

Bioactive Compounds from Fruit Waste and Its Importance

Venkata Kanaka Srivani Maddala 1*

¹*Department of chemistry, Vignan's Foundation for Science Technology and Research deemed to be University, Vadlamudi, Guntur district, Andhra Pradesh Email: sriani77@gmail.com

*Corresponding Author:- Venkata Kanaka Srivani Maddala

DOI: 10.47750/pnr.2022.13.09.756

Abstract

Diseases are most dangerous and spread rapidly. Hundreds of the people are affected with bacteria, viral and fungal diseases and its prevention is difficult even though many drugs were developed. Fruits consists of phytochemicals, vitamins and dietary fibers that help in treating different diseases in man. Diets rich in fruits prevent man from dread full diseases like cancer, cardiovascular and other chronic diseases. Dumping of fruit waste from industries, commercial areas, houses and markets became serious environmental issue today. So utilization of the fruit waste rich in bioactive compounds can help to prevent the diseases and benefit the society. This paper reviews the bioactive compounds present in *Ananus comosus* (Pineapple), *Malus domestica* (Apple), *Musa acuminata* (Banana), *Mangifera indica* (Mango), *Vitis vinifera* (Grapes), *Psidium guajava* (Guava), and *Manilkara zapota* (Sapota) their extraction techniques and throws light on its benefits.

Key words: Introduction of bioactive compounds, extraction, conventional and non-conventional techniques, benefits of bioactive compounds

INTRODUCTION

Consumption of fruits is increasing today which improves health. Fruits like apple, banana, pine apple, mango, guava and sapota are the most popular fruits with highest levels of nutrients. Mostly fruits consist of antioxidants, vitamins, polyphenols, carotenoids, carbohydrates and fiber. Antioxidants maintain blood pressure, resist immunity, controls cholesterol and show antibacterial, antifungal, antiviral, antithrombotic and anti-inflammatory properties (1). Highest quantities of fruit waste produced from household, markets and food processing units and dumping of this waste contribute to immense environmental problems that may release harmful greenhouse gases (2). Fruit waste like seeds, pomace, skin, rind has good source of bioactive compounds and the production of these bioactive compounds from fruit waste move towards sustainable development (3). According to Gupta and Joshi 2000 (4) 35% of banana peel, 20% of skin, stem and seeds from grapes, 10% of core and seed from guava, 45% of peel and stone from mango, 33% of core skin from pine apple (5) were wasted. These fruit wastes rich in bioactive compounds can be used to prevent chronic disorders. It was discussed in many published papers that edible and non-edible parts of tropical fruits are the sources of bioactive compounds like carotenoids, sterols and stanols, phenolic compounds like flavonoids and non-flavonoids phenolics (6, 7, 8). The different parts of the fruits and its waste should not be disregarded. Bio active compounds in the fruit waste are required to treat diseases benefit our health and attain sustainable development. So there is a need to learn about all the bioactive compounds and use them for the benefit of our health in future. The bioactive compounds of *Ananus comosus* (Pineapple), *Malus domestica* (Apple), *Musa acuminata* (Banana), *Mangifera indica* (Mango), *Vitis vinifera* (Grapes), *Psidium guajava* (Guava), and *Manilkara zapota* (Sapota) were reviewed in this paper and highlighted their importance.

Extraction of bioactive compounds

Extraction process varies based on bioactive compounds being extracted. Bioactive compounds extraction depends on several factors like extraction techniques, raw materials and utilization of extraction solvents (9). After extraction of bioactive compounds, they are used in food, pharmaceutical and cosmetic industries.

Extraction techniques are of two types: conventional and non-conventional

Conventional technologies

Percolation: Here the material powder is placed in the percolation tank and continuously the extraction solvent is added and collect the percolation extract simultaneously.

Decoction: Here the plant material is dried made in to pieces and boiled in the water to extract the oil. It's the process of boiling the plant dried material to dissolve the chemicals of that material.

Soxhlet technique: The dry sample is placed on the equipment where the solvent passes through and the process is repeated until the extraction gets complete

Maceration: This process helps to remove bioactive compounds and essential oils. Here the sample is grinded and made in to tiny particles to increase the surface area for a good mixture with the solvent. Maceration process made extraction easier by increasing the diffusion process and remove the concentrated solution from the surface of the sample.

Hydro distillation

Volatile fraction in the foods can be extracted from hydro distillation process. It is performed with water and takes 6-7 hours without using organic solvents. There are three main processes like hydrolysis, hydro diffusion and decomposition by heat. Both volatile organic and non-volatile organic compounds can be removed by this process.

