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DIETARY PATTERN AND DENTAL CARIES
OF THE DECIDUOUS DENTITION IN YOUNG CHILDREN

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ERRATA
Typographical errors
page 16, paragraph 2, line 3
p 20, para 3, l 4
p 22, para 3, l 5
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p 70, Guideline 4
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incidence should be evidence
millionmi should be milleri
Hutchison should be Hutchinson
notobiotic should be gnotobiotic
xylitol should be xylitol
insert of before foods
quality should be quantity
Maternal blood volume = 4.0
Following values to be adjusted
confectionary should be confectionery
insert infant before should
insert the before same
insert not before good
delete repeated phrase
SUMMARY

Dental caries is a multifactorial disease. The principal factors are the host, the microflora, the substrate and time. In the absence of any of these factors caries would not occur, yet the dietary factor has been considered the most important. The necessity of diet in direct contact with teeth for the development of caries has been proven by Kite et al (1950) who showed that tube fed animals developed no caries.

The prevalence of dental caries in pre-industrial countries was more severe in the deciduous dentition than in the permanent dentition. Ancient people rarely had dental caries. For example the Eskimos who lived on animal food that required mastication and who received a diet consisting of protein and fat had excellent dentitions until transportation introduced foods other than their native foods.

According to Miller's Acid Fermentation Theory, micro-organisms colonise on uncleaned teeth and undergo metabolic activity depending on the substrate left from dietary intake. The plaque bacteria produces organic acids from fermentable sugars within seconds and the constant attack of acids on the tooth enamel eventually results in dental caries.

Caries occurs initially in the dental enamel and may progress to affect the dentine. The process is basically the same in deciduous teeth and in permanent teeth, but the carious lesion spreads more rapidly in deciduous teeth probably because of the thinness of enamel and the lower degree of mineralisation (Riordan 1988). So dental caries in deciduous teeth should be given particular importance.

Diet plays an important role during the development of teeth. The type of tooth structure is related to diet during the development period. Dietary factors which are significant to the calcified dental tissues are vitamins D and A, mineral salts (especially calcium and phosphorus) and the trace element fluoride. Foods containing these nutrients form good teeth.
Experiments show a definite relationship between tooth structure and susceptibility to caries in humans. Incidence of caries was higher in severe hypoplastic teeth than in well-formed teeth. Pits and fissures are the most common sites for caries in young children.

Caries can be successfully controlled by:

(i) Combating microbial agents through personal oral hygiene and removal of plaque.
(ii) Increasing tooth resistance by systemic and topical fluoride and occlusal sealants.
(iii) Modifying diet by diet control, restriction of sucrose, use of non-cariogenic sweeteners, and use of sugar substitutes and phosphate additives.

Teeth can be kept clean by brushing, mouth rinsing and by the use of dental floss or interdents or by visiting the dentist or hygienist for mechanical cleansing of plaque. Toothpaste and mouth washes containing fluoride should be used. Fluoride intake during tooth development is most desirable and application of fluoride post-eruptively is suggested.

Nutrient intake like protein, energy, vitamins, minerals and fluoride increases during pregnancy and lactation, but an expectant mother needs more protein than a nursing mother.

As babies have no, or few, teeth and are not capable of digesting foods like adults, they must have a dilute fluid diet. Milk is the best diet for infants and provides all the nutrients a baby needs. The fluid intake of an infant is higher during sickness or when the weather is too hot.

Infants, young children, expectant and nursing mothers have an increased need for calcium.

Phosphate is essential in many metabolic processes of the body and potassium, magnesium, sodium chloride and strontium and iodine, fluoride, cobalt, zinc and manganese are needed in small amounts.
Apart from breast feeding babies can be reared well on cow's milk. Both cow's milk and mother's milk contain small quantities of vitamins, but vitamin K and some of the B vitamins are formed in the intestine by the bacterial flora as part of the body's requirement. Supplements of vitamin C and D must be given as both cow's and mother's milk are deficient in D but mother's milk contains more vitamin C.

After the 1st year, growth rate of the baby slows down and there is diminished appetite. Care should be taken that the child gets the right nutrients. At this stage children will eat a variety of solid foods but milk should still form a part of the diet. Sweets should be restricted and fluoride tablets should be provided from birth if the child is living in a non-fluoridated area.

Foods from five food groups should be eaten as recommended to get all the necessary nutrients for growth and development. Fat, salt and sugar should be restricted in the diet. Fried and over cooked food should be avoided.

A sweet taste is one of the basic taste modalities of man. There is hardly any area left in our diet that does not in some way involve sweeteners and as such sugar consumption has increased. Sugar is either naturally present in the diet, incorporated during processing or is intentionally added.

It is difficult to change the total food habit but certain foods can be eaten cautiously or replaced by other foods. If sugar is to be eaten it should be eaten in liquid form and with low frequency so that it will not harm the precious teeth and health of the child. Sucrose and other sugars in the diet can also be replaced by non-cariogenic or less cariogenic sweeteners or by sugar substitutes to maintain better dental health. In recent years "nursing caries" has received attention and young children and infants should not go to bed with a bottle of sweetened milk or fruit juice. Such habits are potentially dangerous for the child's oral health.
Certain components of the diet like starch and sugars in various forms have a marked effect on the erupted tooth. Sucrose is the "arch criminal" of dental caries as its molecules are smaller and provides an instant source of food for plaque bacteria. On the other hand a number of factors like protein, fat, phosphate and fluoride already present in the diet or added to the diet inhibits, or seems to inhibit, the decay process in an individual.

Milk as a single food contains many of the essential nutrients a baby needs. The composition of milk varies from species to species and within breeds or races of one species, and it depends on physiology, variability of the individual, nutritional status, stage of lactation, age, season of the year and amount of milk produced.

Animals have been bred for centuries to produce quantities of milk. Cow’s milk is widely used for infant feeding as an alternative to breast feeding although breast feeding is the best feeding for human infants. There are milks of other animals too, on which human children can be reared.

Different milk treatments have been established to preserve milk for use as untreated milk decomposes rapidly. With pasteurisation of milk vitamin C and B₁₂ are lost. Thiamine and vitamin C are lost if it is kept in storage for more than a certain time. Sweetened condensed milk is not suitable for infants as the large quantity (45%) of added sucrose increases energy content, reduces its nutrient content, and increases its cariogenicity.

A good family eating pattern is important as children learn from family. Dental caries is preventable. A sound dietary pattern developed from early infancy will prevent the disease.
To my son, Shaker, and to a little podgy daughter Nabila who was born at the beginning of the course and who have inspired me to write this thesis for the benefit of young children.
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1 INTRODUCTION

1.1 DIET AND DENTAL CARIES

Dental caries was not a common problem in ancient days, but this problem began to increase with the development of civilisation. The commonest sites of attack are occlusal pits and fissures and the contact areas of adjacent teeth (Fanning & Smith 1985).

In third world populations, among rural dwellers and those eating traditional diets, caries remains a relatively minor problem. However in urban populations, exposed to westernising influences, prevalence has increased rapidly. This has been attributed to the increased availability and use of sugar and refined flours and foods prepared from them.

As the price of sugar fell, its consumption increased. The rate of caries also increased. Sucrose which is refined from sugar cane and sugar beet is the major dietary component implicated in dental caries.

Dental caries is a multifactorial disease and not completely a dietary disease but diet plays an important role in the development of caries. For the development of caries, the three parameters of Agent, Host, and Environment must occur simultaneously. A change in any of these three parameters can alter the severity of decay either to decrease or increase.

Agent: The presence of Streptococcus mutans, the major bacterial species believed to be responsible for the production of acids in the mouth, is not thought to be related to dietary intake or status, but the activity of the bacterial enzymes may be reduced by the presence of dietary fluoride ions.

Host: The tooth and its susceptibility. The major parts of a tooth are shown in Figure 1. Human teeth are formed over a limited period of time, during development in the womb and the first years of life. Tooth formation may be adversely affected by factors such as malnutrition and infections.
The teeth once mineralised, have no mechanism for repair and any disturbances in their formation will be apparent as irreversible damage in the part of the tooth corresponding to the stage of development. These damaged teeth are more susceptible to attack and caries formation. Reduction of enamel thickness (hypoplasia) has been observed in malnourished children and correlates with low socio-economic status, vitamin D deficiency and associated low blood calcium levels around birth may be responsible. Premature and low birth weight infants are particularly at risk, as they tend to have low vitamin D status, vitamin A and C deficiencies may also be involved. Fluoride acts as an important trace element in the development of caries resistant teeth.

Environment: Acid is produced by bacterial fermentation in the oral environment, thus creating conditions for caries progress. Streptococcus mutans ferments dietary sucrose, producing acid within minutes of sugar ingestion. It also produces long chain polysaccharides (sticky polyglucans) that stick to the teeth in the form of plaque. The
polysaccharides are metabolised over a period of time by the bacteria to organic acids such as citric and pyruvic acids. These acids then solubilise and dissolve the hydroxyapatite of the tooth enamel.

The process of tooth dissolution is reversible in the early stages of attack. Fluoride in the oral environment helps in mineral reposition within the tissue. Further dietary fibre may supply increased phosphate, which also promotes remineralisation. Thus dietary factors influence caries production through action on the agent, environment and host is shown in Table 1 (Barasi & Mottram 1987). The maximum reduction in dental caries of the deciduous teeth can be achieved if preventive measures are taken for the first 6 years of life.

Table 1
The influence of dietary factors in caries production via agent, environment and host.
Source: Barasi & Mottram (1987)

<table>
<thead>
<tr>
<th></th>
<th>Promoting factors</th>
<th>Reducing factors</th>
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<tr>
<td>Agent</td>
<td>?</td>
<td>Fluoride</td>
</tr>
<tr>
<td>Environment</td>
<td>Dietary carbohydrate, especially sugars</td>
<td>Fluoride, Phosphate</td>
</tr>
<tr>
<td>Host</td>
<td>? Low calcium/vitamin D during tooth development, General malnutrition, Vitamin A deficiency, Vitamin C deficiency</td>
<td>Fluoride</td>
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1.2 DIET

Diet is the total intake of substances that provide nourishment and/or calories to the body. These substances are chemicals, and the nourishment may be desirable or undesirable depending on the person’s particular requirement at a given time.

It is expected that if we consume a well-balanced adequate diet, we will probably receive all the necessary amounts of nutrients that are required by the body for optimum growth and maintenance of good health.

These nutrients may be classified into **Six Major Groups**: Protein, carbohydrate, fats, vitamins, minerals and water, which are shown in **Table 2**.

**Table 2**
The major classes of nutrients.
Source: Calloway & Carpenter (1981)

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<th>Functions</th>
<th>Main Food Sources</th>
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<tr>
<td>Protein</td>
<td>Builds, repairs tissue, Regulates body processes, Supplies energy</td>
<td>Meat, fish, poultry, dried beans, peas, seeds, nuts, milk, cheese, eggs, cereal grains</td>
</tr>
<tr>
<td>Fat</td>
<td>Provides the essential fatty acid, linoleic acid, Promotes absorption of fat-soluble vitamins A, D, E, K, Supplies energy</td>
<td>Fats and oils, nuts, meat, fish, poultry, dairy products, some seeds</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>Supplies energy, Spares protein, Aids in burning of fat</td>
<td>Grain products, fruits, some vegetables, milk</td>
</tr>
<tr>
<td>Vitamins</td>
<td>Regulate body processes, including the release of energy from food</td>
<td>All foods except sugar, alcohol and highly refined fats and oils</td>
</tr>
<tr>
<td>Minerals</td>
<td>Regulate body processes, Maintain body tissues</td>
<td>All foods except sugar, alcohol and highly refined fats and oils</td>
</tr>
<tr>
<td>Water</td>
<td>Transports nutrients, Regulates body temperature, Participates in chemical reactions, Removes waste material</td>
<td>Water, tea, coffee, and other beverages, almost all foods have some water</td>
</tr>
</tbody>
</table>
Protein provides energy in the body but it does perform many other functions too. It is essential for the growth and maintenance of tissue throughout the body. Hormones, enzymes and antibodies are all protein materials that must be present for normal body function. These are synthesised in the body from the amino acids provided by dietary proteins. Plasma protein plays an important role in regulating fluid balance in the body, which is essential for the normal functioning of the body. Plasma is able to function as either acids or bases and maintain relative neutrality of the body. Proteins are large molecules made up of nitrogen containing amino acids that are united together by peptide linkage. After water, protein is the major component of body tissue (WHO 1974). Proteins are of two types - animal proteins and plant or vegetable proteins. Animal proteins contain more of the essential amino acids than plant or vegetable proteins and in general have a higher nutritive value.

Carbohydrates include starches, sugars, gums and dextrins. On hydrolysis, the more complex carbohydrates yield the simple sugars. These sugars are the monosaccharides (glucose, fructose, galactose), the disaccharides (sucrose, maltose, lactose), and the polysaccharides (starches, cellulosises). The carbohydrates of major nutritional significance are the disaccharides and starches (McDonald 1969).

Cellulose is a unique carbohydrate but it is not digestible properly by humans and cannot be used as a dietary source of energy. Refined carbohydrates are not good for dental health especially between meals although growing children need more carbohydrates for energy than adults.

The major function of carbohydrates is to provide energy. They also help in the utilisation of fats in the body. With inadequate carbohydrate, ketosis develops because fats cannot be metabolised normally (McDonald 1969).
Fat provides energy. One gram of fat provides about nine calories to the body, whereas a gram of protein or carbohydrate furnishes only about four calories. In addition, fats supply the essential fatty acids that are required by the body for optimum growth and maintenance of tissue. Fats also serve as vehicles for the fat soluble vitamins that are obtained naturally in foods (McDonald 1969). The subcutaneous layer of fat insulates the body against heat loss in cold weather. Like carbohydrates, fats fulfil a psychological role in nutrition. Meals without fat are tasteless but excess fat should be avoided because it may lead to heart disease (McDonald 1969).

Vitamins are accessory food factors, needed for the metabolism of the energy producing nutrients: carbohydrates, fats and proteins. Coenzymes and/or portions of coenzymes often contain one of the compounds. Vitamins must be supplied in the diet because the body does not synthesise the vitamins in amounts sufficient to meet the daily needs. Only vitamin K and some of the B vitamins are synthesised in the intestine by the bacterial flora as per the body requirement.

The action of ultraviolet light on the skin converts 7-dehydro-cholesterol to vitamin D. During the summer months this conversion serves as an important source of vitamin D.

There are two types of vitamins, namely fat soluble and water soluble.

The fat soluble vitamins are A, D, E and K. Vitamin A is known as the anti-infection vitamin, vitamin D as anti-rachitic vitamin, vitamin E as anti-oxidant vitamin, and vitamin K is known as the antihaemorrhagic vitamin.

Fat soluble vitamins are not excreted, any excess is stored in the body. Therefore, deficiency symptoms are slow to develop. Vitamin A is an important vitamin in tooth formation because of the epithelial origin of the enamel organ. Vitamin D is necessary for normal calcification of osseous tissues and is very important in the development of healthy bones and teeth. Vitamin D deficiency causes rickets in children. The primary defect in
vitamin D deficiency is a failure of calcification of bone matrix. Vitamins A and D causes toxic symptoms if ingested in great amounts for a period of several weeks. Although vitamin K is an antihaeorrhagic vitamin, it cannot treat haemorrhagic conditions unless a deficiency or inadequate utilisation of the vitamin exists, or unless a lowered prothrombin level is present. These vitamins are found in food (McDonald 1969).

The water soluble vitamins are B complex vitamins and vitamin C (Ascorbic Acid).

There are numbers of compounds described as vitamin B. Niacin, Riboflavin (B₂), Thiamine (B₁), Pyridoxine (B₆), Folic Acid, Cobalamin (B₁₂) are important.

Water soluble vitamins have totally different and unrelated functions. The water soluble vitamins are generally not stored in the body and are excreted in the urine. Therefore, some daily ingestion of these compounds is necessary.

Thiamine, niacin and riboflavin take part in the carbohydrate metabolism. So excessive use of highly refined carbohydrates in the absence of an adequate thiamine intake is a health hazard. Riboflavin deficiency causes apthous ulcers, in the oral cavity, Niacin aids in the transfer of hydrogen atoms that are by-products of various biochemical reactions. The hydrogen atoms are eventually transferred to oxygen to form water. Pyridoxine (B₆) is a vitamin that functions as a co-enzyme in those reactions involving dicarboxylation and transamination of amino acids (McDonald 1969). Folic acid plays an important role in many stages of the replication process. In combination with pyridoxine (B₆), folic acid is necessary for protein synthesis. The synthesis of red blood cells involves both folic acid and cyanocobalamin (B₁₂). Folic acid is an essential constituent of a co-enzyme involved in the metabolism of the nucleic acids, which contain purines and pyrimidines (Pitkin 1981).

Nucleic acids are critical to rapidly growing tissues, i.e. during trophoblastic growth. Vitamin B₁₂ is essential for the normal function of all cells, especially those of the marrow, nervous system and gastrointestinal tract. Vitamin B₁₂ is linked with protein, carbohydrate and fat metabolism, but its major role is probably in the nucleic acid and folic acid metabolic process.
Vitamin C is classed as a water soluble vitamin but it is quite different chemically from the B-complex vitamins. It is not synthesised in the body so it should be ingested from exogenous sources as a daily requirement. Ascorbic acid is essential for tissues of mesenchymal origin, fibrous tissue, teeth, developing bone and blood vessels. (McDonald 1969)

**Mineral salts** are inorganic compounds that are used as structural components and regulating substances in the body. Most food contains them in a natural form, but they may also be liberated during oxidation in the body. Minerals fulfil various functions in the body, are inter-related and balanced against each other and cannot be considered as single elements with circumscribed functions. Of all the elements, about 35 are recognised as being important in human nutrition and some 19 elements are now considered as being essential to life, some of which are needed in extremely small quantities by the body and so they are referred to as trace elements (McDonald 1969).

Calcium is essential for the proper formation of bones and teeth. Some 99 per cent of calcium is found in the skeletal tissues of the body. The largest portion of the remaining 1 per cent is found in the muscle. It is an indispensable component of the structure of the body. The bones and teeth owe their hardness and strength to the presence of this mineral. It is aided in its structural role by its inter-actions with phosphorus and magnesium. Blood vessels within the bone not only carry nutrients to the bones but also pick up calcium and phosphorus from bone to maintain blood levels of these minerals. Calcium levels in blood are kept in balance by two hormones - calcitonin and parathyroid hormone. Parathyroid hormone also stimulates absorption of calcium from the intestine and prevents its loss in the urine. In the skeleton it serves two purposes: structural and metabolic.

Sodium is an electrolyte and bears a positive electrical charge. Sodium chloride or common salt is essential for the maintenance of fluid balance and normal osmotic pressure
in the body. It is needed for cellular activities. A certain level of sodium chloride must be maintained in the blood, cells and tissue fluid. Salt is essential for increased blood and tissue volumes. A deficiency or severe restriction of sodium may lead to a hormonal imbalance involving the kidneys and adrenaline glands (Pike & Gursky 1970).

Potassium is an indispensable constituent of the body cells. It is needed for all cellular functions. It maintains the alkalinity of bile and blood and stimulates skeletal muscles. It helps in the normal function of the heart.

Phosphorus is extremely vital to health because of its role in all body processes. It is agreed that the diets that supply adequate amounts of calcium also contain sufficient amounts of phosphorus. Not only is phosphorus an important bone mineral, it occupies a primary role in energy transformations.

Soluble phosphates were effective in preventing dental caries. Stookey, Carrol and Muhler have reported that significant reductions in dental caries were observed following the use of presweetened breakfast cereals to which 0.5% NaH₂PO₄ and 0.5% Na₂HPO₄ had been added (McDonald 1969). Eighty per cent of the phosphorus is found combined with calcium and other substances in the bones and teeth. The remaining 20 per cent is distributed in the blood and tissues where it performs a number of vital functions. Phosphorus in the form of inorganic phosphate helps in maintaining a proper acid-base balance.

Iron is an essential mineral for the body. Over 70 per cent is present in haemoglobin and the rest is found in myoglobin, in several enzymes such as catalase, peroxidases, cytochromes and storage compounds (McDonald 1969). It is responsible for the red colouring of blood. It is necessary for the transportation of oxygen to the tissues. Insufficiency causes iron deficiency anaemia.
iodine is necessary for normal physical and mental growth. It is also needed by the thyroid gland for the production of thyroxine which regulates the metabolic rate. Severe iodine deficiency can lead to cretinism in the infant, a disease characterised by hypothyroidism and severely retarded growth (Randolph & Dennison 1981).

Fluorine is never found in the free state in nature but is found as fluoride salts in various compounds. Important fluoride compounds are sodium fluoride, sodium silicofluoride, and fluorosilicic acid. In each of these compounds the extremely reactive fluorine element has reacted to form stable fluoride compounds. These particular stable ion species are used to fluoridate water supplies where there is a deficiency in this trace element.

Most diets are also deficient in fluoride. Fluoride helps in the formation of bone and teeth with the entry of its ions within the apatite crystal during the mineralisation stage. It is necessary in the prevention of dental caries. After mineralisation is completed, there is still fluoride uptake by the teeth.

The importance of water is next to oxygen. When the water supply is inadequate adverse results in the body occur quite promptly. Water serves not only as an essential nutrient, but also forms the major component of the body. It is a means of chemical transport and the medium in which the metabolic reactions occur (McDonald 1969). Water helps to maintain proper body temperature, transports dissolved nutrients, and carries away waste material. It also participates in such chemical reactions as splitting starch into sugar units. Water is generally considered of overwhelming importance in maintaining life.

Fibre is occasionally mentioned as a seventh class of nutrient because, while it is indigestible and, therefore, cannot participate in biological functions within the body, it is thought to be important to digestion and excretion in ways that affect our overall health (Calloway & Carpenter 1981).
1.3 CHANGES OF DIETARY PATTERN

In the palaeolithic era, about one and a half million years of human biological life, people were very active and used to depend on hunting wild animals for their food. Eighty percent of the palaeolithic diet consisted of wild plant foods, high in fibre and complex carbohydrate. The wild animal foods consumed were low in fat and the only sugar and salt consumed was from naturally occurring sources.

During the neolithic era approximately 10,000 years ago, the first major change in dietary pattern was established, when the food was first produced by agricultural methods. This made possible the domestication of wild animals and plants. Dairy products and cereals were developed from wild grasses, thus becoming a part of the diet. Cereals were a dietary staple. Salt was introduced to the diet approximately 4000 years ago, but it was expensive and not widely available. Sugar was introduced widely at the beginning of the 19th century.

Approximately 200 years ago the industrial revolution marked the second major dietary change. As people moved from rural areas to work in factories, new technologies enabled food to be preserved and transported to them in the growing cities. Technological developments made white flour, refined cereals, sugar, fat and salt affordable and readily available. There was a shift away from carbohydrate staples to an increased consumption of animal food. New food habits developed. These changes have been described as the move from an agricultural food supply to a technological food supply.

From the nutritional point of view, the most significant changes in the last 100 years have been the increased consumption of fat and sugar and the decreased intake of complex carbohydrates.

Table 3 puts into historical perspective the major dietary changes which occurred as a result of industrialisation (Fanning & Smith 1985).
Table 3
Changing food patterns.
Source: Fanning & Smith (1985)

I. PALEOLITHIC — 1½ million years ago
Hunting and gathering
Wild plants "grazing", gathering
Wild animals "gorging", hunting
Low fat, salt, sugar. High fibre and starch.
Very active lifestyle

II. NEOLITHIC
First Major Change
— 10,000 years ago.
Beginning of settlements
Introduction of domesticated grasses (cereals) and animals (dairy foods)
Low fat, salt, sugar. High starch and fibre.
Very active lifestyle.

III. INDUSTRIAL REVOLUTION
Second Major Change
— 200 years ago
Gradual shift from an agricultural food supply to a technological food supply.

Changing Food Supply
- New methods for producing and distributing food.
- Processed and fabricated food available
- Ready availability of previously scarce commodities.
  Fat, salt, sugar, animal foods

Life Style Changes
- Urbanization - less involvement in food production - need to buy food.
- Increasing affluence.
- Changing nature of work and leisure-decreased physical activity and decreased energy needs.

Contemporary Affluent Diet
- High intake: fat, sugar, salt, energy.
- Low intake: fibre (especially from cereals)
  complex carbohydrate
  decrease in micronutrients.
The industrial revolution made dramatic changes in dietary pattern in developed countries, but the developing countries are still dependant on an agricultural method of food supply, for example, Bangladesh.

Migration from one's home country to settle permanently in another country ultimately brings some change in the dietary pattern in the long term. Studies on migrants in Britain show that traditional food practices persist strongly in the first generation migrants. In the second generation these practices are less widespread, unless they are associated with religious prescriptions, in which case adherence remains high. Conflict may arise between parents and children over the maintenance of traditional food habits, as the children are exposed more strongly to the host culture through school (Barasi & Mottram 1987).

Ethnic, religious, regional, cultural, social, economical and psychological factors all play important roles in the development of the dietary pattern of an individual or a group of people.

Radio, television, magazine and billboard advertising should not be overlooked because these also influence our food habit (Calloway & Carpenter 1981) and establishes dietary pattern.
1.4 AIM OF THE THESIS

It has been seen in many studies that the prevalence of dental caries is generally increasing in developing countries, especially countries where sugar consumption is increasing. The WHO Global Data Bank has succeeded, since 1969, to follow and to signal important trends in relation to the dental caries experience of populations (Barmes et al 1983).

