NUTRITION, FSM & DIETEICS

II B.SC BIOTECHNOLOGY

NUTRITION FOR THE FAMILY – CNNU44

UNIT - II

Nutrition during Infancy - dietary guidelines for infants, advantages of breast feeding, disadvantages of bottle feeding; Weaning foods (definition) and types of supplementary food.

Kidneys reach their full functional capacity by the end of first year. During the first few months the glomerular filtration rate is somewhat lower and therefore the excretion of high concentration of solutes is more difficult.

The increase in the number of brain cells is most rapid during foetal life and in the first 5-6 months after birth.

NUTRITIONAL REQUIREMENTS

As growth during infancy is very rapid, dietary adaptation is required. During early infancy, much of the nutrient requirements are met by breast feeding and the RDA of an infant is based on composition of breast milk. Growth standards are established based on the growth of children who are fed breast milk. Table 4.1 gives the RDA for infant suggested by ICMR in 2010.

Table 4.1 ICMR Recommended Dietary Allowances for infants–2010

Nutrient	*Months*	
	0–6	*6–12*
Body weight kg	5.4	8.4
Energy kcal/kg	92	80
Protein g/kg	1.16	1.69
Visible fat g	—	19
Calcium mg	500	500
Iron mg	46 μg/kg	05
Vitamin A		
Retinol μg	—	350
β-carotene μg	—	2800
Thiamine mg	0.2	0.3
Riboflavin mg	0.3	0.4
Niacin equivalent μg/kg	710	650
Pyridoxine mg	0.1	0.4
Ascorbic acid mg	25	25
Dietary folate μg	25	25
Vitamin B_{12} μg	0.2	0.2
Magnesium mg	30	45
Zinc mg	—	—

Energy

Studies reveal that basal and total energy requirements for infants are higher than adults per unit body weight. Infants require 92 kcal/kg body weight whereas an adult requires only 40 kcal/kg body weight. For one month old infant, 50 per cent energy intake is used for basal energy, 25 per cent for activity and 25 per cent for growth. Extremely active children may require upto 40 per cent energy for activity. A child who crawls or walks will not gain weight unless additional calories are supplied for proper growth. Seventy per cent of calories can be met by milk alone and rest of the calories have to be supplied by supplementary foods after six months. When excess calorie intake is persistent it may lead to infantile obesity predisposing to adult obesity.

Protein

Protein intake of healthy infants is about 1.16 g/kg body weight. The recommendations for infants are based on the total protein content and amino acid pattern of the average daily intake of human milk. Like calories, infants' protein requirements per kg body weight are higher compared to adults due to increased demands for skeletal and muscle growth. Human milk provides all the amino acids more than the required amount needed for proper growth. Histidine, which is a non-essential amino acid for adults, is necessary for growth and maintenance of an infant. The requirement for essential amino acids are affected by the amounts of protein sparing nutrients and the ratio of essential and non-essential amino acids in the diet. Human milk protein is 100 per cent utilised. Protein content of human milk is 1.1 g/100 ml or 6 per cent total energy. Protein requirement per kg body weight decreases gradually during the first 12 months as do energy requirements.

If calories and protein requirements are not met, infants suffer from protein energy malnutrition. This is a range of clinical disorder resulting in severe cases to marasmus or kwashiorkor.

Excess protein is harmful as it needs to be deaminated. Since the infant has a limited capacity to concentrate waste metabolites, such as urea in the urine, the excretion of more wastes requires a larger volume of water. If the necessary water is not available, urea gets accumulated and ironically the infant will suffer from protein oedema. Higher rate of infection is common in infants fed on cow's milk because the mechanism related to formation of antibodies to protect against infections are diverted to take care of excess milk protein.

Fat and Essential Fatty Acids

Docosahexaenoic acid levels in red blood cells and neural tissues help in improving visual acuity and cognitive performance of infants. Infants maintained on diets adequate in all nutrients except fat, develop skin lesions and diarrhoea and growth impairment. With supplementation of EFA, symptoms disappear. Both cow's milk and mother's milk satisfy the requirements of EFA. EFA requirement of young children is 3% E which can be satisfied by 19 g/day visible fat. Fat also increases calorie density apart from improving palatability.

Calcium and Phosphorus

Rapid growth requires 500 mg of calcium and 750 mg of phosphorus with a ratio 1 : 1.5. Adequate prenatal nutrition supplies a store of bone minerals to prevent rickets provided post-natal care furnishes a liberal supply of calcium and phosphorus. Large percentage of calcium from breast milk is retained by the infant. Bones are poorly calcified at birth. Rapid rate of calcification of bone is needed to support the weight of body by the time the baby walks. When sufficient calcium is not supplied to the infant, his motor development is delayed. Ca : P ratio of 1.2 : 1 as in cow's milk is lower compared to 2 : 1 in human milk. High phosphorus can lead to hypocalcaemic neonatal tetany.

Iron

RDA of iron for an infant is 46 μg/kg body weight starting from three months. At birth, body contains 80 mg/kg. This is about three times that of an adult. During the first four months, the baby's blood volume doubles and concentration of iron in haemoglobin falls to about half that present at birth. That is why infant doubles his birth weight by six months without depending on dietary iron. There is no reserve store of iron after 6 months. Iron requirements increase markedly especially in relation to body size and energy intake during latter 6 months of life. Therefore iron-enriched solid foods should complement breast milk from 7–12 months of age. There is no reserve store of iron. Low birth weight infant requires dietary iron earlier in life. Premature infants are susceptible to anaemia as there is not enough storage of iron.

Zinc

High levels are present in colostrum and it promotes normal growth. Zinc is necessary for normal brain development. ICMR Expert Group has not suggested RDA of zinc for infants.

