Figure 1 Prevalence of cardiovascular diseases

Cardiovascular diseases (CVDs) are a group of disorders of heart and blood vessels that includes coronary heart disease, cerebrovascular disease, peripheral arterial disease, rheumatic heart disease, congenital heart disease, deep vein thrombosis and pulmonary embolism. Coronary artery disease is associated with the blood vessels supplying the heart muscle whereas, cerebrovascular diseases are concerned with blood supply to the brain. Peripheral arterial disease causes lack of blood supply to arms and legs and rheumatic heart disease causes to damage heart muscle and heart valves due to rheumatic fever, caused by streptococcal bacteria. Other forms of diseases include congenital heart disease, concerned with malformations of heart structure existing at birth and deep vein thrombosis and pulmonary embolism that causes blood clots in the leg veins often getting dislodged into heart and lungs.

Heart attacks and strokes are usually acute events and are mainly caused by a blockage that prevents blood from flowing to the heart or brain. The most common reason for this is a build-up of fatty deposits on the inner walls of the blood vessels that supply blood to the heart or brain. Stroke can also be caused due to internal bleeding from a blood vessel in the brain (WHO 2007).
Introduction
Data collected from internet sources reveals that CVDs are also dominantly prevalent (30%) in patients suffering from communicable diseases, nutritional deficiencies and other physiological ailments. CVDs are the number one cause of death globally as more people die annually from CVDs than from any other causes. An estimated 17.3 million people died due to CVDs in 2008, representing 30% of all global deaths. Of these deaths, an estimated 7.3 million were due to coronary heart disease and 6.2 million were due to stroke. Low- and middle-income countries are disproportionally affected: over 80% of CVD deaths take place in low- and middle-income countries and occur almost equally in men and women. By 2030, it is assumed that almost 23.6 million people may die due to CVDs, such as heart disease and stroke.

Cardiovascular disease is a leading cause of global mortality, accounting for almost 17 million deaths annually (Smith et al., 2004; Martinello et al., 2006); atherosclerosis, in particular, is the main contributor for the pathogenesis of myocardial and cerebral infarction. Elevated levels of plasma low-density lipoprotein cholesterol (LDL) and triglycerides, accompanied by reduced high-density lipoprotein (HDL) levels, is often associated with an increased risk of coronary heart disease (Smith et al., 2004; Martinello et al., 2006). High cholesterol diet is regarded as an important factor in the development of hyperlipidemia, atherosclerosis and ischemic heart disease. Cardiovascular disease is the primary cause of mortality in the United States, Europe and most parts of Asia (Braunwald, 1997; Ross, 1999; Ling et al., 2001). In hypercholesterolemia, the cholesterol content of erythrocytes, platelets, polymorph nuclear leucocytes and endothelial cells increases. This increase is reported to activate
these cells and cause the enhanced production of oxygen free radicals (Kok et al., 1991; Prasad and Kalra, 1989; Sudhahar et al., 2006). Erythrocytes, because of their intrinsic potential for free radical generation, might be a very suitable environment for cholesterol to exert its prooxidant action (Kay, 1991). The heart of hyperlipidemic patients adapts poorly to oxidative stress, suggesting that the endogenous adaptive mechanisms against myocardial stress are impaired (Roberts, 1995). Intracellular lipids accumulate in cardiomyocytes and cause several alterations in the structure and functional properties of the myocardium (Hexeberg et al. 1993). Effective cholesterol-lowering drug therapy delays the development or progression of coronary heart disease (Blankenhorn et al., 1987; Sudhahar et al., 2006).

