I.1 Introduction

Vegetables constitute a major part of daily food intake by human population all over the world. Plant foods are rich in macro- and micro-nutrients as well as bioactive compounds, and have been recognized as a major source of dietary antioxidant with therapeutic benefits. Leafy vegetables are the least expensive sources of a number of nutrients. They are rich source of minerals, fibres, vitamins, carbohydrates, proteins and amino acids, both essential and non-essential, which provides important nutrient to human health. Green leafy vegetables are also recognized for their color, flavor and medicinal values. Plant produces a wide range of redox-active secondary metabolites (i.e. antioxidants) such as ascorbic acids, carotenoids, polyphenols and enzymes with antioxidant activity, which protect the cell from oxidative damages. Therefore epidemiological studies have consistently shown that there is a significant positive correlation between the consumption of fruits and vegetables and reduction in the risk of heart diseases mortalities, common cancers, and other degenerative diseases as well as aging. So scientists are giving a special interest to plant based food as they are the main sources of natural antioxidant. Daily consumption of fresh fruits and vegetables (>400 g/day) is recommended to help prevent major non-communicable diseases such as cardiovascular diseases and certain types of cancer.

The most serious concern for the survival of humanity is the ever-increasing gap between population growth and food supply. In order to arrest the situation discovery of new sources of plant food have generated great deal of interest among scientist for protein and non-protein calories to human diet. Malnutrition is of major concern for many developing nations. Integrating wild vegetables into diet has been promoted as one of the most practical, sustainable and inexpensive ways to overcome malnutrition since such vegetables are efficient sources of numbers of nutrients. The search for lesser-known crops, many of which are potentially
valuable as human and animal food, has intensified to maintain the balance between population growth and agricultural productivity, mainly in tropical and subtropical areas of the world. In developing countries numerous types of wild edible plants are exploited as a source of food which provides an adequate level of nutrition to the diet. In India, Thailand and Malaysia, about 150 wild plant species have been recommended for meals. There are various types of underutilized seasonally leafy vegetables of which practically no information is available on nutrient content and antinutritional factors. Consumption of such vegetables is confined to the people living in the areas where they grow.

I.2 Nutrition and Nutrients

Nutrition means the maintenance of health through proper diet. Human nutrition describes the process whereby cellular organelles, cells, tissues, organs, systems, and the body as a whole obtain and use necessary substances obtained from the foods to maintain structural and functional integrity. Again nutrients are the dietary substances that are required by humans and other organisms to live and grow. Nutrients can directly influence the genetic (DNA) expression, determining the types of RNA formed (transcription) and also the proteins synthesized (translation). For example, glucose increases transcription for synthesis of glucokinase, iron increases translation for synthesis of ferritin, while vitamin K increases post-translational carboxylation of glutamic acid residues for the synthesis of prothrombin. Nutrients can also act as substrates and cofactors in all of the metabolic reactions in cells necessary for growth and maintenance of structure and function.

Nutrients may broadly be classified as macronutrients and micronutrients. Macronutrients are the chemical compounds or elements that are required by humans and other organisms in a relatively larger quantity and they provide the bulk energy. Macronutrients include carbohydrates, proteins, fats and some macrominerals such as sodium, potassium, magnesium, calcium, phosphorus and sulphur. Micronutrients are the substances which are required by humans and other organisms throughout the life in trace amounts for normal physiological function and growth. These include mainly trace minerals, all types of vitamins and some organic acids. The science of nutrition is dedicated to learning about foods that the human
body requires at different stages of life in order to meet the nutritional needs for proper growth as well as to maintain health and prevent diseases.

There are more than 50 known nutrients and many more chemicals in foods thought to influence human function and health. Essential nutrients necessary for humans are listed Table I.1.

**Table I.1:** Types of nutrients for human nutrition

<table>
<thead>
<tr>
<th>Class</th>
<th>Sub-class</th>
<th>Nutrient Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbohydrates</td>
<td>Monosaccharides</td>
<td>Glucose, Fructose, Galactose</td>
</tr>
<tr>
<td>(Macronutrients)</td>
<td>Disaccharides</td>
<td>Sucrose, Maltose, Lactose</td>
</tr>
<tr>
<td></td>
<td>Polysaccharides</td>
<td>Starch and Dietary Fibre</td>
</tr>
<tr>
<td>Proteins</td>
<td>Animal proteins and</td>
<td>Amino acids : aliphatic, aromatic, sulphur containing, acidic, basic</td>
</tr>
<tr>
<td>(Macronutrients)</td>
<td>plant source proteins</td>
<td></td>
</tr>
<tr>
<td>Fats and oils</td>
<td>Saturated fatty acids</td>
<td>Palmitic and stearic acid</td>
</tr>
<tr>
<td>(Macronutrients)</td>
<td>Monounsaturated fatty</td>
<td>Oleic(cis) and elaicid (trans) fatty acids</td>
</tr>
<tr>
<td></td>
<td>acids</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Polyunsaturated fatty</td>
<td>Linolenic, α-lenolenic, arachidonic, eicosapentaenoic,</td>
</tr>
<tr>
<td></td>
<td>acids (n=3, n=6, n=9)</td>
<td>docosahexenoic acid</td>
</tr>
<tr>
<td>Minerals</td>
<td>Macroelements</td>
<td>Sodium, potassium, calcium, phosphrus</td>
</tr>
<tr>
<td></td>
<td>Microelements</td>
<td>Iron, zinc, copper, manganese, selenium, nickel etc</td>
</tr>
<tr>
<td>Vitamins</td>
<td>Fat soluble</td>
<td>Vitamin A, vitamin K, vitamin D, and vitamin K</td>
</tr>
<tr>
<td></td>
<td>Water soluble</td>
<td>Vitamin C, vitamin B₁, vitamin B₃, vitamin B₆ and vitamin B₁₂</td>
</tr>
</tbody>
</table>

Nowadays health scientists advocate use of those foods which are rich in natural antioxidants because of their tremendous health benefits. Vegetables and
fruits are the rich source of phenolic compounds such as flavonoids, flavones etc. as well as ascorbic acid, carotenoids. They possess strong antioxidant activity.

