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A COMPREHENSIVE REVIEW ON: NUTRACEUTICALS AND FUNCTIONAL ATTRIBUTES OF TROPICAL FRUITS

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ABSTRACT

A diet high in fruits has been associated with a lower risk of chronic disease, as, in addition to their vitamin and mineral content, they contain various compounds with health-protective effects, particularly antioxidants and anti-inflammatory compounds. Wild plant species are of interest to the food industry because of their ability to replace synthetic chemicals and nutraceuticals; however, the nutritional, economic, and sociocultural values of some neglected and underutilized natural resources have not yet been fully exploited. Some of these less well-known and underutilized fruits, which have the potential to provide novel sources of health-promoting agents, are presented in this chapter (i.e., Asimina triloba (L.) Donal, Crataegus azarolus L., Lycium barbarum L., Morus nigra L., and Amelanchier canadensis(L). Medicus). Underutilized fruits could present an opportunity for growers to access special markets where consumers emphasize high nutrient content capable of preventing degenerative diseases. The development of specific horticultural models for nutraceutical fruit production could be an interesting opportunity to obtain a highly standardized raw material for fresh or derived products.

Keywords: Nutraceuticals, Tropical Fruits, Functional Food, Antioxidants, Health Benefits

INTRODUCTION

Tropical fruits are an important part of our daily diet, not only delicious and nutritious but also providing numerous health benefits. The natural chemical compounds found in these fruits, such as vitamins, minerals, antioxidants, and enzymes, help maintain various bodily functions. These medicinal and nutritional properties are why they are called nutraceuticals. These are ingredients that go beyond normal food and help protect the body from diseases, boost immunity, and maintain a healthy lifestyle. Furthermore, the functional attributes of these fruits, such as antioxidant, anti-inflammatory, anti-cancer, and anti-diabetic effects, make them particularly useful. For example, the high vitamin C content in guava boosts immunity, the papain in papaya improves digestion, and the β-carotene in mango is beneficial for vision. Thus, this topic allows us to understand that consuming tropical fruits is not just about providing energy and nutrition, but also about being a source of natural medicinal properties. These fruits play a vital role in promoting human health, preventing disease, and enhancing the quality of life.

FRUITS AND THEIR ROLE IN NUTRACEUTICALS AND FUNCTIONAL FRUITS

Simple phenolics may be found in wide variety of foods and drinks (hydroxycinnamic acid conjugates and avonoids) (**Rice-Evans, Miller, and Paganga 1997**). In vitro investigations have shown that these compounds possess a broad spectrum of antioxidant properties, suggesting that they may be benecial in the prevention of cancer and heart disease. This list contains substances ranging from the most basic (such as vitamin C and phenolic acids) to the most heavily polymerized (like lutein). Flavonoids and phenolic acids are the phenolic chemicals found in the greatest abundance in plants (**Tabart et al. 2011, 2012**). Because of the differences in their structure and chemistry, organic acids have a variety of action mechanisms (**Eyduran et al. 2015; Komes et al. 2011**). However, due to their rich antioxidant content, they are very benecial to overall well-being.

The main aim of the chapter is to highlight the recent ndings on fruits for human use. Fruits have been an indispensable part of the human diet for ages, but not as a primary food. Secondary metabolites are found in plants' biochemistry (i.e., chemical compounds produced within the plants that are not directly involved in the normal growth, development, or reproduction of the organism). These metabolites have positive impacts on both people and animals. In addition to their high vitamin and mineral content, fruits contain molecules that have health-protective properties, such as antioxidant and anti-inammatory substances. This has been linked to a decreased risk of chronic illnesses. Many degenerative illnesses may be prevented or even reversed with a plant-based diet high in ber and other phytonutrients. These include but are not limited to: Type 2 diabetes and obesity, cardiovascular disease, and cancer. Many other benefits of fruits and their nutraceutical use are described in the following article.