Hypercholesterolemia (HC) is a major risk factor for atherosclerosis and coronary heart disease. It is characterized by coronary endothelial dysfunction that is characterized by altered vasodilatation of endothelial dependent vasodilators (Heistad et al., 1991; Luscher et al., 1992). It may also promote ischemic tissue damage by enhancing the vulnerability of the microcirculation to the deleterious effects of ischemia and other inflammatory stimuli, thus increasing the incidence of myocardial ischemia and cardiac events (Stokes et al., 2002). Hexeberg et al. (1993) have also observed in experimental rats that there is intracellular lipid accumulation in cardiomyocytes that alters its structure and property. Hypercholesterolemia is one of the most important risk factors for atherosclerosis and subsequent cardiovascular disease (Steinberg, 2002). Feeding animals with cholesterol has often been used to elevate serum or tissue cholesterol levels to study the etiology of hypercholesterolemia-related metabolic disorders (Bocan, 1998). Exogenous hypercholesterolemia causes fat deposition in the liver and depletion of the
hepatocyte population. This in turn, may result in malfunctioning of the liver, which apparently follows microvesicular stenosis due to the intracellular accumulation of lipids (Gupta et al., 1976; Assy et al., 2000). Also, feeding cholesterol-rich diets induces free radical production, followed by oxidative stress and hypercholesterolemia (Stehbens, 1986; Bulur et al., 1995). Oxidative stress results from impairment of the equilibrium between production of free radicals and antioxidant defense systems. It is one of the factors that link hypercholesterolemia with atherogenesis (Halliwell, 1996). Thus, there is evidence that oxidative stress contributes to the development of atherosclerosis in the vascular wall through the formation of reactive oxygen species (ROS) (Shi et al., 2000). In order to protect the tissues from damage caused by ROS, organisms possess enzymatic and non-enzymatic antioxidant systems (Parthasarathy et al., 2000). Protection against ROS and the breakdown products of peroxidized lipids and oxidized proteins is provided by enzymes such as catalase (CAT), superoxide dismutase (SOD), glutathione peroxidase (Gpx) and glutathione-S-transferase (GST). Non-enzymatic antioxidants such as reduced glutathione (GSH), vitamins C and E, play a vital role in protecting cells from oxidative stress by participating in various biochemical pathways (Ramesh et al., 2009).

**History of herbal medicine**

Herbs have played a major role and have always been an integral part of the development of modern civilization. Much of the medicinal use of plants has developed through observations of wild animals and by trial and error. With passage of time, each tribe added the medicinal power of herbs in their area to its traditional knowledge base. They methodically collected information on herbs were later translated into well-defined herbal
pharmacopoeias. By the end of 20th century, much of the pharmacopoeia of scientific medicine was derived from the herbal lore of native populace. Many drugs commonly used today are of herbal origin with about 25% of the prescription drugs dispensed in the United States contain at least one active ingredient derived from plant material (Charles and Ramani, 2011; Srichaikul et al., 2012). Some are made from plant extract whereas, others are synthesized to mimic a natural plant compound. Many drugs listed as conventional medications were originally derived from plants. Salicylic acid, a precursor of aspirin, was originally derived from white willow bark and the meadowsweet plant. Cinchona bark is the source of malaria-fighting quinine. Vincristine, used to treat certain types of cancer is derived from periwinkle. The opium poppy yields morphine, codeine and paregoric that is used in the treatment of diarrhea. Laudanum, a tincture of the opium poppy, was a favored tranquilizer in Victorian times. Even today, morphine—the most important alkaloid of the opium poppy—remains the standard against which new synthetic pain relievers is compared.

The World Health Organization (WHO) estimates that 4 billion people, 80% of the world population, presently use herbal medicine for some aspect of primary health care (WHO, 2002). Herbal medicine is a major component in all indigenous peoples' traditional medicine and a common element in Ayurvedic, homeopathic, naturopathic, traditional oriental and Native American Indian medicine. WHO notes that of 119 plant-derived pharmaceutical medicines, about 74% are used in modern medicine in ways that correlated directly with their traditional uses as plant medicines by native cultures (WHO, 1993). Major pharmaceutical companies are currently conducting extensive research on plant materials gathered from the rain forests and other places for their potential
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medicinal value. It is important to note that each chemical compounds or drugs also manifest extensive contraindications and possible side effects. Rather than using a whole plant, pharmacologists identify, isolate, extract, and synthesize individual components, thus capturing the active properties.

