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Review Article

A Review on Exploitation of Nutraceuticals from Potential Fruit Crops

Yogendra Singh[1*] and Prerak Bhatnagar[2]

[1]Ph.D. Scholar, (Fruit Science), [2]Assistant Professor (Fruit Science),

College of Horticulture & Forestry, Jhalawar- 326023, AU, Kota, Rajasthan

*Corresponding Author E-mail: yogendrasinghphd938@gmail.com

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ABSTRACT

"Nutraceutical" is a buzzword these days, owing to the fact that they are seen as a demanding alternative to pharmaceuticals, wherein the later may pose certain side health ill effects. Thus, these days, they have received arousing attention due to their nutritional efficiency, safety and therapeutic effects. Fruits are nutritionally very rich agglomerate and are the potential sources of many nutraceuticals which, if effectively harnessed can play a tremendous role in this sector. Many of the fruit species are known to possess certain inherent beneficial properties as potential functional foods and are used since time immemorial by different ethno botanic cultures of civilization worldwide. Studies have reported the potential scope of nutraceuticals contents in fruits for improving certain chronic health related persistent problems. It is worthwhile to mention here that traditional medicine systems have long back proves know how on their beneficial aspects and have long back prove included these in their area of expertise based on vivid user. The present review gives a brief idea about nutraceuticals and provides a gist on the availability and presence of nutraceuticals from various consumers oriented fruits to cater some of their health protecting roles.

Key words: *Nutraceuticals, Functional foods, Pharmaceuticals, Potential, Antioxidant and Ayurvedic medicines.*

INTRODUCTION

The concept of food has significantly altered and improved with nutritional enrichment under changing and times will continue to do so over with the changes in cultivation & scenario. The transition from primitive, nomadic hunter-gatherers to self-sustaining agrarian society has a deep impact on the nutritional security of *Homo sapiens*. With the wake of globalization, an individual is entangled in the choices of the right kind of food for his proper growth and development. In the fast-paced world, junk foods have taken a toll drastic on the health of individuals. It is also worthwhile to mention that in the recent years, a growing inclination of the consumers towards healthy food imparting macro and micro nutrition with emphasis on nutrition such anti-oxidant foods is observed.

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Consumers prefer foods, which in addition to their nutritional supply and sensory significances play a crucial role in prevention of diseases, related to nutritional imbalances and also improve their mental well-being and physical health as demonstrated by Azzurra and Paola[12]. Nutraceuticals, a buzzword these days, fall in the category of health improving food however a new concept highlighted a way back since 2000 AD. About 2000 years ago, Hippocrates, the famous Greek physician stated "Let food be thy medicine and medicine be thy food." Ayurveda, one of the world's oldest medical systems advocated the use of herbal compounds in health care system Rajasekaran *et al.*[45]. The term "nutraceutical" is a blend of two words, "nutrient" (a nourishing food component) and "pharmaceutical" (a medicinal drug). The name was coined in 1989 by Stephen De Felice, founder and chairman of the Foundation for Innovation in Medicine, an American organization, located in Cranford, New Jersey[44]. Nutraceutical is any substance which is a food or a part of food that provides medical or health benefits apart from providing basic nutrition[20]. Health ministry of Canada which defines nutraceutical as a product isolated or purified from the food, generally sold in medicinal form not associated with food and demonstrated to have a physiological benefits and also benefits against chronic diseases[41]. Mother nature has bestowed mankind with plethora of plant species having medicinal properties which are not fully harnessed till date. Fruits are potential sources of vitamins, minerals, anti-oxidants, anti-inflammatory and antimicrobial phytochemicals[22]. Fruits have the potentiality of being developed and transformed into nutritional ingredients and supplements which have in fact changed the perception of horticultural crops and products[26,30]. Exploitation of fruits is though in its developmental stage and possible in the near future, the rate of production of nutraceuticals on a large scale will come a reality with the advances in science and technology at the global scenario.

