CHAPTER FOUR
PROXIMATE PRINCIPLES AND FIBRE
4.1. Introduction and Review of Literature

4.1.1. Introduction

Man needs a wide range of nutrients to perform various functions in the body and to lead a healthy life. They include proteins, fat, carbohydrates, vitamins and minerals. These are chemical substances which are present in the food we eat daily. Cereals contain these nutrients which are needed for growth. Most foods contain almost all the nutrients in various proportions, some foods being rich in certain nutrients. Depending on the relative concentration of these nutrients, foods are classified as protein rich foods, carbohydrate rich foods and fat rich foods etc. Some foods provide only a single nutrient as in the case of sugars which are source of only carbohydrates while oils, ghee etc. provide only fats. Protein, fat and carbohydrates are sometimes referred to as proximate principles. They are oxidized in the body to yield energy which the body needs. Together with water, which is also an essential component, the proximate principles form bulk of the diet. In plant foods, fibre (dietary fibre) which are indigestible complex molecules also contribute to the bulk and have some useful function in the digestive tract (Gopalan et al., 1989).

4.1.2. Carbohydrates

Carbohydrates are food for energy. Low – protein, high carbohydrate foods are important in taking care of autointoxication, kidney and liver problems, manic behaviour, and low threshold anger tendencies. High - fibre carbohydrates improve bowel transit time and reduce risk of colorectal cancer. Cereals contain a good amount of carbohydrates which are stored in the endosperm. Complex carbohydrates are broken down into simple sugars by the action of enzymes. Carbohydrates supply energy for the human body to function. Carbohydrates are the most abundant bulk
nutrients and form the major source of biological energy through their oxidation in the tissues. They also furnish organic precursors for the biosynthesis of many cell components. Carbohydrates are not essential in the human diet, but because carbohydrate rich foods are abundant and cheap, compared with fats and protein, they naturally form a major part of the diet in most of the world. The four-fifth’s of the world’s population relies mainly on plant food. Carbohydrates provide at least 70 percent and often up to 90 percent of the total caloric intake. They are the most abundant biomolecules produced on earth; photosynthetic plants and algae convert over 100 billion metric tons of $\text{CO}_2$ and water into sugars, starches, and cellulose like substances. Three major classes of carbohydrates are monosaccharides, oligosaccharides, and polysaccharides. They provide a major part of the energy in human diets: about 80% to 85% of the energy for the people of developing countries and about 40% to 45% of the energy of the more affluent western world, though neither of these extremes is desirable nutritionally. Englyst and Kingman (1993) distinguished two types of polysaccharides from plant foods: the storage polysaccharides and non-starch polysaccharides. Cereal grains, pulses and other seeds, root vegetables and stem vegetables and plantains contain large amounts of starch, constituting the world’s most important starchy foods; NSP is the principal and readily measurable food component termed as dietary fibre (Desai, 2000).

4.1.3. Proteins

Proteins are an essential component of the diet needed for survival of animals and humans. Proteins basic function in nutrition is to supply adequate amounts of needed amino acids. The protein quality, also known as the nutritional or nutritive value of a food, depends on its amino acid content and on the physiological utilization of specific amino acids after digestion, absorption and minimal obligatory rates of oxidation. Metabolism of amino acids is determined by the proportion of amino acids
used for protein synthesis. Availability of amino acids varies with protein source, processing treatment, and interaction with other components of the diet (Block, 1989; Reichl, 1989; Scharrer, 1989; Smolin and Benevenga, 1989; Umezawa, 1989).

Protein in the diet is necessary to provide sources of nitrogen and amino acids to be utilized in the synthesis of body proteins and other nitrogen containing substances. The proteins of the body contribute to tissue structure and are involved in a variety of important metabolic functions. Proteins in excess of these serve as a source of energy. The nutritional value of a protein depends upon the composition of its amino acids. Vegetable foods generally contain small quantities of protein and the amino acids present are rarely in the proportions required by animal tissues. Cereals and millets are moderate source of protein as they contain about 10% protein. However, the cereals as they are consumed in large amounts daily, they contribute a considerable amount of protein to the daily intake (Gopalan et al., 1989).