Substances derived from the plants for commercial medications used today are treatment of heart disease, high blood pressure, pain, asthma and other problems. Active ingredients, plants contain minerals, vitamins, volatile oils, glycosides, alkaloids, bioflavonoid and other substances along with isolated or synthesized active compounds can become toxic in relatively small doses. Ephedra is an herb used in Traditional Chinese Medicine for more than two thousand years to treat asthma and other respiratory problems. Ephedrine, the active ingredient present in ephedra, is used in the commercial pharmaceutical preparations for the relief of asthma symptoms and other respiratory problems as it helps the patient to breathe more easily (Srihaikul et al., 2012). Modern pharmacology looks for one active ingredient and seeks to isolate it to the exclusion of all the others. Most of the research that is done on plants continues to focus on identifying and isolating active ingredients, rather than studying the medicinal properties of whole plants. Plants used as medicines offer synergistic interactions between ingredients both known and unknown. The efficacy of many medicinal plants has been validated by scientists abroad, from Europe to the Oriental regions (Srihaikul et al., 2012).

**Herbal drugs and safety concern**

Herbal products are not completely free from side effects. Well-controlled randomized clinical trials have revealed that undesirable side effects are manifested in
patients who have used herbal drugs on a consistent basis. Cardiovascular problems with use of ephedra, hepatotoxicity by kava-kava consumption, anti-cholinergic effects leading to reduced visceral activity associated with asthma medicine containing Datura metel, water-retention by liquorice are reported examples of side effects due to herbal drugs (Elvin-Lewis et al., 2001; Cuzzolin et al., 2006). Due to increased reports on adverse effects regulatory/monitoring agencies in many countries have brought out alerts on herbal drugs. In 1993, the American Herbal Products Association (AHPA) issued an alert to restrict the use of comfrey (herbal medicine that contains pyrrolizidine alkaloids; PAs) for external applications. Cardiovascular ailments were reported with excessive use of a Chinese herb containing ephedra (used to promote weight loss) in the US led to its ban by USFDA in 2004 (Sahoo et al., 2010). The use of three herbal medicines that contain aristolochic acids (AAAs), namely Radix Aristolochiae Fangchi (Guangfangji), Caulis Aristolochiae Manshuriensis (Guanmutong) and Radix Aristolochiae (Qingmuxiang), were banned in China due to the potential risk of nephrotoxicity (Li et al., 2008). The most commonly reported adverse reactions are hypertension, hepatitis, face edema, angioedema, convulsions, thrombocytopenia, dermatitis and death (Uppsala Monitoring Centre, 2009; Sahoo et al., 2010).

The safety problems emerging with herbal medicinal products are due to a largely unregulated growing market wherein, there is a lack of effective quality control. Lack of strict guidelines on the assessment of safety and efficacy, quality control; safety monitoring and knowledge on traditional medicine/complementary and alternative medicine(TM/CAM) are the main aspects which are found in various regulatory systems. Under some regulatory systems, plant may be defined as a food, a functional food, a
dietary supplement or a herbal medicine (Sahoo et al., 2010). As per WHO, herbal medicines include herbs, herbal materials, herbal preparations and finished herbal products that contain as active ingredients parts of plants, or other plant materials, or combinations. Unprocessed exudates are also considered as herbal drugs (Sahoo et al., 2010). When herbal drugs are subjected to treatments such as extraction, distillation, expression, fractionation, purification, concentration or fermentation, they are known as herbal drug preparations. This includes powdered herbal drugs, tinctures, extracts, essential oils, expressed juice or process exudates. A botanical product which is derived from one or more plants, algae, or macroscopic fungi and prepared from botanical raw materials by one or more of the processes such as pulverization, decoction, expression, aqueous extraction, ethanolic extraction, or other similar process, intended for use as a drug is known as Botanical Drug Product (http://www.nistads.res.in/indiasnt2010-11/T3Industry/indian%20Herbal%20Drug%20Industry.pdf).

**Phytochemicals and human health**

Phytochemicals are substances that plants naturally produce to protect themselves various exogenous against such as bacteria, viruses, and fungi. There has been a lot of interest in phytochemicals recently because many of them can help to slow the aging process and reduce the risk for cancer, heart disease and other chronic health conditions (Kennedy and Wightman, 2011). Till date, more than 900 types of phytochemicals have been reported from various herbs and many are yet to be discovered. Fruits, vegetables, whole grains, soy and nuts are rich sources of polyphenols. Phytochemicals are usually related to plant pigments, so fruits and vegetables with bright colors (yellow, orange, red, blue,
purple, green) are rich sources of these disease fighting substances and the same have been recommended to be consumed daily (http://www.carrotmuseum.co.uk/phyto.html).

