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ICAR-NET FOODTECHNOLOGY

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FOODTECHNOLOGY

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PREFACE

It is always a dream of the student to enter in IITs and other prestigious institutes, universities for better future in Research and industrial world. Every year ICAR conduct the national exam as ICAR-ARS-NET entrance in the field of Life Science, Biotechnology and Food technology. This textbook has the principal objective to understand the basics of biology and applied biology for competitive Entrance exams and other National exams as well. We have tried to provide an astonishingly great amount of information from the enormous and ever-growing field in an easily understanding form. It is transcribed in vibrant and crisp language to enhance self-motivation and strategic learning skill of the students and allowing them with a tool to measure and analyse their abilities and the confidence of winning in competitive exams. We have also tried to cover the updated knowledge for better understanding of Life Science in depth without the burden. The most noteworthy feature of this book is its crystal clear, up-to-date and extra information from which ICAR may ask the questions. We have tried to resist the temptation to include more and more information which may add the information but not increasing understanding of the basic concepts and critical thinking. We hope that this text book will be beneficial both to teachers and students.

ACKNOWLEDGMENT

We wish to acknowledge our heartfelt gratitude to our hardworking writer of this book Mr. Manpreet Sharma and Krisha Sharma for their patience and constant support during writing the book. We wish to acknowledge our heartfelt gratitude to our faculties, friends and colleagues Dr. Sandeep Chaudhary (PhD from INMAS-DRDO), Dr. Sandeep Kundu and Dr. Ayush Attery (PhD from NII, Delhi) for their professional guide and encouragement for undertaking this book. We also very thankful to Er. Sachin Saini (Scientist at SSPL-DRDO) for his sustained and technical support.

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At the end we want to say that students are our inspiration for writing this book in concise and precise manner. We look forward for your comments and feedback for improvement of this book.

Delhi, 2022

KapMan Academy

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Ms. Krisha Sharma (CSIR-NET-JRF, IIT-JAM, JNU Biotechnology) is the founder of KapMan Life Science Academy who is the editor and reviewer of this book. She has done her graduation from ANDC Delhi university and M.Sc. from Madurai Kamaraj University, Madurai, Tamil Nādu. Her research work was on plant molecular biology and plant biotechnology and now she is the part of KapMan Life Science Academy. She is ardent about Biological Science and wants to provide best quality books for national competitive exams.

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Mr. Manpreet Sharma (CSIR-UGC-NET-JRF 2011/2013/2014, BARC, DRDO, DU Exam qualified) is the Co-founder of KapMan Life Science Academy who have also done His Research work in CSIR, DRDO-INMAS and Delhi University. His research work was on Cancer biology and Radiation Biology. Mr Manpreet is passionate about Life Science and Research world and is eager to provide best quality class books for CSIR UGC NET JRF, IIT JAM and GATE in the field of Bio-science, Biotechnology and Life Science.

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UNIT 1

INTRODUCTORY FOOD TECHNOLOGY

Introduction

Food Science can be denned as the application of the basic sciences and engineering to study the fundamental physical, chemical, and biochemical nature of foods and the principles of food processing. Food technology is the use of the information generated by food science in the selection, preservation, processing, packaging, and distribution, as it affects the consumption of safe, nutritious and wholesome food. As such, food science is a broad discipline which contains within it many specializations such as in food microbiology, food engineering, and food chemistry. Food engineers deal with the conversion of raw agricultural products such as wheat into more finished food products such as flour or baked goods. Food processing contains many of the same elements as chemical and mechanical engineering. Virtually all foods are derived from living cells. Thus, foods are for the most part composed of "edible biochemicals," and so biochemists often work with foods to understand how processing or storage might chemically affect foods and their biochemistry. Likewise, nutritionists are involved in food manufacture to ensure that foods maintain their expected nutritional content. Other food scientists work for the government in order to ensure that the foods we buy are safe, wholesome, and honestly represented.

Food is one of the basic needs of the human being. It is required for the normal functioning of the body parts and for a healthy growth. Food is any substance, composed of carbohydrates, water, fats and/or proteins, that is either eaten or drunk by any animal, including humans, for nutrition or pleasure. Items considered food may be sourced from plants, animals or another kingdom such as fungus. On the other hand, Food science is a study concerned with all technical aspects of food, beginning with harvesting or slaughtering, and ending with its cooking and consumption. It is considered one of the life sciences, and is usually considered distinct from the field of nutrition.