4.1.4. Lipids

Triacyl glycerols from animals and plant sources rank close behind carbohydrates as major sources of energy. They also are important carbon sources for biosynthesis of cholesterol and other steroids. Moreover plant triacyl glycerols provide essential fatty acids. Lipids including oils and fats are a chemically diverse group of compounds that are insoluble in water and have a variety of functions. Oils and fats are the principle stored forms of energy in many organisms, with phospholipids and sterols making up approximately half the mass of the biological membranes. Other crucial lipids are enzyme cofactors, electron carriers, light – absorbing pigments, hydrophobic anchers, emulsifying agents, hormones and intracellular messengers (Lehninger et al., 1993). Fatty acids are mostly present as derivatives of carboxylic acid in the form of esters and amides, thus rendering them more non polar and less
soluble in water. Common oils and fats are the simplest lipids occurring as triacylglycerols or triglycerides, composed of three same or different fatty acids, each ester – linked with a glycerol molecule. Seeds of many plants also contain triglycerides to provide energy biosynthetic precursors during seed germination. Gurr (1997) has reviewed the nutritional aspects of food lipids, including triacylglycerols, phospholipids, glycolipids, sterols and fat – soluble vitamins. In assessing the roles of dietary lipids in health and disease, it is important to put fat in perspective with other dietary components and diet as well as with the environment factors. Fat calories appear to be more fettering than carbohydrate calories and the reasons for this are complex. The main cause is the body’s inability to increase fat oxidation rapidly in response to increase in the consumption. The human body cannot make either linoleic or linolenic acid and these must come from the diet. A large proportion of the lipids of the brain, and of specialized tissues such as retina, are composed of poly unsaturated fatty acids from dietary alpha – linolenic acid. However only small amounts of this fatty acids are required in human diets (Zollner, 1986). According to Bouchier (1997), essential fatty acids and eicosanoids play important roles in human health and disease.

4.1.5. Dietary Fiber

Plants are composed of a great deal of fiber, which play an important part in the digestive process. Most of the fibers are cellulose and are not digested by the body. It has health benefits in the diet. The rate and extant of starch digestion in the human small intestine is influenced by the botanical source and the type of processing it is subjected to. All the properties of a high – fiber diet, including those related to the structural properties such as encapsulation of nutrients within plant cell walls, have been implicated in the protection from a variety of diseases (Trowell, 1985). Dietary fibre in the diet may bind minerals and protein and reduce their absorption or digestibility (Roberfroid, 1993; Torre et al., 1991; Southgate, 1982; Ikeda et al., 1986). However,
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high intake of dietary fibre is not likely to be problematic when protein and minerals in the diet are adequate (Roberfroid, 1993).

During their transit through the alimentary tract, dietary fibers have ample opportunity to interact with the substrates, effectors and products of digestion as well as a variety of other substances progressing towards absorption or evacuation. Adequate dietary cellulose has long been recognized as a factor in preventing constipation. Both soluble and insoluble fibers contribute to increased fecal bulking through absorption of water and by the addition of indigestible material. Gas produced during fermentation of soluble fibres contributes to moving fecal material through the colon fiber, particularly insoluble fiber, seems to “normalize’ intestinal transit time, hastening it in persons with constipation and prolonging it in those with rapid transit or diarrhea. Increasing soluble fiber may play a role in reducing total intake by increasing fullness and satiety (Marlet et al., 2002).

