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ALLAMA IQBAL OPEN UNIVERSITY, ISLAMABAD

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Assignment No. 1 (Units 1–4)

SOLVED ASSIGNMENT GUIDE

(For Study & Reference)

Note: This guide is prepared for study and reference purposes. Students are advised to read the relevant units of the course book and write the assignment in their own words.

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Question 1: Daily Nutrient Requirements, BMR, Physical Activity and Total Energy Expenditure (20 Marks)

Explain the concept of daily nutrient requirements. Describe how BMR and physical activity level contribute to total energy expenditure.

Introduction

Every human body is like a machine that works continuously, day and night, whether we are awake or asleep, working or resting. To keep this machine running, to repair its worn-out parts and, in the case of children, to build new tissues, the body needs a regular daily supply of energy and nutrients from food. The amounts of energy and nutrients that a person must obtain every day in order to remain healthy, active and free from deficiency diseases are known as the daily nutrient requirements. These requirements are not the same for every person: they change with age, sex, body size, physiological state such as pregnancy and lactation, the

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climate, and above all the amount of physical work a person performs. Understanding daily nutrient requirements is the foundation of diet planning, because a diet that supplies less than the requirement leads gradually to malnutrition, while a diet that supplies far more than the requirement leads to overweight and obesity. In this answer, the concept of daily nutrient requirements is explained first, and then the two main determinants of energy need — Basal Metabolic Rate (BMR) and Physical Activity Level (PAL) — are described in detail to show how together they make up the total energy expenditure of the body.

The Concept of Daily Nutrient Requirements

The daily nutrient requirement of a person is the amount of each nutrient that must be supplied through food every day to meet the body's physiological needs, to replace daily losses, and to maintain the body in a state of good health. The body requires more than forty different nutrients, which are grouped into macronutrients — carbohydrates, proteins, fats and water, needed in large amounts — and micronutrients — vitamins and minerals, needed in very small amounts but equally essential. Energy itself is not a nutrient, but it is obtained from the oxidation of carbohydrates, proteins and fats in the body, and it is expressed in kilocalories (kcal).

Because it is impossible to measure the exact requirement of every individual, nutrition scientists express requirements in the form of Recommended Dietary Allowances (RDA) or Recommended Nutrient Intakes (RNI). These are the daily levels of intake of essential nutrients considered adequate to meet the known nutritional needs of practically all healthy persons in a particular age and sex group. The RDA is deliberately set a little above the average requirement,

usually at the average plus two standard deviations, so that it covers about 97–98 percent of healthy individuals. For energy, however, the recommendation is kept close to the average requirement, because excess energy is stored as fat and is harmful rather than safe.

Daily requirements are usually expressed for a 'reference' man and woman of standard body weight doing moderate activity, and are then adjusted for other groups. For example, requirements increase sharply during growth in childhood and adolescence, during pregnancy when the mother must nourish the foetus, and during lactation when she must produce milk. Requirements are also raised in fever, infection, injury and recovery from illness, when the body needs extra energy and protein for repair.

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Factors Affecting Daily Nutrient Requirements

Several factors determine how much food a person needs daily. Age is the first: a growing child needs more nutrients per kilogram of body weight than an adult, while in old age the total energy requirement falls because of reduced activity and loss of lean body mass. Sex matters because men generally have more muscle mass and therefore a higher metabolic rate than women of the same weight. Body size and composition matter because a large, muscular person burns more energy than a small person with more body fat. Climate has a smaller effect: very cold or very hot environments slightly raise energy expenditure. Physiological states such as pregnancy and lactation add fixed amounts to the requirement — roughly an extra 300 kcal per day in pregnancy and about 500 kcal per day during lactation in standard recommendations. Finally, and most importantly for energy, the level of physical activity can

nearly double a person's requirement, from that of a sedentary office worker to that of a heavy manual labourer or athlete.

Basal Metabolic Rate (BMR)

Basal Metabolic Rate is the rate at which the body uses energy when it is in a state of complete physical and mental rest. It is the minimum amount of energy required to keep the body alive — to keep the heart beating, the lungs breathing, the blood circulating, the kidneys working, the brain functioning and the body temperature maintained at about 37°C. BMR is measured under strict conditions: the person should be awake but lying quietly, at a comfortable room temperature, at least twelve hours after the last meal (post-absorptive state), and free from any physical or emotional excitement. Under ordinary practical conditions the closely related Resting Metabolic Rate (RMR) is measured instead, which is only slightly higher.

BMR is surprisingly large. In a typical adult it accounts for about 60 to 75 percent of the total daily energy expenditure — far more than physical activity in most people's lives. A common rough estimate is about 1 kcal per kilogram of body weight per hour for men and about 0.9 kcal per kilogram per hour for women, which gives roughly 1,600–1,800 kcal per day for an average man and 1,300–1,450 kcal per day for an average woman. More accurate values are calculated from prediction equations such as the Harris–Benedict or Schofield equations, which use body weight, height, age and sex. In the FAO/WHO system used in this course, BMR is first estimated from body weight and then multiplied by the physical activity level to obtain the total requirement.

Factors Affecting BMR

BMR differs from person to person because of several factors. Body size and composition are the most important: the more lean body mass (muscle and organs) a person has, the higher the BMR, because fat tissue is metabolically much less active than muscle. This is why men, who carry more muscle, have a BMR about 5–10 percent higher than women of the same weight. Age reduces BMR by roughly 2 percent per decade after early adulthood, mainly because of loss of muscle. Body surface area is closely linked to BMR, since heat is lost from the surface of the body and must be replaced.