I.3 Relationships between Nutrition and Health

Nutrition is a major, modifiable and powerful factor in promoting health, preventing and treating diseases and improving quality of life. Many health problems are related to diet. It is a big tragedy that millions of people worldwide currently live with hunger and fear starvation. According to World Health Organization (WHO) malnutrition is the greatest single threat to the world’s public health. Though food security (i.e. access for all, at all times, to a sustainable supply of nutritionally adequate and safe food for normal physical and mental development and healthy, productive life) is a normal human rights for many countries, Food and Agricultural Organization (FAO), 2012 reports show that there are 925 million hungry people worldwide, 13.1% of total population or almost 1 in 7 people are hungry. WHO estimated that approximately 60% of all childhood death in developing countries is associated with chronic hunger and malnutrition. Nutritional status can be broadly categorized into two types:

(a) Optimal nutrition: When an individual gets the adequate, balanced and prudent diets. An optimal nutrition may be achieved by eating the right amounts of nutrients on a proper schedule.

(b) Malnutrition: Malnutrition arises due to an unbalanced diet where some nutrients are lacking, or in excess or in wrong proportions. Malnutrition, mainly under-nutrition, is caused by diet lacking adequate amounts of calories and proteins. This type of malnutrition is more common in poor and developing countries. Another form of malnutrition is over-nutrition which is mainly caused by overconsumption of diet specially macronutrients. It is not only one of the major health concerns in wealthier nations but also in the developing countries. The relationship between nutrition and health is listed in the Table I.2.
Table I.2: Relationship between nutrition and health

<table>
<thead>
<tr>
<th>Nutritional Status</th>
<th>Health Consequences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimal Nutrition:</td>
<td>Good health, well-being, normal development and high quality of life.</td>
</tr>
<tr>
<td>Malnutrition:</td>
<td>Decreased physical and mental development, compromised immune system, increased infectious diseases, cardiovascular diseases, diabetes, certain cancer, chronic non communicable diseases (NCD)</td>
</tr>
</tbody>
</table>

Micronutrients are involved in numerous biochemical processes and an adequate intake of certain micronutrients can prevent some deficiency diseases. Micronutrient deficiency, particularly vitamin A, iodine and iron, which can cause vision impairment, goiter and anemia respectively, is a major health concern worldwide. For example, iron deficiency related anemia affects 30% of the world’s population.\(^ {21}\)

Again overweight or obesity due to over-nutrition or imbalanced nutrition, another form of malnutrition, is also a serious health concern worldwide. According to medical sciences obesity is directly associated with many chronic illness such as heart disease, hypertension, hyperlipidemia, cancer, stroke and diabetes. For example, diabetes mellitus is also one of the major health concerns all over the world. WHO estimated that 150 million people had diabetes worldwide in 2002 and the number is projected to be double by 2025. The main causes of diabetes are the population growth, aging, unhealthy diets, obesity and sedentary lifestyle.\(^ {9}\) Diet habits mostly help to prevent and control such types of chronic illness; regular consumption of foods and vegetables are found to be beneficial for the same.

Body mass index (BMI) is a number that correlates a person’s height and weight. It is a useful tool for diagnosing obesity and protein-energy malnutrition. The BMI has also been associated with mortality, with lower values generally correlates with longer life.

\[
\text{BMI} = \frac{\text{weight (kg)}}{\text{height (m)}^2} \times 100
\]
Calculations based on values for ideal body weight suggest that BMI for normal man and women should be in between 19-27 kg/m\(^2\). The significance of BMI are listed in the Table I.3

**Table I.3: Significance of BMI values\(^{19}\)**

<table>
<thead>
<tr>
<th>Condition indicated</th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein-energy malnutrition</td>
<td>&lt; 17</td>
<td>&lt; 17</td>
</tr>
<tr>
<td>Underweight</td>
<td>&lt; 20</td>
<td>&lt; 19</td>
</tr>
<tr>
<td>Acceptable weight</td>
<td>20.7-27.8</td>
<td>19.1-27.3</td>
</tr>
<tr>
<td>Intervention indicated</td>
<td>&gt; 26.4</td>
<td>&gt; 25.8</td>
</tr>
<tr>
<td>Obese</td>
<td>&gt; 27.8</td>
<td>&gt; 27.3</td>
</tr>
<tr>
<td>Severely obese</td>
<td>&gt; 31.1</td>
<td>&gt; 32.2</td>
</tr>
</tbody>
</table>

Normal BMI values for infants

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Infant (at birth)</td>
<td>13</td>
</tr>
<tr>
<td>1 year</td>
<td>18</td>
</tr>
<tr>
<td>6 year</td>
<td>15</td>
</tr>
</tbody>
</table>

### I.4 Importance of Wild Leafy Vegetables

The multiple roles of traditional wild green leafy vegetables as both food and medicinal sources have been widely documented. Green leafy vegetables are rich source of many nutrients and form a major category of vegetable groups that have been designated as nature’s anti-aging wonders.\(^{22}\) Nowadays numerous types of wild vegetables are exploited as sources of food as they provide an adequate level of nutrition. Wild vegetables play a significant role in nutrition, food security and income generation. According to Food and Agricultural Organization, at least one billion people are thought to use wild food in their diet.\(^{17}\) In Ghana alone, the leaves of over 300 species of wild plants and fruits are consumed.\(^{16}\)Nesamvuniet al.\(^{22}\) reported that about 1400 edible plant species are used in diet in South Africa. In the Sahel region of Africa, over 200 wild foods were identified as used by the rural communities.\(^{24}\) Adebooye and Opabode\(^{25}\) reported the medicinal uses of 24 indigenous leafy vegetables in south western Nigeria. In most of these reports, it was emphasized that nutritionally, these unconventional plant foods could be comparable to or even sometimes superior to the introduced cultivars.\(^{26}\) Furthermore wild green
Leafy vegetables are found to be rich sources of natural antioxidants as they contain polyphenols, vitamins C and vitamin A. Consumption of these vegetables promotes good health by assisting in prevention of cancer and high blood pressure, stimulation of the immune system, improvement in drug metabolism, and tissue regeneration.\textsuperscript{27,28} It is, therefore, worthwhile to note that the incorporation of wild vegetables could be beneficial to nutritionally marginal population or to certain vulnerable groups within population, especially in developing countries where poverty and climatic changes are causing havoc to the rural populace. The most commonly consumed green leafy vegetable in India is amaranthus. In addition to this, a great variety of less familiar green leafy vegetables like basella, chekkurmanis, alternanthera etc. are also consumed locally in different parts of the country.