NUTRACEUTICALS PROPERTIES OF FRUITS

Plants, particularly fruits, are one of the most Signiant sources of human nourishment and have been used for thousands of years as a natural source of therapeutic chemicals. Natural goods and health-promoting foods have attracted much attention lately, thanks to recent developments in medical and nutrition sciences. Phytonutrients, phytomedicines, and phytotherapy are gaining importance in our daily lives (**Bagchi 2006; Berger and Shenkin 2006; Bland 1996**) and are playing a positive role in enhancing medical benets and further improving immune function to prevent septic diseases with the promise of fewer side effects. Some of the fruits with nutraceutical properties are discussed below.

Amelanchier canadensis is a sweet serviceberry whose products have grown dramatically over the past two decades (Michigan). For centuries, fruits have been used to make wine, beer, and tea. Much research has been done into the health advantages of serviceberries, particularly as a source of minerals (such as manganese) and carotenoids (such as β-carotenes). Nutraceuticals, such as phenolics, are also present in the fruit (e.g., anthocyanins, chlorogenic acid, catechins, and rutin). Sterols and unsaturated fatty acids may also be found in the oil produced from the seeds of Amelanchier spp. **(Juríková et al. 2013**). Serviceberry juice, for example, was historically used in Canada to treat stomach and intestine problems. Ripe serviceberries were also

used to make eye and ear drops, as well as other products. Additionally, if pregnant mothers experienced an injury, they could drink the boiled tree bark to prevent miscarriage.

FUNCTIONAL ATTRIBUTES OF TROPICAL FRUITS

Tropical fruits are widely recognized not only for their appealing taste and rich nutritional profile but also for their unique functional attributes, which contribute significantly to the promotion of human health. The term functional attributes refers to the biological activities or physiological effects of certain natural compounds present in foods that go beyond basic nutrition. These attributes include antioxidant, anti-inflammatory, anti-cancer, anti-diabetic, antimicrobial, and cardioprotective properties, which make tropical fruits an important component of a healthy diet. Most tropical fruits are rich in bioactive compounds such as flavonoids, carotenoids, phenolic acids, dietary fiber, and natural enzymes. These compounds work synergistically to improve the body's defense system and prevent chronic disorders. For instance, mango (Mangifera indica) contains β-carotene and polyphenols that protect the body from oxidative stress and enhance vision. Papaya (Carica papaya) contains papain and lycopene, which improve digestion and exhibit anti-inflammatory effects. Guava (Psidium guajava) is a potent source of Vitamin C and flavonoids that boost immunity and protect against microbial infections. Pineapple (Ananas comosus) provides bromelain enzyme, known for its anti-inflammatory and tissue-healing properties, while banana (Musa spp.) offers dietary fiber and potassium that regulate blood pressure and promote gut health.

The antioxidant activity of these fruits is one of their most important functional attributes. Antioxidants neutralize reactive oxygen species (ROS) that cause oxidative damage to cells, leading to ageing, cardiovascular diseases, and cancer. The presence of compounds such as ascorbic acid (Vitamin C), phenolic acids, and carotenoids plays a vital role in reducing oxidative stress. Similarly, the anti-inflammatory effects of tropical fruits are mainly due to polyphenols, flavonoids, and natural enzymes that inhibit inflammatory mediators in the body, thereby preventing diseases like arthritis and obesity.

CONCEPT AND IMPORTANCE

Tropical fruits hold immense importance in human life because they serve as a natural source of essential nutrients and bioactive compounds that promote overall health and well-being. These fruits are not only delicious and refreshing but also rich in nutraceutical components such as vitamins, minerals, antioxidants, flavonoids, phenolic acids, and carotenoids. Nutraceuticals are substances that provide both nutritional and medicinal value, playing a crucial role in preventing chronic diseases and improving physiological functions of the human body.

