International Journal of Trend in Scientific Research and Development (IJTSRD)
International Open Access Journal
ISSN No: 2456 - 6470 | www.ijtsrd.com | Volume - 2 | Issue – 1

Bio-fortification of underutilized Himalayan pear and plum- A next hotspot for nutritional strategies of the "neglected" micronutrients

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ABSTRACT

Functional foods/nutraceuticals have received considerable interest in recent times, because of their presumed safety and potential nutritional and pharmaceutical value. Nutraceuticals are the substances which are not traditionally recognized nutrients, but which have positive physiological effects on the human health and claimed to possess multiple therapeutic benefits. The medicinal plants represent one of the important fields of traditional medicine all over the world and hence established constituents of nutraceuticals. The use of food for promoting health is as old as the practice of phyto-medicine for treating or preventing various types of illness. Presently, health awareness around the globe is increasing, leading to the demand for functional food products with special characteristics and health benefits. These functional foods can play an important role in preventing the occurrence of certain chronic diseases besides providing a means to reduce increasing burden on the health care system with a continuous preventive mechanism. Further, fruits and herbs are considered as protective foods, as they contain numerous phytochemicals and natural bioactive compounds such as polyphenols, flavonoids, anthocyanins and carotenoids, which provide protection against many diseases. Therefore, the fruits and herbs rich in different bioactive compounds can be investigated for the development of functional food products and the present review could eventually be helpful in drawing the attention of researchers and scientists to work on it.

Keywords: *Pyrus pyrifolia, Prunus domestica and Fortification*

Introduction

"Naturally derived bioactive compounds that are found in foods, dietary supplements and herbal products" are termed as Nutraceuticals. These have health promoting, disease preventing and medicinal properties. Plants contain a broad range of bioactive compounds such as lipids, phytochemicals, pharmaceutics, flavors, fragrances and pigments. Plant derived nutraceuticals/functional foods have received considerable attention because of their presumed safety and potential nutritional and therapeutic effects. India has got a wide range of soil and climatic conditions, due to which a large variety of fruits and vegetables (both indigenous and introduced) are grown here. Today, India is the largest producer, consumer and exporter of spices and spice products. India's fruit production has grown faster than vegetables, making it the second largest fruit producer in the world. India's horticulture output, is estimated to be 287.3 million tonnes in 2016-17 after the first advance estimate. Nature has been abundantly generous to Himachal Pradesh in endowing it with conditions conducive for growing of large variety of fruits that is why it is known as the fruit bowl of India. The total annual production of the fruits in Himachal Pradesh is 45, 9623 tonnes (Statistical Year Book India, 2017). The local fruits of Himachal Pradesh can serve as an ideal source of dietary antioxidants. Due to seasonal constraints and low cost, these fruits are always within the reach of the normal populace. Consumption of antioxidant rich fruits is able to play a protective role against a number of seasonal diseases as well as improve general well-being. Currently, much attention is being focused on the consumption of fruits because of their valuable constituents, which contribute towards prevention of degenerative diseases caused by oxidative stress (Lopez *et al.,* 2007; Reddy *et al.,* 2010). Fruits contain a wide array of dietary phytonutrients such as flavonoids, phenolic acids, carotenoids and vitamins with strong antioxidant capacities (De Oliveira *et al.,* 2007). In the majority of fruit cultivars of the *Rosaceae* family, especially in the genera of *Malus*, *Pyrus* and *Prunus* species are reported to contain a considerable amount of valuable natural antioxidant compounds such as phenolics, flavonoids, carotenoids and anthocyanins that impart health-promoting effects to the consumers (Gil *et al.,* 2002; Kim *et al.,* 2003). It has been proven that plum fruits have several times higher total antioxidant capacity than apples, the latter being one of the most commonly consumed fruits in our diet (Wang *et al.,* 1996). Plum is commonly known as Asian plum. Plum fruits demonstrated very good scavenger activity against oxygen-derived free radicals, such as hydroxyl and peroxyl radicals (Murcia *et al.,* 2001). Pear is commonly known as Asian pear. Pear fruits are a good source of pectin, help in maintaining desirable acid balance in the body helpful in heart diseases, gastrointestinal tract disorders. It is also recommended to the patients suffering from diabetes, because of low sucrose content and included in low antigen content diets to alleviate the symptoms in the management of immune mediated diseases (Challice and Wood *et al.,* 1972). Based on numerous evidences on the strong biological activity of phytonutrients and on the scarcity of data for their content in foods, the present review was focused to understand the neutraceutical potential of the underutilized Himalayan pear and plum for the health benefits of these fruits.

