NATIONAL OPEN UNIVERSITY OF NIGERIA

AFS 202

Introduction to Food Science and Technology

Module 1

AFS 202 (Introduction to Food Science and Technology) Module 1

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Module 1 Principles of Food Science and Technology

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1.0 Introduction

Food is a complex biochemical material. It is anything eaten to satisfy appetite, meet physiological needs for growth, maintain all body processes and supply energy to maintain body temperature and activity. *Food, from the professional point of view, is any substance, whether processed, semi-processed or raw, which is intended for human consumption, and includes drink and any other substance which has been used in the manufacture, preparation or treatment of "food", **but does not include cosmetics or tobacco or substances used only as drugs.*** Because foods differ markedly in the amount of the nutrients they contain, they are classified on the basis of their composition and the source from which they are derived.
A normal healthy diet should not just consist of the three major nutrients, namely: fat, carbohydrates and protein, but should also provide a range of essential macro- and micronutrients, in the form of dietary fibre, minerals and vitamins.

- **Micronutrient:** nutrient needed in tiny amounts; a substance that an organism requires for normal growth and development but only in very small quantities, e.g. a vitamin or mineral

- **Macronutrient:** element needed in large amounts for normal growth and development.

For good health and vitality, a range of micronutrients is needed in sufficient but not excessive quantities, combined with the absence of toxic components, whether naturally present or as contaminants. Food Science and Technologists apply their scientific knowledge to ensure that food gets to all in the best possible state.

2.0 Objectives

By the end of this unit, you should be able to:

- define food science and technology
- explain the different disciplines of food science and technology
- distinguish between food science and technology (fst) and cooking, home-economics nutrition and food service
- discuss Food situation and regulation in Nigeria.

3.0 Main Content

3.1 What is Food Science?

Food Science is the study of the physical, biological, (including microbiological), and chemical makeup of food. Food Scientists and Technologists apply many scientific disciplines, including Chemistry, Engineering, Microbiology, Epidemiology, Nutrition, and Molecular Biology to the study of food to improve the safety, nutrition, wholesomeness, and availability of food. Depending on their area of specialization, Food Scientists develop ways to process, preserve, package, and/or store food, according to industry and government specifications and regulations. Consumers seldom think of the vast array of foods and the research and development that has resulted in the means to deliver tasty, nutritious, safe, and convenient foods.

What Food Science is not?

- ***Food Science is Not Nutrition:*** While some food scientists may focus on making foods more nutritious or determining what components of food provides health benefits, Nutrition and Food Science are actually very different.

- ***Food Science is not cooking:*** Although Food Scientists play a large part in making sure food tastes good, they are not chefs. They do, however, share a common objective: to prepare and present food that will deliver satisfaction to the consumer, and to do it in a safe, healthy, and cost-effective way.

- ***Food Science is Not Food Service:*** Most of the employees we see on the front-lines of a restaurant are in the food service industry. The directors of food safety and those developing new food products for chain restaurants, however, are most likely Food Scientists.

3.1.1 Scope of Food Science and Technology

Food Science and Technology encompasses the following major areas of specialisations:

3.1.2 Food Chemistry

Food chemistry is the study of the composition of foods, their properties and how they interact with each other and the environment. It may also include Food Analysis which is subdivided into two main areas, qualitative and quantitative analysis. The former involves the determination of unknown constituents of a substance, and the latter concerns the determination of the relative amounts of such constituents.

The major chemical classes of food are: Proteins, carbohydrates and fats. Other components are minerals and vitamins.
The following is a brief summary of some reactions that can be induced in various food classes

Proteins, Amino Acids and Polypeptides:
- —hydrolysis→ Polypeptides + Peptides + Amino Acids
- —proteinaces→ Peptides (responsible for bitter taste)
- —peptidases→ Simpler peptides + Amino acids

(Responsible for both desirable and undesirable flavours)

Proteins } Anaerobic breakdown → Foul smelling sulphur and nitrogen-containing
Peptides products like Amino acids ethyl sulphides, amines, indole, ammonia etc. This is putrefaction

Glucose → Anaerobic Oxidation → Carbon Dioxide + Water

Glucose → Alcoholic Fermentation → Ethanol + Carbon Dioxide + Energy

Glucose → Lactic Acid Fermentation → Carbon Dioxide + Water

Organic Acids Aerobic Oxidation Carbon Dioxide + Water
This oxidation leads to loss of acidity and increased susceptibility to microbial attack and other alkaline deteriorative reactions.

Fats → Microbes → Glycerol + Fatty Acids

A thorough understanding of these reactions is required to ensure that foods delivered to consumers are safe, wholesome, nutritious and tasty.

3.1.3 Food Microbiology

Food microbiology is the scientific study of microscopic organisms and their effects in food systems. Microscopic organisms commonly encountered in food systems are bacteria and fungi (comprising yeasts and moulds).

3.1.3.1Bacteria

Bacteria are of major importance in the food industry. On the one hand, they cause food spoilage and food borne diseases, and so must be controlled. On the other hand, they improve food flavour and nutrition. On the helpful side, bacteria contribute to the fermentation (chemical breakdown) of many dairy products people eat every day. Yogurt, considered a healthful food, is produced by bacterial fermentation of milk. The bacteria produce lactic acid, which turns the milk sour, hampers the growth of disease-causing bacteria, and gives a desirable flavour to the resulting yogurt. Cheese also is produced by fermentation. First, bacteria ferment milk sugar to lactic acid. Then, cheese makers can introduce various microorganisms to produce the flavours they desire. The process is complicated and may take months or even years to complete, but it gives cheeses their characteristic flavours.

3.1.3.2 Fungi

Fungi are single-celled or multicellular organism without chlorophyll that reproduces by spores and lives by absorbing nutrients from organic matter. Thousands of different types of fungi grow on and absorb food from substances such as soil, wood, decaying organic matter, or living plants and other organisms. They range from tiny, single-celled organisms invisible to the naked eye to some of the largest living multicellular organisms. They are among the foremost decomposers of organic matter, breaking down plant and animal remains and wastes into their chemical components. As such, fungi play a critical role in the recycling of minerals and carbon. Fungi's value to humankind is inestimable. Certain types of fungi, including several types of mould, have proven extremely valuable in the synthesis of antibiotics and hormones used in medicine and of enzymes used in certain manufacturing processes.

Black bread mould, *Aspergillus niger,* one of the most familiar molds, begins as a microscopic, airborne spore that germinates on contact with the moist surface of nonliving organic matter. It spreads rapidly, forming the mycelium (fungal body), which is made up of a fine network of filaments (hyphae). The mycelium produces other clusters of rootlike hyphae, called rhizoids, which penetrate the organic material, secreting enzymes and absorbing water and the digested sugars and starches.

Yeasts are small single-celled fungus that ferments sugars and other carbohydrates and reproduces by budding. Yeasts in general are widespread in nature, occurring in the soil and on plants. Most cultivated yeasts belong to the genus *Saccharomyces;* those known as brewer's yeasts are strains of *S. cerevisiae.* Today they are used industrially in a wide range of fermentation processes; medicinally, as a source of B-complex vitamins and thiamine and as a stage in the production of various antibiotics and steroid hormones; and as feed and foodstuffs. Pure yeast cultures are grown in a medium of sugars, nitrogen sources, minerals, and water. The final product may take the form of dried yeast cells, or the yeast may be pressed into cakes with some starchy material. When a batch of yeast for baking, medicinal, or food purposes is completed, the medium in which the yeast was grown is discarded. In the making of wines, beers, spirits, and industrial alcohol, however, the fermented medium is the desired product, and the yeast itself is discarded or used to make animal feeds.

3.1.4 Food Packaging

Packaging of food is essential to make sure the food remains wholesome during its journey from processor to consumer. Packaging contains food, makes it easier to handle, and protects it from environmental conditions, such as temperature extremes, during transport. It locks out microorganisms and chemicals that could contaminate the food, and helps prevent physical and chemical changes and maintain the nutritional qualities of food. The type of food and the processing method used often influence the choice of packaging. For example, since oxygen makes fats go rancid, oils are packaged in containers that are impermeable to oxygen. On the other hand, oxygen-permeable plastic wraps allow fruits and vegetables to "breathe" and ensure that meats will maintain a vibrant red colour. Metal and glass containers have traditionally been used in canning because these materials can withstand the high temperatures and changes in pressure that are involved in this processing method.

In addition to metal, glass is often used for packaging heat-sterilized foods. Glass is impermeable to oxygen and water and does not change the flavour of food. Another advantage of glass is that it is transparent, enabling the consumer to see the product inside. However, glass is not impact-resistant and is relatively heavy.

Plastic, by contrast, is lightweight and unbreakable, and it has become an extremely common material for use in food packaging. Most plastics used in food packaging are heat resistant so that they can go through high-temperature sterilization processes. Plastic is made into a wide variety of shapes, including bottles, jars, trays, and tubs, as well as thin films that are used as bags and wraps.

Paper alone is not frequently used in packaging, except for certain dry foods, such as flour and sugar. However, when paper is coated with plastic or other materials to make it stronger and impermeable to water, it can be more widely used. Paperboard is often used for cartons, and plastic-coated paperboard for packaging frozen foods. Cartons and containers for shipping are usually made of corrugated cardboard.

3.1.5 Food Processing and Preservation

Food Processing encompasses all the steps that food goes through from the time it is harvested to the time it gets to the retailer. Some processing methods convert raw materials into a different form or change the nature of the product, as in the manufacture of sugar from sugar beets, oil from corn or soybeans, or wara (unripened soft cheese) from milk. Processing may also involve an extremely complex set of techniques and ingredients to create ready-to-eat convenience foods.

Food Preservation refers specifically to the processing techniques that are used to keep food from spoiling. Spoilage is any change that makes food unfit for consumption, and includes chemical and physical changes, such as bruising and browning; infestation by insects or other pests; or growth of microorganisms, such as bacteria, yeast, and molds.

Food Processing and Preservation therefore is a branch of Food Technology that is concerned with the transformation of raw animal, vegetable, or marine materials into tasty, nutritious, and safe food products. It also provides a means of creating products that are convenient for consumers, like those that are ready to eat or require minimal preparation and cooking. Combining Food Processing and Preservation techniques with modern distribution networks makes seasonal crops available year-round.

3.2 Food Distribution and Marketing

After food is processed and packaged, it enters an extensive distribution network that brings food products from the manufacturer to various retail outlets across the country and even around the world. Modern, high-speed methods of transportation – trucks, trains, and planes – and reliable methods of environmental control – especially refrigeration – enable even perishable food to be transported great distances.

Distribution networks help satisfy consumer demand for variety, making available, even in remote areas, foods that are not locally grown or processed. In fact, although food distribution network is invisible to the average consumer, it plays a vital role in ensuring the availability of even the most basic foodstuffs.

Some large supermarkets have the resources to buy food products directly from processors, transport the products, and store them in warehouses until they are needed at the store. However, for independent grocery stores and other small retailers, food wholesalers fulfill these roles. One type of wholesaler is a cooperative wholesaler, which is owned by the retailers that buy from them and usually sells only to these member-owners. In contrast, voluntary wholesalers are public companies that sell to any retailers without having membership requirements. Some food is sold directly to a retail store without going through a wholesaler first. This is common for foods such as bread and dairy products that must be delivered fresh every day or every few days. Smaller manufacturers often use food brokers as agents to arrange for their products to be sent to retailers or warehouses.

Through these various distribution channels, food makes its way to food retailers, such as restaurants, fast food outlets, supermarkets, convenience stores, specialty shops, drug stores, and some department stores. Minimarkets and open market selling are the predominant means of distributing foods in Nigeria.

3.2.1 What is Market?

Many different definitions and views of what marketing is have been presented. A Marketing Manager may think of a market in a more comprehensive way taking a broad look at the word market. Another may include a geographical place to demarcate a market. Yet, some can use demographic, sociological or psychological variables in defining their markets. Markets can also be seen in terms of units sold within a specific period of time. A common way of defining a market by the re-sellers is in terms of demand and supply. It is clear therefore that the term market depends largely on individual's perspective and judgement.

The earliest usage of market put market as a physical place where buyers and sellers gather to exchange goods and services. An economist sees market as all the combination of buyers and sellers involved in the purchase of goods and services. In other words, a market is seen here in terms of structure, conduct and performance relationship. This is best illustrated with demand and supply patterns. To the marketers, a market is seen as the set of all individuals and organisations who are actual and potential buyers of a product or service.

3.3 Food Situation in Nigeria

Most Nigerians are subsistence farmers, producing sorghum, millet, and cattle in the north, and maize, rice, and yams in the south. Cassava, legumes, and tomatoes are raised throughout Nigeria, as are poultry, goats, and sheep. Large amounts of plantains and sugar cane are also produced. Agriculture, including farming and herding, accounts for 26 percent of Nigeria's GDP and engages 3 percent of the economically active population.

