Phytochemical profiling of curry (*Murraya koenijii*) leaves and its health benefits

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ABSTRACT

Nutraceuticals and functional foods provide a chance to attenuate different physiological threats by improving the human health. Powerful bioactive components are responsible for antioxidant properties of herbs that help to alleviate different metabolic disorders. Plant based products are defensive against various metabolic disorders because of their bioactive components. *Murraya Koenijii* is a spicy plant that contains significant amount of vitamin C and minerals viz., calcium, iron, potassium and sodium. Major phyto-chemicals present in curry leaves are phenolic, carbazole alkaloids and phenols. Bioactive components in *Murraya Koenijii* can be extracted by different methods i.e. solvent extraction, soxhlet extraction and hydro-distillation. Antioxidant property of curry leaves helps to protect from high cholesterol level, cardiovascular diseases, diabetes and many other degenerative illnesses. In bakery products, replacement of wheat flour with curry leaf powder increase the carotenoid content and extract replaces the shortening along with improvement in phytochemicals content via lowering calories. Conclusively, the aim of this review is to explore the nutraceutical and functional aspects of *Murraya Koenijii* and its utilization in baked product to mitigate the lifestyle related ailments.

Keywords: Nutraceuticals, Antioxidants, Phytochemistry, carbazole alkaloids, Hypercholesterolemia, hyperglycemia

Introduction

The main purpose of eating food is our appetite but it also gives nutrients which are required by the human body. It also helps to prevent the human body from different dietary diseases and keeps the health in good condition (Menrad, 2003). Consumer preference regarding food commodities has also been changed to promote good health (Mollet and Rowland, 2002). Changing life style has modified basic food habits of people. Consumption of junk food is a major trend leading towards a number of diseases due to improper nutrition. Among them, heart diseases are leading cause of mortality in developing countries followed by cancer, arthritis, diabetes and cholesterol. A good quality food has good impact on consumer health as there is a direct relationship between food and health. In this respect, functional and nutraceuticals have opportunities for food industries not only to develop novel food products but also reduce care cost and improve source of revenue for rural population (Das et al., 2011).

Contemporary nutritional regime has revealed diet as one of the primary interventions to alleviate various metabolic syndromes for optimal health. In reliance to the modernized concept, functional and nutraceutical foods are gaining popularity among the masses. There are significant evidences supporting the presence of bioactive moieties in fruits and vegetables, helpful to attenuate lifestyle related disorders. These phytomolecules exert potential health benefits by mitigating degenerative risk factors like cardiovascular complications, diabetes, stroke, cancer etc. The proven facts also provide an insight regarding balanced nutrition and disease prevention. Thereby, functional and nutraceutical foods are imperative due to their assuaging nature, nutritional worth, sustainability and safe status (Aruoma et al., 2012; Barboza et al., 2012).

Phytochemical compounds have multiple health benefits so they are introduced in the food products to make the food rich in the nutrients. The benefits of phytochemicals include regulate the glucose level in human blood (Oestmann et al., 2006). They can decrease the blood cholesterol level (Cui et al., 2011), and also have anti-cancer effects (Kesari et al., 2007). Currently, lifestyle matters in a variety of ways; ease in life, diet with less hectic preparation and to relish palatability have adversely affected dietary pattern thereby worsened the metabolic pathways along with production of free radicals (Shahidi, 2009). The antioxidant components e.g. flavonoids and anthocyanin enhance the plasma antioxidant ability and protects from oxidation of LDL, which in turn provide protection from cardiovascular disease. They
also have a link to lower the systolic pressure. Many antioxidants prevent the lipid peroxidation (Sehmet et al., 2011).

The herbs and spices play a conspicuous role in human nutrition and therefore can be termed as nutraceutical (Srividya et al., 2010). Herbs and spices are important in human life as they are a good source of different antioxidant compounds, which have therapeutic effects against cancer and cardiovascular diseases (Suarez et al., 2010). Spices and herbs, in addition to contributing taste and aroma to foods, also contain a variety of bioactive substances which are of importance for health as well as for foods. These substances act as antioxidants, hypolipidemics and digestive stimulants. In recent years, spice extracts have achieved a lot of attention because they can easily be added to fats and oils in large amounts (Rao et al., 2007).

*Murraya koenigii* belongs to family Rutaceae, is an aromatic, pubescent, deciduous shrub or small tree. It is widely distributed in south-east Asia, Australia and the Pacific islands. In India, it occurs in wild and cultivated forms. In India it is very popular and medicinal plant. It has strongly aromatic leaves so they can retain their color and flavor even after drying. The fresh leaves of *Murraya koenigii* are a good source of β-carotene (Rao et al., 2011). The extract of the leaves of *Murraya koenigii* is thought to be an antidiabetic agent, as a spice and condiment in India. In tropical countries like Malaysia; it is found to be very effective in the treatment of kidney illness. These leaves also prevent the renal failure (Yankuzo et al., 2011).