Food fortification

Food fortification refers to the addition of micronutrients to processed foods. In many situations, this strategy can lead to relatively rapid improvements in the micronutrient status of a population and at a very reasonable cost, especially if advantage can be taken of existing technology and local distribution networks. Since the benefits are potentially large, food fortification can be a very cost-effective public health intervention. However, an obvious requirement is that the fortified food needs to be consumed in adequate amounts by a large proportion of the target individuals in a population. It is also necessary to have access to, and to use, fortificants that are well absorbed yet do not affect the sensory properties of foods. In most cases, it is preferable to use food vehicles that are centrally processed, and to have the support of the food industry. Fortification of food with micronutrients is a valid technology for reducing micronutrient malnutrition as part of a food-based approach when and where existing food supplies and limited access fail to provide adequate levels of the respective nutrients in the diet. In such cases, food fortification reinforces and supports ongoing nutrition improvement programs and should be regarded as part of a broader, integrated approach to prevent MNM (Micronutrient malnutrition), thereby complementing other approaches to improve micronutrient status. Micronutrient malnutrition is widespread in the industrialized nations, but even more so in the developing regions of the world. It can affect all age groups, but young children and women of reproductive age tend to be among those most at risk of developing micronutrient deficiencies. Micronutrient malnutrition has many adverse effects on human health, not all of which are clinically evident. Even moderate levels of deficiency (which can be detected by biochemical or clinical measurements) can have serious detrimental effects on human function. Thus, in addition to the obvious and direct health effects, the existence of MNM has profound implications for economic development and productivity, particularly in terms of the potentially huge public health costs and the loss of human capital formation (Allen *et al.,* 1999). The control of vitamin and mineral deficiencies is an essential part of the overall effort to fight hunger and malnutrition. As deficiencies in some of these "neglected" micronutrients (i.e., zinc, vitamin D_2 and calcium) are likely to be common throughout much of the developing world and among the poorest populations in the industrialized nations. Fortification provides a means of lowering the prevalence of deficiencies in all of these micronutrients, and their inclusion in mass fortification programs, in particular, could produce significant public health benefits. The aim is for all people to be able to obtain from their diet all the energy, macro and micronutrients, they need to enjoy a healthy and productive life (Houston, 2010).

Phenolic and flavonoid rich fruits produced in Himachal Pradesh

Fruits and fruit products together are an important supplement to the human diet as they provide almost all the vital components required for normal growth and development of the human body leading to the healthy physique and mind (Sasikumar, 2013). Per capita fresh fruit consumption in India is limited as there are huge post harvest losses, due to limited shelf life of the horticultural produce and the poor supply chain linkage. Thus processing the farm produce into various products and fortification of the same with nutritionally rich adjuncts provides a viable mean of reaching the large masses and at the same time gives various biological and therapeutic advantages. Consumption of fruit juices has become a dietary concern worldwide. It retains the physic-chemical and organoleptic characteristics of fruits from which they are produced; therefore, their intake also should contribute to maintain health (Takebayashi *et al*., 2013). Health benefits of fruit juices are attributed to a large number of compounds with biological activity include radical scavenging activity, protecting proteins, lipids, and DNA from oxidative damage (Liu, 2003). The major bioactive antioxidant compounds of fruit and fruit juices are vitamin C and phenolic compounds (Perales *et al*., 2008). Blending of fruit juices is practiced to overcome the high cost of some exotic fruit juices, scarcity or seasonal availability, balancing of strong flavors, high acidity, astringency or bitterness, improving total soluble solids, bland flavor, improving and stabilizing color. Nutritional or phytochemical properties can be improved by blending, which offers to adjust sugar/acid ratios and compensate undesirable juice consistency (Singh *et al.,* 2004).

Pear and plum are major fruit crops of family Rosaceae especially in the genera of *Malus* produced in subtropical and temperate regions of Himachal Pradesh. These fruits are recognized for their health prompting properties, especially with respect to chronic diseases such as CVD, neurodegenerative diseases and gastrointestinal disorders, prompting the development of functional ingredients and value-added products. Numerous in vitro studies have been showed the presence of wide range of phenolic compounds in pear (Schieber *et al*., 2001; Petkou *et al*., 2002; Salta *et al*., 2010) and plum (Weinert *et al*., 1990; Gil *et al*., 2002; Cevallos-Casals *et al*., 2006; Vizzotto *et al*., 2007; Kristl *et al*. 2011).