Palm oil became an export crop to Europe in the early 19th century. Cocoa and groundnuts later grew in importance, surpassing palm oil as export crops in the early 1950's. Most crops are grown on small family farms. Large plantations were discouraged until the 1950's, but since then, they have been significant in the production of rubber, palm oil, and cocoa. Principal crops in 1999 (with annual output in tonnes) included: cassava (33.1 million); sorghum (7 million); millet (5.96 million); peanuts (3 million); and sugar cane (675,000). Palm oil, palm kernels, yams, and maize are also important. Livestock included 24.5 million goats, 19.6 million cattle and 14 million sheep.

However, food production is seasonal in Nigeria. Thus, during periods of harvest, a false impression of surplus is given. However, within a short time, they are exhausted through direct consumption, wastages, deterioration and spoilage. This is all the more so because adequate processing, preservation and storage facilities are not available during periods of plenty. In sharp contrast, constant food supply is ensured by extra-seasonal conservation and storage of food products in developed countries. In Nigeria where these facilities are not present, food consumption and industrial production patterns are markedly seasonal.

Food, by its very nature, is perishable. In a survey carried out in 1996, losses in food produce were as high as 25 – 65% in plantains, tomatoes, oranges, banana, leafy vegetables and citrus fruits. Apart from physical losses, nutritional losses were also recorded: as much as 15 – 20% of Vitamin C was reportedly lost during transportation between the farm gate and the eventual consumers. A 1994 survey conducted by the Central Bank of Nigeria reported losses in agricultural output in the following commodities: maize 6.852 million tonnes, cassava 22.3 million tonnes and beans 1.47 million tonnes. Other sources show losses in the following produce: maize 13%, rice 9%, sorghum 14%, millet 10%, cowpea 19%, groundnut 8%, soybean 5%, yam 16%, cassava 8%, cocoyam 10%, plantain 13%, other fruits 5%. These no doubt, represent massive losses in farm produce that ought to have been consumed and lost income if the commodities have been sold. This situation is further compounded by the fact that food availability has not been able to keep pace with the present rate of population growth.

Only when appropriate processing, storage and preservation techniques are developed and applied, will Nigeria break free from the shackles of poverty, which at present, is threatening to rock the nation to its foundation. The fact that fresh foods cannot be found at all times and in all places makes food processing essential if consumers are to remain satisfied.

One of the major problems facing the producer has always been that the crops he grows are generally ripe for harvesting during a single short period of the year. Yam, cassava, potatoes and other root crops have to be harvested when they are ready. Rice, millet and maize are ready for harvest after rains at the start of the dry season. A feasible solution to this problem is citing of specialised food processing plants close to the main producing areas.

These industrial factories can be set up to:

- Provide wholesome foods to the consumers
- See that the finished product meets all applicable government standard and regulations
- Ensure that food is produced under conditions acceptable to the governmental authorities.

As Nigeria embarks on her industrialisation effort, the products of its factories have to compete with imported goods so that her locally processed foods will be acceptable to consumers. The achievement of quality, therefore, cannot be accidental, in as much as it is the result of organised effort by the producer of the commodity.

In concise terms, the purpose of quality control is to provide information and the organisation necessary to achieve the production of good quality foods. To this end, the National Agency for Food Drug Administration and Control (NAFDAC) set up in Nigeria has established several quality standards for different products and has exposed a wide range of fake and adulterated products in recent times.

These standards and regulations established by NAFDAC are aimed at achieving the following:

1. Prevent adulteration
2. Prevent manufacture and processing of foods under unsanitary conditions
3. Control the use of chemicals and products as additives
4. Create awareness and sensitise the populace to the need to avoid patronising fake and substandard products.

However, very little has been achieved in terms of implementation and enforcement among both multinational and cottage industries. In Nigeria, only few food industries have quality control services. The majority take advantage of the fact that the few existing regulations are not effectively monitored and enforced. Not to be overlooked is the bureaucratic bottlenecks associated with prosecution of defaulters and the slow pace of Nigeria's judiciary system. Nevertheless, NAFDAC is undaunted in its avowed war against fake, adulterated and substandard products. Nigeria's survival, with the upsurge of population (with a projected figure of 230 million by 2020) lies in a sustained massive and coordinated production of foodstuff. These must be coupled with modern and scientific methods of food processing and preservation to offset colossal waste of foodstuff.

Modernisation of native Nigerian technology is a must if the nation is to overcome her food problems. Appropriate technology is important because it permits the optimum utilisation of available resources and improvements in food products that are peculiarly Nigerian. It would therefore be necessary to develop improved processing methods as has been done of late for *garri* (fermented cassava meal), *ogi* (fermented corn meal) and *iru (Parkia biglobosa)*, otherwise, development pressures will make these indigenous products disappear and Nigeria would then have to depend almost exclusively on foreign products. This is already happening with lager beer, imported canned beverages and fruit drinks vis-à-vis native beverages like *Pito, Burukutu, Kunnu, Tsobo (zobo)* and *Sekete*.

4.0 Conclusion

Food Science and Technology (FST) involve many disciplines which ensure the processing, wholesomeness, safety, and marketing of foods. It also deals with the ultimate metabolism and utilization in body cells.

5.0 Summary

In this unit we have learnt that:

- Food contains micro and macro nutrients.
- Food Science and Technology (FST) involve many disciplines including Chemistry, Engineering, Microbiology, Epidemiology, Nutrition, Toxicology and Molecular Biology.
- The sales, distribution and marketing of processed food are essential to make foods accessible.
- Food production and marketing are seasonal in Nigeria.
- Food quality control and the prevention of adulteration in the Nigerian Food Industries are regulated by NAFDAC.

Self-Assessment Exercise

Define Food Science and Technology. How is this discipline different from cooking or Home Economics?

6.0 Self assessement exercise

Define Food in terms of macro and micro nutrients. Suggest sources for the major macronutrient and micronutrients.

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Unit 2 Food Composition and its Functions

1.0 Introduction

Foods that are commonly consumed by humans include: Cereals, and Cereal Products, Starchy roots and tubers. Legumes (Pulses) leafy vegetables, fruits, nuts and seeds, sugars, syrups, sweets and preserves, meat, poultry and other meat products, sea food, shell fish, eggs, and roe, milk, cream and cheese, fats and oils, herbs and spices, non-alcoholic and non-dairy beverages, alcoholic beverages, dietetic preparations, miscellaneous (salt, maggi cubes, iru, vinegar and fermented condiments).

This unit will enable you to gain an insight into quantity and quality of the food you eat. You will be able to identify many of the major and minor chemical components in your food. It will be possible, by the end of the unit, to determine whether your diet fulfills the natural requirements to keep you healthy.

2.0 Objectives

By the end of this unit you should be able to:

- define the major and minor constituents of food
- describe the food major groups
- classify human foods according to their functions
- describe the functions of each food major group
- differentiate between high and low energy foods
- enumerate the deficiency symptoms of low food intake
- explain the consequences of processing on the nutritive values of food major groups.

3.0 Main Content

3.1 Food Groups Necessary in Human Diet

3.1.1 Bread and Cereal

Cereals common in sub-saharan Africa include corn, sorghum and millet. Corn differs from other cereals in that the yellow form contains carotenoids with *provitamin A* activity. Its other special feature is its low content of tryptophan. The niacin in corn is in a bound form that cannot be digested and absorbed by humans unless pre-treated with lime (calcium hydroxide) or by roasting. Most cereals contain little fat, although oats contain 7 percent. Wheat contains a type of dietary fibre (arabinoxylan hemicellulose) that is particularly valuable for treatment and prevention of constipation. It increases the bulk of the faeces and shortens the mouth-to-anus transit time. Bran is a concentrated source of the same dietary fibre.

Cereals are largely consumed as bread and to a lesser extent as cakes, crackers and breakfast cereals. They are also consumed in other forms in some countries; *e.g.*, boiled, crushed, or rolled, made into pasta, etc. Wheat and rice are the two major cereals for human consumption; wheat in Europe, North America, and northern India, and rice in East and Southeast Asia. The nutritional weakness of rice is its low thiamine and riboflavin (resulting in beriberi) content when it is milled to polished rice.

The bread-cereal group include all breads and cereals that are whole-grain or enriched. The protein content is not high in cereals, but these products can be a significant source of protein when they are consumed in large quantities. All cereals are very high in starch and are generally inexpensive sources of energy. The fat content of cereal products generally is very low unless the *germ* is included. Whole-grain products contribute significant quantities of fibre and such trace vitamins and minerals as pantothenic acid, vitamin E, zinc, copper, manganese and molybdenum.

3.1.2 Fruits and Vegetables

Fruits and vegetables have similar nutritive properties. Because 70 percent or more of their weight is water, they provide comparatively little energy or protein, however many contain vitamin C and carotene, two nutrients not found in cereals. Fresh fruits, particularly the citrus variety, and their juices are usually rich in vitamin C, which is easily destroyed when cooked. Fruits and vegetables also contain fibre, which adds bulk to the intestinal content and is useful in preventing constipation.

Most vegetables are important sources of minerals, vitamins and cellulose. Certain vegetables, such as potatoes, contribute appreciable quantities of starch. Large amounts of the minerals, calcium and iron are in vegetables, particularly beans, peas and broccoli. Vegetables also help meet the body's need for sodium, chloride, cobalt, copper, magnesium, manganese, phosphorus and potassium. Carotenes (the precursor of vitamin A) and ascorbic acid (vitamin C) are abundant in many vegetables. Vegetables are useful as sources of roughage. Citrus fruits are valuable sources of vitamin C and yellow-coloured fruits, such as peaches, contain carotene. Dried fruits contain ample amounts of iron. Figs and oranges are excellent sources of calcium. Like vegetables, fruits have high cellulose content.

3.1.3 Milk

The milk of each species of animal is a complete food for its young. One pint of cow's milk contributes about 90% of the calcium, 30 to 40% of the riboflavin, 25 to 30% of the protein, 10 to 20% of the calories and vitamins A and B, and up to 10% of the iron and vitamin D needed by an adult. The milks of mammals contain all essential nutrients. Human milk is the perfect food for infants, provided it comes from a *healthy, well-nourished mother* and the infant is full-term. Breast milk contains important antibodies, white cells and nutrients. In communities where hygiene is poor, breast-fed babies have fewer infections than formula-fed babies.

The milk group includes milk and milk products as well as cheese and ice cream. Milk is a complete protein food containing several protein complexes. It also contains important amounts of most nutrients, but it is very low in iron, ascorbic acid and niacin. Calcium and phosphorus levels in milk are very high. Vitamin A levels are high in whole milk, but this fat-soluble vitamin is removed in the production of skim milk. Riboflavin is present in significant quantities in milk unless the milk has been exposed to light.

Cow's milk is good food for human adults, but the cream (*i.e.* fat) contains 52 percent saturated fatty acids (longer than 10 carbon atoms in length) as compared to only 3 percent polyunsaturated fat. This fat raises the plasma cholesterol and is thought to be one of the dietary components that contribute to coronary heart disease, along with the same fat in concentrated forms (cream and butter). To circumvent this, the dairy industry has developed low-fat cow's milk (with 2 percent instead of almost 4 percent fat), very low-fat skim milk, or skim milk with extra non-fat milk solids (lactose, protein and calcium), which gives more body to the milk. Lactose, the characteristic sugar of milk, is a disaccharide made of the monosaccharides – glucose and galactose. While these monosaccharides are easily absorbed, lactose is not. Lactose passes to the large intestine, where it is fermented by the resident bacteria to produce gas and leading, sometimes, to diarrhoea.

In the late 1960's, it was discovered that the adults of many ethnic groups couldn't break down the lactose of large quantities of milk into galactose and glucose; they lose most of their intestinal lactase enzyme activity as they grow up (lactose intolerance). It is now recognised that such individuals share this deficiency with adults throughout the world, such as in Asia and Africa, and with most of the animal kingdom. People originating in northern Europe are the exception from the global viewpoint: they usually retain full intestinal lactase activity into adult life. People who have little of the enzyme lactase in their bodies can still take large amounts of milk if it has been allowed to go sour, if lactobacilli have split most of the lactose into lactic acid, or if the lactose has been treated with commercially available lactase.

The vitamin C present in milk is destroyed by heating (pasteurisation), which in many countries is required to prevent the milk from spreading bacterial and other infections. Cheese making is an ancient art formerly used on farms to convert surplus milk into a food that could be stored without refrigeration. Cheese is rich in protein and calcium and is a good source of vitamin A and riboflavin. Most cheeses, however, contain about 25 to 30% fat, which is mostly saturated, and they are usually high in salt (sodium).