Curry leaves are a rich source of minor constituents, such as Ca, K, Mg, P, along with Fe, Mn, Se and Zn, in trace amounts. Toxic element (As, Cd, Hg and Pb) contents were found to be below USFDA limits (Choudhury, 2007). The mineral content of curry leaves are: Fe 152 to 158 mg/kg, Na 795 to 800 mg/kg, Mg 14 to 18 mg/kg, Mn 96 to 98 mg/kg (Subramanian et al., 2012). According to the proximate analysis leaves of *Murraya Koennigi* consists moisture 63%, total nitrogen 1%, fat 6%, total sugar 14%, crude fiber 7% and ash 13% (Ganesan et al., 2013).

Bioactive compound of curry leaves have many functional properties. The *Murraya Koennigi* contains alkaloids like muconicine, mahanimbine, koenimbine, mahanimbidine, isomahanimbine, koene, koenigne and koenidine which have bioactive functions like anticancer,antidiabetic, anti-oxidative and antiulcer. The leaves contain the free amino acids: asparagin, glycine, serine, aspartic acid, glutamic acid, theonine, alanine, proline, tyrosine, tryptophan, amino butyric acid, phenylalanine, leucine, isoleucine and traces of ornithine, lysine, arginine and histidine. Extracts of spices, aromatic herbs and medicinal plants are most beneficial natural products that are widely utilized as ingredients in food products, pharmaceuticals and cosmetics because of their intense flavor, medicinal and antiseptic properties (Strehle et al., 2005).

Since last few years, prevalence of cardiovascular disorders is increasing tremendously and it is shooting up to alarming point not only in the developing countries but also in the developed countries. Antioxidant and cholesterol lowering activities of the isolated extracts/components of plants can prevent the lipid peroxidation (Sehm et al., 2010). Hypercholestrolemia is a condition characterized by abnormally increased levels of lipids (triglycerides, phospholipids, cholesterol and cholesterol esters) in the blood. It is a major modifiable causative factor for the prevalence of cardiovascular disease (CVD). Cholesterol has aroused as a sovereign menace for the occurrence of coronary heart diseases in the adults and elderly population. To reduce the incidence rate of mortality, it is homeopathically recommended to take controlled and undergo diet based therapy to reduce the lipid levels within the safe range (Bhutani et al., 2014).

A greater proportion of phenolic compounds in the diet have been found to diminish triglyceride and serum cholesterol quantity in rats (Biesalski et al., 2009). In a study on hypercholesterolemic type 2 diabetics, the impact of curry leaf powder was investigated by administrating curry leaf powder and extract at the concentration of the results in remarkable (P<0.01) diminution of serum total cholesterol, LDL-cholesterol and triacylglyceride in hypercholesterolemic patients (Yadav et al., 2002).
Another alarming disorder, diabetes mellitus is one of the major risk factors for the mankind around the whole globe. Diabetes mellitus (DM) is one of the complicated ailments which is increasing tremendously all around the world. The global prevalence of type II diabetes mellitus (DMT2) is on the rise and according to a nutritional survey by the year 2000 the sum of individual suffering with DM II in the whole world was estimated to reach more than 300 million by the year 2025 (Ismail et al., 2010). Nowadays diabetes mellitus is one of the most terrifying disarray for the mankind around the whole globe. Medicinally, herbs and spices have been used for the treatment of diabetes for more than 2000 years. Curry leaves is a spice which is used for the prevention of diabetes due to pharmacological properties owing to its essential oil as it reduces the blood glucose level. It can also ameliorate glucose intolerance (Watal et al., 2005). By ingesting curry leaf powder and curry leaf extract there was a clear reduction in blood glucose level whilst is inversely related with the insulin resistance. Curry leaves essential oil corrects pathological and hyperglycemia abnormalities in the diabetic rats due to its antioxidant effect and restorative potential of redox homeostasis mechanism, excellent recovery of pancreatic tissue can be explained by positive effect of curry leaves oil on the production of insulin because of regenerative effect of the exocrine pancreatic cells (Amin et al., 2011).

Functional and nutraceutical foods
Among the latest intrusions, functional foods and nutraceuticals are show high potential to improve consumer health as well as to assuage disease risks. Lately, scientific research has radically recommended the use of phytochemicals as a diet based regimen to secure the wellbeing of human health against certain lifestyle related maladies as obesity, hyperglycemia and hypercholesterolemia (Shahidi, 2009).

