Composition of Bioactive Carotenoid, Flavonoid, and Terpene compounds in selected fruits: A mini review

Abstract

Bioactive substances are secondary metabolites that are produced by plants to protect their body; yet, such substances are able to control metabolic functions and have beneficial effects on the human body. Vitamins, minerals, phenolics, antioxidants, flavonoids, carotenoids, and micronutrients and fiber appear to be responsible for beneficial health effects such as curing diabetics, cardiac ailments, etc. Fruit-extracted/isolated bioactive components are considered to have antioxidant, anti-inflammatory, antibacterial, cardioprotective, and neuroprotective activities, according to research data from a variety of in vitro and in vivo studies. As a result, fruits have the potential to be turned into medications and functional foods that may be used to avoid or alleviate a variety of chronic issues. The nutritional and phytochemical composition of fruits is determined by their maturation level, variety, environmental conditions, agricultural practices, and post-harvest handling and processing. This review aims to describe the importance of different fruits as a significant source of phytocompounds, which are being studied in clinical trials to create drugs for curing various human ailments, such as obesity, diabetes, cardiac, and cancer conditions. The vast and varied wealth of fruits may yet include undiscovered and extremely strong bioactive chemicals, which require more investigation.

Key Words- Phytochemical, bioactive, phenol, carotenoid, anthocyanin, flavonoid.

Introduction

India is the world's second-largest producer of fruits and vegetables after China, contributing about 10% and 15% of total global production, correspondingly (Sah *et al.*, 2022). Fruits are an important part of our everyday nutrition. Fruit-rich diets are frequently advised for people because of their benefits to health (Šeregelj *et al.*, 2022). Bioactive substances are secondary metabolites that plants produce to sustain homeostasis; yet, they also control metabolic processes and have beneficial impacts on the human body (Sharma *et al.*, 2022). Three groups of bioactive substances are distinguished: phenolic compounds, terpenoids and terpenes, and alkaloids. According to reports, fruits include bioactive substances such as phytochemicals (phenolics, flavonoids, and carotenoids),

vitamins (vitamin C, folate, and pro-vitamin A), minerals (potassium, calcium, and magnesium), and fibres, all of which are important for maintaining human health and nutrition (Sarkar *et al.*, 2022). Nutraceuticals, a more modern and broad term, refer to a class of natural compounds which comprise herbs and other substances used as dietary supplements and regulated as foods (Shahgholian *et al.*, 2022). Fruits are a great source of bioactive substances, including pectin, terpenoids (limonoids and carotenoids), and phenolic compounds (flavonoids, phenolic acids, and coumarins) {Adetuyi, *et al.*, 2022}. Polyphenols, anthocyanidins, carotenoids, flavonoids, glucosinolates, isoflavonoids, limonoids, lycopenes, omega-3 and 6 fatty acids, phytoestrogens, phytosterols, polyphenols, probiotics, resveratrol, and terpenoids are a few of the significant bioactive dietary ingredients (Gangway *et al.*, 2023). They have particular pharmacological impacts on human health, including those that are anti-inflammatory, anti-allergic, antioxidant, antibacterial, antifungal, antispasmodic, chemopreventive, hepato-protective, hypolipidemic, neuroprotective, hypotensive, anti-aging, antidiabetic, osteoporosis, safeguard of DNA damage, cancer and heart diseases, induce apoptosis, diuretic, CNS stimulant (Kabilan *et al.*, 2022).

With functional qualities such as anti-inflammatory, antibacterial, anticancer, antidiabetic, and antibiotic, bioactive chemicals provide a variety of health advantages (Thangaraju *et al.*, 2022). These bioactive may be isolated using a variety of extraction procedures, and to determine their potential health benefits, the derived bioactive are tested in a variety of *in vitro* and *in vivo* ways (Echave *et al.*, 2022). 31 aldehydes, 37 esters, 29 ketones, 28 alcohols, 23 furanic compounds, 22 hydrocarbons, 19 benzene compounds, 13 nitrogenous compounds, 9 carboxylic acids, 7 ethers, 4 halogenated compounds, and 3 naphthalene derivatives were among the 320 volatile metabolites that were definitely confirmed (Aguiar *et al.*, 2021). Genetic engineering approaches can be used to improve or add the bioactive components of functional foods to conventional diets (Gupta *et al.*, 2022). The potentially bioactive food ingredients have positive effects on health and well-being and may play a significant impact (Santhiravel *et al.*, 2022). This review emphasizes the bioactive elements of various fruits, particularly phytochemicals associated with advantages to human health.