Difference between Pharmaceutical and Nutraceutical

There is a lot of confusion regarding the terminologies like "nutraceuticals", "functional foods", "dietary supplements", "food stuff" "designer foods", "medical foods", "pharm foods", fortified foods and "phytochemicals" etc. There seems to be thin dividing line in their interchangeable usage by different people on different occasions. "Pharmaceuticals" may be considered as drugs used mainly to combat diseases, while "nutraceuticals" are those that are functionally intended to control diseases. Pharmaceuticals are substances which have patent protection as a result of expensive testing to conform to the specifications of respective Governments[45]. Various pharmaceuticals have their origin from plants and animals and are no less "natural" than nutrients.

Nutraceutical

Nutraceuticals are referred as "functional foods" have caused heated debate because they blur the traditional dividing line between food, and medicine. When food is being cooked or prepared using "scientific intelligence" with or without the knowledge of how or why it is being used, then the food is called as "functional food." Pandey *et al.*[41] classified nutraceuticals as potential and established nutraceuticals. Potential nutraceuticals are the ones which has promising approach towards a particular health or medicinal benefit. Established nutraceuticals are those potential nutraceutical which becomes an established nutraceutical only when they have undergone sufficient clinical tests to demonstrate its results and potency.

Source Manufacture and Analysis of Major Nutraceuticals

Most of the nutraceuticals and natural products are obtained from plants and animals. Example Lycopene extracted from plant, carnitine, creatine and carotenoids produced by fermentation. A number of nutraceuticals possessing GRAS status as defined by the FDA and increasingly the manufacturers gain GRAS certification of their products. Nutraceuticals uses the same analytical

procedure for identification and quantification as pharmaceuticals as demonstrated by Chaturvedi *et al.*[18].

Fruit as a Source of Nutraceuticals

Fruits can be harnessed as potential sources of nutraceuticals owing to their inherent healthy composition of beneficial elements. Fruits are at par with the medicinal plants in the arena of preventive healthcare. The fruits are now recognized and found on a daily basis can cut down the risks of several chronic diseases and promotes health[16]. Most of the fruits have nutraceutical properties of which berries are the most common. Some fruits are rich sources of nutraceutical properties and strong antioxidant properties like Apple (*Malus domestica* Borkh.), Banana (*Musa spp.*). Bael (*Aegle marmelos*), Custard apple (*Annona squamosa*), Citrus (*Citrus* sp.), Grape (*Vitis vinifera*), Guava (*Psidium guajava*), Indian blackberry *(Syzygium cumini),* Lemon (*Citrus limon*), Mango (*Mangifera indica* L.), Mangosteen (*Garcinia mangostana*), Papaya (*Carica papaya*), Pomegranate (*Punica granatum*), Pineapple (*Ananas comosus*) and Sweet orange (*Citrus sinensis*) etc. are well established sources of nutraceuticals. With the advent in science and technology, the list is getting inclusion of other fruits besides traditional fruits and showing in an increasing trend as revealed by Tikunov *et al.*[56]. Some of the fruit crops having tremendous potentialities and possible outcome are studies by many researchers being exploited as nutraceuticals are highlighted alphabetically by key finding of several research workers as under.

ANNONA

Custard apple holds promise as super fruit of 21st century. Custard apple (*Annona squamosa*) belongs to the family of Annonaceae is a vital source of nutraceuticals. The custard apple *as* a potential source of phenolic compounds, natural antioxidants and minerals demonstrated by Bhardwaj *et al.*[15]. The antidiabetic property of *Annona muricata* using leaf aqueous extract on pancreating b-cells of streptozotocin-treated diabetic rats was demonstrated by Adewole and Caxton-Martins[1]. The effect of extracts of various parts of *Annona reticulata* against breast cancer cells (T-47D) and found that *Annona reticulata* leaves' methanoic extract (ARME) was found effective against T- 47D investigated Roham *et al.*[47]. The active component present in annonaceous fruits are annonaceous acetogenins responsible for anti-tumor properties. Annonaceous acetogenins are believed to inhibit mammalian mitochondrial NADH-ubiquinone reductase (Complex I) and induces gastric cell death. The annonaceous acetogenin can induce cancer cell death via apoptosis thereby implying a novel cancer treatment as investigated by Han *et al.*[24].