3.1.4 Meat, Meat Substitutes, Fish and Eggs

Meats generally consist of about 20% protein, 20% fat and 60% water. The amount of fat present in a particular portion of meat varies greatly, not only with the kind of meat – pork, beef, lamb, etc. – but also with its quality. The "energy value" varies in direct proportion with the fat content. Meat is valuable for its protein, which is of high biological value. Meat also is an excellent source of B vitamins. Pork is the best source of thiamine, liver is next, and skeletal muscle, from any meat source, is third. Meat is also a good source of niacin, vitamin B_6, vitamin B_{12}, other vitamins of the B group, and the mineral nutrients iron, zinc, phosphorus, potassium, and magnesium. Liver is the storage organ for, and is very rich in, vitamins A and B_{12}. It is also an excellent source of riboflavin and folic acid.

The meat and meat substitutes group include beef, veal (calf's flesh), lamb, pork, organ meats such as liver, heart and kidney; poultry and eggs; fish and shellfish; and dried peas, beans and nuts. The meat group contains many valuable nutrients. One of its main nutrients is protein, but meat also contains cholesterol, which is believed to contribute to coronary artery disease. The minerals copper, iron and phosphorus occur in meats in significant amounts, particularly iron and copper in liver. Different meats vary in their vitamin content. Liver usually contains useful amounts of vitamin A, thiamine, riboflavin and niacin. All B vitamins occur in significant amounts in all meats.

The muscular tissue of fishes consists of 13-20% protein; varying amounts of fat, ranging from less than 1 to more than 20% and 60-82% water, varying inversely with fat content.

Exact proportions of nutrients vary among different species. Furthermore, variations also exist within the same species due largely to seasonal and feeding variations. The fatty acids in fish are largely polyunsaturated. One of the major fatty acids, eicosapentaenoic acid, in large amounts reduces the tendency to thrombosis.

Eggs have a deservedly high reputation as a food. The white is protein and the yolk is rich in both protein and vitamins A, D, E and B. Eggs also provide zinc, calcium and iron with little saturated fat and few calories; egg yolk, however, has high cholesterol content, which at elevated level in the bloodstream, can increase one's risk of coronary heart disease. Research has shown that consuming up to one egg a day is unlikely to increase the risk of coronary heart disease in healthy men and women. Eggs are better kept fresh in the refrigerator for 4 – 5 weeks whereas hardboiled egg will only last a week. Consumers are reminded that eggs age more in one day at room temperature than during one week in a refrigerator. All eggs should be cooked at low or medium heat and should be served when the white is completely coagulated and the yolk has begun thickening to prevent food poisoning. Eggs should not be cooked whole in the microwave oven (they'll explode).

3.1.5 Starchy Roots

Potatoes, cassava and yams are valuable and cheap sources of energy. Their nutritive value, in general, resembles that of cereals, but their protein content is lower. Protein deficiency may be common in tropical communities in which the staple food is cassava or yams. Potato, however, provides some protein – less than cereal does – but also contains some vitamin C. Sweet Potatoes contain the pigment beta-carotene, convertible in the body into vitamin A.

Although the quantity of protein in potatoes is only small (2%), its nutritive value appears to be high. Cassava contains half the protein of potatoes. There are toxic substances in some of the starchy root foods that have to be avoided or dealt with by careful preparation; *e.g.*, solanine in the green sprouts of potatoes and cyanide compound in the leaves and outer parts of the roots of cassava.

3.1.6 Legumes (Pulses)

Peas and beans resemble the cereals in nutritive value but have higher protein content and, since they are not subject to milling, are good sources of B vitamins. They are thus valuable supplements to cereal diets, especially in tropical or subtropical countries; moreover, they, particularly the soybean, are also valued for their taste. Soybean is especially rich in protein (about 38%) and is a major commercial source of edible oil. They are however known to be good sources of antinutrients, which, if not properly taken care of, could limit the uptake and utilisation of other essential nutrients.

3.1.7 Sugars, Preserves & Syrups

Sugars, mostly sucrose and high-fructose corn syrup, are added both in processing and at the table. Together sucrose and fructose provide 12% of the average total calories in adults and a little more in children. There are also naturally occurring sugars in foods (fructose, glucose, sucrose in fruits and some vegetables, and lactose in milk). Sugar contains no protein, no minerals, and no vitamins and thus has been called a source of "*empty calories*." Sugar is an excellent preservative because it adsorbs water and prevents the growth of microorganisms. Jams contain from 30 to 60% sugar, and honey and natural syrups (e.g. maple) are composed of more than 75 percent sugar.

3.1.8 Fat and Oil-Based Foods

Animal fats used by humans are butter, suet from beef, lard from pork, and fish oils. Important vegetable oils include oils from olive, peanut (groundnut),, coconut, cottonseed, sunflower seed, soybean, safflower, rape, sesame, mustard,, red palm and corn. All these are high in calories. Only butter (other than the previously mentioned fish-liver oils) contains any of the vitamins A and D, but red palm oil does contain carotene, which is converted to vitamin A in the body. Vitamins A and D in controlled amounts are added to margarines. Butter, margarine, other fats, oils, sugars, or unenriched refined-grain products are included in the diet to round out meals and satisfy the appetite. Fats, oils and sugars are added to other foods during preparation of the meal or at the table. These foods supply calories and can add to total nutrients in meals.

3.1.9 Beverages

Although most adults drink one to two litres of water a day, much of this is in the form of liquids such as coffee, tea, fruit juices, soft drinks, beer, wines, or spirits. In general, these are appreciated more for their taste or for their effects than for their nutritive value. Fruit juices are, of course, useful for their vitamin C content and good sources of potassium but low in sodium. Coffee and tea by themselves are of no nutritive value, except that coffee contains some niacin and tea contains fluoride and manganese, but they may be a vehicle for intakes of sugar, milk or lemon. Beer contains 2 to 6% alcohol, natural wines 10-13%, and most spirits up to 40 percent.

Since ethyl alcohol has an energy value of seven kilocalories per gram, very significant amounts of energy can be obtained from alcoholic drinks; in addition, beer and wine contain natural sugars as well. The only vitamin present in significant amounts in beer from a brewery is riboflavin. Wines are devoid of vitamins but sometimes contain large amounts of iron, probably acquired from iron vessels used in preparation, especially of cheap wine. It is possible for excess iron to be absorbed and stored in the liver where it may contribute to toxic manifestations.

3.2 Changing Food Habits and Related Problems

Traditional food habits in themselves have rarely been the cause of malnutrition and nutritional-deficiency diseases. The usual cause of such problems has been a simple lack of food, whether because of environmental conditions or of poverty. The poor in any society may be forced to consume less food or a more limited variety of foods than they require. If the staple is protein-low (e.g. cassava or plantain based), the poor who cannot afford legumes or animal products to supplement the staple may suffer from kwashiorkor; if the staple is maize, pellagra may become prevalent if other foods are not consumed along with the maize.

Advances in agricultural and food-processing techniques have led to increased food supply and a nutritionally enriched diet. Nevertheless, modernisation and westernisation of traditional food habits have also had their deleterious effects. For example, the wide acceptance of refined rice (like *Uncle Bens*, *Arosso*, *Tomato* etc) at the expense of locally parboiled rice (like *Ofada*, *Abakaliki, Ekiti* etc) at the turn of the 20th century caused a scourge of beriberi (a niacin-deficiency disease) in many developing countries, resulting in thousands of deaths. The substitution of bottle-feeding for breast-feeding among poor families has also been implicated in a great deal of malnutrition and diarrhoeal diseases in Nigeria.

Changing food habits have had harmful effects in the affluent developed nations, as well. The proportion of energy obtained from carbohydrates has dropped significantly (often ranging from 35 to 50%), while that obtained from fats and protein – particularly animal protein – is on a steady rise. This represents gross inefficient use of agricultural resources; in addition, the increasing sedentary nature of jobs and dependence on fast – foods as replacement for normal healthy meals increases nutritional deficiency diseases, even among the educated. Furthermore, the increased intake of saturated fat and cholesterol, coupled with inadequate exercises has been related to an increased prevalence of cardiovascular disease in both developing and developed nations. In the developed countries, about 40% of the calories supplied by their diets are derived from fat and about 20% from sugar. There has also been notable increase in fat and sugar intake especially in developing countries. However, fat and sugar crowd out other foods. In a population that is largely sedentary, this tends to lead to obesity and deficiencies in iron, calcium, complex carbohydrates and fibres – which can, in turn, cause a host of health problems.

3.3 Food Composition

3.3.1 Proteins

Proteins are essential structural and functional components of all living organisms. They are large molecules with widely varied properties and many different functions. Proteins consist of many amino acids linked together by *peptide bonds*. Haemoglobin, for example, is a red blood cell protein involved in the transport of oxygen. Enzymes are proteins that catalyse the chemical reactions of cells. Collagen is a major structural protein in bones, tendons and skin. Antibodies, which are critical components of the immune system, and crystallins, found in the lens of the eye, are proteins. Many hormones are proteins.

The primary functions of protein are to build body tissue, regulate functions such as muscle contraction and blood pressure, synthesize enzymes and some hormones (such as insulin, that regulate communication among organs and cells) and other complex substances that govern body processes.

Structure and Composition of Proteins

There are about 20 common amino acids in most proteins. The name of the acids comes from the stem word amine, meaning "derived from ammonia." Amino acids join together in long chains, the amino group (-NH-) of one amino acid linking with the carboxyl group (-COO-) of another. The linkage is known as a peptide bond ($-COONH_2$), and a chain of amino acids is known as a polypeptide. Proteins are large, naturally occurring polypeptides. A few rare amino acids and several other kinds of chemical substances – metal ions, heme, prosthetic groups derived from vitamins, carbohydrates and lipids – are also frequently present. The amino acids differ in structure and properties; each has an amino group, a carboxylic acid group and an alky side chain (-R). The side chains differ in size, structure and properties. Some are composed of only carbon and hydrogen atoms and are *hydrophobic* (water hating). Others contain oxygen and nitrogen atoms and are *hydrophilic* (water loving); some ionise and have positive or negative electrostatic charges. Each protein has a specific number and sequence of amino acids, where peptide bonds connect the amino group of one to the carboxyl group of the next. The resulting linear sequences give each protein a specific size, a unique three-dimensional structure and in one way or another, account for its properties.

Protein and Nutrition

Plants, bacteria and most other microorganisms synthesize all of the amino acids required for protein synthesis. Humans and most animals, however, cannot synthesise all of the amino acids and must obtain some of them from their diet. Proteins are usually readily available from both animal and plant sources. Of the 20 amino acids that make up protein, eight are considered essential – that is, because the body cannot synthesise them, they must be supplied ready-made in foods. If these essential amino acids are not all present at the same time and in specific proportions, the other amino acids, in whole or in part, cannot be used for metabolising human protein. Therefore, a diet containing these essential amino acids is very important for sustaining growth and health. When any of the essential amino acids is lacking, the remaining ones are converted into energy-yielding compounds, resulting in the excretion of its nitrogen. However, when excess protein is eaten, which is often the case in countries with heavy meat diets, the extra protein is similarly broken down into energy-yielding compounds. Because protein is by far more scarce than carbohydrates and yields the same 4 calories per gram, the eating of meat beyond the tissue-building demands of the body becomes an inefficient way of procuring energy. Foods from animal sources contain complete proteins because they include all the essential amino acids. In most diets, a combination of plant and animal protein is recommended: 0.8 grams per kg of body weight is considered a safe daily allowance for normal adults.

Increased risks of gout (disease with inflammation of the smaller joints, especially of the toe), certain cancers and heart disease have been correlated with high protein diets. Kwashiorkor, a protein-deficiency disease that primarily affects children 1 to 4 years old who are weaned on starchy foods, is still endemic to parts of Africa, Asia, and South America.

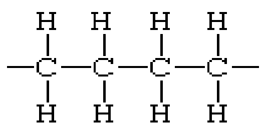
3.3.2 Fats

Fats or lipids are a family of chemical compounds stored by plants and animals as a source of energy. In most animals, fats are stored in special cells that tend to form pads of tissue under the skin and around certain organs and joints, the locations depending on the species. Stored fat, or adipose tissue, serves as a fuel reserve for metabolism. Fat protects the body from shocks, jolts and provides insulation. In plants, fats in the form of oil are found in the stems, seeds and fruit.

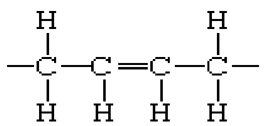
Fat is a concentrated source of energy, producing more than twice as much energy as equal amounts of carbohydrates and proteins. Being a compact fuel, fat is efficiently stored in the body for later use when carbohydrates are in short supply. Animals obviously need stored fat to tide them over dry or cold seasons, as do humans during times of scarce food supply. In industrial nations, however, with food always available and with machines replacing human labour, the accumulation of body fat has become a serious health concern. All fats are made up of units of glycerol and fatty acids. The kind of fatty acids eaten can affect a person's health. Saturated fatty acids found in butter, milk and other animal products can raise the level of cholesterol in the blood, thus leading to *arteriosclerosis*. Unsaturated fats found in vegetable oils can reduce high levels of blood cholesterol.