Hormones strongly influence BMR. Thyroxine, secreted by the thyroid gland, is the main regulator: in hyperthyroidism BMR may rise by 50 percent or more, while in hypothyroidism it may fall by 30–40 percent, which is one reason thyroid patients gain or lose weight. Fever raises BMR by about 13 percent for every 1°C rise in body temperature, and infection, trauma and burns raise it further. Growth, pregnancy and lactation also raise metabolic activity. On the other hand, prolonged undernutrition and starvation lower BMR as the body tries to conserve energy — an important survival adaptation, but one that makes weight regain easy after dieting.

Physical Activity Level (PAL)

Physical Activity Level is a simple way of expressing the total energy cost of a person's daily activities as a multiple of BMR. All activities — sitting, standing, walking, household work, occupational work, sports and exercise — cost energy above the basal level, because working muscles need fuel. In addition to BMR and activity, a small part of energy (about 10 percent of

intake) is spent in the thermic effect of food, that is, the energy used in digesting, absorbing and storing food; in the PAL method this is included within the activity factor.

PAL values are grouped into lifestyle categories. A sedentary or light-activity lifestyle, typical of office workers who sit most of the day and do little exercise, has a PAL of about 1.40–1.69. An active or moderately active lifestyle, involving regular walking, standing work or moderate manual labour, has a PAL of about 1.70–1.99. A vigorously active lifestyle, typical of agricultural labourers, construction workers and competitive athletes, has a PAL of about 2.00–2.40. The table below summarises the components of total energy expenditure.

Components of Total Energy Expenditure and PAL Categories

Component / Category	Description	Approximate Share or Value
Basal Metabolic Rate (BMR)	Energy for vital functions at complete rest	60–75% of total expenditure
Physical activity	Energy for occupation, household work, walking, exercise	15–30% of total expenditure
Thermic effect of food	Energy used in digestion, absorption and storage of food	About 10% of energy intake
Sedentary / light lifestyle	Desk work, little or no exercise	PAL 1.40–1.69
Moderately active lifestyle	Standing work, regular walking, moderate labour	PAL 1.70–1.99
Vigorously active lifestyle	Heavy manual labour, farming, competitive sport	PAL 2.00–2.40

Total Energy Expenditure: Putting BMR and PAL Together

Total Energy Expenditure (TEE) is the total amount of energy a person uses in twenty-four hours, and the daily energy requirement is simply equal to this expenditure if body weight is to remain stable. The practical formula is: TEE = BMR × PAL. A worked example makes this clear. Consider a man weighing 65 kg whose estimated BMR is about 1,550 kcal per day. If he is a

sedentary office worker with a PAL of 1.55, his total requirement is 1,550 × 1.55 ≈ 2,400 kcal per day. If the same man becomes a construction labourer with a PAL of 2.10, his requirement rises to 1,550 × 2.10 ≈ 3,255 kcal per day — about 850 kcal more, purely because of activity. Similarly, a woman of 55 kg with a BMR of about 1,300 kcal needs about 2,015 kcal at PAL 1.55, but about 2,730 kcal at PAL 2.10.

This relationship explains many practical observations. Weight remains constant when energy intake equals expenditure; when intake regularly exceeds expenditure, the surplus is stored as fat and weight increases; when intake is less than expenditure, the body draws on its fat and protein stores and weight falls. It also explains why two people of the same weight may need very different diets, and why diet plans, hospital feeding regimens and national food policies are all calculated from BMR and activity data. In clinical and community practice, estimating BMR and PAL is therefore the first step in assessing whether a person's diet is adequate.

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Conclusion

To conclude, daily nutrient requirements are the amounts of energy and nutrients a person needs each day to maintain health, activity and normal body weight, and they are expressed practically through recommended allowances for different ages, sexes and physiological states. Of all the components of energy need, Basal Metabolic Rate is the largest and most constant, providing the energy for the vital functions of life and depending on body size, composition, age, sex and hormonal status. Physical Activity Level, expressed as a multiple of BMR, converts this resting need into the real-life total: Total Energy Expenditure = BMR × PAL. Understanding this simple but powerful relationship allows students, dietitians and health workers to calculate

energy needs accurately, plan balanced diets, and understand the causes of both undernutrition and obesity.

Question 2: Role of Macronutrients in Human Nutrition and Protein-Energy Malnutrition (20 Marks)

Discuss the role of macronutrients in human nutrition. Explain protein-energy malnutrition and its effects on health.

Introduction

The nutrients required by the body in large quantities every day are called macronutrients. They are carbohydrates, proteins, fats and water. Together they supply all the energy the body needs and all the raw materials for building, maintaining and repairing its tissues. Although vitamins and minerals are essential too, they are needed only in milligram or microgram amounts; the macronutrients, by contrast, are consumed in tens or hundreds of grams daily, and any serious shortage or excess of them quickly disturbs health. Carbohydrates and fats are the main fuels of the body, proteins are its building material, and water is the medium in which all life processes take place. In this answer the role of each macronutrient is discussed, and then protein-energy malnutrition — the condition that results when energy and protein are lacking together — is explained along with its serious effects on health, particularly in young children.

