International Journal of Agriculture Innovations and Research
Volume 5, Issue 6, ISSN (Online) 2319-1473
Manuscript Processing Details (dd/mm/yyyy) :
Received: 15/04/2017 | Accepted on : 21/04/2017 | Published : 01/05/2017

Nutraceuticals from Major Fruit Crops

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Abstract **– "Nutraceutical" is a buzzword these days, owing to the fact that they are seen as an alternative to pharmaceuticals, wherein the later may pose certain side-effects. Thus, these days, they have received considerable attention due to their potential nutritional, safety and therapeutic effects. Fruits are nutritionally very dense products 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 and are used since time immemorial by different cultures worldwide. Studies have reported the potential scope of nutraceuticals in fruits in improving certain chronic health problems. Also it is worthwhile to mention that traditional medicine systems have long back knowhow on their beneficial aspects and have included these in their area of expertise. The present review gives a brief idea about nutraceuticals and provides a gist on the presence of nutraceuticals from various common fruits and some of their health protecting roles.**

Keywords **– Fruits, Health, Pharmaceuticals, Nutraceutical.**

I. INTRODUCTION

The concept of food has significantly altered over time. 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 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 is observed. Consumers prefer foods, which in addition to their nutritional and sensory significances, plays a crucial role in prevention the diseases, related to nutritional imbalances and also improve their mental well-being and physical health (Azzurra and Paola, 2009). Nutraceuticals, a buzzword these days, fall in the category of health improving food, isn't a new concept. 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 promoted the use of herbal compounds in health care system (Rajasekaran *et al.*, 2008).

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 DeFelice, founder and chairman of the Foundation for Innovation in Medicine, an American organization, located in Cranford, New Jersey(Radhika *et al.*, 2011). Nutraceutical is any substance which is a food or a part of food that provides medical or health benefits apart from providing basic nutrition (DeFelice, 1995). 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(Pandey *et al.*, 2010).

Mother Nature has bestowed mankind with variety of plant species having medicinal properties which aren't fully harnessed till date. Fruit are rich sources of vitamins, minerals, anti-oxidants, anti-inflammatory and antimicrobial phytochemicals (Goff and Klee, 2006).Fruits and vegetables have the potentiality of being developed into nutritional ingredients and supplements which have in fact changed the perception of horticultural crops and products (Hui *et al.*, 2010; Kalra, 2003). Exploitation of fruits and vegetables, is though in its nascent stage, in the near future production of nutraceuticals in a large scale is a reality with the advances in science and technology.

II. DIFFERENCE BETWEEN PHARMACEUTICAL AND NUTRACEUTICAL

There is a lot of confusion regarding the terminologies like "nutraceuticals", "functional foods", "dietary supplements" "designer foods", "medical foods", "pharmafoods", "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 treat diseases, while "nutraceuticals" are those that are intended to prevent diseases. Pharmaceuticals are substances which have (or have had) patent protection as a result of expensive testing to conform to the specifications of respective Governments (Rajasekaran *et al.*, 2008). Many pharmaceuticals have their origin in plants and animals and are no less "natural" than nutrients. Classic example of nutrients is synthetic vitamins.

III. NUTRACEUTICAL

Nutraceuticals sometimes 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.* (2010) classified nutraceuticals as potential and established nutraceuticals. Potential nutraceuticals: One which has promising approach towards a particular health or medicinal benefit.

Established nutraceuticals: A potential nutraceutical becomes an established nutraceutical only when there are sufficient clinical tests to demonstrate its results.

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IV. 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 nutraceuticals have 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 (Chaturvedi *et al.*, 2011).

V. Fruit as Asources of Nutraceuticals

Fruits can be harnessed as potential sources of nutraceuticals owing to their inherent composition of beneficial elements. Fruits are at par with the medicinal plants in the arena of preventive healthcare. Intake of fruits as well as vegetables on a daily basis can cut down the risks of several chronic diseases and promotes health (Boeing *et al.*, 2012). Most of the fruits have nutraceutical properties, of which berries are the most common. Some classic examples are grape (*Vitis vinifera*), watermelon (*Citrullus lanatus*), banana (*Musa spp.*). Fruits like bael (*Aegle marmelos*), pomegranate (*Punicagranatum*), amla / Indian gooseberry (*Phyllanthus emblica*), cranberry (*Vaccinium* spp.), orange (*Citrus sinensis*) lemon (*Citrus limon*) etc. are well established sources of nutraceuticals. With the advances in science and technology, the list is in an increasing trend(Tikunov *et al.*, 2010).