The first clear trend affecting large numbers of countries, indicated in 1974, was an increasing prevalence of caries in developing countries particularly in urban centres (Barmes & Sardo Inifiri 1982).

From the writer's own experience, dental caries in Bangladesh is increasing. Most of the teeth of young children are being taken out because of pain and infection from dental caries which eventually leads to occlusion problems, which are the most expensive of all community dental health problems.

It is observed that a number of factors, like poor oral hygiene, inappropriate consumption of sugar and sugary foods, insufficient use of fluoride, poor dentist:population ratio, poor socio-economical condition, and lack of dental health education might be responsible for the increase in the caries prevalence. Of all these factors, the amount and form of sugar consumption seems to play the most important role.

These observations have spurred the writer to investigate dietary aspects of dental health.

The specific aim of this thesis is to review text and literature on dietary patterns of food and to determine an appropriate dietary pattern as a preventive measure for the reduction of dental caries in young children.
2 DENTAL CARIES IN YOUNG CHILDREN

2.1 AETIOLOGY AND MECHANISM OF DENTAL CARIES

The earliest recorded theory of tooth decay dates back to 4000 BC (Levine 1977). This is the theory of the "tooth worm". As the time passed a number of theories have been postulated, namely Humors theory, Vital theory, Chemical theory and Parasitic or septic theory. However, the "worm theory" was still widely accepted until just over a century ago.

In 1889 an American Dentist, Willoughby D Miller, most of whose work had been done at the University of Berlin, came up with the acidogenic or chemoparasitic theory, which was a blend of the chemical theory and parasitic theory. He supported his theory with writings and experiments and was widely accepted. According to Miller's theory acid was produced from the action of micro-organisms on carbohydrates. It is characterised by a decalcification of the inorganic phase followed by a disintegration of the organic substance of the tooth.

Later two more theories received attention. In 1944 Gottlieb suggested that caries was initiated by proteolytic enzymes destroying the organic matrix of the enamel which opened up pathways for bacteria to colonise. The bacteria then produced acid from sugars which remove the minerals. This is commonly known as the proteolytic theory. Frisbie (1944) also described caries as a proteolytic process involving depolymerisation and liquefaction of the organic matrix of enamel. The second, the proteolytic chelation theory was advocated by Schatz and Martin (1962). According to this theory dental caries is a bacterial destruction of teeth where the initial attack is essentially on organic components of enamel. The breakdown products of this organic matter have chelating properties and thereby dissolve the minerals in the enamel. The validity of these two theories are questionable due to the lack of experimental evidence and support of data.

On the other hand, Miller's basic concept has built up support and a great deal of experimental evidence has been documented in its favour. Even the destruction of organic matrix which was not been very well explained by Miller has been clarified by the discovery of proteolytic enzymes of bacterial origin in carious cavities.
It is clear now that caries is initiated by acid, which is a by-product of bacterial metabolism of dietary carbohydrates within plaque. Thus it is necessary to look into the various factors that take place in producing the varying patterns of caries attack in teeth of different individuals. The basic chain of events responsible for the formation of dental caries has been simply shown by Mathewson et al (1987) in Figure 2.

Figure 2
Chain of events responsible for the formation of dental caries.

2.1.1 Teeth
A susceptible tooth is essential for caries to occur and caries susceptibility of a tooth at one time was thought to be dependent upon degree of mineralisation. There is insufficient incidence to accept this as a contributing factor, although it is accepted in cases of gross developmental disturbance. There is some evidence to support the relation between a higher concentration of carbohydrates in enamel and lowered solubility to acid (Gron et al 1963). Fluoride has been found as the most important trace element in enamel and an optimal level (1ppm) of fluoride gives maximum protection to the teeth against acid attack.

Clinical observation reveals that pit and fissure areas of the posterior teeth are highly susceptible to caries, because these are the difficult areas to clean and, as such, food debris and micro-organisms can readily become impacted in these areas and left undisturbed. The extent and depth of these areas vary in different individuals and hence
the susceptibility to caries. Parfitt reported that prior to the age of 7 years, a greater number of involved occlusal surfaces than proximal surfaces is seen (McDonald 1969).

Irregularities in arch form, crowding, and overlapping renders them more susceptible to a caries attack (Newbrun 1978). Carious lesions do develop, however, in the enamel defects. Dental caries in deciduous teeth often develop in the line of fusion of the crown. Hypoplastic teeth tend to be more carious than sound teeth (McDonald 1969).

2.1.2 Saliva
Saliva is a mixture of the secretions in the oral cavity, from the three pairs of major salivary glands with contributions from numerous minor mucous glands (Newbrun 1978). However, it is essential to maintain the integrity of the teeth. Caries susceptibility of an individual is very much influenced by the various characteristics of saliva.

Rate of flow: A higher rate of flow better washes away food debris and helps by diluting the acids formed. This is well understood when a patient undergoes radiation therapy. In such patients the salivary glands get irradiated in the process and there is diminished salivary flow which reduces greatly the quantity of saliva. They quite rapidly develop carious lesions, termed as rampant caries.

Rates of flow of saliva vary in different individuals in different glands and in response to different stimuli and the chemical composition of the saliva may be altered by such variations (Silverstone et al 1981).

Viscosity: Studies show that there is a significant relationship between the viscosity of saliva and dental decay, as regardless of age (McDonald 1969). Saliva of low viscosity would help clear the oral cavity and dilute the acids produced much better than saliva of high viscosity would.
Buffering capacity: The recent most accepted relationship that has been reported between saliva composition and caries, is buffering capacity. When the rate of flow of saliva is higher there is increased buffer capacity. Patients whose saliva has a higher buffer capacity tend to have less caries (Newbrun 1978). The chief buffering systems are bicarbonate, carbonic acid, phosphate and urea. Bicarbonate is considered as the most important salivary buffer for several reasons (Newbrun 1978). These systems help to neutralise the acid and thus maintain a constant pH.

Antibacterial factors: This may be considered as the most important factor in saliva. These include lysozyme, lactoperoxidase and immunoglobulins.

Lysozyme - is a hydrolytic enzyme in saliva, which destroys most of the bacteria by breaking down their cell walls (Newbrun 1978).

Lactoperoxidase - is a haemoprotein enzyme requiring thiocyanate ion as a cofactor. The lactoperoxidase system blocks the uptake of lysine and glutamic acid, which are essential for growth of susceptible bacteria which accumulate peroxide (Newbrun 1978).

Immunoglobulins: These are specific antibody proteins found in saliva. Different immunoglobulins present in human saliva are IgG, IgA, IgM, IgD and IgE. The highest concentration of immunoglobulin present in serum is IgG but the major immunoglobulin present in saliva is IgA. The IgA of saliva differs from that of serum by containing an additional glycopeptide referred to as the "secretory component". This IgA is synthesised by immunocytes in the salivary glands whereas IgG and IgM in saliva are partly derived from their corresponding serum counterparts.

These antibodies may represent a defense mechanism in three ways. Firstly these antibodies may lyse the bacterial cells. Secondly, they may inhibit adherence of the cells to the tooth surface and finally they may coat the bacterial cells and interfere with their metabolism. It is wise that immunisation be done early in life, preferably before the eruption of primary teeth or their colonisation by Strep. mutans.
2.1.3 Dental Plaque

In the fourth century B.C., Aristotle thought about tooth decay and related this to the soft adherent food debris on the tooth, but this idea was not very clear until the advent of the microscope in the seventeenth century when microorganisms were seen in dental plaque. In the years that followed a number of attempts were made to define dental plaque. Of all these definitions the definition that was formulated by Löe in 1969 was explained well and widely accepted. "Plaque" is the soft, nonmineralized bacterial deposit which forms on teeth (and dental prosthesis) that are not adequately cleaned (Löe 1969).

It is clearly understood now that dental plaque is composed mainly of bacteria and their products. The first step in plaque formation is the deposition of an organic film called acquired pellicle which forms within two hours after the tooth has been cleaned and polished. This is largely derived from the salivary glycoprotein. Bacteria is not essential for its formation as it already contains bacteria. After 8 hours to two days of formation of acquired pellicle, there is rapid bacterial growth. The early organisms that colonise the tooth surface become firmly attached to the pellicle and, as they continue to multiply, the layers of bacteria are held together by interbacterial adherence. The adherence of layers of bacteria is further facilitated by the production of extracellular polysaccharides by some oral streptococci, mainly Strep. mutans and Strep. sanguis.

The bulk of dental plaque finally formed by bacteria embedded in an organic matrix comprises a protein and carbohydrate substrate derived partly from endogenous sources and partly from the diet (Murray 1989). Formation of plaque may be influenced by diet depending on the content and texture. Although plaque will form in patients fed by stomach tube (Newman 1980). The amount of plaque formed and the type of microorganisms in plaque, varies on different teeth and on different areas of the tooth. After two days matured plaque undergoes constant remodelling as a bacterial mass is not a static entity. These plaque play an essential role in the etiology of caries as it allows the diffusion of carbohydrates into it from the oral fluids. These carbohydrates are taken up by plaque organisms and acid is produced which causes drop in pH (Pollack & Kraviz 1985). Plaque also prevents the acid from being easily washed away from the enamel surface by oral fluid, and thus prolongs demineralisation of the tooth surface.
2.1.4 Microorganisms

It is now widely accepted that dental caries cannot occur in the absence of microorganisms. The classical germ free animal studies of Orland et al firmly established the fact that germ free animals do not develop caries (Orland et al. 1954) and animals fed with antibiotics are effective in reducing the incidence and severity of caries (McClure & Helwitt 1946). Caries do not develop on unerupted teeth and oral bacteria can demineralise enamel and dentine in vitro to produce caries like lesions (von der Fehr et al. 1970). Microorganisms invading carious enamel and dentine have been histologically demonstrated which can be isolated and cultivated.

Early plaque formation is mainly dominated by streptococci with significant numbers of other cocci such as neis seria and veillonella and gram positive rods. With the longer exposure time, the plaque undergoes a transition from a predominantly coccal flora to one which is increasingly filamentous particularly by the actinomyces species. At the same time there is a shift from mainly aerobic and facultative organisms to a more anaerobic flora (Pitt Ford 1985).

All organisms are not cariogenic and cariogenic organisms are not equally virulent. Moreover different organisms display some selectivity as to the tooth surface they will attack. Organisms responsible for carious lesions are, Strep. mutans (several strains), a Strep. salivarius strain, a Strep. millionmi strain, Strep. sanguis (several strains), a lactobacillus acidophilus strain, a lactobacillus casei strain. Peptostreptococcus intermedius, actinomyces viscosus and actinomyces naeslundii.

Four types of carious processes have been mentioned. They are pit and fissure caries, smooth surface caries, root caries and deep dentinal caries. Pit and fissure caries is most common in deciduous dentition. The organisms and their degree of virulence in each of the carious processes have been taken from animal studies and tabulated in Table 4 (Newbrun 1978). Emphasis has been given to the importance of Strep. mutans in the etiology of caries by most research workers, although there is no evidence directly from human studies, except considerable indirect evidence (Newbrun 1978).
Table 4
Types of dental caries in animal model system.
Source: Newbrun (1978)

<table>
<thead>
<tr>
<th>Type of Caries</th>
<th>Etiological Organism</th>
<th>Possible Significance in Human Disease</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pit and fissure</td>
<td><em>Streptococcus mutans</em></td>
<td>Very significant</td>
</tr>
<tr>
<td></td>
<td><em>Streptococcus sanguis</em></td>
<td>Not very significant</td>
</tr>
<tr>
<td></td>
<td>Other streptococci</td>
<td>Not very significant</td>
</tr>
<tr>
<td></td>
<td><em>Lactobacillus sp.</em></td>
<td>Very significant</td>
</tr>
<tr>
<td></td>
<td>Actinomyces sp.</td>
<td>May be significant</td>
</tr>
<tr>
<td>Smooth surface</td>
<td><em>Streptococcus mutans</em></td>
<td>Very significant</td>
</tr>
<tr>
<td></td>
<td><em>Streptococcus salivarius</em></td>
<td>Probably not significant</td>
</tr>
<tr>
<td>Root surface</td>
<td><em>Actinomyces viscosus</em></td>
<td>Very significant</td>
</tr>
<tr>
<td></td>
<td><em>Actinomyces naeslundii</em></td>
<td>Very significant</td>
</tr>
<tr>
<td></td>
<td>Other filamentous rods</td>
<td>Very significant</td>
</tr>
<tr>
<td></td>
<td><em>Streptococcus mutans</em></td>
<td>Significant</td>
</tr>
<tr>
<td></td>
<td><em>Streptococcus sanguis</em></td>
<td>May be significant</td>
</tr>
<tr>
<td></td>
<td><em>Streptococcus salivarius</em></td>
<td>Probably not significant</td>
</tr>
<tr>
<td>Deep dentinal caries</td>
<td><em>Lactobacillus sp.</em></td>
<td>Very significant</td>
</tr>
<tr>
<td></td>
<td><em>Actinomyces naeslundii</em></td>
<td>Very significant</td>
</tr>
<tr>
<td></td>
<td><em>Actinomyces viscosus</em></td>
<td>Significant</td>
</tr>
<tr>
<td></td>
<td>Other filamentous rods</td>
<td>Very significant</td>
</tr>
<tr>
<td></td>
<td><em>Streptococcus mutans</em></td>
<td>May be significant</td>
</tr>
</tbody>
</table>

2.1.5 Diet

Several epidemiological studies and experiments have shown that carbohydrates are essential in the etiology of caries (Murray 1989). Animal experiments have shown that the severity of caries is directly related to the frequency of carbohydrate intake (Konig et al 1969). Gustafsson in Sweden investigated and found that the subjects, who consume more sugar at meal time have less caries than subjects who consume less sugar but with part of the sugar being taken in between meals experienced more caries (Gustafsson et al 1954). This suggests that the duration of sugar being in the mouth is more important than the amount of sugar consumed. A study was made on institutionalised children (80 children) at Hopewood House in Bowral, NSW, Australia (Harris 1963). Babies were either born at that home or were brought up there right from the first few weeks of their life. Sugar and other carbohydrates were cut off from the children’s diet. Carbohydrates were given in the form of wholemeal bread, soya beans, wheat germs, oats, rice, potatoes and some treacle and molasses. Dairy products, fruits, raw vegetable and nuts featured prominently in the typical menu. This was a vegetarian diet, and was inadequate in
proteins, fats, minerals and vitamins. Dental surveys carried out on these children during the ages of 5 to 13 revealed an average def and DMFT score of 1.1 or about 10 per cent of the caries prevalence in other children. This observation is certainly interesting. It can be mentioned here that their water supply contained insufficient fluoride (<0.1 ppm) and children's oral hygiene was poor. When the children grew older and left the home they started eating a different diet and a steep increase of DMFT was observed.

Individuals with fructose intolerance (Marthaler & Froesch 1967) and who have to restrict the intake of sucrose and sweet tasting substances hardly ever have dental caries (Newbrun 1978). In experiments carried out (Kite, Shaw & Sognnaes 1950) where rats were fed a cariogenic diet by stomach tube, they remained caries free.

Animal studies have shown that cariogenicity of all carbohydrates are not equal. Monosaccharides and disaccharides are comparatively more cariogenic than starch (Shaw, Krumins & Gibbons 1967). Among all sugars, sucrose is considered as the most cariogenic, though very little difference is indicated between glucose, sucrose and fructose (Colman, Bowen & Cole 1977). Grenby and Hutchison (1969) and Green and Hartles (1969) also found the same result when studying the cariogenicity of sucrose and other sugars, although all the sugars are highly cariogenic (Murray 1989).

The composition of the noncarbohydrate part is also important in the cariogenicity of an amount of sugar. In notobiotic rats monoinfected with Strep. mutans, Michalek et al (1977) observed that a sucrose concentration of 1 per cent produced marked caries development and minimum caries development occurred at 5 per cent concentration. As little as 2-5 per cent sugar causes much caries in the presence of 50-70 per cent starch, whereas five times as much sugar is necessary in a high fat diet (Shaw 1979). Sugar taken in a liquid form tends to be less cariogenic than sugars taken in a solid or sticky form, such as toffees, candies or cookies (McDonald 1969).
Intake of sugar has an effect on the composition of plaque microorganisms. It has been well proved that intake of sugar increases the ability of Strep. mutans to adhere and colonise on the tooth surface (Krasse 1965). Also glucane and fructane are synthesised from sucrose especially by Strep. mutans and Strep. sanguis which aids in their adhesion to the tooth surface. Moreover, these polysaccharides act as a reserve source of carbohydrates which probably protects the plaque microorganisms from harmful effects of the oral environment. Cariogenicity of carbohydrate can only be determined by the ease with which it can be taken up and metabolised by plaque microorganisms to produce acid.

It is now agreed that the critical pH of dental plaque is 5.5, below which enamel can demineralise. The most common acid produced in plaque is lactic acid, although other acids are also produced. It is also observed that pH can fall as low as 4.1 each time when sucrose is introduced in the mouth (Hassell & Mühlemann 1971). The effect of different carbohydrates on plaque pH is shown in Figure 3. The greatest drop in pH is seen when glucose, fructose or sucrose is applied to dental plaque. Caries risk will increase if there is frequent intake of sucrose in sticky form between meals. (Krasse 1985)

Figure 3
pH changes in plaque following application of different carbohydrate solutions. Source: Newbrun (1983)
2.1.6 Summary

Dental caries is a localized, chronic disease. It is initiated by acids produced by plaque bacteria which causes demineralisation of the outer surface of the tooth followed by disintegration of the organic matrix. This acid is produced by bacteria through fermentable carbohydrates. As demineralisation by acids and proteolytic activity by bacteria continues, it leads to the formation of a cavity.

Dental caries is primarily a disease of children. This indicates that the tooth is more resistant in older individuals. Three principal factors (Newbrun 1978), the host (particularly the saliva and teeth), the microflora and the substrate (that is the diet) are essential for the development of caries. In addition a fourth factor, time, has to be taken into consideration in the etiology of caries but it is the diet which is the main causative factor (Pitt Ford 1985). Diagrammatically these factors can be portrayed as four overlapping circles which is shown in Figure 4.

Figure 4
Parameters involved in the caries process.
2.2 CONTROL AND PREVENTION OF DENTAL CARIES IN YOUNG CHILDREN

2.2.1 Introduction

Prevalence: Ancient populations had a low prevalence of dental caries. The reason behind this remains undiscovered until the 19th century (James 1975). However, the teeth being very durable organs remain in excellent condition for a considerable time after death for investigation into the epidemiology of dental caries to be carried out. During archaeological investigation, skulls discovered (Brothwell 1959, Moore & Corbett 1971, 1973) show that for over 2000 years in Britain there were no major changes in the prevalence of caries.

The children of Tristan da Cunha were remarkably free from caries in 1937, when their diet consisted mainly of potatoes, fish and occasionally some sea birds, sea bird eggs as well as beef, mutton, apples and berries but no added sugar. They became progressively affected with severe dental caries as they grew more sophisticated in terms of lifestyle and the adoption of a modern diet rich in carbohydrates and sugars and low in fibre. Studies have been done in Britain, Sweden, Denmark, USA and French Polynesia with children aged between 2 and 5 years and show that 57-80 per cent of these children already suffer from caries (Poulsen & Möller 1972, Bronstein 1969, Todd 1975). It seems that dental caries is the result of civilisation, urbanisation and affluence.

The problem of dental caries is not the same in all countries. It varies from place to place and between different social economic groups. Widely divergent figures have been reported from different parts of the world on caries. In a study of 528 Guatemalan children caries prevalence in the deciduous dentition was found to be two times greater than in Caucasian children in the United States. Higher caries attack rates were observed in the anterior teeth (Pollack & Kravitz 1985). Almost 100 per cent of the Australian community was affected by dental caries (Barnard 1965). It has been well documented that the occurrence of dental caries in several of the preindustrial countries is more severe in the deciduous dentition than in the permanent dentition. Whether the degree of caries

Prevalence during preschool years is of particular importance because the magnitude and impact of this disease at such a young age is a shocking revelation demanding resolution. **Table 5** is a compiled summary by Mathewson et al (1987) of surveys taken in fluoride deficient communities (Toverud et al 1953, Hennon et al 1969, Winter et al 1971) and simplified to account for differences in methodological design. By the age of three, the age at which some dentists recommend a child’s first dental visit, the number of carious surfaces may range between three to six if the child resides in a low fluoride area (Hennon et al 1969, Winter et al 1971, Holm & Arvidsson 1974).

**Table 5**
**Dental caries experience of preschool children in fluoride deficient areas.**
**Source:** Mathewson et al (1987)

<table>
<thead>
<tr>
<th>Chronologic Age</th>
<th>Caries Prevalence *</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 year</td>
<td>5 %</td>
</tr>
<tr>
<td>2 years</td>
<td>10 %</td>
</tr>
<tr>
<td>3 years</td>
<td>50 %</td>
</tr>
<tr>
<td>5 years</td>
<td>75 %</td>
</tr>
</tbody>
</table>

* per cent of population having one or more carious teeth

In 1985 the National Health and Medical Research Council recommended a few goals, and put forward by the World Health Organization and the International Dental Federation Goal 1, may be mentioned here, “sixty five per cent of five to six year old children will be caries free by the year 2000” (Commonwealth Department of Health 1987).

**Approach to prevention:** As dental caries is a multifactorial disease it is unlikely that any one approach will lead to its prevention and control (Newbrun 1978). Prevention can be
considered as it relates to each factor. For instance, a balanced diet with optimum daily fluoride intake while the teeth are forming and erupting will enhance sound tooth development, making teeth more resistant to caries. Daily disruption of the colonising bacteria through plaque removal and a reduction in the amount or frequency of sugar intake can also assist in reducing caries (Shawder 1980). Pit and fissure sealants were introduced successfully in the 1970s as an additional means of preventing dental caries (Loey 1981).

Newbrun in his book "Cariology" summarises the above facts by the following strategies:

(i) Combat microbial agent through personal oral hygiene and removal of plaque.
(ii) Increase the tooth resistance by systemic and topical fluoride, occlusal sealants.
(iii) Modify the diet by diet control, restriction of sucrose containing foods and beverages, use of non-cariogenic sweeteners, phosphate additives.

2.2.2 Methods of Prevention and Control of Caries

Dental caries is so widespread that virtually everybody in the world suffers from this disease (Murray 1989). No individual can be considered fully healthy while there is active disease present in the mouth.

In the financial year 1985-86 the total expenditure for dental health services was estimated at $942.315 million Australian dollars in Australia. In the next financial year 1986-87 approximately $993.087 million Australian dollars were spent for dental health services (Barnard 1989). This was an increase of approximately 6 per cent over the previous year and only about 50 per cent of the Australian population received dental services during that year. It is very clear that if the total population was to receive dental health services the cost would be much higher. At the same time the cost of dental treatment is going up every day leading to a greater and greater financial burden on an ever increasing proportion of the population and this situation is more or less the same throughout the world. It has been reported in Britain that in terms of single specific illness or disease the cost of dentistry is second only to cost of mental illness and is greater than direct national
health service expenditure on conditions such as pregnancy or the treatment of heart
disease, bronchitis or tuberculosis (Office of Health Economics 1969).

Untreated caries can cause considerable pain and discomfort and needs time, money and
dental manpower (Newbrun 1978). Hence this should receive significant consideration in
every day dental practice not only from the standpoint of extractive and restorative
treatment but also from the standpoint of preventive treatment (McDonald 1969) and the
fact that caries is preventable (Pitt Ford 1985, Newbrun 1978).

If preventive measures are taken successfully it would reduce the prevalence of dental
caries, thus reducing pain and suffering and disability due to tooth loss. In fact, the quality
of human life is enhanced considerably when caries is prevented. It would also cut down
the cost and manpower requirement. This is of special importance to underdeveloped and
developing countries which cannot come up with the money and manpower for
sophisticated restorative dental work.

Although the prevalence of dental caries and the provision of dental services varies in
different countries, the same underlying general principles of prevention must apply
throughout the world (Murray 1989).

**Oral Hygiene:** Daily rinses of antimicrobial agents like Vancomycin and Chlorohexidine
have shown good short term benefits in the inhibition of plaque growth and colonisation
(Mathewson et al 1987). *Strep. mutans*, which is responsible for caries, is particularly
susceptible to these chemical agents. Dextranase is an enzyme which prevents adherence
of plaque to the tooth surface, but it is not yet well accepted.

Tooth brushing is the most widely used and socially accepted means of achieving good
oral hygiene (Newbrun 1978). However, if carefully observed, tooth brushing alone does
not have much effect in the reduction of new carious lesions.
The impact of maintenance of oral hygiene is the removal of dental plaque and help in the prevention of the formation of acid, which is a major aetiological factor in caries formation. Tooth brushing is more effective when used along with a disclosing solution or tablet fortnightly or monthly. If half a red disclosing tablet is chewed until it dissolves in the mouth and thoroughly swished around the teeth, the plaque on the teeth will be stained red. The teeth can then be cleaned to remove all the red stains and the most effective method for the individual can be ascertained. Figure 5 shows teeth before and after the plaque is coloured or disclosed. The extent of plaque on the visible tooth surfaces can be measured using a plaque index.