APPLE

Apple (*Malus domestica* Borkh.), belongs to the family of Rosaceae is an important and mostly grown and consumed temperate fruit crop in the world. Apples have preponderance of numerous phytonutrients, especially phenolic compounds and dietary carbohydrates. Apple phenolics are naturally occurring compounds that act as effective antioxidants. Moreover, apple consumption was reported to be related to positive effects on ageing and cognitive decline, asthma and pulmonary function, weight management, bone health and gastrointestinal health[27]. The polyphenols isolated in apples include flavonols (quercetin, kaempferol, and rutin), dihydrochalcones (phloretin and phloridzin), flavan-3-ols (epicatechin and procyanidins) and phenolic acids (caffeic acid and coumaric acid). Moreover, apple leaves contains phenolic compounds such as 3-hydroxyphloridzin, phloridzin and quercetin-3-O-arabinoside and rutin as reported by Walia *et al.*[58].

BANANA

Banana (*Musa paradisica* L.) belongs to the family of Musaseae has been traditionally used in many cultures word wide for prevention and treatment of a wide range of health disorders since time immemorial. Banana has proven high nutraceutical and pharmaceutical value gained popularity nowadays as reported by Anjum *et al.*[9]. Banana is a potential sources of

Vitamins like Thaimine (0.031 mg), Riboflavin(0.073 mg), Niacin (0.065 mg), pantothenic acid (0.034 mg), Vitamin B6 (0.4 mg), Folate (20 µg), Choline (9.8 mg) and Vitamin C (8.7 mg) and minerals like Iron (0.26mg), Magnesium (27mg), Manganese (0.27mg), Phosphorus (22mg), Potassium (358mg), Sodium (1mg) and Zinc (0.15mg) per 100gm of raw banana[10]. The presence of serotonin, norepinephrine and related compounds in bananas as reported by Waalkes *et al.*[57]. Serotonin or 5-hydroxytryptamine (5-HT) is a monoamine neurotransmitter. It is derived from tryptophan and it mainly found in the gastrointestinal tract, blood platelets and central nervous system of animals. It is popularly thought to be a contributor to feelings of wellbeing and happiness[61]. Schimelpfening[53] investigated on bananas and serotonin content hereby reported that though bananas contain serotonin, the serotonin is not able to cross the blood-brain barrier and thereby it can't be an effective way to combat depression directly. But it is also worthwhile to mention that bananas also contain high amounts of vitamin B6, which is necessary for the body to synthesize its own serotonin, thereby consumption of bananas can indirectly supplement the body with serotonin in transformed form. Kanazawa and Sakakibara[31] investigate on bananas contain dopamine at high levels in both peel and pulp in case of Cavendish cultivar which ranged from 80-560mg per 100gm in peel and 2.5-10 mg in the pulp. Dopamine (3-4-dihydroxyphenethylamine), one of the catecholamines, suppresses the oxygen intake of linoleic acid and scavenges diphenil picrylhydrazyl radical. Thereby banana, due to the presence of higher dopamine levels can be cited as one of the nature rich antioxidant foods.

BAEL

Bael (*Aegle marmelos* Linn), belongs to the family of Rutaceae. Bael is one of the most important wonder tree species used in various indigenous systems of medicine in India, China, Burma and Sri Lanka as reported by Kirtikar *et al.*[32]. It is also known as Bale fruit tree it is moderate sized, slender, aromatic tree, 6.0 -7.5 m in height and range between 90 to 120 cm in girth, with a somewhat fluted bole of 3.0-4.5 meter growing wild throughout the scattered forests niches of India. Bael is the only member of the monotypic genus Aegle as reported by C.S.I.R.[17]. Every part of the tree viz. stems, barks, roots, leaves, flowers & fruits at all stages of maturity have medicinal virtues and have been used in various Ayurvedic medicines since long time for the treatment of specific disorders such as respiratory disorders, constipation, ulcer, diarrhoea, dysentery and many others. It is also an important environmental protector and purifier as leaves and bark act as a sink by absorbing dust and foul and poisonous gases from surrounding atmosphere and makes them clean was demonstrated by Agarwal *et al.*[3]. Thus, bael plants are the most important source for the new drug development because of the growing recognition that the natural products are non-toxic, have fewer side effects and are available at affordable price as reported by Dahanukar *et al.*[19].