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Carbohydrates: The Main Source of Energy

Carbohydrates are the cheapest, most abundant and most readily available source of energy in the human diet. Each gram of carbohydrate yields about 4 kcal of energy. In a typical Pakistani and Asian diet, cereals such as wheat, rice and maize, together with potatoes, sugar and pulses, supply 55–65 percent of total daily energy. Glucose, the end product of carbohydrate digestion, is the preferred fuel of the brain, the nervous system and the red blood cells; the brain alone uses about 100–120 grams of glucose per day.

Carbohydrates also have a protein-sparing action: when enough carbohydrate is eaten, the body uses it for energy and saves dietary protein for its proper building functions, instead of burning protein as fuel. A minimum of about 100 grams of carbohydrate per day is needed to prevent ketosis, the incomplete burning of fats that occurs when carbohydrate is severely restricted. Dietary fibre, the indigestible part of carbohydrate foods, adds bulk to the diet, helps bowel movement, prevents constipation, slows the absorption of glucose (useful in diabetes) and helps lower blood cholesterol. Excess carbohydrate, however, is converted to fat and stored, contributing to obesity.

Proteins: The Body-Building Nutrients

Proteins are the structural foundation of the body. Every cell, enzyme, hormone, antibody and muscle fibre is made wholly or partly of protein. Each gram of protein yields about 4 kcal, but energy supply is its secondary function; its primary role is growth, maintenance and repair. During childhood, pregnancy and recovery from illness, new tissue is being built, so protein needs rise. Proteins are made of amino acids, nine of which are 'essential' because the body

cannot make them and they must come from food. Animal proteins — milk, egg, meat and fish — contain all essential amino acids in good proportions and are called complete or high-biological-value proteins, whereas most single plant proteins lack one or more essential amino acids. Combining cereals with pulses, as in the common dishes of dal with rice or roti, makes the mixture complete, because the amino acids missing in one are present in the other.

Proteins also perform regulatory and protective roles: enzymes that speed up all chemical reactions, hormones such as insulin, antibodies that defend against infection, haemoglobin that carries oxygen, and plasma proteins that maintain the fluid balance of the blood are all proteins. The recommended intake for an adult is about 0.8–1.0 gram of protein per kilogram of body weight per day, with higher allowances for children, pregnant and lactating women, and patients recovering from illness or surgery.

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Fats: Concentrated Energy and Much More

Fats are the most concentrated source of energy, yielding about 9 kcal per gram — more than twice the energy of carbohydrate or protein. They form the body's long-term energy store in adipose tissue, which also insulates the body against cold and protects delicate organs such as the kidneys from injury. Fats are essential for the absorption and transport of the fat-soluble vitamins A, D, E and K; a very low-fat diet can therefore cause deficiency of these vitamins even when they are present in food. Certain fatty acids, especially linoleic and alpha-linolenic acids, are essential nutrients needed for cell membranes, brain development in infants and the production of hormone-like substances called prostaglandins. Fats also make food tasty, give a feeling of fullness by slowing stomach emptying, and supply material for steroid hormones and

bile acids. However, excessive intake — particularly of saturated fats and trans fats — is associated with obesity, high blood cholesterol, heart disease and diabetes, so fats should normally provide about 20–30 percent of total energy.

Water: The Forgotten Macronutrient

Water makes up about 60 percent of the adult body and is needed in larger quantity than any other nutrient — about 2 to 3 litres per day from drinks and food together. It is the solvent in which all chemical reactions of the body occur, the transport medium of blood, the main part of digestive juices, urine and sweat, and the regulator of body temperature. Even a loss of 1–2 percent of body water causes thirst and reduced performance, a loss of around 10 percent is dangerous, and a loss of 20 percent is fatal. The roles of the macronutrients are summarised in the table below.

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Summary of the Macronutrients

Macronutrient	Energy Yield	Main Functions	Important Sources
Carbohydrates	4 kcal/g	Main energy source; fuel for brain; protein-sparing; fibre for bowel health	Wheat, rice, maize, potato, sugar, pulses
Proteins	4 kcal/g	Growth, repair, enzymes, hormones, antibodies, haemoglobin	Milk, egg, meat, fish, pulses, soyabean
Fats	9 kcal/g	Concentrated energy store; insulation; absorption of vitamins A, D, E, K; essential fatty acids	Ghee, butter, oils, nuts, fatty fish
Water	0 kcal/g	Solvent, transport, temperature regulation, part of all body fluids	Drinking water, milk, fruits, all foods

Protein-Energy Malnutrition: Definition and Causes

Protein-Energy Malnutrition (PEM), also called protein-calorie malnutrition, is a condition that develops when the diet fails to supply enough energy and protein to meet the body's needs over a long period. It is one of the most widespread nutritional problems in the world and mainly affects young children in poor communities, whose requirements are high because they are growing rapidly, while their diets are often based on bulky, starchy staple foods with very little milk, egg, meat or pulses. PEM rarely results from food shortage alone: repeated infections such as diarrhoea, measles, pneumonia and worm infestations reduce appetite, increase losses and raise requirements, creating a vicious cycle in which malnutrition increases infection and infection worsens malnutrition. Poor feeding practices — delayed complementary feeding, over-diluted milk, and stopping breastfeeding during illness — along with poverty, ignorance and poor sanitation, are its root causes. PEM takes two classic clinical forms, marasmus and kwashiorkor, with many children showing features of both (marasmic kwashiorkor).