The regular intake of tropical fruits like mango, papaya, banana, guava, pineapple, and coconut helps in boosting immunity, improving digestion, maintaining heart health, and protecting the body against oxidative stress. The antioxidants present in these fruits neutralize harmful free radicals, which are responsible for ageing, tissue damage, and several degenerative diseases. Moreover, tropical fruits possess anti-inflammatory, anti-cancer, anti-diabetic, and hepatoprotective properties, which make

them highly beneficial for human health. In addition, nutraceutical-rich fruits contribute to maintaining hormonal balance, enhancing skin glow, and improving mental alertness and energy levels. For instance, papaya contains papain which supports digestion, mango provides β-carotene that promotes good vision, guava offers high Vitamin C content for strong immunity, and banana supplies potassium that regulates blood pressure. These natural compounds act as therapeutic agents and reduce dependency on synthetic medicines. Therefore, the nutraceuticals found in tropical fruits are essential for sustaining a healthy lifestyle. They offer a holistic approach to nutrition by combining health protection, disease prevention, and natural healing. Incorporating such fruits into the daily diet ensures physical, mental, and emotional wellness, thereby making them an invaluable gift of nature to human life.

Examples of Important Tropical Fruits

Tropical fruits are rich in essential nutrients and bioactive compounds that play a major role in promoting human health. Each tropical fruit possesses unique nutraceutical and functional properties that make it beneficial for disease prevention and overall well-being. Some of the most important tropical fruits and their characteristics are discussed below.

Mango (*Mangifera indica*): Mango is often called the "King of Fruits" and is an abundant source of β-carotene, vitamin A, vitamin C, and polyphenols. These compounds provide strong antioxidant and anticancer properties and help in improving eye health, skin glow, and immunity. Mango polyphenols, such as mangiferae, have shown anti-inflammatory and lipid-lowering effects in various studies (**Suleria et al., 2015**).

Papaya (*Carica papaya*): Papaya contains papain enzyme, lycopene, vitamin C, and folate, which enhance digestion, detoxify the liver, and support cardiovascular health. The antioxidant lycopene protects the body from oxidative stress, while papain aids in protein digestion and tissue repair. Its regular intake reduces inflammation and improves metabolic balance (**Yahia, 2010**).

Guava (*Psidium guajava*): Guava is one of the richest sources of Vitamin C (four times more than orange), along with dietary fiber and flavonoids. It helps in boosting immunity, regulating blood sugar levels, and improving digestive health. Guava leaf extracts have demonstrated antimicrobial and anti-diabetic properties in several clinical studies (**Reddy & Odhav, 2013**).

Banana (*Musa spp.)* Banana is an easily available tropical fruit that contains potassium, magnesium, tryptophan, and dietary fiber. These nutrients help regulate blood pressure, maintain heart function, and reduce stress and anxiety. The resistant starch in unripe banana acts as a prebiotic, improving gut microflora and nutrient absorption (**Penafiel et al., 2018**).

Pineapple (*Ananas comosus*): Pineapple contains the enzyme bromelain, which has powerful anti-inflammatory and proteolytic properties. It aids in digestion, reduces sinus inflammation, and supports tissue healing. In addition, pineapple is rich in manganese and vitamin C, which act as antioxidants to promote bone and skin health (**Liu, 2013**).

Coconut (*Cocos nucifera*): Coconut is a unique tropical fruit rich in medium-chain fatty acids (MCFAs), electrolytes, and antioxidants. Coconut

water helps in rehydration, maintaining electrolyte balance, and detoxifying the body. Coconut oil and kernel extracts exhibit antimicrobial and immune-modulating effects, making it a versatile functional food (**Shahidi, 2009**).

Papaya Melon and Passion Fruit: Other tropical fruits such as passion fruit (*Passiflora edulis*) and melon (*Cucumis melo*) are also rich in vitamins A, C, polyphenols, and fiber, which improve skin health, digestion, and prevent free radical damage. These fruits are gaining importance in nutraceutical formulations due to their antioxidant potential.