North-East region of India is rich in plant biodiversity along with human race diversity with distinct culture and food habits. The states are abundant in hills, rivers, forest and very large wetlands which are mostly inhabited by tribal people. These people use different untapped wild plants as their food and medicine. Phytochemical investigation of these wild vegetables may solve the problems of malnutrition of these poor people and systematic cultivation of these vegetables may improve their financial status. Only a few of the vast plant resources including large number of edible vegetables found in North-East India are cultivated. Vast population of this region, especially those tribal populations living in rural areas, foothills and near reserve forests are still fond of wild vegetables and these are their main source of nutrient supplements. There is a need that nutritional values of these wild vegetables should be scientifically studied, and their importance be compared with cultivated ones. This would open an avenue for popularizing these vegetables for mass consumption leading to cultivation and commercialization with an ultimate objective of removing malnutrition with easily available vegetables at affordable cost. This investigation is a small step towards this objective.
I.5 Importance of Mineral in Human Health

Minerals are of critical importance in the diet, even though they comprise only 4-6% of human body. A sufficient supply of mineral nutrients in a balanced diet is required to maintain vital organ function. Minerals play an essential role in the physiologic process of cell metabolism, cell division, energy metabolism and immune response. Minerals can be classified broadly as macro minerals and trace minerals. Macro minerals are those required in amounts greater than 100 mg per day and they represent 1% or less of bodyweight. Major elements include calcium, magnesium, phosphorus, potassium, sodium, chlorine and sulfur. Again trace elements are those which are required by our body in trace amount, less than 100 mg per day and makes up less than 0.01% of body weight, but are essential for the sustenance of life and their absence results in severe malfunction of the organs or even death. The essential trace elements are zinc, iron, silicon, manganese, copper, iodine and chromium.

Functions and impact on human health of macro and trace elements are discussed below:

Sodium

Sodium is present in all of the body's cells, as well as the blood and other body fluids. Sodium is an essential element required in appropriate amounts in daily diet to maintain acid-base balance, body fluid balance, muscle contraction and nerve impulse transmissions. Chronic sodium deficiency is rare, although sodium loss can occur because of diarrhea, vomiting, profuse perspiration due to athletics and other strenuous activity, and the overuse of diuretics. Deficiency symptoms include dehydration, low blood pressure, muscle cramping and twitching, and muscle weakness. The increased level of Na content in our body and low intake of K has direct link to high blood pressure. The K/Na ratio in our body is of great concern to prevent high blood pressure and the ratio should be greater than 5:1 to maintain optimal health. The recommended Na intake by an individual in the developing countries is between 2400 – 5175 mg/day.
Potassium

Potassium is the major extracellular cation which plays a vital role in cellular mechanism. A proper level of K is important for normal cell function. Potassium works closely with sodium and chloride to maintain fluid distribution and pH balance, and to maintain nerve impulse transmission, muscle contraction, and regulation of heartbeat and blood pressure. Potassium has a role in the synthesis of protein and muscle tissue. An abnormal increase of potassium (called hyperkalemia) or decrease of potassium (called hypokalemia) can profoundly affect the nervous system and heart and, when extreme, can be fatal. Potassium also plays an important role in mental function as it helps to promote efficient cognitive function by playing a significant role in getting oxygen to brain. According to medical science the daily recommended potassium intake is 4700 mg/day. Fruits and vegetables are the major source of potassium and potassium/sodium ratio in fruits and vegetables is found to be well balanced. Consumption of fruits and vegetable in daily diet can provide sufficient and balanced amount of potassium to our body which can help to prevent high blood pressure.

Calcium

Calcium is one the most abundant mineral in the human body, with approximately 99% of it occurring in bone tissue, and the remaining one percent being used for a variety of other biochemical functions, including blood clotting, muscle contraction, and nerve function. Calcium along with phosphorus is important for growth and healthy maintenance of bones, teeth, muscles and blood. Calcium provides energy and participates in the protein structuring of RNA and DNA. It is also involved in the activation of several enzymes including lipase. The amino acid lysine is needed for calcium absorption. Calcium protects the bones and teeth from lead by inhibiting absorption of this toxic metal. Calcium deficiency may result in muscle cramps, nervousness, heart palpitations, brittle nails, eczema, hypertension, aching joints, increased cholesterol levels, rheumatoid arthritis, tooth decay, insomnia, rickets, and numbness in the arms and/or legs. Insufficient vitamin D intake or excess phosphorus and magnesium hinder the uptake of calcium. Although
heavy exercising also hinders calcium uptake, moderate exercising contributes to its uptake. Milk and dairy products are excellent sources of calcium, both qualitatively and quantitatively. Green leafy vegetables, seeds and legumes are good alternative sources of calcium, in addition to cow milk and fish with bones.36

**Phosphorus**

Phosphorus is essential as it is involved in numerous normal physiological functions including skeletal development, mineral metabolism, energy transfer through mitochondrial metabolism, cell membrane phospholipid content and function, cell signaling and platelet aggregation. About 85% of an adult’s body phosphorus is found in bones while the remaining 15% are in the soft tissues. It is essential for growth, maintenance, and repair of all body tissue, and is necessary, along with calcium and magnesium, for proper growth and formation of bones in infants and children. Adequate phosphorus intake is essential throughout life to ensure the proper balance of essential minerals in order to promote remineralization of bones and teeth to keep them in a healthy state. According to Institute of Medicine (IOM)37 recommended dietary allowance of phosphorus is 1250 mg/day at young age (9 to 18 yr.) while for adults the value is 700 mg/day.

**Magnesium**

Magnesium is essential for humans as it is involved in biochemical functions like bone mineralization, protein synthesis, converting blood sugar to energy, muscular contraction and relaxation, proper heart function, nerve transmission, absorption of calcium, vitamin C, phosphorus, sodium, and potassium.38 Magnesium acts as a muscle relaxant in the body, and is involved in hundreds of enzymatic reactions. Approximately 65% of the body's magnesium supply is contained in the bones and teeth, with the second highest concentration occurring in the muscles. In addition to its ability to relax skeletal muscles, magnesium is an important nutrient for the heart, especially in preventing spasms of the coronary arteries, which can cause heart attacks. Magnesium ion helps to stabilize three dimensional structures of RNA and DNA and is thus crucial to proper functioning of the genetic machinery of the cell. Deficiency of Mg is rare in healthy individuals; prevalent in chronic alcoholism, renal dysfunction, hyperparathyroidism, and diabetes. The daily
recommended allowance of Mg is 320-420 mg/day. Deficiency may cause weakness, confusion, hypertension, arrhythmia, depressed pancreatic hormone secretion, heart arrhythmia, growth failure, behavioral disturbances, and muscle spasms. Green leafy vegetables, fruits, cereals, legumes and sea foods are the richest sources of magnesium.