Phytochemicals, in combination with vitamins, minerals and fiber can provide immunity against diseases. Much of the protective effect of fruits and vegetables has been attributed to phytochemicals, which are the non-nutrient plant compounds such as the carotenoids, flavonoids, isoflavonoids, and phenolic acids (Boyer and Liu, 2004). Phytochemicals may inhibit induction and proliferation of cancer, regulate inflammatory and immune response and protect against oxidative modification of lipids (Hollman and Katan, 1997; Liu, 2003). We live in a highly oxidative environment, and many processes involved in metabolism may result in the production of more oxidants (Boyer and Liu, 2004). Both cardiovascular disease and cancer are thought to be resulting due to oxidative stress, leading to damage of the larger biomolecules, such as DNA, lipids, and proteins. It has been estimated that there are 10,000 oxidative hits to DNA per cell per day in humans (Ames et al., 1993). Hence, a major role of the phytochemicals is in providing much needed protection against oxidation of biomolecules.

**Importance of Anthocyanins**

Anthocyanins are the largest group of water-soluble pigments in the plant kingdom (Mazza et al., 1993). Chemically, they are polyhydroxylated or polymethoxylated glycosides or acylglycosides of anthocyanidins which are oxygenated derivatives of 2-phenylbenzopyryliumor flavylium salts.
They belong to the family of compounds known as flavonoids and they are distinguished from other flavonoids as a separate class by their ability to form flavylium cations. Anthocyanins are responsible for the red, blue and purple colors of fruits, vegetables, flowers and other plant tissues or products. They are particularly abundant in berries and other fruits with red, blue, or purple color and in red wines (Brouillard et al., 1982, Brouillard et al., 1989, Mazza et al., 1993, Mazza et al., 2004). Till date, about 400 individual anthocyanins have been identified. The six anthocyanidins commonly found in plants are classified according to the number and position of hydroxyl and methoxyl groups on the flavan nucleus and are named pelargonidin, cyanidin, delphinidin, peonidin, petunidin, and malvidin. The most commonly occurring anthocyanidin in nature is cyanidin. The antioxidant activity (scavenging free radicals, metal chelation, protein binding) of anthocyanins including the protection of LDL against oxidation, has been demonstrated in a number of different in vitro systems (Wrolstad et al., 2000, Mateus et al., 2001, Mateus et al., 2003)
Introduction

Flavonoids and their importance

Flavonoids are a group of phenolic compounds widely distributed in plant kingdom and they are important components of various foods of plant origin. Over 4000 structurally unique flavonoids have been identified in plant sources (Patel, 2008). These are recognized as the pigments responsible for the colors of leaves. They are rich in seeds, citrus fruits, olive oil, tea, and red wine. They are low molecular weight compounds composed of a three-ring structure with various substitutions. This basic structure is shared by tocopherols (vitamin E). Flavonoids can be subdivided according to the presence of an oxy group at position 4, a double bond between carbon atoms 2 and 3, or a hydroxyl group in position 3 of the C (middle) ring (Middleton et al., 2000).

**Figure 3:** Classification of flavonoids.

Dietary flavonoids have received considerable attention since epidemiological studies suggesting that regular consumption of flavonoid-rich foods or beverages is associated with a decreased risk of cardiovascular mortality (Hertog et al., 1993; Knekt et al., 1996). For instance, the Mediterranean diet, which is rich in these bioactive
compounds, has been shown to protect against chronic diseases, including coronary heart
diseases. Flavonoids have been shown to display a wide range of biological effects
although their health benefits have been attributed primarily to their antioxidant
properties (Patel, 2008). Certain plants and spices containing flavonoids have been used
for thousands of years in traditional Eastern medicine. Flavonoids have important effects
in plant biochemistry and physiology, acting as antioxidants, enzyme inhibitors,
precursors of toxic substances and pigments. It has been shown to possess several
biological properties such as hepato-protective, anti-thrombotic, anti-inflammatory, and
antiviral activities primarily due to their antioxidant and free-radical-scavenging ability
(Patel, 2008). The antiradical property of flavonoids is directed mostly toward HO; and
O2 - as well as peroxyl and alkoxyl radicals. Furthermore, as these compounds present a
strong affinity for iron ions (which are known to catalyze many processes leading to the
appearance of free radicals), their antiperoxidative activity could also be ascribed to a
concomitant capability of chelating iron. Several flavonoid compounds have been shown
to have antioxidant properties in vitro, inhibiting the oxidation of low density lipoproteins
and reducing thrombotic tendencies by inhibiting platelet aggregation (Cook and
Samman, 1996).