CITRUS

Citrus (*Citrus* sp.) fruits are rich sources of flavonoids. Hesperidin, a citrus bioflavonoid is a flavanone glycoside. Sweet orange (*Citrus sinensis*) and tangelos are the richest dietary sources of hesperidin. The membranous parts and peel of lemons and oranges have the highest hesperidin concentrations. Hesperidin is used for the treatment of venous insufficiency and haemorrhoids as revealed by Garg *et al.*[21]. Citrus fruits are also potential sources of limonoides which are human health promoters and have anticancer, antioxidant, antibacterial and antifungal properties as demonstrated by Russo *et al.*[50]. Some drugs exhibit a significantly greater (up to 3-fold) mean oral bioavailability of coadministration with grapefruit juice as reported by[8]. Yeum and Choi[60] reported that naringin can increase the bioavailability of verampil in rabbits. Naringin and its aglycone naringenin are found especially in grapefruit is found to display strong anticancer, fat reduction and antioxidant activities as reported by Alam *et al.*[5].

Grapes

Grapes (*Vitis* sp.) belongs to the family of Vitaceae, pomace represents approximately 20% of the weight of grapes. Its composition however varies considerably depending on grape variety and technology of wine making. However, wine making leads to the generation of large quantities of wastes (around 5–9 million tonnes per year, worldwide) which considerably increase the Chemical Oxygen Demand (COD) and the Biochemical Oxygen Demand (BOD) due to a high pollution load. Grape pomace is considered as a valuable source of phenolic compounds which could be recovered as functional food ingredients. The seeds constitute a considerable proportion of the pomace, amounting to 38–52% on a dry matter basis. Their oil is rich in unsaturated fatty acids, linoleic acid in particular. Grape seed oil is mainly produced in Italy, France and Spain; however, the demand for this oil has also increased in the rest of Europe. Apart from being a rich source of high value fatty oil, grape seeds have also been appreciated because of their good available content of phenolic compounds such as gallic acid, catechin and epicatechin, and a wide variety of procyanidins. Catechin, epicatechin, epicatechin gallate and epigallocatechin are the major constitutive units of grape skin tannins. Also, a great range of products such as ethanol, tartrates, citric acid, grape seed oil, hydrocolloids, and dietary fibre are recovered from grape pomace as reported by Russ *et al*.[49] have diverse industries user. Hot water extracts of Grape Skin Pulp Extract (GSPE) can serve as a good substrate for fermentation with *Aureobasidium pullulans* (a yeast like fungus) for the production of pullulan (-glucan). Pullulan is a commercially important polysaccharide with many industrial applications. Fermentation parameters for pullulan production from Grape Skin Pulp Extract (GSPE) have been developed by Israilides *et al*.[28]. The high efficiency of natural phenolic extracts obtained from grape seeds as potent antioxidants was confirmed by the fact that it encourages the prospect of their commercialization as natural powerful antioxidants in foods in order to increase the shelf life of food by preventing lipid peroxidation and protecting from oxidative damage. Many of the grape seed products are commercially available. Recent reports indicate a wide range of biological activities, e.g. radio protective effects, prevention of cataract, anti-hyperglycemic effects, enhancement of postprandial lipemia, and modulation of expression of antioxidant enzyme systems, inhibition of protein kinase activity of the epidermal growth factor receptor, protective effects against oxidative damage in mouse brain cells, and anti-inflammatory effects as reported by Nawirska *et al*.[39]. Pomace of red grapes (*Vitis vinifera*) is also the richest natural source of resveratrol which has anti-oxidant properties. It is a phytoestrogen that exert neuro-protective effects as well as beneficial effects on the cardiovascular system, osteoporosis and anti-cancer properties was demonstrated by Gupta *et al*.[23].

GUAVA

Guava (*Psidium guajava*) belongs the family of Myrtaceae. Guava is a tropical fruit crop having potential source of nutrients. It has unique flavor, taste, and health-promoting qualities the fruit easily fits into the category of new functional foods, often labelled as "apple of the tropics." Guava fruits are rich in Vitamin C (299mg per 100g) and minerals like calcium (0.01%), phosphorus (0.04%) and iron (1%)[38]. Guava is a good source of essential oils which are claimed to have antinoiceptive, repellent, insecticidal, anticancer and anti-inflammatory effects[29]. Guava is a potential source of lycopene 100 g of pink guava fruit provides 5204 µg of lycopene which is nearly twice the amount than in tomatoes. Weng[59] demonstrated that lycopene in pink guavas prevents skin damage from UV rays and offer protection from prostate cancer.