Non-conventional techniques

Non-conventional techniques are the eco-friendly techniques as they reduce energy consumption and implement organic solvent and benefit environment (10). Super critical extraction, microwave assisted extraction, ultrasound assisted extraction, electric high voltage discharge, pulse electric field and high hydrostatic pressure are used in extraction of bioactive compounds.

Super critical fluid extraction

This method is characterized by changes in the temperature and pressure that changes the gas in supercritical fluid as gas and liquid phases are different. Here supercritical fluids called extracting solvents used for separation of one component called extractant from another i.e. matrix. Examples of supercritical fluids: carbon dioxide, methane, ethanol, propane, nitrous oxide, n-butene, n-pentene.

Microwave assisted extraction

In this method the microwave energy is used to heat the solvent in contact with the sample to separate analytes from sample matrix in to the solvent. Micro wave energy can be converted in to heat energy which makes the mass transfer from inside to outside of plant cell.

High voltage electric discharge

In this the energy is directly introduced in to the aqueous solution through plasma channel that is formed from the high electric discharge between the two submerged electrodes (11). The electric field intensity induce the electrons that are used for starting the spread of positive streamer for the negative electrode. Bubble cavitation, pressure shock waves damage the cell resulting in the release of compounds and extraction of biomolecules from cytoplasm of the cell (12).

Pulse electric field assisted extraction

PEF increase the extraction by inducing the electroporation of cell membrane. Electric potential enters through cell membrane and separates molecules. This repulsion forms pores and increase their permeability (12, 13). This tool recovers valuable compounds from fruits due to its capacity to soften and disrupt cell membrane and release intracellular compounds (14). All the extraction methods are mentioned in the figure-1

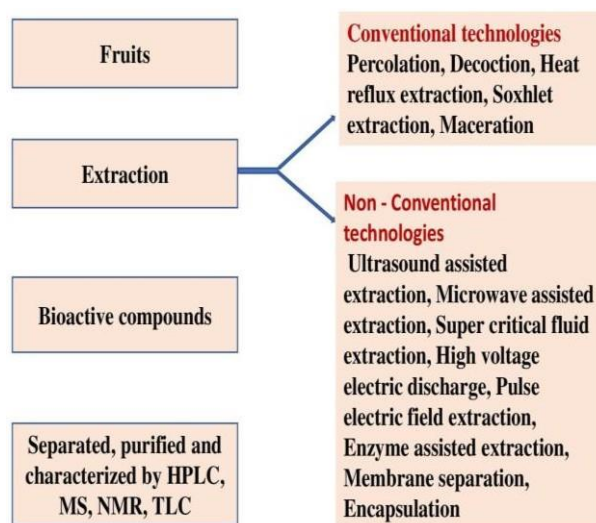


Figure-1 Extraction of Bioactive compounds and characterization

Benefits of bioactive compounds

Actually tropical and subtropical fruits have highest content of bioactive compounds. Vitamin C, flavonoids and phenols are present in apples show antioxidant activities. Phenolic compounds present in the apple treat colon cancer (15). They treat neurodegenerative disorders. 50% of coronary heart disease reduced with high flavonol and flavone from apple (16). Carotenoids, phenolics, biogenic amines, phytosterols shows positive effects on man due to antioxidant activities. Pineapple consists of many bioactive compounds in crown, peel, stem and core. Myricetin, Sali cyclic acid, trans- cinnamic and p-coumaric acid, tannic acid from pineapple shell show anti-oxidant properties. Ferulic and syringic acid have anti-microbial and anti-oxidant properties. Bromelain in core, stem, peel and crown shows anticancer, anti-inflammatory and immunomodulatory properties. Ferulic acid treats atherosclerosis and lowers cholesterol levels in man. Citric acid prevents liver injury. Consumption of grapes shows antioxidant (18,19) anticancer (20) and antidiabetic activity (21). Bioactive compounds like polyphenolic compounds having proanthocyanidins, anthocyanins, flavonols, phenolic acids and stibenes are present in grapes (22). Previously banana was used to treat chronic degenerative diseases (17). Recent studies indicate that banana fruit consumption result in retardation of aging and prevents cancer and heart diseases. In banana the bioactive compounds like alkaloids, phenols, flavonoids, tannins, saponins have antibiotic, anticancer, anti-inflammatory and antimicrobial activities. Flavonoids present in banana can prevent the spread of bacterial and tumor metastases. They inhibit the enzymes that initiate cancer (23) Husk of banana consists of flavonoids and polyphenols having plenty medicinal properties. Mango pulp consists of mangiferin, gallic acid, catechin, quercetin, propyl and methyl gallate, kaempferol, anthocyanins and hexoside, galloyl glucoside (24, 25). Carotenoids and polyphenols in mango show antioxidant activity and prevents coronary atherosclerosis.