*Red cabbage (Brassica oleracea var. capitata f. rubra)*

The red cabbage (RC; *Brassica oleracea* var. capitata f. rubra) is a variety of cabbage
(family *Cruciferae*) with dark red/purple colored leaves that is grown in Northern
Europe, America and China (Singh et al., 2006). The plant changes its color according to
the pH value of the soil and amount of flavins (a type of anthocyanins). Wherever the soil
is acidic, the leaves of RC grow more reddish while in alkaline soil they are greenish-yellow in color. This explains the reason for their color variation and hence the same plant is known by different names based on color and geo-climatic variations. The juice of RC can act as a pH indicator as it turns red in acidic and blue in basic solutions. (http://en.wikipedia.org/wiki/Red_cabbage).

Figure 4: Classification of *B. Oleracea* (Red cabbage).

RC needs well fertilized soil and sufficient humidity to grow. It is a seasonal plant which is seeded in spring and harvested in late fall. (http://en.wikipedia.org/wiki/Red_cabbage).

Recently, RC has attracted much attention because of its physiological functions and applications. The anthocyanins from RC are stable under the acidic gastric digestion conditions, although all of the anthocyanins are reduced after pancreatic digestion but acylated forms were notably more stable than non-acylated forms (McDougall et al.,
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2007). Thus, RC dye has been used as a pH indicator in pharmaceutical formulations (Chigurupati et al., 2002) and as a colorant in food systems (Giusti and Wrolstad, 2003).

**Phytochemistry of red cabbage**

A total of 23 anthocyanins have been detected in red cabbage leaves, the major acylated anthocyanins in this vegetable included cyanidin-3-diglucoside-5-glucoside derivatives with various acylated groups connected to the diglucoside, mostly sinapoyl esters (Wu and Prior 2005; Scalzo et al. 2008). It was shown that *Brassica oleracea* rubrum extract was the source of cyanidin-3,5-diglucoside and cyaniding 3-sophoroside-5-glycoside acylated with sinapic, ferulic, caffeic, coumaric or malonic acids (Stintzing et al. 2002). Red cabbage (*B. oleracea*) leaves contain cyanidin 3,5-diglucoside, cyanidin3-sophoroside-5-glucoside, cyanidin 3-sophoroside-5-glucoside and cyanidin-3-sophoroside-5-glucoside acylated with 1 and 2 mol of sinapic acid (Tanchev & Timberlake, 1969). Also, presence of natural antioxidants such as, ascorbic acid, α-tocopherol and β-carotene, lutein etc. has been reported in the RC extract (Singh et al., 2006).

**Pharmacology of Red cabbage**

Published reports on RC extract have established its hypocholesterolemic (Komatsu et al., 1998), hepatoprotective (Igarashi et al., 2000; Singab et al., 2009), neuroprotective (Lee et al., 2002; Heo and Lee, 2006), nephroprotective in diabetic rats (Kataya and Hamza, 2008), anti-inflammatory (Lin et al., 2008) and anti-cancer (Fowke et al., 2003; Morsy et al., 2010) properties. Further, it has been shown to limits copper stress injury in
Introduction

meristematic cells of *Vicia faba* (Posmyk et al., 2008) and protects blood plasma proteins and lipids from hydrogen peroxide (Kolodziejczyk et al., 2011).

\[ \text{Cyanidin 3,5-diglucoside} \]

\[ \text{Cyanidin 3-sophoroside-5-glucoside} \]

\[ \text{Ascorbic acid,} \]

\[ \text{\( \alpha \)-tocopherol} \]
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Figure 6 Phytochemical constituents of red cabbage.