**Iron**

Iron is the most widespread of transition metals in living systems. It is the core component of red blood cells. The primary function of iron is to manufacture of hemoglobin. In addition it is essential for healthy immune system and energy production. Iron is also an essential cofactor in the synthesis of neurotransmitter such as dopamine, epinephrine, and serotonin. Iron deficiency may lead to diseases like anemia, bone weakness, headache, depressed immunity, behavioral abnormalities, reduced cognitive function, etc. Excessive iron intake may interfere with absorption of copper and zinc and also it can cause a rare hereditary condition known as Wilson's disease. The recommended daily allowance of iron for adults is 11-18 mg/day. Animal food sources of iron include beef, pork, poultry, fish, shellfish, eggs, etc. which contain heme iron. Plant sources such as dried beans, peas, lentils, whole wheat, oatmeal prunes, green leafy vegetables, mushrooms, cocoa and chocolate, bananas, eggplants, soy products, oranges, raisins, coffee, farina, legumes, dried fruits, beets, whole grains, nuts and seeds, broccoli, tomatoes, brewer's yeast, enriched pasta, pumpkin, fortified cereals, as well as foods cooked in cast iron pots are all non-heme iron sources.

**Zinc**

Zinc is one of the most essential trace mineral found in every cell of human body which plays many diverse roles in enabling healthy growth and development and in promoting good health in general. Zinc is reported as coenzyme for over 200 enzymes involved in immunity, new cell growth, acid base regulation etc. Zinc plays an important role in the manufacture of protein and genetic material, normal growth and skeletal development. It also assists in hormonal activity, reproduction and lactation. Zinc deficiency may cause decreased appetite, impaired taste, and growth failure in children, delayed development of sex organs, reduced immune function,
poor wound healing, and metabolic disturbances. The recommended daily allowance is 10 mg/day in growing children over one year old and 15 mg/day for adults. The main dietary sources of zinc are the meat, liver, egg, seafood. Zinc is also available from other food sources such as legumes, whole grain cereals, nuts, fruits and green leafy vegetables.

**Copper**

Copper is an essential trace elements as it is a component of several enzymes necessary for normal metabolic function. Among its many functions, copper aids in the formation of bone, hemoglobin, and red blood cells, and works in balance with zinc and vitamin C to form elastin. It is involved in the healing process, energy production, hair and skin coloring, and taste sensitivity. This mineral is also needed for healthy nerves. A diet low in copper can contribute to both osteoporosis and ischemic heart disease. Recommended daily allowance (RDA) of copper for adults is 0.9 mg/day. The best food sources of copper include almonds, avocados, barley, beans, beet roots, blackstrap molasses, broccoli, dandelion greens, garlic, lentils, liver, mushrooms, nuts, oats, oranges, organ meats, pecans, radishes, raisins, salmon, seafood, soybeans dark green leafy vegetables, eggs, organ meats, poultry, nuts, shellfish, and wholegrain breads and cereals.

**Manganese**

Manganese is a ubiquitous element that is essential for normal physiological functioning in all animal species. Manganese is located largely in the mitochondria. It activates numerous enzymes, such as hydrolase, transferases, kinase, and decarboxylases and is constituents of some enzymes. Manganese activates enzymes associated with fatty acid metabolism and protein synthesis, and is involved in neurological function. Manganese is also required for thyroid function and is involved in the formation of thyroxin. Several disease states in humans have been associated with both deficiencies and excess intakes of manganese. National Research Council (NRC) determined an "estimated safe and adequate daily dietary intake" (ESADDI) of manganese to be 2-5 mg/day for adults. Manganese deficiency may cause skeletal abnormalities, postural defects, impaired growth, impaired reproductive function and disturbances in lipid and carbohydrate metabolism.
Nickel

Nickel is one of the essential elements which is indispensable for many of metabolic reactions in living beings. Nickel is present as a coenzyme in different enzymes such as urease. According to Agency for Toxic Substances and Disease Registry (ATSDR) the acceptable range of nickel daily intake is 3-7 mg/day. No specific deficiency state of Nickel has been identified although it is considered likely be an essential micronutrient.

I.6 Antioxidant Activity and its Impact on Human Health

Antioxidants are the compounds that slow or inhibit the oxidation of lipids or other molecules by inhibiting the initiation and propagation of oxidizing chain reactions. Antioxidant are present in fruits, vegetables, cereals, leguminous plant, juices, red wine, tea and many herbs. The major antioxidants of vegetables are vitamin C and E, carotenoids, and phenolic compounds especially flavonoids. In our body free radicals, mainly reactive oxygen species (ROS) such as superoxide (O$_2^-$), hydroxyl radical (OH$^-$), peroxyl radical (ROO$^•$), and singlet oxygen (O$_2^1$) are generated constantly as a result of normal oxidative metabolic process. Also some exogenous factors such as certain disease, smoking, pollution, alcoholism and ionizing radiation promote the generation of excess free radicals.

Our body has antioxidant defense system which is controlled by some enzymes such as superoxide dismutase (SOD), glutathione peroxidase (GPx), catalase (CAT) etc. If there is an excess generation of free radicals in our body, antioxidant defense system cannot protect from the oxidative damage of cells and oxidative stress is generated in our body. All cellular components, proteins, polyunsaturated fatty acids, nucleic acids and carbohydrates, are prominent biological targets of ROS, giving rise to metabolic and cellular disturbances and accelerating aging. ROS can easily initiate the peroxidation of membrane lipids, leading to the accumulation of lipid peroxides. Also ROS may cause DNA damage leading to mutation. Various studies have demonstrated a close link between oxidative stress and development of different chronic and degenerative diseases such
as cancers, heart diseases, liver disease, inflammation, diabetes, atherosclerosis, Alzheimer’s and Parkinson’s disease. Therefore human health depends on the efficiency of antioxidant mechanism. Intriguing new research suggests that regular consumption of leafy vegetables and fruits can enhance the activity of superoxide dismutase throughout the body. Regular supplement of antioxidant can assist the endogenous defense system to counterbalance the harmful effect of excessive ROS.

Antioxidants are of two types - synthetic and natural. But synthetic antioxidants such as butylatedhydroxytoluene (BHT), butylatedhydroxyanisole (BHA), tert-butylhydroquinone (TBHQ) are suspected of being responsible for some severe toxic and carcinogenic effect. In contrast natural antioxidants are healthier and safer than synthetic antioxidants. Thus natural antioxidants, from medicinal plants, vegetables, and fruits, are considered to be better alternatives and receive increasing attention.