Bioactive compounds in sapota are ellagitannins, gallotannins, phenolic acid, depsides and flavonoids that shows antioxidant activity, Both edible and non-edible portions of sapota act as anticancer, antitumor, antimicrobial, analgesic and hepato protective agent. The bioactive compounds present in Guava treats different types of cancer, diabetes, cardiovascular disease and obesity. Guava extract have powerful antioxidant properties that treats hepatic diseases and cancer. Benefits of bioactive compounds in pineapple, apple, banana, mango, grapes, guava and sapota are mentioned in Table-1.

Table-1 Bioactive compounds and its benefits in pineapple, apple, banana, mango, grapes, guava and sapota

Name of the fruit	Bioactive compounds	Benefits
<i>Malus domestica</i> (Apple)	Vitamin C, flavonoids and phenols	show anti-oxidant properties
	Phenolic compounds present in the apple	treat colon cancer(15) and neurodegenerative disorders
	flavonol and flavone from apple	coronary heart disease (26)
	Kaempferol	antioxidant and anti-carcinogenic property
<i>Ananus comosus</i> (Pineapple)	Myricetin, salicyclic acid, trans-cinnamic and p-coumaric acid, tannic acid from pineapple shell	show anti-oxidant properties.
	Ferulic and syringic acid.	have anti-microbial and anti-oxidant properties.
	Ferulic acid	treats atherosclerosis and lowers cholesterol levels in man.
	Citric acid	Protects liver
	Bromelain in core, stem, peel and crown	anticancer, anti-inflammatory and immunomodulatory properties
	Flavonoid compounds like catechin and epicatechin	Antioxidant activity
<i>Vitisvinifera</i> (Grapes)	fruit peel consists of Pectin chemicals	Act as dietary fiber provider (27) Help in digestion and prevents constipation
	Resveratrol from grape peels	Reduces cellular damage and mitochondrial dysfunction (28, 29)
	Flavonoids in grape peels	Prevents cardiovascular events
	kaempferol	Antioxidant and anti-carcinogenic property
	Grape pomace (<i>Cabernet sauvignon</i>) consists of phenolic compounds, flavonoids and monomeric anthocyanin	Antioxidant properties
<i>Musa acuminata</i> Banana)	Dopamine and L-dopa, catecholamines	Antioxidant activity
	alkaloids, phenols, flavonoids, tannins, saponins	Show antibiotic, anticancer, anti-inflammatory and antimicrobial activities
	Flavonoids	Prevent the spread of bacterial and tumor metastases. Inhibit the enzymes that develops cancer (23)
<i>Mangifera indica</i> (Mango)	Carotenoids and polyphenols in mango	show antioxidant activity and prevents coronary atherosclerosis
	Polyphenolics in mango pulp	antioxidant activity
<i>Psidium guajava</i> (Guava)	Polyphenols	increases the level of lipoprotein
	Guavinosides and quercetin glycosides from ethanolic extract of guava	cytotoxic activity (30). Inhibits the proliferation of cells from gastric carcinoma cells
<i>Manilkara zapota</i> (Sapota)	ellagitannins, gallotannins, phenolic acid, depsides and flavonoids	antioxidant property

CONCLUSION

Fruits are most important for its beneficial health properties. This review discusses the wastage of pine apple, banana, mango, grapes, guava and sapota fruits containing bioactive compounds and their benefits. More fruit waste is generated from fruit processing industries, houses and markets. Instead of wasting them bioactive compounds can be extracted for further use which prevents health issues and benefit our society. Many suitable techniques were developed to extract valuable bioactive compounds from the fruit waste. In some cases, bioactive compounds are interesting alternative to prevent the diseases and act as antibacterial, anti-inflammatory and antioxidant agents. Extension of research is required and more innovative should be developed to extract bioactive compounds from fruit waste

CONFLICTS OF INTEREST

Author declares no conflict of interest

ACKNOWLEDGEMENTS

I thank the management of Vignan's Foundation for Science Technology and Research (deemed to be university) for their encouragement.