Quality nutrition is a core element for optimal health to mitigate various physiological disorders during different stages of life from childhood to elderly age. The health and Nutrition paradigm has significantly modified during the last few decades. Nowadays, food is not merely considered as a vehicle to supply nutrients for proper body functioning but also a source to maintain good health. Thus, core attention has been paid to illuminate the therapeautic role of the diet. This has set the ideology of functional and nutraceuticals as the food that exerts beneficial effects beyond nutrition thereby reducing various ailments (Hardy et al., 2000). Earlier, the US Foundation for Innovation in Medicine introduced the concept of nutraceuticals in 1989 as any food or a part of it that provides health benefits including disease prevention (Alissa & Ferns, 2012).

Hippocrates stated “Let food be your medicine and medicine be your food”. At the moment, the connection between diet and medicine is gaining more appreciation. For an extended period of time, natural products acquired chiefly from herbal sources have been consumed as noticeable source of protective mediators for the inhibition and remedy of disorders in human beings (Wildman and Kelley2007). Even though medicines cut down human torment with time, their high curing cost along with side effects make the nutritionists shift to diet based therapy as an alternative.

Now “nutraceutical a day may keep the doctor away” interchanges the old proverb “An apple a day will keep doctor away”. Failure of pharmaceuticals urged consumers to seek food supplements for improvement of health (Chaturvedi et al., 2011). However, the perception of functional food is dissimilar from the nutraceuticals and could be demarcated as particular food commodities that are consumed as part of the worthwhile diet in order to bestow specific positive influence apart from what are known as conventional nutritional properties. With the advent of nutraceuticals, the main focus is to achieve an ideal state of nutrition and health has become a challenge now (Srividya et al., 2010).

People lifestyle is changing along with poor cultural habits have made mind of scientists and researchers to explore out diet based therapies that are cost effective and safe (Robert, 2007). According to IFIC (International food info council-functional foods are dietary components in which health benefits are provided beyond the basic nutrition (Keservani et al., 2010). Functional foods are also called designer foods. Functional foods regulate biological processes in terms of controlling and preventing diseases. These foods should be an important part of our daily diet as well as they should be in their natural occurring state (Hardy, 2000).

Phytochemicals and antioxidant are two particular categories of nutraceuticals. The term phytochemical is related to plant chemicals. It is originated from the Greek word, “Phyto” denoting plant. Approximately more than 900 phytochemicals occurs in foods and 1 serving of each, either vegetable or fruit, could have around 100 diverse phytochemicals. Bright colored fruits and vegetables possess the most nutrients and
phytochemicals. Antioxidants are also imperative compounds that may be favorable in reducing chronic diseases. They perform the defense mechanism of body against oxidative damage and may be helpful in averting chronic disorders as well as provide anti-aging effects (Sivakumar et al., 2013).

**Herbs and spices: an inexplicable approach**

About 80% of entire world population depends upon the plants for food as well as medicinal needs. Different plant parts *e.g.* flowers, flower stems, roots, and young shoots, young leaves can be utilized as herbs, vegetables, spices and for many other therapeutic purposes. In the form of dietary supplements, these herbs can be offered in the formula of powders and capsules which may be different from food components/conventional foods.

Herbs and spices possess exceptional antioxidant worth owing to the occurrence of assorted phenolic moieties. The antioxidant assets of herbs and spices are valuable due to oxidative amendment of low density lipoprotein cholesterol in the buildup of atherosclerosis. Spices are not only consumed as flavorings agents and seasonings to enhance the flavor, but they can also be exploited as conventional medicines (Pal et al., 2003; Sinha, 2012).

Herbs and spices comprise traditional history with strong characters in the cultural heritage to appreciate food intake and its links to the health status. Herbs and spices contain many bioactive components that have been studied for their antioxidant activities in different researches (Tapsell et al., 2006). Herbal medicines also provide therapeutics for age-related maladies like memory loss, osteoporosis, immune disorders, etc. for which no modern medicine is available (Kumar and Reddy, 2012). Similarly, use of herbs and spices is also common to cure diabetes which is known as mother of diseases. Diet is considered as a corner stone to manage diabetes mellitus like problems. Dietary treatment of diabetes includes tremendous research for bioactive components from plants for antidiabetic action. Spices, common and natural food adjuncts are considered as effective in this way (Donga et al., 2011).