Vegetables and fruits are excellent dietary sources of natural antioxidant. Plant derived antioxidants such as vitamin E, vitamin C, polyphenols including phenolic acids, phenolic diterpenes, flavonoids, catechins, procyanidins and anthocyanins are being increasingly suggested as important dietary factor. Synergistically these natural dietary antioxidants provide bioactive mechanism to reduce free radical-induced oxidative stress. These antioxidants scavenge radicals and inhibit the chain initiation or break the chain propagation. Consumption of fruits and vegetables has been associated with reduced risk of some chronic diseases including the most dangerous coronary atherosclerosis. Epidemiological studies have demonstrated an inverse association between intake of fruits and vegetables and mortality from age related diseases, such as coronary heart diseases and cancer which may be attributed to their antioxidant activity. Researchers have estimated that every serving increase in fruits and vegetable consumption reduces the risk of cancer by 15%, cardiovascular disease by 30% and mortality by any cause by 20%.

Study of antioxidants present in vegetables, fruits and other foods has become one of the most popular topics in the area of food and agricultural research today. Accordingly, many assays for investigation of antioxidant activity have been developed and applied. The majority of assays are based on spectrophotometry, such
as thiobarbituric acid (TBA) assay, ferric thiocyanate (FTC) assay, 2,2-diphenyl-1-picrylhydrazyl (DPPH) assay, 2,2′-azinobis(3-ethylbenzothiazoline-6-sulphonic acid) (ABTS) assay, ferric reducing antioxidant power (FRAP) assay etc. It is generally recognized practice to used more than two different methods for the investigation of antioxidant activities of plant materials.

1.7 Polyphenols in Vegetables

Phenolic compounds are secondary plant metabolites that are thought to be an integral part of human diet and naturally present in almost all plant including food products of plant origin. Phenolic compounds are classified into three major groups based on the chemical structures: simple phenol and phenolic acid (Benzoic acid derivatives), hydroxycinnamic acid derivatives, and flavonoids. The phenolic profiles of the plants may change depending on the condition imposed by soil, season, climate, plant component and other parameters. The majority of natural antioxidants are phenolic compounds, and the most important group of natural antioxidants are the tocopherols, flavonoids and phenolic acids. The antioxidant activity of phenolic compounds is mainly due to their redox properties, which allow them to act as reducing agents, hydrogen donors, and singlet oxygen quencher. Also they have a metal chelation potential. The antioxidant properties of phenolic compounds are responsible for the inhibition of oxidation of low density lipoprotein cholesterol.

Flavonoids are a large group of naturally occurring plant phenolic compounds including flavones, flavonols, isoflavones, flavanones and chalcones which occur in all type of higher plant tissues. Flavones and flavonols are found in almost every plant, particularly in leaves and petals, with flavonols occurring more frequently than flavones. More than 8000 polyphenolics, including 4000 flavonoids, have been identified in different plant species and the number is still growing. Flavonoids contain a characteristic C$_6$-C$_3$-C$_6$ structure (Table I.4), with free hydroxyl groups attached to aromatic rings, and they inhibit lipid oxidation by scavenging radicals or by other mechanisms such as singlet oxygen quenching, metal chelation, and lipoxygenase inhibition. Flavonoids and other phenolics have been suggested to play a protective role in the development of cardiovascular disease and cancer. Also flavonoids are among the major antioxidant constituents of our diet. The most
significant roles of flavonoids are the protection against oxidative diseases, ability to modulate the activity of various enzymes, and interaction with some specific receptors.

**Table I.4: Structure of flavonoids**

A. Flavones & flavonols

<table>
<thead>
<tr>
<th></th>
<th>R₁</th>
<th>R₂</th>
<th>R₃</th>
<th>R₄</th>
<th>R₅</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flavones</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apigenin</td>
<td>H</td>
<td>H</td>
<td>H</td>
<td>OH</td>
<td>H</td>
</tr>
<tr>
<td>Chrysin</td>
<td>H</td>
<td>H</td>
<td>H</td>
<td>H</td>
<td>H</td>
</tr>
<tr>
<td>Luteolin</td>
<td>H</td>
<td>H</td>
<td>OH</td>
<td>OH</td>
<td>H</td>
</tr>
<tr>
<td>Flavonols</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Datiscein</td>
<td>OH</td>
<td>H</td>
<td>OH</td>
<td>OH</td>
<td>H</td>
</tr>
<tr>
<td>Quercetin</td>
<td>OH</td>
<td>H</td>
<td>OH</td>
<td>OH</td>
<td>H</td>
</tr>
<tr>
<td>Myricetin</td>
<td>OH</td>
<td>H</td>
<td>OH</td>
<td>OH</td>
<td>OH</td>
</tr>
<tr>
<td>Morlin</td>
<td>OH</td>
<td>OH</td>
<td>H</td>
<td>OH</td>
<td>H</td>
</tr>
<tr>
<td>Kaempferol</td>
<td>OH</td>
<td>H</td>
<td>H</td>
<td>OH</td>
<td>H</td>
</tr>
</tbody>
</table>

B. Flavanones

<table>
<thead>
<tr>
<th></th>
<th>R₁</th>
<th>R₂</th>
<th>R₃</th>
<th>R₄</th>
<th>R₅</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flavanones</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hesperetin</td>
<td>H</td>
<td>H</td>
<td>OH</td>
<td>OCH₃</td>
<td>H</td>
</tr>
<tr>
<td>Naringenin</td>
<td>H</td>
<td>H</td>
<td>H</td>
<td>OH</td>
<td>H</td>
</tr>
</tbody>
</table>
C. Flavanonol

\[
\begin{align*}
&\text{Flavanonol} & \text{Taxifolin} & \text{OH} & \text{H} & \text{OH} & \text{OH} & \text{H} \\
\hline
\end{align*}
\]

D. Isoflavones

\[
\begin{align*}
&\text{Isoflavones} & A_5 & A_7 & R_4 \\
&\text{Genistein} & \text{OH} & \text{OH} & \text{OH} \\
&\text{Genistin} & \text{OH} & \text{Oglc} & \text{OH} \\
&\text{Daidzein} & \text{H} & \text{OH} & \text{OH} \\
&\text{Daidzin} & \text{H} & \text{Oglc} & \text{OH} \\
&\text{Biochanin A} & \text{OH} & \text{OH} & \text{OCH}_3 \\
&\text{Formononetin} & \text{H} & \text{OH} & \text{OCH}_3
\end{align*}
\]

Oglc = O-glycosidic residue

Polyphenols have become an intense focus of research interest because of their numerous beneficial effects on health, including anticarcinogenic, antiatherogenic, antiulcer, anti-thrombotic, anti-inflammatory, immune modulating, antimicrobial, vasodilatory, and analgesic effects.$^{67}$ Therefore search for natural antioxidants, especially of plant origin, has greatly increased in recent years.
I.8 Vitamin C Content of Vegetables