Food science is a highly interdisciplinary applied science. It incorporates concepts from many different fields including microbiology, chemical engineering, biochemistry, and many others. Some of the subdisciplines of food science include:

• **Food processing -** the set of methods and techniques used to transform raw ingredients into food or to transform food into other forms for consumption by humans or animals either in the home or by the food processing industry

• **Food safety** - the causes, prevention and communication dealing with foodborne illness

• **Food microbiology** - the positive and negative interactions between micro-organisms and foods

• **Food preservation** - the causes and prevention of quality degradation

• **Food engineering** - the industrial processes used to manufacture food

• **Product development** - the invention of new food products

• **Sensory analysis** - the study of how food is perceived by the consumer's senses

• **Food chemistry** - the molecular composition of food and the involvement of these molecules in chemical reactions

• **Food packaging** - the study of how packaging is used to preserve food after it has been processed and contain it through distribution

• **Food technology** - the technological aspects of food

• **Food physics** - the physical aspects of foods (such as viscosity, creaminess, and texture)

BASIC COMPOSITION OF FOOD

Our body requires carbohydrates, proteins, fats, enzymes, vitamins and minerals for a healthy growth. However, our body cannot produce all these nutrients. Hence, food is the only source to obtain these nutrients in an adequate quantity. If we don't get these nutrients in sufficient amount, then we may suffer from a number of health problems. So, a balanced diet is always recommended which is defined as a diet containing carbohydrate, protein, fat, dietary fibers, vitamin & minerals in right proportion. Carbohydrates, proteins, and fats supply 90% of the dry weight of the diet and 100% of its energy. All three provide energy (measured in calories), but the amount of energy in 1 gram differs: 4 calories in a gram of carbohydrate or protein and 9 calories in a gram of fat.

These nutrients also differ in how quickly they supply energy. Carbohydrates are the quickest, and fats are the slowest. Carbohydrates, proteins, and fats are digested in the intestine, where they are broken down into their basic units: carbohydrates into sugars, proteins into amino acids, and fats into fatty acids and glycerol. The body uses these basic units to build substances it needs for growth, maintenance, and activity (including other carbohydrates, proteins, and fats).

WATER IN DIET

Water is a combination of hydrogen and oxygen. It is the basis for the fluids of the body.

Function

Water makes up more than two-thirds of the weight of the human body. Without water, humans would die in a few days. All the cells and organs need water to function. Water serves as a lubricant and is the basis of saliva and the fluids surrounding the joints. Water regulates the body temperature through perspiration. It also helps prevent and alleviate constipation by moving food through the intestinal tract.

Food Sources

Some of the water in our body is obtained through foods we eat and some is the byproduct of metabolism. But drinking water is our main, and best, source of water. We also obtain water through liquid foods and beverages, such as soup, milk, and juices. Alcoholic beverages and beverages containing caffeine (such as coffee, tea, and colas) are not the best choices because they have a diuretic (water-excreting) effect.

Side Effects

If adequate water is not consumed on a daily basis the body fluids will be out of balance, causing dehydration. When dehydration is severe, it can be life-threatening.

Recommendations

Six to eight 8-ounce glasses of water are generally recommended on a daily basis.

CARBOHYDRATES

A carbohydrate is an organic compound with the general formula $C_n(H_2O)_n$, that is, consisting only of carbon, hydrogen and oxygen. The carbohydrates (saccharides) are divided into four chemical groupings: monosaccharides, disaccharides, oligosaccharides, and polysaccharides. In general, the monosaccharides and disaccharides, which are smaller (lower molecular weight) carbohydrates, are commonly referred to as sugars.

Carbohydrates perform numerous roles in living things. Polysaccharides serve for the storage of energy (e.g., starch and glycogen) and as structural components (e.g., cellulose in plants and chitin in arthropods) Monosaccharides are the simplest carbohydrates in that they cannot be hydrolyzed to smaller carbohydrates. Monosaccharides are the major source of fuel for metabolism, being used both as an energy source (glucose being the most important in nature) and in biosynthesis. When monosaccharides are not immediately needed by many cells, they are often converted to more space efficient forms, often polysaccharides.

In many animals, including humans, this storage form is **glycogen**, especially in liver and muscle cells. In plants, **starch** is used for the same purpose. **Sucrose**, also known as table sugar, is a common **disaccharide**. Sucrose is composed of two monosaccharides: **D-glucose (left) and D-fructose (right)**. Two joined monosaccharides are called a **disaccharide** and these are the simplest polysaccharides. Examples include **sucrose and lactose**. They are composed of two monosaccharide units bound together by a **covalent bond** known as a **glycosidic linkage** formed via a **dehydration reaction**, resulting in the loss of a hydrogen atom from one monosaccharide and a hydroxyl group from the other. Sucrose is the most abundant disaccharide, and the main form in which carbohydrates are transported in plants. It is composed of one D-glucose molecule and one D-fructose molecule. **Lactose**, a disaccharide composed of one **D-galactose molecule and one D-glucose** molecule, occurs naturally in mammalian milk.

Depending on the size of the molecule, carbohydrates may be simple or complex.

- **Simple carbohydrates**: Various forms of sugar, such as glucose and sucrose (table sugar), are simple carbohydrates. They are small molecules, so they can be broken down and absorbed by the body quickly and are the quickest source of energy. They quickly increase the level of blood glucose (blood sugar). Fruits, dairy products, honey, and maple syrup contain large amounts of simple carbohydrates, which provide the sweet taste in most candies and cakes.
- **Complex carbohydrates**: These carbohydrates are composed of long strings of simple carbohydrates. Because complex carbohydrates are larger molecules than simple carbohydrates, they must be broken down into simple carbohydrates before they can be

absorbed. Thus, they tend to provide energy to the body more slowly than simple carbohydrates but still more quickly than protein or fat. Because they are digested more slowly than simple carbohydrates, they are less likely to be converted to fat. They also increase blood sugar levels more slowly and to lower levels than simple carbohydrates but for a longer time. Complex carbohydrates include starches and fibers, which occur in wheat products (such as breads and pastas), other grains (such as rye and corn), beans, and root vegetables (such as potatoes).