Carotenoids

Carotenoids are irreplaceable micronutrients in human nourishment and are broadly tracked down in various bacteria, fungi, algae, and plants (Maghsoudi *et al*., 2022). Up until this point, in excess of 800 natural carotenoids have been found, with shades of red, orange, yellow, and so on (Igreja *et al*., 2021). Chloroplast and chromoplast membranes carry these natural lipophilic pigments in plants (Hermanns *et al*., 2020). They are indirectly responsible for the colors of fruits red, yellow and orange (Rodriguez-Concepcion *et al*., 2018). Carotenoids are equally present in green tissues along with photosynthetic pigments (Sun *et al*., 2022). They can catch light energy and convey it to chlorophyll An

in the energized state, which carries out the role of changing light energy. Furthermore, carotenoids diminish oxidative stress in the human body and compel active oxygen scavengers with provitamin activity (Fig. 1).

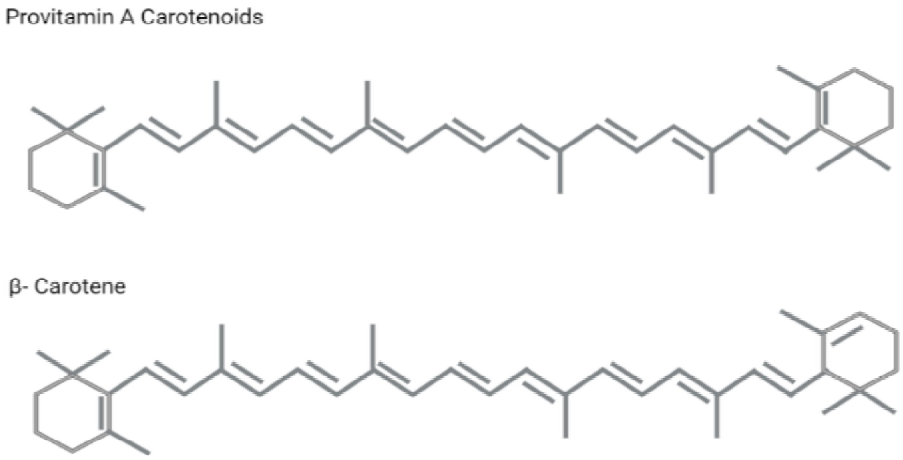

Fig. 1 Structure of carotenoids.

Flavonoids

Flavonoids have a place with the polyphenol superfamily and are combined by plants and generally exist in stems, leaves, flowers, and fruits (Fig. 2). Flavonoids are normally yellow, light yellow, or white (Lu *et al.*, 2021). Seed disseminators are drawn in by the attractive shade of fruits, which is conspicuously contributed by flavonoids (Saivinayak *et al.*, 2022).

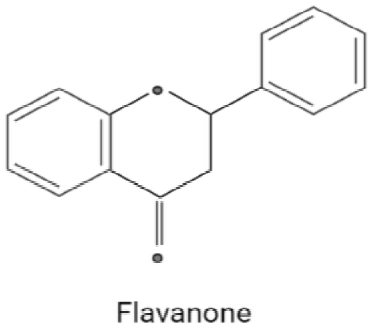

Fig. 2 Structure of flavonoid.

Plants produce flavonoids because of different abiotic and biotic stresses, and flavonoids additionally partake in managing plant development and improvement (Marone *et al.*, 2022). There are various flavonoids with rich items in fruits, and in excess of 5000 various types have been distinguished from

plants (Mikołajczak *et al.*, 2021). Flavonoids have slowly turned into a research area of interest in biology, food science, medicine, and different fields (Kumar *et al.*, 2023).

Anthocyanins

Anthocyanins are effective antioxidants that exert various biological properties like anti-tumor, anticancer, anti-diabetic and neuroprotective (Dhalaria *et al*., 2020) (Fig. 4). These compounds impart colors like pink, blue, red and purple to flowers, fruits and leaves. These are vaguely diversified among different fruits and vegetables with notifiable concentrations (Zitterl-Eglseer & Marschik, 2020). Anthocyanins have indicated characteristics that suppress free radical formation, and cancers, and improve aging and memory (Rana *et al*., 2022). Anthocyanins were notifiable for their role in regulating blood glucose and normalizing insulin secretion. Their instability has drawn the attention of researchers (Kumar *et al.*, 2022).

