologies*, *9*(1), 85–91. https://doi.org/10.1016/j.ifset.2007.06.002.

de la Rosa, O., Flores-Gallegos, A. C., Muñíz-Marquez, D., Nobre, C., Contreras-Esquivel, J. C., & Aguilar, C. N. (2019). Fructooligosaccharides production from agro-wastes as alternative low-cost source. *Trends in Food Science and Technology*, *91*, 139–146. https://doi.org/10.1016/j.tifs.2019.06.013.

Deliza, R., Rosenthal, A., Abadio, F. B. D., Silva, C. H. O., & Castillo, C. (2005). Application of high pressure technology in the fruit juice processing: Benefits perceived by consumers. *Journal of Food Engineering*, *67*(1–2), 241–246. https://doi.org/10.1016/j.jfoodeng.2004.05.068.

Diaz-Vela, J., Totosaus, A., Cruz-Guerrero, A. E., & De Lourdes Pérez-Chabela, M. (2013). In vitro evaluation of the fermentation of added-value agroindustrial by-products: Cactus pear (Opuntia ficus-indica L.) peel and pineapple (Ananas comosus) peel as functional ingredients. *International Journal of Food Science and Technology*, *48*(7), 1460–1467. https://doi.org/10.1111/ijfs.12113.

Dimou, C., Karantonis, H. C., Skalkos, D., & Koutelidakis, A. E. (2019). Valorization of Fruits by-products to Unconventional Sources of Additives, Oil, Biomolecules and Innovative Functional Foods. *Current Pharmaceutical Biotechnology*, *20*(10), 776–786. https://doi.org/10.2174/1389201020666190405181537.

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*(April), 1–8. https://doi.org/10.3389/fbioe.2020.003

19.

Garcia-Mendoza, M. P., Paula, J. T., Paviani, L. C., Cabral, F. A., & Martinez-Correa, H. A. (2015). Extracts from mango peel by-product obtained by supercritical CO2 and pressurized solvent processes. *LWT - Food Science and Technology*, *62*(1), 131–137. https://doi.org/10.1016/j.lwt.2015.01.026.

González-Montelongo, R., Gloria Lobo, M., & González, M. (2010). Antioxidant activity in banana peel extracts: Testing extraction conditions and related bioactive compounds. *Food Chemistry*, *119*(3), 1030–1039. https://doi.org/10.1016/j.foodchem.2009.08.012.

Gowe, C. (2015). Review on Potential Use of Fruit and Vegetables By-Products as A Valuable Source of Natural Food Additives Some of the authors of this publication are also working on these related projects: review on fruit and vegetables View project Review on Potential. *Food Science and Quality Management*, *45*(December), 47–61. www.iiste.org.

Hanani, Z. A. N., Yee, F. C., & Nor-Khaizura, M. A. R. (2019). Effect of pomegranate (Punica granatum L.) peel powder on the antioxidant and antimicrobial properties of fish gelatin films as active packaging. *Food Hydrocolloids*, *89*, 253–259. https://doi.org/10.1016/j.foodhyd.2018.10.007.

Huang, Y. L., Chow, C. J., & Fang, Y. J. (2011). Preparation and physicochemical properties of fiber-rich fraction from pineapple peels as a potential ingredient. *Journal of Food and Drug Analysis*, *19*(3), 318–323. https://doi.org/10.38212/2224-6614.2179.

Kim, H., Moon, J. Y., Kim, H., Lee, D. S., Cho, M., Choi, H. K., Kim, Y. S., Mosaddik, A., & Cho, S. K. (2010). Antioxidant and antiproliferative activities of mango (Mangifera indica L.) flesh and peel. *Food Chemistry*, *121*(2), 429–436. https://doi.org/10.1016/j.foodchem.2009.12.060.

Kodagoda, K. H. G. K., & Marapana, R. A. U. J. (2017). Utilization of fruit processing by-products for industrial applications: A review. *International Journal of Food Science and Nutrition*, *2*(6), 24–30. www.foodsciencejournal.com.

Kodagoda, K., & Marapana, R. (2017). Development of non-alcoholic wines from the wastes of Mauritius pineapple variety and its physicochemical properties KHGK Kodagoda and RAUJ Marapana. *Journal of Pharmacognosy and Phytochemistry*, *6*(3), 492–497. https://pdfs.semanticscholar.org/eb27/1c2ab90a5564bbb01aadfb140858942a8acb.pdf.

Lachos-Perez, D., Baseggio, A. M., Mayanga-Torres, P. C., Maróstica, M. R., Rostagno, M. A., Martínez, J., & Forster-Carneiro, T. (2018). Subcritical water extraction of flavanones from defatted orange peel. *Journal of Supercritical Fluids*, *138*, 7–16. https://doi.org/10.1016/j.supflu.2018.03.015.

Liu, L., You, Y., Deng, H., Guo, Y., & Meng, Y. (2019). Promoting hydrolysis of apple pomace by pectinase and cellulase to produce microbial oils using engineered Yarrowia lipolytica. *Biomass and Bioenergy*, *126*(August 2018), 62–69. https://doi.org/10.1016/j.biombioe.2019.04.025.

Luengo, E., Condón-Abanto, S., Condón, S., Álvarez, I., & Raso, J. (2014). Improving the extraction of carotenoids from tomato waste by application of ultrasound under pressure. *Separation and Purification*

Technology, *136*, 130–136. https://doi.org/10.1016/j.seppur.2014.09.008.

Masmoudi, M., Besbes, S., Chaabouni, M., Robert, C., Paquot, M., Blecker, C., & Attia, H. (2008). Optimization of pectin extraction from lemon by-product with acidified date juice using response surface methodology. *Carbohydrate Polymers*, *74*(2), 185–192. https://doi.org/10.1016/j.carbpol.2008.02.003.