Carbohydrates may be **refined or unrefined**. **Refined** means that the food is highly processed. The fiber and bran, as well as many of the vitamins and minerals they contain, have been stripped away. Thus, the body processes these carbohydrates quickly, and they provide little nutrition although they contain about the same number of calories. Refined products are often enriched, meaning vitamins and minerals have been added back to increase their nutritional value. A diet high in simple or refined carbohydrates tends to increase the risk of obesity and diabetes. If people consume more carbohydrates than they need at the time, the body stores some of these carbohydrates within cells (as glycogen) and converts the rest to fat. Glycogen is a complex carbohydrate that the body can easily and rapidly convert to energy. Glycogen is stored in the liver and the muscles. Muscles use glycogen for energy during periods of intense exercise. The amount of carbohydrates stored as glycogen can provide almost a day's worth of calories. A few other body tissues store carbohydrates as complex carbohydrates that cannot be used to provide energy.

Most authorities recommend that about 50 to 55% of total daily calories should consist of carbohydrates.

Glycemic Index: The glycemic index of a carbohydrate represents how quickly its consumption increases blood sugar levels. Values range from 1 (the slowest) to 100 (the fastest, the index of pure glucose). However, how quickly the level actually increases also depends on what other foods are ingested at the same time and other factors. The glycemic index tends to be lower for complex carbohydrates than for simple carbohydrates, but there are exceptions. For example, fructose (the sugar in fruits) has little effect on blood sugar.

DIETARY FIBER

Dietary fiber (fibre), sometimes called roughage, is the indigestible portion of plant foods having two main components — soluble (prebiotic, viscous) fiber that is readily fermented in the colon into gases and physiologically active byproducts, and insoluble fiber that is metabolically inert, absorbing water throughout the digestive system and easing defecation. It acts by changing the nature of the contents of the gastrointestinal tract, and by changing how other nutrients and chemicals are absorbed. Food sources of dietary fiber are often divided according to whether they provide (predominantly) soluble or insoluble fiber. Plant foods contain both types of fiber in varying degrees according to the plant's characteristics.

Sources of fiber

Dietary fiber is found in plants. While all plants contain some fiber, plants with high fiber concentrations are generally the most practical source. Fiber-rich plants can be eaten directly. Or, alternatively, they can be used to make supplements and fiber-rich processed foods.

Soluble fiber is found in varying quantities in all plant foods, including:

- legumes (peas, soybeans, and other beans)
- oats, rye, chia, and barley
- some fruits and fruit juices (including plums, berries, bananas, and the insides of apples and pears)
- certain vegetables such as broccoli, carrots,
- root vegetables such as potatoes, sweet potatoes, and onions (skins of these vegetables are sources of insoluble fiber)
- psyllium seed husk (a mucilage soluble fiber).

Sources of insoluble fiber include:

- whole grain foods
- wheat and corn bran
- nuts and seeds
- potato skins
- flax seed
- lignans
- vegetables such as green beans, cauliflower, zucchini (courgette), celery, and nopal

- some fruits including avocado, and bananas
- the skins of some fruits, including tomatoes

Mechanism

The main action of dietary fiber is to change the nature of the contents of the gastrointestinal tract, and to change how other nutrients and chemicals are absorbed. Soluble fiber binds to bile acids in the small intestine, making them less likely to enter the body; this in turn lowers cholesterol levels in the blood. Soluble fiber also attenuates the absorption of sugar, reduces sugar response after eating, normalizes blood lipid levels and, once fermented in the colon, produces short-chain fatty acids as byproducts with wide-ranging physiological activities (discussion below).

Benefits of fiber intake

Research has shown that fiber may benefit health in several different ways.

Dietary fiber functions & benefits

Type of fiber	Functions	Benefits
Both soluble & insoluble fiber	Adds bulk to your diet, making you feel full faster	May reduce appetite
Soluble fiber only	Attracts water and turns to gel during digestion, trapping carbohydrates and slowing absorption of glucose	Lowers variance in blood sugar levels
Soluble fiber only	Lowers total and LDL cholesterol	Reduces risk of heart disease
Soluble fiber only	Regulates blood sugar	May reduce onset risk or symptoms of metabolic syndrome and diabetes
Insoluble fiber only	Speeds the passage of foods through the digestive system	Facilitates regularity
Insoluble fiber only	Adds bulk to the stool	Alleviates constipation
Soluble fiber only	Balances intestinal pH and stimulates intestinal	May reduce risk of colorectal cancer

	fermentation production of short-chain fatty acids	

Fiber does not bind to minerals and vitamins and therefore does not restrict their absorption, but rather evidence exists that fermentable fiber sources improve absorption of minerals, especially calcium. Some plant foods can reduce the absorption of minerals and vitamins like calcium, zinc, vitamin C, and magnesium, but this is caused by the presence of phytate (which is also thought to have important health benefits), not by fiber.