Figure 5
Teeth before and after the plaque is coloured or disclosed.
Source: Towner (1982)

Good oral hygiene habits should develop from early in life, when the child has all the front teeth. Preschool children should be encouraged to develop these habits and continue them throughout life (Loevy 1981). Although Starkey (1961) pointed out that before age seven it is unrealistic to expect an adequate brushing habit and a successful preventive program requires parental participation. One study of tooth brushing habits of children has shown that those aged five years and under, brush less than 20 seconds. In the same study, about 35 per cent of the children in this age group were unable to "wield" the brush. Also it was found that the tooth brushing performance of children under age seven years
was much more brief and haphazard than that of older children. Preschool age children usually have not yet developed their skills for efficient tooth brushing. Parents brush their child's teeth significantly more effectively than do the children themselves and when parents are given specific instruction for brushing their child's teeth they are more motivated to follow instruction (McDonald 1969). There is little difference in effectiveness between the various methods of removing plaque (Newbrun 1985). A horizontal scrub method is shown to be the most effective and comfortable (Sognnaes 1974) and is recommended for children. A technique for the parent brushing the child's teeth is shown in Figure 6. The ideal time is immediately after each meal but if it is not possible then at least after breakfast and before going to bed.

Figure 6
A technique for the parent brushing the child's teeth.
Source: MacDonald (1969)
The American Dental Association recommended the criteria of a good toothbrush and method of maintenance. Small children should have brushes one quarter to one third smaller than those used for adults but of the same design. The type of toothbrush and the frequency will not usually determine the effectiveness of toothbrushing as a preventive measure, unless toothbrushing is done efficiently. Naturally, the quality of cleaning is more important than the frequency of its performance (Bellini et al 1981). Electric toothbrushes offer mechanical aid to the disabled and to many others who are not adept at hand manipulation.

For reasonable brushing, three minutes is recommended for each time. When toothbrushing is not possible after meals or after between meal snacks, oral rinsing is very helpful in promoting the clearance of fermentable carbohydrate.

Interproximal plaque removal is very difficult even with efficient toothbrushing. Dental floss is useful when all the plaque is to be removed from interproximal spaces (Axelsson 1981), but dental floss is not indicated for use by small preschool children (Pollack & Kravitz 1985) because proximal contacts between teeth are often lacking. Chewing gum is another aid to oral hygiene. The most desirable chewing gum will make use of artificial flavouring instead of sugar. Chewing gums containing Sorbitol, Mannitol and Xylitol are beneficial in neutralising plaque acids by stimulation of salivary flow and promotion of enamel remineralisation.

**Fluorides:** Fluorides are now widely used as the single most effective and successful method for caries preventive program because of their cariostatic effects. When systemically ingested or topically applied or both, fluoride will confer on the tooth a greater resistance to carious destruction through formation of fluorapatite and CaF$_2$ (Masato, Tsuguo & Masahiro 1986, Mathewson et al 1987).
Fluoride ions act on the hydroxyapatite crystal in enamel, substituting themselves for the hydroxyl ions, forming fluorapatite. This chemical substitution is:

$$\text{Ca}_{10}(\text{PO}_4)_6(\text{OH})_2 + 2\text{F}^- \rightarrow \text{Ca}_{10}(\text{PO}_4)_6\text{F}_2 + 2\text{OH}^-$$

Hydroxyapatite \hspace{1cm} Fluorapatite

This forms a more resistant surface layer to acid dissolution by promoting remineralisation, improving crystallinity and decreasing solubility of the enamel. Also fluoride ions act on cariogenic bacteria by inhibiting glycolysis (fermentation of sugars into acid) and plaque colonisation through suppression of salivary protein adsorption onto the enamel and by a direct antibacterial effect (Moss & Wei 1976).

There are various types of fluorides in use today and various methods of application. These can all be basically divided into two methods: systemic; and topical. These methods can be used singularly or in combination and employ several different vehicles for administration; water, tablets, drops, paste, gel and solutions.

**Systemic Fluorides:** When fluoride is ingested at an optimal level (1ppm) to the mother during pregnancy and the child through the years of tooth formation, the reduction of caries will be greater than 50 per cent in permanent teeth (Backer-Dirks 1974) and slightly less than 50 per cent in deciduous teeth (Scherp 1971). It is also found that smooth surfaces benefited most from fluoride exposure (88% reduction) and pit and fissure caries benefited least from fluoride exposure (43% reduction) (Murray 1976).

Fluoridation of communal water supply is the usual means of supplying fluoride to the population. The US Public Health Service conducted epidemiological surveys and concluded that 1ppm fluoride concentration is the optimal level depending on the weather conditions and the amount of water consumed per individual, when teeth get maximum protection against caries (US Dept HEW Centre for Disease Control 1977). For countries where public water supply system is well established, fluoridation is the most efficacious and cost-effective measure available to prevent tooth decay in the community (Burt 1979).
On 25 January 1945, fluoridation was first instituted at Grand Rapids in America. It is now estimated that more than 230 million people in over 40 countries are receiving fluoridated water at home for drinking and other uses (Barasi & Mottram, 1987). The summarised findings of some early water fluoridation studies are given in Figure 7. The Grand Rapids study in every year's examination showed confidence limits (p=0.95) depending on several age groups with fluoride water supplementation starting at various ages from 0-6 years. The result shows little difference in the percentage reduction (50-60%) of caries in the permanent dentition whether fluoride is used at birth or from the age of one or two years. Moreover, all studies show a 50 per cent reduction if fluoridation starts at four years of age or later. However, these data show that fluoridated water acts systemically during tooth formation to make enamel more resistant to decay (WHO 1986). The maximum resistance to tooth decay is achieved by the systemic administration of fluoride during the tooth formation as fluoride is then available for incorporation into enamel and dentine.

**Figure 7**
Reduction of DMFT according to age that children were first exposed to fluoridated water.
Source: Murray (1986)
In places where the communal water supply is not fluoridated, daily ingestion of dietary fluoride supplements from shortly after birth until at least age 13 can provide protection against caries of almost the same as water fluoridation, that is about a 50-60 per cent lower prevalence of dental caries (Driscoll 1974, Binder et al 1978, Thylstrup et al 1979). These supplements can be in the form of drops, tablets or lozenges. The regime in the United States (Table 6) is that recommended by the American Dental Association’s Council on Dental Therapeutics (1979) and the American Academy of Paediatrics (1979). Studies have shown that few parents and children follow the consistent daily dosage of dietary fluoride supplements (Newbrun 1980). Fanning et al in a study concluded that self administration of fluoride tablets is unsatisfactory due to general failure to maintain the fluoride supplements required (Report of the Committee of Enquiry into the Fluoridation of Victorian Water Supplies 1979-80).

**Table 6**

**Dosage levels of supplemental fluoride recommended in the USA.**

*Source: Newbrun (1986)*

<table>
<thead>
<tr>
<th>Age</th>
<th>&lt;0.3 p.p.m</th>
<th>0.3-0.7 p.p.m</th>
<th>&gt;0.7 p.p.m</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-2 years</td>
<td>0.25 mg</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2-3 years</td>
<td>0.50 mg</td>
<td>0.25 mg</td>
<td>0</td>
</tr>
<tr>
<td>3-13 years</td>
<td>1.00 mg</td>
<td>0.50 mg</td>
<td>0</td>
</tr>
</tbody>
</table>

In some countries where water is not fluoridated attempts have been made to fluoridate milk while others have tried fluoridating domestic salt, but it is now understood that neither salt fluoridation nor milk fluoridation can be seriously considered as a community public health measure at present. Although Toth (1973) reported 40 per cent caries reduction in deciduous dentition with fluoridated salt, the means by which an individual obtains the fluoride is not important so long as an optimal level of intake is maintained for maximum protection against caries.
**Topical fluoride:** The aim of the application of topical fluoride to the erupted teeth is to reduce susceptibility to dental caries (Report of the Committee of Enquiry into Fluoridation of Victorian Water Supplies, 1979-80). Topical fluorides have an additive effect on teeth when used along with systemic fluorides. Sodium fluoride, stannous fluoride and acidulated phosphate fluoride are some of the common ones in use.

It is recommended that before the use of topical fluoride teeth should be cleaned and polished well. However, harsh abrasives should be avoided. Interdental spaces should be cleaned well with dental floss or a very fine abrasive strip, but for preschool children dental flossing is contraindicated. The teeth should then be isolated with cotton wool rolls and dried well. Each quadrant is then treated at a time. Topical application of fluoride should be carried out two to three times a year and should be started with the deciduous teeth, preferably at the age of 2½-3 years.

Two per cent NaF solution in distilled water is sufficient to apply to each quadrant for a period of four minutes. Stannous fluoride solution of eight or ten per cent in distilled water can be applied to the teeth for two minutes, 1.23 per cent acidulated phosphate fluoride in the form of solution or gel is used for four minutes as a topical fluoride therapy. Children in areas with insufficient fluoride in their water supply have been shown to develop 30-40 per cent less decay when these agents are applied semi-annually (Horowitz & Helfetz, 1975). Acidulated phosphate fluoride is frequently preferred because it does not discolour decalcified enamel, has an acceptable taste and is stable when kept in a plastic container. APF in gel form is better because it takes less time for application.

Fluoride containing varnishes and coatings are used in some countries. This gives long term effect on tooth enamel. Heuser and Schmidt (1968) claimed 30 per cent reduction in dental caries with this agent over a 15 month period. Because of lack of sufficient data, this is not yet well accepted for the use in public health program (Murray et al 1977, Holm 1979, Koch et al 1979).

Professionally applied topical fluoride is very expensive and cannot be considered as a public health measure both in fluoridated and non-fluoridated areas. It may be more appropriate for special groups such as the mentally handicapped.
Brushing with a fluoride toothpaste will reduce 20-30 per cent incidence of dental caries (WHO 1986), 0.76% sodium monofluorophosphate dentifrice (0.1% fluoride ion) is more effective than others in reducing caries (von der Fehr & Möller 1978). Fluoride mouth rinse is contraindicated for preschool age children because many of them cannot control their swallowing. In areas of endemic fluorosis, fluoride toothpastes should not be recommended for children under seven years of age.

Combined fluoride therapies have been successful in controlling rampant caries in patients who have undergone radiation therapy for the treatment of oral cancer (Dreizen et al 1977). Brushing once a month with a prophylactic paste or gel is the preferred method for the preschool child who is not yet able to swish properly (Loevy 1981).

**Occlusal Sealants:** The most common sites for caries to occur are pits and fissures of occlusal surfaces (Graves & Burt 1975). The National Dental Caries Prevalence Survey carried out in America (1979-80) showed that 84 per cent of the caries experience of 5-17 year old children occurred in pits and fissures (National Institutes of Health 1984). They are also sites which benefit least from fluoride (Backer-Dirks et al 1961). The pit and fissures to be sealed should be deep and narrow but not decayed (Loevy 1981). Occlusal sealants are considered as an effective caries reducing agent when proper patient selection and application techniques are maintained (Horowitz 1982, Silverstone 1982, Ripa 1973, 1983, 1985). It is now well documented that sealants gives 100 per cent reduction in the incidence of dental caries when the material is completely retained (Collier et al 1984, Eve et al 1984) and reduction is as high as 83 per cent when sealant is partially retained (Elderton 1985).

The materials presently used as dental sealants are composites and glass ionomer cements. The best time to apply pit and fissure sealant (occlusal sealants) would be within the first three years or so of eruption. Ultraviolet light is required for some sealants whereas others depend on a chemical polymerising system. Acid etching of the tooth
enamel surface is necessary to produce satisfactory bonding between enamel and sealant. Usual time for acid etching is 30 seconds to one minute depending on the particular product. Up to 90 seconds may be required to improve sealant retention on the occlusal surfaces of the primary teeth (Gourley 1974). Special care in the technique of application is essential as moisture control is specifically important. Contamination with saliva affects the retention of the sealants considerably (Pitt Ford 1985, Boksman et al 1987, McLean et al 1977).

Studies have shown that auxiliary dental personnel, with adequate training, have applied the material as effectively as dentists (Leske et al 1976). The consensus to date is that fissure sealing is expensive (Bagramian 1979), though sealants provide the intangible benefit of preserving intact natural teeth (Horowitz 1980). Fissure sealants not only prevent caries on occlusal surfaces but also decrease enamel caries on approximal surfaces (Bandilsh 1984). This should be re-evaluated at each six months follow up visit and replaced as necessary (Loevy 1981).

**Modification of Diet:** Nature of the diet, frequency of ingestion and other variables in the mouth is very significant in relation to dental caries (Gustafsson et al 1953, Weiss & Trithart 1960, Bagramian & Russell 1973, Bagramian et al 1974, Richardson et al 1977, Jackson 1978, Burt & Eklund 1981, Rugg-Gunn et al 1981). About 94 per cent of USA sugar intake is sucrose, 3 per cent fructose and 3 per cent lactose. Sucrose has been found most responsible for caries in our modern diet which is taken up by plaque microorganisms to produce acid leading to carious lesions. So too are other sugars and refined carbohydrates, though to a lesser extent. Mendale with his animal study found that caries severity increases with increase in sugar consumption, although the increase in severity falls with sugar concentration above 40 per cent. The sweet taste is one of the basic taste sensations (Jenkins 1978). So, it is not possible to avoid such foods completely. It may be advisable to reduce the consumption of such cariogenic foods and increase the consumption of non-cariogenic foods like fruits and vegetables. If sugary foods are to be
taken they should be taken all at meal times followed by thorough tooth brushing rather than spread out over the whole day. Research has shown that the same amount of sugar taken at meals, causes about one third the decay of equivalent amounts taken between meals (Barnard 1965).

It is better to take sugar in liquid form than solid or sticky forms, because solid or sticky food remains in the mouth longer than liquid and has more cariogenic effect (Newbrun, 1978). Soft drinks are less cariogenic than toffees. Frequent between meal sugary snacks should be avoided as far as possible, as it causes teeth to be more susceptible to carious attack. If food containing sugar is consumed once a day, the single attack will not cause a great deal of damage. This barrage of acid attack is shown in Figure 8 (Brown et al 1983). Moreover, between meal sugary snacks destroy the appetite for foods, which are so essential for normal growth and development.

Figure 8
Mouth acid levels when eating sugar at each meal or snack.

There are many foods that do not contain sugar, like nuts, crisps, potato, corn or cheese, eggs and ham snacks which can be eaten between meals. It is found that the more often sugar enters the mouth and the longer it remains, the more likely is the tooth to be attacked by acids (Towner 1982). To limit refined carbohydrate ingestion a preference for savory as opposed to sweet foods must develop from early infancy. It is unnecessary to sweeten cereals or orange juice as there is plenty of natural carbohydrate in these foods to supply energy requirements.
The consistency of food is also important. Our soft modern diet lacks the detergent properties of primitive man's food which cleaned his teeth and massaged his gums. Children should be encouraged to eat fibrous food. It is important to remember that food habits and tastes developed in early childhood form the basis of lifelong habits.

Sucrose can be replaced by non-cariogenic sweeteners. But biological, toxicological, economic and technical considerations, as well as taste preferences, complicate the issue. In Switzerland, for example, manufacturers may label their products "Zahnschond" (Safe for teeth) if in laboratory testing they do not lower the pH of interdental plaque below 5.7 for up to 30 minutes after ingestion (Imfeld & Mühlemann 1977). "Zahnschond" products usually contain non-acidogenic xylitol or slowly fermenting sorbitol, mannitol, maltitol or lycasin.

Use of non-sugar sweeteners on a small scale in certain medicines, lozenges, chewing gum and soft drinks may be acceptable to the people (Dansk Tandlægeforenings Sukkerudvalg 1979). Studies in Turku, Finland, showed promising results when sucrose was replaced by fructose or xylitol in most food stuffs for two years (Scheinin 1976, Scheinin & Makinen 1976). It is difficult to determine the caries preventive effect of substitution of sucrose by artificial sweeteners in only a limited range of products. Xylitol is still the most effective sugar substitute at present (Shaw 1981) in food processing. Phosphates have been added to a variety of foods and drinks, mostly alone (Lilenthal 1977), and also in combination with fluoride (Luoma et al 1979). Results with fluoride fortification are promising (Haugejorden & Heløe 1981).

A national food and nutritional policy has been adopted in Norway (Norwegian Ministry of Agriculture 1975), which considers global as well as consumer, producer and social needs. The aim is reduction of caloric intake from sugar and fat, and increased intake from starch to be achieved through 1990 by fiscal, regulatory and educational means.

In many countries, legislation and regulations to control production labelling, advertising and marketing of certain foods might promote good dietary habits. Studies in institutions
have shown up to 75 per cent decrease in caries incidence where the amount and frequency of carbohydrate consumption have been strictly reduced (Hartles & Leech 1975).

Parental counselling for sound dietary and nutritional habits may help in decreasing the incidence of caries in children (Sawder 1980). Dietary survey may also be helpful.

**Successful prevention and control of dental caries** in children require a number of procedures:

**Tooth**
- Improve quality and structure
- Increase resistance of enamel surface

**Bacteria**
- Decrease dental plaque formation
- Interfere with bacterial enzyme formation
- Remove dental plaque mechanically

**Saliva**
- Stimulate flow rate of saliva
- Increase ability to neutralize acid
- Increase remineralization capacity

**Diet**
- Decrease sucrose intake
- Decrease frequency of eating
- Increase oral clearance
  - Food less sticky, more firm and detersive
- Improve food quality and food practices
3 DIET AND DENTAL CARIES

3.1 INTRODUCTION:
Carbohydrates are produced in abundance, are cheaper relative to fats and protein, and are consumed in larger amounts than other foods by most populations in the world (Nikiforuk 1985). There are several reports that indicate an effect of diet and particularly of dietary carbohydrates upon dental caries (Silverstone et al 1981).

Diet can affect the teeth in two ways, systemically during the development of the teeth and mainly locally after the eruption of the teeth. There is evidence that once the teeth are erupted, local effect of food is very important and sugar is the most important dietary factor in this local effect.

But although sugar is the most responsible dietary factor in the incidence of dental caries, it is not possible completely to eliminate sugar from our diet. It is, therefore, necessary to determine whether there are any particular sugary foods or drinks or any particular eating habits which are especially responsible for aggravation of the condition of the disease process, so that we can guide individuals in the practice of a correct dietary pattern.

Various food items have been tested and verified for their cariogenicities. Considering the findings, we will only discuss here those dietary components (namely fermentable carbohydrates, specially sucrose) which are specifically considered to be significant in relation to dental caries (Murray 1983).

We will also discuss here the effect of detersive (cleansing) foods and the existence of various protective factors in our diet. As sugar is the major cause in caries incidence, the search for sugar substitutes would be of value.
3.2 CARIOGENICITY OF DIFFERENT CARBOHYDRATES

Starch, sugars and cellulose are examples of carbohydrates which perform some important functions in the body metabolism and maintains good health. In relation to dental caries in humans not all of the fermentable carbohydrates are of importance. The principal carbohydrates available in human diets are starches and sugars, especially sucrose and some lactose (Newbrun 1983).

Research has shown that it is the pattern of dietary intake of carbohydrates rather than any unique characteristic of the sugars themselves which is specifically responsible for cariogenicity of the diet (Ludwig & Bibby 1957, Marthaler 1967, Nizel 1969, Bowen 1978).

Cariogenicity of different carbohydrates depends on:

(i) The type of carbohydrates.
(ii) The physical form and oral clearance rate.
(iii) Their frequency and time patterns in the daily diets.
(Bibby 1970)

Sucrose is a disaccharide. When eaten, sucrose is broken down into two monosaccharides, glucose and fructose in the intestine and these two simple sugars are readily absorbed into the blood stream. Most of the fructose is converted into glucose in the liver. Like all carbohydrates sucrose is ultimately used by the body as a glucose for energy (Australian Sugar Industry 1983).

Lactose or milk sugar is also a disaccharide. It is the combination of glucose and galactose. It is found in milk of mammals. It is the only carbohydrate of animal origin which has nutritional significance. Its function is to supply carbohydrate to the nursing young. Starch is a polysaccharide, containing long chains of repeating monosaccharides of the polysaccharides. Amylose and amylpectin are two types of starch. Plants manufacture starches from simple sugars and store them in fruits, in roots (potatoes) and in seeds (Mak 1982).
A breakdown of dietary carbohydrates is shown in Figure 9. In both the United States and Europe, 90 per cent of the total carbohydrates consumed are mainly from sucrose, and then from starches. So it is understood that the relative cariogenicity of carbohydrates is mainly dependant on the comparison between starches and sugars, notably sucrose.

Figure 9
Breakdown of dietary carbohydrates.

The American Dental Association, in a statement in July 1983, indicates the role of all carbohydrates in tooth decay. The Association concluded that the single action of decreasing total sucrose intake may be incomplete as a caries preventive measure. Many foods which contain little or no sucrose (but contain other fermentable carbohydrates) are capable of promoting decay. If glucose and fructose were as widely eaten as sucrose, they would probably cause decay to the same extent (Australian Sugar Industry 1983).

There has been great controversy and confusion surrounding the relative cariogenic potential of the various carbohydrates available in food. Research has shown that di and monosaccharides are similar in cariogenic potential. It has also been found that sucrose is more cariogenic than its constituents, glucose and fructose, and they are similar to each other in cariogenicity (Grenby & Hutchinson 1969). In most studies sucrose has been found to be the most cariogenic because of its ability to be converted into extracellular polysaccharides like dextran which form part of the matrix of dental plaque.
Starch diffuses slowly into plaque compared to mono or disaccharides. Raw wheat starch and when the starch is cooked, dried and powdered to resemble raw starch in physical texture prior to incorporation in the diet, both cause a little dental caries (Grenby 1965). Physiochemical properties of different carbohydrates provides evidence that starch is much less cariogenic than sugar (Nizel 1981).

Glucose, fructose, lactose and mannose are found to be cariogenic in animal experiments and they are usually minor constituents of human foods as they are only found in dried fruits, honey and milk (Nikiforuk 1985). Intake of lactose-containing products, i.e milk, can cause caries under certain circumstances. However, lactose and milk are normally of low cariogenicity.

Physical form, concentration and solubility of sugars, are more important in determining cariogenicity than the type of sugar eaten. Fruit sugars, basically fructose and glucose, are potentially as cariogenic as sucrose. However, in their natural forms in fruits these sugars are diluted and generally non-retentive on oral tissues (Caldwell 1970).

The concentration of sugar in a food may be a key factor in the dental caries process because the molar concentration of available sugar determines the rate of diffusion through plaque. A concentration of 0.8M is essential for sugar to pass through 1mm of dental plaque and lower the pH to 5.2 in a five minute period (Fosdick 1964). On the other hand sugar solutions of 0.3M concentration, such as fruit juices, are too weak to pass through 1mm of plaque in thirty minutes time. Thus, they may not be highly cariogenic.

The amount of sugar content of a food is not very important in determining cariogenic potential of that food. Small amounts of highly concentrated caloric sweeteners are just as cariogenic as large amounts. For example, an apple which has a sugar content of 17 grams and one ounce of sugar frosted cereal has a sugar content of 16 grams, but the apple has only 11% sugar concentration and the frosted cereal has a 57% sugar concentration. Also the oral clearance time for the apple is much less then the sugar
frosted cereal. Thus even though the sugar content of both the foods is almost the same, the cariogenic potential of the cereal in this case is much greater than the raw fruit because of its higher sugar concentration and its slower oral clearance (Nizel 1981).

In the classic Vipelholm study a positive relationship was found between the amount of food retained on teeth after eating and the amount of dental decay (Gustafsson et al 1954). Therefore, in general, liquid sugar is less cariogenic than the same amount of solid or sticky sugar.

Several investigations have been done both in animal and man that frequency of intake has a significant influence on the cariogenicity of the diet (Thylstrup & Fejerskov 1986), although the actual amount of sugar is probably not significant (Berkowitz 1979).

A number of studies have shown the importance of the frequency of eating and times of eating in relation to caries activity (Bagramian et al 1973, Weiss & Trithart 1960, Larson et al 1962). The Vipelholm study (Gustafsson et al 1954) and the Weiss and Trithart research (1960) on the frequency of eating between meal snacks and the incidence of dental caries are those most mentioned.

Weiss and Trithart (1960) studied 783 four to five year old children taking one diet as a sample. A positive correlation between the number of between meal snacks and the dental caries rate was observed (Figure 10). It is understood that with each exposure of the oral bacteria to sugar, acid is formed within approximately 20 seconds and lasts for about 20 minutes. Therefore, if five hard candies were eaten at one time in a gap of 15 minutes, the teeth would only be exposed to acid for 20-30 minutes. If, however, the five candies were spaced throughout the day, with each exposure lasting 20 plus minutes, approximately one hundred or more minutes of acid production would result. If sugar is consumed only at meal times, the teeth are exposed to much less sugar produced acid than if acid production is spread through between meal snacking (Newbrun 1978).
Figure 10
The effect of between-meal eating on caries activity in five to six year old children.
Source: Weiss & Trithart (1960)

With between meal snacks there is little chance for remineralization as there is constant demineralization. But with only three meal patterns there is some time for remineralization potential during the between meal periods (Weiss & Trithart 1960). Approximately three hours is required by a tooth to recover from each cariogenic exposure as suggested by Grafs telemetric pH findings. If the interval is shortened by even one between meal exposure significant caries may develop (Nizel 1981).

The Vipeholm study on the cariogenicity of different carbohydrates concluded as follows:

(i) The frequency of eating is the prime factor in caries activity.
(ii) Sugar has a topical effect on teeth.
(iii) The amount of sugar is not the critical factor.
(iv) Bread or starchy foods are not as cariogenic as sugar.
(v) Liquid sweets are not as cariogenic as retentive sweets.