REFERENCES

1. Bub A, Watzl B, Blockhaus M, Briviba K, Liegibel U, Müller H, Pool-Zobel BL and Rechkemmer G. Fruit juice consumption modulates anti-oxidative status, immune status and DNA damage. *The Journal of Nutritional Biochemistry* 2003; 14:90–98
2. Vilarino MV, Franco C, Quarrington C. 2017. Food loss and waste ~ reduction as an integral part of a circular economy. *Front Environ Sci* 5:1–5.
3. Sagar, N. A., Pareek, S., Sharma, S., Yahia, E. M., & Lobo, M. G. (2018). Fruit and vegetable waste: Bioactive compounds, their extraction, and possible utilization. *Comprehensive reviews in food science and food safety*, 17(3), 512–531
4. Gupta K, Joshi VK. 2000. Fermentative utilization of waste from food processing industry. In: Joshi VK, editor, *Postharvest technology of fruits and vegetables: handling, processing, fermentation and waste management*. New Delhi: Indus Pub Co. p 1171–93
5. Ketnawa S, Chaiwut P, Rawdkuen S. 2011. Aqueous two-phase extraction of bromelain from pineapple peels ('Phu Lae'cv.) and its biochemical properties. *Food Sci Biotechnol* 20:1219–26) ketnawa and others 2011
6. De la Luz Cádiz-Gurrea M., del Carmen Villegas-Aguilar M., Leyva-Jiménez F.J., Pimentel-Moral S., Fernández-Ochoa Á., Alañón M.E., Segura-Carretero A. Revalorization of bioactive compounds from tropical fruit by-products and industrial applications by means of sustainable approaches. *Food Res. Int.* 2020; 138:109786.
7. Can-Cauich C.A., Sauri-Duch E., Betancur-Ancona D., Chel-Guerrero L., González-Aguilar G.A., Cuevas-Glory L.F., Pérez-Pacheco E., Moo-Huchin V.M. Tropical fruit peel powders as functional ingredients: Evaluation of their bioactive compounds and antioxidant activity. *J. Funct. Foods*. 2017; 37:501–506. doi: 10.1016/j.jff.2017.08.028.
8. Pereira-Netto A.B. Tropical fruits as natural, exceptionally rich, sources of bioactive compounds. *Int. J. Fruit Sci.* 2018; 18:231–242. doi: 10.1080/15538362.2018.1444532
9. Tiwari, B. K. (2015). Ultrasound: A clean, green extraction technology. *TrAC Trends in Analytical Chemistry*, 71, 100–109
10. Rodríguez-Pérez, C., Quirantes-Piné, R., Fernández-Gutiérrez, A., & Segura-Carretero, A. (2015). Optimization of extraction method to obtain a phenolic compounds-rich extract from moringa oleifera lam leaves. *Industrial Crops And Products*, 66, 246–254.
11. Barba, F. J., Boussetta, N., & Vorobiev, E. (2015). Emerging technologies for the recovery of isothiocyanates, protein and phenolic compounds from rapeseed and rapeseed press-cake: Effect of high voltage electrical discharges. *Innovative Food Science & Emerging Technologies*, 31, 67–72.
12. Rajha, H. N., Boussetta, N., Louka, N., Maroun, R. G., & Vorobiev, E. (2015). Effect of alternative physical pre-treatments (pulsed electric field, high voltage electrical discharges and ultrasound) on the dead-end ultrafiltration of vine-shoot extracts. *Separation and Purification Technology*, 146, 243–251.
13. Azmir, J., Zaidul, I. S. M., Rahman, M. M., Sharif, K. M., Mohamed, A., Sahena, F., & Omar, A. K. M. (2013). Techniques for extraction of bioactive compounds from plant materials: A review. *Journal of Food Engineering*, 117(4), 426–436.
14. Roselló-Soto, E., Koubaa, M., Moubarik, A., Lopes, R. P., Saraiva, J. A., Boussetta, N., ... Barba, F. J. (2015). Emerging opportunities for the effective valorization of wastes and by-products generated during olive oil production process: Non-conventional methods for the recovery of high-added value compounds. *Trends in Food Science & Technology*, 45(2), 296–310.