*Eugenia jambolana*
Introduction

**Kingdom** Plantae

**Division** Angiosperms

**Group** Eudicots

**Order** Myrtales

**Family** Myrtaceae

**Genus** Syzygium

**Species** *S. cumini*

*Figure 7:* Aerial parts and classification of *Syzygium cumini* (*Eugenia jambolana* Lam).

*Eugenia jambolana* Lam. (Syn. *Syzygium cumini* Skeels or *Syzygium jambolana* Dc or *Eugenia cuminii* Druce; family Myrtaceae) is a large evergreen tree indigenous to the Indian subcontinent. However today these trees are found growing throughout the
Asian subcontinent, Eastern Africa, South America, Madagascar and have also naturalized to the armer regions of the United States of America (in Florida and Hawaii) (Li et al. 2009; Warrier et al., 1996). The trees are famous for their fruits and their colloquial names, which include Java plum, Portuguese plum, Malabar plum, black plum, Indian blackberry, jaman, jambu, jambul and jambool are attributed to the fruits (Warrier et al. 1996). Based on the morphological and organoleptic features, there are two main morphotypes of Jamun - the Kaatha jamun (which are small and acidic to taste) and the Ras Jaman (oblong, dark-purple or bluish, with pink, sweet fleshy pulp and small seeds) found in the Indian subcontinent (Jabbar and Jazuddin 1994; Morton, 1987).

**Traditional uses**

Jamun is used extensively in the various traditional systems of medicine like in the Ayurveda, Unani, Siddha, in the Sri Lankan, in the Tibetan and in the Homeopathy systems of alternative and complementary medicine (Bhandary et al., 1999; Warrier et al., 1996). Prior to the discovery of insulin in Europe, Jamun was used for treating diabetes either alone, or in combination with other hypoglycemic plants (Helmstädter, 2007). According to Ayurveda, their barks are acrid, digestive and astringent and useful for treating sore throat, bronchitis, asthma, thirst, biliousness, dysentery and ulcers (Warrier et al. 1996). The ash of the leaves is used as a dentrificant and is effective at strengthening the teeth and the gums. The bark is also known to possess wound healing
Table 1: Scientific and vernacular names of *Eugenia jambolana* (Baliga et al., 2011).

<table>
<thead>
<tr>
<th>Language</th>
<th>Scientific name</th>
<th>Names</th>
</tr>
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<tbody>
<tr>
<td>Scientific name</td>
<td><em>Syzygium jambolanum</em>, <em>Eugenia cumini</em>, <em>Syzygium cumini</em>, <em>Eugenia jambolana</em></td>
<td>Jaman, black plum, damson plum, duhat plum, Indian blackberry, jambolan, jambolan plum, Java plum, Malabar plum, Portuguese plum, black plum, black plum tree, Indian blackberry, Jambolan, jambolan-plum, Java plum, malabar plum, Portuguese plum</td>
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<tr>
<td>English</td>
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<td>Indian languages</td>
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<tr>
<td>Assamese</td>
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<td>Jamu, kala jamu</td>
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<td>Bengali</td>
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<td>Kala jam</td>
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<td>Gujarati</td>
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<td>Jambu, jaambu</td>
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<td>Hindi</td>
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<td>Janun, duhat, jam, jaman</td>
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<td>Kannada</td>
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<td>Nerale hannu</td>
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<td>Konkani</td>
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<td>Jambul</td>
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<td>Malayalam</td>
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<td>Kaattukaampa, njaaval, njaara, perinjaara</td>
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<tr>
<td>Manipuri</td>
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<td>Gulamchat, jam</td>
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<td>Marathi</td>
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<td>Jambool</td>
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<td>Mizo</td>
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<td>Himunpui</td>
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<td>Nepalese</td>
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<td>Jamunu, phanrir</td>
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<tr>
<td>Nepalese</td>
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<td>Pali</td>
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<td>Prakrit</td>
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<td>Jambulo, jammulo</td>
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<td>Punjabi</td>
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<td>Jaman</td>
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<td>Sanskrit</td>
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<td>Jambu, jambulah, meghamodini</td>
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<td>Tamil</td>
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<td>Kottai-nakam, naval</td>
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<td>Telugu</td>
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<td>Nerodu</td>
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<tr>
<td>Urdu</td>
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<td>Jaman</td>
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properties. In the Siddha system of medicine, Jamun is considered to be a haematinic, semen promoting and to decrease excessive heat of the body (Warrier et al. 1996) whereas, in the Unani system of medicine, it has been reported as a liver tonic, to purify blood, strengthen teeth and gums. The decoction is supposed to be a good lotion for removing ringworm infection of the head (Warrier et al. 1996).
Phytochemistry of *Eugenia jambolana* (EJ)