Vitamin C (ascorbic acid) is considered to be one of the most powerful and least toxic natural antioxidant.\textsuperscript{68,69} It is a water soluble vitamin and is found in high concentration in fruits especially in citrus fruits, kiwi fruits, cherries, melons and in vegetables such as tomatoes, green leafy vegetables, broccoli, and cabbage. Since human cannot synthesize ascorbate, their main source is the dietary fruits and vegetables. Humans do not store vitamin C in the body; therefore, they must be consumed regularly to avoid deficiencies. Ascorbic acid is a very effective scavenger of ROS especially superoxide radical anion, $\text{H}_2\text{O}_2$, hydroxyl radical, and singlet oxygen.\textsuperscript{66} In aqueous solution it also scavenges the reactive nitrogen oxide specie efficiently. In vitro studies show that vitamin C is capable of regeneration of tocopherol from tocopheroxyl radical which generated on inhibition of lipid peroxidation of vitamin E. In addition vitamin C has well established biological functions including cofactor activity of several important enzymes such as hydroxylases\textsuperscript{66}. Ascorbic acid is an effective reductone as it can donate a proton and forms a relatively stable ascorbate anion. In other words, ascorbic acid can be considered as an enol where the deprotonated form is a stabilized enolate (Scheme I.1). Also the human plasma contains about 60 $\mu$molascorbate. On interaction with ROS, ascorbate is oxidized to dehydro-ascorbate via an intermediate ascorbyl free radical. Dehydro-ascorbate is recycled back to ascorbic acid by the enzyme dehydroascorbatereductase.

![Scheme I.1: Deprotonation of ascorbic acid and formation of enolate](image-url)
I.9 Dietary Fibre Content of Vegetables

I.9.1 What is dietary fibre?

Dietary fibre (DF) is among the food ingredients, called nutraceuticals, which are shown to have the potential to improve human health, if consumed in adequate amounts. It is difficult to define by a single definition, as it encompasses a wide range of complex materials. According to American Association of Cereal Chemists (AACC) dietary fibre (DF) is defined as the ‘edible part of plants or analogous carbohydrates that are resistant to digestion and absorption in the human small intestine with complete or partial fermentation in the large intestine’. DF promotes beneficial physiological effects including laxation, and/or blood cholesterol attenuation, and/or blood glucose attenuation. This definition typically includes the non-starch polysaccharides (NPS) and resistant oligosaccharides, lignin, substance associated with NPS and lignin complex in plants, and other analogous carbohydrates, such as resistant starch and dextrins and synthesized carbohydrates compounds such as polydextrose. Fibres are an integral part of food stuffs we consume daily; the main source of which are vegetables, cereals, grains, woody plants, fruits, legumes etc. Dietary fibre constituents are listed in Table I.5.

Based on their simulated intestinal solubility dietary fibres are classified as:

**Insoluble Dietary Fibre (IDF):** It includes lignin, cellulose, and hemicellulose. Leafy vegetables and whole grains are a major food source for insoluble fibre.

**Soluble Dietary Fibre (SDF):** It includes pectins, beta-glucans, galactomannan gums, mucilages, and a large range of nondigestible oligosaccharides including inulin. Fruits, oats, beans and vegetables are the main source of SDF.

Nowadays food fibres have led to the development of a large and potential market for fibre rich products and ingredients. DF holds all the characteristics required to be considered as an important ingredient in the formulation of functional foods, due to its beneficial effects, such as increasing the volume of faecal bulk,
decreasing the time of intestinal transit, cholesterol and glycaemia levels, trapping substances that can be dangerous for human organism etc.

Table I.5: Dietary fibre constituents and their sources

<table>
<thead>
<tr>
<th>Fibre Constituents</th>
<th>Principal Groupings</th>
<th>Fibre Constituents/Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-starch-polysaccharides and oligosaccharides</td>
<td>Cellulose</td>
<td>Cellulose-plant (vegetables, sugar beet, various brans)</td>
</tr>
<tr>
<td></td>
<td>Hemicellulose</td>
<td>Arabinogalactans, β-glucan, arabinoxylans, glucuronoxylans, galactomannas, xyloglucans, pectic substances</td>
</tr>
<tr>
<td></td>
<td>Polyfructoses</td>
<td>Inulin, oligofructans</td>
</tr>
<tr>
<td></td>
<td>Gums and Mucilages</td>
<td>Seed extracts (galactomannans - guar and locust bean gum), tree exudates (gum acacia, gum karaya, gum tragacanth), algal polysaccharides (algamates, agar, carrageenas), psyllium</td>
</tr>
<tr>
<td></td>
<td>Carbohydrate analogue</td>
<td>Pectins</td>
</tr>
<tr>
<td></td>
<td>Resistance starches and maltodextrins</td>
<td>Fruits, vegetables, legumes, sweet beets, potato</td>
</tr>
<tr>
<td></td>
<td>Chemical synthesis</td>
<td>Various plats such as maize, pea, potato etc.</td>
</tr>
<tr>
<td></td>
<td>Enzymatic synthesis</td>
<td>Polydextrose, lactulose, cellulose derivatives</td>
</tr>
<tr>
<td></td>
<td>Lignin</td>
<td>Lignin</td>
</tr>
<tr>
<td>Substances associated with non-starch polysaccharides</td>
<td>Waxes, cutinsuberin</td>
<td>Plant fibres</td>
</tr>
<tr>
<td>Animal origin fibres</td>
<td>Chitin, chitosan, collagen, chondroitin</td>
<td>Fungi, yeasts, invertebrates</td>
</tr>
</tbody>
</table>

**I.9.2 Dietary fibre and health benefits**

Dietary fibre plays an important role in human health. In developing countries like India rapid urbanization, industrialization, as well as increased number of women workforce have resulted in rapid inclination towards fast foods many of which do not contain minimum amounts of dietary fibre.\(^{74}\) Epidemiological study has demonstrated a relationship between a diet containing an excess of energy dense foods rich in fat and sugar and the emergence of a range of chronic diseases, including colon cancer, obesity, cardiovascular diseases, diabetes and several other disorders.\(^{75-77}\) Scientific research has proved that adequate intake of fibre reduces the risk of such diseases and promotes a healthier lifestyle.\(^{78-80}\) Furthermore, increased consumption of dietary fiber improves serum lipid concentrations, lowers blood pressure, improves blood glucose control in diabetes, promotes regularity, aids in weight loss, and appears to improve immune function. The diet rich in fibre helps to reduce the risk of several types of diseases mentioned above due to its beneficial effects like increasing the volume of fecal bulk, decreasing the time of intestinal transit, cholesterol and glycaemic levels, trapping substances that can be harmful for human organism (mutagenic and carcinogenic agent), stimulating the proliferation of the intestinal flora etc.\(^{77,81}\)