**Curry leaf: an insight**

*Murraya Koenigii* is a tropical to sub-tropical tree belonging to the family *Rutaceae*. It is commonly known as curry-leaf tree, is a native of India, Sri Lanka and other Asian countries like Bhutan, Laos, Nepal, Pakistan, Sri Lanka, Thailand (Kumar et al., 2013). It produces the leaves also known as sweet neem leaves. It is aromatic in nature, more or less deciduous shrub or tree up to 6 m in height and diameter is about 15-40 cm with short trunk. The leaves are pinnate and 15-30 cm long, with 11-25 leaflets, each leaflet length is about 2-4 cm and breadth is of 1-2 cm. Margins irregularly create, petioles 2-3 mm long. Flowers of this tree are bisexual, complete, sweetly scented, white, stalked, regular with average diameter of fully opened flower being in average 1.12 cm inflorescence, terminal cymes each bearing 60-90 flowers (Saini et al., 2013).

The useful parts of this plant are the leaves, root and the bark. *Murraya koenigii* is being used as stimulant, anti-dysentric and for the management of cholesterol and diabetes mellitus. (Onyade and Adebajo, 2009). Owing to its beneficial aspects it is utilized as traditional functional food and nutraceuticals as well as for anatomical applications such as antioxidant, anticancer, hyperglycemic, hypercholesterolemic, anticancer, antibacterial, antiulcer and anthelmintic agent.

Curry leaves possess strong spicy and seasoning type flavor. Scented and flavorful curry leaves is a popular spice and is widely cultivated for well recognized medicinal and culinary purpose. Culinary value of curry leaf is related to the organoleptic properties e.g. color, odor and flavor to its carbohydrates richness including sugars and minerals (Shrithi et al., 2010). The major constituent responsible for the aroma and flavor has been reported as pinene, sabinen, caryophyllene, cadinol and cadinene. The leaves have a slightly pungent, bitter and feebly acidic taste, (Singh et al., 2009; Kale et al., 2014).

Compositional profile of curry leaf includes; moisture 63.2%, fiber 6.8%, starch 14.6%, ash 13%, and total sugars 18.9% and fat 6.15% (Vandana et al., 2011). Udousoro et al. (2013) determined protein 6.1%, carbohydrates 16% and 4.4% total lipids in curry leaves. Curry leaves owns a diverse mineral profile. A study on curry leaves samples revealed concentrations of Ca, K, Mg and Mn, Hg ranging as 22.9±1.05, 17.8±0.6, 67.15±3.31, 1710±70 and 17.8±0.6, correspondingly. Afterwards, Singh and Garg (2006) estimated curry leaves minerals as Fe, K, Hg, Mn, Na and Zn as 1920, 22.6, 133, 86.9, 1020, 89.4., respectively. Lipid composition of seeds revealed 4.4% of total lipids of which 85.4 % neutral lipids, 5.1 % glycolipids and 9.5 % phospho-lipids (Jain et al., 2012). In addition, leaves are also rich in fibers, minerals and vitamins such as calcium, carotene, nicototinic acid and vitamin A in curry leaves and phosphorous, calcium, iron, vitamin B2,
niacin and vitamin C in curry leaves (Ganesan et al., 2013). *Murraya koenigii* leaves contain different phytochemicals including alkaloids, flavonoids, furocoumarins, terpenoids and tannins. A few bioactive compounds such as mahanimbily acetate, girinimbily acetate and bicyclomahanimbileine have been isolated and reported to possess antimicrobial and antioxidant activity (Naczk and Shahidi, 2004; Jain et al, 2012).

Leaves are rich in many bioactive compounds like polyphenols, alkaloids and flavonoids which showed multiple bioactive functions like antioxidant, anticancer, antimicrobial, antidiabetic and hepatoprotective The two carbazole alkaloids namely mahanimbine and koenigine found in these leaves showed higher antioxidant activities (Ganesan et al., 2013). The root extract also associated with many medicinal properties such as anti-bacterial, anti-inflammatory and anti-feedant. The major group of phytochemicals that may contribute to antioxidant capacity of fruits include polyphenols, carotenoids, and the traditional antioxidant vitamins such as vitamin C and E. The fruit polyphenols are the most important group of natural antioxidants because of their diversity and extensive distribution, and they possess the ability to scavenge both active oxygen species and electrophiles (Rani et al., 2012).

The chemical composition of the essential oil from leaves of *M. Koenigii* varies with variation in agro climatic and geographical variation. Monoterpenoids and its oxygenated derivatives are the main constituents of essential oil. Volatile oil obtained from flowers consists of 34.2% monoterpenoids and 43.9% % of sesquiterpenoids. Leaves constitute major components such as cis-ocimene (34.1%), β-caryophyllene (35.8%), α-pinene (19.1%), δ-terpenene (6.7%) and β-phellandrene (2.55%) and linalool (8.0%). There are some other components include are α- caryophyllene (9.16%), cardinene (8.40%), selinene (8.7), linalool (0.25 %), trans ocimene (3.1%), gujune (1.45%) which appear to be responsible for the intense odor associated with the stalk and flower parts of curry leaves (Nayak et al., 2008).