Sodium

Mature human milk, contains 7 mmol/L. Cow's milk contains 21 mmol/L. Infant needs 4–8 mmol/d. Intake of sodium by breast fed infant is less than 1/3rd that of one fed on cow's milk. The smaller amount present in human milk is considered adequate.

Iodine

Infants from 0–12 months require 6–30 μg/kg/d of iodine. Breast milk gives 90 μg/d.

Vitamin A

The RDA for retinol is 350 μg. The amount of vitamin A content of breast milk is sufficient, provided mothers' diet is rich in vitamin A. Daily intake of vitamin A by Indian infants through breast milk is about 140 μg during the first six months of life. Rest of the requirement is met by reserves. A healthy infant has sufficient store of vitamin A in liver at birth which may last for six months. After six months egg yolk is supplemented in the infants' diet.

Vitamin D

It is essential for utilization and retention of calcium and phosphorus. Neither human nor cow's milk provides enough vitamin D to prevent rickets. A good supply of vitamin D during pregnancy benefits the mother and helps satisfactory development of the infant. The requirement may be obtained in great measure in tropical countries through exposure to adequate sunlight.

Vitamin K

The newborns are susceptible to haemorrhage caused by lack of vitamin K. Breast-fed baby is more susceptible than artificially fed. Deficiency of vitamin K in children can occur if mothers have received anticoagulants. A single dose of 1 mg of water miscible form of vitamin K immediately after birth is considered adequate in premature newborn infants to prevent haemorrhage. Excess dosage is harmful.

Vitamin B Complex

Thiamine requirement of infants less than 6 months of age is generally computed from the quantity available through breast milk of healthy well nourished mothers. Assuming thiamine content 20 µg/100 ml and secretion of breast milk 700 ml, the RDA for infants 0–6 months is 0.3 mg/1000 kcal or 0.2 mg/day. The vitamin B_6 content of Indian mothers' milk is 60–80 µg/l. At this level, no deficiency of B_6 is found in children.

Vitamin C

The RDA prescribed by ICMR is 25 mg. Human milk contains twice the ascorbic acid in comparison to cow's milk though both are not good sources of vitamin C. Deficiency in mothers during pregnancy and lactation results in very little reserve of vitamin C in body. If less vitamin C is present in breast milk the infant may develop scurvy. Suddenly the body swells due to internal bleeding and the condition is fatal.

Fruit juice should be introduced in sufficient amounts in the diet from the 4th month onwards to prevent vitamin C deficiency.

Nutritional Assessment

Each individual serves as his or her own control in the measurement of progress. Weight, length, head circumference, skin fold thickness and haemoglobin level can be used to assess the nutritional status. Eruption of teeth is complete by the end of first year. Healthy child has normal elimination and is active and sleeps well.

Studies conducted at National Institute of Nutrition showed that growth rate of infants upto one year is influenced to a large extent by the birth weight.

FOOD REQUIREMENTS

The word Nutrition is derived from 'nutricus' which means to 'suckle at the breast'. Breast milk is the natural food for the infant. Successful breast feeding is an important child rearing skill to be learnt and practiced.

BREAST FEEDING

The infant should be put to breast within half an hour after normal delivery and within four hours after caesarian sections. Prelacteal foods like honey, distilled water or glucose should not be given. These foods will satisfy the thirst and will reduce the vigour to suck and may lead to diarrhoea and helminthic infestation. Breast feeding can be initiated even when the mother is sedated or on IV fluids. Sucking reflex is most active at birth.

Colostrum: During the first two or three days after delivery, thick and yellowish fluid is secreted from the mammary gland. This differs from the mature milk and is called colostrum. It is secreted in small quantity of about 10–40 ml. It is rich in protein. The total fat content of colostrum is less than mature milk. Concentration of arachidonic acid and docosahexaenoic acid (DHA) as per cent of total fatty acids is higher in colostrum than mature milk. It has more amount of vitamin A and K. The concentration of lactose is less. The levels of niacin, pantothenic acid, biotin and riboflavin are also low. Vitamin C is secreted at about the same level as in mature milk. Zinc content of colostrum is 20 mg/l whereas mature milk has 2.6 mg/l. The composition of colostrum is given in Table 4.2.

Table 4.2 Composition of colostrum

Nutrient	Amount
Energy kcal	58
Lactose g	5.3
Protein g	2.7
Fat g	2.9
Calcium mg	31
Phosphorus mg	14
Iron mg	0.09
Carotene I.U.	186
Vitamin A.I.U.	296

Studies show that in India 51 percent of the mothers do not give colostrum to the new born.

Source: Guthrie A.H., 1989, Introductory Nutrition, Times Mirror/Mosby College publishing, St. Louis.

Fig. 4.2 Colostrum should be given within half an hour of birth

Colostrum is the first immunisation to the infant. It contains an interferon like substance which possesses strong antiviral activity. Colostrum contains B_{12} binding protein which renders B_{12} unavailable for the growth of E. Coli and other bacteria. It also contains antibodies against viral diseases such as small pox, polio, measles and influenza. Enzymes like lysozyme, peroxidase and xanthine oxidase that promote cell maturation are found to be more in colostrum. Colostrum contains large quantities of protective substances and enhances the development and maturation of the baby's gastrointestinal tract. Colostrum helps a baby pass his or her first stool and help in the excretion of excess bilirurin and prevent jaundice.

Transition milk: During the next two weeks, the milk increases in quantity and changes in appearance and composition. This is called transition milk. The immunoglobulin and protein content decreases while the fat and sugar content increases. Exclusive breast feeding of colostrum and transition milk minimises infection related to neonatal deaths.

The composition of milk changes even during the length of a single feed to exactly suit the need of a particular baby.

Foremilk: The milk that comes at the start of a feed is called foremilk. Foremilk which is watery has a low level of fat and is high in lactose sugar, protein, vitamins, minerals and water. It satisfies the baby's thirst.