Dietary fibre increases stool bulk and promotes normal laxation.\(^{82}\) The fermentation of DF in colon gives bacterial biomass which not only increases the stool bulk but also increases the metabolic activity of main saccharolytic bacterial species.\(^{74,83}\) Increased stool bulk increases the colonic transit time which is beneficial not only for the relief and prevention of constipation, but also reduces the effect of toxic nitrogenous compounds, hydrogen sulphide, and production of carcinogenic and genotoxic compounds.\(^{84}\) Bacterial fermentation also results in lowering of colonic pH, which helps in the excretion of carcinogens, which bind to dietary fibre\(^{85}\). Therefore DF is protective against the colorectal cancer (CRC). The possible effect of dietary fibre in large intestine is shown in the Scheme I.2
Scheme I.2: Possible effect of dietary fibre in large intestine

It has been reported that DF may act as a protective role in the large bowel cancer by shortening the transit time, thus reducing the time for the formation and action of carcinogens. In addition, through its stool-bulking effect, fibre may lower the fecal carcinogens thereby reducing the amount of carcinogens that come in
contact with the gut wall.\textsuperscript{86,87} The soluble fibres that produce relatively high viscosity are associated with decrease in the cholesterol levels and bile acids.\textsuperscript{88} In addition DF may delay the absorption of carbohydrates and fats which leads to increase in the insulin sensitivity\textsuperscript{89} and decrease intracylglycerol concentrations.\textsuperscript{90} This helps to reduce the risk of coronary heart diseases. Some function and health beneficial effect of DF can be summarized in the Table I.6

**Table I.6: Important functions of dietary fibre and its benefits on human health**

<table>
<thead>
<tr>
<th>Functions</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adds bulk to the diet, making feel full faster</td>
<td>May reduce appetite</td>
</tr>
<tr>
<td>Attract water and turns to gel during digestion, trapping carbohydrates and slowing absorption of glucose</td>
<td>Lowsers variance in blood sugar levels</td>
</tr>
<tr>
<td>Lowers total and LDL cholesterol</td>
<td>Reduces the risk of heart disease</td>
</tr>
<tr>
<td>Regulates blood pressure</td>
<td>May reduce onset risk or symptoms of metabolic syndrome and diabetes</td>
</tr>
<tr>
<td>Speeds the passage of foods through the digestive system</td>
<td>Facilitates regularity</td>
</tr>
<tr>
<td>Adds bulk to stool</td>
<td>Alleviates constipation</td>
</tr>
<tr>
<td>Balances intestinal pH and stimulates intestinal fermentation production of short-chain fatty acids</td>
<td>May reduce risk of colorectal cancers</td>
</tr>
</tbody>
</table>

**I.9.3 Functional property of Dietary Fibre**

Dietary fibres are not only important for their nutritional properties, but also for their functional and technological properties because of which agricultural products and byproducts may be upgraded for use as food ingredients.\textsuperscript{91,92} Functional properties of fibre include hydration properties (water holding capacity, WHC and swelling, SW), solubility, fat absorption capacity (FAC) and textural properties. Functional properties of DF are related to structure of the constituent
polysaccharides and may be influenced by porosity, particle size, ionic form, pH, temperature and ionic strength.93,94

**Hydration property:**

Hydration properties of DF refer to its ability to retain water within its matrix. It is due to the hydrophilic nature of the saccharide residues. The hydration properties partly determine the fate of dietary fibre in the digestive tract and accounts for some of their physiological effect. Water holding capacity (WHC) and swelling (SW) provides the general view of hydration property of fibres. WHC of DF has important effect on stool bulking. Increased stool weight can cause shorter gut transit time limiting the exposure of gut to secondary bile acids and other toxins.95 The WHC and SW of DF are dependent on the structure, chemical composition and the particle size.

**Solubility:**

Solubility has significant effect of functionality of DF. Soluble viscous polysaccharides can impede the digestion and absorption of nutrients from the gut.81 The solubility of fibre depends on the structure and the chemical composition. The presence of more branching ionic groups and the potential for inter unit positional bonding increases the solubility.

**Fat absorption capacity (FAC):**

FAC depends on surface properties, overall charge density, thickness, and hydrophobic nature of the fibre particle.96 High FAC is related to decrease the cholesterol level in our body. FAC of fibre is important for its application as a food ingredient.

**I.10 Proximate Composition**

The proximate composition i.e. moisture content, ash, crude protein, crude lipids, carbohydrates and calorific value of the vegetables, determines the nutritional property of vegetables. Fruits and vegetables contain large quantity of water in proportion to their weight. Vegetable contains approximately 70% - 96% of water.
Vegetables with high moisture content are called high water content food. For the body to function properly we need to consume sufficient amount of water. Due to high water content vegetables contains sufficient amount of minerals. The amount of ash content is a measure of nutritionally important mineral content present in the vegetables.\textsuperscript{97} Higher ash content in the vegetables indicates the presence of sufficient amount on mineral elements.

Proteins are essential nutrients for human body for normal growth and maintenance. They are one of the building blocks of body tissue and can also serve as a fuel source. Protein is present in all cells of the body. It is present in variable level in different tissues of the body like muscles contain about 20% whereas in blood plasma it is 7%. Proteins are formed when amino acids get polymerized. There are about 21 amino acids in the body. Most of the amino acids can be synthesized in the body but few cannot be synthesized and need to be provided in the food. Since it is essential to be provided in food for normal functioning of the body, they are called essential amino acids. There are eight essential amino acids and they are isoleucine, leucine, lysine, methionine, phenylalanine, tryptophan, threonine and valine. In infants apart from these amino acids histidine is essential to be provided in food. It is wrong to think that since non-essential amino acids can be synthesised in the body, their inclusion in the diet has no value. Some non-essential amino acids can be synthesised only from other essential amino acids so if they are not supplied in the diet some of the essential amino acids will have to be used for their synthesis. During digestion proteins break down into smaller polypeptides by enzyme proteases to provide amino acids for the body including the essential amino acids which cannot be biosynthesized by the body itself. Dietary sources of proteins are meat, egg, fish and also vegetables.

Carbohydrates are the single most abundant economic sources of food energy in human diet, constituting 40-80\% of total energy intake in different populations. Carbohydrates play several important roles in all life form, including sources of metabolic fuels and energy stores, structural components of cell wall in plants and of the exoskeleton of arthropods, parts of RNA and DNA in which ribose and deoxyribose, respectively, are linked by N-glycosidic bonds to purine and pyrimidine bases, integral features of many proteins and lipids, such as glycoprotein and glycolipids, especially in cell membranes where they are essential for cell-cell
recognition and molecular targeting. Carbohydrates are classified according to their degree of polymerization into monosaccharide (sugar), oligosaccharides, and polysaccharides. Examples of food carbohydrates and an overview of their digestive fates are given in Table I.7.