**In vitro studies of Murraya koenijii**

Medicinal plants consists significant amount of many antioxidants e.g. polyphenols, flavonoids etc. such phytochemicals contribute momentous perspectives of antioxidant potentials that are correlated with decreased mortality rates and lower occurrences of many human diseases. This property is due to their redox potential that plays a vital role in neutralizing, absorbing free radicals, triplet oxygen, quenching singlets as well as also in decomposition of peroxides (Ningappa et al., 2008). Natural antioxidants can be utilized to protect human beings from oxidative damage stress. These naturally occurring plant sources contain antioxidant compounds that are considered as free radical and active oxygen scavengers (Rani et al., 2012). Antioxidants reduce the risk of heart disease and enhance immunity; therefore it is imperative that it should be supplied to body through external sources (Gupta and Singh, 2007; Maharjan & Barsal, 2008).

A research was conducted to determine total antioxidant activity of curry leafed extract that showed 16.20g/100 g of extraction yield from water and 10.95g/100 g from ethanol while 21.25 micro sighn GAE from water and 90.00 µgGAE from ethanol. Water and ethanolic extract of curry leave showed 91.6 and 98.6% lipid peroxidation inhibition while alpha tocopherol, BHA and BHT exhibited 36.9, 94 and 976% inhibition of lipid peroxidation respectively. Ethanolic and water extract of curry leaved exhibits very effective antioxidant activity at all concentration but it increases with increasing concentration of sample (Kamarul et al., 2003).

Free radical scavenging potential of curry leaf extracts was determined by DPPH assay. It was increased with increasing con of curry leaves extract. Ethanol and essential oil of curry leaves showed excellent free radical scavenging potential with IC₅₀ of 23.61-26.75 and 32.32 microg/ml, respectively. IC₅₀ is concentration of extract which provides 50% inhibition. Free radical scavenging activity of ethanolic extract of curry leaves was greater than essential oil. 80% extracts of methanol and ethanol showed more free radical scavenging potential as compare to absolute methanol and ethanol extracts (Sivakumar et al., 2013). Antioxidant potential of phenolic components plays a significant role for stability of food products and antioxidant defense mechanisms of the biological systems. As the alcoholic extract shows ability to lower ferric ions to ferrous ions as noticed in the FRAP assay which is considered as an excellent actions of antioxidants.

**Certain lifestyle related metabolic disorders**

Each ethnic group has its own food cultures and food habits. These traditional habits have been adopted and influenced through contact with mainstream culture. Nowadays people are more attracted towards using fast foods due to inadequate food habit that are the main cause of many ill health effects (Kulkarni et al., 2004). In developing world, industrialized
countries are at greater risks of diseases such as overweight and cardio vascular problems have become potential cause of disability and death among population of developing countries (Jafar et al., 2006). The mortality rate of about 200,000 people around the world is due to obesity caused by diabetes every year. Obesity is chronic, costly and stigmatized disease that is rarely curable. It is noticed that about 13% children and 14% adolescents in age of 6 to 8 are overweight and 28% adults are obese and 61% are overweight (Vasudeva et al., 2012).

Obesity is a state in which concentration of lipid storing adipose tissue increase. It possess potential risks on life related diseases e.g. coronary heart problems, glucose intolerance, hypertension, dyslipidemia, diabetes and some types of cancers. Certain factors like lack of exercise, consumption of energy rich foods and sedentary lifestyle are contributive to etiology of obesity. Other complications e.g. hypertension, hyperandrogenism in women, hyperglycemia, insulin resistance and hyperlipidemia are related to upper body fat or intra-abdominal fat than overall fat adiposity. BMI range is between 25 and 30 can be considered as worthy of therapeutic intervention and medically significant especially in presence of certain risk factors e.g. glucose intolerance and hypertension that can be cause by adiposity. An efficient and urgent safe remedy is needed to control obesity (George and Nimmi, 2011).

Diabetes Mellitus is a class of metabolic disorders that comes from insulin defective actions, insulin secretions and often characterized by hyperglycemia. It has become one of most aggressively spreading lifestyle diseases. Diabetic patients are rest increase risks of peripheral arterial, atherosclerosis cardiovascular and cerebro vascular disease. Abnormal lipoprotein metabolism and hypertension are more common in the diabetic patients. Majority of diabetic cases comes under two broad and major pathogenic cases. First is type 1 diabetes with destruction of beta cells that lead to absolute deficiency of insulin A and also called as immune-mediated diabetes and the second is type 2 diabetes with the combination of insulin resistance action and an improper compensatory response of the insulin secretion (Joseph et al., 2011) type 1 diabetes was previously encompassed by many terms e.g. juvenile onset diabetes, insulin dependent diabetes that comes from cellular mediated auto-immune destruction of pancreatic b-cells. Auto-immune beta cells destruction has many multiple and genetic pre-dispositions but some time it is linked to environmental factors (Amartya et al., 2012).