Marasmus

Marasmus results mainly from a severe deficiency of energy (calories) with a relative deficiency of all nutrients, and it usually appears in the first year of life when breast milk or its substitute is grossly insufficient. The marasmic child is extremely thin — weight for age may be less than 60 percent of the expected value — with almost no fat under the skin and muscles badly wasted, so that the ribs stand out, the arms and legs look like sticks, and the face has the wrinkled 'old man' appearance. The child is usually alert but irritable, hungry and crying for food. Importantly, there is no oedema (swelling), the hair remains mostly normal, and appetite is

often present. Because the body adapts by slowing growth and breaking down its own tissues for fuel, marasmus is sometimes described as the adapted form of PEM; given food and care, recovery is possible, though prolonged deprivation permanently stunts growth and brain development.

Kwashiorkor

Kwashiorkor develops mainly from protein deficiency when energy intake from starchy foods is comparatively less reduced, and it typically affects children aged one to three years, often after early weaning onto a diet of gruels and staples when a new baby arrives — the word itself, from Ghana, means 'the disease of the displaced child'. Its most characteristic sign is oedema: the feet, legs, hands and face become swollen with fluid because lack of plasma protein (albumin) allows water to leak out of the blood into the tissues, and this swelling can mask the underlying wasting. Other typical features are misery and apathy, loss of appetite, a distended abdomen, an enlarged fatty liver, and striking changes in the hair, which becomes thin, straight, and reddish-brown or pale, and in the skin, which develops dark patches that peel like flaky paint ('flaky paint dermatosis'). Kwashiorkor is more immediately life-threatening than marasmus because of severe infection risk, electrolyte disturbance and liver failure.

Effects of PEM on Health

The effects of protein-energy malnutrition reach far beyond body weight. Growth fails first: children become stunted (too short for age) and wasted (too thin for height), and severe early malnutrition can leave permanent effects on height and body proportions. The developing brain is highly vulnerable; malnutrition in the first two years of life is associated with smaller

brain growth, poorer learning ability, lower school achievement and reduced earning capacity in adult life. The immune system is badly weakened — antibody production, cell-mediated immunity and the barrier function of the skin and gut all decline — so malnourished children suffer more frequent, more severe and longer-lasting infections, and common illnesses like diarrhoea and measles become killers. PEM is estimated to underlie a large share of deaths in children under five worldwide.

Other effects include anaemia, delayed wound healing, loss of muscle strength, reduced work capacity in adults, irregular or stopped menstruation, poor pregnancy outcome with low-birth-weight babies, and in severe cases hypothermia, low blood sugar, heart failure and death. Treatment requires careful, staged feeding (as in the WHO protocol), correction of infections and deficiencies, and gradual rehabilitation with energy- and protein-rich foods, because feeding a severely malnourished child too aggressively at first can itself be fatal (refeeding syndrome). Prevention lies in exclusive breastfeeding for six months, timely and adequate complementary feeding, immunisation, prompt treatment of infections, growth monitoring, nutrition education of mothers and improvement of household food security.

Conclusion

In conclusion, the macronutrients form the bulk and the working substance of the diet: carbohydrates supply the main share of energy, fats provide concentrated energy, insulation and essential fatty acids and carry the fat-soluble vitamins, proteins build and repair the body and form its enzymes, hormones and defences, and water is the medium of all life processes. When energy and protein are lacking together for a long time, the result is protein-energy

malnutrition, seen as marasmus, kwashiorkor or a mixture of both. Its effects — failed growth, damaged brain development, weakened immunity, repeated infection and, in severe cases, death — make PEM one of the most serious public health problems of the developing world, yet it is preventable by adequate feeding, infection control and nutrition education.

Question 3: Complementary Feeding — Timing, Types and Importance in Infant Growth (20 Marks)

What is complementary feeding? Discuss its timing, types, and importance in infant growth.

Introduction

The first two years of life are the period of fastest growth and brain development in the whole human lifespan, and the way an infant is fed during this period has lifelong consequences. For the first six months, breast milk alone provides everything a healthy baby needs. After that, breast milk alone is no longer sufficient, and other foods must be added gradually while breastfeeding continues. This process is called complementary feeding. It is one of the most critical transitions in a child's life: done properly and on time, it protects the child from malnutrition and infection; done too early, too late, or with unsuitable foods, it becomes a major cause of the growth failure, anaemia and repeated illness so common among young children in Pakistan and other developing countries. This answer defines complementary feeding, explains the right time to start it, describes its types and guiding principles, and discusses its importance in infant growth.

What Is Complementary Feeding?

Complementary feeding is the process of giving foods and liquids in addition to breast milk when breast milk alone is no longer sufficient to meet the nutritional requirements of the infant. The word 'complementary' is important: these foods complement — that is, complete and add to — breast milk; they do not replace it. The term has replaced the older word 'weaning', which wrongly suggested stopping breastfeeding. According to WHO and UNICEF recommendations, complementary feeding should begin at six completed months of age, and breastfeeding should continue up to two years of age or beyond, because breast milk still supplies a valuable share of energy, protein, vitamin A and protective antibodies throughout the second year.

Good complementary feeding is not only about what is given but also how: the food must be timely, adequate in energy and nutrients, safe and hygienically prepared, and given in the right amounts, frequency and consistency for the child's age, with patient and responsive feeding by the caregiver.