Dietary fibre is primarily the storage and cell wall polysaccharides of plants that cannot be hydrolyzed by human digestive enzymes. Lignin, which is a complex molecule of polyphenylpropane units and present only in small amounts in the human diet, is also usually included as a component of dietary fiber (DRIPDDF, 2001). Many fibre sources and a mixed high-fibre diet increases stool weight, there by promoting normal laxation (Cummings, 1993). A fibre-rich meal is processed more slowly and nutrient absorption occurs over a greater time period (Jenkins et al., 1995). Further a diet of foods providing adequate fiber is usually less energy dense and larger in volume than a low fiber diet which may limit spontaneous intake of energy (Rolls et al., 1999). This larger mass of food taken longer to eat and its presence in the stomach may bring a feeling of satiety sooner, although this feeling of fullness is short term. A diet of a wide variety of fibre – containing foods also is usually richer in micronutrients. When viscous fibres are isolated and there by concentrated, their effects on digestion are
frequently easier to detect; when these types of fibres are added to a diet, the rate of glucose appearance in the blood is slowed and insulin secretion is subsequently reduced (Jenkins et al., 1995; Anderson and Akanji, 1993).

4.1.6. Review of Literature

Kattiyar and Bhatia (1991) had studied the essential amino acids in eight traditional cereal cultivars of trans himalayan regions. Nishizawa et al. (1990) reported the protein content of seven high yield rice varieties. Some human data suggest that fructo oligosaccharides may increase calcium absorption (Coudray et al., 1997; Van den Henvel et al., 1999). Hipsley (1953), estimated dietary fiber as the material derived from plant cell wall in foods. There is observational evidence that fibre may protect against duodenal ulcers (Aldoori et al., 1997) and cancer in the gastric cardia region (Terry et al., 2001). Animal experiments suggest that the type and amount of fibre consumed may affect intestinal immune function (Field et al., 1999; Lim et al., 1997). As a result of fibre serving as a substrate for bacteria in the large bowel, changes in intestinal bacterial populations especially with the consumption of large amounts of purified, homogenous fibres have been reported by Roberfroid and Slavin, (2000).

Mishra et al. (2000) reported that starch is a major carbohydrate constituent (72 %) of the polished millet. Paramahans and Tharanathan (1980) had studied the carbohydrate composition of the millet varagu. Geervani and Eggum (1989) had studied the nutrient composition and protein quality of minor millets. In 2000, AnilaKumar and Rajyalakshmi studied on qualitative aspects, product suitability and invitro starch digestibility of caryota palm sago. They also reported the amylose and starch contents of sago. In 2006, Ragee et al. reported that refined flours, hard wheat flour and soft wheat flour had the highest starch content (77.7%). According to them barley and rye contained relatively lower starch content (53.6% and 58.0%) compared
to millet and sorghum having starch content of 67.5%. Mishra et al. (2000) reported the protein content of the Kodo millet and the biological value of the proteins. Kodo millet is deficient in tryptophan, lysine, methionine and threonine (Ambegoakar et al., 1965). Salih et al. in 1991 reported that the protein of debittered maikah had a chemical score of 85 indicating a quality superior to that of the local cereals.

Khan and Eggum in 1979 reported that the protein content of some Pakistani wheat varieties ranged from 12.3% to 16.7%. Ragee et al. (2006) reported that barley whole grain had protein content of approximately 19.4 % while rye and wheat flour averaging 13.4 %, millet whole grain 8.8%, soft wheat flour 11.0 % and sorghum 12.1 %. According to de Lumen et al. (1993), acha, “hungary rice” is high in methionine, making it a potentially good compliment to legumes, which are low in methionine (4.8%). Anjum et al. (1991) and Friedman and Atsmon (1988) has reported that Hordeum spontaneum grains has a protein content of approximately 21.5 % and Ruth, a standard Isricala cultivar, with 13 % protein. Mertz in 1978 discovered that the opaque – 2 gene in maize plants suppresses the synthesis of nutritionally inadequate prolamine proteins, resulting in increased contents of lysine and tryptophan.