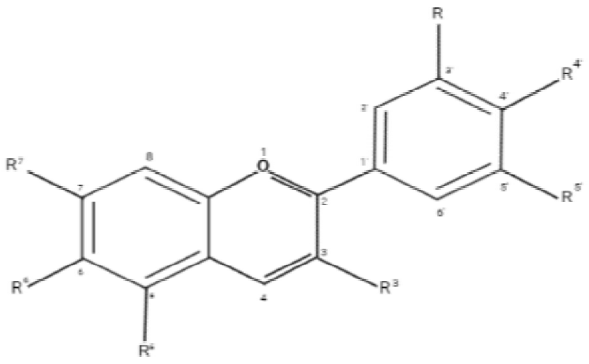

Fig. 3 Structure of Anthocyanin.

Terpenoids

Terpenes, the largest natural compounds, with substantial molecular variations (Fig. 4). Moreover, 55,000 are known to date (Ninkuu *et al*., 2021). Terpenoids are formed when they undergo oxidation and hydrogenation (Chesnokov & Gademann, 2022). These are found in elevated quantities in citrus plant parts. Terpenoid compounds are antifungal, antiviral and antiparasitic (Zulhendri *et al*., 2021). Terpenes are broadly classified and named monoterpenes, hemiterpenes (simplest form), and sesquiterpenes (Mosquera *et al*., 2021). Terpenes act as deterrent antifeedant substances, alarm substances, trail markers, and defensive emissions in plants (Barberis *et al*., 2023). These confer against cancer by necrosis to constrain cell proliferation.

Fig. 4 Structure of Limonoid.

Table 1.- Different bioactive compounds of fruits and their health benefits

NAME OF FRUIT	**BIOACTIVE COMPOUND**	**COMPOSITION (PER 100g)**	**HEALTH BENEFITS**	**REFERENCES**
Amla	Ellagic acid	36-91 mg	Inhibit mutations in genes.	Gul *et al.*, 2022
Mango	β- carotene (Carotenoid)	640 µg	Anti-diabetic, anti-obesity, cytotoxic and apoptotic activity.	Lebaka *et al.*, 2021.
Citrus	Flavonenes (flavonoid)	10 µM	Minimise lipid absorption.	Denaro *et al.*, 2021.
	β-cryptoxanthin (carotenoids)	4.5 µM	Enhances ROS generation.	Gansukh *et al.*, 2019.
	Limonin, Nomilin, and Limoneic acid (limonoids)	20-60 µM	Inhibit the proliferation of pancreatic cancer cells.	Murthy *et al.*, 2021.
	Limonene	100 mg/mL	Alzheimer's disease	Piccialli *et al.*,

	(Terpenes)		(AD).	2021.
Banana	ProVitamin A Carotenoids	560-4680 µg (unripe), 1680-10630 µg (ripe)	Neurodegenerative impairments.	Amah *et al.*, 2019
Pomegranate	Naringenin hexoside	-	Insulin resistance.	Fourati *et al.*, 2020
Himalayan Raspberries	Coumarins	40.45 mg	Protect plants from infections.	Rehman *et al.*, 2022; Shikha *et al.*, 2020
Lingonberry (Koralle)	Quercitrin	7826.68 ± 319.52 µg/g	Scavenge particles in the body.	Raudone *et al.*, 2019
Strawberry	Pelargonidin (anthocyanins)	-	Anti-inflammatory effects.	Durate *et al.*, 2018

Conclusion

Urbanization and contemporary lifestyle have a crucial role in the aetiology of chronic illnesses in humans, and a prospective dietary intervention, particularly fruits, might be of considerable interest. Fruit consumption has expanded dramatically due to the availability of many bioactive components. Aside from traditional and customary uses, scientific data has clearly shown that bioactive components in fruits are crucial for the prevention, management, and treatment of a wide range of health issues in patients. Our review of the literature reveals that several phytochemical and dietary elements, such as vitamins, carotenoids, flavonoids, and phenolic compounds, are present in diverse fruits.

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