The leaves of Jamun plant are known to contain β-sitosterol, betulinic acid, mycaminose, crategolic (maslinic) acid, n-heptacosane, n-nonacosane, n-hentriacontane, noctacosanol, n-triacontanol, n-dotricontanol, quercetin, myricetin, myricitrin and flavonol glycosides myricetin 3-O-(4″-acetyl)-α-L-rhamnopyranosides, acylated flavonol glycosides (Mahmoud et al., 2001; Sagrawat et al., 2006). The essential oil from the leaves is shown to contain the phytochemicals pinocarveol, α-terpeneol, myrtenol, eucarvone, muurolol, α-myrtenal, cineole, geranyl acetone, α-cadinol and pinocarvone (Shafi et al., 2002). The stem bark is reported to possess friedelin, friedelan-3-α-ol, betulinic acid, β-sitosterol, kaempferol, β-sitosterol-D-glucoside, gallic acid, ellagic acid, gallotannin and ellagitannin and myricetin (Rastogi and Mehrotra, 1990; Sagrawat et al. 2006). The flowers are observed to contain oleanolic acid, ellagic acids, isoquercetin, quercetin, kampferol and myricetin (Sagrawat et al. 2006). Studies conducted by various research groups have shown that the pulp of Jamun contains theanthocyanins, delphinidin, petunidin, malvidin-diglucosides, and these compounds are responsible for their bright purple color (Li and Seeram 2009; Sagrawat et al. 2006; Veigas et al. 2007; Sharma et al., 2008a; Sharma et al., 2008b). Seeds of EJ are the most studied and reported to contain jambosine, gallic acid, ellagic acid, corilagin, 3,6-hexahydroxy diphenoylg glucose, 4,6-hexahydroxy diphenoylg glucose, 1-galloylglucose, 3-galloylglucose, quercetin, β-sitoterol (Rastogi and Mehrotra 1990; Sagrawat et al. 2006). Details shown in Figure 7.

**Table 2**: Phytochemical constituents of *Eugenia jambolana* (Baliga et al., 2011).

<table>
<thead>
<tr>
<th>Plant part</th>
<th>Phytochemicals</th>
<th>References</th>
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<tr>
<td><strong>Introduction</strong></td>
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<table>
<thead>
<tr>
<th>Component</th>
<th>Constituents</th>
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</thead>
<tbody>
<tr>
<td>Stem bark</td>
<td>Friedelin, friedelan-3-ol, betulinic acid, β-sitosterol, kaempferol, gallic acid, ellagic acid, gallotannin and ellagitannin and myricetin.</td>
</tr>
<tr>
<td>Leaves</td>
<td>β-sitosterol, betulinic acid, mycaminoose, crategolic (maslinic) acid, n-heptacosane, n-nonacosane, n-hentriacontane, n-octacosanol, n-triacontanol, n-dotriacontanol, quercetin, myricetin, and the flavonol glycosides.</td>
</tr>
<tr>
<td>Flowers</td>
<td>Oleanolic acid, ellagic acids, isoquercetin, quercetin, kaempferol and myricetin.</td>
</tr>
<tr>
<td>Fruit pulp</td>
<td>Anthocyanins, delphinidin, petunidin, malvidin-diglucosides.</td>
</tr>
<tr>
<td>Seed</td>
<td>Largosine, gallic acid, ellagic acid, corilagin, 3, 6-hexahydroxydiphenoylgucose, 1-galloylglucose, 3-galloylglucose, quercetin, β-sitosterol, 4,6-hexahydroxydiphenoylgucose.</td>
</tr>
<tr>
<td>Essential oils</td>
<td>α-terpeneol, myrtenol, eucarvone, muurolol, α-myrenol, 1, 8-cineole, geranyl acetone, α-cadinol and pinocarvone.</td>
</tr>
</tbody>
</table>
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Friedelan-3-α-ol