Guidelines on fiber intake

Authorities generally recommend that about 30 grams of fiber be consumed daily. The average amount of fiber consumed daily is usually less because people tend to eat products made with highly refined wheat flour and do not eat many fruits and vegetables. Meat and dairy foods do not contain fiber. An average serving of fruit, a vegetable, or cereal contains 2 to 4 grams of fiber and should be the part of the diet.

FATS

Fats consist of a wide group of compounds that are generally soluble in organic solvents and largely insoluble in water. Chemically, fats are generally triesters of glycerol and fatty acids. Fats may be either solid or liquid at room temperature, depending on their structure and composition. Although the words "oils", "fats", and "lipids" are all used to refer to fats, "oils" is usually used to refer to fats that are liquids at normal room temperature, while "fats" is usually used to refer to fats that are solids at normal room temperature. "Lipids" is used to refer to both liquid and solid fats, along with other related substances. The word "oil" is used for any substance that does not mix with water and has a greasy feel, such as petroleum (or crude oil) and heating oil, regardless of its chemical structure.

Examples of edible animal fats are lard (pig fat), fish oil, and butter or ghee. They are obtained from fats in the milk, meat and under the skin of the animal. Examples of edible plant fats are peanut, soya bean, sunflower, sesame, coconut, olive, and vegetable oils. Margarine and vegetable shortening, which can be derived from the above oils, are used mainly for baking. These examples of fats can be categorized into **saturated fats and unsaturated fats**.

Types of fats in food

• **Unsaturated fat**

- Monounsaturated fat
- Polyunsaturated fat
- Trans fat
- Cis fat
- Omega fatty acids:
  - ω−3
  - ω−6
  - ω−9

• **Saturated fat**

- Inter-esterified fat

Importance for living organisms

- Vitamins A, D, E, and K are fat-soluble, meaning they can only be digested, absorbed, and transported in conjunction with fats. Fats are also sources of essential fatty acids, an important dietary requirement.
- Fats play a vital role in maintaining healthy skin and hair, insulating body organs against shock, maintaining body temperature, and promoting healthy cell function.
- Fats also serve as energy stores for the body, containing about 37.8 kilojoules (9 calories) per gram of fat. They are broken down in the body to release glycerol and free fatty acids. The glycerol can be converted to glucose by the liver and thus used as a source of energy.
- Fat also serves as a useful buffer towards a host of diseases. When a particular substance, whether chemical or biotic—reaches unsafe levels in the bloodstream, the body can effectively dilute—or at least maintain equilibrium of—the offending substances by storing it in new fat tissue. This helps to protect vital organs, until such time as the offending

substances can be metabolized and/or removed from the body by such means as excretion, urination, accidental or intentional bloodletting, sebum excretion, and hair growth.

- While it is nearly impossible to remove fat completely from the diet, it would be unhealthy to do so. Some fatty acids are essential nutrients, meaning that they can't be produced in the body from other compounds and need to be consumed in small amounts. All other fats required by the body are non-essential and can be produced in the body from other compounds.

Essential fatty acids

Essential fatty acids, or EFAs, are fatty acids that cannot be constructed within an organism (generally all references are to humans) from other components by any known chemical pathways, and therefore must be obtained from the diet. The term refers to fatty acids involved in biological processes, and not those which may just play a role as fuel. There are two families of EFAs: ω-3 (or omega-3 or n−3) and ω-6 (omega-6, n−6). Fats from each of these families are essential, as the body can convert one omega-3 to another omega-3, for example, but cannot create an omega-3 from omega-6 or saturated fats. They were originally designated as Vitamin F when they were discovered as essential nutrients in 1923. In 1930, work by Burr, Burr and Miller showed that they are better classified with the fats than with the vitamins.

Nomenclature and terminology

Fatty acids are straight chain hydrocarbons possessing a carboxyl (COOH) group at one end. The carbon next to the carboxylate is known as α, the next carbon β, and so forth. Since biological fatty acids can be of different lengths, the last position is labelled as a "ω", the last letter in the Greek alphabet. Since the physiological properties of unsaturated fatty acids largely depend on the position of the first unsaturation relative to the end position and not the carboxylate, the position is signified by (ω minus n). For example, the term ω-3 signifies that the first double bond exists as the third carbon-carbon bond from the terminal CH3 end (ω) of the carbon chain. The number of carbons and the number of double bonds is also listed. ω-3 18:4 (stearidonic acid) or 18:4 ω-3 or 18:4 n−3 indicates an 18- carbon chain with 4 double bonds, and with the first double bond in the third position from the CH3 end. Double bonds are cis and separated by a single methylene (CH2) group unless otherwise noted.

Examples

The essential fatty acids start with the short chain polyunsaturated fatty acids (SC-PUFA):

• **ω-3 fatty acids**:

o α-Linolenic acid or ALA (18:3)

• **ω-6 fatty acids:**

o Linoleic acid or LA (18:2)

These two fatty acids cannot be synthesized by humans, as humans lack the desaturase enzymes required for their production.