Some of the fruit crops having tremendous potentialities of being exploited as nutraceuticals are as under.

Anona

Custard apple (*Annona squamosa*) of Annonaceae family is a potential source of nutraceuticals. Bhardwaj *et al.* (2014) reported that *Annona squamosa* as a good source of phenolic compounds, natural antioxidants and minerals.

Adewole and Caxton-Martins (2006) reported the anti-diabetic property of *Annona muricata* using leaf aqueous extract on pancreating b-cells of streptozotocin-treated diabetic rats.

Roham *et al.* (2015) studied 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.

The active component responsible for anti-tumor properties in annonaceous fruits are annonaceous acetogenins. Annonaceous acetogenins are believed to inhibit mammalian mitochondrial NADH-ubiquinone reductase (Complex I) and induces gastric cell death. Han *et al.* (2015) reported that annonaceous acetogenin can induce cancer cell death via apoptosis thereby implying a novel cancer treatment.

Apple

Apple (*Malus domestica* Borkh.), a member of Rosaceae family, is an important and most widely grown temperate fruit crop in the world. Apples are rich source 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 (Hyson, 2011).

The polyphenols present 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(Walia *et al.*, 2016).

Banana

Banana, *Musa paradisica* L. (Musaseae) has been traditionally used in many cultures for prevention and treatment of a wide range of health disorders since time immemorial. Banana has high nutraceutical and pharmaceutical value, an aspect for which it is gaining popularity nowadays (Anjum *et al.*, 2014). Banana is a rich source of Vitamins like Thaimine (0.031 mg), Riboflavin(0.073 mg), Niacin (0.065 mg), pantothenic acid (0.034 mg), Vitamin B_6 (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 (Anonymous, 2016).

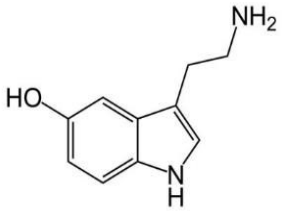

Fig. 1. Chemical structure of serotonin

Waalkes *et al.* (1958) reported the presence of serotonin, norepinephrine and related compounds in bananas. 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 (Young, 2007). Schimelpfening (2016), on bananas and serotonin content, 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 B_6, which is necessary for the body to synthesize its own serotonin, thereby consumption of

bananas can indirectly supplement the body with serotonin if not directly.

Kanazawa and Sakakibara (2000) reported that 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 antioxidant foods.

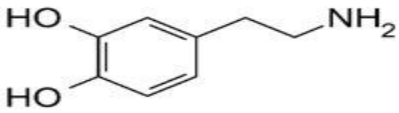

Fig. 2. Chemical structure of dopamine

CITRUS

Citrus fruits are rich sources of flavonoids. Hesperidin, a citrus bioflavonoid is a flavanone glycoside. *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 hemorrhoids (Garg *et al.*, 2001).

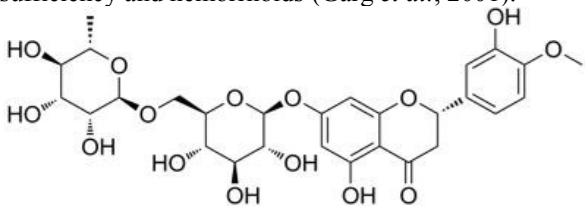

Fig. 3. Chemical structure of hesperidin

Citrus fruits are also rich sources of limonoides which are human health promoters, and have anticancer, antioxidant, antibacterial and antifungal properties (Russo *et al.*, 2016).

Some drugs exhibit a significantly greater (up to 3-fold) mean oral bioavailability of coadministration with grapefruit juice (Ameer and Weintraub, 1997).Yeum and Choi (2006) 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 anti-cancer and antioxidant activities (Alam *et al.*, 2014).

GUAVA

Guava (*Psidium guajava*) of Myrtaceae family is a tropical fruit rich in high-profile nutrients. With its unique flavor, taste, and health-promoting qualities, the fruit easily fits into the category of new functional foods, often labelled as "super-fruits." Guava fruits are rich in Vitamin C (299mg per 100g) and minerals like calcium (0.01%), phosphorus (0.04%) and iron (1%) (Nanjundaswamy *et al.*, 1964)**.**Guava is a rich source of essential oils which are claimed to have antinoiceptive, repellent, insecticidal, anti-cancer and anti-inflammatory effects(Joseph and Priya, 2011).Guava is a rich source of lycopene, 100 g of pink guava fruit provides 5204 µg of lycopene which is nearly twice the amount than in tomatoes. Weng (2010)reported that lycopene in pink guavas prevents skin damage from UV rays and offer protection from prostate cancer.