JAMUN

Jamun (*Syzygium cumunii*) belongs to family of Myrtaceae. Jamun though is native to tropical South East Asia, but is available in Indian plains ranging from the Himalayas to southern India reported by Ayyanar *et al*.[11]. It

is a tropical tree of great economic utility. Jamun has been used since ancient time for the treatment of various diseases in traditional and folk love medicine. Jamun is used extensively in the Unani system of medicine wherein the use of the plant in liver tonic, enrich blood, strengthen teeth and gums and form good lotion for cleaning ringworm infection of the head as reported by Ayyanar and Babu[11]. The antioxidant activity of the fruit peel has been analyzed using different assays such as DPPH radical-scavenging assay. A significant correlation was found between concentration of the extract and percentage inhibition of free radicals as well as percentage inhibition of lipid peroxidation. Alam *et al.*[6] isolated four different compounds, *viz.* Lupeol, 12-oleanen-3-ol-3ß-acetate, Stigmasterol, ßsitosterol from n-hexane fraction of Jamun leaf extract. These compounds have rich potential for antidiabetic activities which support the traditional use of the leaves along with fruits important as remedy for treating diabetic patients. The antioxidant property of the fruit peel was partially from the antioxidant vitamins, phenols or tannins and anthocyanins present in the fruit as demonstrated by Banerjee *et al*.[13] and same result as Parashar *et al*.[42].

PAPAYA

Papaya (*Carica papaya*) belongs to the family of Caricaceae. Papaya is good rich sources of Vitamin and minerals. Papaya is play importance role to improving health and besides it is a potential source of phenolics compound. Papaya is also known worldwide for its food and good nutritional values. During the last two decades, considerable progress has been made regarding the biological activity and medicinal application of papaya and now it is valued for its nutraceutical properties as revealed by Krishna *et al.*[33]. Bertuccelli *et al.*[14] studied and investigated the effect of quality controlled fermented papaya preparation, which is a nutraceutical, acts as skin aging markers and reported the consistent biological and gene regulatory improvement in the skin. Papaya skin and pulp contains benzyl isothiocyanates and benzyl glucosinates, which delay at the time of ripening revealed by Rossetto *et al.*[48]. Papaya skin, pulp and skin contains a wide range of phytochemicals including carotenoids and polyphenols reported by Rivera-Pastrana *et al.*[46]. Papain, the proteolytic enzyme present in papaya has antioxidant and gelationlytic properties reported by Manosroi *et al.*[34].

POMEGRANATE

Pomegranate (*Punica granatum*) belongs to the family of Punicaceae. It is good sources of antioxidant compounds such as tannins and flavonoids. These phenolic compounds are responsible for its exceptional healing qualities as demonstrated by Parashar *et al*.[42]. The antimicrobial activity of various extracts prepared from pomegranate fruit peels were evaluated and it was found that 80% methanolic extract of peels was a potent inhibitor for *Yersinia enterocolitica*, *Listeria monocytogenes*, *Staphylococcus aureus* and *Escherichia coli*. This is due to the presence of active inhibitors in peels including phenolics and flavonoids as potent constituents as demonstrated by Adhami *et al.*[2] and Al-Zoreky *et al.*[7].

PINEAPPLE

Pineapple (*Ananas comosus)* belongs to the family of Bromeliaceae. It is well known as a storehouse of several unique health promoting compounds, minerals and vitamins that are important for good health. The active compound present in pineapple is Bromelin, which belongs to a group of proteolytic enzyme. Bromelain has therapeutic benefits like the treatment of angina pectoris, bronchitis, sinusitis, surgical trauma, and thrombophlebitis, debridement of wounds, and enhanced absorption of drugs, particularly antibiotics. Pineapple encompasses diverse uses as it relieves osteoarthritis, diarrhoea, and reducer the extent various cardiovascular disorders as demonstrated by Pavan *et al.*[43]. Saxena and Panjwan[51] evaluated effects of hydro alcohol extract of *Ananas comosus* (HEAC), on isoproterenol induced myocardial infarction in albino wistar rats and concluded that HEAC possesses cardioprotective activity isoproterenol induced myocardial infarction.