15. Tarozzi A, Marchesi A, Cantelli-Forti G and Hrelia P. Cold-storage affects antioxidant properties of apples in Caco-2 Cells. *Journal of Nutrition* 2004; 134:1105–1109.
16. Hertog MGL, Feskens EJM, Hollman PCH, Katan MB and Kromhout D. Dietary antioxidant flavonoids and risk of coronary heart disease: the Zutphen Elderly Study. *Lancet* 1993; 342:1007–1011
17. Singh, B., Singh, J. P., Kaur, A., & Singh, N. (2016). Bioactive compounds in banana and their associated health benefits—A review. *Food Chemistry*, 206, 1–11.
18. Liu Q., Tang G.-Y., Zhao C.-N., Feng X.-L., Xu X.-Y., Cao S.-Y., Meng X., Li S., Gan R.-Y., Li H.-B. Comparison of antioxidant activities of different grape varieties. *Molecules*. 2018; 23:2432. doi: 10.3390/molecules23102432.
19. Andrade M.A., Lima V., Silva A.S., Vilarinho F., Castilho M.C., Khwaldia K., Ramos F. Pomegranate and grape by-Products and their active compounds: Are they a valuable source for food applications? *Trends Food Sci. Technol.* 2019; 86:68–84. doi: 10.1016/j.tifs.2019.02.010.
20. El-Din N.K.B., Ali D.A., Abou-El-Magd R.F. Grape seeds and skin induce tumour growth inhibition via g1-Phase arrest and apoptosis in mice inoculated with ehrlichascites carcinoma. *Nutrition*. 2019; 58:100–109. doi: 10.1016/j.nut.2018.06.018
21. Irak K., Yildirim S., Mert H., Mert N. Grape seed extract effects on serum amylase levels and immune histochemical alterations in streptozotocin-Induced diabetic rats. *Cell. Mol. Biol.* 2018; 64:92–97. doi: 10.14715/cmb/2018.64.4.15.
22. Yang J., Xiao Y.-Y. Grape phytochemicals and associated health benefits. *Crit. Rev. Food Sci. Nutr.* 2013; 53:1202–1225. doi: 10.1080/10408398.2012.692408.
23. Oliveira B.G., Pimentel E.F., Pereira A.C.H., Tosato F., Pinto F.E., Ventura J.A., Endringer D.C., Romão W. Phenolic and glycidic profiling of bananas *Musa* spp. associated with maturation stage and cancer chemoprevention activities. *Microchem. J.* 2020; 153:104391. doi: 10.1016/j.microc.2019.104391
24. Ediriweera M.K., Tennekoon K.H., Samarakoon S.R. A Review on Ethnopharmacological Applications, pharmacological activities, and bioactive compounds of *Mangifera indica* (Mango) Evid. Based Complement. *Altern. Med.* 2017; 2017:6949835. doi: 10.1155/2017/6949835.
25. Nguyen N.M.P., Le T.T., Vissenaekens H., Gonzales G.B., Van Camp J., Smaghe G., Raes K. In vitro antioxidant activity and phenolic profiles of tropical fruit by-products. *Int.J.FoodSci.Technol.* 2019;54:1169–1178. doi: 10.1111/ijfs.14093
26. Hertog MGL, Feskens EJM, Hollman PCH, Katan MB and Kromhout D. Dietary antioxidant flavonoids and risk of coronary heart disease: the Zutphen Elderly Study. *Lancet* 1993; 342:1007–1011

27. Kadzińska, J.; Janowicz, M.; Kalisz, S.; Bryś, J.; Lenart, A. An overview of fruit and vegetable edible packaging materials. *Packag. Technol. Sci.* **2019**, *32*, 483–495.
28. Jiang, Q.; Im, S.; Wagner, J.G.; Hernandez, M.L.; Peden, D.B. Gamma-tocopherol, a major form of vitamin E in diets: Insights into antioxidant and anti-inflammatory effects, mechanisms, and roles in disease management. *Free Radic. Biol. Med.* **2022**, *178*, 347–359.
29. Sergi, D.; Naumovski, N.; Heilbronn, L.K.; Abeywardena, M.; O'Callaghan, N.; Lionetti, L.; Luscombe-Marsh, N. Mitochondrial (dys) function and insulin resistance: From pathophysiological molecular mechanisms to the impact of diet. *Front. Physiol.* **2019**, *10*, 532.
30. Feng X., Wang Z., Meng D., Li X. Cytotoxic and antioxidant constituents from the leaves of *Psidium guajava*. *Bioorg. Med. Chem. Lett.* **2015**; *25*:2193–2198. doi: 10.1016/j.bmcl.2015.03.058.