Betulinic acid

β-sitosterol

Kaempferol

Gallic acid
Figure 8: Phytochemical constituents of *Eugenia jambolana*.
Introduction

n-nonacosane  n-hentriacontane

n-octacosanol  n-triacontanol

Quercetin  Oleanolic acid  Delphinidin

Petunidin  Malvidin-diglucosides  Corilagin
Figure 9: Phytochemical constituents of *Eugenia jambolana*. 
Figure 10: Phytochemical constituents of *Eugenia jambolana*.
**Pharmacology of Eugenia jambolana**

Jamun has been thoroughly investigated for its antidiabetic effects and the seed, pulp and bark have been found to have effective antidiabetic action (Sharma et al., 2006; Gohil et al., 2010; Saravanan and Leelavinothan, 2006; Sharma et al., 2006; Pepato et al., 2005), while the leaf was ineffective (Pepato et al., 2001). The seed is the most studied and the effective in causing anti-hyperglycemic effects in different experimental models of study (Achrekar et al., 1991; Panda et al., 2009; Rathi et al., 2002; Ravi et al., 2005, 2004a, 2004b, 2004c, 2004d; Sharma et al., 2008a, b; Sharma et al., 2003; Sridhar et al., 2005). Jamun seeds prevent the diabetes-induced secondary complications like nephropathy (Grover et al., 2002), neuropathy (Grover et al., 2002), gastropathy (Grover et al., 2002), diabetic cataract (Rathi et al., 2002) and also decreased peptic ulceration (Chaturvedi et al., 2007). Human studies have shown that Jamun possess promising anti-hyperglycemic effects (Kohli and Singh 1993; Sahana et al., 2010). Other reported pharmacological activities include, Antibacterial (Shafi et al., 2002), Antifungal (Jabeen and Javaid, 2010), Antiviral (Bhanuprakash et al., 2008), Free radical scavenging (Nahar et al., 2009), Anti-inflammatory (Muruganandan et al., 2001), Gastroprotective (Chaturvedi et al., 2007, 2009a,b), Hepatoprotective (Sisodia and Bhatnagar, 2009), Hypolipidemic (Sharma et al., 2008a,b), Cardioprotective (Mastan et al., 2009), Anti-diarrheal (Mukherjee et al., 1998), Antifertility (Rajasekaran et al., 1988), Anti-allergic (Brito et al., 2007), Antipyretic (Chaudhuri et al., 1990), Chemopreventive (Goyal et al., 2010).
Objectives and Work envisaged in a nutshell

1. Acute and subchronic toxicity evaluations of *Eugenia jambolana* seeds (EJSE) and *Brassica oleracea* leaf extracts or anthocyanin rich red cabbage extract (ARCE).
   Preparation of Anthocyanin rich extracts of the above mentioned herbals.
   To assess acute toxicity of these herbal extracts in mice model.
   To assess subchronic toxicity of these herbal extracts in rat model.

2. Assessment of therapeutic potentials of *Eugenia jambolana* seeds (EJSE) and *Brassica oleracea* (ARCE) leaf extracts against experimentally induced cardiac and hepatic oxidative stress.
   Hypothesis to be tested: Can anthocyanin rich extracts of these herbals successfully mitigate isoproterenol induced myocardial necrosis or CCl₄ induced hepatotoxicity in rats.

3. Assessment of *Eugenia jambolana* seeds (EJSE) and *Brassica oleracea* (ARCE) leaf extracts in mitigating experimentally induced atherosclerosis.
   Hypothesis to be tested: Can these herbals successfully mitigate PTU + vitamin D₃ + high fat diet induced atherosclerosis in Sprague dawley rats.