Hindmilk: Hindmilk which comes later in a feed, is richer in fat. It satisfies the baby's hunger and supplies more energy than foremilk. Babies who are fed fore and hind milk sleep well and grow healthy.

There is no tailor made schedule for breast feeding, as milk production, sucking habits and stomach capacity vary from infant to infant. A few days after the initiation of breast feeding, the length of each feed and the interval between two feeds will automatically get regularised. Exclusive breast feeding for the first six months gives a baby best start to life. No water or supplementary food is given during this period.

Advantages of Breast Feeding

Breast feeding is not only beneficial to the infant but also to the mother. The advantages of breast feeding can be considered under nutritional, immunological, psychological, economical and physiological and other factors.

Nutritional benefits

The composition of human milk is best suited to the infants and provides nutrients in easily digestible and bioavailable form. Table 4.3 shows the comparative data of human milk with cow's and buffalo's milk.

Table 4.3 Comparison of human milk with cow's and buffalo's milk (Values per 100 g)

Nutrient	Human milk	Cow's milk	Buffalo's milk
Water g	88	87.5	81
Energy kcal	65	67	117
Protein g	1.1	3.2	4.3
Carbohydrate g	7.4	4.4	5
Fat g	3.4	4.1	6.5
Calcium mg	28	120	210
Phosphorus mg	11	90	130
Iron mg	—	0.2	0.2
β-Carotene/Carotene μg	41	53	48
Thiamine mg	0.02	0.05	0.04
Riboflavin mg	0.02	0.19	0.1
Vitamin C mg	3	2	1
Caseinogen and Lactalbumin ratio	1:2	3:1	—

Source: Gopalan C., B.V. Ramasastri and S.C. Balasubramanian (Reprinted 2011), Nutritive Value of Indian Foods, National Institute of Nutrition, ICMR, Hyderabad, India.

Energy: Calorie value of human milk and cow's milk are similar as is the total fat content. Lower protein content of human milk is compensated by higher amount of lactose. Table 4.4 shows the percentage calories from protein, fat and carbohydrate in human and cow's milk.

Table 4.4 Calorie percentage from protein, fat and carbohydrate in human and cow's milk

Nutrient	Human milk	Cow's milk
Total energy (per 100 ml)	65	67
Protein	7	19
Fat	47	55
Carbohydrates	31	26

From Table 4.4 it is clear that human milk protein calorie per cent is less than cow's milk whereas carbohydrate calorie per cent is higher in human milk. Ideally for an infant 6 per cent of calories should come from protein. Fat content in human milk is comparatively less. It is advantageous, as it is absorbed easily.

In first 24 hours, glycogen is used for energy. Later on, glucose and fatty acid from the diet or from body fat stores are used up. Free fatty acids are released from triglycerides by lipase which is present in human milk. These are preferred source of energy for the infant's heart, throughout the sucking period. The switch over to fatty acid calls for a source of carnitine to transport fatty acid within the cell. Newborns do not have a fully developed ability to synthesise carnitine and they must obtain it from breast milk or from formulas where carnitine is added. Carnitine is absent in cow's milk.

Carbohydrate: Human milk is the sweetest milk due to the high amount of lactose. Lactose which is present in higher levels in human milk facilitates the absorption of magnesium and calcium and favours amino acid absorption and nitrogen retention. Galactose is present only in milk and is essential for the formation of myelin, which in turn is essential for the normal nerve function. Myelin is a protective sheath that surrounds the nerve fibre and protects their ability to transmit nerve messages. High content of galacto lipids promotes rapid brain growth of infant. Lactose promotes synthesis of cerebrosides in the brain. Lactose which is least soluble cannot be added to milk at home. Lactose is added in commercial formulas. Sucrose if added may cause gastrointestinal distress in infants. Human milk contains a salivary enzyme-like amylase which helps in digesting lactose at a stage in life when little or no pancreatic amylase is produced.

Protein: Human milk contains 1.1g per cent protein. The protein content in cow's milk is three times more than that in human milk. However, it is biochemically different and less digestible.

Human milk has 20 per cent β-casein and 80 per cent whey proteins which constitute lactalbumin and lactoferrin. Cow's milk has 80 per cent α-casein and 20 per cent whey proteins which constitute lactoglobulin. This lactoglobulin is one of the causes of intolerance to cow's milk. β-lactoglobulin which is an allergen is absent in human milk.

Lactalbumin has an amino acid pattern that mainly approaches that of body protein and provides more essential aminoacids than does casein. Among the aminoacids, glutamic acid is maximum and glycine is absent in human milk.

Casein forms a firm curd with rennin and lactalbumin forms a soft flocculent curd that is most rapidly digested and absorbed by the infant.

Human milk with its low protein and solute load is suitable for immature kidney, for the slower somatic growth in the baby and for rapid brain growth in the first year of life. Breast milk contains amino acids specific for brain development. It is rich in sulphur containing amino acids and cysteine to methionine ratio is high. This compensates for low cysteine methionine conversion which is essential for central nervous system development. Taurine is an important neurotransmitter and neuromodulator for brain and retina. Taurine is present in large amounts in human milk compared to cow's milk.

Human milk offers a high tryptophan to neutral amino acids ratio which controls brain serotonin synthesis. Human milk also contains binding proteins of thyroxine, corticosterol, vitamin D, folate and B_{12}.

Even though protein content is low in human milk, non-protein nitrogen content is high and net nitrogen content is comparable to cow's milk. The non-protein nitrogens in human milk are urea, amino acids, peptides, nucleic acids, N-acetyl glutamine and N-acetyl neuraminic acid.

Presence of protein splitting enzymes in breast milk reduces protein to the less complex peptone stage, on which digestive enzymes act more effectively. These enzymes in cow's milk are destroyed by the heat of pasteurisation.