Pear

Pear (*Pyrus pyrifolia*) is among the most economically important fruit tree crops of the temperate zones**.** It belongs to the genus *Pyrus* and family *Rosaceae*. Its habitat is distributed in the temperate regions of Europe and West Asia and grown in Punjab, Himachal Pradesh and Kashmir. Pear is a rich source of vitamin C, ascorbic acid and it is an antioxidant. It acts against reactive oxygen species. Arbutin is commonly used in urinary therapeutics and as a human skin whitening agent. It decreases melanin in the skin (Petkou *et al.,* 2002). More than 300 volatile compounds have been identified in pears, including hydrocarbons, aldehydes, alcohols, esters, ketones and sulfur compounds. Methyl to hexyl esters of decadienoate are the character impact compounds of the European pear. Other volatile esters e.g. hexyl acetate, 2-methylpropyl acetate, butyl acetate, butyl butanoate, pentyl acetate and ethyl hexanoate also possess strong pear like aromas. Ethyl octanoate and ethyl (E) - 2-octenoate contribute with floral sweet or fruity odours in pears. Pears with a high concentration of 2, 4-decadienoates in the fruit flesh are more accepted by consumers than those with low content. The acetate ester concentrations increase in La France pears during maturation Butyl acetate and hexyl acetate are the major ester components in the volatile compound profile (Berger, 1999). Upadhyay and Prakash (2015) evaluated the antioxidant activity of the peel and pulp of pear. In DPPH assay the methanol extract of peel showed 75.20% activity which was much higher than pulp extract which was 52.38%. And in reducing assay peel extract showed 0.612 while the pulp extract showed 0.568 activities. Thus, the result indicated that pear peel exhibited higher antioxidant activity than pulp so it was concluded that the pear fruit has a viable source of natural antioxidants for the functional food and in medicinal application also. Sharma *et al.,* (2015) investigated the edible, raw (whole) *Pyrus communis* (L) (Rosaceae family) fruit for its phytochemical and antioxidant potential. The fruit was observed to be an alternative source of phenolic compounds, natural antioxidants and secondary metabolites. Antioxidant potential was analysed by ABTS radical scavenging and FRAP assay. GC/MS analysis showed the presence of furfuryl alcohol, oleic acid, squalene and other fatty acids, which are known to have industrial and therapeutic applications. This study demonstrates the potential of *Pyruscommunis* (L) for the development of value added products with high amount of antioxidants and health promoting factors. Hussain *et al.,* (2013) and Velmurugan and Bhargava (2013) also examined physio-chemical and functional attributes of different four pear cultivars. Kaur and Arya (2012) studied that ethno medicinal involves the usage of medicinal plants used by a group of people on account of their traditional knowledge and phytochemical means the individual chemical that plant contains. This review involves the ethnomedicinal and phytochemical perspectives of *Pyrus communis* Linn. In the "The Indian Materia Medica", the common pear or gabbu gosha is considered as 'Amritphale' because of its immense potential in human health care system. Various phenolic glucoside compounds have been isolated and identified from *Pyrus communis* Linn. e.g., arbutin, quercetin, kaempferol, fredielin, sterols, isoquercitrin, ursolic acid, sorbitol, astragalin, phloridzin and various tannins. These are responsible for different activities viz. in urinary therapeutics, as skin whitening agent, antiinflammatory, antioxidant, antibacterial, analgesic, astringent and spasmolytic. It is also used in diabetes because of low sucrose content.