Type-2 diabetes is accountable for 90-95% in the individuals with diabetes best known as non-insulin dependent diabetes or adult-onset diabetes. It includes those individuals with insulin resistance as they have relative deficiency of insulin. Throughout their life, these patients do not require treatment of insulin for survival initially. Type 2 diabetic patients are usually obese but obesity itself results into insulin resistance to some degree. For many years, this type of diabetes usually goes undiagnosed as hyperglycemia gradually develops. At early phases it is not serious enough for any patient to observe any classic symptoms of the diabetes. These patients are at greater risks of macro vascular and microvascular complications. In these patients secretions of insulin is defective and quite insufficient to compensate resistance of insulin. This resistance can be improved by the pharmacological treatment of hyperglycemia as well as weight reduction but it is often restored to normal. It is more common in the women with pre-gestational diabetes mellitus and among individuals with hypertension and dyslipidemia (Sudha et al., 2013). Type 2 diabetes genetics are complicated and not fully defined. Its frequency varies within different ethnic and different subracial groups (Sato et al., 2009). Control of blood sugar level is very crucial to cure diabetes. Herbal medicinal plants can be used to lower blood sugar level and for treatment of insulin resistance in diabetic patients (Babu et al., 2012).

Hyperglycemic aspects of curry leaves

The change in the dietary style and low physical activity generate many lifestyle related disorders like blood pressure, obesity, CVD and many others. Among these diabetes mellitus is rapidly growing health complication and one of the foremost reason of casualties in the world. In a survey it has been estimated that if this disease remain increasing with the current rate then in 2030 it will harm about 367 million peoples worldwide. It is a persistent metabolic disorder occurs in result of lower physiological activity and high caloric intake (Eckel et al., 2005).

In diabetes, chronic stage of hyperglycemia is related with long term damages, failure of any different organ e.g. kidneys, heart, blood vessels, eyes and nerves. Some pathogenic pathways include in the development of diabetes. In diabetes, the basic abnormalities in fat, protein complex processes of hormonal actions, inadequate secretion of insulin or diminished response of insulin to tissues at one or more than one points cause insufficient insulin actions. Chronic hyperglycemia can be accompanied by susceptibility to many certain infections and
impaired growth. Uncontrolled diabetes results into acute and life threatening consequences e.g. hyperglycemia with non ketotic and keto acidosis hypersmolar syndrome. An adequate glycemic control can be attained with exercise, oral glucose lowering components with proper glycemic control and weight reduction. Therefore, such individuals don’t need insulin. However, other individuals who have some residual insulin secretions can survive without it as they take exogenous insulin to fight against extensive beta cells destruction for adequate control of glycemic index (Metzger et al., 2010).

According to a research administration of curry leaf in alloxan induced diabetic rats helps to improve protein contents in the renal tubules of kidney in comparison to rats subjected to alloxan only. As an effective antioxidant curry leaves can protect SH-group of metallothionine and other proteins to prevent oxidation. When rats are treated with curry leaf extracts, it causes to increase amount of ribosomes in rough ER in the cells that reflect their ability to synthesize proteins (Lawal et al., 2008). In vivo study suggested that antioxidant component of curry leaf have the potential to decrease protein damages in tissues because curry leaf have high protein contains that are effective to improve pancreatic and kidney cell dysfunction produced by alloxan (Sierens et al., 2001).

Hypoholesterolemic aspects of curry leaf

Cholesterol is a type of fat that is present virtually in all cell membrane of body cells. Its main function in body is not only to provide cell integrity but also facilitates in transportation of phospholipids, synthesis of aldosterone, cortisol and secretion of hormones. However it should be in narrow limit as its deviation from normal range is life threatening. In body, there are two carrier proteins for transportation of cholesterol: low density proteins (LDL) and high density protein (HDL), each one has its own specific job (Onder et al., 2003).

LDL “referred as bad cholesterol” is primary carrier of cholesterol in blood. In atherosclerosis, LDL tends to accumulate into endothelial cells that lines inner walls of blood vessels and deposits in arteries. Further oxidation of LDL by free radicals modifies deposits structure that causes foaming and leads towards a hard plaque formation. This prevents flow of blood as well as oxygen to heart, brain and other organ due to which risk of heart attack and stroke increases that alleviates rate of mortality due to cardiovascular diseases (Brescianini et al., 2003).