Lipids: Lipids present in human milk are unsaturated fat, essential fatty acids, prostaglandin precursors, fat soluble vitamins, steroids, phospholipid and cholesterol.

Infants have only a limited ability to convert α-linolenic acid to eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) but these are present in human milk. Human milk has arachidonic acid content of about 0.5 per cent and DHA content of about 0.3 per cent of

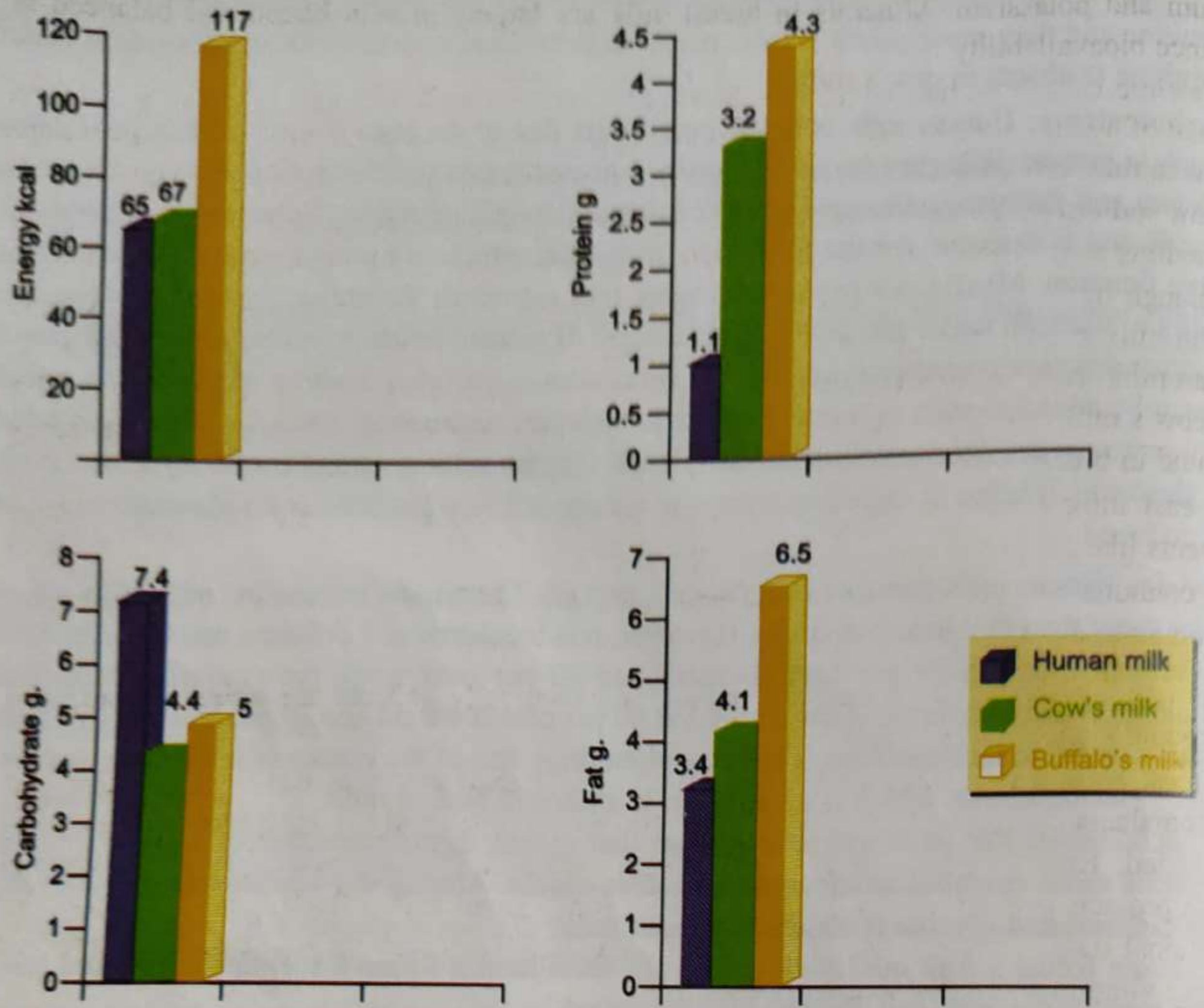

Fig. 4.3 Comparison of nutrients of human, cow's and buffalo's milk

total fatty acids. In cow's milk and infant formula, on the other hand, EPA and DHA are either absent or present at low levels.

Lipids involved in the development of brain are mostly long chain polyunsaturated fatty acids. These are abundant in breast milk. DHA is important for neural division. If mother's intake of fish is increased, the level of EPA and DHA in milk can be increased. Type of fat present in human milk depends on dietary fat of the mother.

Human milk also has high carnitine content which increases metabolism by mitochondrial oxidation and transport of essential fatty acid. Human milk contains cholesterol and is essential for the synthesis of myelin of the nervous system. Presence of choline, acetylcholine, phospholipid precursors and carnitine ensure optimum metabolism and brain development. Carnitine levels are low in pre-term babies.

Breast milk meets the essential fatty acid needs of infants which is about 6 en%. The polyunsaturated to saturated fat ratio is 1.2 : 1 in breast milk, compared to 1:2 in cow's milk.

The increase in the fat content of human milk from the beginning of feeding to the end is believed to increase its satiety value. This makes the breast fed infant to regulate caloric intake and weight gain.

Minerals: Unlike vitamins, mineral content of human milk is minimally influenced by the mother's stores and immediate intake of calcium, magnesium, phosphorus, iron, copper, zinc, sodium and potassium. Minerals in breast milk are largely protein bound and balanced to enhance bioavailability.

Calcium content in human milk is 28 mg and in cow's milk 120 mg. Though the calcium content of human milk is 1/4th of cow's milk, calcium phosphorus ratio of 2:1 in human milk is favourable. Infantile tetany rarely occurs in breast-fed infants.