Rao, (1994) found that PER of ragi consumed by low socio economic groups in India, was lower than that of casein (2.5%). Becker and Hanners (1991) found that Oahe intermediate wheat grass has a high protein content (20.8%) about double that of wheat. Chang et al. (1986), Eggum et al. (1993), Gastanduy et al. (1990), Kennedy, (1995), Nishazawa et al. (1990) and Sotelo, (1994) stated that rice with a protein content between 5 and 7 %, are lower than those found in most other cereals.

Salih et al. (1992) reported that the chemical scores of Cenchrus, Dactyloctenium, Echinochloa colona & Oryza proteins as 20, 36, 38 and 65 respectively. Ragee et al. (2006) investigated that crude fat content range from 0.9 % in wheat
flour to 4.2 % in millet whole grain meal. Trowel (1985), defined dietary fibre as the skeletal remains of plant cells that are resistant to digestion by man’s enzymes. Thebaudin et al. (1995) reported that the fiber content of different foods varies greatly.
4.2. MATERIALS AND METHODS

4.2.1. Moisture content

Seed grains were collected, dried and ground in a grinder. Analysis were done on dry matter basis using standard AOAC methods (1990). The average of two values were taken and given in the table -8. Moisture content in samples was determined by the method described in AOAC (1990).

4.2.2. Crude protein content

The total nitrogen content of the samples were determined by modified micro – Kjeldahl method (Jackson, 1973) and the crude protein content was calculated by multiplying the nitrogen content by the factor 6.25 (Simpson et al., 1965) and expressed as percentage.

4.2.3. Carbohydrate and crude fat.

Carbohydrate and crude fat were determined using standard AOAC methods (1990).

4.2.4. Crude fibre content

Crude fibre content was determined by AOAC method (1990).

4.2.5. Energy content

The energy content, in kcal / 100 g, was calculated using the factors: 4 for protein and carbohydrate and 9 for fat (Marero et al., 1988).
4.3. RESULTS AND DISCUSSION

The results are given in table-8 and fig-17. *Dactyloctenium aegyptium* contain moisture-9.12%, crude protein-12.55%, fat-2.49 %, carbohydrate-72.5%, crude fibre -2.84% and energy -363kcal. These values are comparable to the earlier reports by salih et al. (1992). *Eleusine indica* contain moisture-12.04%, protein- 8.06%, fat-2.48%, carbohydrate-72.6 % crude fibre-4.26% and energy-345kcal. *Setaria intermedia* contain moisture-9.46%, protein -9.66 %, fat -3.16 %, carbohydrate- 66.01%, crude fiber-10.24%, and energy-331 k cal. *Setaria pumila* contain moisture-9.96%, protein-10.06%, fat-4.16%, carbohydrate-64.2%, crude fibre-10.05% and energy -333 k cal. *Sporobolus indicus* contain moisture-11.35%, protein-10.21%, fat-3.13%, 65.0% carbohydrate, fibre -3.86 % and energy -329 k cal. *Echinochloa crus–galli* contain moisture-9.7%, protein-10.1%, fat-2.3%, carbohydrate -65.00%, crude fibre -10.3% and energy -310 k cal. The value reported for ragi is moisture-13.1%, protein -7.3%, fat -1.3%, carbohydrate -72.0%, crude fiber -3.6% and energy -328 k cal.

The result shows that *Dactyloctenium aegyptium* has the highest protein content (12.55%) followed by *Sporobolus indicus* (10.21%), *Echinochloa crus–galli* (10.1%), *Setaria pumila* (10.06%), *Setaria intermedia* (9.66%), *Eleusine indica* (8.06%) and *Eleusine coracana* (7.3%). All the grains used in the present study have a higher protein content over the control. The cereals are generally poor in protein. Wheat (12.1%) and maize (11.1%) are the highest protein containing cereals, whereas Italian millet (*Setaria italica*) 12.3% and *Setaria* (12.5%) are the top protein containing millets. There are also reports which says that barley whole grain have a higher protein content (Ragee *et al.*,2006). However consumption of this cereal is not very extent.