Silverstone et al (1981) concluded that it can be said that all carbohydrate foods containing the lower molecular weight forms of the common saccharides are more cariogenic than those comprising the corresponding polymers. Depending on the different plaque pH techniques and experience gained, it may be concluded that plaque pH is one of the most reliable and simple methods of evaluating the cariogenicity of foods but at present this method cannot be used to develop a scale of relative cariogenicity. The method used in Switzerland to label non-acidogenic products “safe for teeth” is known as intraoral plaque pH telemetry. This method was introduced in 1969 by the Swiss Office of Health (Thylstrup & Fejerskov 1986). The term critical pH can be defined as the level of pH below which demineralization of enamel begins. It has been shown to be around 5.5. The ability of food items to cause low pH values in plaque is the main factor in determining its cariogenic potential. Accurate measurement of pH changes in the oral cavity against a large variety of foods eaten has identified dietary factors and foods of varying cariogenic potential. Some of these foods are listed in Table 7. This method can only give cariogenic potential of particular foods and not the relative cariogenicity of foods (Barasi & Mottram 1987).

Table 7
Relative cariogenicity of some dietary factors and foods, based on acid-producing potential in the mouth.
Source: Barasi & Mottram (1987)

<table>
<thead>
<tr>
<th>Dietary factors</th>
<th>Most acidogenic</th>
<th>Moderately acidogenic</th>
<th>Non-acidogenic</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sucrose</td>
<td>Galactose</td>
<td>Xylitol</td>
</tr>
<tr>
<td></td>
<td>Fructose</td>
<td>Lactose</td>
<td>Mannitol</td>
</tr>
<tr>
<td></td>
<td>Glucose</td>
<td>Starch</td>
<td>Sorbitol</td>
</tr>
<tr>
<td></td>
<td>Maltose</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Foods</td>
<td>Boiled sweets</td>
<td>Apples</td>
<td>Peanuts</td>
</tr>
<tr>
<td></td>
<td>Toffees</td>
<td>Chocolates</td>
<td>Crisps</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bananas</td>
<td>Dried apples</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Dried apricots</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Fresh oranges</td>
</tr>
<tr>
<td></td>
<td></td>
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<td>Cheese</td>
</tr>
<tr>
<td></td>
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<td>Eggs</td>
</tr>
</tbody>
</table>
3.3. SUGARS IN THE DIET

The sweet taste is one of man's four basic taste modalities. The sweet taste of sugar is liked by many, especially newborn infants who show a preference for things which are sweet.

Like starch, sugar is a pure carbohydrate and as such provides energy. It plays an important role in increasing the palatability of a variety of foods and, therefore, it is more widely accepted. Sugar eaten along with other carbohydrates, proteins, fats, vitamins, minerals, fibres and water contributes to good health.

Sugar is found in all green plants but the major industrial sources of sugar are the sugar cane and sugar beet. For use, different types of refined sugars are produced from raw sugar. Ninety nine per cent of sugar made from sugar cane is sucrose, whether it is raw sugar or refined sugar. There is no variation in nutritional status between white sugars, raw sugars, brown sugars and honey. As pure carbohydrates, they all provide kilojoules.

Sucrose is a natural and economical sweetener. It is also a popular food ingredient. It is the most versatile of all the sweeteners which perform different functions in a range foods:

(i) As a sweetener.
(ii) As a preservative in jams, processed fruits and condensed milk.
(iii) As an enhancing flavour in foods such as preserved meats and tomato sauce.
(iv) As a provider of bulk and texture in ice cream, custard, baked goods and confectionery.
(v) As a food for yeast in baking and in brewing beer and cider.
(vi) As a contributor to crust colour and flavour in delaying staleness in cakes and biscuits.
(Australian Sugar Industry 1983).

Sugar cane was probably first cultivated in the Ganges Valley of India where the alluvial soil was favourable for growing cane, then spread to China around the first century A.D., and then gradually to many other countries. Most of the sugar now is produced in North and Central America. Surplus sugar, especially from America, is exported to Asia and to Western and Eastern Europe (Australian Sugar Industry 1983).
Sugar became a well-known dietary item during the 11th to 15th Centuries, although it was not easily available and was expensive. Sugar was consumed primarily by nobility and Kings. At that time, one of the earliest uses of sugar was to disguise the acrid taste of the medicines. Gradually the expected taste attribute of sugar was recognised and the demand and production grew in a spectacular fashion (Nikiforuk 1985).

The consumption of sugar in the USA is about 200g/person/day, 66 per cent of which is consumed as pure sucrose and as various sugars in syrups, approximately 13 per cent is from dairy products and fruits, and the rest from other food items as shown in Figure 11 (Nikiforuk 1985).

**Figure 11**
Per capita daily consumption of sugar and the sources of the sugar in the major food supply, 1909-1913 to 1972 (Page & Friend 1974).
Source: Nikiforuk (1985)

The changing pattern of the use of sugar has been observed in many western countries in recent decades. In the 1930s, two thirds of sugar consumption in Australia was in home food preparation such as baking and preserving. Now three quarters of sugar consumption is through manufactured foods. This is mostly because of change in lifestyle and food habits. Forty four per cent of Australian women are now in the workforce outside the home.
(Australian Sugar Industry 1983) and they consume at least one meal outside the home. Small children are taking food in Day Care Centres and schoolchildren are eating one meal in the school cafeteria. All these foods are different from food at home and hence the increased demand for different manufactured foods. These foods usually have a high sugar content and are mostly soft and sticky.

Historical records of dietary change show increases in dental caries with the introduction of sugar and reductions when sugar was rationed and less refined cereal eaten as in wartime in the UK (Barasi & Mottram 1987).

Since 1972, the US Food and Drug Administration has been re-evaluating on the basis of current scientific information, the safety of some 400 substances including sugar which had previously been granted GRAS status (that is generally recognised as safe). A Committee had been formed with the independent scientists from the Federation of American Societies for Experimental Biology to examine the accumulated facts and scientific findings about sugar. A total of 1980 scientific papers were reviewed by this committee who issued this report in 1976 which concluded that "Reasonable evidence exists that sucrose is responsible for the formation of caries when used at the levels that are now current and in the manner now practiced" (Australian Sugar Industry 1983).
3.4 SUCROSE vs OTHER SUGARS

A number of oral bacteria utilise sucrose, glucose, fructose and other simple sugars and liberates organic acids like lactic, acetic and propionic acids in sufficient concentration to lower the pH of plaque to levels that may result in some demineralisation of enamel. It is only from sucrose, however, that most bacteria are able to synthesize both soluble and insoluble extracellular polymers (dextrans and mutans) which increase the bulk of plaque and facilitate the adherence of bacteria, especially streptococcus mutans, to it. Sucrose can serve directly as a glycosol donor in the synthesis of extracellular polymers which cannot be possible by other disaccharides, such as maltose or lactose.

Animal experiments on the relative cariogenicity of sucrose and other sugars have indicated contradictory results based on many factors such as the type of basal diet, whether fissure or smooth surface caries are compared and whether the animals had been infected with Strep. mutans. Usually, sucrose has been considered to be more cariogenic than monosaccharides or other disaccharides but the differences have only been large and consistent when the rats were infected with Strep. mutans, which forms smooth surface plaques heavily loaded with glucans when sucrose is eaten. In experiments with conventional rats, sucrose seemed to be more cariogenic (Figure 12) but all the sugars tested were cariogenic and under certain conditions, as cariogenic as sucrose. (Nikiforuk 1985)

Figure 12
Relative cariogenicity of various sugars (sucrose = 1.0) in conventional rats.
Source: Nikiforuk (1985)
Two experiments on human caries can be mentioned here in which sucrose has been compared with other sugars. The Turku experiment is one in which the cariogenicity of xylitol and sucrose were compared, a third group used fructose in place of sucrose for 2 years. This experiment gives lower caries effects from xylitol although the results were indecisive (Figure 13).

Figure 13
Increase in DMFS surfaces in the three groups in the Turku experiment based on clinical and radiographic findings and including white spots. Source: Nikiforuk (1985)

In other experiments (Frostell et al. 1981), caries increment was compared in the deciduous teeth of 150 young children who were either on a normal sucrose diet or on a similar diet in which sucrose had been completely replaced by invert sugar (glucose and fructose in equal proportions) for 2 years. Like the Turku experiment, a little difference has been observed with invert sugar after the first year, but a significantly lower dmfs score observed at the end of the second year.

Although these animal and human experiments suggest that sucrose is more cariogenic than other sugars this is not agreed by all and this may only be accepted for experimental situations in which only one sugar was in each diet. It may strictly be concluded that all common sugars are cariogenic but sucrose may be little more cariogenic under certain conditions and it is so because sucrose is eaten frequently and in greatest quality by all age groups especially by young children because of its sweet taste (Nikiforuk 1985).
3.5 SWEETENERS AND SUGAR SUBSTITUTES

Most persons enjoy sweet tasting foods. The sweet taste is one of man’s four basic taste modalities. Young children like things sweet (Newbrun 1978). Sweet taste differs in different compounds. The slightly bitter after taste of saccharine is well known although a combination of cyclamate and saccharine has a pleasant sweet taste (Murray 1983).

Considering sweetening power of sucrose as the standard, other sweeteners can be compared on a relative weight basis, as the intensity of a compound’s sweetness cannot be measured quantitatively in absolute physical or chemical terms (Newbrun 1978). Some of the compounds are destroyed in food manufacture because they are not thermostable.

The relative sweetness of different compounds are shown in Table 8.

Table 8
Some sweet tasting compounds.
Source: Drucker (1979)

<table>
<thead>
<tr>
<th></th>
<th>Approx. sweetness relative to sucrose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sugars</td>
<td></td>
</tr>
<tr>
<td>Glucose</td>
<td>0.7</td>
</tr>
<tr>
<td>Fructose</td>
<td>1.2</td>
</tr>
<tr>
<td>Sorbose</td>
<td>0.9</td>
</tr>
<tr>
<td>Sucrose</td>
<td>1.0</td>
</tr>
<tr>
<td>Lactose</td>
<td>0.3</td>
</tr>
<tr>
<td>Maltose</td>
<td>0.4</td>
</tr>
<tr>
<td>Glucosylsucrose*</td>
<td></td>
</tr>
<tr>
<td>Maltoylsucrose*</td>
<td></td>
</tr>
<tr>
<td>Trichlorosucrose*</td>
<td>2000</td>
</tr>
<tr>
<td>Sugar alcohols</td>
<td></td>
</tr>
<tr>
<td>Xyitol</td>
<td>1.0</td>
</tr>
<tr>
<td>Sorbitol</td>
<td>0.5</td>
</tr>
<tr>
<td>Mannitoll</td>
<td>0.7</td>
</tr>
<tr>
<td>Maltitol*</td>
<td>0.75</td>
</tr>
<tr>
<td>Complex</td>
<td></td>
</tr>
<tr>
<td>Lycasin*</td>
<td></td>
</tr>
<tr>
<td>Palatinic*</td>
<td></td>
</tr>
<tr>
<td>Hydrogenated glucose syrup*</td>
<td>0.75</td>
</tr>
<tr>
<td>Isomalt*</td>
<td>0.5</td>
</tr>
<tr>
<td>Aspartame*</td>
<td>180</td>
</tr>
<tr>
<td>Polypeptides</td>
<td></td>
</tr>
<tr>
<td>Monellin</td>
<td>3000</td>
</tr>
<tr>
<td>Thauvinatin</td>
<td>4000</td>
</tr>
<tr>
<td>Saccharin*</td>
<td>500</td>
</tr>
<tr>
<td>Cyclamate*</td>
<td>50</td>
</tr>
<tr>
<td>Acaciaflame potassium*</td>
<td>130</td>
</tr>
<tr>
<td>Glycerizin</td>
<td>50</td>
</tr>
</tbody>
</table>

*Not naturally occurring.
In food regulations, a sweetener is defined as any substance, other than a natural carbohydrate food, whose primary organoleptic characteristic is sweetness.

However, the most widely used sweetener is sugar, mainly sucrose. Since sugar, particularly sucrose, is so heavily incriminated as the major cause of caries, the search for alternative sweeteners and or sugar substitutes is most desirable. The search for a suitable sugar substitute or non-nutritive sweetener was basically first required by diabetic patients for a tasty diet (Newbrun 1978). The use of sucrose substitute in the effective control of dental caries strongly depends upon the palatability of the products and active cooperation of the food industry (Silverstone et al 1981). Although a very large number of sweet compounds are known, comparatively few are permitted to be used in foods. The list of those that are permitted will vary from country to country.

Since last century, artificial (synthesised) sweeteners have increased in number. Previously only sorbitol and mannitol were permitted as bulk sweeteners in the United Kingdom but a 1982 report recommended three more sweeteners namely hydrogenated glucose syrup, isomalt and xylitol. This report also recommended two more intense sweeteners - acesulfame potassium and aspartame in addition to saccharin. Glycerol is permitted under the solvents in foods regulations (1967). Because of differences in opinion, cyclamates are not permitted for use in foods and drinks in the United Kingdom. The expansion of different permitted sweeteners will allow manufacturers, particularly of confectionery and soft drinks to increase their range of "sugarless" foods and drinks (Murray 1983).

Human clinical studies are the definitive guide to the cariogenicity of foods but these are very difficult and expensive to carry out (Murray 1983). Koulourides et al (1976) using an Intraoral cariogenicity test (ICT) device in human subjects found that xylitol was noncariogenic, while lactose, mannitol and sorbitol were less cariogenic than sucrose, fructose and glucose. Using the same technique, Rundegren et al (1980) found lycasin and maltitol noncariogenic.
Plaque pH studies have reported that snacks containing saccharin, sorbitol, mannitol and lycasin are nonacidogenic and therefore it is likely to be noncariogenic (Imfeld 1977).

There have been only three human clinical studies investigating substitution of sucrose by other sweeteners. Among those the Turku study is most mentionable. It showed that total replacement of sucrose by xylitol led to virtual elimination of caries increment while substitution by fructose may reduce caries (Murray 1983). Some of these sweeteners are noncariogenic and some of them are less cariogenic. Noncariogenic sweeteners are literally called sugar substitutes.

Several pieces of research have been done in order to find suitable sugar substitutes. The usefulness of these compounds should be justified from a nutritional, dental, toxicological, economic, and technical point of view (Ikeda 1982). There are a large number of noncariogenic sweeteners available but for practical purposes they can be divided into bulk sweeteners and intense sweeteners.

Noncariogenic bulk sweeteners: A bulk sweetener is a sweetener whose sweetness is similar to sucrose and supplies a significant amount of energy. This is also called a nutritive sweetener (Imfeld 1983).

Sorbitol, xylitol and mannitol are reduced sugars or polyols. Isomalt is a mixture of polyols. Lycasin is a hydrogenated starch hydrolysate which consists of a mixture of polyols and saccharides. All these come under the class of noncariogenic bulk sweeteners. These compounds are carbohydrates but not sugars in the strict sense. They are usually produced by hydrogenation of appropriate sugars. These compounds are highly used as sugar substitutes, especially for sucrose in confectionery products to reduce incidence of dental caries (Guggenheim 1984).
Noncariogenic bulk sweeteners are used in chewing gums, lozenges, hard candies, lollipops, medicines, food products and tooth pastes. The consumption of these sweeteners has to be kept low, because they have an osmotic effect in the intestine (osmotic diarrhoea) (Thylstrup & Fejerskov 1986). Reports from animal and some human experiments have shown that these compounds are non or extremely low cariogenic. They have also equally been shown to be non or hypo acidogenic in plaque pH telemetry (Guggenheim 1984).

Sorbitol - Sorbitol is a hexahydric sugar alcohol or hexitol, naturally occurs in many berries (except grapes), cherries, plums, apples, pears, sea weeds and algae (Newbrun 1978). Industrially it is prepared by high pressure hydrogenation or electrolytic reduction of glucose (Imfeld 1983). Its relative sweetness is 0.5 compared with sucrose (Nikiforuk 1985). This is the most widely used sugar substitute today, e.g. in chewing gum and lozenges. This is much cheaper and gives satisfactory taste. It provides a cool taste due to its negative heat of dissolution. It is stable in a dry state and soluble in water.

Metabolism of sorbitol is insulin-independent and has been used widely in foods manufactured for diabetics. In 1929, sorbitol was first introduced in the diet of diabetics (Nikiforuk 1985). Sorbitol acts as a laxative due to its imperfect absorption from the alimentary canal which can cause osmotic diarrhoea. Daily intake of sorbitol is restricted to 150 mg/kg body weight. In Switzerland, sorbitol and sorbitol containing products considered as "safe for teeth", based on plaque pH experiments (Imfeld 1977).

Most other micro-organisms other than Strep. mutans cannot ferment sorbitol. Strepto mutans can ferment sorbitol very slowly and the rate of acid production is much slower compared to other fermentable hexoses and disaccharides (Newbrun 1978). This permits salivary buffers to neutralize acid end products as they are formed.
Xylitol - This is known as pentahydric sugar alcohol or penitol (Imfeld 1983). Xylitol is found widely in nature in many fruits, such as berries, yellow plums and vegetables such as lettuce, mushrooms and cauliflower (Nikiforuk 1985). Xylitol can be produced industrially from xylan rich material such as hard wood, oat seed and cotton seed hulls, corn (maize) cobs, sugar cane, bagasse etc (Imfeld 1983). Its relative sweetness is almost the same as sucrose (Silverstone et al 1981). Like sorbitol, when xylitol solutions are applied to dental plaque little or no fall in pH occurs (Mühlemann & de Boever 1970). It is stable in solution and at high temperatures which may occur during food processing. Like sorbitol it has a marked mouth cooling effect and metabolism is insulin independent. It has less laxative effect than sorbitol. At present it is 10 times as expensive as sucrose. (Nikiforuk 1985)

Animal and human studies have shown that xylitol is noncariogenic. Xylitol has also been claimed as anticariogenic, that it prevents dental caries (Scheinin & Makinen 1975, Karle & Gehring 1975). Xylitol cannot be metabolised to acids by oral micro-organisms or by dental plaque in vivo (Imfeld 1977). Although xylitol is expensive it is now used in chewing gum and a few other products (saliva substitutes, tooth pastes) (Thystrup & Fejerskov 1986).

The complete replacement of dietary sucrose with xylitol is most impractical at the very beginning because of its high cost of manufacture and gastrointestinal side effects (Newbrun 1978) when xylitol is taken in large amounts.

Mannitol - Mannitol is a hexahydric sugar alcohol, or hexitol (Imfeld 1983). This naturally occurs in onions, pumpkins, beets and olives. It can be industrially prepared by electrolytic reduction of glucose or hydrogenation of invert sugar, monosaccharides or sucrose (Imfeld 1983). The relative sweetness of mannitol compared with sucrose is 0.7. Like sorbitol and xylitol, it also gives satisfactory taste and a cool mouth feel. It is stable both in dry state and in aqueous solution. It is used in the preparation of confectionery and in some baked products.
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Maltitol - This is produced by hydrogenation of maltose and commercially available under the trade name of malbit (Imfeld 1983). It has a fragrant caramel like odour and is used as a flavouring and odouring agent in the preparation of breads, cakes etc. It has a relative sweetness of 0.75 compared with sucrose (Murray 1983).

Isomalt - Isomalt is a mixture of polyols and is marketed under the trade name of palatinit. Its relative sweetness is 0.5 compared with sucrose. Its properties are similar to that of individual polyols except it does not produce a mouth cooling effect.

Lycasin - Lycasin does not occur in nature (Imfeld 1983). Lycasin is a hydrogenated glucose syrup prepared from corn syrup and other starches by partial hydrolysis and subsequent hydrogenation (Nikiforuk 1985). The relative sweetness of lycasin is 0.75 compared to sucrose (Imfeld 1983). The replacement of sugar (sucrose) by lycasin in candy eaten by children 3-6 years old resulted in a reduction of about 25 per cent in the two year caries increment of one study (Murray 1983). Lycasin is “safe for teeth” has shown in plaque pH experiments in vivo (Imfeld 1977). It has a low cariogenicity in both animals (Frostell 1976) and humans (Frostell et al 1974). It is used in the manufacture of boiled sweets and other confectionery, soft drinks and in diabetic foods.

Polyols or polyalcohols are carbohydrates but not sugars. Polyols are made to substitute sugars especially for sucrose in foods, beverages and in confectionery products to reduce incidence of dental caries. Of all the abovementioned noncariogenic bulk sweeteners, only xylitol has been blamed as a tumour promoter in toxicity studies carried out on male mice ingesting diets with high xylitol content. Xylitol and isomalt are the best known sugar substitutes on food technological grounds at this time.
Noncariogenic intense sweeteners: An intense sweetener is many times sweeter than sucrose and provides very negligible energy in use (Nikiforuk 1985). The most widely used sweeteners of this group are cyclamate and saccharine. New compounds are still in demand. Aspartame has been recently accepted as a sugar substitute. They are not metabolised to acids by the oral micro-organisms (Thylstrup & Fejerskov 1986). They are nonacidogenic in plaque pH telemetry and have never been shown to be cariogenic in either animal or man (Imfeld 1983). Aspartame was reported effective in reducing acid induced enamel demineralization (Berry & Henry 1982). Where intensive sweeteners are substituted for sugars in foods and beverages, some other material, such as polysaccharide protein, lipid or a thickening agent, should be incorporated to build up the volume, weight and consistency of the product (as these properties are lacking in intensive sweeteners) (Imfeld 1983). They are successfully used in gelatine desserts, puddings, dessert toppings, soft drinks, chewing gum, medicinal preparations, dentifrices and mouth washes (Nikiforuk 1985).

Saccharin - Since its discovery in 1879 it has been widely used till today as a sugar substitute (Newbrun 1978). This is 500 times sweeter than sucrose but the concentration over 0.1 per cent has a bitter taste and the degree of bitterness varies considerably between people. Saccharin is stable under conditions normally present in food processing and it is used widely in "diet" soft drinks, diabetic foods, mouth washes, medicinal preparations and as a sweetener for table use.

Walker et al (1982) reported a weak association between the use of saccharin and the risk of bladder cancer while in other reports no association was detected. Because of these findings a ban on the use of saccharin has been reported in Canada and the USA (Nikiforuk 1985) but the consumption of saccharin has increased dramatically in many countries.

Cyclamate - The cyclamate salt is approximately 50 times sweeter than sucrose. It has a pleasant taste and is soluble in water. It was initially expensive but now it is even cheaper than sucrose (Newbrun 1978). Like saccharin, it is excreted unchanged in the urine.
Aspartame - Aspartame is a dipeptide of aspartic acid and phenylalanine. It is about 180-200 times sweeter than sucrose and has a similar taste (Nikiforuk 1985). It is moderately stable in solution but loss of sweetness results from prolonged heat treatment and storage. It is digested as a protein and its safety depends on its phenylalanine content. Aspartame should not be used by people who have a genetic defect of phenylalanine metabolism. For these people, if phenylalanine levels in blood are not maintained below approximately 12 mg/100 ml during pregnancy and development, increased risk of foetal anomalies and mental retardation develops. Aspartame as a sugar substitute is rather new on the market. It is used in tablets, chewing gum, beverages and ice cream (Thylstrup & Fejerskov 1986).

Other than the abovementioned synthetic intensive sweeteners, there are a few other intensive sweeteners of natural origin such as dihydrochalcones, glycyrrhizin, monellin, thaumatin etc. They are of special importance in the production of low calorie foods, beverages and confectionery products and for diabetics (Guggenheim 1984). They are also used as a flavouring agent in pharmaceutical preparations (Nikiforuk 1985).

Low calorie sweeteners like dihydrochalcones and glycyrrhizin are not metabolised by oral micro-organisms. They are nonacidogenic in plaque pH telemetry (Imfeld 1983) and have never been shown to be cariogenic in either animal or man. Glycyrrhizin (Berry & Henry 1982) and dihydrochalcones (Berry & Henry 1983) have been claimed to inhibit growth of Strep. mutans in vitro. These sweeteners have a sweetness ranging from 500 to 3000 times that of sucrose (Nikiforuk 1985).

Of these sweeteners thaumatin and monellin are extracted from plants. Both of them are at least 3000 times as sweet as sucrose but have different properties. The sweet taste with thaumatin is delayed and it has a slight liquorice after taste. There is a complete loss of sweetness on heat treatment. Monellin is the sweetest compound known and this sweet sensation remains in the mouth for a long time. They are unstable at room temperature and loses sweetness within 24 hours. Because of this reason, these sweeteners do not have any practical use as yet. But sweetness is maintained at temperatures used for making chocolate bars with monellin (Nikiforuk 1985).
A number of sugars are slowly fermented by oral micro-organisms and prove hypoacidogenic in plaque pH telemetry. Most of them are not suitable as a sugar substitute because of toxicological and commercial (price) reasons. Sorbose, xylose, polydextrose and more recently reported coupling sugars have been considered as alternatives for sugar in confectionery products (Imfeld 1983).

The success of coupling sugar was first reported by Okada and Kitahata (1982) in Japan. Coupling sugars have proved less acidogenic than sucrose in the Japanese plaque using the pH telemetry system (Igarashi et al 1981) and the Intraoral Cariogenicity Test (ICT) (Ikeda 1982). In Japan, a variety of confectioneries like candies, chocolates, cookies, and jam prepared with coupling sugars are currently marketed.

Many compounds have been tested and tried, and a number of compounds have been accepted as a replacement of sucrose, but it is still very difficult to duplicate the flavour, texture and other characteristics of sucrose. In products such as jams, fruit syrups and condensed milk, sucrose provides an osmotic preservative protection. If sucrose is replaced, the risk of micro-biological spoilage is increased, unless other corrective measures are adopted (Brooks 1970). Therefore the search for a safe, noncariogenic sweetener is still very much needed.