Low sodium content of human milk is advantageous to the infant as kidneys have difficulty in handling excess sodium. Sodium content of milk is influenced by diet of the mother.

Though iron content is low in human milk a full-term infant needs only 0.3 mg/day and human milk meets this requirement. Iron is more available in the presence of lactoferrin in human milk. Human milk enhances zinc absorption. Human milk has high Cu:Zn ratio of 1:5 and cow's milk has 1:15 ratio. Copper content of human milk is more. No copper deficiency is found in breast-fed infants.

Breast milk ensures better oxygen saturation and increases the bioavailability of trace elements like copper, cobalt, selenium, iron and zinc.

It contains less poisonous residues than cow's milk which are neurotoxic like chromium, aluminum and manganese.

Vitamins: The vitamin content of human milk generally reflects the vitamin intake and nutritional status of the mother.

Breast milk contains more vitamin A, C and E than cow's milk. Xerophthalmia and keratomalacia can occur in the first year of life among artificially fed infants but rare among breast fed. Breast milk contains water soluble vitamin D along with fat soluble fraction which protects against rickets. Vitamin D content of human milk reflects maternal intakes and nutritional status of the mother. Human milk may be low in vitamin K and all infants should receive vitamin K supplement soon after birth.

Riboflavin, pyridoxine and B_{12} content of human milk are also related to the dietary intake of mother. Heat labile vitamins like thiamine and ascorbic acid are completely available in human milk. Cow's milk is heated before consumption and these heat labile vitamins may be lost.

Breast-fed infants receive about 25–30 µg of folate daily, most of which is available for absorption.

Hormones and growth factor benefits

Breast milk is a rich source of hormones like thyroid stimulating hormone (TSH), thyroxine, parathyroid hormone, corticosteroids, calcitonin, erythropoietin, oxytocin, growth hormone releasing factor, insulin and prolactin. It contains growth regulating factors, growth promoting factors and growth modulators. Epidermal growth factor enhances maturation of the infant gastrointestinal tract.

Immunological benefits

These factors are present in colostrum as well as in matured milk. Colostrum particles which have anti-infective properties of human milk are stable in acid medium of the stomach and resistant to the digestive enzymes. Human milk provides cellular components and humoral factors. With different factors bestow passive immunity, that is, they provide a form of immunity that does not require the activation of the infant's own immune defenses.

Macrophages: Human milk contains macrophages. They contribute immunity in two ways:

(*a*) They engulf and digest bacteria.

(*b*) These cells synthesize complement, a protein involved in establishing immunity to infectious organism.

The bacteria and viruses that are responsible for diseases such as poliomyelitis, influenza and diphtheria can be destroyed by this way.

Lymphocytes: Lymphocytes are the white blood cells responsible for mediating most aspects of the immune system, with its ability to attack a wide range of infectious microorganisms. Human milk contains T and B lymphocytes. T. lymphocytes are responsible for transfer of immunological memory. Transfer of maternal antibodies and T. lymphocytes may offer some protection against malaria.

Lymphocytes produce lymphokynes and other growth factors which stimulate proliferation and differentiation in lymphoid tissue and its capacity to react antigens. Lymphocytes also produce an antiviral substance called interferon.

These cells in breast milk may therefore play an important role in the infant's transition from passive to active immunity.

Immunoglobulins: Immunoglobulins are the defensive proteins that include all types of antibodies. Secretary IgA plays a major role in defending an infant against viruses, bacteria and other pathogens and harmful food components in the first few days of life. It acts within the gastrointestinal tract and is especially effective against pathogens to which the mother has been exposed such as polio virus, streptococcus and pneumococcus. Infants with a strong family history of allergic disease benefit from this protection particularly through extended breast feeding.

Human milk also contains IgG and IgM immunoglobulins but at a much lower level than that of IgA. It is interesting that the infant makes relatively low levels of its own IgA immunoglobulin and high levels of its own IgG and IgM immunoglobulin during the first year of life. This is an example of the functional development of the infant working in harmony with the composition of the milk it receives from its mother. Immunoglobulins are resistant to the acidity of the stomach.

Research indicates that breast feeding must be maintained until the infant is atleast 3 months of age in order to get this protection.

Lactoferrin and vitamin B_{12} binding protein: Lactoferrin is an iron containing protein found both in colostrum and mature milk. It inhibits the growth of *staphylococcus* organism and *E. Coli* by tying iron that is needed for growth. By removing free iron and thus preventing bacterial proliferation and free radical generation, lactoferrin has a protective effect. If excess of iron is provided in the diet the infant is susceptible for infection. Similarly vitamin B_{12} binding protein present in breast milk makes vitamin B_{12} unavailable to pathogens that require B_{12} to survive in the infant's gastrointestinal tract.

Lactobacillus Bifidus Factor: The bifidus factor as Gyorgy called it, is present in human milk in a concentration 40 times greater than in cow's milk. It is an amino sugar and contains N-acetyl neuraminic acid, a substance that has a very wide biological role. It is a nitrogen containing carbohydrate in human milk. It encourages the growth of microorganism, *lactobacillus bifidus* and produces acetic acid or lactic acid from lactose and depresses the growth of pathogenic or disease producing organisms like *Escherichia coli*. Growth of *lactobacillus bifidus* is enhanced on a high lactose and low protein diet. Lactose/protein ratio in human milk is 7:1 compared to cow's milk which is 4:1.