They form the starting point for the creation of longer and more desaturated fatty acids, which are also referred to as long-chain polyunsaturated fatty acids (LC-PUFA):

• **ω-3 fatty acids:**

o eicosapentaenoic acid or EPA (20:5)

o docosahexaenoic acid or DHA (22:6)

• **ω-6 fatty acids:**

o gamma-linolenic acid or GLA (18:3)

o dihomo-gamma-linolenic acid or DGLA (20:3)

o arachidonic acid or AA (20:4)

ω-9 fatty acids are not essential in humans, because humans generally possess all the enzymes required for their synthesis.

Essentiality

Human metabolism requires both ω-3 and ω-6 fatty acids. To some extent, any ω-3 and any ω-6 can relieve the worst symptoms of fatty acid deficiency. Particular fatty acids are still needed at critical life stages (e.g. lactation) and in some disease states. The human body can make some long-chain PUFA (arachidonic acid, EPA and DHA) from lineolate or lineolinate. Traditionally speaking the LC-PUFA are not essential. Because the LC-PUFA are sometimes required, they may be considered "conditionally essential", or not essential to healthy adults. A deficiency of essential fatty acids results in scaly dermatitis, hair loss, and poor wound healing.

Food sources

Almost all the polyunsaturated fat in the human diet is from EFA. Some of the food sources of ω-3 and ω-6 fatty acids are fish and shellfish, flaxseed (linseed), hemp oil, soya oil, canola (rapeseed) oil, pumpkin seeds, sunflower seeds, leafy vegetables, and walnuts. Essential fatty acids play a part in many metabolic processes, and there is evidence to suggest that low levels of essential fatty acids, or the wrong balance of types among the essential fatty acids, may be a factor in a number of illnesses, including osteoporosis.

Plant sources of ω-3 contain neither eicosapentaenoic acid (EPA) nor docosahexaenoic acid (DHA). The human body can (and in case of a purely vegetarian diet often must, unless certain algae or supplements derived from them are consumed) convert α-linolenic acid (ALA) to EPA and subsequently DHA. This however requires more metabolic work, which is thought to be the reason that the absorption of essential fatty acids is much greater from animal rather than plant sources.

Human health

Almost all the polyunsaturated fats in the human diet are EFAs. Essential fatty acids play an important role in the life and death of cardiac cells.

Trans fat

Trans fat is the common name for unsaturated fat with trans-isomer fatty acid(s). Trans fats may be monounsaturated or polyunsaturated but never saturated. **Unsaturated fat** is a fat molecule containing one or more double bonds between the carbon atoms. Since the carbons are double-bonded to each other, there are fewer bonds connected to hydrogen, so there are fewer hydrogen atoms, hence "**unsaturated"**. Cis and trans are terms that refer to the arrangement of chains of carbon atoms across the double bond. In the cis arrangement, the chains are on the same side of the double bond, resulting in a kink. In the trans arrangement, the chains are on opposite sides of the double bond, and the chain is straight.

The process of hydrogenation adds hydrogen atoms to cis-unsaturated fats, eliminating a double bond and making them more saturated. These saturated fats have a higher melting point, which makes them attractive for baking and extends shelf-life. However, the process frequently has a side effect that turns some cis-isomers into trans-unsaturated fats instead of hydrogenating them completely.

There is another class of trans fats, vaccenic acid, which occurs naturally in trace amounts in meat and dairy products from ruminants. Unlike other dietary fats, trans fats are not essential, and they do not promote good health. The consumption of trans fats increases the risk of coronary heart disease by raising levels of "bad" LDL cholesterol and lowering levels of "good" HDL cholesterol. Health authorities worldwide recommend that consumption of trans fat be reduced to trace amounts. Trans fats from partially hydrogenated oils are more harmful than naturally occurring oils.

Presence in food

Milk and meat from cows and other ruminants contain naturally occurring trans fats in small quantities. A type of trans fat occurs naturally in the milk and body fat of ruminants (such as cattle and sheep) at a level of 2–5% of total fat. Natural trans fats, which include conjugated linoleic acid (CLA) and vaccenic acid, originate in the rumen of these animals. It should be noted that CLA has two double bonds, one in the cis configuration and one in trans, which makes it simultaneously a cis- and a trans-fatty acid. Animal-based fats were once the only trans fats consumed, but by far the largest amount of trans fat consumed today is created by the processed food industry as a side-effect of partially hydrogenating unsaturated plant fats (generally vegetable oils). These partially-hydrogenated fats have displaced natural solid fats and liquid oils in many areas, notably in the fast food, snack food, fried food and baked goods industries. Partially hydrogenated oils have been used in food for many reasons. Partial hydrogenation increases product shelf life and decreases refrigeration requirements. Many baked foods require semi-solid fats to suspend solids at room temperature; partially hydrogenated oils have the right consistency to replace animal fats such as butter and lard at lower cost. They are also an inexpensive alternative to other semi-solid oils such as palm oil.

Foods containing artificial trans fats formed by partially hydrogenating plant fats may contain up to 45% trans-fat compared to their total fat. Baking shortenings generally contain 30% trans fats compared to their total fats, while animal fats from ruminants such as butter contain up to 4%. Margarines not reformulated to reduce trans fats may contain up to 15% trans-fat by weight.