Timing of Complementary Feeding

The recommended time to start complementary feeding is at six completed months (180 days) of age. There are clear physiological reasons for this timing. By six months, the infant's digestive system has matured enough to handle starches and other foods, the kidneys can manage a higher solute load, and the immune system is better developed. Developmentally, the baby can now sit with support, hold the head steady, show interest in food, open the mouth for a spoon and swallow semi-solid food instead of pushing it out with the tongue (the extrusion reflex

disappears). A very important nutritional reason is iron: the store of iron a full-term baby is born with is used up by about six months, and breast milk alone cannot supply enough iron after this point, so iron-containing foods become essential to prevent anaemia.

Starting too early — before four months — is harmful: it exposes the immature gut to germs and foreign proteins, increases the risk of diarrhoea, chest infections and allergy, reduces breast milk intake and therefore the mother's milk production, and raises the risk of obesity later in life. Starting too late — well after six months — is equally harmful: the gap between what breast milk provides and what the growing baby needs becomes too wide, growth falters, and deficiencies of energy, iron, zinc and vitamin A develop. This is why growth curves of infants in poor communities so often begin to fall exactly between six and twenty-four months.

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Types of Complementary Foods

Complementary foods are usually introduced in a sequence of increasing thickness and variety as the child grows, and they can be grouped into several types. First are the liquid and semi-liquid foods offered at the very start, such as thin cereal gruels and mashed ripe banana, though these should quickly be thickened because watery gruels fill the stomach without providing enough energy. Second are mashed and puréed family staples — soft khichri (rice and lentils cooked together), porridge (dalia), mashed potato, suji (semolina) halwa, and mashed fruits such as banana, papaya and mango. Third are enriched mixtures: adding oil, ghee, milk, ground nuts or sugar to a staple raises its energy density, and adding egg, minced meat, liver, chicken, fish or pulses raises its protein, iron and vitamin content. Fourth are finger foods from about eight to nine months, such as soft fruit pieces, cooked vegetable sticks and pieces of roti,

which encourage self-feeding and chewing skills. By twelve months the child should be eating chopped family foods from the family pot, modified only in salt and chillies.

A good complementary diet in the Pakistani home can be built from local, cheap ingredients: khichri with a teaspoon of oil and mashed egg; dalia cooked in milk; rice with dal and vegetables; mashed banana with yogurt; and iron-rich foods such as minced meat or liver once or twice a week. Commercial baby cereals are convenient but expensive and are not necessary where home foods are well prepared. The recommended pattern by age is summarised below.

Complementary Feeding Pattern by Age

Age	Frequency of Meals	Consistency and Examples	Amount per Meal
6 months	2–3 times daily	Thick porridge, well-mashed foods: khichri, dalia, mashed banana	2–3 tablespoons, increasing gradually
7–8 months	3 times daily + nutritious snacks	Mashed family foods, egg, pulses, finger foods	About ½ cup (125 ml)
9–11 months	3–4 times daily + snacks	Finely chopped family foods, minced meat, fruits	About ½–¾ cup (125–175 ml)
12–24 months	3 meals + 2 snacks daily	Family foods, chopped or mashed as needed	About ¾–1 cup (175–250 ml)

Guiding Principles of Good Complementary Feeding

WHO's guiding principles emphasise that feeding must be adequate, safe and responsive. Adequacy means the food should provide enough energy and nutrients: meals must be frequent enough and thick enough, because a young child's stomach is small — roughly the size of his own fist — and he cannot eat large volumes at one sitting. Variety is essential, with foods from several groups daily: staples, animal-source foods, pulses, vegetables and fruits. Safety

means freshly prepared food, clean hands, clean utensils and water, thorough cooking, and avoiding feeding bottles, which are difficult to clean and spread infection; a cup and spoon are safer. Responsive feeding means the caregiver feeds slowly and patiently, encourages but never forces the child, talks and maintains eye contact during meals, feeds the child directly or supervises self-feeding, and continues feeding during and after illness, with extra food during recovery to regain lost growth.

Importance of Complementary Feeding in Infant Growth

The importance of complementary feeding can hardly be overstated, because it covers exactly the window — six to twenty-four months — when growth velocity is highest after the newborn period and when the brain reaches about 80 percent of its adult size. Breast milk production does not increase after six months, so without complementary foods an energy and nutrient 'gap' opens: by 9–11 months a breastfed child needs roughly 300 kcal per day from other foods, and by 12–23 months about 550 kcal per day, together with most of his iron, zinc and a large share of vitamin A from those foods. Proper complementary feeding fills this gap and keeps the child growing along his normal growth curve; its absence is the single most important cause of the stunting and underweight seen in young children.

Complementary feeding also develops the child in non-nutritional ways. Chewing and swallowing foods of increasing texture develops the muscles of the mouth needed later for speech; experiencing new tastes and textures shapes healthy food preferences for life; and self-feeding builds fine motor skills, independence and a close, responsive bond with the caregiver. Timely introduction of iron-rich foods prevents iron-deficiency anaemia, which impairs mental

development, and vitamin-A-rich foods protect vision and immunity. In short, the quality of complementary feeding in large part decides whether a child reaches his full physical and mental potential or carries the lifelong burden of early malnutrition.

Common Problems and Their Prevention

Several common errors undermine complementary feeding in practice. The most frequent is giving over-diluted, watery gruels and soups that look like food but provide little energy per spoonful; the remedy is to thicken the food and enrich it with oil or ghee. Another is relying on bottle-feeding, tea, or sweetened drinks, which displace nutritious food and spread infection. Delaying the start beyond six or seven months 'because the baby is still breastfeeding', giving only starchy foods without animal protein, and stopping feeding during diarrhoea or fever are other damaging practices. All of these can be prevented by practical nutrition education — especially by demonstrating actual recipes to mothers in clinics and communities — along with growth monitoring so that faltering is detected and corrected early.