Dietary fats are broken down into fatty acids – the source of metabolic energy for muscle contraction – that pass into the blood to form the body's own triglycerides. The body's adipose tissue is in a constant state of build-up and breakdown, thus ensuring a continual supply of fatty acids. Fatty acids containing as many hydrogen atoms as possible on the carbon chain are called *saturated fatty acids* and are derived mostly from animal sources. *Unsaturated fatty acids* are those that have some of the hydrogen atoms missing; this group includes *monounsaturated fatty acids,* which have a single pair of hydrogen missing, and *polyunsaturated fatty acids,* which have more than one pair missing. Polyunsaturated fats are found mostly in seed oils. Saturated fats in the bloodstream have been found to raise the level of cholesterol, and polyunsaturated fat tends to lower it. Saturated fats are generally solid at room temperature; polyunsaturated fats are liquid.

The predominant substances in fats and oils are triglycerides, chemical compounds containing any three fatty acids combined with a molecule of glycerol. The fatty acids consist of a chain of carbon atoms with a carboxylic acid group (-COOH) at one end. The number of carbon atoms ranges from four to more than 22, but the most common chain length is 16 or 18. Because they are synthesised in the body from two-carbon units (acetyl coenzyme A), chain lengths are nearly always even numbers. Butyric acid is an example of a saturated fatty acid. The four valences of each carbon atom are attached to two hydrogen atoms and to the two adjacent carbons:



When adjacent carbon atoms are linked by a double bond, each has only one valence available for hydrogen:



When no double bonds are present, the fatty acid is said to be saturated; with the presence of one (monounsaturated) or more (polyunsaturated) double bonds, the fatty acid is said to be unsaturated.

Fats with a high percentage of saturated fatty acids tend to be solid at room temperature; *e.g.* butter and lard. Those with a high percentage of unsaturated fatty acids are usually liquid oils; *e.g.* sunflower, safflower and corn oils. In the shorthand notation for fatty acids, the number to the left of the colon is the number of carbon atoms, while the number to the right of the colon represents the number of double bonds; *e.g.* 4:0 has four carbon atoms and no double bonds (*i.e.* saturated). This is the shorthand notation for butyric acid.

A small group of fatty acids are essential in the diet. They occur in body structures, especially the different membranes inside and around cells, and cannot be synthesised in the body from other fats. Linoleic acid (18:2) is the most important of these fatty acids because it is convertible to the other essential fatty acids. Linoleic acid has two double bonds and is a polyunsaturated fatty acid. As well as being an essential fatty acid, it tends to lower the plasma cholesterol. Linoleic acid occurs in moderate to high proportions in many of the seed oils; *e.g.* corn, sunflower, cottonseed and safflower oils. Some margarines (polyunsaturated margarines) use a blend of oils selected so that they have a moderately high linoleic acid content. Edible fats and oils contain smaller amounts of other lipids as well as triglycerides).

3.3.3 Carbohydrates

Carbohydrates, which include cellulose, starches, sugars and many other compounds, are the most abundant single class of organic substances found in nature. They are formed in green plants by a process known as photosynthesis, in which energy derived from sunlight is used for the assimilation of carbon dioxide from the air. Most naturally occurring sugars belong to the D-series, the most common being the aldohexoses, which have six carbon atoms and four asymmetric centres. Aldohexoses include glucose, mannose, galactose and the fruit sugar fructose. The aldopentose sugars ribose and deoxyribose – having 5 carbon atoms – are important constituents of nucleic acids.

Disaccharides and polysaccharides are formed from two or more monosaccharides joined by chemical bonds. Glucose linked to fructose, forms the disaccharide sucrose (cane sugar); glucose linked to galactose forms the disaccharide lactose (milk sugar); glucose linked to glucose forms the disaccharide maltose. Starch, glycogen and cellulose are all chains of glucose units, differing only in their modes of bonding and degree of chain branching. Some biologically important sugar derivatives are sugar alcohols, sugar acids, deoxy sugars, amino sugars, sugar phosphates, muramic and neuraminic acids.

Carbohydrates function as the main structural elements and storage products of energy in plants. The principal forms are starch in plants and glycogen in animal tissues. These are polymers of glucose; they are deposited in cells in the form of granules when a surplus of glucose is available. In times of metabolic need, the polymers are broken down by enzymatic action and become fuel. Plants store starch in roots, tubers and leafy parts mainly during photosynthetic activity; some plants, such as sugar beets and sugarcane, also store sucrose.

Carbohydrates and Nutrition

Carbohydrates are the most abundant food sources of energy. The two kinds of carbohydrates are *starches* and *sugars*. Starches are found mainly in grains, legumes and pulses, roots and tubers and some rhizomes, while sugars are found in plants and fruits the most important being sucrose (obtained from sugarcane or the sugar beet). The carbohydrates containing the most nutrients are the complex carbohydrates, such as unrefined grains, tubers, vegetables and fruits, which also provide protein, vitamins, minerals and fats. Less beneficial sources are foods made from refined sugar, such as confectionery and soft drinks, which are high in calories but low in nutrients and fill the body with what nutritionists call *empty calories.*

A large part of the human diet consists of carbohydrates in the form of starch and sucrose. Both must first be broken down to their component sugars by digestive enzymes before absorption into the bloodstream can take place. In humans, carbohydrates are used by the cells in the form of glucose, the body's main fuel. After absorption from the small intestine, glucose is processed in the liver, which stores some as *glycogen,* a starch-like substance, and passes the rest into the bloodstream. In combination with fatty acids, glucose forms *triglycerides* – fat compounds that can easily be broken down into combustible ketones. Glucose and triglycerides are carried by the bloodstream to the muscles and organs to be oxidised. Excess quantities are stored as fat in the adipose and other tissues, to be retrieved and burned at times of low carbohydrate intake.

4.0 Conclusion

Cereals, roots and tubers supply energy and vitamin B complex, legumes and leafy vegetables supply proteins and carotenoids or pro-vitamin A, while meat, fish and eggs supply proteins. Animal fats contain mainly saturated fatty acids, whereas vegetable oils contain poly-unsaturated fatty acids which are essential to humans. Food therefore is composed of major nutrients such as proteins, Fats and Carbohydrates. It also consists of minor but essential nutrients such as vitamins and minerals.

5.0 Summary

In this unit we have learnt that:

- Foods can be classified into 17 major groups e.g. Cereals, Roots, Meat and Meat Products etc.
- Food contains different compositions depending on the group that it belongs to
- Cereals include Rice, Corn, Millet, Sorghum which supply low tryptophan needed for body build up of Niacin. Polished rice is also low in thiamine. Cereals however supply fibre.
- Legumes, Meat, and Milk supply high proteins but also legumes contain anti-nutrients.
- Fruits and vegetables contain 70% water but supply high vitamin C (Ascorbic acid)
- Milk and milk products are rich in proteins, while infants survive on breast milk which contains antibodies which prevents infections.

SELF-ASSESSMENT EXERCISE

1. Define major and minor constituents of food.
2. Classify Foods in terms of their composition, i.e. those that are rich in proteins, fats and carbohydrates and those that are rather rich in vitamins and minerals.

6.0 Self assessement exercise

1. Discuss the effects of food processing on the nutritive values of cereals and legumes.
2. Differentiate between animal fats and vegetable fats. Why are vegetable fats essential in human foods?

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Unit 3 The Role of Vitamins in Nutrition

1.0 Introduction

Vitamins are organic compounds that function mainly in enzyme systems to enhance the metabolism of proteins, carbohydrates, and fats. They are not synthesised in the body hence must be obtained, therefore, from outside sources as food. Exceptions to this definition include vitamin D, which is synthesised in the body to a limited extent, and vitamins B_{12} and K, which are synthesised by bacterial flora in the intestinal tract. Without these substances, the breakdown and assimilation of foods could not occur. Certain vitamins participate in the formation of blood cells, hormones, nervous-system chemicals, and genetic materials. Vitamins and minerals function as "*cofactors*" in the metabolism of products in the body. Most aspects of body metabolism proceed with the aid of specific enzymes, but if additional catalysts were not present – for example, the cofactor vitamins and minerals – the reactions would proceed so slowly that they would be ineffective.

Vitamins are classified into two groups, the fat-soluble and the water-soluble vitamins. Fat-soluble vitamins include vitamins A, D, E, and K. The water-soluble vitamins include vitamin C and the B-vitamin complex.

2.0 Objectives

By the end of this unit you should be able to:

- define a vitamin
- list the fat soluble vitamins
- list the water soluble vitamins
- discuss dietary sources of the vitamins
- explain the deficiency symptoms of three named vitamins.

3.0 Main Content

3.1 Vitamins

3.1.1 Fat Soluble Vitamins

3.1.1.1 Vitamin A (Retinol)

Vitamin A is found in animal foods, especially in liver of land animals or fish. It exists in a variety of forms, including retinol, which is currently considered the most active form. Most of the world's population, however, derive most or all of their vitamin A from plant foods, many of which contain the yellow-orange pigment carotene. Carotene, a pigment in some plants, can be converted in the human body to vitamin A. One molecule of *β*-carotene can be cleaved by an intestinal enzyme into two molecules of vitamin A. The pigment *β*-carotene occurs in fruits such as apricots, peaches, melons, mangoes and pumpkins. It is also a companion of chlorophyll, the green pigment in leaves, so that green vegetables are good sources. Enough vitamin A is stored in the liver of a well-nourished adult to last about two years of deprivation.

Vitamin A has many important functions in the body that relate to the maintenance of membrane integrity, especially of epithelial cells and mucous membranes. It is also essential for bone growth, reproduction and embryonic development. Vitamin A deficiency results in *night blindness*, in which the ability of the eye to see in dim light is impaired, permanent blindness and extremely dry skin *Hypervitaminosis A*, which results from excessive intake over a long period of time, is most common in children. Symptoms consist of irritability, vomiting, loss of appetite, headache, dry and scaling of skin.

3.1.1.2 Vitamin D

Dairy products, eggs and cod liver oil are good sources of vitamin D. The active forms of vitamin D are *ergocalciferol* (vitamin D_2) and *cholecalciferol* (vitamin D_3), both of which arise in the body from ingested precursors by exposure of the skin to ultraviolet light. Vitamin D primarily regulates calcium metabolism by determining the movement of calcium from intestines to blood and from blood to bone. It interacts with parathyroid hormone and calcitonin in controlling calcium levels. Thus, vitamin D is today more legitimately considered a hormone rather than a vitamin. In tropical countries, where exposure to sunlight is high, vitamin D deficiency is rare. Ultraviolet irradiation of food products increases their vitamin D content.

Whether formed in the skin from a derivative of cholesterol or taken from the diet (*e.g.,* in fatty fish and dairy products), vitamin D is changed in the liver to 25-hydroxyvitamin D. This is further changed in the kidney by an enzyme (regulated by parathormone) to 1,25-dihydroxyvitamin D (1,25-$(OH)_2$ vitamin D), the active form. The best-known action of activated vitamin D at the cellular level is to turn on synthesis of calcium transport protein in the cells lining the small intestine.

A deficiency of vitamin D results in failure to absorb calcium and phosphorus, causing faulty formation of bone. In children, the syndrome is known as *rickets* and is manifested by deformities of the rib cage and skull and bowlegs. Adult rickets, or *osteomalacia*, is characterised by generalised bone decalcification and, eventually, gross bone deformities. Symptoms of *hypervitaminosis D* consist of weakness, fatigue, lassitude, headache, nausea, vomiting and diarrhoea. Urinary symptoms occur when calcium deposits build up in the kidneys (kidney stones).

3.1.1.3 Vitamin E

Vitamin E, chemically known as *alpha tocopherol*, is the most active of the group of tocopherols. It is present in seed oils, especially wheat-germ oil, margarine, seeds and green leafy vegetables. Vitamin E protects fatty acids and cell membranes from oxidation. Few vitamins have been implicated for more diseases than has vitamin E, including such diverse disorders as coronary artery disease, muscular dystrophy, habitual abortion and schizophrenia (mental disease marked by a breakdown in the relation between thoughts, feelings and actions, and often with delusions and retreat from social life). Thus far, vitamin E is considered to have possible value in decreasing the risk of cancer. It is relatively non-toxic.