Trans fats are used in shortenings for deep frying in restaurants, as they can be used for longer than most conventional oils before becoming rancid. In the early twenty first century non-hydrogenated vegetable oils became available that have lifespan exceeding that of the frying shortenings. As fast-food chains routinely use different fats in different locations, trans fat levels in fast food can have large variations.

Uses of Fats and Oils

Culinary uses

Many vegetable oils are consumed directly, or used directly as ingredients in food and dogfood - a role that they share with some animal fats, including butter and ghee. The oils serve a number of purposes in this role:

- Shortening - to give pastry a crumbly texture.
- Texture - oils can serve to make other ingredients stick together less.
- Flavor - while less-flavorful oils command premium prices, oils such as olive oil or almond oil may be chosen specifically for the flavor they impart.
- Flavor base - oils can also "carry" flavors of other ingredients, since many flavors are present in chemicals that are soluble in oil.

Secondly, oils can be heated, and used to cook other foods. Oils that are suitable for this purpose must have a high flash point. Such oils include the major cooking oils - canola, sunflower, safflower, peanut etc. Tropical oils, like palm oil, coconut oil and rice bran oil, are particularly valued in Asian cultures for high temperature cooking, because of their unusually high flash point.

Health risks

Partially hydrogenated vegetable oils have been an increasingly significant part of the human diet for about 100 years (particularly since the latter half of the 20th century and in the West where more processed foods are consumed), and some deleterious effects of trans fat consumption are scientifically accepted.

Obesity

Obesity is a medical condition in which excess body fat has accumulated to the extent that it may have an adverse effect on health, leading to reduced life expectancy and/or increased health problems. Body mass index (BMI), a measurement which compares weight and height, defines people as overweight (pre-obese) when their BMI is between 25 kg/m^2 and 30 kg/m^2, and obese when it is greater than 30 kg/m^2.

Obesity increases the likelihood of various diseases, particularly heart disease, type 2 diabetes, breathing difficulties during sleep, certain types of cancer, and osteoarthritis. Obesity is most commonly caused by a combination of excessive dietary calories, lack of physical activity, and genetic susceptibility, although a few cases are caused primarily by genes, endocrine disorders, medications or psychiatric illness. Obesity is a leading preventable cause of death worldwide, with increasing prevalence in adults and children, and authorities view it as one of the most serious public health problems of the 21st century.

Fat in the Diet

Authorities generally recommend that fat be limited to less than 30% of daily total calories (or fewer than 90 grams per day) and that saturated fats and trans fats should be limited to less than 10%. When possible, monounsaturated fats and polyunsaturated fats, particularly omega-3 fats, should be substituted for saturated fats and trans fats. People with high cholesterol levels may need to reduce their total fat intake even more. When fat intake is reduced to 10% or less of daily total calories, cholesterol levels tend to decrease dramatically.

PROTEINS

Another very important constituent of food, proteins are found in all cells and in almost all parts of cell. They contribute to almost half of the body dry weight. Proteins are major organic constituents of protoplasm and a number of extra cellular components. These are important dietary constituents and perform a wide range of functions like providing structure to the body, transporting oxygen and other substances within an organism, regulating the body chemistry etc. Proteins are essential not only as constituents of food but they also have a significant role to play in the processing and preparation of food. This is primarily due to their water binding capacity and ability to coagulate on heating. Proteins find applications as gel formers, emulsifiers and foaming agents etc. Protein is a nutrient that the body needs to grow and maintain itself. Next to water, protein is the most plentiful substance in our bodies. Just about everyone knows that muscles are made of protein. Actually, every single cell in the body has some protein. In addition, other important parts of the body like hair, skin, eyes, and body organs are all made from protein.

Many substances that control body functions, such as enzymes and hormones, also are made from protein. Other important functions of protein include forming blood cells and making antibodies to protect us from illness and infections.

Enzymes are also proteins, and they work as catalysts in carrying out the biological reactions. Several enzymes like amylase, invertase, pectinases, proteases etc. find applications in food processing. Generally, a protein has approximately the following composition:

- Carbon, 53%;
- Hydrogen, 7%;
- Oxygen, 23%;
- Nitrogen, 16%; and
- Sulfur, 1%

Foods that Contain Protein

Animal Sources

Foods that provide all the essential amino acids are called high quality proteins. Animal foods, like meat, fish, poultry, eggs, and dairy products, are all high-quality protein sources. These are the foods people usually think of when they want to eat protein. The essential amino acids in animal products are in the right balance.

Protein Content of Some Animal Foods

S.No.	Source	Protein (%)

1	Meat	18-22
2	Milk	3.5
3	Egg white	12
4	Fresh water fish	13-25

Plant Sources

Foods that do not provide a good balance of all the essential amino acids are called lower quality proteins. Plant foods contain lower quality proteins. Most fruits and vegetable are poor sources of protein. Other plant foods, like baked beans, split peas and lentils, peanuts and other nuts, seeds, and grains like wheat, are better sources. They contribute a lot to our protein intake. However, each type of plant protein is low in one or more of the essential amino acids. This makes them a lower quality protein. Animal proteins contain a better balance of the essential amino acids than plant proteins. Cereals like wheat and rice are important sources of protein and are the staple foods of the populations in India. On average, wheat has 12-13% protein while rice has 7-9% protein. Gluten proteins are responsible for the unique bread making property of wheat. Legumes (pulses) and oil seeds are major sources of vegetable proteins. Besides, nuts like cashew nuts, almond nuts, coconuts, walnuts, etc. are the excellent sources of proteins.