Table 4.5 Protective and other bioactive factors unique to human milk

Factor in milk	*Target or function*
IgG	*E coli., B. pertussis, H influenza type b, S pneumonia, N meningitidis* and more.
Secretory IgA	Protects intestinal epithelium. Targets enteric and respiratory pathogens, *e.g., Salmonella* spp, *G lamblia, S pneumonia, Influenza virus*
IgM and IgD	*V cholerae, E coli, S flexneri*
Cytokines	Activate T cells, enhance IgA production, induce proliferation of macrophages, decrease inflammatory cytokine synthesis
Anti-inflammatory components, such as histaminase, antiproteases, prostaglandins	Histaminase degrades hydrogen peroxide, antiproteases neutralize enzymes that act in inflammation, and prostaglandins are cytoprotective.
Bifidobacterium bifidum, growth factors oligosaccharides, glycopeptides, alpha-lactoglobulin, lactoferrin, sialyllactose	Enteric bacteria, lactoferrin competes with bacteria for nonprotein-bound iron.
Macrophages	Engulf bacteria
Interferon	Antiviral agent
Oligosaccharides	Inhibit bacteria adhesion to epithelium
B-12 and folate-binding proteins	Compete with bacteria for these vitamins
Anti-*Giardia* factor	Lipid with anti-*Giardia* action
Trophic factors	Accelerate gut development
Growth factors in colostrum and milk	Insulin, EGF, NGF, IGF-I, IGF-II* for continued rapid growth of infant, especially important for gut development.
Bile-salt-stimulated lipase	Improves fat digestion in the neonates
Docosahexaenoic and arachidonic acids	Constituents of cell membranes in brain and neural tissue
Lysozyme	An antibacterial enzyme, lyses cell walls.

*EGF – Epidermal Growth Factor; NGF – Nerve Growth Factor.

IGF – I and II. Insulin like growth Factor I and II.

Source: Cited from Levin - Folino Nancy 2008, Nutrition for the full term infant, Pediatric manual of clinical dietetics, American Dietetic Association.

Enzymes: Breast milk supplies enzymes like amylase, lipoprotein lipase, bile salt stimulated lipases, oxidases, lacto peroxidase and leucocyte myeloperioxidase. These enzymes increase digestibility and also act as defence against microbes. Lipases kill bacteria. Bile salt stimulated lipase kills amoeba and giardia. Lysozyme digests the cell wall of bacteria after the bacteria have been inactivated by the peroxide and vitamin C. Lactoperoxidase attacks the streptococcus organism.

Enzymes like lysozyme, peroxidase and xanthine oxidase promote cell maturation.

Fatty acids and Monoglycerides: These are present in human milk and are able to penetrate the membranes of viruses and bacteria and destroy them. They contribute for passive immunity and provide protection without the use of medicines or vaccines.

Para Amino Benzoic acid: Para amino benzoic acid is absolutely essential for erythrocytic stages of malarial parasite. Lack of PABA in human milk inhibits malaria.

Human milk may be useful in the treatment of protracted diarrhoea presumably through local effects in the gut. More generally, the ability of the mother to secrete antibodies directed against specific antigens in her environment, imparts to human milk an environmental specificity with significant protective potential.

Psychological benefits

An infant derives a sense of security and belonging in the mother and child relationship from the comfort of being held than from feeding process. Mother also feels that she is involved in a unique process for which there is no substitute.

Economic benefits

It is economical to breast-feed an infant, even though mother's requirements are increased. Commercial preparations are expensive. In artificial feeding money has to be spent not only for milk or milk powder but also for sterilising the equipment. Also there is no wastage of human milk. By breast feeding the child, one can save money spent on gastrointestinal and respiratory diseases for children. Breast feeding is capable of saving 13 per cent of all under 5 child deaths. Breast feeding is associated with reduced need for hospitalisation and improved child survival.

Infant and child morbidity

Infants fed human milk substitutes have five fold more gastrointestinal illnesses, three fold more respiratory illnesses and double the episodes of otitis media—inflammation of the middle ear cavity. Studies confirm that the relationship between breast feeding and reduced risk for childhood asthma, childhood leukemia, childhood obesity and malalignment of teeth and Sudden Infant Death Syndrome (SIDS).

Mental development

Breast milk contains specific substances involved in brain development. It is rich in sulphur containing amino acids. Cysteine methionine ratio is high and this compensates for low cysteine methionine conversion which is essential for CNS development. It is rich in taurine which is an important neurotransmitter and neuromodulator for brain and retina. It offers high tryptophan to neutral amino acid ratio which controls brain serotonin synthesis. The arachidonic acid and DHA present in breast milk are essential for neural division. The linoleic acid and α linolenic acids are required for myelination. Arachidonic acid acts as precursor for prostaglandins. Presence of choline, acetyl choline, phospholipid precursors and carnitine ensure optimum metabolism and brain development.

Exclusive breast fed preterms have shown higher IQ scores and better cognitive abilities.

Other advantages to the infant

- Infant's jaw is more fully developed and teeth are less crowded as he works harder to extract mother's milk.

- Microbiologically it is sterile and less danger of contamination and gastrointestinal problems. Mortality rate is lower in children who are breastfed.
- Reduced risk for otitis, severe lower respiratory tract infections and asthma.
- Low danger of incorrect formula and overfeeding.
- Reduced chances of allergic reactions, as human milk protein do not cause allergies.
- Lower rate of sudden infant death or cot death, as infant is not sensitive to human milk and less possibility of aspiration following regurgitation or higher vitamin E content in human milk that protects the membrane in the lungs.
- Less renal solute load as there is less urea and sodium to excrete.
- Less colic as fats and protein in human milk are more easily digested and less likely to create gastric and intestinal distress.
- Human milk is always fresh and at the right temperature. It has optimum fluidity.
- Breast feeding can be continued during illness of the infant like diarrhoea and also can be given after vaccinating the infant.
- There is evidence to suggest that breast fed babies are less likely to develop obesity, hypertension, diabetes mellitus and atherosclerosis in later life. Perhaps adiponectin, the protein present in human milk may have some influence. Late onset tetany, metabolic acidosis and acrodermatitis enteropathica are limited to top fed babies.
- There is evidence to suggest that breast fed babies have better cognition and IQ score later in life.
- It is one food that makes a complete meal. Food is always ready; no need of any preparation and there are no leftovers.
- Breast milk is a renewable resource. It cannot be adulterated. It cannot be diluted nor concentrated. It is organic.