3.1.1.4 Vitamin K

Vitamin K, found mainly in green leafy vegetables egg yolk, liver and fish oils, is essential for synthesis by the liver of several factors necessary for the clotting of blood. Although the alphabetical letters for most vitamins are arbitrary, the letter *K* came from the German *Koagulationsvitamin*. One vitamin (K_1) occurs in some plant foods; others (the vitamin K_2 group) are formed by bacteria in the large intestine Chemically, *phylloquinone* is the natural plant source of vitamin K, and a synthetic derivative, *menadione*, is used therapeutically. Although deficiency of vitamin K rarely occurs, when it does the result is uncontrolled bleeding. It is used medically in treating specific deficiencies that occur during anticoagulant therapy, in haemorrhagic disease of the newborn, and in *hepatocellular* (liver related) diseases.

3.2 Water Soluble Vitamins

3.2.1 Thiamine (B1)

Thiamine, the first B vitamin to be identified chemically in 1926, consists of a complex organic molecule containing a pyrimidine and a thiazole nucleus. In the body, it functions as a coenzyme in the form of thiamine pyrophosphate and is important in alcohol, some amino acids and carbohydrate intermediary metabolism. Alcoholics are at special risk of thiamine deficiency because the more alcohol a person drinks, the less thiamine-containing food he consumes. Alcohol requires thiamine for its metabolism, and body's reservoir of thiamine is smaller than for any other vitamin. It only takes about 30 days without thiamine intake before signs of deficiency appear, provided the calorie intake is maintained. The symptoms of thiamine deficiency are known as *beriberi*, a syndrome consisting primarily of peripheral neuritis marked by sensory and motor paralysis of the limbs and, finally, heart failure. Thiamine deficiency is prevalent during damage and most often occurs in nutritionally deficient alcoholics. Thiamine is found in whole-grain cereals, meats, yeasts, and nuts.

When thiamine is deficient, the two most prominent biochemical abnormalities are *the accumulation of pyruvic acid*, because the enzyme that processes pyruvic acid for entry into the tricarboxylic acid cycle cannot function without thiamine, and *disturbances in areas of the nervous system*, a system highly dependent on glucose as fuel and thus requiring thiamine as an essential coenzyme for three steps in glucose metabolism. Thiamine deficiency can lead to *beriberi*, *Wernicke's encephalopathy* in association with *Korsakoff's* syndrome, or a *peripheral neuropathy* (a disorder of the peripheral nervous system). Beriberi is a high-output cardiac failure associated with general dilatation of small blood vessels in response to accumulation of pyruvic and lactic acids. It was formerly common in rice-eating peoples of East Asia but is now rare. In Wernicke's encephalopathy, the abnormalities are in the central part of the brain. There is progressive mental deterioration, disorientation, and a characteristic paralysis of eye movements. Like beriberi, it responds dramatically to injection of thiamine, but unlike beriberi, there may be a residual abnormality of memory. Thiamine deficiency is one of many causes of peripheral neuropathy, generally involving an impairment of the sensory, motor and reflex functions of the limbs. However, other B-vitamin deficiencies and a number of toxins can produce a similar effect. Response to nutrient therapy always takes weeks and it is advisable to treat the disease with multiple B vitamins. Good sources of thiamine are cereals, yeast, meat (pork, liver, poultry), nuts, beans, potatoes, egg yolk, milk, peanut butter, enriched and whole grain bread.

3.2.2 Riboflavin (B_2)

Riboflavin is a fluorescent yellow-green water-soluble vitamin colour which plays a vital role in intermediary metabolism. It has a complex organic ring structure to which the sugar ribose is joined. In the body, riboflavin is conjugated by phosphate to yield riboflavin 5'-phosphate (FMN) and by Adenine Dinucleotide to yield Flavin Adenine Dinucleotide (FAD). Both serve as coenzymes for a wide variety of respiratory proteins. Riboflavin deficiency in humans is characterised by growth failure in children, nerve degradation (particularly of the eyes), sore throat; seborrheic dermatitis of the face (and body mass) and anaemia. The only established use of riboflavin is in the therapy or prevention of deficiency disease. Food sources include: dairy products (milk, cheese), meat (liver, kidney, poultry), fish, wheat, yeast, enriched and whole grain breads.

3.2.3 Niacin (B_3)

Niacin is a water-soluble vitamin that is made in the human liver by the conversion of the amino acid tryptophan. If the protein intake is low, pre-formed niacin must be provided in the diet; if the protein intake is generous, the body makes its niacin from the tryptophan. Some animals (such as cats) do not have this ability. Two forms of niacin exist: nicotinic acid and nicotinamide. In the body, niacin is present in Nicotinamide Adenine Dinucleotide (NAD) and Nicotinamide Adenine Dinucleotide Phosphate (NADP), which serve as coenzymes in conjunction with protein in tissue respiration and also as dehydrogenases.
Pellagra, caused by niacin deficiency, is characterised by a cutaneous eruption, which at first resembles sunburn because it affects the areas of the body exposed to sunlight. The tongue becomes red and swollen, with excessive salivary secretion. Diarrhoea also occurs along with nausea and vomiting. Later, central-nervous-system symptoms appear with headache, dizziness, insomnia, depression and even overt psychosis with hallucinations and other mental disturbances.

Nicotinic acid (in doses about 200 times the RDA) is used in medicine as a drug that lowers the cholesterol level in the plasma. This is an example of a pharmacological action of a nutrient. Because nicotinic acid in large doses lowers blood lipids, it has been extensively used in the therapy and prevention of arteriosclerotic vascular disease. It is also used in the treatment of pellagra. Toxicity may occur in the form of liver damage with large doses over a prolonged period. Food sources of niacin are meat, poultry, dark green vegetables, cereals, whole grain or enriched breads.

3.2.4 Pyridoxine (B_6)

Pyridoxine, found mostly in whole-grain cereals, vegetables and meats, is a substituted pyridine ring structure that exists in three forms, all of which may be converted in the body to pyridoxal-5-phosphate (PLP), the active coenzyme form. PLP functions in human metabolism in the conversion processes of amino acids, including decarboxylation, transamination and racemization.

Pyridoxine in megadoses (100 and more times the RDA of around two milligrams per day) has been taken to ameliorate the effects of premenstrual syndrome (prescribed or selfmedication), but its efficacy has not been established. Symptoms of deficiency in humans consist of seborrhoea-like skin lesions of the face, increased irritability, convulsive seizures (particularly in children), kidney stones and neuritis (inflammation of nerves) resulting in degeneration of peripheral nerves. On the other hand, prolonged dosage of 500 milligrams and above of vitamin B_6 over a period of time causes damage to peripheral nerves, with a loss of sensation in legs and hands.

3.2.5 Pantothenic Acid

Pantothenic acid was first identified in 1933 as a factor necessary to cure certain skin lesions in chicks. It is found mainly in milk products, liver, eggs, grains and legumes. Pantothenic acid is converted to coenzyme A, which serves a vital role for a variety of reactions involving transfer of 2-carbon fragments (acetyl groups). It is also essential for the production of metabolic products crucial to all living organisms. Pantothenic acid has no specific curative indications but is included in multivitamin preparations.

3.2.6 Folic Acid

The name comes from Latin *folia* ("leaf"). This vitamin is found in animal organs, legumes, whole-grain cereals, as well as vegetables. Chemically, folic acid is pteroylglutamic acid. In the body, folic acid is converted to folinic acid (5-formyl-tetrahydrofolic acid), the coenzyme form, which accepts 1-carbon units important in the metabolism of many body compounds.

The main function of folic acid is in the synthesis of DNA, thus in folic acid deficiency, replication of DNA and cell division are slowed or stopped; nucleic acid synthesis will also not take place. Cells that rapidly turn over, such as blood cells and epithelial cells lining the intestine are affected first. The requirement for folic acid is notably increased in pregnancy. It is sensitive to heat and is mostly destroyed when vegetables are over-boiled. Folic acid deficiency can occur in late pregnancy, when the requirement is double that in other adults. It is also fairly common in patients with diseases in which cell division is increased; *e.g.,* in blood diseases or cancer. The most common cause of vitamin B_{12} deficiency is pernicious anaemia, in which absorption of the vitamin is defective because of the failure of the stomach to secrete a special protein (intrinsic factor) that assists absorption of vitamin B_{12} in the lower intestine. Dietary deficiency occurs in vegetarians, who eat no animal food. It takes five or more years of such a diet before symptoms appear because the stores of vitamin B_{12} in the liver (about 1.5 milligrams are enough to last about five years with the daily requirement as small as one microgramme).

Deficiency in humans results in various anaemias and diarrhoea. Deficiency can also be induced by antivitamins such as methotrexate, which is used in cancer chemotherapy. Folic acid is present in many common foods like vegetables and liver – but can be destroyed by excessive cooking. Deficiency is relatively rare unless caused by an antivitamin or pregnancy.

3.2.7 Cyanocobalamin (B_{12})

Vitamin B_{12}, the last of the vitamins to be isolated in 1948, is chemically the most complex of all the vitamins. It has the highest molecular weight (1,355) compared with any vitamin, and is absorbed by a complex mechanism. It has a central ringed structure called a corrin nucleus, linked to an amino propanol esterified by a nucleotide, and also an atom of cobalt to which is attached a cyanide group. Few vitamins are as important metabolically as B_{12}, because it is involved in many of the synthetic steps required in the manufacture of nucleoproteins and proteins. Almost all organisms need this vitamin but only in very small amounts.

The ability to absorb this vitamin depends on the production by the stomach of an intrinsic factor, a glycoprotein. Cases of B_{12} deficiency often involve patients with defective production of this intrinsic factor. Failure of absorption (pernicious anaemia) is more common than dietary deficiency. Vitamin B_{12} is found only in animal foods, so that *vegans* (pure vegetarians) are at risk of deficiency over the course of several years. The requirement of vitamin B_{12} (with vitamin D) is the smallest of all the vitamins, only two micrograms per day. What is stored in the liver is enough to last for five years of deprivation. Vitamin B_{12} participates with folic acid in DNA synthesis so its deficiency leads to a similar anaemia.

The symptoms of deficiency are identical to the classical syndrome of pernicious anaemia: ineffective manufacture of red blood cells; faulty myelin synthesis, leading to paralysing neuritis (inflammation of nerves) and a failure to maintain the epithelium of the intestinal tract. Marked anaemia and generalised debility, which eventually develop, are always fatal unless treated. Cyanocobalamin has only one established use, the treatment of this deficiency disease, but is included nevertheless in many multivitamin preparations. Food sources are mainly of animal origin, namely: milk, eggs, meat, poultry, fish, liver, kidney and heart.

3.2.8 Ascorbic Acid (Vitamin C)

Ascorbic acid is a plant sugar in the acid form, hexuronic acid. It is the opposite of vitamin B_{12} in that it is found in almost all plant foods, notably citrus fruits, green leafy vegetables and tomatoes, but not in meat. It is a powerful antioxidant and is required for the formation of collagen; *i.e.,* in wound healing. Unlike vitamins of the B complex, ascorbic acid does not act as a cofactor. In the body, ascorbic acid is reduced to dehydroascorbic acid and is involved in oxidation-reduction reactions. Vitamin C functions mainly in the formation and maintenance of intercellular ground substance and collagen in teeth, bone and connective tissue of blood vessels.

Symptoms of deficiency are manifested mainly in bone and blood vessels: teeth loosen because dentin is absorbed and the gums become spongy and bleed easily; haemorrhages in other tissues also occur easily with the slightest trauma. Vitamin C is used to prevent and treat scurvy and many other disorders, including various dental problems. Intake of very large amounts for long periods of time can be harmful, even though vitamin C is well tolerated, as it may contribute to the formation of kidney stones in the urinary tract. A daily intake of sufficient fresh orange juice provides enough vitamin C for most purposes.

3.2.9 Biotin, Choline and Inositol

Biotin, a complex organic acid containing sulphur, is a coenzyme for several carboxylation reactions involving carbon dioxide fixation. It is synthesized by intestinal bacteria and is widespread in food products like meats, vegetables and legumes. A natural deficiency in humans is unknown, even in individuals on extremely deficient diets.

Choline, a simple amino alcohol, is a component of lecithin and of acetylcholine, the latter of which is one of the most important neurotransmitters. Unlike most vitamins, choline can be synthesised in the body, provided that methionine intake is sufficient. It is present in large amounts in egg yolk, milk and seafood. Human deficiency rarely occurs.

Inositol is an isomer of glucose, the common sugar of human diets. It is a component of certain phospholipids. No coenzyme function has been established, but inositol promotes the growth of yeast.

4.0 Conclusion

Vitamins are micronutrients present in the body system regulating the metabolism of proteins, fats and carbohydrates. They are mainly obtained from dietary sources although some of them can be synthesized in the body system (e.g. vitamin D) and by bacterial flora in the intestine (e.g. vitamins B_{12} and K).