The food industry should be encouraged to manufacture different foods, especially snacks with nonacidogenic or hypoacidogenic sugar substitutes and labelled accordingly "dentally safe" before they are marketed (Guggenheim 1984).
3.6 PROTECTIVE FACTORS IN THE DIET

A number of factors already present in the diet, or added to the diet, and which inhibit the decay process in an individual, are mentioned in this section although sufficient and definitive evidence for a significant effect on human caries is still lacking (Jenkins 1970, Nikiforuk 1970).

Fluoride has been appreciated for almost half a century. An optimal level (1pm) of fluoride ions present in the diet during tooth development causes a 50 per cent or more reduction in dental caries; compared with controls (Barasi & Mottram 1987). It is an important mineral for teeth and children benefit most from fluoride. There are several opinions regarding the dietary supplementation of fluoride depending on the age of the child and the fluoride concentration of the respective water supply.

Human or bovine milk contains very little fluoride, however, a wide variation seems to exist in different formulas. It is advisable to wait the first 6 months for supplementary fluoride even though children are living in nonfluoridated areas (Snawder 1980).

Fluoride is believed to act in several ways:

(i) fluoride makes teeth stronger by converting hydroxyapatite crystals in the enamel to the less soluble fluorapatite.
(ii) fluoride in the oral cavity inhibits the metabolism of streptococcus mutans, thereby reducing its ability to form acids and plaque.
(iii) fluoride in the oral cavity can enter the outer enamel layers of the teeth, producing a higher content there than in the underlying dentine, with associated greater resistance to acid.

Fluoride is mainly provided in the diet through drinking water. If the total period of tooth development is to be covered to have maximum benefit, fluoride should be available from birth to the age of fourteen years (Barasi & Mottram 1987).
Allegations that water fluoridation results in a risk to the community health, have been raised many times, but evidence in favour of fluoridation is overwhelming (Commonwealth Department of Health 1985). More than 230 million people in over 40 countries drink fluoridated water. Water fluoridation at a concentration of 1 ppm is the most effective and practical method for preventing dental caries (Barasi & Mottram 1987). Different methods of administration of fluorides and dosages at different ages are discussed elsewhere in this thesis.

Phosphate as an anticariogenic agent has been tested on experimental animals and human clinical trials (Newbrun 1983). The effects of inorganic phosphates on caries have been reviewed (Nizel & Harris 1964, Ericson 1965, Harris 1970, Gillmore 1969) and claimed that high concentrations of inorganic phosphates decrease the acid production by oral streptococci including Strep. mutans (Handelman & Kreinces 1973).

Of the various phosphates tested, trimetaphosphate was found most effective in preventing caries in rodents (Harris, Nizel & Walsh 1967). When 2% CaHPO₄ was added to sucrose, flour, cakes and bread in the diet of children over a 2-3 year period, a 3-9 per cent reduction in dmfs was reported (Harris 1970).

More successful results from sodium phosphate investigations have been recorded by Stookey et al (1967). He recorded a 20-40 per cent reduction in caries in 5-16 year old children consuming cereals fortified with 1 per cent NaH₂PO₄ over two years.

Investigators have also found statistically significant reductions in caries increment by adding 1-3% of sodium phosphates or calcium sucrose phosphate to various food items or chewing gum. Part of these positive results may be because of high fluoride content in some phosphate products, but this encouraged attempts to develop more efficient additives (Luoma & Nuuja 1977, Shibata & Morioka 1982). Organic phosphates (phytates and glycerophosphates) also reduce caries (Harris 1970). The exact mechanism of action
of phosphates in caries reduction is uncertain. But several investigations support local effects of phosphates in the mouth rather than systemic ingestion. Local effects are:

(i) phosphate ions reduce the rate of dissolution of the hydroxyapatite of the enamel.
(ii) supersaturated solutions of phosphate ions redeposits calcium phosphate, particularly in places of enamel which have been partially demineralized.
(iii) phosphate can buffer organic acids which are formed by fermentation of sugars fermented by plaque microorganisms.
(iv) phosphate ions desorb proteins from the enamel surface, thereby modifying the acquired pellicle (Pruitt, Jamieson & Caldwell 1970).

Unrefined carbohydrates are less harmful than refined carbohydrates in relation to dental caries, because they contain protective factors (like phosphates) which are lost during the refining process (Jenkins 1966). It is also suggested that the beneficial effects of dietary fibre on teeth may in part be originated by the phosphate present in them. Phosphate may release from particular phytate into the mouth during chewing which enhances the remineralisation effect. Calcium glycerophosphate has been used as an additive to some fluoride tooth pastes to enhance the effects of the fluoride ion (Barasi & Mottram 1987). Within reasonable limits of intake, many dietary phosphate supplements are generally accepted by the Food and Drug Administration. But due to limited evidence, commercial implementation of phosphates as a food additive in the prevention of human dental caries at the present time is not recommended (WHO 1972).

Animal studies have shown that adding lipids to a cariogenic diet reduces caries (Bavetta et al 1959, Gustafson et al 1953, Rosebury & Karshan 1939, Shaw 1950). Human studies have shown a change in plaque flora, including a reduction in the proportion of acidogenic organisms, when a mouth wash containing non-anoate has been used on a daily basis (Griffiths 1979, Hayes & Carter 1980).

The antimicrobial effect of certain fatty acids inhibits glycolysis in human dental plaque (Hayes 1981). This also reduces plaque formation and has substantial cariostatic effect in rats when added to a high sucrose diet (William et al 1982). The effectiveness of lipids as
an anticariogenic food additive needs further research (US Senate Select Committee 1977).

Protein is also cariostatic, when this is substituted for cariogenic carbohydrates. It has been observed that some proteins especially casein (found in milk) bind to enamel and reduce enamel solubility in vitro (Weiss & Bibby 1966).

Animal experiments have suggested that cocoa may have a caries protective factor (Stralfors 1966). Gravenmade et al (1977) reported the properties of the active factor in cocoa but probably no human studies have been done. Likewise Edgar (1978) reported caries preventive properties of liquorice. Cariostatic effects of various compounds extracted from several foods and drinks such as coffee, tea, cocoa, beer, wine, fruit, berries, nuts, wheat, bran and the hulls of oat and rice have been observed in experiments with hamsters (Stralfors 1967). Some of them have an antibacterial effect in vitro and some reduce the solubility of calcium phosphate (Jenkins & Smales 1966).

Cariostatic effects of pyridoxine have been reported from some animal and human studies (Thylstrup & Fejerskov 1986).

Cariostatic effects of trace elements other than fluoride have not yet been well supported. In order to assess dietary component on caries, it is important that the amount of the component in the basic diet as well as the amount of supplement should be known (Newbrun 1983).
4 NUTRITIONAL REQUIREMENTS

4.1 NUTRITION IN PREGNANCY

The relationship between poor maternal nutrition and retardation of physical growth of the foetus, with particular emphasis on subnormal brain development has been demonstrated by several studies. So the nutritional factors during pregnancy are vital to both the mother and the foetus and strongly influence the outcome of the pregnancy (Fanning & Smith 1985).

The nutritional status of the mother at conception is the result of her nutrient intake since birth. During the period of pregnancy significant changes occur in the body of the mother. The mother will gain an average of 24 pounds from an infant weighing 7.5 pounds at birth (Pollack & Kravitz 1985), although this gain in weight greatly varies depending on the maternal size, metabolism and other factors. The distribution of the weight gained during pregnancy is shown in Table 9.

Table 9
Distribution of weight gained during pregnancy.
Source: Pollack & Kravitz (1985)

<table>
<thead>
<tr>
<th>Tissue or organ</th>
<th>weight gain (pounds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Placenta</td>
<td>1.0</td>
</tr>
<tr>
<td>Uterus</td>
<td>2.5</td>
</tr>
<tr>
<td>Maternal blood volume</td>
<td>3.0</td>
</tr>
<tr>
<td>Breast tissue</td>
<td>4.0</td>
</tr>
<tr>
<td>Maternal stores</td>
<td>2.0</td>
</tr>
<tr>
<td>Amniotic fluid</td>
<td>7.5</td>
</tr>
<tr>
<td>Foetus</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>24.0 (11 kg)</td>
</tr>
</tbody>
</table>

The actual nutrient requirements vary accordingly to the stage of pregnancy and to foetal demands. For example, early in the first trimester of gestation quality of food is more
important than the quantity of food. In fact, at this stage increased quantity of food is not required. It is only in the second and third trimesters of pregnancy that nutrient requirements increase. The major nutrient increases are reflected in the increased food intake shown in the five food group plan.

These increases are related to the demands made by the physiological changes in the mother and the foetus. To achieve the increased nutrient needs without an excessive energy increase, the intake of high energy, low nutrient dietary items such as sugar and sugary foods, confectionery, soft drinks, fats and fatty foods, pastries, cream and rich foods must be avoided (Fanning & Smith 1985).

Nutritional requirements during pregnancy can be summarised as the requirement for energy, protein, minerals and vitamins. In order to anabolize maternal tissue and to compensate for an increase in metabolism during pregnancy, an increase in energy is required. The World Health Organization has suggested that an increase of 150 kcal/day during 1st trimester and 350 kcal/day during the remaining months of pregnancy is required (WHO 1974).

The importance of additional protein during gestation is manifested in the growth and development of both maternal and foetal tissue. The RDA (recommended daily allowance) for protein during pregnancy is 74 gm/day. This is 30 gm/day above the normal requirements for a nonpregnant female (Food & Nutrition Board 1980).

The minerals that play an important role during pregnancy can be summarised as calcium, phosphorus, sodium, iron, magnesium, zinc and iodine.

During early pregnancy calcium is stored in maternal bone and may be utilised by the foetus during 3rd trimester, when most calcification occurs in the foetus (Pitkin 1980). The RDA for calcium is increased from 800 mg/day in a nonpregnant woman to 1200 mg/day for a pregnant woman (Pollack & Kravitz 1985). Calcium is responsible for the hardness and strength of the bone and teeth.
Phosphorus in combination with calcium contributes to the mineralisation of bone and teeth. Therefore phosphorus is essential in a pregnant woman. The optimal ratio of calcium:phosphorus is 1:1. A phosphorus level that is too high can result in leg cramps towards the end of the pregnancy (Williams 1977).

The relationship between sodium and its effects on pregnant women has not been conclusively substantiated. However, it is unlikely that most western diets would be deficient in sodium. During pregnancy salt is essential for increased blood and tissue volumes. Restriction of sodium intake has been suggested in the past to prevent natural oedema. A deficiency or severe restriction of sodium may lead to hormonal imbalance involving the kidneys and adrenaline glands (Pike & Gursky 1970), a decrease in blood pressure and constriction in blood vessels (Kruetler 1980).

Iron intake is imperative for an expectant mother since it is necessary for the maintenance of RBC synthesis (erythropoiesis) in both mother and foetus. An infant is born with a sufficient supply of iron to last for the first four months of life. This natural store is crucial since milk contains little iron. The RDA for iron is 18 mg/day for nonpregnant women and an additional supplement of 30-60 mg/day is recommended during pregnancy.

The RDA for magnesium during pregnancy is 450 mg/day, which is an additional 150 mg/day over that recommended for non-pregnant women of child bearing age.

The RDA for zinc is usually 15 mg/day but during pregnancy it is 20 mg/day.

Iodine is a component of the thyroid hormone and is essential for proper basal metabolism (Food & Nutrition Board 1980). An iodine deficiency may result in maternal goitre. This is more likely to occur in the adolescent mother (Guthrie 1975). Severe iodine deficiency may result in cretinism in the infant. The RDA for iodine in nonpregnant women is 150 μg/day. This is increased to 175 μg/day during pregnancy.
Vitamins are essential for body metabolism. These include fat soluble vitamins and water soluble vitamins.

The fat soluble vitamins are A, D, E and K. They are not excreted, any excess is stored in the body.

Vitamin D works in combination with calcium and phosphorus in the absorption and deposition required for the mineralisation of hard tissues. It acts as a hormone and maintains calcium levels in the blood. The RDA for vitamin D is 15 μg/day during pregnancy.

Vitamin A is responsible for the maintenance of skin and epithelial tissue lining the internal organs (Kruekler 1980). The RDA for vitamin A increases from 800 RE to 1000 RE (retinal equivalents) during pregnancy.

Vitamin E is an antioxidant and helps to protect cell membrane from lipid peroxidation (Nizel 1981). Because of the increase in caloric intake, including lipids, the RDA for vitamin E is increased from 8-10 d-alpha-tocopherol equivalents.

Vitamin K is essential to the blood clotting process, since it stimulates production of prothrombin as well as clotting factors VIII, IX and X.

All these vitamins are readily available in a balanced diet that includes a variety of foods.

The water soluble vitamins are the B-complex vitamins and vitamin C. These vitamins are generally not stored in the body and are excreted in the urine. Therefore some daily ingestion of these compounds is necessary.

Thiamine, riboflavin and niacin are responsible for the carbohydrate metabolism (Randolph & Dannison 1981). These are usually associated with increased energy intake during pregnancy. In conjunction with vitamin B_{12}, folic acid is essential for synthesis of RBC. Folate deficient (megaloblastic) anaemia is most often found in pregnant women (Pitkin 1980). The RDA for folacin for pregnant women is 800 μg/day, where the RDA for folacin for nonpregnant women is 400 μg/day. The RDA for vitamin B_{12} (cyanocobal amine) increases from 3 μg/day during the nonpregnant state to 4 μg/day during pregnancy.
Vitamin C is essential for collagen formation in connective tissue and mineralized body structures (Randolph & Dannison 1981). In addition, vitamin C enhances the iron absorption (Food & Nutrition Board 1980). The RDA for vitamin C is 60 mg/day and this is increased to 80 mg/day during pregnancy.

GUIDELINES IN PREGNANCY (From the Nutritional point of view)

1. Avoid high calorie, low nutrient foods
2. Avoid alcohol throughout pregnancy
3. Avoid fat and fatty foods (pastries, cream etc)
4. Avoid sugar and sugary foods, confectionary and soft drinks
5. Encourage fresh fruits, dried fruits or canned fruit instead of fruit in heavy syrup
6. Encourage snacks of raw vegetables such as celery, carrots, cauliflower and broccoli instead of snacks and desserts rich in sugar like cakes, cookies, candy, soda pop etc
7. Meat can be eaten after trimming excess fat

(Pollack & Kravitz 1985)
4.2 NUTRITION IN LACTATION

Breast feeding is becoming more appreciated among mothers of all ages (Deutsch 1976). This change may be due to the realisation by mothers that maternal milk is an excellent food for the infant (Berg 1977).

The physiological and nutritional demands of lactation on the mother are high and may last for a longer period than those of pregnancy. Hence the relationship between maternal nutritional status and lactation performance is a public health issue of significant importance (Neville & Neifert 1983).

Preparation for lactation starts during pregnancy when storage of fat and other nutrients begins and physiological adjustment continues such as decreased urinary calcium excretion (Fanning & Smith 1985). Two stages are involved in the process of lactation, namely, milk production or secretion and milk ejection or let down.

Milk production or secretion: Milk is prepared in the breast by mammary glands through appropriate transfer of specific nutrients from the blood into the gland.

Milk ejection or let down: Once milk is formed it is not immediately released from the breasts. The normal release of milk occurs when the baby suckles at the breast and initiates a reflex in the mother. It is believed that the stimulus of suckling by the baby is an essential trigger for the ejection or let down reflex. This reflex can be influenced by the mother's mental state. If she is unhappy with the prospect of breast feeding, this can limit the let down reflex and make the process of feeding unsuccessful (Barasi & Mottram 1987).

Inadequate nutrition during lactation will drain her nutrient stores although the quality of breast milk will remain relatively constant. Inadequate nutrients and water will decrease the quantity of milk but the quality will be maintained (Randolph & Dannison 1981).
Energy: The average daily volume of milk produced varies from mother to mother. Data from around the world suggest that an established lactating mother will produce 850 ml of milk/day. It has been estimated that 3.1 MJ of energy are used each day in milk production. Part of this energy can be made up from the 4 kg of fat stored during pregnancy. It is considered to be used up gradually at a rate of 900 Kj per day, partially providing the energy requirements for lactation for six months. The remaining 2.2 MJ must be supplied from the diet (Barasi & Mottram 1987).

Protein: Daily protein requirements for lactating mother is 64 gm, recommended by RDA. This shows a decline of 10 gm/day of protein from that recommended during pregnancy. The essential amino acids necessary for the alveolar cells to synthesize milk protein are supplied from maternal stores, if protein consumption is inadequate (Kruetler 1980).

Minerals: Human milk contains the following minerals: calcium, phosphorus, iodine, fluoride, iron, magnesium and zinc.

Calcium is essential for the growth of bone and teeth in infants. Breast milk contains approximately 300 mg of calcium/litre in established lactation. By ensuring sufficient calcium levels in breast milk without maternal demineralisation (Ptitkin 1976), the RDA for calcium during lactation is maintained at 1200 mg, same level as during pregnancy. The recommended ratio of calcium:phosphorus has been set at 1.5:1 for infants decreasing to 1:1 after one year of age (Food & Nutrition Board 1980). The RDA for phosphorus also remains at 1200 mg during the lactation period.

Iodine is excreted in breast milk at levels of 30-100 μg/l (Man & Benești 1969, Fomon 1974). The RDA for iodine has been set at 200 μg to meet the needs for both lactating mother and the child.
A daily loss of 0.5-1.0 mg of iron occurs during lactation (Food & Nutrition Board 1980). This iron loss is almost the same as that lost during menstruation. Iron requirement during lactation is the same as required by a non-pregnant woman. A supplement of 30-60 mg of iron daily should be ingested for 2-3 months in order to resupply the maternal stores exhausted during pregnancy (Committee on Maternal Nutrition 1970).

Breast milk also contains magnesium at a level of 40 mg/l. But magnesium needs during lactation are not known correctly (Food & Nutrition Board 1980). The RDA for magnesium is 450 mg for both pregnant women and lactating mothers.

Zinc is an important factor in the activities of enzymes involved in numerous metabolic pathways (Underwood 1977).

Loss of appetite, failure to grow, skin changes, impaired wound healing and decreased taste acuity, all these symptoms are found with zinc deficiency. The RDA for zinc for lactating mothers is 25 mg which is 5 mg above the RDA for pregnant women (Food & Nutrition Board 1980).

Fluoride is deposited into bones and teeth. It replaces the hydroxyl ion in hydroxyapatite crystals to yield fluorapatite, which makes teeth more resistant to dental caries (Sognnaes 1965). Maternal supplementation of fluoride is not recommended in a fluoridated area because negligible amounts of fluoride are secreted from breast milk (Leverett 1982).

**Vitamins:** Approximately 450 µg of vitamin A is secreted daily in maternal milk (Barasi & Mottram 1987). Therefore the RDA during lactation is increased from 800 RE/day for nonpregnant females to 1200 RE during lactation (Food & Nutrition Board 1980), which is a daily increase of 200 RE over that recommended during pregnancy. The RDA for vitamin D remains 600 IU, which is the same as pregnancy. The RDA for vitamin E is 11 d-alphatocopherol equivalents (Food & Nutrition Board 1980).
Breast milk contains vitamin C at levels of 30-55 mg/l, depending on the dietary intake (Selleg & King 1936). The RDA for vitamin C is 100 mg/day during lactation (Pollack & Kravitz 1985).

Diet during lactation is almost the same as recommended during pregnancy. The food eaten by a lactating mother has to meet her own needs and all the needs of the baby (first 4-6 months), which is considerably greater than its needs while in the womb (Barasi & Mottram 1987). Nutrients that might warrant particular attention are calcium and vitamin D; foods containing these vitamins should be present regularly in the diet (Barasi & Mottram 1987).

One quart of milk per day, or foods supplying similar calcium equivalents (e.g. cheese, yoghurt and ice cream) should be included in the diet. High quality protein should also be taken, as well as adequate servings of fresh fruits, vegetables and grain products. A varied diet will help a lot to ensure adequate levels of essential nutrients (amino acids, vitamins, minerals etc). Sufficient water should also be consumed to compensate daily loss through milk secretion and for other physiological functions. A fluid intake of 2-3 quarts per day is recommended (Kruetler 1980). Increased kilocalories should be ingested during lactation to supply sufficient energy for milk production and to ensure adequate milk content (Kruetler 1980).
4.3 NUTRITION IN CHILDHOOD

Foetal nutrition depends on the nutritional status of the mother. This section only considers nutrition from after the birth of the child to preschool age (that is up to the age before the eruption of 1st molar). Nutrition for this period of childhood can well be mentioned under the headings of infants, toddlers, and preschoolers.

4.3.1 Nutrition in Infants

The diet of the should be liquid because an infant at birth is able to suck but not bite or chew. The basic material for infants diet is milk and the source of milk is either from breast feeding or from commercially prepared formulas or modified milk from other mammals. Rapid growth occurs at this stage and there is a high nutritional need. Perfect nutrition is necessary for perfect jaws and teeth. A balanced diet will supply all necessary nutrients except fluoride for optimal tooth formation (Snawder 1980). Breast milk is the most perfect food for the baby from the nutritional point of view. It is always better than any other milk because it is more digestible, economical in time and energy and maintains right temperature. Moreover it contains the natural antibodies that can protect the infant from infection. Human milk is unique and uniquely suited for human infants. Modern technology cannot reproduce it (Ibsister 1985).

Milk of cow, buffalo, goat, reindeer, yak, camel and horse etc have been used successfully to rear human children in different cultures. However, cows milk is more widely used throughout the world than any other milch animal.

Milk is a solution of protein, sugar and salts in which fat is suspended (Mackeith 1971). These major components are accompanied by various minerals (notably calcium and phosphorus), vitamins, enzymes and various minor organic compounds. The composition of milk not only differs from species to species but also varies widely within one species and even within breeds or races of one species. Tables 10 and 11 give values for the main constituents of nutritional importance of the milk of humans and the milch animals.
Table 10
Representative values for some major constituents of good quality milk of different species.
Source: Adapted from Kon (1972)

<table>
<thead>
<tr>
<th>Species</th>
<th>Fat</th>
<th>Solids (non-fat)</th>
<th>Protein (NX6.38)</th>
<th>Lactose (only drams)</th>
<th>Calcium</th>
<th>Water</th>
<th>Physiological energy</th>
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<td>89</td>
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<td>8.65</td>
<td>3.25</td>
<td>4.60</td>
<td>0.115</td>
<td>87</td>
<td>62</td>
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<td>0.19</td>
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<tr>
<td>Goat</td>
<td>4.50</td>
<td>8.70</td>
<td>3.30</td>
<td>4.40</td>
<td>0.13</td>
<td>82</td>
<td>71</td>
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*In the tables a dash(-) denotes lack of information or unreliable information.*
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</table>

Adapted from: Kon, S.K. (1972), Milk and Milk Products.
The fat of milk, like animal or vegetable fats, is a mixture of chemical combination of many saturated and unsaturated different fatty acids, lecithin and cholesterol with glycerol. It contains some vitamin A and D as these are fat soluble (Mackeith 1971). Fat represents the major energy source as well as the source of fat soluble vitamins and essential fatty acids (Hall 1979).

Milk proteins consist of casein which is a phosphoprotein found only in milk and forming the curd when milk is acidified or together with the soluble proteins, mainly lactalbumins and lactoglobulins. Like all proteins, those of milk are composed of amino acids. There are more than twenty individual amino acids in the milk proteins. The amount and quality of protein are important factors in influencing dental caries. Protein deficiency causes delayed eruption and hypoplasia of the deciduous teeth.

Sugar present in milk is the disaccharide lactose. In digestion it breaks down into its two components - monosaccharides, glucose and galactose. Milk also contains oligosaccharides containing 2 to 8 monosaccharides unit (Mackeith 1971). When lactose is taken the production of lactic acid by the acid forming components of the flora controls the growth of other organisms, and it is often beneficial in digestive order.

Fat soluble vitamins A, D and E, and water soluble vitamins C and B, occur in milk in small quantities. There is little or no nicotinic acid in milk (Mackeith 1971). Milk contains various minerals, like potassium, sodium, calcium, phosphorus, magnesium, carbonates, chlorides and iron, copper, manganese which are concerned in blood formation, present in traces only. Of all minerals calcium and phosphorus is mentionable. Milk also contains enzymes and various organic compounds, such as citric acid.

Much of what will be said about the milk of the cow and changes in its composition applies to the milk of the other ruminant milch animals. Two examples are given for the cow in Tables 10 & 11 to represent the range of composition of milk among dairy breeds of the world. The Friesian, a popular breed in Europe and North America typifies the high yielding cow of many countries. As an example of breeds yielding "richer" milk, the
Guernsey has been chosen, which, together with the other Channel Island breed, the Jersey is very widely distributed. Its milk is more concentrated in fat and nonfatty solids. The composition of the milk of most dairy breeds of the world probably falls within the range shown by these two examples.

It has been known for decades that cows milk contains three times more protein than human milk (Gyorgy 1971, Wickes 1953). Cows milk curd is tough and rubbery, while the curd of human milk is soft and flocculent (Fomon 1974). There is much more casein in cows milk than in women's milk. This and perhaps other differences between these two milks affect the composition of casein curd. Modified cows milk, for infant feeding is intended to prevent the formation of such curds (Mackieith 1971). Cholesterol level of cows milk is lower than human milk (Jelliffe & Jelliffe 1978). Fat concentration is approximately the same in human milk and cows milk.

Buffalos milk is almost the same as the cows milk except that it contains much more fat and nonfatty solids than cows milk but less riboflavin. The buffalo converts carotene into vitamin A more efficiently than the cow and its milk contains only traces of carotene. Buffalo milk is completely white, while kangaroo milk is pink (Jelliffe & Jelliffe 1978).