APPLICATION IN HUMAN HEALTH

Tropical fruits serve as a rich source of bioactive compounds that contribute significantly to the promotion of human health and the prevention of chronic diseases. Their nutraceutical properties, including antioxidant, anti-inflammatory, antimicrobial, and anticancer activities, play a vital role in maintaining physiological balance and enhancing immunity. For instance, mango (*Mangifera indica*) is rich in β-carotene, vitamin C, and polyphenols, which help in protecting cells from oxidative stress and reducing the risk of cardiovascular diseases. Similarly, papaya *(Carica papaya)* contains papain enzyme and lycopene, which aid in digestion, skin rejuvenation, and cancer prevention.

Guava (*Psidium guajava*) is considered a "super fruit" because of its high vitamin C and dietary fiber content that support immune function and regulate blood glucose levels. Pineapple (Ananas comosus) contains bromelain, an enzyme known for its anti-inflammatory and wound-healing properties. Banana (*Musa spp*.) provides potassium and prebiotic fibers that maintain heart health and promote gut microbiota balance. Additionally, tropical fruits such as pomegranate, jackfruit, and coconut exhibit lipid-lowering and anti-aging properties due to their unique phytochemical composition.

Overall, the consumption of tropical fruits as part of the daily diet not only fulfills nutritional requirements but also offers therapeutic benefits that contribute to disease prevention and overall well-being. Hence, these fruits are increasingly being recognized as natural nutraceutical agents for promoting a healthy lifestyle and longevity.

CHALLENGES AND FUTURE PROSPECTS

Despite their immense nutritional and therapeutic potential, the utilization of tropical fruits as nutraceutical sources faces several challenges. One major limitation is the lack of standardized processing, preservation, and extraction technologies to maintain the stability and bioavailability of active compounds such as polyphenols, flavonoids, and carotenoids. Post-harvest losses due to poor handling, inadequate cold-chain management, and limited infrastructure also reduce the economic value and accessibility of these fruits in developing countries. Moreover, variability in phytochemical composition caused by environmental and genetic factors make it difficult to establish consistent quality parameters for nutraceutical applications. Another challenge lies in consumer awareness and regulatory frameworks. In many regions, nutraceuticals derived from tropical fruits are not properly classified or regulated, which hinders their integration into the mainstream health and pharmaceutical sectors. Further, the cost of nutraceutical product development and

limited large-scale clinical validation restricts their global market expansion. However, the future prospects remain highly promising. Advancements in biotechnology, nanotechnology, and food processing innovations can significantly enhance the extraction efficiency and stability of functional bioactive. The increasing global demand for natural, plant-based, and sustainable health products is expected to drive more research and industrial investments into tropical fruit nutraceuticals. Establishing value-added supply chains and public–private collaborations can also improve farmer income, rural employment, and global health outcomes. Hence, with proper research, policy support, and technological innovation, tropical fruits have the potential to become the cornerstone of the global nutraceutical industry, addressing both nutrition security and preventive healthcare in the coming decades.

CONCLUSION

Tropical fruits are an abundant source of nutraceutical compounds that play a crucial role in improving human health and preventing lifestyle-related disorders. Their rich composition of antioxidants, vitamins, minerals, and phytochemicals contributes to the enhancement of immune function, cardiovascular health, and metabolic balance. The incorporation of these fruits into the daily diet not only provides essential nutrients but also offers therapeutic benefits against oxidative stress, inflammation, and chronic diseases. However, despite their vast potential, challenges such as lack of standardized processing methods, inadequate awareness, and limited scientific validation hinder their large-scale utilization. To realize their full potential, more interdisciplinary research, technological innovations, and policy-level interventions are needed. By combining modern food technology with traditional knowledge, tropical fruits can be effectively developed into sustainable nutraceutical products. In the future, tropical fruits will play a pivotal role in global nutrition, preventive healthcare, and economic sustainability, contributing significantly to the advancement of human well-being and the nutraceutical industry worldwide.

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