Conclusion

To conclude, complementary feeding is the gradual addition of foods and liquids to the breastfed infant's diet from six completed months of age, while breastfeeding continues up to two years and beyond. Its correct timing is dictated by the maturity of the baby and the exhaustion of his iron stores; starting too early invites infection, and starting too late invites malnutrition. Its types progress from thick porridges and mashed foods to chopped family meals, ideally prepared at home from local staples enriched with oil, pulses, egg, meat and fruits. Because it covers the most rapid phase of growth and brain development, good

complementary feeding is one of the most powerful and cost-effective interventions in child health — it prevents stunting, anaemia and deficiency diseases and lays the foundation for the child's lifelong health and learning.

Question 4: Food Fortification and its Role in Improving Public Health (20 Marks)

Discuss food fortification and its role in improving public health. Provide examples.

Introduction

Deficiencies of micronutrients — vitamins and minerals — affect billions of people worldwide, causing conditions such as goitre, anaemia, blindness and birth defects even in populations that eat enough calories to feel full. This 'hidden hunger' cannot be solved quickly by dietary change alone, because the poorest people cannot always afford the animal foods, fruits and vegetables that supply these nutrients. Food fortification offers a practical answer: it adds the missing nutrients to foods that people already eat every day. Because it works through the existing food supply, requires no change in eating habits, and costs only a few rupees per person per year, fortification has become one of the most successful public health strategies in nutrition. This answer explains what food fortification is, describes its types and principles, discusses its role in improving public health, gives examples from Pakistan and the world, and finally notes its limitations.

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What Is Food Fortification?

Food fortification (also called food enrichment in some contexts) is the deliberate addition of one or more essential micronutrients to a food during processing, at levels above those naturally present, in order to prevent or correct a demonstrated deficiency in the population. The food chosen for this purpose is called the vehicle, and the added nutrient is the fortificant. A good vehicle must be eaten regularly by almost everyone, including the poor and the target groups, in fairly predictable amounts; it must be produced centrally in large factories so that the nutrient can be added evenly and quality can be controlled; and the addition must not change the food's taste, colour, smell or price to any noticeable degree. A good fortificant must be stable during storage and cooking, well absorbed by the body, and safe even if people eat more of the food than average.

Fortification must be distinguished from related terms. 'Enrichment' usually means restoring nutrients lost during processing, such as adding back B-vitamins to refined flour. 'Supplementation' means giving nutrients in medicinal form, such as iron tablets to pregnant women — effective, but dependent on distribution and compliance. 'Biofortification' means breeding crops themselves to contain more nutrients, such as zinc-enriched wheat or vitamin-A-rich orange sweet potato. All four approaches complement one another, but fortification of staple foods is usually the cheapest way to reach an entire population.

Types of Fortification

Fortification is generally classified into three types. Mass fortification adds nutrients to foods consumed by the whole population — for example, iodine in salt, iron and folic acid in wheat

flour, and vitamins A and D in edible oil. It is usually mandated and regulated by law because it is a public health measure. Targeted fortification aims at a specific group: iron-fortified complementary foods for infants, fortified milk for schoolchildren, or fortified rations distributed to pregnant women and refugees. Market-driven (voluntary) fortification is carried out by manufacturers for commercial reasons, such as breakfast cereals with added vitamins, iodised branded salts, or drinks with added vitamin C; it can help, but it reaches mainly those who can afford branded products and must be regulated so that claims are truthful and levels are safe.

Role of Fortification in Improving Public Health

The public health value of fortification rests on four strengths. First, coverage: because the vehicle is a daily staple, the nutrient reaches nearly everyone — rich and poor, urban and rural, compliant or careless — without any behaviour change. Second, cost-effectiveness: iodising salt costs only a few cents per person per year, and flour and oil fortification are similarly cheap compared with the medical and economic costs of deficiency. Third, prevention of serious, irreversible harm: iodine deficiency in pregnancy is the world's leading preventable cause of mental retardation, and folic acid deficiency around conception causes neural tube defects such as spina bifida — conditions that treatment after birth cannot undo, but fortification can prevent. Fourth, measurable impact: countries that introduced salt iodisation saw goitre rates fall dramatically within a decade, and flour fortification with folic acid in countries such as the USA, Canada and Chile reduced neural tube defects by roughly a third to a half.

In Pakistan, fortification carries special importance. Iodine deficiency was once widespread in the northern mountain areas, where goitre was common; universal salt iodisation has greatly reduced it, though monitoring of iodine content in salt at household level remains necessary. Iron-deficiency anaemia affects a large proportion of women and children, and wheat flour — consumed daily by virtually the whole population as roti and chapati — is an ideal vehicle for iron and folic acid; national programmes have therefore promoted fortification of flour from roller mills and of edible oil and ghee with vitamins A and D. Fortification also supports other goals: it reduces the burden on hospitals, improves children's learning and adults' work capacity, and works silently in the background alongside supplementation, dietary diversification and nutrition education.