Goats milk contains more nicotinic acid but markedly less vitamin B_12 than cows milk. This probably causes "goats milk anaemia", sometimes observed in infants reared on goats milk. Ewes milk contains more fat than the cows milk. Ewes milk also contains more nonfatty solids notably protein and calcium, and decidedly more riboflavin, nicotinic acid and vitamin C than in cows milk.

Of all the milch animals, horse and asses milk is very much nearest to human milk in composition, they are entirely herbivorous not ruminants. Mares and asses milk is believed by many to be very suitable for infants, though mares contain low fat milk. The major constituents of camels milk is very much like those of cows milk. It is characterised by a high content of vitamin C.
Yaks milk is almost like ewes milk. It is rich in fat and total solids and hence in energy. It is rich in yellow colour. Thus, like the cow, it converts carotene incompletely into vitamin A. Reindeers milk contains very high fat. Whales and seals also produce a concentrated milk very high in fat.

In the case of breast feeding, the problem of keeping milk does not arise because milk passes directly from mother to offspring. But in the case of bottle feeding preservation of milk is important, because milk is very prone to spoilage by micro-organisms either originally present or introduced in handling. Moreover it may contain organisms which are harmful, such as tuberculosis or brucellosis or acquire noxious germs during handling. Modern bacteriology and technology have found many ways of making milk safe and stable. Heat treatment preserves milk by destroying certain enzymes which are not significant.

To replace breast milk adequately, the original nutrients of milk should be preserved as far as possible and then should be adjusted. The form in which milk is used are many and various. Cows milk is the one that is used widely and normally. The 3 basic forms of cows milk, liquid milk, dried milk and evaporated milk from which artificial feeds are prepared are all satisfactory (Mackelth 1971). Soya bean and goats milk preparations are available for infants who are allergic to cows milk or who cannot drink it for other reasons. (Cohen et al 1979)

"Ready to feed" milks are liquid preparations sold in bottles which are usually based on the dried milk formula (Mackelth 1971). This is bulky and less convenient for transporting home. This is usually given to preterm babies (Bremer 1987).

As the infant grows, a milk diet alone cannot provide all the necessary nutritional requirements, specially iron, vitamin D and vitamin C. In fact supplements of vitamin C and D are usually started during the 1st month of the infants life. Iron intake is important
because the haemopoetic demands of the infant increases rapidly after 3 months of age and they cannot be met by milk alone. Iron deficiency is the most common nutritional disorder of infants.

Hence a variety of specially prepared semifluid foods which are rich in iron and other nutrients should be given when the infant is 3 months old. Negligible amounts of fluoride are present in human or bovine milk (Snavder 1980). Children in communities with inadequate fluoride in their water supply should be supplemented with fluoride daily.

At the age of one year the child's growth slows due to decreased skeletal growth. However, continuing mineralisation strengthens the bones and allows the child to support his weight and begin to walk. Most children have 6-8 deciduous teeth at the age of one year. When the teeth erupt, parents need to be aware of the influence of diet on oral health. During infancy the dental practitioner can provide parents with information that can prevent nursing caries.

Soon after its first birthday, the infant develops diminished appetite and the nutritional demands do not increase at rate as fast as they did during the first year. At this stage parents should be careful about the adequate nutrition of the infants diet. Milk continues to be an important source of calcium and phosphorus for bones and teeth formation.

4.3.2 Nutrition in Toddlers

Nutrition surveys indicate that three nutrients are often lacking in the diet of children between the ages of 1 and 3 years: iron, vitamin A and vitamin C. Therefore children 1-3 years old should be offered a variety of fruits, vegetables, meat and egg prepared in different ways. The caloric needs of toddlers are less per pound body weight than are those of infants (The recommended dietary allowances RDAs by age groups are given in Table 12).
Toddlers may not like milk, but they need as much calcium as adults do and those who reject milk can get the additional calcium by non-fat dry milk added to milk, mashed potatoes and other prepared dishes and a variety of cheese and dark green vegetables. Those children who are satisfying their appetite with milk only and not receiving nutrients from other foods may develop iron deficiency anaemia.

Excessive sugar intake not only is harmful to the teeth but also may decrease the intake of other necessary nutrients.

4.3.3 Nutrition in Preschoolers

The nutrients most often lacking in the diet of preschoolers (3 to 6 years) of both high and low socioeconomic groups is iron.

Preschoolers are in an age group of growth spurts and increased activity. They sometimes imitate adults but need to assert their independence. They prefer to wait on themselves, enjoy finger foods and if willing to eat it have meat prepared tender and easy to chew. Stringy foods like celery are usually unacceptable. Preschool age children often refuse their regular meals, usually the evening meal. If the two other regular meals and snacks are nutritious, then still the child may receive adequate daily nutrients. The mothers nutritional knowledge correlates directly with her educational level and therefore also with the nutrient intake for her child.

Close attention to adequate amounts of iron, vitamin A, and vitamin C from a variety of sources is needed since these nutrients are often in short supply.

Recommended daily intakes for major nutrients by young children are shown in Table 12.
Table 12

Source: Barasi & Mottram (1987).

<table>
<thead>
<tr>
<th>Age (yrs)</th>
<th>Energy (MJ)</th>
<th>Protein (g)</th>
<th>Thiamin (mg)</th>
<th>Riboflavin (mg)</th>
<th>Niacin (mg)</th>
<th>Ascorbic acid (mg)</th>
<th>Vitamin A (mg)</th>
<th>Vitamin D (mg)</th>
<th>Calcium (mg)</th>
<th>Iron (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boys Under 1</td>
<td>4.1 (max)</td>
<td>24.5 (max)</td>
<td>0.3</td>
<td>0.4</td>
<td>5</td>
<td>20</td>
<td>450</td>
<td>7.5</td>
<td>600</td>
<td>6</td>
</tr>
<tr>
<td>1</td>
<td>5.0</td>
<td>30</td>
<td>0.5</td>
<td>0.6</td>
<td>7</td>
<td>20</td>
<td>300</td>
<td>10</td>
<td>600</td>
<td>7</td>
</tr>
<tr>
<td>2</td>
<td>5.75</td>
<td>35</td>
<td>0.6</td>
<td>0.7</td>
<td>8</td>
<td>20</td>
<td>300</td>
<td>10</td>
<td>600</td>
<td>7</td>
</tr>
<tr>
<td>3-4</td>
<td>6.5</td>
<td>39</td>
<td>0.6</td>
<td>0.8</td>
<td>9</td>
<td>20</td>
<td>300</td>
<td>10</td>
<td>600</td>
<td>8</td>
</tr>
<tr>
<td>5-6</td>
<td>7.25</td>
<td>43</td>
<td>0.7</td>
<td>0.9</td>
<td>10</td>
<td>20</td>
<td>300</td>
<td>a</td>
<td>600</td>
<td>10</td>
</tr>
<tr>
<td>Girls Under 1</td>
<td>3.8 (max)</td>
<td>23.0 (max)</td>
<td>0.3</td>
<td>0.4</td>
<td>5</td>
<td>20</td>
<td>450</td>
<td>7.5</td>
<td>600</td>
<td>6</td>
</tr>
<tr>
<td>1</td>
<td>4.5</td>
<td>27</td>
<td>0.4</td>
<td>0.6</td>
<td>7</td>
<td>20</td>
<td>300</td>
<td>10</td>
<td>600</td>
<td>7</td>
</tr>
<tr>
<td>2</td>
<td>5.5</td>
<td>32</td>
<td>0.5</td>
<td>0.7</td>
<td>8</td>
<td>20</td>
<td>300</td>
<td>10</td>
<td>600</td>
<td>7</td>
</tr>
<tr>
<td>3-4</td>
<td>6.25</td>
<td>37</td>
<td>0.6</td>
<td>0.8</td>
<td>9</td>
<td>20</td>
<td>300</td>
<td>10</td>
<td>600</td>
<td>8</td>
</tr>
<tr>
<td>5-6</td>
<td>7.0</td>
<td>42</td>
<td>0.7</td>
<td>0.9</td>
<td>10</td>
<td>20</td>
<td>300</td>
<td>a</td>
<td>600</td>
<td>10</td>
</tr>
</tbody>
</table>

*a = no intake is necessary where there is sufficient exposure to sunlight; supplements may be needed in winter*
5 DIETARY PATTERNS

5.1 INTRODUCTION

The connection between diet and dental caries is well substantiated. Diet affects our teeth locally that is when food is retained in the oral environment and depends on the following:

i frequency of eating
ii physical form of food
iii concentration and amount of added sugar
iv relative cariogenic potential of the food

What we eat, when we eat, how we eat, how frequently we eat and how long the food is in contact with the teeth are all important factors in relation to dental caries and reflect one's dietary pattern. Hankin et al (1973) reported a correlation between the dietary pattern and caries prevalence in Hawaiian children when the frequency of daily eating ranged from three to eight food exposure periods per day.

Dietary patterns lead to dietary habit, which is based on an individual's work, family life and social situation. Family dietary pattern is very important for children because they learn from the family and imitate parents. The dietary patterns last throughout their life and are passed to the next generation. So parents must have sound food habits. Older children are also influenced by persons, other than their parents, whom they admire and respect.

Television, particularly through commercials aimed at children, also strongly influence their food habits. Food habits also depend on food availability, geographic location and seasonal differences, although modern technology has made it possible to have a wide choice of foods at any time.

In some families attitudes and beliefs may lead to poor nutritional habits. One of the most significant influences on family food habits today is the phenomenon of working parents. Fulltime employment on the part of the parents may not allow time for shopping and preparation of traditionally wholesome meals. Thus convenience foods and restaurant meals may constitute a large portion of the family's food intake; these foods tend to contain more...
carbohydrates and fats. It is also more common for the individual family members to eat at different times and different places. For example young children may have food at a day care centre.

There have been many changes in the pattern of daily eating throughout the world. In the United States, years ago, eating only three meals a day was the norm. Today the regimen of food intake is to eat lightly in the morning and at noon but to eat a heavy evening meal and to have numerous between meal snacks.

A 1969 US Governmental report showed that sugar containing foods are used less frequently with meals, when they are least destructive from a dental caries standpoint and more frequently as snacks, when they are most damaging (Nizel 1981).

If the main meals are short of proteins and vegetables, we will not be satisfied for long and will be hungry again soon with craving for something sweet. If the main meals are well balanced the risk of feelings of hunger and of eating between meal sugary snacks will be reduced. It is important to realise that sugar consumed with a meal may be much less cariogenic than sugar between meals (Thylstrup & Fejerskov 1986).

The taste and appearance of the food are important factors in our food selection. We like the sweet taste. Even the newborn child can distinguish between water and a sugar solution and shows a preference for the sweet taste. Taste preference for different food develops from early childhood.

If sugar has been consumed on 5-6 occasions per day it is not reasonable to expect the patient to immediately give up sugar or even reduce the frequency of intake. All changes have to be gradual. Frequent sweet eating habits in young children may be reduced through motivation of parents, when the parents still make the decision.
In the Vipeholm study, results showed that caramel, chocolate, cookies and pastries had the highest caries potential and that apples, fruit juices, lemonade and carrots had the least. It shows that sticky foods are more cariogenic and four times more dangerous than liquid form (Nizel 1981).

The amount of sugar in a food does not always mean that it is significantly cariogenic. The important factor is the concentration of sugar in the food. The higher the sugar concentration the greater is the possibility of caries. Before selecting any food, food labelling has to be checked for nutritional information and safety expiry date which may help the consumer to plan and serve more adequate, varied and balanced diets, which should be the main thrust of developing a good dietary pattern. Faulty dietary pattern is partly due to poor food selection, poor food habit and even fad diets, although every individual has likes or dislikes for certain foods.

Observations both in man, in animals and in the laboratory (in vitro) have clearly shown the relationship between frequent consumption of fermentable carbohydrates and high caries activity (Thylstrup & Fejerskov 1986). Thus, when clinical examination reveals high caries activity, relevant information about the patients food habits must be collected to identify those dietary factors believed to be of major importance for the uncontrolled progress of caries. On this basis, it is possible to help the patient to reduce the cariogenic potential of their diet by finding attractive alternate foods and suggesting realistic modification of consumption pattern.

A typical 24 hour recall method which lists everything consumed and how much consumed in the last 24 hour period will reflect the dietary pattern of an individual. The 24 hour recall is also a useful way of establishing an infants dietary pattern.

Nutrition, diet and health are very much related to one another. A sound dietary pattern established in infancy may have long term beneficial effects in reducing the risk of nutritionally related disorders such as obesity, heart disease, hypertension and dental caries (Allen et al 1981).
In this chapter we will be discussing dietary pattern of normal infants, toddlers and preschoolers but it can also be said that children of these age groups who are ill, premature, handicapped who are not normal can also be fed successfully often by only minor adjustments of the normal practices.

5.2 BREASTFEEDING

The birth of a baby launches a new life in the world. Good health is what every mother wants for her child (Isbister 1985). The National Health and Medical Research Council of Australia in October 1976, adopted the following statement on feeding of infants and young children:

"Breast feeding is the ideal feeding for infants and fosters optimal growth and development. The success of breast feeding depends on the attitudes of the mother and the father and the adequacy of the mothers diet. It should begin soon after birth so that valuable colostrum is not lost" (NH&MRC 1977).

Breast feeding is recommended and included in the dietary goals proposed by the Department of Health. The incidence of breast feeding in Australia is high but the duration is short. A survey was carried out in the Sydney metropolitan area (Allen & Heywood 1979) showed that 79 per cent of mothers had started breast feeding but almost half of them stopped breast feeding within the first 12 weeks.

It is assumed that the rate of breast feeding in a developing country like Bangladesh is much higher specially in urban areas, although many of the lactating mothers are not having proper nutrition. Breast feeding may be unsuccessful if there is malnutrition in the mother.

Healthy human milk provides all that a baby requires for the first six months of life although there is little basic difference between the milk of different women from different parts of the world. In fact breast milk is a continuation of the feeding of the baby while he was in the mothers womb (Messenger 1982).

Nutritional factors: From the nutritional standpoint there are many differences between cows milk and human breast milk.

(i) breast milk contains the correct proportions of protein, fat, carbohydrate, vitamins and minerals. The protein and electrolyte content of human milk does not stress the infants kidneys. The composition of human milk is well balanced with the growth rate and requirements of the infant.

(ii) the most digestible milk for infants is human milk. Curds formed from humans are much smaller and softer than those from cows milk.

(iii) various nutrients, specially iron, copper and fat are better absorbed from human milk than cows milk (Weddowson et al 1974, McMillan et al 1976).

(iv) breast milk does not contain common allergens, beta lactoglobulin and bovine serum albumin which is present in cows milk. So allergy to breast milk is almost impossible. An investigation with 300 allergic children aged 4 to 14 was carried out in England and showed that no child had developed eczema while being exclusively breast fed (Llewellyn-Jones 1983).

(v) the amino acid and fatty acid composition of human milk speeds up the development of the infant, especially rapid growth of the brain (Fomon 1974).

Resistance to infection: Breast milk contains protective factors which help in protecting infants against infection.

(i) secretory immunoglobulin A (IgA). This is an antibody which reacts with foreign proteins, bacteria and viruses entering the intestinal tract. IgA is not present in cows milk. There are also other immunoglobulins present in breast milk and IgA is not produced by the bowel lining until 3 to 4 months of age.

(ii) breast fed infants may have an acid environment in the intestine produced by the bifidus factor, which offers lactobacillus bifidus to inhibit the growth of less favourable organisms.

(iii) breast milk contains three times the concentration of lysozyme level of cows milk. Lysozyme works directly against many bacteria and indirectly by potentiating bactericidal activity of immune antibodies.

(iv) lactoferrin is a milk protein and binds with iron. Lactoferrin interferes with the growth of certain pathogens such as E coli and staphylococci (Jelliffe & Jelliffe 1978).
(v) breast milk contains other proteins which bind folate and vitamin B₁₂ and rendering them unavailable for bacterial metabolism.

(vi) the enzyme, lactoperoxidase, helps in combating streptococci.

(vii) cellular factors like amoeboid macrophages and interferon-producing lymphocytes give protection against infection.

(viii) it is most unexpected that breast milk will become contaminated with disease causing organisms, whereas cows milk may be contaminated.

Benefits to the mother:

(i) most mothers enjoy breast feeding and get satisfaction from their ability to provide their babys nourishment. This also creates a feeling of security in the infant and a close bond between mother and child. This bond or interaction is recently considered as an important factor in the childs development (Llewellyn-Jones 1983). Breast fed children showed a lower incidence of dental caries because they escape neonatal hypocalcaemia which if it produces symptoms, seems to be associated with enamel hypoplasia.

In December 1977 one hundred children under five years were examined in the childs polyclinic at the General Hospital, Medm, Indonesia (Aldy et al 1979). No sugar was added to the milk. Fifty four were found to have suffered from dental caries of which 48 had caries similar to bottle caries. Among those 48 children 35 were breast fed for short periods and then bottle fed. In breast fed children over one year, there was no incidence of caries (Table 13).

(ii) breast feeding helps in bringing back the uterus to its normal size.

(iii) breast feeding is very convenient for the mother because milk is always available at the right temperature and consistency.

(iv) breast feeding helps in bringing back the normal weight of the mother.

(v) breast feeding is economical. It does not require the cost of formula milk, bottles, sterilisers, teats and so on.
Table 13
Caries in breastfed and bottlefed children.
Source: Aldy et al (1979)

<table>
<thead>
<tr>
<th>Age (in months)</th>
<th>Method of Suckle</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Breast</td>
<td>Breast and Bottle</td>
</tr>
<tr>
<td>6-12</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>12-18</td>
<td>-</td>
<td>3</td>
</tr>
<tr>
<td>18-24</td>
<td>-</td>
<td>5</td>
</tr>
<tr>
<td>24-30</td>
<td>-</td>
<td>5</td>
</tr>
<tr>
<td>30-36</td>
<td>-</td>
<td>4</td>
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<tr>
<td>36-42</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>42-48</td>
<td>-</td>
<td>5</td>
</tr>
<tr>
<td>48-54</td>
<td>-</td>
<td>7</td>
</tr>
<tr>
<td>54-60</td>
<td>-</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>35</td>
</tr>
</tbody>
</table>

Table 14
Breast and artificial feeding, morbidity and mortality rates
Liverpool England 1936 - 1942.
Source: Adapted from Nutrition in Developing Countries (1977)

Liverpool, England 1936-1942

<table>
<thead>
<tr>
<th></th>
<th>Number</th>
<th>Illness/1000</th>
<th>Death/1000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breast-fed</td>
<td>971</td>
<td>223</td>
<td>10.2</td>
</tr>
<tr>
<td>Bottle-fed</td>
<td>854</td>
<td>574</td>
<td>57.3</td>
</tr>
</tbody>
</table>

Punjab, India 1954-1959

<table>
<thead>
<tr>
<th></th>
<th>Number</th>
<th>Neo-Natal Deaths</th>
<th>Post neo-Natal Deaths</th>
<th>Infant Mortality Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breast-fed</td>
<td>739</td>
<td>34</td>
<td>55</td>
<td>120</td>
</tr>
<tr>
<td>Artificially-fed</td>
<td>20</td>
<td>15</td>
<td>4</td>
<td>950</td>
</tr>
</tbody>
</table>
Benefits to the child:

(i) morbidity and mortality rate is lower among breast fed infants than among bottle fed infants in developed countries as well as developing countries. Table 14

(ii) nutritional problems are usually much less in the breast fed infant than in the bottle fed infant.

(iii) the breast fed baby is expected to have well formed jaws and well aligned teeth because breast fed babys exert more energy to get their food than does the bottle fed baby (Allen et al 1981).

(iv) breast fed infants feel more secure through close relationship with their mother.

Physiology of breast feeding:
During pregnancy the breasts enlarge and the nipples and areola begin to darken. There is development of granular tissue and proliferation of the milk ducts. Each breast on average weighs 750 grams more at the end of the pregnancy.

During the second half of pregnancy colostrum, the forerunner of breast milk starts leaking from the nipples. At birth the baby should receive colostrum as protection against infection. Colostrum cannot be replaced artificially. About the third day after birth, the colostrum becomes more milky and the transition to mature human milk is completed by about the 10th day.

The two distinct processes of milk production and milk ejection which occur during breast feeding have already been discussed in chapter IV of this thesis.

Preparation for breast feeding:
Most mothers are physically capable of making enough milk and can cope with her baby's needs. The normal well nourished mother will produce about 600 ml- of milk per day in the first month, increasing to 700-750 ml per day in the third month and up to about 800 ml in the sixth month. By then the baby is receiving extra food, so there is no increase in milk.
(i) First of all expectant mothers should make the decision whether she is proceeding to breast feeding. Some 20 per cent of women have nipples which are not fully protractile but a nursing mothers nipples must be protractile so that the baby can suck adequately. If there are inverted nipples antenatal preparation is required. The most important aspect of successful breast feeding is whether the nipple and areola can be drawn forward easily (Llewellyn-Jones 1983).

(ii) A comfortable maternity brassiere is required during the fifth month of pregnancy. It must support the breasts well and wide adjustable shoulder straps. The breasts will be at least double in weight and they need support to keep their shape and stop skin stretching more than necessary. It must open down the front allowing the breast to be lifted out while feeding. If the breasts simply hang without support, ducts can become blocked. This results in areas of gland that are full of milk but not emptying, making them more liable to infection.

(iii) during pregnancy nipple secretion should be washed with soap daily but not excessively as soap removes natural fats. Replace the fat normally washed out by applying lanoline or a similar cream. At the same time pull the nipple forwards gently to loosen it and clear the ducts. Also roll it from side to side between thumb and forefinger. Express small amount of colostrum in the last week of pregnancy to clear ducts and promote the flow. If possible, expose the nipples to sunlight for a few minutes each day. Rub the nipples with a towel and try to toughen them a little.

The protection test should be done. It is a test to determine whether the nipple will ride forward into the babys mouth when he sucks. It is done by compressing the area behind the nipple between the thumb and forefinger (Isbister 1985).

(iv) As the breasts grow in size the skin may show stretch marks as on the abdomen. Rubbing with oil may help to fade marks quicker.

(v) have a demonstration on breast feeding technique by nursing mothers or a friend who is breast feeding her baby.

(vi) breast feeding is something worth doing. Breasts certainly have an erotic role and women who enjoy having their breasts caressed in love making, more easily accept the intimacy of breast feeding. Failure to breast feed for some women threatens their image of themselves as women and can be emotionally upsetting. There may be some problems in breast feeding but these are usually minor if tackled early. In fact one must have confidence and knowledge about the advantages of breast feeding. Breast feeding is not just a fashion nor is the breast just a sex object. It has significant importance in life.

(vii) mothering: expectant mothers should have the support of an experienced woman, who knows about milk, babies and how a woman feels, to give emotional support.
when she gets home with her new baby. Her own mother would be the best. She should do the mothering herself. She should ask somebody for help with the housework for an hour or so each day.

(viii) nutrition: an expectant mother should have a satisfactory diet. She needs extra protein, fresh fruits and vegetables. She should try to stop smoking if she is smoking. She should also avoid alcohol totally right from the beginning of the pregnancy because even small amounts of alcohol, taken infrequently can harm the development of the baby (Breakspere & Starmer 1986). Foods that commonly cause allergic reactions should not be taken if she is bringing the child into an allergic family.

Lastly, the main idea is breast feeding should be encouraged, but if for any reason breast feeding is not possible, relax and be willing to offer some formula. There are excellent formulas for babies available.

**After birth:**

Nursing mothers should start breast feeding immediately after birth unless it is advised otherwise. At the very beginning of breast feeding the baby is given short feeding, approximately 5 minutes on each breast. This may increase gradually up to 10 minutes on each breast as the milk production increases. Nursing more than 8 to 10 minute intervals on one side can be emotionally satisfying to the baby but is almost non-nutritive (Schreiner & Bradburn 1988). The sucking reflex is at its strongest in the first few hours after a baby is born (Elliot 1982). A flexible feeding schedule helps to establish lactation as the babys sucking triggers milk production. Both breasts should be offered at each feed right from the beginning of breast feeding. Relaxation is important for the release of enough milk and successful lactation.

The first introduction to the breast is hardly a feed. For the next two days these feeds will be mainly for learning breast feeding techniques, as only a few millilitres of colostrum are available each time. It is also a time of tenderness, caressing, fondling, cuddling, talking and starting communication.
The colostrum secreted in the glands in the first day is thick, yellow and scanty, rich in protein and protective substances but not producing much fluid or energy. The baby loses weight up to 10 per cent in the first few days but is back to birth weight by the tenth day. There is no need for extra fluid or kilojoules before the milk comes in unless the weather is very hot. If the baby is dehydrated for any reason, water or glucose in water is offered at least once a day. Fluid if required should be given to the baby by a spoon or dropper rather than by bottle because a baby sucks a bottle differently from the way he suckles the breast and if both the methods are applied before fully established lactation, the baby may be confused (Llewellyn-Jones 1983).

The National Health and Medical Research Council of Australia has issued a detailed "Guidance to promote breast feeding" with the advice of the Australian College of Paediatrics and states that there should be no routine feeding of any kind before the milk comes in and no routine use of complimentary feeding. The glands usually secrete mature milk some time in the third 24 hours after birth. The breasts fill, sometimes very suddenly and very uncomfortably. The breast milk may flow easily if the baby has removed colostrum efficiently and has opened all the ducts in the nipples and stimulated the let down reflex with his sucking.