JAMUN

Jamun, *Syzygium cumunii*, of Myrtaceae family is a tropical tree of great economic utility. It has been used since time immemorial for the treatment of various diseases in traditional and folk medicine. It is used 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 removing ringworm infection of the head is done (Ayyanar and Babu, 2012).

Alam *et al.* (2012) isolated four different compounds, *viz.* Lupeol, 12-oleanen-3-ol-3ß-acetate, Stigmasterol, ßsitosterol from n-hexane fraction of *S. cumunii* leaf extract. These compounds have potential antidiabetic activities which support the traditional use of the leaves as being remedy for treating diabetic patients.

PAPAYA

Papaya (*Carica papaya*) of Caricaceae family is known worldwide for its food and 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 (Krishna *et al.*, 2008).Bertuccelli *et al.* (2016) studied the effect of quality controlled fermented papaya preparation, which is a nutraceutical, on skin aging markers and reported the consistent biological and gene-regulatory improvement in the skin. Papaya skin, pulp and skin contains a wide range of phytochemicals including carotenoids and polyphenols (Rivera-Pastrana *et al.*, 2010). Papaya skin and pup contains benzyl isothiocyanates and benzyl glucosinates, which increases at the time of ripening (Rossetto *et al.*, 2008). Papain, the proteolytic enzyme present in papaya has antioxidant and gelationlytic properties(Manosroi *et al.*, 2014).

PINEAPPLE

Pineapple, *Ananas comosus* of Bromeliaceae family is a storehouse for several unique health promoting compounds, minerals and vitamins that are important for optimum health. The active principle present in pineapple is Bromelein, 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. It also relieves osteoarthritis, diarrhea, and various cardiovascular disorders (Pavan *et al.*, 2012).Saxena and Panjwan (2014) 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 against isoproterenol induced myocardial infarction.

MANGO

Mango (*Mangifera indica* L.) of Anacadiaceae family, is an important fruit plant highly valued for its strong

aroma, intense peel coloration, delicious taste and high nutritive value, owing to its high Vitamin C content, β-carotene and minerals (Tharanathan *et al.*, 2006). In mango, every part of the plant is utilizable in one way or another. There is an abundance in the presence of polyphenolic compounds in mango, which are higher in peel than pulp and highest in leaves and stem barks (Masibo and He, 2009). Schieber *et al.* (2000) reported 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.

Mangiferin has tremendous potentiality of being exploited as a nutraceutical, since it possesses antimicrobial and antioxidant activities (Stoilova *et al.*, 2005). Muruganandan *et al.* (2005) 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.

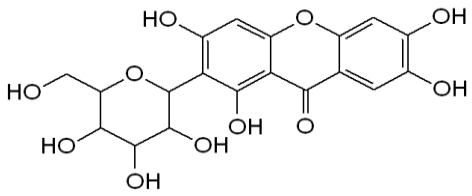

Fig. 4. Chemical structure of mangiferin

Mango is a rich 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 compared to 203-326 mg/ 100g in raw peels (Ajila *et al.*, 2007).

MANGOSTEEN

Mangosteen or Purple mangosteen (*Garcinia mangostana*) of Guttiferae family is a tropical evergreen tree having tremendous potentiality of being exploited as a source of nutraceuticals. Traditionally, various parts of the plant has been used as medicine in Southeast Asia since to treat skin implications, dysentery and urinary tract infections(UTI) (Morton, 1987). The peel of mangosteen contains xanthonoids like mangostin and other phytochemicals (Obolskiy *et al.*, 2009).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(Hayamizu *et al.*, 2003).

VI. 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 nowadays. Nutraceuticals is a broad terminology which has several sub-sections. Fruits alongside with vegetable, fall under the category of protective foods and 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 in detail. Apart from the major fruits, minor fruits also have tremendous potentiality of being exploited as sources of nutraceuticals, since these fruits are 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 market of nutraceuticals is ever growing, there is an urgent need to explore the potential nutraceutical properties of fruits.

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