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Important Examples of Food Fortification

Food Vehicle	Nutrient(s) Added	Deficiency Prevented / Benefit
Salt	Iodine (as potassium iodate)	Goitre, cretinism, mental retardation from iodine deficiency
Wheat flour	Iron and folic acid (also B-vitamins, zinc in some programmes)	Iron-deficiency anaemia; neural tube defects in newborns
Edible oil and ghee	Vitamins A and D	Night blindness and xerophthalmia; rickets and weak bones
Milk	Vitamin D (and vitamin A in skimmed milk)	Rickets and osteomalacia
Sugar (in some countries)	Vitamin A	Vitamin A deficiency in children
Crops by breeding (biofortification)	Zinc wheat, iron beans, vitamin-A sweet potato	Zinc, iron and vitamin A deficiencies at farm level

Requirements for a Successful Fortification Programme

Experience shows that fortification succeeds only when several conditions are met. There must be scientific evidence of a real deficiency problem in the population and a suitable staple vehicle. Legislation and standards should define exactly how much nutrient is to be added, and government laboratories must monitor factories and market samples, because both under-fortification (which fails to correct deficiency) and over-fortification (which may be unsafe) defeat the purpose. The food industry must be involved as a partner, since small producers — for example, the small chakki flour mills common in Pakistan — are difficult to fortify and monitor, which is one of the main practical obstacles in our country. Finally, the public must be informed, for example so that consumers choose iodised salt and understand that fortified flour is safe and beneficial.

Limitations and Challenges

Fortification is not a complete solution to malnutrition. It corrects specific micronutrient deficiencies but does nothing for protein-energy malnutrition, which requires more food, not just better food. It cannot easily supply nutrients needed in large amounts, such as protein, calcium or energy. Some nutrients are technically difficult: iron can change the colour and taste of flour and is poorly absorbed from plant diets, so the compound chosen matters greatly. Populations that buy loose staples from small local producers may be missed entirely. There is also a small risk of excess intake of nutrients such as vitamin A or iron in some individuals if several fortified products and supplements are combined. For these reasons, fortification is best seen as one part of an overall strategy together with dietary diversification, supplementation of high-risk groups, control of infections, and nutrition education.

Conclusion

In conclusion, food fortification is the planned addition of micronutrients to widely consumed foods in order to prevent deficiency diseases in the whole population. Its classic examples — iodine in salt against goitre and mental retardation, iron and folic acid in wheat flour against anaemia and birth defects, and vitamins A and D in oil and milk against blindness and rickets — show how a small, inexpensive change in food processing can produce large gains in public health. In a country like Pakistan, where hidden hunger is widespread and daily staples are few and predictable, well-legislated, well-monitored fortification of salt, flour and oil is one of the most cost-effective investments in the health, intelligence and productivity of the nation, provided it is combined with education and broader efforts to improve the diet.

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Question 5: Impact of Cooking and Processing on Food Nutrients and Methods to Minimise Nutrient Loss (20 Marks)

Explain the impact of cooking and processing on food nutrients. Suggest methods to minimize nutrient loss.

Introduction

Very few foods are eaten exactly as nature provides them. Between the farm and the plate, food is cleaned, milled, peeled, cut, soaked, boiled, fried, baked, dried, frozen or canned. Cooking and processing are necessary and beneficial in many ways — they make food safe, digestible and tasty — but they also change its nutritional value. Some nutrients are destroyed

by heat, some dissolve into cooking water and are thrown away, and some are lost when the most nutritious parts of a grain or vegetable are removed in milling and peeling. Losses of vitamin C, the B-vitamins and minerals during careless cooking can be very large, sometimes more than half of what the raw food contained. Understanding how cooking and processing affect each nutrient, and how to minimise these losses, is therefore an essential part of practical nutrition, both in the home and in the food industry. This answer first notes the benefits of cooking, then explains the effects on the major nutrients and food groups, and finally suggests practical methods to conserve nutrients.

Benefits of Cooking: The Other Side of the Picture

Cooking is not merely destructive. Heat kills harmful bacteria, viruses and parasites, making food safe; it destroys natural toxins and anti-nutritional factors, such as trypsin inhibitors in pulses and goitrogens in some vegetables, thereby improving both safety and protein digestibility. Cooking softens fibres and connective tissue, gelatinises starch, and breaks cell walls, so that cooked cereals, pulses and vegetables are digested and absorbed far better than raw ones — the energy and protein actually obtained from cooked food is often higher even if some vitamins are lost. Cooking also develops flavour, aroma and colour, improving appetite and acceptability, and it allows preservation through methods such as bottling and canning. In some cases processing even increases nutrient availability: the lycopene of cooked tomatoes and the beta-carotene of cooked carrots are absorbed better than from the raw foods. The aim, therefore, is not to avoid cooking but to cook wisely.

Effect of Cooking on Vitamins

Vitamins are the nutrients most vulnerable to cooking. Vitamin C (ascorbic acid) is the most fragile of all: it is soluble in water, destroyed by heat, oxidised by exposure to air, and destroyed faster in alkaline conditions (for example when soda is added to keep vegetables green) and in the presence of copper vessels. Boiling vegetables in excess water and discarding the water can destroy or remove 50 percent or more of their vitamin C. The B-group vitamins — thiamine (B1), riboflavin, niacin and folate — are also water-soluble and leach into cooking water; thiamine is additionally destroyed by heat and by alkaline substances, and riboflavin is sensitive to light, so milk should not be left standing in sunlight. Folate in green leafy vegetables is easily lost in prolonged boiling. The fat-soluble vitamins A, D, E and K are more stable to ordinary cooking, since they do not dissolve in water, but vitamin A and carotene can be oxidised during prolonged frying at high temperature and during storage of oils in light, and vitamin E is gradually lost in repeatedly heated frying oils.