Babies can be fed in different ways but it is essential to be comfortable. A nursing mother should wash her hands before starting each feed and make this a firm routine for future feeds. A daily bath or shower is adequate for breast hygiene (Schreiner & Bradburn 1988). When the baby is small, mother can feed the baby in a sitting up position, she leans forward, supports her babys back with cushions, and places the baby in a pillow across her knees. She can then stroke the babys cheek or the corner of his mouth with the nipple and the baby will probably open his mouth as he turns towards the nipple and starts feeding when he finds the nipple. This searching movement is an inborn reflex in newborn babies. As the milk reservoir is under the areola, so the nipple and as much of the areola as possible needs to be taken into the babys mouth and needs to be emptied by the babys mouth movements.
If the baby simply chews on the nipple he may crack or blister it. Cracked nipples which may develop in the first two or three days may disturb the establishment of lactation. Baby may have thrush in his mouth or skin infection and may infect the breast tissue through the cracked nipples.

Mothers can feed baby by lying down and rolling to one side and lay the baby down, so that he is on his side with his head facing the breast. The baby should be given the breast until he has had enough and loses interest in the first breast. If the mother wants to release the baby from the nipple, she should put the tip of her little finger in the corner of the babys mouth. If both breasts are offered to the baby and emptied in every feed, this will help in mothers milk supply. Always nursing mothers should start feeding with the breast she fed with last.

Some babies enjoy physical contact and want to suck longer than others if the mothers nipples are comfortable and the baby is well supported. Babies also develop their own individual preference for feeding patterns.

Common problems in breast feeding:
There are some problems in breast feeding but these are usually minor if tackled early. **Sore nipples:** Particularly during the first week, many breast feeding mothers experience pain in their nipples as soon as the baby starts feeding. This usually goes once the milk is let down. It can also be overcome by frequent short feeding and careful positioning of the baby at the breast. If there is a sore nipple rest the nipple by feeding from the other breast or collect milk by hand or pump expression and then feed the baby till the soreness of the nipple is over. For treatment keep the nipple dry after each nursing session by exposing it to the sunlight for 15 to 30 minutes.

**Over supply:** During the establishment of lactation, some mothers may have the problem of over supply of milk and may take a while to match her babys requirements. Frequent
short feeds may be helpful. Otherwise the milk can build up and the breasts become swollen and engorged. If the breasts become engorged she can massage them gently under a warm shower and express a little milk in between frequent and longer feedings.

If the milk comes so quickly that the baby gasps and splutters the mother can posture feed, that is feeding in such a way that the milk is flowing up hill to the baby.

**Low supply:** Some mothers may have a low supply of breast milk when they are anxious or worried especially with the first baby. In that case she should be encouraged to rest and relax and to increase the frequency of feeding. Formula milk should not be offered as this can reduce the babys sucking stimulus which can result in a further decrease in supply.

**Sore breasts:** This is the condition when the milk ducts are blocked and is characterised by a sore and tender spot on the breast. Frequent short feeds, starting from the blocked side each time then rest and application of warmth to the sore area by warm cloths may be helpful. Medical help may be required if the mother is feeling sick and the duct stays blocked.

**Reasons for success or failure of breast feeding:**

A number of factors can affect the establishment and success of breast feeding.

**Cultural attitudes:** In countries where breast feeding is the norm and there are no other ways, women have little difficulty in establishing lactation. On the other hand, where bottle feeding is readily available many women discontinue breast feeding after a few weeks.

Cultural factors that affect breast feeding in Australia are as follows:

(i) infant bottle feeding is well accepted in this community. Medical and paramedical professionals are well trained in artificial feeding but not in the importance of successful breast feeding.

(ii) widespread advertising encourages commercial formulas as equivalent or even superior to breast milk.

(iii) breasts are considered as sexual objects in the society and public breast feeding may cause embarrassment.

(iv) some women decide not to breast feed because of fear that breast feeding will cause them to lose their shape.
(v) some women discontinue breast feeding because facilities are not available for child care on the job if they wish to return to work.

(vi) women from higher socioeconomic groups with higher educational levels are more likely to breast feed.

**Physical factors:** Physical factors that affect breast feeding are as follows:

(i) women in poor health due to serious illness may be less capable of producing milk adequately.

(ii) some older women, particularly those having their first child produce less milk or have a later onset of full lactation than those who have had several babies.

**Other factors:**

(i) poor nutrition of the mother because of dieting or of other reasons may cause fatigue which may in turn, cause the mother to cease breast feeding.

(ii) certain drugs may interfere with milk production such as high dose oral contraceptives and excessive cigarette smoking (Catz & Giaccola 1972, Vorherr 1974).

(iii) early introduction of solids to an infant reduces his appetite and hence his sucking reflex which results in less milk production by the mother.

(iv) some lactating mothers believe that bottle feeding is an easy and simple method.

(v) mothers in crowded households may be less interested in breast feeding.

**Nutrition of the mother during lactation:**

Adequate nutrition of the mother during lactation is very important because a poor nutritional diet may lower the quality and decrease the volume of the breast milk. Although the protein, carbohydrate and fat content of breast milk are not changed significantly, there is a reduction in vitamin levels (Fomon 1974) and for that the infant may be vulnerable to health problems. Nutrition of the mother during lactation has already been discussed in detail in chapter IV of this thesis.
Adequacy of the maternal diet:

During lactation daily requirements for all nutrients including kilojoules are increased (NH & MRC 1979). Nursing mothers need an extra 2500 kilojoules per day depending on the age of the child. Although some energy will be provided by fat stores laid down during pregnancy. The energy requirement is affected by the mothers nutritional status. This extra energy may be provided if a well balanced diet, which contains foods such as meat, milk, cereal, citrus fruits and vegetables are consumed. The maternal diet should cope with the recommended allowances for vitamins, specially vitamin C. Mothers diet during lactation is important because everything she eats will pass to the baby and affect the baby.

In developing countries nutritional status of the nursing mother can be improved by supplementing the mothers diet with protein, vitamins and iron which ultimately have good effect on breast fed babys health.

Recommended daily food intake during lactation:

Milk
- 600-900 ml of milk or equivalent dairy product should be taken daily in different preparations such as a drink, flavoured milk, on cereal, in tea or coffee, in desserts and in soups or in the form of cheese or yoghurt.

Meat or fish
- 2-3 average servings of meat, fish, poultry, eggs, dried beans, legumes or nuts should be taken daily. One serving is approximately 60-100 gms.

Fruit, fruit juice and vegetables
- 3-4 average servings should be taken in cooked or salad form which should include one fruit high in vitamin C such as citrus fruit, raw tomato, rock melon, paw paw, berry fruits, raw capsicum, fresh pineapple or juices from these fruits.

Bread and cereals
- according to appetite 3-4 average servings or more of whole grain breads and cereals are recommended.
Suggested meal pattern:

**Breakfast** -
- cereal
- eggs, meat or cheese
- toast or bread
- milk

**Lunch** -
- meat, fish, chicken, eggs
- cheese or legumes
- salad or cooked vegetables
- bread
- fresh fruit
- milk

**Dinner** -
- meat, fish, chicken, eggs
- cheese or legumes
- salad or cooked vegetables
- bread
- fruit
- milk

Between meal snacks:

Fruit or fruit juices, savour biscuits with cheese; nuts, milk, yoghurt or sandwiches are suggested as nutritious between meal snacks.

Refined carbohydrates and fatty foods, like sugar, honey, jam, soft drinks, cordials, sweet biscuits, lollies, chocolates, cakes, pies, crisps, sausage rolls etc should be taken minimally because these foods contain considerable energy and have little nutritive value. Moreover it may lead to some dietary disease like dental caries, obesity and heart disease.

Lactating mothers should also take some extra fluid.

Most drugs are transmitted from the maternal serum to the breast milk and may affect the infant. Drugs which are harmful for the baby should not be taken by the breast feeding mother. If at all necessary, drugs can be taken just after breast feeding and then to avoid nursing for 4 hours or more if possible. This gap will markedly decrease the drug concentration in the breast milk (Berlin 1981). It is clearly known that the amount of drug excreted in breast milk is usually not more than 1 to 2% of the maternal dose; therefore it is very rare that any drug would be pharmacologically significant to the infant (Bassard
1976), although a few drugs or categories of drugs are definitely contraindicated for the nursing mother.

If any drug is essential to the mother's health and its safety is not known, then breast feeding should be stopped (Schreiner & Bradbrun 1988).

Smoking cigarettes may decrease secretion of breast milk and nicotine passes into breast milk. Smoking mothers may have cranky babies. Alcohol is also transmitted through mothers milk.

Certain groups of women need special nutritional care. These groups include (Maternal and Child Health Unit 1975):

adolescents, underweight mothers, low income mothers, dietary faddists, vegetarians, women with a history of numerous pregnancies, women with poor dietary practices and others such as drug addicts, alcoholics and the psychologically disturbed.
5.3 BOTTLE FEEDING

Growth is faster in infancy than at any later stage and as such infants need adequate and proper feeding.

During the preantibiotic era, breast feeding was believed to be essential for the health and survival of infants. Babies used to die without breast milk but now they can be reared just as well with scientifically prepared formulas. Powdered milk for babies was first introduced around 1917. Since then many changes have been made to formulae. Thus, when breast feeding is not possible, bottle feeding can be offered as a suitable available alternative. This is based usually on cows milk and appears to be satisfactory for the majority of infants.

Formula milk based on cows milk which is used (in Australia) for infants is as follows:

(i) a humanised milk formula such as S26, NAN, SMA, Enfamil, Similac and new Lactogen. These foods are based on cows milk, modified to a greater or lesser extent to approximate the composition of breast milk.
(ii) cows milk (dried, evaporated or whole) with the adequate modification and supplements.
(iii) the third type of milk is made from soya beans. This milk is popular and is vegetable in origin and nutritionally it is as good as human or cows milk. It is especially useful when the baby is allergic to other types of milk.

There are other milks which have already been discussed in Chapter IV of this thesis.

Skim milk, reduced fat milk and condensed milk are not appropriate for infant feeding. When selecting a variety, it is best to stick to one of the extensively modified formulas. There is no point in keeping on changing milk brand because babies will usually tolerate any of these milks.

Baby should be fed on demand, at least at the beginning, until a regular feeding pattern is established. It is not expected that the baby will take the same quantity at each feed, as appetite is not constant. A new born baby will take 140-160 ml/kg per day by the end of the first week, but some more should be handy in case the baby is extra hungry. The quantity of milk intake increases gradually with age. Demand feeding pattern reaches its peak during the first week and then the feeding pattern settles down to a three or four hourly interval between feeds.
Problems related to bottle feeding:
There are some problems present with bottle feeding. These include the need for exact preparation of feeds, the problem of infections and allergies, the differences in composition between human milk and cows milk and the possibility of over feeding causing obesity.

Preparation of feeds:
There are two main problems with exact preparation of feeds. These include *microbial contamination* and *incorrect concentration*.

*Microbial contamination:* There can be microbial contamination during processing, preparation and giving of feeds. Necessary precautions should be taken to avoid contamination. The risk of infection among bottle fed infants is much higher than for breast fed infants. All bottles, teats and utensils should be sterilised immediately after use as stale milk in the bottle will act as a growth medium for bacteria. Cooled boiled water should be used according to the manufacturers instructions in making up feeds with formulas but if cows milk is used it must be boiled until the child is 6 months of age.

After preparation of the feed in both cases it can be either used immediately or can be sealed and stored in the refrigerator. Formulas may be fed at cool room or body temperature considering infants preference. The bottle of formula can be heated in a saucepan with water or in an electric bottle warmer, if needed. Bottles should not be kept outside the refrigerator to warm at room temperature because bacteria may have the chance to multiply rapidly. Leftover milk should not be saved for the next feeding. Formula can be prepared for one feed or at best for one day supply at one time and not more than that. Once a can of commercially prepared liquid formula is opened it cannot be used for more than 48 hours even it is well covered and refrigerated.

*Incorrect concentration:* There are great risks with bottle feeding, when feeds are made up incorrectly and there is reasonable evidence to prove that this is often done (Taitz & Byers
1972, Oats 1973, Wilkinson et al 1973). Underconcentration can result in under nutrition and overconcentration can lead to overfeeding. Incorrect concentration may cause health disorders. Standard instructions for making up feeds may remove confusion and inaccuracies in measuring milk powders.

Problems of infection, immunity and allergy:
Because of foreign milk proteins present in cows milk, it is more allergenic for sensitive infants than breast milk. Bottle milk does not contain a number of protective factors contained in breast milk which help to protect the infant against infection and allergies.

Differences in composition between human and cows milk:
A number of problems arise because of differences in composition between human milk and cows milk. These problems are greatly reduced if the cows milk is modified to resemble breast milk.

Obesity due to overfeeding:
Incorrect preparation with over-concentration of milk formulas may result in obesity. Mothers often feed babies when they cry, whether the baby is really hungry or not. That is a mistake. The practice of propping the bottle or desire to check whether the bottle is emptied may also lead to overfeeding.

There are no such problems with breast feeding. The concentration is unique, the baby usually adjusts the volume according to his appetite. There are other problems which include:

(i) problems with teat - the teat has to be checked by inverting the bottle and watching the way the drops of milk flow. They should flow quite rapidly. If the hole in the teat is too small, baby will become too tired before getting enough milk and may swallow excessive amounts of air. If the hole is too large milk will overflow and the baby may choke.

(ii) wind - air is swallowed during feeding and crying. Some babies may swallow a lot. This causes discomfort if it remains inside and usually comes up as a burp and it takes a few minutes to coax a burp out of baby.
5.4 SOLID FOOD PATTERNS

Whether breast fed or bottle fed, it is recommended that solids be introduced in the diet of infants from 4-6 months of age (Schreiner & Bradburn 1988). A variety of nutritious food of different food groups from the family dietary menu can be given to the child, but in a suitably modified form. There is sufficient evidence that introduction of solids in infants feed before 4 to 6 months is undesirable for the following reasons:

(i) early solid food introduction encourages over feeding resulting in obesity (Bampfylde & Dickerson 1985). The addition of cereals to milk in the bottle before that time should be discouraged.

(ii) solid foods offered such as cereals, meat, eggs often have a higher sodium content than is desirable for infants which causes stress on the infants kidney and hypernatraemia and hypertension in later life.

(iii) early introduction of solids may develop allergic illness as the immune systems of infants are not fully developed.

(iv) coeliac disease may develop in a sensitive child at an early age if there is early introduction of gluten. It is not recommended that gluten containing foods be fed before 6 months of age during period of brain development.

(v) in fact early introduction of solids may spoil future attractiveness of the child, as it cuts down milk intake resulting in reduction in calcium which is essential for same (Bampfylde & Dickerson 1985).

When the child is weaned off breast milk or modified cows milk, he needs vitamin C supplementation. Freshly squeezed strained fruit juice is ideal. Canned and bottled fruit juices are also suitable. These should be diluted with cooled boiled water and no added sugar. Fruit juices may be introduced to the breast fed baby between the ages of 3 to 6 months, to educate the babys palate and to confirm that he is having an adequate intake by the time he is weaned. Commercially prepared vitamin C syrups which have high sugar content are not recommended as they may cultivate a sweet tooth and may lead to dental caries (Roots 1974). Fruit juice drinks, fruit flavoured drinks, fruit drinks and vitamin C containing cordials containing added sugar should not be used.
Solid or semisolid foods are introduced during the period of 4-6 months to educate the infant to new tastes, colours and textures of foods. Usually one type of food is introduced at one time and other foods gradually added. Initially a small amount of rice cereal of thin consistency (Bampfyld & Dickerson 1985) with no added salt or sugar is offered first and then gradually other cereals with thicker consistency may be offered. Cereal is a high energy food and if the baby is putting on too much weight then too much cereal should be avoided. Palate training is important during weaning. Fruit and vegetables are essential to palate training and avoid problems later on. (Bampfyld & Dickerson 1985)

The types and amounts of well mashed or soft foods like fruit and vegetables, milk puddings, finely minced meat, liver or fish can gradually be increased to satisfy the infants appetite. As the quantity of solid food is increased, the infant will accordingly drink less milk. Salt, sugar or honey should not be added to the babys food as these are not recommended. Solid food should be given to the infant either by spoon or fingers and not added to the bottle. It is more likely that the infant will receive solid foods with new tastes and textures if it is given when he is hungry before the milk feeds.

**Age 6 to 9 months:** During this period the baby may have a dietary pattern as follows:

| Morning | cereal or porridge  
|         | fingers of toast or bread with butter or margarine |
| Noon   | mashed fruit  
|        | custard or other milk pudding |
| Afternoon | orange juice  
| Evening | finely minced meat, fish or chicken  
|         | mashed cooked dried peas or beans or soft cooked egg  
|         | mashed vegetables |

If required noon and evening meals may be interchanged.

During this period the mother can continue to breast feed as often as the baby wants. If bottle feeding the baby will take the amount he needs. Most bottle fed babies drink about 180 ml to 250 ml three times a day.

**Age 9 to 12 months:** When the mashed foods are accepted by the infant, new textures in foods may be introduced to encourage the infant to chew. These may include cooked
egg, flaked fish, minced or finely chopped chicken, liver or meat, well cooked vegetables and soft fruits and finger foods (such as baked crusts or rusks, fruit pieces, for example, pear, apple, banana and raw vegetable sticks, for example celery, carrot). Suitable meat substitutes are mashed split peas, lentils and dried beans.

*During the period between 9 and 12 months* an infant’s dietary pattern may be as follows:

**Morning** - orange juice
   cereal or egg
   toast with margarine or butter

**Noon** - meat, fish, chicken, egg, cheese or mashed dried peas or beans
   bread
   fruit

**Evening** - Meat, fish, chicken, egg, cheese or mashed dried peas or beans
   potatoes, pasta or rice
   cooked or salad vegetables
   fruit
   custard or other milk pudding or yoghurt

If required noon and evening meals may be interchanged.

During this period the mother can continue to breast feed as often as the baby wants to, or if bottle feeding, the baby should not be offered more than three 250 ml bottles a day. At this stage the baby should be encouraged to drink milk from a cup. Then the number of bottles should be reduced. At the end of 12 months the baby should be weaned off the bottle feeding because prolonged bottle feeding has been shown to produce dental caries especially if the child sleeps with the bottle in his mouth.

**Age 1 to 2 years:** By one year a child should attempt to feed himself three meals a day, mostly from the family menu and should drink about 600 ml of milk from a cup.

**Recommended daily food intake:**

**Milk** - 600 ml of milk and milk products like cheese, yoghurt should be taken by the child
   [30 g cheese = 200 ml of milk, 1 carton = 200 g yoghurt = 300 ml of milk].

Meat, fish, poultry, eggs, cheese, legumes (such as dried beans, peas, lentils) - should be taken in 2-3 small serves.
Fruit, fruit juice and vegetables -
2-3 small serves should be taken from these groups, of which 1 fruit or fruit juice (without added sugar) should be high in vitamin C, for example citrus fruits, tomato, rock melon, paw paw, berry fruits, capsicum, fresh pineapple or juices from these fruits.

Bread and cereals - 2-3 serves from these groups should be taken.

These foods can be arranged in the dietary pattern as specified for age 9 to 12 months. Nuts and other small hard foods such as popcorn, small lollies and so on should not be fed to children under 5 years to avoid accidental inhalation.

*Toddlers food* is a step up from infant food. Older toddlers do not like infants food and this seems babyish to them. A toddler likes piles of interesting food on his plate to eat like his parents. He can also share family food if it is healthy and suitable for him. Range of food intake also increases as he develops a full dentition by about the age of two years (Barasi & Mottram 1987).

He is now more active and mobile than during the first year of his life. This is the age when the toddler develops some independence in relation to his food. He prefers to eat by himself and he should be encouraged. By this age he should eat a varied diet in which all essential nutrients are roughly balanced including a little fibre to reach his full physical and intellectual potential. He can get adequate dietary fibre from eating some wholemeal bread and a daily serving of fresh fruit and vegetables. Research has shown that fibre in cereal is much more effective than fibre in fruit and green vegetables for the maintenance of normal intestinal behaviour and content (Burkitt 1979).

Growth rate will be slower at this age and he does not require large meals. Most toddlers eat only a third of an adult sized portion at any meal. So it is not essential to increase his food drastically. He will decide his food intake as he needs. Food intake will vary according to his mood, age, activity level, appetite, growth rate, general state of health and even the time of year. For example, he will probably eat less in warm weather or when he is inactive or ill. Over feeding may lead to weight problems which are hard to overcome.
Herbs or mild spices in small quantities can be added to toddlers meals gradually. A little nutmeg to his rice pudding, a pinch of cinnamon to his baked apple or a tiny sliver of garlic to his soup can be added gradually to make his meals more interesting. Salt should be avoided in toddlers meals.

_Snack foods:_ After the first year the growth rate gets slower, there is less energy required and the baby starts eating less. Many toddlers prefer more frequent small meals. They should be provided with nutritious snacks in between meals, for example, pieces of fruit, fruit juice, bread and vegemite, marmite or peanut butter, cheese, finger foods (such as carrots or celery) and small cups of milk are recommended as in between meal snacks and sweet biscuits, lollies, sweet drinks such as soft drinks, cordials and fruit drinks are not recommended as they contain high sugar levels which are responsible for deciduous dental caries.

_Commercial baby foods_ are convenient but have certain disadvantages such as high cost, less nutrients and more difficulty in weaning children to the family menu in later stages. As a result, it is always wise to use commercial baby foods only as convenience foods, rather than depending on them for total diet. Once the child is eating three full meals a day regularly as specified for age 1 to 2 years, all nutrients should be adequate. He should not have any vitamin and mineral supplementation other than fluoride. If the water is fluoridated and the child is drinking 500 ml of water each day, then he will not require extra fluoride.

A supplement of 0.25 mg of fluoride for child up to 2 years, 0.50 mg of fluoride for child up to 3 years and 1.00 mg of fluoride for child up to 13 years are recommended when the concentration of fluoride in water is <0.3 ppm (American Dental Association 1979 and American Academy of Pediatrics 1979 _Table 6_) Glenn et al in his study with 492 children found that when a daily 2.2 mg tablet of sodium fluoride was administered to mothers during the second and third trimester in combination with fluoridated water the offspring were virtually free of caries for up to 10 years and the prematurity rate was reduced, there were slight increases in height and birth weight (Glenn et al 1982).
Guidelines for feeding young children (solids)

Feeding situation:

(i) Mother should adopt a relaxed, easy going approach to feeding and should never rush. Baby may not want to gobble down his food, he may prefer to linger over it and enjoy the different flavours. If baby joins in the family meal time, then avoid heated discussions and arguments, and the baby knows that meal time is a happy time for chatting and sharing food (Bampfylde & Dickerson 1985).

(ii) Introduction of solids should be one at a time, so that the child can be accustomed to each new sensation.

(iii) The child should be offered different foods with a variety of shape, colour, texture and taste, so that these foods stimulate his interest.

Foods should preferably be offered to the child separately rather than as a mixture. Children should be encouraged in feeding themselves from the first time they attempt to do so. A physical environment with suitable table, chair, dishes and eating utensils should be provided for a young eater.

Common problems:

There are problems but steps can be taken to nip these bad habits in the bud before a pattern is established.

Refusal to eat: Children often refuse food because of fatigue and this may result from a meal being delayed. Meals served at a particular time every day helps to develop a good appetite and saves children from fatigue. The meal time for a child should be adjusted to the time when he usually gets hungry. It is not recommended that parents push or force their children to eat, either by bribery or by threat of punishment. A healthy child will take his food when he is hungry. If he is forced to eat this may often result in feeding problems.

Food dislikes: Children imitate their parents and others in the family. Sometimes dislike of certain food items by the parents or others is transferred to their children. It is recommended that parents should not demonstrate their own food dislikes in front of their
children. If a child dislikes certain food items, then he can be offered other well liked foods containing similar nutrients. For example if the child does not like vegetables, nutrient needs can be met by fresh fruit or fruit juice. Milk can be substituted by cheese, yoghurt, or custard. Protein rich foods can be varied and include chicken, eggs, fish and fish fingers, and made up meat dishes such as rissoles and hamburgers. Of course, child preferences often change. So disliked food can again be tried at a later stage.

*Difficulty in swallowing:* Many children have swallowing difficulty and often they hold food in their cheeks for some time. Such children should be encouraged to take a small bite and to chew and swallow each mouthful before the next.

*Sweet foods:* Children like sweet food once they have tasted it. The child's enjoyment of sweet foods may reflect the value his parents and other adults place on such foods. Sweet foods are often offered as a reward and this speeds up the child's desire for such foods. Children should not be encouraged to eat sweet food containing high sugar, because this may affect their dental health. Moreover these sugar containing foods do not have any nutritional value other than energy which may lead to obesity.

*Practices to be avoided:* (Roots 1974)

(i) offering dummy with honey or sweetened syrup

(ii) when full strength cows milk is used, do not add sugar to milk feeds

(iii) babies should not be given frequent bottles of sugar containing fruit or vitamin C syrups, cordials, soft drinks, sweetened tea or other sweetened drinks.

(iv) babies should not be given a bottle of syrup or sweetened milk at nap or bed time

(v) avoid putting sugar on babies gum during teething

(vi) sugar containing foods should not be offered to child in between meals

(vii) prolonged bottle feeding should be avoided

Sugar content of certain foods is shown in Table 15.
Table 15  
Sugar content of foods.  