5.0 Summary

Fat-soluble vitamins are usually absorbed with foods that contain fat. They are broken down by bile in the liver, and the emulsified molecules pass through the lymphatic system and veins to be distributed through the arteries. Excess amounts are stored in the body's fat and in the liver and kidneys. Because fat-soluble vitamins can be stored, they do not have to be consumed every day.

With the exception of vitamin C (ascorbic acid), water-soluble vitamins belong mainly to what has been termed the B complex of vitamins. The better-known B vitamins are thiamine (B_1), riboflavin (B_2), niacin (B_3), pyridoxine (B_6), pantothenic acid, lecithin, choline, inositol, and paraaminobenzoic acid (PABA). Two other members are folic acid and cyanocobalamin (B_{12}). Yeast and liver are natural sources of most of these vitamins.

Self-Assessment Exercise

List the water soluble vitamins and fat soluble vitamins.

6.0 Self assessement exercise

1. Compare and contrast the functions of Vitamin A and Vitamin C.

2(a)Name two vitamins that are derived only from animal sources.

(b) Name two vitamins that are available mainly in plants and cereals.

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Unit 4 The Role of Minerals in Human

1.0 Introduction

Unlike sodium and potassium which are staple elements of the diet and are present in ample amounts in all food of vegetable and animal origins, certain minerals are additional dietary requirements. Although most are present in the average diet, these minerals may not always be ingested in quantities sufficient to satisfy metabolic needs, especially during growth, stress, trauma, blood loss and in some diseases. Minerals are classified as major or trace depending on the body's requirements. Major minerals are: calcium, magnesium, chlorine, phosphorus, potassium, sulphur, sodium and potassium. Trace elements are other inorganic substances that appear in the body in minute amounts and are essential for good health. Little is known about how they function, and most knowledge about them comes from how their absence, especially in animals, affects health. Trace elements appear in sufficient amounts in most foods. They include chromium, copper, fluorine, iodine, iron, selenium and zinc.

2.0 Objectives

By the end of this unit you should be able to:

- classify minerals in the body into major and trace elements
- discuss main metabolic functions of each mineral element through the deficiency symptoms
- identify major dietary sources of these mineral elements
- discuss the advantages of eating foods containing dietary fibre.

3.0 Main Content

3.1 Mineral Elements

3.1.1 Major Elements

3.1.1.1 Calcium

The body's requirements for calcium are generally met by eating or drinking dairy products, especially milk and cheese as well as dried legumes and vegetables. Most calcium (about 90%) is stored in bone, with a constant exchange occurring among blood, tissue and bone. The intake is balanced by losses in urine and faeces. The blood levels of calcium and its intestinal absorption, deposition, or mobilisation from bone are all controlled by a complex interplay of vitamin D, parathyroid hormone and calcitonin. Contrary to some long-held beliefs, high intakes of protein and phosphorus do not lead to a loss of calcium. Excessive dietary fibre, however, can hinder its absorption.

Calcium promotes bone rigidity and is important in maintaining the integrity of intracellular cement and cellular membranes. It also regulates nervous excitability and muscle contraction and may be protective against high blood pressure. During periods of growth, pregnancy and lactation, calcium intake should be increased. Diseases of calcium metabolism include vitamin D deficiency, hypervitaminosis D, hypo- and hyper-parathyroidism, and some forms of renal disease.

Calcium depletion is difficult to recognise because 99 percent of the calcium in the body is in the bones. A 1 % reduction of bone calcium is impossible to detect. This amount, though small, is quite large (it amounts to about 10 – 12 g). *Osteoporosis*, a calcium deficiency disease, is manifested by reduced bone mass for a particular length or volume of bone. This implies less mineral [calcium phosphate] and bone protein, and by extension, reduced or impaired bone mobility. Osteoporosis is common in postmenopausal women in industrial societies. It causes bone pain and a tendency to fractures. It clearly has multiple causes, including lack of exercise as well as the possibility of insufficient dietary calcium.

3.1.1.2 Phosphorus

Phosphorus plays important roles in conjunction with calcium in bone and teeth formation, acid-base balance maintenance, haemostasis of calcium and in reactions involving carbohydrates, lipids and proteins. The chemical energy of the body is stored in "high energy phosphate" compounds (ATP's). Elemental phosphorus is extremely poisonous, but phosphorus ingested as phosphates in the diets based on milk, cheese, yoghurt, fish, poultry, meats and grains, is not toxic. Deficiency is manifested in general body weakness and loss of calcium.

3.1.1.3 Magnesium

Magnesium is an essential element in human metabolism and functions in the activities of muscles and nerves, enzyme activation, protein synthesis and many other reactions. Magnesium is also important for maintaining the electrical potential in nerve and muscle cells. It is found mainly in whole grains and green, leafy vegetables. Magnesium deficiency results in growth failure, behaviour problems and occasional spasms. Magnesium deficiency may also occur in cases of alcoholism, diabetes mellitus, pancreatitis and renal diseases. Prolonged deficiency can cause changes in heart and skeletal muscle. Excessive retention of magnesium can occur in renal disease and results in muscle weakness and hypertension. A deficiency in magnesium among malnourished people, especially alcoholics, leads to tremors and convulsions.

3.1.1.4 Sodium

Sodium, which is present in small and usually sufficient quantities in most natural foods, is found in liberal amounts in salted prepared and cooked foods. It functions mainly in the maintenance of acid-base and body water balance, and nerve function regulation. Its depletion occurs, usually with accompanying water loss, as a result of massive loss of fluids as in severe cases of diarrhoea, vomiting and excessive urination. The patient ends up being weak and exhausted. Sodium depletion (usually accompanied by chloride depletion) occurs in a number of disease states. Deficiency results in muscle cramps, reduced appetite and mental apathy. Too much sodium causes *oedema*, an over accumulation of extra cellular fluid. Evidence now exists that excess dietary salt contributes to high blood pressure.

3.1.1.5 Potassium

Potassium occurs naturally in bananas, leafy vegetables, potatoes, milk and meats. It functions mainly in maintenance of acid-base and fluid balance and nerve transmission Depletion occurs in situations similar to sodium and may become obvious if sodium and water, but not potassium, are replaced. Potassium loss is especially likely to occur with diarrhoea or overuse of purgatives, with regular use of diuretic drugs (drugs causing increased output of urine), with corticosteroid treatment. In potassium depletion the serum-potassium level is low, there is weakness of voluntary muscles and intestinal peristalsis may stop. Under these conditions, the electrocardiograph shows low T waves. Deficiency results in muscle cramps, mental confusion, loss of appetite, and irregular cardiac rhythm

3.2 Trace Metals

3.2.1 Iodine

Iodine is found naturally in salt-water fishes, shellfish, dairy products and vegetables. The one important function of iodine is associated with the synthesis of thyroxine and the function of the thyroid gland. Persons living in coastal regions usually receive an adequate supply of iodine because of the high content in seafood. In geographic regions located far inland, however, a lack of iodine in food is apt to occur, causing goitre, so a small amount of iodine is often added by manufacturers of table salt (iodised salt). Elemental iodine is highly poisonous, and its only use in medicine is as an antiseptic.

Iodine is necessary for the synthesis of the hormones of the thyroid gland. In the absence of adequate iodine, the thyroid enlarges because of increased secretion of pituitary thyrotrophin. Where the frequency of endemic goitre is high, babies are often born with cretinism (a cause of mental defect and dwarfism), in addition, a large percentage of apparently normal people in the community develop abnormalities such as learning disabilities, deafness, a higher rate of stillbirths and malformed babies. Iodised salt is effective only in developed communities. For remote, isolated communities the best method of prevention is an injection of two millilitres of iodised oil to all women of childbearing age.

3.2.2 Iron

Iron is a vital component of haemoglobin and also of certain respiratory enzymes. The main function of iron is in the formation of haemoglobin, the red pigment of the blood that carries oxygen from the lungs to other tissues. Foods high in iron content include meat (liver and heart), Lean meats, eggs, whole grains, wheat germ, legumes and most green vegetables. Increased requirements for iron occur during the growth period, pregnancy, excessive menses and other instances of blood loss. An average diet containing 10 to 15 mg a day is adequate for most people. Iron deficiency, resulting in anaemia, can be treated by large amounts of iron in order to gain positive absorption.

Iron deficiency is common throughout the world, much more so in women than in men. Bleeding depletes the body of iron because each millilitre of blood contains 0.5 milligram of iron. When iron stores are empty, there is anaemia (reduced red blood cell count) with small cells containing less haemoglobin than normal (microcytic, hypochromic anaemia).

3.2.3 Zinc

Zinc, found mainly in lean meat, whole-grain breads and cereals, dried beans and seafood serves as a cofactor of dehydrogenases and carbonic anhydrase. Zinc loss occurs during such stress situations as surgical operations and its replacement aids in wound healing. Dietary programmes often promote zinc loss, while the use of concentrated zinc supplements can lead to calcium deficiency. Features of zinc deficiency in humans have been protean: various combinations of loss of taste, retarded growth, delayed wound healing, baldness, pustular skin lesions, growth failure, small sex glands, impotence in males, infertility in females, delayed wound healing, mental lethargy and reduced immunity to infections. Over ingestion of zinc or inhalation of its vapours can cause depression, vomiting and headache.

3.2.4 Fluorine

Fluorine is concentrated in the dental enamel and in bones as fluoride. It functions in bone structure maintenance and increases the resistance of the enamel to erosion by acid. The chronic toxic dose of fluoride starts at intakes of about five milligrams per day; the first sign is mottling of the teeth. Above 10 milligrams per day bony outgrowths may occur (skeletal fluorosis). The only foods that contain appreciable amounts of fluoride are tea and fish. In communities and countries where the drinking water is not fluoridated many obtain some fluoride from toothpastes, a few give fluoride tablets to children prophylactically, and dentists apply fluoride solution directly to their patients' teeth periodically. Deficiency results in osteoporosis and tooth decay.

3.2.5 Other Trace Minerals

Selenium, found mainly in seafoods, meat and grains, prevents breakdown of fats and other body chemicals. However, its deficiency is manifested in various forms of anaemia. *Copper* occurs naturally in meats and drinking water. It aids red blood cell formation. Deficiency results in anaemia and impaired bone and nervous tissue development. *Chromium* occurs naturally in legumes, cereals, organ meats, fats, vegetable oils, meats and whole grains. It functions mainly in glucose metabolism. Deficiency results in adult onset diabetes.

3.3 Dietary Fibre

Dietary Fibre can be defined as food material, particularly plant material, that is not hydrolysed by enzymes secreted by the human digestive tract but may be digested by microflora in the gut. It refers to the remains of plant cell walls, a complex mixture of carbohydrates that resist digestion in the intestinal tract and are therefore apparently of no nutritional value in the diet. Dietary fibre, also known as bulk and roughage, is essential in the diet even though it provides no nutrients. Human nutritionists have thus disregarded dietary fibre for many years.

Over the past two decades, however, there has been a widespread appreciation of the importance of dietary fibre for health. With the development of precise methods for measuring the different compounds present, the term *non-starch polysaccharide* (NSP) is preferred to the less-precise term dietary fibre. These include cellulose, hemicelluloses, pectins, fructans (e.g. inulin), gums and lignins. They are all polysaccharides (*i.e.,* unavailable carbohydrates) except lignin, which occurs with cellulose in the structure of plants. The various types of NSP can be divided into two broad groups: those that are insoluble (celluloses, some hemicelluloses and lignin) and those that are soluble in water (beta-glucans, pectins, gums, mucilages and some hemicelluloses), forming viscous gels. However, the Codex definition recognises that there are other materials that are not hydrolysed within the human digestive tract, the principal class being the resistant starches (oligosaccharides based on galactose, maltose and other sugars) and lignin. There are three forms of resistant starches: (a) protected starch molecules, (b) unswollen granules, e.g. potato starch and (c) retrograded starch. These materials (a – c) are resistant to digestion in the upper reaches of the alimentary canal and arrive intact in the colon where they are digested by the microflora of the gut, a definining characteristic of dietary fibre.

The increased bulk of high-fibre foods give them greater satiety value (that is, they make a person feel "full up"), which is beneficial in preventing obesity. More importantly, a diet low in fibre leads to constipation and the development of high pressures in the intestinal tract. This has been linked with the development of *diverticular* disease of the colon, hiatus hernia, *haemorrhoids* (piles), and varicose veins. All of these conditions are more common in people with a low intake of NSP, and high-fibre diets are protective.

High-fibre diets lower blood cholesterol thereby reducing the risk of heart disease. Bile salts are formed in the liver from cholesterol; normally some 30g are secreted daily in the bile. Most of this is reabsorbed and recycled. Fibre will bind a proportion of the bile salts (and cholesterol itself, which is also secreted in the bile), so that they are excreted in the faeces rather than being reabsorbed, thus causing more cholesterol to be used for bile salt synthesis.