Plum

Prunus domestica belongs to the genus *Prunus* and family *Rosaceae* commonly known as Plum, Alu-Bukhara, Alucha. It is commonly found in India, Pakistan, Afghanistan and Persia (Narayan, 2003). Many pharmacological activities of plum are reported for blood circulation, measles, digestive problems, anticancer, anti-diabetes, anti-obesity, cardiovascular problems, dyspepsia, nausea, vomiting, thirst, in bilious fevers, headache, jaundice and hepatitis, leucorrhea, miscarriage, antioxidant, antihyperlipidemic, anxiolytic, asthma and laxative (Soni *et al.,* 2011). The major chemical constituents present in *P. domestica* are carbohydrates, amino acids, vitamin A, vitamin Bcomplex, vitamin K, potassium, calcium, magnesium, zinc, copper, manganese, selenium, boron and dietary, fibers, pectin, hemicellulose, cellulose, lignins, sorbitol, glucose, fructose and sucrose, malic, citric, tartaric, benzoic and boric acids, benzaldehyde, linalool, ethylnonanoate, methyl cinnamate and γ-decalactone, benzaldehyde, 2-furancarboxyaldehyde, ethyl cinnamate, chlorogenic acid, neochlorogenic acid, caffeic acid, coumaric acid, rutin, proanthocyanidin and melanodins (Jabeen and Aslam, 2011). Mehta *et al.,* (2014) studied the nutritional, phytochemical, antioxidant and antibacterial activity of dried plum (*Prunus domestica*) to understand its health benefits. The GC/MS screening exhibited the presence of vitamin E, furfural, phytosterol, fatty acids, eugenol and maltol, which have different therapeutic uses. In preliminary study, the extract was screened against four bacterial strains. It showed a highest zone of inhibition against *Staphylococcus epidermidis* followed by *Staphylococcus aureus* and *Proteus mirabilis*. Najafabad *et al.,* (2014) suggested that the fresh samples are more successful in collecting oxygen free radicals, such as superoxide (O^{2-}) and peroxy radicals ($ROO^{.}$) than dried. Donovan *et al.,* (1998) analyzed the prune and prune juice extracts for phenolics by reversed phase HPLC with diode array detection and tested for the ability to inhibit the Cu^{2+} catalyzed oxidation of human LDL and result indicated that prunes and prune juice may provide a source of dietary antioxidants. Dhingra *et al.,* (2014) carried out the evaluation of phenolic and flavonoid contents as well as different antioxidant activities in whole fruit of *P. domestica* by using four different solvent systems (hexane, ethyl acetate, n-butanol and water). The simple warring blender method was used in the study for the preparation of whole fruit extract. It may have better yield potential and more total phenolic and flavonoid contents. A comparative evaluation of different fractions of *P. domestica* fruit showed that ethyl acetate fraction contains highest antioxidative activities. Similar results were observed in n-butanol fraction. In the light of these results, we conclude that highest antioxidant activity in ethyl acetate fraction was possibly due to its high phenolic and flavonoid contents. Therefore, the ethyl acetate and n-butanol fractions of *P. domestica* may further be studied to explore the therapeutic potential in treating different chronic diseases.

Herbs as another Source of health-protective Bioactives

India has one of the oldest, richest and most diverse cultural traditions associated with the use of medicinal herbs and although the variety of climatic conditions and seasons favorable for growth of many species of herbs (Shah *et al.,* 2011). This knowledge is accessible from thousands of medical texts and manuscripts. Medicinal and aromatic plants have been used for many years in human nutrition Spices and medical additives have been used for animals to increase dietary energy utilization, improve the performance efficiency and as a new source of proteins (Mostafa *et al.,* 2011). In India, herbs have long been used for promotion of health, prevention and treatment of diseases (Jayanthi *et al.,* 2013). Herbs have changed the course of history and in economic term have greater importance as ingredients in food, medicine, perfumery, cosmetics and garden plants (Mc Partland, 1997). Herbs are used in foods to improve sensory acceptability, taste, flavor, pungency and color. They also have antioxidant, antimicrobial, pharmaceutical and nutritional properties. In addition to the known direct effects, the use of these plants can also lead to complex secondary effects, such as salt and sugar reduction, improvement of texture, food preservation and prevention of food spoilage and increase shelf life (Samson *et al.,* 2004). Plants and plant extracts are safer than chemical products; therefore natural products are becoming more popular.

The use of herbal beverages has been on the rise in recent years due to their low prices. Herbal beverages are effective both prophylactically as well as treating the issue of diseases at a grass roots level and effective at bringing the system gently into balance.

The medicinal herbs are an important source of phytochemicals that offer traditional medicinal treatment of various ailments (Maobe *et al*., 2013). They contain inherent active ingredients used to cure disease or relieve pain (Okigbo *et al*., 2008). The use of these traditional medicinal plants in most developing countries as therapeutic agents for the maintenance of good health has been widely observed. Modern pharmacopoeia still contains at least 25% drugs derived from plants and many others, which are synthetic analogues, built on prototype compounds isolated from plants. Interest in medicinal plants as a re-emerging health said has been fuelled by the rising costs of prescription. Medicinal plants produce several secondary metabolite compounds including alkaloids, cyanogenic glycosides, flavanoids, saponins, steroids and terpenoids to protect themselves from the continuous attack of naturally occurring pathogens, insect pests and environmental stresses (Kumar *et al*., 2009).