MANGO

Mango (*Mangifera indica* L.) belongs to the family of Anacadiaceae. It is an important fruit plant highly nutritive valued for its strong aroma, intense peel coloration, and delicious taste. It has high nutritive value, owing to its high Vitamin C content, β- carotene and minerals as reported by Tharanathan *et al.*[55]. Every part of mango plant is utilizable in one way or another. The profuse abundance in the presence of polyphenolic compounds in mango, which are highest in peel than pulp and highest in leaves and stem barks reported by Masibo and He[35]. The presence of polyphenolic compounds, *viz.* gallic acids, (*m*digallic and *m*-trigallic acids), gallotannins, quercetin, isoquercetin, mangiferin, ellagic acid, and β-glucogallin in the mango pulp as reported by Schieber *et al.*[52] have well known medicinal values. Mangiferin has tremendous potentiality of being exploited as a nutraceutical, since it possesses antimicrobial and antioxidant activities as reported by Stoilova *et al.*[54]. Muruganandan *et al.*[37] reported that mangiferin significantly reduced plasma total cholesterol, triglycerides and LDL-C associated with concomitant increase in HDL-C levels and a decrease in atherogenic index of diabetic rats indicating a potent antihyperlipidemic and antiatherogenic activity. Mango is a huge source of anthocyanins, which are a group of phenolic compounds exhibiting antioxidant properties. Anthocyanins content was found to be more in ripe mango peel where it ranged from 360-565 mg/ 100g vis a vis 203-326 mg/ 100g in raw peels as reported by Ajila *et al.*[4].

MANGOSTEEN

Mangosteen or Purple mangosteen (*Garcinia mangostana*) belongs to the family Guttiferae is a tropical evergreen tree having tremendous potentiality of being exploited as a good source of nutraceuticals. Traditionally, various parts of the plant have been used as medicine in South - East Asia to treat skin implications, dysentery and urinary tract infections (UTI) reported by Morton[36]. The peel of mangosteen contains xanthonoids like mangostin and other phytochemicals as reported by Obolskiy *et al.*[40]. Presence of Hydroxy Citric Acid (HCA) is reported, which imparts the detectable tart taste of mangosteen. HCA is considered appetite suppressant and useful for the prevention and reduction of accumulation of visceral fat reported by Hayamizu *et al.*[25].

CONCLUSION

The inclination of modern day consumer towards healthy food is ever-growing. Nutraceuticals, which fall under the category of health improving foods has been gaining tremendous popularity now a day. Nutraceuticals in broad sense terminology which has several sub-sections. Fruits alongside with vegetable, fall under the category of protective foods as well as dietary supplements and its adjuvants are tremendous sources of nutraceuticals and therefore for optimizing health of an individual, regular consumption of fruits and vegetables is of utmost importance. Most of the fruits have their own, unique active ingredients, having tremendous nutraceutical significances and are yet to be explored and should be utilised human beings in sufficient quantities for better wellness and improved health consciousness of the people. Apart from the major fruits, minor fruits also have tremendous potentiality of being exploited as sources of nutraceuticals, since these fruits are being used in traditional medicinal systems from time immemorial. These nutraceuticals present in the fruits, if effectively harnessed, can raise the economic significance of the fruits. Since the consumer oriented market of nutraceuticals is ever growing, there is an urgent need to explore the potential nutraceutical properties of fruits in terms for their utility by the end users. The fruit profile studies encompassing differential utility of each and every component in terms of functional and protective foods holds the key for future generations. With an advent of newer techniques for isolation, characterization and extraction of different valuable ingredients, the word nutraceutical holds greater reference under the present context of golden revolution. The utilization of fruits encompassing nutraceutical importance

has already begin to gain inclusion in dietary schedule of developed countries for better wellness, health, fitness and prosperity of the mankind.

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