High-fibre diet also reduces the risk of gallstone formation, since a high-fibre diet results in more bile salts and less cholesterol being present in the bile – it is the insolubility of cholesterol when its concentration in bile is high that causes the formation of gallstones. Bile salts have been implicated in the development of cancer of the large intestine. However, if the salts are bound to dietary fibre rather than being free in solution, they will not be able to interact with the intestinal wall in such a way to promote the development of tumours.

Dietary fibre has two further important effects in reducing the risk of cancer. All diets contain a number of potentially carcinogenic (cancer-causing) compounds; many of these will bind to dietary fibre, and so will be unavailable for absorption into the body, and unable to interact with intestinal cells. Furthermore, the intestinal bacteria ferment a proportion of the dietary fibre, and some of the products of this bacterial metabolism (especially butyric acid) have anti-proliferative action (that is, they help prevent cells from multiplying), and so will provide further protection against the development of intestinal cancer.
The food sources of fibre are fruits, vegetables, cereals (especially whole grain), whole-grain bread, wheat bran and products made from nuts and legumes. A diet overly abundant in fibre, however, can cut down on the absorption of important trace minerals during digestion.

4.0 Conclusion

Minerals are micro nutrients which can be classified into major elements and trace in organic components which are present in foods required for good health.

5.0 Summary

In this unit we have learnt that:

- Calcium and phosphorus are minerals required for bone and teeth formation. A small amount of calcium is however required in the serum which regulates nervous excitability and muscle contraction.
- Enzymes require magnesium for activation of the activities of muscle and nerves. Similarly Zinc is required as a cofactor in the dehydrogenases and carbonic anhydrases required in intermediary metabolism.
- Both sodium and potassium are elements found in small quantities for the maintenance of acid-base and body water balance, and nerve function regulation. Both minerals are involved in hypertension.
- Blood contains haemoglobin which requires iron as a cofactor. Lack of iron result in hypochromic and microcytic anaemia.
- Fluorine derived from water or dental sources, aid in the formation of strong teeth and bones.
- Eating foods containing fibre e.g. from leafy vegetables cereals and legumes promote many advantages even though fibre itself is not a nutrient.

Self-Assessment Exercise

Classify the mineral micronutrients according to their physiological functions in the body.

6.0 Self assessement exercise

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Discuss the role of minerals in enzyme activities.

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Unit 5 Food Poisoning

1.0 Introduction

Food Poisoning, in the broadest sense, refers to any condition in which a food causes a toxic reaction, whether as a result of *a toxin naturally present in the food* (for example, green or sprouting potatoes, partially cooked red kidney beans, many mushrooms and so on); *a toxin acquired by the food as a result of natural accident* (such as contamination of fish or shellfish with toxins from dinoflagellate organisms in plankton); *fungal spoilage leading to the production of mycotoxins in the food*; or *contamination of the food with toxins during agricultural processing* (for example, pesticide residues) or *food processing* (such as accidental contamination with industrial chemicals). It may also result from *ingestion of heavy metals* (intoxication) such as copper and mercury.

However, ***the term is generally reserved for gastrointestinal disease resulting from bacterial (or sometimes viral) contamination of foods***. Food poisoning (or intoxication) is generally characterised by the symptoms of nausea, vomiting, loss of appetite (anorexia), fever, abdominal pain or discomfort (gastroenteritis) and diarrhoea, in varying degrees.

By far the most important cause of food poisoning is contamination of foods with bacteria that do not cause any obvious spoilage, so that the food is still apparently fit to eat, but may contain hazardous amounts of toxins, or sufficient numbers of bacteria to cause infection in people eating the food. While in some cases the symptoms develop within a few hours of eating the contaminated food, in other cases there may be a delay of several days or even weeks before there are any signs of infection. Obviously in such cases, it is difficult to ascertain which food caused the infection.

2.0 Objectives

At the end of this unit, you should be able to:

- define food poisoning, botulism and cross contamination
- enumerate the types of botulism
- explain main sources of mineral poisoning
- enlist the symptoms of bacteria and mineral poisoning
- propose measures for the control of food poisoning.

3.0 Main Content

3.1 Causes and Management of Food Poisoning

3.1.1 Causes of Food Poisoning

Direct or indirect contamination of food may cause infections in man. The transmission of these diseases by food depends on the following conditions:

- The presence of a food that supports the growth of the microorganism

- The inoculation of the food with a sufficient number of microorganisms, which may come from a patient with clinical disease, a carrier, or from contaminated environment (water, sewage etc)
- Contamination at suitable temperatures for a period long enough to permit the growth of the organism or the elaboration of the toxin
- The absence of suitable treatment or processing of the food to inactivate the organism or the toxin
- Ingestion of food by the host.

This series of events usually occurs in a setting where there is a reservoir of organism in man, animals, or the environment; where knowledge and practice of food hygiene and personal hygiene is inadequate to prevent transmission of the organism; and where sanitation facilities are insufficient to prevent contamination of the environment with human excreta and its transfer to food.

Contamination of food leading to food poisoning can occur as a result of the way in which the food is handled and prepared. The major causes are:

3.1.1.1 Inadequate Cooking

Inadequate cooking of contaminated raw food and inadequate reheating of pre-cooked food, so that the temperature is not sufficiently high to kill the bacteria.

3.1.1.2 Food Storage Conditions

Keeping cooked food at temperatures that favour the growth of bacteria. *Bacillus cereus* is a special problem because it forms spores that are relatively resistant to heat, and these spores are commonly found on cereal grains. If cooked rice is kept warm, as often occurs in take-away restaurants, the spores germinate and the organism multiplies, producing its toxin.

3.1.1.3 Cross - Contamination between Raw and Cooked Food

Cross-contamination is commonly a problem in domestic food preparation, but may also occur, sometimes with dramatic effects, in industrial food processing. In one incident in 1994, some 224,000 people were infected with *Salmonella* as a result of pasteurised ice cream being carried in tankers that had previously been used to transport unpasteurised egg contaminated with *Salmonella enteritidis*.

3.1.1.4 Poor Personal Hygiene in Food Handlers

3.1.1.5 Ingestion of Toxins

The ingestion of naturally occurring poisons present in mushrooms, toadstools, fish and shellfish and other contaminants. Mushroom poisoning from mushrooms, such as *Amanita phalloides* or muscaria, result in sweating, cramps, diarrhoea, confusion and sometimes convulsions. Patients usually recover within 24 hours. If the infecting mushroom is *Amanita phalloides*, however, liver damage is common, leading to jaundice. Remissions may occur, but the mortality rate is about 60 percent or higher. Fish poisoning can result from Pacific types such as sea bass, Caribbean types such as *Cavallas*, Scrombroid types such as *Mackerel*, and Tetraodon types such as *Puffers*. Symptoms include numbness of the limbs, joint aches, chills and fever. Muscle weakness and paralysis can also occur, and death may result within 24 hours. Mussels and clams may ingest a poisonous dinoflagellate (red tide) from June to October that produces a toxin not destroyed by cooking. Symptoms include nausea, vomiting and abdominal cramps and death can occur as a result of respiratory failure.

3.1.1.6 Ingestion of Heavy Metals

Ingestion of heavy metals, such as lead and mercury, can cause acute nausea, vomiting and diarrhoea and may cause respiratory or nervous system damage over the long term. The severity of the symptoms depends on the irritant and the dose, as well as the resistance of the patient. Treatment includes bed rest, fluids and blood or plasma expanders in severe cases where shock is anticipated.

3.2 Types of Food Poisoning Organisms

Food poisoning organisms can be classified into four groups, depending on the mechanism involved in causing disease:

Organisms that Produce Toxin in the Food

The main examples of such food poisoning organisms are *Clostridium botulinum*, *Staphylococcus aureus* and some strains of *Bacillus cereus*. Here the problem is one of intoxication rather than infection, as occurs with the other classes of food poisoning organism. This means that if the food contains a significant amount of the toxin then subsequent cooking will not reduce the risk of food poisoning.

Clostridium botulinum **Food Borne Poisoning**

Botulism is poisoning caused mainly by eating food containing *Clostridium botulinum,* a poisonous bacterium. There are three main kinds of botulism. *Food-borne botulism* caused by eating foods that contain the botulism toxin; *wound botulism*, caused by toxin produced from a wound infected with *Clostridium botulinum*; *infant botulism*, caused by consuming the spores of the botulinum bacteria, which then grow in the intestines and release toxin. All forms of botulism are fatal and are medical emergencies.

Food-borne botulism is especially dangerous because eating a batch of contaminated food can poison a large number of people. The food-borne organism, which is derived from the soil, grows in many meats and vegetables. Its spores are killed by boiling for 30 minutes, while the toxins may be destroyed by moist heat at 80° C (176° F) for the same period. Because the spores grow best in the absence of oxygen, improperly processed foods in sealed containers offer a perfect environment for their development.

If food contaminated by the bacterium *Clostridium botulinum* is improperly canned or bottled, the bacteria are able to produce a toxin (botulin), which produces the disease botulism. Within 8 to 36 hours of ingestion of the contaminated food, the botulin toxin paralyses nerves regulating muscle function, resulting in respiratory failure, as the muscles that control breathing weaken. In addition, the toxin affects the central nervous system and interrupts nerve impulses, but the mind continues to function normally (symptoms usually appear 18 to 36 hours after ingestion). Disability progresses from difficulty in walking and swallowing, along with impaired vision and speech, to occasional convulsions, and ultimately to paralysis of the respiratory muscles, suffocation, and death, all within a few hours or days, depending on the amount of toxin ingested.

The most direct way to confirm diagnosis is to demonstrate the presence botulinum toxin in the patient's serum or stool by injecting serum or stool into mice and looking for signs of botulism. The bacteria can also be isolated from the stool of persons with food-borne and infant botulism.

Botulism antitoxin may be effective if administered early. Surgical opening of the trachea and use of a respirator may be lifesaving. Physicians may try to remove contaminated food still in the gut by inducing vomiting or by using enemas. The respiratory failure and paralysis that occur with severe botulism may require a patient to be on a ventilator for weeks. Research into the use of botulism in biological warfare has produced a toxoid, an inactivated poison for use in a vaccine, to induce immunity.

Staphylococcus Food Borne Poisoning

The most common species of Staphylococcus is *Staphylococcus aureus* (also known as *Staphylococcus pyogenes*), which is found on the skin, mouth, external ear and in the nostrils of many healthy individuals. Another species of staphylococcus, *Staphylococcus epidermidis (Staphylococcus albus),* is very widespread but is not normally pathogenic. However, either of these bacteria can cause serious infections under the right conditions. For example, they may infect wounds or give rise to *endocarditis* (inflammation of the heart membrane) if the host's immune system is weak. They may also cause pneumonia and internal abscesses. Although they do not form spores, staphylococci can survive for several weeks in dry conditions. Some strains can withstand high temperatures; they do not often grow outside the body, but may do so in meat, milk or dirty water.

The various species of *Staphylococcus* bacteria multiply rapidly at room temperature and may directly infect the gastrointestinal tract. This is due largely to careless food handling: workers may sneeze or cough on food or may have infected pimples or wounds on the hands or face and transmit the bacteria to the food. *Staphylococcus aureus* infections are characterised by the presence of pus and formation of abscesses.

This form of staphylococcus is responsible for skin pustules (pimple containing pus), boils and carbuncles (severe skin abscess), impetigo (contagious skin infection forming pimples and sores), infections of wounds and burns, breast abscesses, whitlow, osteomyelitis, bronchopneumonia, septicaemia (blood-poisoning), acute endocarditis, food poisoning and scalded skin syndrome. Symptoms of nausea, vomiting and diarrhoea develop 1 to 8 hours after exposure to the *Staphylococcus* bacteria. Treatment is usually a combination of fluid and electrolyte replacement; deaths are rare. Much more rarely, *Staphylococcus aureus* give rise to more serious infections when the resistance of a tissue or the host is reduced.

3.2.2 Organisms that Multiply in the Intestinal Tract and Produce Toxins that Causes the Symptoms

Such organisms may multiply in the intestinal cavity (for example, some strains of *Bacillus Cereus* and *Clostridium perfringens*), in which case the onset of symptoms is relatively rapid after eating the contaminated food, and the infection lasts generally for only a day or so. Other organisms, including the various pathogenic strains of *Escherichia coli*, species of *Aeromonas* and *Vibrio cholerae* (causing cholera) invade and multiply inside the cells of the intestinal wall, secreting toxins. The onset of symptoms from such organisms is typically one to two days and the symptoms may last for several days.