Protein Content of some Pulses, Oilseeds and Fresh Vegetables

Sources	Name	Protein (%)
Dals and Pulses	1. Bengal gram dal	**20.8**
	2. Black gram dal	**24.6**
	3. Green gram dal	**24.5**
	4. Lentil	**25.1**
	5. Dry bean	**24.9**
	6. Dry pea	**19.7**
Fresh vegetables	7. Fresh bean	**2**
	8. Fresh pea	**6**
	9. Carrot	**1**
Oilseeds	10. Ground nut	**26.7**
	11. Soybean	**43.2**

	12. Sesame	**18.3**
	13. Cotton seed	**19.5**
	14. Sunflower seed	**12.5**

Combinations

People who do not eat animal products should eat different types of plant foods together or within the same day to get the proper balance and amount of essential amino acids their bodies need. Combining beans and rice, or beans and corn, or peanut butter and bread will provide all of the essential amino acids in the right amounts. These food combinations mix foods from different plant groups to complement the amino acids provided by each. Combining foods from any two of the following plant groups will make a higher quality protein:

- Legumes, such as dry beans, peas, peanuts, lentils, and soybeans
- Grains, such as wheat, rye, rice, corn, oats, and barley
- Seeds and nuts, such as sunflower and pumpkin seeds, pecans, and walnuts

Any of the following products eaten with any one of the plant groups listed above also will make a higher quality protein:

- Eggs
- Milk products, such as milk, cheese, and yogurt
- Meat, such as beef, poultry, fish, lamb, and pork

A small amount of animal product mixed with a larger amount of plant product can also meet a person‘s protein needs.

Amino Acids

Structurally proteins are polymers of α- amino acids, which join together through peptide bonds. These polymeric molecules acquire different arrangements depending on their composition and the nature of amino acids constituting them. These arrangements are stabilized with the help of different types of interactions. There are 20 amino acids in the protein that we eat every day. The body takes these amino acids and links them together in very long strings. This is how the body makes all of the different proteins it needs to function properly.

Essential and Non-essential Amino Acids

Eight of the amino acids are called essential because bodies cannot make them. The requirement of **essential amino acids** (**g per kg dietary protein**)

1. **Isoleucine: 42**
2. **Leucine: 48**
3. **Lysine: 42**
4. **Methionine: 22**
5. **Phenylalanine: 28**
6. **Threonine: 28**
7. **Tryptophan: 14**
8. **Valine: 42**

The classification of an amino acid as essential or non-essential does not reflect its importance as all the twenty amino acids are necessary for normal functioning of the body. It simply reflects whether or not the body is capable of synthesizing a particular amino acid. The requirement of essential amino acids per kilogram of the dietary protein is called the reference pattern of the amino acids and acts as a standard to determine the quality of the protein being consumed.

The net protein utilization of a human eating only one protein source (only wheat, for instance) is affected by the limiting amino acid content (the essential amino acid found in the smallest quantity in the foodstuff) of that source.

Protein source	Limiting amino acid
Wheat	lysine
Rice	lysine
Legumes	tryptophan or methionine (or cysteine)

Maize	lysine and tryptophan
Egg, chicken	none; the reference for absorbable protein

Biological value

Biological value (BV) is a ***measure of the proportion of absorbed protein from a food which becomes incorporated into the proteins of the organism's body***. It summarizes how readily the broken-down protein can be used in protein synthesis in the cells of the organism. This method assumes protein is the only source of nitrogen and measures the proportion of this nitrogen absorbed by the body which is then excreted. The remainder must have been incorporated into the proteins of the organism's body. A ratio of nitrogen incorporated into the body over nitrogen absorbed gives a measure of protein 'usability' - the BV.

Egg whites have been determined to have the standard biological value of 100 (though some sources may have higher biological values), which means that most of the absorbed nitrogen from egg white protein can be retained and used by the body. The biological value of plant protein sources is usually considerably lower than animal sources. For example, corn has a BA of 70 while peanuts have a relatively low BA of 40. Due to experimental limitations BV is often measured relative to an easily utilizable protein. Normally egg protein is assumed to be the most readily utilizable protein and given a BV of 100.

Adults need to eat about 60 grams of protein per day (0.8 grams per kilogram of weight or 10 to 15% of total calories). Adults who are trying to build muscle need slightly more. Children also need more because they are growing.

Deficiency

Protein deficiency is a serious cause of ill health and death in developing countries. Protein deficiency plays a part in the **disease kwashiorkor**. If enough energy is not taken in through diet, as in the process of starvation, the body will use protein from the muscle mass to meet its energy needs, leading to muscle wasting over time. If the individual does not consume adequate protein in nutrition, then muscle will also waste as more vital cellular processes (e.g., respiration enzymes, blood cells) recycle muscle protein for their own requirements.