On the other hand, HDL that is called as “good quality cholesterol” helps to remove excess cholesterol from atherosclerotic deposit and prevents plaque formation thus minimizing chances for cardiovascular disorders among person with high HDL level (Brown et al., 2004). Out of total body cholesterol 80% is produced within body by liver cells while 20% comes from dietary sources. Two key enzymes are of prime importance: HMG-CoA (3-hydroxy-3-methylglutaryl coenzyme A) reductase; the rate limiting enzyme engaged in cholesterol biosynthesis and other ACAT (acyl CoA: cholesterol O-acyltransferase) which participates in esterification of cholesterol in body tissues. Unfortunately, changing lifestyle and dietary trends modified body enzyme system that has increased risk of heart diseases and atherosclerosis (Bok et al., 1999).

Recent advances in medical research have triggered health expertise to suggest various drugs to normalize body cholesterol level. Various HMG CoA reductase inhibitors are being utilized in hypcholesterolemic drugs that are effective both for animal and human such as statins. They facilitate in removing circulatory LDL by inhibiting activities of HMG CoA reductase thus reducing cholesterol synthesis by liver. ACAT inhibitors are used as cholesterol lowering and anti-atherosclerotic agents in pharmaceutical products (Garg et al., 2012).

Statins (lovastatin) have been used as LDL cholesterol lowering drug but they have side effects if used for long time. Similarly, chronic use of statins for a long time also causes liver dysfunctioning (Bermudez and Ridker, 2002; Chang et al., 2004). There is a need to identify natural sources that are not only having therapeutic effects against hypercholesterolemia but also are cost effective, safer, non-toxic and readily available. It has been reported that bioflavonoids from plant sources are effective against life threatening diseases such as cancer, diabetes and hyperlipidemia. Among them curry leaf powder and extract are of crucial importance due to its wide biological spectrum.

Epidemiological studies revealed that curry leaves contains high level of antioxidants and help to reduce risks of cardiovascular problems by showing hypolipidmic and anti-atherogenic potential. Ethanolic extracts of Murraya Koenii shows very high antioxidant potential which contribute to potential probabilities of this plant to be used for therapeutic purpose for the treatment of hypercholesterolemia (Cosge et al., 2008). Phenolic compounds, flavonoids with linolenic acid, oleic acid and palmitic acid are the contributive towards
beneficial effect against arteriosclerosis (Singh and Jialal, 2006).

In a research work, ethanolic extract of curry leaf was investigated to check the effect on plasma lipid metabolism and liver for histopathological study in mice. This treatment resulted in a significant decrease in plasma lipid level. After 24 hours of treatment total plasma cholesterol, LDL cholesterol, triglycerides and Apo-lipo-protein B was decreased by 35, 50, 50 and 60% respectively. For histopathological studies it was revealed that ethanolic extract of curry leaf mitigate triglycerides deposition in fatty liver and facilitate flow of blood in coronary arteries by reducing serum and liver lipids. Overproduction of lipoproteins leads to the problem of lipoprotein metabolism called as dyslipidemia which is caused by elevation of total serum cholesterol, LDL cholesterol, triglycerides and lower level of HDL cholesterol. A research experiment revealed that animals fed with high fat diet significantly increased their fat pad weight and organ wt. When the animals were administrated with extract of curry leaf, it restricted disturbance in HDL triglycerides and HDL as well as body and fat pad weights (Garg et al., 2012).

**Health claims of curry leaf and its extract**

Risk potentials of synthetic food additives have changed interests, concerns and awareness of consumers. As a result, herbal and healthy nutraceutical market is gaining more attention to offer functional efficacy (Prabu et al., 2015). Metabolic syndrome which is characterized by visceral obesity, dyslipidemia, hyperglycemia, and hypertension has been progressively rising over the last few decades and has become a major public health trial across the world (Alberti et al., 2005). High consumption of natural foods e.g. herbs, spices, fruits and vegetables have been reported to mitigate risks of many serious health effects. *Murraya Koenigii* leaves contain many phytochemical compounds that stimulate significant detoxification process in body to eliminate risk strengthen and stimulate body’s immune system. Herbs have numerous free radical scavenging properties that assist to lower blood cholesterol along with sugar level. Thousands of herbs are known to possess therapeutic values around globe but >1% have been studied and many of them remain to be discovered (Heema et al., 2011).