Advantages to the mother

- Breast feeding creates strong bonding with infant.
- Breast feeding is an important birth control method. Prolactin which stimulates milk production, decreases the synthesis of ovarian hormones. It is the most cost effective method of family planning.
- It reduces postpartum bleeding and delays the menstrual cycle. When the mother feeds the infant, the uterus comes back to normal size and arrests bleeding due to the secretion of oxytocin.
- Breast feeding enables the mother to shed extra weight accumulated during pregnancy under the effect of various hormones.
- It is convenient to administer for the mother at any place and time. It saves time, money and energy.
- Risk of breast and ovarian cancer is higher in women who have not breastfed their children. It decreases the risk of type 2 diabetes. By breast feeding, the requirement of insulin decreases for a diabetic mother.
- Breast feeding provides in a mother a sense of calm and satisfaction which favours the production of required hormones.

There is emerging evidence that low birth weight or growth retarded neonates are prone to manifest diabetes mellitus, hypertension and coronary artery disease in later life. Therefore low birth weight is a key risk factor for adverse outcome in life.

Feeding Problems of Infants

Tooth decay: A pattern of tooth decay that involves the upper anterior and sometimes lower posterior teeth is common among infants and children who are given sugar-sweetened beverages or fruit juice in a bottle at bed time. Infants should be fed, burped and put to bed without milk or juice bottle.

Underfeeding: Underfeeding is suggested by restlessness and crying and by failure to gain weight adequately, despite complete emptying of the breast or bottle. Underfeeding may also result from the infant's failure to take a sufficient quantity of food even when offered. Constipation, failure to sleep, irritability and excess crying can result due to underfeeding.

Diarrhoea: Diarrhoea in a breast fed infant is unusual. Mild diarrhoeal disturbances due to over feeding respond quickly to temporary decrease or cessation of feeding. Withholding all solid food as well as one or several milk feedings and substituting boiled water or a balanced electrolyte solution are usually all that is required.

Constipation: Constipation in the artificially fed infant may be caused by insufficient amount of food or fluid. In other cases, it may result from diets too high in fat or protein or deficient in bulk. Simply increasing the amount of fluid or sugar in the formula may be corrective in the first few months of life. After this age, better results are obtained by adding or increasing the amounts of cereal, vegetables and fruits.

Colic: The term colic describes a frequent symptom complex of paroxysmal abdominal pain, presumably of intestinal origin and of severe crying. It occurs usually in infants younger than 3 months. Prevention of attacks should be sought by improving feeding techniques, including burping, providing a stable emotional environment, identifying possibly allergenic foods in the infant's or nursing mother's diet and avoiding underfeeding or overfeeding.

WEANING

The term 'weaning' comes from the word 'wemian' which means to accustom. Weaning begins from the moment supplementary food is started and continues till the child is taken off the breast completely. Solid food added to an infant's diet is called beikost. There is an increase in activities of enzymes at the time of weaning.

The ideal time to start introducing semisolid food is when a baby is ready to sit up, swallow and eat and taste other foods, the baby's stomach is ready to digest food and the baby has good appetite and accepts food readily and there is more activity in the child.

Need for weaning

Infants in our country thrive on breast milk alone up to six months of life and their growth rate during this period is satisfactory. After six months, increasing needs of calories and protein of growing children cannot be met by diminishing output of mother's milk. Milk is also a poor source of vitamin C and supplementation with fruit juice is essential. Iron stores in liver of the infant would last only upto 4–6 months. Hence iron-rich foods should be given at least from six months onwards. Milk is deficient in vitamin D.

If the baby is to maintain the expected rate of growth, remain healthy and well nourished, supplementary feeding has to be resorted around 6th month.

Investigations conducted at National Institute of Nutrition, Hyderabad, suggest that early introduction of supplements before six months of age is not associated with any beneficial effect on infant's growth. The supply of breast milk decreases because the baby suckles less frequently, less vigorously and less effectively at the breast. The baby runs the risk of recurrent infection which is likely to result in malnutrition, diarrhoea and respiratory infection. Shorter duration of lactation and shorter duration of lactational amenorrhoea can reduce inter-pregnancy interval.

Introduction of weaning food too late can lead to undernutrition and increased diarrhoeal morbidity. The child may be unwilling to accept new food.

Though Indian babies are given supplementary foods, either they are introduced very late or given adult form of diet. The age of introduction of supplementation is 3–5 months in the urban elite and middle income group. The supplementation is delayed in urban poor by 7–9 months and rural poor by 9–11 months.

Bulky adult diet, when given to infants, usually does not meet the nutritional requirement, particularly calories. Nutrient density of weaning foods of western diet is 1.0 kcal/g of food whereas in Asia, the nutrient density is 0.25 kcal to 0.4 kcal/g. Hence calorie dense foods like malted food should be given to infants. Weaning food should provide at least 10 per cent of the energy as protein.

According to NNMB (2000–2001) survey about 43 per cent of mothers started complementary feeding such as milk or biscuits in addition to the breast milk during 4–6 months of age.

Types of Supplementary Foods

Liquid supplements

Milk: At about the sixth month of life the frequency of breast feeding is reduced to 3 or 4 times per day and animal milk is substituted. Since the proportion of nutrients in animal milk differs from that of human milk, the cow's milk is diluted with boiled and cooled water in the proportion of 2:1 for the first feeds. The amount of water is gradually reduced so that in the course of a few weeks the baby receives undiluted animal milk. Two feeds, with 225 ml of milk per feed is an ideal replacement. Sugar can be added for taste and to increase calories.