Escherichia coli Food Borne Poisoning

E. coli infection is a potentially fatal form of food poisoning caused by certain strains of the bacterium *Escherichia coli.* Some 5 million *E. coli* bacteria normally inhabit the human and animal intestinal tract, and are vital to processing vitamins in the diet. However, a number of strains are pathogenic and cause gastroenteritis. Some strains, known as entero-pathogenic strains, are associated with undercooked meat, and are a common cause of diarrhoea in infants, but rarely produce gastroenteritis in adults. Other "entero-toxicogenic" strains are the main cause of "travellers' diarrhoea". A relatively large number of organisms (100 million or more) are normally required to cause such infections, which are generally associated with food and water contaminated by faeces.

Entero-invasive strains of the bacterium invade cells of the intestines, causing dysentery, with bloody diarrhoea. These are highly virulent strains, and ingestion of just a few organisms may cause infection. Outbreaks of such infection have been associated with undercooked hamburgers and unpasteurised milk. The entero-haemorrhagic strains are also highly virulent, causing both bloody diarrhoea and possibly fatal systemic infection. In particular, the strain *E. coli* 0157:H7, which also exists in animals and humans, is thought to be a virally infected, highly toxic strain of the *E. coli* bacterium. Ingestion of as few as 10 organisms may cause intestinal haemorrhaging and possible kidney failure. The fatality rate from the infection is 50 per cent in children and the elderly. The main source of infection is undercooked beef that has been contaminated, often in abattoirs, with faeces containing the bacterium. Infection through nursing of victims can also occur. Once infected, people in confined areas can pass on the infection.

Certain rare strains of the bacteria *Escherichia coli* cause food poisoning in young children, the elderly, and people with impaired immune systems. *E. coli* 0157:H7 normally found in the intestines and faecal matter of humans and animals, can survive in meat if the meat is not cooked past 155°F. Outbreaks are due mainly to contaminated cooked meats bought from local retail butchers. These incidences underscore the need for improved food regulations, preparation and hygiene as bacteria from meat surfaces are incorporated during grinding and cutting, and subsequent insufficient cooking.

Symptoms appear after four to nine days, and include bloody diarrhoea, cramping pain and fever. Complications include septicaemia, kidney failure and brain damage. There is no cure for *E. coli* infection. Patients recover once the infection has run its course, although digestive and renal problems may persist. Prevention is by maintaining high standards of food hygiene. This includes always washing the hands before handling food, scalding the utensils used to prepare meat and keeping raw meat separate from other foods and kitchen surface areas during preparation. Meat should be thoroughly cooked to 70° C (160° F).

Vibrio Cholerae Infection

Vibrio cholerae cause cholera, a severe infectious disease endemic to tropical countries and occasionally spreading to temperate climates. The major means of infection is through the use of contaminated water in cold drinks and in the preparation of foods such as fruits and vegetables. In addition, ready-to-eat foods may be contaminated by storage in contaminated containers or by sprinkling with contaminated water. The symptoms of cholera are diarrhoea and the loss of water and salts in the stool. In severe cholera, the patient develops violent diarrhoea with characteristic "rice-water stools", vomiting, thirst, muscle cramps and sometimes, circulatory collapse. Death can occur as quickly as a few hours after the onset of symptoms. The mortality rate is more than 50% in untreated cases, but falls to less than 1% with effective treatment.

Prevention of the disease is therefore a matter of sanitation. Treatment consists mainly of intravenous or oral replacement of fluids and salts containing the correct mixture of sodium, potassium, chloride, bicarbonate and glucose. A vaccine made from dead bacteria is commercially available and offers partial protection for a period of three to six months after immunization.

3.2.3 Organisms that Invade the Body, but: (a) Generally Remain in the Region of the Intestinal Tract (b) Cause Widespread Systemic Infection

Organisms like species of *Campylobacter*, *Salmonella*, *Shigella* and *Yersinia* remain in the intestinal tract. The onset of symptoms is relatively slow (up to several days after eating the contaminated food) and the infection may persist for weeks. Organisms that invade and cause systemic infections in the body include *Listeria monocytogenes, Salmonella typhi* (causing typhoid fever) and *Salmonella paratyphi*. The onset of symptoms may occur many days after consuming the contaminated food and symptoms may persist for many weeks.

Salmonella Food Borne Infection
Salmonella is a genus of infectious bacteria, named after the American veterinarian Daniel Elmer Salmon, who first isolated it in 1885. The organism is transmitted through contaminated poultry, eggs and certain other foods. Three species are recognised: *Salmonella typhi, S. cholerasius* and *S. enteritidis,* which have more than 1,400 antigenically distinct serotypes. *S. typhi* cause typhoid fever. *S. typhimurium,* a serotype of *S. enteritidis,* causes salmonella gastroenteritis, a type of food poisoning characterised by abdominal pain, fever, nausea and vomiting, and diarrhoea. The incubation period is 8 to 48 hours, and an attack may last from three to seven days. Mild cases usually are treated with anti-diarrhoeal remedies while more severe cases require antibiotics. *S. enteritidis* occurs in most flocks of hens, thus undercooked chicken or eggs are the usual source of infection. Careful cleaning and thorough cooking of food prevent salmonella infections.

Typhoid Fever
Typhoid fever is an acute infectious disease caused by the typhoid bacillus *Salmonella typhi.* The bacillus is transmitted by milk, water, or solid food contaminated by faeces of typhoid victims or of carriers (healthy people who harbour typhoid bacilli without presenting symptoms). The incubation period of typhoid fever lasts one to three weeks. The bacteria collect in the small intestine, from where they enter the bloodstream. This induces the first symptoms, chills followed by high fever and prostration. Victims may also experience headache, cough, vomiting and diarrhoea. The disease spontaneously subsides after several weeks in most instances, but in about 20% of untreated cases the disease progresses to pneumonia, intestinal haemorrhage and even death.

Compulsory inspection of milk and water supplies, and the pasteurisation of milk in particular, have greatly reduced the incidence of the typhoid bacilli. Of equal importance in the control of typhoid fever has been the recognition of carriers (who can then be prevented from handling food), and improvement of sewerage facilities. Another important factor in the control of typhoid fever is typhoid inoculation of people exposed to the disease, such as hospital employees and travellers to areas with poor sanitary facilities.

3.2.4 Other Microbial Infection

Clostridium perfringens, found mainly in poultry products, cause mild form of food poisoning. Symptoms include abdominal pain, nausea, diarrhoea and vomiting. Symptoms last only a day and starts about 8 – 22 hours after ingestion.

In *Shigella* infection, no specific food is dominant. It is however found in chicken spread, fruit and fish salad. It is characterised by sudden appearance of abdominal pains, cramps, diarrhoea, fever and vomiting; blood, pus and mucous may be found in stools of about $^{1}/_{3}$ of infected patients.

3.3 Control of Food Poisoning

Around the world there are enormous variations in climate, eating habits, cooking methods, food storage and preservation, and public health advice. Recommended food hygiene practices must therefore take these conditions into consideration. Food Hygiene refers to the totality of practices in food handling that help keep food clean and safe to eat in order to avoid food poisoning. People's attitude to the importance of food hygiene will depend upon their awareness, education and the standard of living they can afford. Food hygiene regulations have been brought into force in many countries around the world to protect the public and reduce the number of outbreaks of food poisoning. These regulations must be followed by anyone responsible for handling food in the food business.

3.3.1 Food Hygiene at Home and the Catering Industry

Food hygiene advice falls into three main sections: personal hygiene, cleanliness of the food area and food hygiene practice.

Personal Hygiene
Prevention of food poisoning starts with personal hygiene. Food poisoning bacteria can be found on human skin, hair, and clothes, and in ears, noses, mouths and faeces. If people touch affected parts of their bodies during the preparation of food, they can transfer the bacteria to the food. This is why hands must always be washed **before** working with food, **especially after visiting the toilet**. The bacterium *Staphylococcus aureus* is found in the human nose, infected wounds and boils, so cuts and grazes must be covered to avoid food contamination. Clean, protective clothing such as aprons or overalls should also be worn during food preparation.

In food businesses, food handlers should not work with food if they are suffering from or are carriers of food-poisoning infections as they can accidentally contaminate foodstuffs. Many food factories insist that workers' hair and beards are covered with hats and nets. Food handlers should not smoke, chew tobacco, or spit in food-preparation areas.

At home, be sure to wash your hands in hot soapy water before preparing each dish. Always wash after using the bathroom, dealing with a child's hygienic needs (such as changing a diaper or wiping a nose), or handling any animal (including household pets). Wash fruits and vegetables in lukewarm water to get rid of insects and pesticide residue. In many cases, skinning, peeling and boiling are the best ways to cleanse foodstuff. With lettuce or cabbage, remove and throw away the outermost leaves.

Cleanliness of the Food Area

Areas where food is stored and prepared must be kept clean and free from pests and pets. Dirt, soil and food residues can harbour bacteria and pests. Detergents should be added to hot water, and the solution used to wipe down and clean surfaces, equipment, floors and walls. In addition, all utensils, cutting boards and countertops should be washed with hot soapy water after preparing each dish – especially after handling raw meat, poultry or seafood. Food waste should be regularly removed from the food preparation area. Bacteria grow rapidly in warm conditions, especially at the normal human body temperature of 37°C.

The danger zone is anywhere between 5°C and 63°C. Temperature control is important, so cold food must be stored correctly then cooked at a temperature high enough to kill bacteria. Although the refrigerator can inhibit the growth of dangerous bacteria, the temperature should not be greater than 4°C. The freezer should be –17°C.

Food Hygiene Practice

The most serious cross contamination occurs between raw foods and cooked foods, so they should not be stored together or prepared using the same equipment. Keep raw meat, poultry or seafood separate from other food **at all times** (when shopping, storing and preparing). Do not let the juices flow or drip onto each other or unto other food. Never put cooked food unto a dish that formerly held raw meat, fish or poultry, unless that dish has been washed thoroughly with hot soapy water.

It is also important to cook all food items thoroughly. If internal heat of food exceeds 70°C, even briefly, almost all bacteria, viruses and parasites will be killed. Poultry should be cooked even more than that, up to 80°C. Reheated foods should be brought to a temperature of 75°C or it should be hot and steaming. Avoid eating poultry that is still pink inside, eggs with runny yolks or whites, or fish that is not yet opaque and that you cannot readily flake apart with a fork.

When dining out, make sure the restaurant you visit satisfies the health standards required by law. Always order well-cooked meat when eating out. With take-away meals, make sure it is eaten within 2 hours from the time of purchase. If more time elapses, reheat the food to a temperature not less than 75°C.

If you are in doubt as to whether some food item is good or spoiled, play safe and throw it out. **Throw away any questionable food.** Granted, it is unwise to waste good food, still, getting sick from bad food may prove even more costly.

3.3.2 Health Education

Health education programmes are concerned with turning knowledge to action. The actions include:

- Changing food habits to incorporate the boiling of drinking water, cooking all food and avoiding raw meat and fish.
- Taking specific precautions including the adequate cooking of food and the avoidance of foods and food preparation methods that have caused outbreaks in the past.

- Avoiding long delays in consuming prepared food and following approved food sanitation methods and procedures.
- Giving positive support to community activities such as improvement of water supply and the construction and use of latrines
- Accepting expert advice on food hygiene and control of enteric diseases.
- Health education methods include both person-to-person contacts and the use of mass information media. The methods must be carefully chosen to match the educational level of the target group and effective use should be made of community leaders in the educational effort. The educational programme should be designed specifically for the community. The task is difficult since a number of anti-health factors exist. These include ignorance, superstition, lethargy and poverty as well as opposition from vested interests.

4.0 Conclusion

Food poisoning may occur as a consequence of non control of environmental temperature leading to growth of spores from microorganisms including Clostridium and staphylococcus species. Mineral poisoning from heavy metals may also occur from contaminations and cross-contaminations.

5.0 Summary

In this unit we have learnt that:

- Food poisoning may result from poor environmental and personal hygiene, storage conditions and contaminations.
- The most deadly and pathogenic microorganisms include 3 types of clostridium botulinum and staphylococcus aureus.
- Mineral poisoning may occur from heavy metals such as lead and mercury from contaminations.
- Other microorganisms that cause food poisoning include:

  - *Escherichia coli* especially in children and the elderly.
  - *Vibrio cholerae* which causes cholera.
  - Salmonella transmitted through contaminated poultry, eggs and certain foods.
  - *Salmonella typhi* which causes typhoid fever is transmitted by milk, water or solid food contaminated by faeces of carriers.

- The recommended control pressures against food poisoning include:

  - Good hygiene in the handling, processing and storage of foods.
  - Application of low Temperature: Refrigeration at less than 4^0C and deep-freezers at less than 17^0C.
  - Application of proper Health Education by applying methods from contacts and information media.

Self-Assessment Exercise

Enumerate the pathogenic microorganisms involving *Clostridium botulinum* and *Staphylococcus aureus* species.

6.0 Self assessement exercise

What are the major sources of food poisoning and how can they be controlled?

7.0 References/Further Reading

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