Effect of Cooking and Processing on Minerals, Proteins, Carbohydrates and Fats

Minerals such as iron, calcium, potassium and zinc are elements, so they cannot be destroyed by heat; but they are lost physically when they dissolve into cooking or soaking water that is then thrown away, and when mineral-rich parts of foods — the bran of grains, the peel of potatoes, the outer leaves of vegetables — are removed. Processing can also improve mineral availability: soaking, germination and fermentation reduce phytic acid in cereals and pulses, which otherwise binds iron, zinc and calcium and prevents their absorption.

Proteins are generally improved by moderate cooking: heat denatures protein, unfolds its structure and inactivates enzyme inhibitors, making it more digestible. Severe heating, however, damages protein quality — the essential amino acid lysine is lost when foods are roasted or toasted intensely or heated with sugars (the Maillard browning reaction), and milk and eggs overheated for long periods lose nutritive value. Carbohydrates are changed rather than lost: starch granules absorb water and gelatinise, becoming digestible, while dry heat produces dextrins and browning; sugars caramelise and, in excess, burnt sugars have no food value. Fats melt and may be absorbed into fried foods, increasing their energy value; repeatedly reheating frying oil produces harmful oxidation products and destroys vitamin E, so oil should not be reused many times.

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Effect of Cooking on Meat, Cereals and Pulses

Cooking meat illustrates many of these effects together. As meat cooks, its proteins denature and coagulate, connective tissue (collagen) slowly converts to soft gelatine in moist cooking, and the meat becomes tender and digestible. Water and juices are squeezed out as cooking proceeds, carrying soluble B-vitamins and minerals with them; well-done meat may lose a quarter or more of its weight as juice, which is why gravies and soups should be consumed rather than discarded. Dry, intense heat chars the surface and can form undesirable compounds, while gentle stewing and pressure cooking conserve more nutrients in less time.

Cereals and pulses suffer their biggest losses not in cooking but in processing before cooking — milling and polishing. When wheat is refined into white flour, or brown rice is polished into white rice, the bran and germ are removed, and with them most of the fibre, B-vitamins

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(especially thiamine), vitamin E and minerals such as iron. Historically, epidemics of beriberi followed the introduction of polished rice in Asia. Parboiling rice — a traditional process in which paddy is soaked and steamed before milling — drives nutrients from the bran into the grain, so parboiled rice retains much more thiamine than raw-milled polished rice. Pulses, on the other hand, gain from proper processing: soaking and cooking destroy their trypsin inhibitors and soften them, and germination (sprouting) actually increases their vitamin C and B-vitamin content.

Storage and Other Processing Effects

Nutrient losses also occur before and after cooking. Vitamin C falls steadily during storage of fruits and vegetables, especially at warm temperatures; cutting and peeling long before cooking exposes large surfaces to air and light; and keeping cooked food hot for many hours, as in some institutional catering, continues to destroy vitamin C and thiamine. Freezing, properly done after brief blanching, preserves nutrients well, whereas sun-drying destroys much vitamin C and carotene, although it remains a useful low-cost preservation method. Canning involves heat and liquid losses, but the canned food then remains stable for a long time. Fortification, discussed in the previous answer, is one processing technique that deliberately raises nutrient content, and fermentation — as in yogurt and fermented batters — can increase B-vitamins and improve mineral absorption.

Methods to Minimise Nutrient Loss

Most nutrient losses can be greatly reduced by simple, practical methods. (1) Prepare vegetables just before cooking: wash them before cutting, not after, cut them into large pieces

with a sharp knife, and peel them thinly or not at all where the skin is edible. (2) Use as little water as possible: steam, pressure-cook, microwave or cook in minimal water, and always use the cooking water in soups, gravies, dals and rice instead of throwing it away, since it contains the dissolved minerals and B-vitamins. (3) Cook for the shortest possible time: put vegetables into already-boiling water, keep the lid on, and serve food after cooking rather than keeping food hot for hours. (4) Avoid harmful additions: do not add baking soda to vegetables, as it destroys vitamin C and thiamine; add acidic ingredients such as lemon or tomato where suitable, because vitamin C is more stable in acid. (5) Choose better-processed staples: prefer whole-wheat (chakki) flour, unpolished or parboiled rice, and sprouted or fermented pulses. (6) Handle milk and oils carefully: store milk away from light, avoid repeatedly reheating frying oil, and store oils in closed, dark containers. (7) Store fresh foods in a cool place or refrigerator and use them quickly, and reheat leftovers only once and thoroughly. By following these steps, a household can preserve most of the nutritional value that it has paid for in the raw food.

Conclusion

To conclude, cooking and processing have a double effect on food: they make it safe, digestible, tasty and preservable, yet they also cause real losses — vitamin C and the B-vitamins are destroyed by heat, air, light and alkali and leach into cooking water; minerals leach into water and are stripped away with bran and peel in milling; proteins are improved by moderate heat but damaged by severe heating; and refined grains lose much of their original value. These losses are not inevitable. Washing before cutting, using little water, cooking briefly in covered vessels or under pressure, reusing cooking liquids, avoiding soda, choosing whole and parboiled grains, and storing food with care can conserve most nutrients. Wise cooking is thus an

essential part of good nutrition: it is not only what we eat, but how we prepare it, that decides how well we are nourished.

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