Juice of fresh fruits: Oranges, tomatoes, sweet lime, grapes serve to supplement the protective nutrients not present in sufficient amounts in breast milk as well as in animal milk. It is advantageous to start feeding small quantities of fresh fruit juice even in the 3rd or 4th month of life.

In the early stages, the fruit juice is diluted with an equal amount of boiled water and only a couple of teaspoonfuls are fed. The amount of fruit juice fed is gradually increased and at the same time the dilution with water is cut down. In a week's time the baby receives 85 ml orange juice or about 170 ml fresh tomato juice. Since tomato juice does not contain the same proportion of nutrients as orange juice, double the quantity is required.

Soup from green leafy vegetables: In case fresh fruits are not available, green leafy vegetables may be used as an alternative. Strained soup can be given in the beginning with unstrained soup later on.

Fish liver oil: Fish liver oils are good source of vitamin A and D. Infants should be given a few drops to 1/2 tsp per day mixed in small quantity of milk.

Solid supplements mashed well before feeding

Mashed food is started around the 7th or 8th month of life. Around this time, the infant is already receiving animal milk, fruit juice or vegetable soup and fish liver oil.

Cereal and starchy gruels: To meet the increasing demands of calories and protein, well cooked mashed cereals like rice, rice flour, rice flakes, and ragi flour mixed with milk and sugar can be given. Addition of a small amount of vegetable oil to the porridge makes it less glutinous increasing the energy density.

Calorie dense cereals can be prepared using malted wheat or ragi. To prepare amylase rich food, the cereal is soaked overnight. Water is removed and the cereal is tied in a moist cloth and kept in a warm place. After 48 hours or so sprouts come out. It should be dried in the sun or can be roasted. The malted cereal is powdered after removing the sprouts. During the process of malting, starch is converted to maltose due to increased production of enzyme amylase. This is also called Amylase Rich Food. Due to the conversion of starch into amylose, thinner gruels are made. With this either the infant can consume more gruel or more flour can be added to make thick gruel. This way calorie consumption can be increased. Fig. 4.6 gives steps involved in making amylase rich food.

Fig. 4.6 Preparation of amylase rich food

Vegetables: Cooked, mashed vegetables like potato, green leafy vegetables and carrots can be introduced to get vitamins and minerals and different flavours in the diet.

Fruits: All fruits, with the exception of banana which is mashed, must be stewed and sieved for one year old baby. Thereafter, it is given simply stewed, with the addition of a little sugar and lime juice for favour.

Non-vegetarian foods: A small amount of hard boiled yolk of egg is given to start with and if the infant tolerates, the amount may be gradually increased to a complete yolk of an egg. Yolk is a good source of vitamin A, iron and protein. Soft custard is also a suitable way in which to introduce egg yolk. Egg white, because of the frequency of allergic manifestations, is not given until the infant is 8 to 10 months old and then it is given very cautiously. The whole egg may be poached or soft boiled and fed by the time the baby reaches the age of one year.

Finally, minced and cooked meat or boiled fish may be fed after suitably flavouring with salt, 3 to 4 times a week.

Pulses: Well cooked pulses along with cereals in the form of kichidi/pongal can be given or can be made into porridge. Pulse and meat preparations can be given in alternate days.

Solid supplements unmashed

When the baby starts cutting his teeth, it is time to start chopped and lumpy foods. Cooked cereals, pulses and vegetables can be given to the child. Solids like idli, idiappam, bread, chapathi, rice and dal can be given after the child gets used to semi-solids.

Vegetables may be chopped into small pieces, and boiled. Cooked potato can be given. After a year, leafy vegetables can be given well boiled and soft. A slice of raw carrot or fruit segments with all skin and seeds removed is a good exercise for the gums. As the child grows, it is better to give fruit segments instead of juice. Fruit provides bulk in the diet and is good for bowel movement.

Processed Foods: Home made or commercial processed foods can be given as weaning foods. Home made processed weaning foods can be prepared by using cereals, pulses, nuts and jaggery with or without milk products. Processed foods like bread, pasta, rusks and biscuits can also be given. Commercially available weaning foods are predigested but are expensive. Commercially available weaning foods like vegetable soups and fruit desserts, puddings and vegetable juices and fruit juices can be given as part of weaning food. Weaning foods can be ready to eat or ready to reconstitute foods. Processed foods are standardised, convenient and suitable to the infant.

A spray dried milk based infant formula containing 0.5 per cent lactulose or carrot juice is available in the market. It stimulates bifidobacterial growth in human infants comparable with that observed in breast fed babies.

Addition of foods to the infants results in slight changes in the gut flora. By 2 years of age the intestine is thought to be colonised, known as the Microbiodata Finger print. Genetics and environment contribute for the type of flora present.

Points to be considered in introducing weaning foods

- Introduce only one food at a time.
- Allow the infant to become familiar with the food before trying to give another.
- Give very small amounts of any new food at the beginning, for example, one teaspoon full or less.
- At first strained fruits, vegetables and cereals are given.
- Fruit juice should be fed only by cup not by bottle.
- When the baby is able to chew, gradually substitute finely chopped fruits and vegetables usually at 8 to 9 months.
- Variety in choice of foods is important.
- Infants may object to taking some foods by themselves but will take them willingly if one is mixed with another, e.g., egg may be mixed with formula, cereal or vegetable. Vegetables may sometimes be made into soup with little milk until the baby becomes accustomed to the new flavour.
- If, after several trials, the baby has an acute dislike for a particular food, omit that item for a week or two and then try again. If the dislike persists it is better to forget about the food for a while and substitute another.
- The mother or anyone feeding the infant must be careful to avoid showing in any way a dislike for a food which is being given.