<table>
<thead>
<tr>
<th>Food</th>
<th>Size</th>
<th>Amount of sugar (tsp)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chocolate cake, 2-layer, icing</td>
<td>1 average piece</td>
<td>15</td>
</tr>
<tr>
<td>Apple pie</td>
<td>1 medium piece</td>
<td>12</td>
</tr>
<tr>
<td>Doughnut (plain)</td>
<td>1 average</td>
<td>4</td>
</tr>
<tr>
<td>Gelatin (Jello)</td>
<td>½ cup</td>
<td>4</td>
</tr>
<tr>
<td>Jelly</td>
<td>1 level tablespoon</td>
<td>2½</td>
</tr>
<tr>
<td>Chocolate fudge</td>
<td>1½ inch square</td>
<td>4</td>
</tr>
<tr>
<td>Chewing gum (including Dentyne)</td>
<td>1 stick</td>
<td>½</td>
</tr>
<tr>
<td>Hard candy</td>
<td>1 piece</td>
<td>⅓</td>
</tr>
<tr>
<td>Marshmallow</td>
<td>1 average</td>
<td>1½</td>
</tr>
<tr>
<td>Ice cream</td>
<td>1 cone or bar</td>
<td>5 or 6</td>
</tr>
<tr>
<td>Chocolate milk</td>
<td>1 cup (5 oz.)</td>
<td>6</td>
</tr>
<tr>
<td>Soft drinks</td>
<td>6 oz. bottle</td>
<td>4</td>
</tr>
<tr>
<td>Candy bar</td>
<td>5 oz.</td>
<td>20</td>
</tr>
</tbody>
</table>
Practices that should be encouraged: (Roots 1974)

(i) plain water for extra fluids should be given by bottle or cup

(ii) babies should be given finger foods like rusks, strips of toast and firm raw vegetables that he can chew on.

(iii) if needed nutritious snacks such as cheese, fruit, fruit juice, raw vegetables, milk, whole grain bread should be encouraged.

A sample menu selection of healthy foods for children in one day has been put forward by the Australian Nutrition Foundation (1987):

Breakfast:
* ½ - 1 cup whole grain cereal with no added sugar or salt
* low fat milk
* 1 slice of wholemeal toast (reduced salt varieties), butter or polyunsaturated margarine (reduced salt varieties) thinly spread
* topping e.g. cheese, baked beans, tomato, peanut butter, banana, sweet corn (with no added salt).

Mid morning snack:
* A piece of fruit or
* milk drink
* milk ice block or frozen yoghurt

Lunch:
* sandwich of 2-4 slices of bread or a roll preferably wholemeal or ½ white and ½ wholemeal
* filling with salad, cheese, lean meat, egg, bean sprouts, baked beans, mixed beans, sweet corn
* 1 piece of fruit
* milk or yoghurt

Afternoon snack:
* 1 or 2 scones, pikelet, plain wholemeal biscuit, breakfast biscuit or bread
* butter or polyunsaturated margarine, thinly spread
* milk drink

Evening:
* lean meat, chicken or fish
* potato, rice or pasta
* 1 or more vegetables cooked, or salad or
* vegetarian dish such as macaroni cheese with salad, or bean casserole with brown rice
* fresh fruit or canned fruit or fruit salad/milk, yoghurt, custard or ice cream.
Foods that can be fed happily: (Bampfylde & Dickerson 1985)

Wholegrain cereals (wholemeal bread, brown rice, whole wheat pasta, millet, porridge, unsweetened muesli, shredded wheat), sprouted grains.
Fresh fruit and vegetables, herbs, sprouted beans.
Beans, lentils, pulses, ground nuts, seeds.
Milk, yoghurt, low fat soft cheeses, eggs.
Meat, poultry, fish, offal, game.
Dried fruit - apricots, raisins, apple rings etc.
Fruit and vegetable juices, yoghurt shakes, egg nogs.
Peanut butter, sesame spread, tahini, apple and pear spread, carob powder.

Foods that should be eaten in moderation: (Bampfylde & Dickerson 1985)

Honey as a sweetener
Sausages with low fat and no chemical additives
Muesli bars and carob bars
Home made cakes and biscuits made with wholemeal flour and sweetened with honey or dried fruit
Mild spices
Home made ice cream made with fruit, eggs and milk
Polyunsaturated margarine

Foods to be avoided: (Bampfylde & Dickerson 1985)

White bread and white flour products (cakes, biscuits, pastry)
Sweetened and sugar coated breakfast cereals
Sweets, crisps, salted nuts
Soft drinks and fizzy pop
Chocolate and candy bars
Processed convenience foods that contain additives, salt and sugar
Canned meats, frankfurters and commercial pate
Jam which is high in sugar and chocolate spread
Most commercial ice creams which contain sugar and additives
Cream and imitation cream, butter, cream toppings and instant whip desserts

Busy mums who have little time for preparation and cooking can make food for their child with the following acceptable convenience foods: (Bampfylde & Dickerson 1985)

Canned sardines, salmon and tuna. Frozen fish fillets without coloured crumbs.
Pure 100% beef burgers
Frozen peas, beans and other frozen vegetables
Pure ice cream that contains no additives
Vegetable burgers and rissoles from health food stores
Canned fruit in unsweetened pure juice
Canned tomatoes
Potato crisps - unsalted and additive free from health food stores
Baked beans without sugar.
Preschools are run by qualified teachers and they expose the child to both socialising and learning experiences which are essential for them. *Children from 3-5 years* of age usually go to preschool, although this can vary from state to state. These schools are sessional, that is child can attend half day sessions for so many mornings or afternoons each week. Preschools usually end around 3 - 3.30 pm. This is good for children whose mothers are not working or working part time and can pick up their children after preschool time. It is not good for full time working mothers who need to have their children in care every day until late in the afternoon. For full time working mothers, some sort of childcare facilities may be helpful if they have children up to preschool age (Toms 1985).

When a child starts preschool their eating patterns change even if they are eating the same healthy meals at home (Bampfylde & Dickerson 1985). At preschool children become more active and mix with other children which makes their range of food habits much wider and broader.

School meals are often high in sugar, fat, salt and laden with additives but low in fibre. Canned and frozen vegetables are often served instead of fresh and it is sad to say that in some schools meals are overcooked. Stodgy steamed puddings and fatty tarts are still the norm while fresh fruit is very rare on most dessert menus (Bampfylde & Dickerson 1985). Children may like these foods when served in a bright, colourful attractive packet. But this confused or misled children to select nutritionally balanced diets. Preschool children need and enjoy snacks. So every effort should be made to encourage good selections.

Yoghurt, ice cream, milk shakes, pizza, mixed nuts, seeds and raisins are better selection than soda, candy and cake for the active child. For the overweight child fresh fruits, salad, raw vegetables and fruit juice are better choices (Calloway & Carpenter 1981).

School tuckshops, if available to the preschooler, often sell a wide range of non-nutritious items. Tuckshops are usually run by a profit making venture and it is assumed that to
make a profit they have to sell sweets and snacks. But evidence has shown that they can make profit even by selling nutritional food items. In 1982, for the first time in NSW a law was made against the sale of junk food at school tuckshops (Toms 1985).

Traditional school meals and self selected cash cafeteria meals both provide at least 33% of the recommended daily allowances for energy and has shown that school meals are reasonably better than other sources of lunch time food such as cafes and take away outlets (Barasi & Mottram 1987). Many schools now have student committees to help plan the school menus and in some areas the cafeteria menu is posted ahead of time to allow the child to select those meals he wishes to eat. Also many enlightened local authorities are now trying to improve the quality of school meals.

The early school years are especially important for moulding the child's future eating habits. Even if the children are eating highly refined foods at preschool and in his/her friends houses, it does not affect much if they are taking nutritionally balanced varied diet at home in two other main meals based on five food group. While entertaining others children, mothers should take the opportunity to educate and introduce them to a healthier way of eating.

Mothers should try to make their older child (e.g. five years) nutritionally conscious by explaining to them about food, a good example would be that nutritious food is needed so the child can have the energy to play games and do all the things they enjoy. Mother can give her child a healthy package of lunch to eat at school if possible.

Many schools have a salad option or permit children to take their own packed lunch and eat it in the refectory or dining hall, which can be healthier and enables mother to control her child's eating pattern (Bampfylde & Dickerson 1985).
Mothers can prepare nutritional and varied packed lunch for their child. White bread jam sandwiches and chocolate bars will not supply the nutrients the child needs, but wholemeal sandwiches, rolls or pitta bread pouches filled with salad stuff, cheese, chicken or tuna and followed by fresh fruit and a yoghurt, cubes of cheese or hot home made soup will be substantial and filling. Some finger foods like fresh vegetables (carrot, cucumber etc) or fruits (apple, apricots, banana) can be given in child's school bag to avoid unhealthy snacks at the mid morning break in school.

Timing of meals is important. A filling healthy breakfast before leaving for school is vital if he or she is to perform well and concentrate in class. The quality of breakfast cereal is very important to the child because they vary widely in their nutritional content as they may contain high proportion of sugar and should be checked before buying. Preschoolers (until 4 or 5 years) may eat high fibre cereals (bran cereals) but this should not be given to younger ones (Bampfylde & Dickerson 1985). Lunch should be eaten between midday and one o'clock, while tea or supper should not be taken too late. If food is to be properly digested and utilised then there should be adequate gap of time between supper and bed time. In that gap the child can play or do some activity which will burn up calories and tire him out before bedtime. At bedtime if he is still hungry he may be given a milky drink or a medium sized apple but no sweet biscuits, chocolate or sweets. However, bedtime snacks should not be encouraged and hearty breakfasts should be encouraged. Children should drink plenty of plain water during the day both in preschool and at home.

A suggestion for a typical days meals: (Bampfylde & Dickerson 1985)

| Breakfast - | protein - eggs, boiled, poached or scrambled  
|            | fruit - chopped fruit in muesli or fresh juice  
|            | cereal - muesli, shredded wheat or wholemeal toast |
| Lunch -    | protein, fish or chicken, grilled cold or in a casserole  
|            | vegetables - cooked green vegetables or salad  
|            | cereal - brown rice, pasta or wholemeal bread  
|            | fruit - fresh fruit salad or fruit or baked apple |
| Tea/supper - | protein - milk, cheese or yoghurt, beans on toast  
|            | cereal - wholemeal bread or wholewheat crackers or oatcakes  
|            | vegetables - baked jacket potato, vegetable dippers  
|            | fruit - fruit juice or fresh whole fruit |
5.5 FAMILY EATING PATTERNS

Children imitate parents and others in the family. The food they see parents or others eating will be the ones they want most. This sometimes creates problems for many parents especially those who are not having good dietary practice. Many adults eat more salt, sugar and fatty foods which are good for health. Too much salt added in cooking or use as a table salt may result in high blood pressure in later life.

Sugar in lollies, soft drinks and cordials, biscuits, sweet desserts or added to other foods can lead to obesity and dental caries. Too many fried and fatty foods can also put on weight.

Changing these bad food habits in later life can be difficult for some people, like giving up smoking. So if parents can keep children apart from these harmful food habits from the start, then they will be saving them the problems of trying to change to healthier eating habits in later life. So parents must have good food habits based on the 5 food groups and served as recommended. It is good to prepare a child's meal from the family food recipe and serve in amounts as needed by the child.

Older brothers and sisters have a great influence on the eating habits of the younger ones. A bonus of giving first baby a solid is that he or will set a good eating pattern for any others. Sweet biscuits and lollies given to the child by parents or grandparents as a reward or a bribe is not a good idea. It disturbs establishing their good dietary pattern.

Praising baby for finishing his food is a bad practice and this also disturbs their normal dietary pattern. With this situation he may tend to eat more than he needs.

Parents may think that without added salt or sugar food may taste bland. But this is not applicable in case of a new child. Parents should read the label for nutrition before buying any food especially if the growing child is eating the same food. Family meal time should
be a happy time for chatting and sharing of food. It is assumed that a simple healthy meal served in a relaxed environment is better than a more exotic meal served in the midst of chaos and argument. In fact the total environment for eating is important to children for establishing sound dietary patterns.

Once the child’s dietary pattern is established it will last for life and will pass from one generation to another.
6 DIETARY GUIDELINES

The Commonwealth Department of Health has developed certain dietary guidelines to promote good health for all Australians and to help prevent diet related diseases like obesity, heart disease, high blood pressure, diabetes, diverticular disease and dental caries.

Many of these diseases begin to develop at a young age and as such prevention should commence in childhood.

The dietary guidelines are:
(i) choose a nutritious diet from a variety of foods
(ii) eat more breads and cereals (preferably whole grain) and vegetables and fruits
(iii) avoid eating excessive fat
(iv) avoid eating too much sugar
(v) use less salt
(vi) control weight
(vii) limit alcohol intake
(viii) encourage breast feeding

When planning and preparing for meals and snacks for family and choosing foods for school canteen, guidelines i to v should be considered. Children should have explained to them the idea of using the guidelines in healthy food selection. Guideline vi will automatically be followed if regular exercise is undertaken in addition to the abovementioned foods. "Limit alcohol intake" is the guide for adults as children imitate them at an early age, which may be dangerous in later life. Guideline vii "breast feeding" should be encouraged for the first 4 to 6 months of life. Children will learn when they see infants being breast fed and they can learn the importance of breast feeding at an early age. Parents can set a good example for children by following these dietary guidelines when planning meals, shopping and cooking.
Children may be encouraged to eat healthy food by participating in planning meals at home and choosing foods for sale in the school canteen.

The five food groups:
The abovementioned guide divides commonly eaten foods into five groups according to their respective nutritional contributions. Children need to eat a variety of foods from the 5 food groups to provide food for optimal growth and development.

**Group 1 - Bread and cereals:** This group is the most economical source of nutrients in our daily diets. Different cereals are available - wheat, rice, corn, rye, oats and barley. Whole grain or enriched bread and cereals contain significant amounts of the B-complex vitamins (particularly thiamine or vitamin B1) and iron. This also provides starch. Bread and cereals also provide protein which may be a major source of this nutrient in vegetarians diet. Whole grain products also provide magnesium, folacin and fibre. Fortification of breakfast cereals especially with vitamin A and D are not recommended.

Four or more servings daily are recommended especially of whole grain products.
1 slice bread, use some brown, wholemeal or mixed grain (try reduced salt varieties), 2 savoury biscuits, wholemeal biscuits or crispbreads. ½ bread roll, muffin or crumpet. ½ pitta round. ¼ lebanese round. ½ cup cooked porridge or ready to eat breakfast cereal.
1 wheat flake breakfast biscuit (vita brits, weet bix, good start). ¼ cup muesli (unsweetened). ½ cup cooked rice (brown) or pasta (spaghetti, macaroni, noodles - try some wholemeal).

**Group 2 - Vegetables and fruit:** These foods are important as they provide vitamin A and C and fibre as well as trace amounts of other nutrients.

Colour of the vegetable or fruit is usually a guide to its food value. Dark green and deep yellow vegetables are good sources of vitamin A; for example, carrots are better than corn because of its deeper yellow colour, and spinach is better than celery due to its darker green colour.
Apricots, broccoli, cantaloupe, carrots, chard collards, cress, kale, mangoes, persimmons, pumpkins, spinach, sweet potatoes, turnip greens and winter squash are good sources of vitamin A.

Most dark green vegetables, if not too much cooked are also good sources of vitamin C as well as riboflavin, folacin, iron and magnesium. Collards, kale, mustard greens, turnips and dandelions contribute calcium.

Oranges and orange juice, cantaloupes, grapefruit, broccoli and strawberries are good sources of vitamin C. Cabbage salad, and potato baked or cooked in its skin should not be overlooked as sources of vitamin C. Fresh, frozen or canned and dried varieties can be used, the dried varieties contain very little vitamin C and juices do not contain fibre.

Four or more servings daily are recommended from this group by the food guide of which one should be a good source of vitamin C and a dark green and a deep yellow vegetable at least every other day. To ensure adequate fibre, unpeeled raw fruits and vegetables and edible seeds such as berries should be eaten when possible.

One serving of Vegetable: 1 small medium potato, ¼ cup mashed, ½ cup salad vegetables, 1/3 cup fresh, frozen or canned vegetables, ½ cup thick vegetable soup.
One serving of Fruit: 1 small medium piece fruit, 1/3 cup grapes, strawberries, cherries, fruit salad, stewed, canned or frozen fruit. ¼ - ½ cup fruit juice, fresh, canned or in cartons, ¼ cup dried fruit.

Group 3 - Milk, cheese and yoghurt: Milk and milk products like cheese, yoghurt etc provide protein and varying amounts of carbohydrate (lactose) and fat. These are the good sources of calcium and riboflavin (B₂) and many other essential nutrients in significant amounts than does any single food.

Milk is low in ascorbic acid and iron. Cheese contains most of the protein, calcium and riboflavin. Fresh, UHT, canned or dried varieties can be used.
When children over 2 years are on a mixed diet they should be given reduced fat and low fat milk, yoghurt and cheese. This is recommended by National Heart Foundation and many paediatricians. Cheese contains very little lactose and may be good for children with lactose intolerance. They often better tolerate yoghurt because the lactose has been partially broken down during processing.

*6 servings daily has been recommended from this group.*

One serving:

100 ml milk, full cream, reduced fat or low fat.

100 ml (½ small carton) yoghurt, full cream or low fat.

20 grams cheddar or hard cheese

60 grams cottage or ricotta cheese

Some of the milk can be served in the form of flavoured milk, milk shakes, milk ice blocks, frozen yoghurt and milk desserts (Australian Nutrition Foundation 1987).

*Group 4 - Meat, chicken, fish, legumes, eggs, nuts:*

Foods from this group contain protein, phosphorus, niacin, vitamin B₁₂, iron and zinc.

Foods of animal origin only provide vitamin B₁₂.

Dried beans and peas (lentils) are economical but their protein is not complete. When they are used with other vegetables, such as corn, or with milk or cheese or mixed with small amounts of meat, they may meet the complete amino acid requirement of the body.

It is recommended that choices among these foods should be varied and distributed in different meals of the day because each has distinct nutritional advantages. 1 or 2 servings daily have been recommended from this group.

One serving:

50-100 grams meat (raw weight after fat and bone removed)

1 or 2 slices roast meat or chicken

1/3 or ½ cup casserole of meat

1 small hamburger
1 lean chop
2 or 3 slices lamb’s fry or calf’s liver
½ small can sardines, salmon or tuna
1 egg
1 small fillet fish
2 or 3 fish fingers
1 portion chicken without skin
1/3 cup cooked or canned dried peas, dried beans, baked beans, chick peas or lentils
1 tablespoon peanut butter
¼ cup (approximately 30 grams) shelled nuts
¼ cup dry textured vegetable protein

Group 5 - Butter, margarine, oil:

This food group contains 80 per cent or more fat and as such should be used only in small amounts. Butter and table margarine contain vitamins A and D, the polyunsaturated margarines and vegetable oils provide vitamins E and K. Polyunsaturated margarines, safflower, sunflower, maize, grape seed and walnut oils are rich in polyunsaturated fat. 3 or 4 small servings daily are recommended.

One serving:

1 level teaspoon butter, margarine or oil
2 teaspoons unwhipped cream
1 tablespoon whipped cream
2 teaspoons salad dressing or mayonnaise
(Australian Nutrition Foundation 1987).

Almost all countries in the world have devised food grouping systems. All food grouping systems divide foods into categories based on nutrient content. The number of food groups may vary from country to country.
7 DISCUSSION

We need food for our survival and fitness. General dental health and specific resistance to caries are the result of good dietary habit. A good varied diet maintains life and health of the individual, which every mother wants for her child. This can be achieved if a nutritionally balanced dietary habit is developed from early infancy.

Breast milk is the best food for the baby at least for the first 4 to 6 months from a nutritional point of view and no-one can argue on that. Breast feeding should start immediately after birth to reach to his full genetic potential. Breast fed baby works hard on breast for his food and this in turn helps in developing normal jaws. The most important thing is that breast milk contain antibodies which protect baby from infection.

Breast feeding has proven immunological, nutritional and behavioural advantages over bottle feeding (Toms 1985). Cows milk, however modified or adapted in formula preparations, can never be as good as human milk. However, babies will thrive on formula milk, if it is prepared properly and hygienically (Llewellyn-Jones 1983). In the preantibiotic era breast feeding was essential for the health and survival of infants (Schreiner & Bradbrun 1988). Pediatricians and obstetricians encourage breast feeding because it is best both for the baby and his mother. From the dental health point of view, most pedodontists agree that breast feeding should be encouraged.

It is misfortune that todays children are the biggest consumers of processed convenience foods from infancy onwards, due to the progress in food technology. In addition, the development of substitutes for breast milk of mothers who for various reasons do not breast feed, has led to a declined breast feeding rate. The most serious effect is that it has also influenced the decline in breast feeding in the developing countries where from socioeconomic reasons the use of infant formula is not a practical and effective alternative to breast feeding. Eventually the rate of malnutrition in new borns is higher. In developing countries like Bangladesh, breast feeding should be encouraged to maintain health and well being of the child for many reasons.
By preparing meals for a child, parents can control exactly what a child needs and what he should eat. Parents can offer a more varied diet, including some healthy ingredients which are not available in baby foods and processed meals. However, many parents normally do not know what to feed and how to feed to their newborn onward. They get their information through friends who may be just as ignorant as themselves on infant feeding. This is especially true in a country where medical resources and public education are not adequate and updated. This should be considered as a public health problem.

Children depend on their mother right from the time spent in the womb. It is the mother who can give him an opportunity for a good start in life. So the mothers food habit is important as it affects the future health and development of the child.

Today children are having various diet related problems, from tooth decay and gum disease and a higher than average share of coughs and colds. Obesity, stomach upsets, diarrhoea and constipation, eczema, allergies and hyperactive behaviour are bigger problems than ever before and scientists are now mentioning poor diet as being one of the main culprits.

Abrupt change of traditional dietary patterns, has led to a drastic increase in caries among many populations which used to be considered immune from the disease. When sugar especially sucrose is retained in the oral environment surrounding the teeth the bacteria on the teeth convert the sugar into organic acids within seconds. The constant attack of the acids on the teeth loses minerals and eventually results in dental caries.

Our modern diet is too high in fats, sugars, refined carbohydrates, salt and additives and too low in fibre, whole grain cereals, fresh fruits and vegetables. It was found that there was anticaries activity present in unrefined cereals that may protect the tooth against enamel decalcification, whereas refined sugar products such as brown sugar, honey and syrup results in enamel decalcification. It is concluded that organic phosphates were the
main factors that prevented enamel dissolution when unrefined flours were incubated with saliva. It is very essential that young children should get all the right nutrients from the food they eat, because this is the time for rapid growth and development when the requirement for basic nutrients is very high indeed.

In developed countries like in Australia the dental health of children has improved a lot in the last 20 years or more. But the dental health of children is decreasing in developing countries. Restorative care for the control of the growing problem of dental caries is practically nonexistent as an option because of shortages of resources. Moreover it is found that diet (mainly the form and frequency of sugar consumption) is responsible for the development of dental caries and it is also found that this disease is preventable, so something has to be done with the diet as a preventive measure.
8 CONCLUSIONS

From various studies it can be concluded that the form and frequency of sugar consumption is responsible for the development of dental caries in a population. In young children dental caries progresses faster in the deciduous dentition and the disease is more prevalent in susceptible teeth.

Today's children are the strong pillar of a future nation and they should be protected from all sorts of health hazards. Programs to promote health in a community should be based on overall policy decisions. But it is sad that dental health is neglected in many countries, especially in many of the developing countries. In Bangladesh, it is speculated that less than 2-3 per cent of the national health budget has been spent in dental health in the past. There should be an interdisciplinary approach supported by funds for implementation and evaluation for all aspects of health.

From the dental health standpoint, breast feeding is highly recommended for children at least up to two and a half years of age. Pediatricians and obstetricians around the world encourage breast feeding.

The 34th Assembly of the World Health Organization in Geneva adopted the international code on marketing of breast milk substitutes. Some developing countries, including Sri Lanka and Papua New Guinea have already introduced laws to prohibit promotion of breast milk substitutes.

It is suggested that mothers who are working could also breast feed their child while they are at home and in between, the babies could be bottle fed.

Mothers should be educated at mother and child care centres and health centres by both health and dental nurses concerning the advantages and technique of successful breast feeding.
Preschool teachers could be educated to talk on specific health information for the child with the parents on parents day or on some other suitable day.

Film shows could be arranged to encourage mothers on breast feeding and on the practices required for a nutritionally balanced diet. Mothers should be told the types and patterns of food that are appropriate for the young child.

Mothers should be clearly informed to:

a) restrict sugar in the diet of young children
b) restrict snacks
c) use proper brushing technique for her child. Such brushing should start as soon as teeth erupt and until the child learns to brush properly by himself
d) take the child to a dentist for their first regular check up as soon as the teeth erupt
e) take her child to the dentist for fluoride supplements if they are living in a nonfluoridated area

Any nutritionally unsound claim on baby food on television advertising should be rectified promptly.

Dental surveys should be carried out at a community level to monitor trends in dental caries and to determine treatment needs, especially in countries where restorative dental treatment is expensive and inadequate,

Dental health education should be promoted by a concerned health department as a public health measure.

In a country like Bangladesh preventive dental health measures should be encouraged.

Manufacturers should display the constituents of their foods clearly.
Noncariogenic sweeteners should be used in highly cariogenic foods, such as chewing gum and sticky candies, such as chewing gum and sticky candies. Use of xylitol produces a dramatic reduction in the incidence of dental caries when compared to sucrose or fructose.

A nutritional survey carried out in Boston with a group of children from age 3 to 12 showed that caries could be reduced significantly by restricting sweets intake. If we all rejected sugared baby foods, sweets and high calorie sugared processed foods, we would have a new generation of slimmer, fitter children with stronger teeth.
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