Whole plants, leaves and root barks of curry leaves are antiemetic, stomachic and tonic; green leaves; infusion used as anti-diarrheal, anti-dysenteric and antiemetic; bruised and applied locally to eruption and poisonous bites; root-bark; relieves renal pain. Curry leaves play an important role in the treatment of wounds, burns, intestinal problems, coughs and general torpor. Use of traditional remedies and plants in the treatment of burns and wounds is an important aspect of health management and is also an efficient way to promote cheaper healthcare options. Removal and prevention of infection is essential for rapid and effective wound healing (Nagappan et al., 2012). Ganesan et al. (2013) reported that these are also used in the treatment of various diseases includes diabetes mellitus, body pain, inflammation, and vomiting and kidney pain. It has potential to act as it has anti-emetics, antidiarrheal, febrifuge, antifungal, blood purifier, depressant, anti-inflammatory, for kidney pain and vomiting when used as whole or as a part. Singh et al. (2012) reported that curry leaves are also used in calcium deficiency. It has Vitamin A, Vitamin B, Vitamin C, Vitamin B2, Calcium and iron in plenty, it is implicated in the treatment of several ailments including traumatic injury, diabetes, jaundice, and dysentery. The leaves of this plant have antidiabetic, anti lipidemic and antioxidant effect.

Different parts of *Murraya Koenigii* have been used in traditional Ayurveda medicine for the treatment of cough, hypertension, hysteria, hepatitis, rheumatism, poisonous bites, and skin eruptions. In addition, curry leaf has been found to have antitumor, anti-inflammatory, anti-hyperglycemic and hypoglycemic effects (Ghasezmadeh et al., 2014). The extract of curry leaves contains carbazole alkaloids which have various pharmacological activities such as anti-oxidant activities, diuretic, anti-tumor, anti-inflammatory, anti-convulsant, and anti-viral. The curry leaves have been known to promote appetite and digestion and have been popularly used as stomachic, purgative, anti-emetic, anti-inflammatory and carminative (Ramawamy et al., 2012).

Diabetic retinopathy or vision loss from diabetes can occur when the level of glucose is too high that elevates the level of sorbitol. Elevated sorbitol traps in the cells of retina that damage nerves to cause cataracts and eventually loss of vision. Diabetic retinopathy is categorized into (NDPR) non-proliferative diabetic retinopathy and (PDR) proliferative diabetic retinopathy which is characterized by the proliferation of novel blood vessels. NPDR is further classified into mild, moderate and severe stages that may or may not include macula diabetic macular oedema (DMO) development. Common causes of serious visual impairments are DMO and PDR. About all patients with diabetes Type 1 n more than 60% patients with...
diabetes 2 may have retinopathy by first decade of the incidence of diabetes (Tarr et al., 2013).

Medicinal plants can be used to treat patients with diabetic retinopathy as 80% of entire world population depends on traditional medicines. Carbazole alkaloids such as Isomahanine, Mahanimbine and Mahanimbinine were found to be very effective against diabetes (Shruti et al., 2012). Kumar et al., (2014) stated that extracts of Murraya koenigii provide protection to pancreatic beta cell and functional pancreatic islets that produce insulin. This was evident by the normalization of plasma insulin and C-peptide levels, indicating endogenous insulin secretion. Additionally, extracts of Murraya koenigii increased the levels of glucose-6-phosphate dehydrogenase enzyme, normalized hepatic and muscle glycogenesis, resulting in proper glucose utilization. The levels of post-prandial hyperglycemia were also reduced due to the pancreatic and intestinal glucosidase inhibitory activity of the extracts of Murraya koenigii.

CONCLUSION

Diet based therapies have recently been introduced throughout the world owing to positive physiological impacts on human body. Functional foods/nutraceuticals commonly known as dietary therapies are most effective, safe & economical with respect to present scenario of sedentary lifestyle, poor eating habits and higher medicinal cost. Moreover, nutraceutical and functional foods have captured considerable attention both in developed as well as in developing countries attributed to cardio-protective, antidiabetic and neuroprotective health effects. In addition, scientific facts support the concept of functional foods and/or nutraceuticals that have encouraging influence on physical condition and healthiness, beyond the provision of fundamental dietary requirements. In this perspective, curry leaf is a spice belonging to family Rotaceae. Curry leaf is rich with antioxidant components e.g. phenolic contents and flavonoids that enhance the plasma antioxidant ability and protection from oxidation of LDL, which in turn provide protection from cardiovascular diseases. They also have a link to lower the systolic pressure. Many antioxidants prevent the lipid peroxidation. Numerous literature has been depicted have revealed that Murraya Koenijii leaves and extract has great potential to mitigate metabolic syndromes. Murraya koenigii thus seems to be a promising plant with respect to its hypoglycemic effect and hypcholesterolemic effect may be prescribed as adjunct to dietary therapy and drug treatment for controlling diabetes mellitus and cardiovascular diseases have the hypocholesterolemic potential that affects the serum lipid profile by increasing high density lipoprotein (HDL) and decreasing low density lipoprotein (LDL), total cholesterol and triglycerides.

REFERENCES


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