*Setaria pumila* shows highest fat content (4.16%). *Echinochloa crus–galli* shows lowest fat content (2.3%) and all other values are close to that of
Dactyloctenium aegyptium (2.49%). Eleusine indica (2.48%), Sporobolus indicus (3.13%), Setaria intermedia (3.16%), but higher than Eleusine coracana (1.3%). Even the highest fat containing grain in the present study has lesser fat compared to bajra (5%) and Italian millet (4.3%).

Dactyloctenium aegyptium and Eleusine indica shows almost similar carbohydrate values to that of Eleusine coracana (72.5%, 72.6% and 72.0% respectively). All other members Setaria intermedia (66.01%), Setaria pumila (64.2%), Sporobolus indicus (65.0%), Echinochloa crus-galli (65.0%) have lesser carbohydrate content compared to Eleusine coracana (72.0%). Among cereals and millets rice have higher carbohydrate content (78.2%) than Dactyloctenium aegyptium and Eleusine indica.

Considering crude fibre, Setaria pumila, Setaria intermedia and Echinochloa crus-galli shows higher values (10.5%, 10.24%, 10.3%) than Eleusine coracana (3.6%). Dactyloctenium aegyptium shows lowest crude fibre value (2.84%), Eleusine indica (4.26%) and Sporobolus indicus (3.86%). The fiber content in food is important because it protect against duodenal ulcers (Aldoori et al., 1997), cancer (Terry et al., 2001) and may affect intestinal immune function (Field et al., 1999; Lim et al., 1997).

Considering energy, Dactyloctenium aegyptium shows the highest value (363 kcal) and Echinochloa crus-galli shows least energy (310 kcal) which is lower than control (328 kcal) also. All members except Dactyloctenium aegyptium have almost comparable values.
### Table - 8

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Name of Plants</th>
<th>Moisture %</th>
<th>Protein %</th>
<th>Fat %</th>
<th>Carbohydrate %</th>
<th>Crude fibre %</th>
<th>Energy kcal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><em>Dactyloctenium aegyptium</em></td>
<td>9.12</td>
<td>12.55</td>
<td>2.49</td>
<td>72.5</td>
<td>2.84</td>
<td>363</td>
</tr>
<tr>
<td>2</td>
<td><em>Eleusine indica</em></td>
<td>12.04</td>
<td>8.06</td>
<td>2.48</td>
<td>72.6</td>
<td>4.26</td>
<td>345</td>
</tr>
<tr>
<td>3</td>
<td><em>Setaria intermedia</em></td>
<td>9.46</td>
<td>9.66</td>
<td>3.16</td>
<td>66.01</td>
<td>10.24</td>
<td>331</td>
</tr>
<tr>
<td>4</td>
<td><em>Setaria pumila</em></td>
<td>9.96</td>
<td>10.06</td>
<td>4.16</td>
<td>64.2</td>
<td>10.05</td>
<td>333</td>
</tr>
<tr>
<td>5</td>
<td><em>Sporobolus indicus</em></td>
<td>11.35</td>
<td>10.21</td>
<td>3.13</td>
<td>65</td>
<td>3.86</td>
<td>329</td>
</tr>
<tr>
<td>6</td>
<td><em>Echinochloa crus –galli</em></td>
<td>9.7</td>
<td>10.1</td>
<td>2.3</td>
<td>65</td>
<td>10.3</td>
<td>310</td>
</tr>
<tr>
<td>7</td>
<td><em>Eleusine coracana</em>(control)</td>
<td>13.1</td>
<td>7.3</td>
<td>1.3</td>
<td>72</td>
<td>3.6</td>
<td>328</td>
</tr>
</tbody>
</table>

**Composition of grains in six different grasses**
Fig-17a-g. Pie diagram of the grains showing proximate principles, moisture and crude fibre