Nawirska, A., & Kwaśniewska, M. (2005). Dietary fibre fractions from fruit and vegetable processing waste. *Food Chemistry*, *91*(2), 221–225. https://doi.org/10.1016/j.foodchem.2003.10.005.

Negro, V., Ruggeri, B., Fino, D., & Tonini, D. (2017). Life cycle assessment of orange peel waste management. *Resources, Conservation and Recycling*, *127*(August), 148–158. https://doi.org/10.1016/j.resconrec.2017.08.014.

Ong, K. L., Tan, B. W., & Liew, S. L. (2014). Pineapple cannery waste as a potential substrate for microbial biotranformation to produce vanillic acid and vanillin. *International Food Research Journal*, *21*(3), 953–958.

Padam, B. S., Tin, H. S., Chye, F. Y., & Abdullah, M. I. (2014). Banana by-products: an under-utilized renewable food biomass with great potential. *Journal of Food Science and Technology*, *51*(12), 3527–3545. https://doi.org/10.1007/s13197-012-0861-2.

Panouillé, M., Ralet, M. C., Bonnin, E., & Thibault, J. F. (2007). Recovery and reuse of trimmings and pulps from fruit and vegetable processing. In *Handbook of Waste Management and Co-Product Recovery in Food Processing* (*1*), Woodhead Publishing Limited. https://doi.org/10.1533/9781845692520.4.417.

Park, J. H., Lee, M., & Park, E. (2014). Antioxidant activity of orange flesh and peel extracted with various solvents. *Preventive Nutrition and Food Science*, *19*(4), 291–298. https://doi.org/10.3746/pnf.2014.19.4.291.

Ruiz-Montañez, G., Ragazzo-Sánchez, J. A., Calderón-Santoyo, M., Velázquez-De La Cruz, G., Ramírez De León, J. A., & Navarro-Ocaña, A. (2014). Evaluation of extraction methods for preparative scale obtention of mangiferin and lupeol from mango peels (Mangifera indica L.). *Food Chemistry*, *159*, 267–272. https://doi.org/10.1016/j.foodchem.2014.03.009.

Satari, B., & Karimi, K. (2018). Citrus processing wastes: Environmental impacts, recent advances, and future perspectives in total valorization. *Resources*, *Conservation and Recycling*, *129* (September 2017), 153–167. https://doi.org/10.1016/j.resconrec.2017.10.032.

Schieber, A. (2019). By-Products of Plant Food Processing as a Source of Valuable Compounds. *Reference Module in Food Science*, *12*(2001), 401–413. https://doi.org/10.1016/b978-0-08-100596-5.21346-2.

Schieber, A., Hilt, P., Endreß, H. U., Rentschler, C., & Carle, R. (2003). A new process for the combined recovery of pectin and phenolic compounds from apple pomace. *Innovative Food Science and Emerging Technologies*, *4*(1), 99–107. https://doi.org/10.1016/S1466-8564(02)00087-5.

Shirode, A. B., Kovvuru, P., Chittur, S. V., Henning, S. M., Heber, D., & Reliene, R. (2014). Antiproliferative effects of pomegranate extract in MCF-7 breast cancer cells are associated with reduced DNA repair gene expression and induction of double strand breaks. *Molecular Carcinogenesis*, *53*(6), 458–470. https://doi.org/10.1002/mc.21995.

Someya, S., Yoshiki, Y., & Okubo, K. (2002). Antioxidant compounds from bananas (Musa Cavendish). *Food Chemistry*, *79*(3), 351–354. https://doi.org/10.1016/S0308-8146(02)00186-3.

Soong, Y. Y., & Barlow, P. J. (2004). Antioxidant activity and phenolic content of selected fruit seeds. *Food Chemistry*, *88*(3), 411–417. https://doi.org/10.1016/j.foodchem.2004.02.003.

Stinco, C. M., Escudero-Gilete, M. L., Heredia, F. J., Vicario, I. M., & Meléndez-Martínez, A. J. (2016). Multivariate analyses of a wide selection of orange varieties based on carotenoid contents, color and in vitro antioxidant capacity. *Food Research International*, *90*, 194–204. https://doi.org/10.1016/j.foodres.2016.11.005.

Swaminathan, M. S., & Swaminathan, M. S. 1., & Swaminathan, M. S., S. M. (2015). F. L. and F. W. C. H. A. F. S. 37–46. https://doi. org/10. 1017/cbo9781316389485. 00. (2015). Food Losses and Food Waste. *Combating Hunger and Achieving Food Security*, 37–46. https://doi.org/10.1017/cbo9781316389485.009.

Tremocoldi, M. A., Rosalen, P. L., Franchin, M., Massarioli, A. P., Denny, C., Daiuto, É. R., Paschoal, J. A. R., Melo, P. S., & De Alencar, S. M. (2018). Exploration of avocado by-products as natural sources of bioactive compounds. *PLoS ONE*, *13*(2), 1–12. https://doi.org/10.1371/journal.pone.0192577.

Wang, X., & Lü, X. (2014). Characterization of pectic polysaccharides extracted from apple pomace by hot-compressed water. *Carbohydrate Polymers*, *102*(1), 174–184. https://doi.org/10.1016/j.carbpol.2013.11.012.

Yousuf, O., Singh, A., Shahi, N. C., Kumar, A., & Verma, A. K. (2019). Microwave Assisted Extraction: A Technological Alternative for Valorization of Orange Peel for Pectin Extraction. *International Research Journal of Pure and Applied Chemistry*, *17*(3), 1–10. https://doi.org/10.9734/irjpac/2018/46089.