Fruits and herbs are known as protective foods, as they contain significant amounts of polyphenolic antioxidants, essential vitamins, minerals and fiber at varying concentrations, which are essential for maintaining good health. With the discovery of the presence of phytochemicals in the fruits and herbs and their strong antioxidant potential in scavenging free radical has generated tremendous attention of the scientists (Kaur and Maini, 2001).An increase in the intake of fruits and herbs rich in antioxidants are effective strategies to minimize oxidative stress, cardiovascular diseases, cancer and various degenerative diseases (Liu, 2003; Vattem *et al.*, 2005).

Cardiovascular diseases and hypertension

Cardiovascular diseases (CVD) are considered collectively as the one of the leading causes of death in most industrialized countries (Gersh *et al.*, 2010). CVD mainly includes heart disease, stroke, atherosclerosis and hypertension. Hypertension is defined as blood pressure of 140/90 mm Hg or higher, which is considered a major risk factor for myocardial infarction (Kearney *et al.,* 2005). The World Health Organization (WHO) strongly advocates for the prevention, treatment, and management of hypertension and other CVD as a top priority (Kearney *et al.,* 2005, WHO, 2008). Atherosclerosis, accumulation of cholesterol in the arterial wall and formation of atherosclerotic plaque, has been known as a major pathophysiological process that leads to development of CVD (Stocker and Keany, 2004). There is now a consensus that atherosclerosis represents a higher oxidative stress characterized by lipid and protein oxidation in the vascular wall (Stocker and Keany, 2004).

Oxidative stress and atherosclerosis development

Free radicals and reactive oxygen species (ROS) are highly reactive byproducts of cellular metabolism, which play a role in cell signaling and regulation (Thannickal and Fanburg**,** 2000). The most common free radicals and ROS of importance in living organisms include hydroxyl, superoxide, singlet oxygen and hydrogen peroxides. Some of these reactive species can cause cell injury, while attacking susceptible substrates, such as nucleotides and lipids. However, cells have evolved with antioxidative defense mechanisms which consists of both enzymatic and non-enzymatic mechanisms to prevent injury caused by these ROS and free radicals. Enzymes, such as superoxide dismutase (SOD), glutathione peroxidase and catalase, are the main antioxidants involved in cellular antioxidant defense mechanism. Ascorbate, α-tocopherol and glutathione are some of the non-enzymatic antioxidants in the defense system (Madamanchi *et al.*, 2005). Antioxidant rich foods are prepared most commonly from plant sources, which contain a number of healthy components which make them a positive addition to the diet as supplement to the body's antioxidant defense system. Other than fruits and vegetables, antioxidant properties of herbs and spices are of particular interest in view of the impact of oxidative modification of LDL cholesterol in the development of atherosclerosis (Tapsell *et al.,* 2006). Functional foods are one of the choices that people, researchers and industry are examining to enrich diets with bioactives with known functional properties, designed to attempt to combat oxidative stress related chronic diseases including CVD.

Functional foods and market trends

Functional foods can be described as "a food which is similar in appearance to, or may be a conventional food and is consumed as a part of a usual diet. It is demonstrated to have physiological benefits and/or reduce the risk of chronic diseases beyond basic nutritional functions". The global market for functional beverages is rapidly growing due to increasing health consciousness, obesity concerns and life style choices, along with an aging population. These have been the main market drivers for functional food (Mintel, 2007). A recent market analysis study conducted in Nova Scotia revealed that consumers are willing to obtain nutritional and functional benefits through a food rather than dietary supplements in the form of a pill (McIntosh *et al.,* 2006). Currently, there are number of commercial beverages, which claim to have high antioxidant potencies due to their perceived high content of polyphenolic antioxidants (Mintel, 2007). Functional beverages are gaining importance in the market in the form of fruit drink/squashes/jams/health drinks etc. It has been reported that the organoleptic quality of beverages prepared from juice could be increased by the addition of plant extracts. These extracts apart from their nutritional properties also possess medicinal and therapeutic values, which have a profound effect on human health, since they affect many functional processes. This establishes the possibility of formulating a functional beverage with a balanced bioactive profile using antioxidant rich fruits and plant extracts. The profile of phenolic phytochemicals determines the functionality of the whole food through additive or synergistic interaction of phenolic phytochemicals.

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