**Table I.7:** Classes of food carbohydrates and their likely fates in human gut

<table>
<thead>
<tr>
<th>Class</th>
<th>DP</th>
<th>Example</th>
<th>Site of digestion</th>
<th>Absorbed molecule</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monosaccharaides</td>
<td>1</td>
<td>Glucose</td>
<td>Small bowel</td>
<td>Glucose</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Fructose</td>
<td>Small bowel</td>
<td>Fructose</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Sucrose</td>
<td>Small bowel</td>
<td>Glucose &amp; fructose</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Lactose</td>
<td>Small bowel</td>
<td>Glucose &amp; galactose</td>
</tr>
<tr>
<td>Oligosaccharides</td>
<td>3</td>
<td>Raffinose</td>
<td>Large bowel</td>
<td>SCFA</td>
</tr>
<tr>
<td></td>
<td>3-9</td>
<td>Inulin</td>
<td>Large bowel</td>
<td>SCFA</td>
</tr>
<tr>
<td>Polysaccharides</td>
<td>&gt; 9</td>
<td>Starches</td>
<td>Predominantly</td>
<td>Glucose</td>
</tr>
<tr>
<td></td>
<td>&gt; 9</td>
<td>Nonstarch</td>
<td>Large bowel</td>
<td>SCFA</td>
</tr>
</tbody>
</table>

DP: Degree of Polymerization. SCFA: Short-Chain Fatty Acids.

Intake of optimum amount of different types of carbohydrates is associated with good health through effects on energy balance, digestive functions, blood glucose control, and other risk factor of several chronic diseases. In human diet carbohydrates come from different plant sources, except galactose which comes from milk or milk products.

Lipids are broadly defined as the naturally occurring molecules, such as fats, oil, waxes, cholesterols, sterols, fat soluble vitamins (vitamin A, D, E and K), monoglycerides, diglycerides, phospholipids and others, which are insoluble in water but soluble in other organic solvents. There are four categories of lipids, simple, complex, derived and miscellaneous (Table I.6).
Table I.8: Classification of lipids

<table>
<thead>
<tr>
<th>Simple lipids (fatty acids esterified with alcohol)</th>
<th>Fats (fatty acids esterified with glycerol)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waxes (true waxes, sterol esters, vitamin A and D esters)</td>
<td></td>
</tr>
<tr>
<td>Complex lipids (fatty acids esterified with alcohol plus other groups)</td>
<td>Phospholipids (contain phosphoric acids and, usually, a nitrogenous base)</td>
</tr>
<tr>
<td>Glycolipids (lipids containing a carbohydrate and nitrogen but no phosphate and no glycerol)</td>
<td></td>
</tr>
<tr>
<td>Sulfolipids (lipid containing a sulfur group)</td>
<td></td>
</tr>
<tr>
<td>Lipoprotein (lipids attached to protein)</td>
<td></td>
</tr>
<tr>
<td>Lipopolysaccharides (lipids attached to polysaccharides)</td>
<td></td>
</tr>
<tr>
<td>Derived lipids (obtain from hydrolysis of simple or complex lipids)</td>
<td>Fatty acids (saturated, monounsaturated and polyunsaturated)</td>
</tr>
<tr>
<td>Monoacylglycerol and diacylglycerol</td>
<td></td>
</tr>
<tr>
<td>Alcohol (includes sterol, steroids, vitamin A and D)</td>
<td></td>
</tr>
<tr>
<td>Miscellaneous lipids</td>
<td>Straight chain hydrocarbons</td>
</tr>
<tr>
<td>Carotenoids</td>
<td></td>
</tr>
<tr>
<td>Squalenes</td>
<td></td>
</tr>
<tr>
<td>Vitamin E and K</td>
<td></td>
</tr>
</tbody>
</table>

The main biological functions of lipids include, energy storage, as structural component of cell membrane and as important signaling molecules. Eating a diet too low in fat can interfere with the absorption of the fat-soluble vitamins A, D, E and K. Because these nutrients are fat soluble, our body needs dietary fat to utilize them. These vitamins are stored mostly in the liver and fat tissue and are important in bodily functions such as growth, immunity, cell repair and blood clotting. Some
dietary lipids are potentially significant risk factors for obesity and other chronic degenerative diseases that influence human morbidity and mortality. The major dietary sources of lipids are meat, egg, milk and milk products, fish and different seed oils. Amongst various foodstuff, fats provide the body with maximum energy (9 kcal/g), approximately twice that for an equal amount of protein and carbohydrate. Fatty acids can be grouped into three different types namely saturated fatty acids, monounsaturated fatty acids and polyunsaturated fatty acids. Polyunsaturated fatty acids consist of two types, omega-3 and omega-6. Saturated fatty acids increase the blood cholesterol level. Diet rich in high fats are one of the major causes of obesity and other chronic diseases like heart diseases, diabetes etc. Therefore there is an increasing interest on low fat diet mainly fruits and green vegetables. The leafy vegetables and fruits contain phospholipids and sterols, whereas seeds contain triglycerides. Green leafy vegetables are potentially much richer in α-linoleate than are seeds. Seed oils are usually rich in linoleate and oleate. Common plant sterol includes β-sitosterols, β-sitostanol and compesterols. Food enriched with esters of plant sterols are used widely to lower blood cholesterol via the inhibition of cholesterol absorption in the gut.
I.10 Objective

The main objective of the present study was to evaluate a few nutritional parameters of some wild green leafy vegetables consumed traditionally by the rural and tribal inhabitants of North East India. The study encompasses the following parameters:

1. Evaluation of antioxidant activity
2. Determination of total phenolic and total flavonoid content
3. Estimation of vitamin C content
4. Determination of minerals
5. Dietary fibre content
6. Proximate composition analysis
References


(Cydoniaoblonga Miller) pulp and peel polyphenolic extract. *Journal of Agricultural and Food Chemistry,* **55**, 963-969.


disease, treatment with antioxidants seems to be a damage promising approach for slowing disease progression. Oxidative damage and Alzheimer’s disease: are antioxidant therapies useful? Drug News Perspect, 18, 13-19.


66. Loganayaki N., Rajendrakumaran D. &Manain S. (2010). Antioxidant capacity and phenolic content of different solvent extract from banana (Musa paradisiaca) and mustai (Riveahypocrateriformis). *Food Science Biotechnology, 19(5)*, 1251-1258.