METABOLIZABLE ENERGY (ME)

Food energy is the amount of energy available from food that is available through respiration. Like other forms of energy, food energy is expressed in **calories or joules**. Some countries use the food calorie, which is equal to 1 kilocalorie (kcal), or 1,000 calories. The **kilojoule** is the unit officially recommended by the World Health Organization and other international organizations.

Fiber, fats, proteins, organic acids, polyols, and ethanol all release energy during respiration - this is often called, **'food energy'**. It is only when the food (providing fuel) reacts with oxygen in the cells of living things that energy is released. A small amount of energy is available through anaerobic respiration.

Each gram of food (fuel) is associated with a particular amount of energy (released when the food is respired). Fats and ethanol have the greatest amount of food energy per gram, 9 and 7 kcal/g (38 and 30 kJ/g), respectively. Proteins and most carbohydrates have about 4 kcal/g (17 kJ/g). Carbohydrates that are not easily absorbed, such as fiber or lactose in lactose-intolerant individuals, contribute less food energy. Polyols (including sugar alcohols) and organic acids have fewer than 4 kcal/g.

VITAMINS AND MINERALS

Whereas vitamins are organic substances (made by plants or animals), minerals are inorganic elements that come from the soil and water and are absorbed by plants or eaten by animals.

VITAMINS

A vitamin is an organic compound required as a nutrient in tiny amounts by an organism. Vitamins are classified by their biological and chemical activity, not their structure. Vitamins have diverse biochemical functions. Some have **hormone-like functions** as regulators of mineral metabolism (e.g., vitamin D), or **regulators of cell and tissue growth** and **differentiation** (e.g., some forms of vitamin A). Others function **as antioxidants** (e.g., vitamin E and sometimes vitamin C). The largest number of vitamins (e.g., B complex vitamins) function as **precursors for enzyme cofactors**, that help enzymes in their work as catalysts in metabolism. In this role, vitamins may be tightly bound to enzymes as part of prosthetic groups: for example, biotin is part of enzymes involved in making fatty acids. Alternately, vitamins may also be less tightly bound to enzyme catalysts as coenzymes, detachable molecules which function to carry chemical groups or electrons between molecules. For example, folic acid carries various forms of carbon group – methyl, formyl and methylene - in the cell.

Vitamins are classified as either **water-soluble or fat soluble**. In humans there are **13 vitamins**: **4 fat-soluble** (A, D, E and K) and **9 water-soluble** (8 B vitamins and vitamin C). **Water-soluble vitamins** dissolve easily in water, and in general, are readily excreted from the body, to the degree that urinary output is a strong predictor of vitamin consumption. Because they are not readily stored, consistent daily intake is important. Many types of water-soluble vitamins are synthesized by bacteria. Fat-soluble vitamins are absorbed through the intestinal tract with the help of lipids (fats). Because they are more likely to accumulate in the body, they are more likely to lead to hypervitaminosis than are water-soluble vitamins.

Role of Vitamins

Vitamins are essential for the normal growth and development of a multicellular organism. For the most part, vitamins are obtained with food, but a few are obtained by other means. For example, microorganisms in the intestine—commonly known as "gut flora"—produce vitamin K and biotin, while one form of vitamin D is synthesized in the skin with the help of the natural ultraviolet wavelength of sunlight. Humans can produce some vitamins from precursors they consume. Examples include vitamin A, produced from beta carotene, and niacin, from the amino acid tryptophan. Once growth and development are completed, vitamins remain essential nutrients for the healthy maintenance of the cells, tissues, and organs.

Deficiencies

Because human bodies do not store most vitamins, humans must consume them regularly to avoid deficiency. Deficiencies of vitamins are classified as either primary or secondary. **A primary deficiency** occurs when an organism does not get enough of the vitamin in its food. **A secondary deficiency** may be due to an underlying disorder that prevents or limits the absorption or use of the vitamin, due to a **—**lifestyle factor, such as smoking, excessive alcohol consumption, or the use of medications that interfere with the absorption or use of the vitamin. People who eat a varied diet are unlikely to develop a severe primary vitamin deficiency.

Well-known human vitamin deficiencies involve **thiamine (beriberi), niacin (pellagra), vitamin C (scurvy) and vitamin D (rickets).**

Side effects and overdose

In large doses, some vitamins have documented side effects that tend to be more severe with a larger dosage. The likelihood of consuming too much of any vitamin from food is remote, but overdosing from vitamin supplementation does occur. At high enough dosages some vitamins cause side effects such as nausea, diarrhea, and vomiting.

Functions, Major Food Source and Deficiency diseases of various vitamins

Vitamin	Functions	Significant food source	Deficiency Diseases
A (retinol)	Supports vision, skin, bone and tooth growth, immunity and reproduction	Mango, Broccoli, Butter Nut squash, Carrots, Tomato juice, sweet potatoes, pumpkin, cod liver	**Night- blindness and Keratomalacia**
B1 (thiamin)	Supports energy metabolism and nerve function	Spinach, Green peas, tomato juice, Watermelon, Sunflower seeds, Lean ham, Pork chops, Soy milk	**Beriberi, Wernicke-Korsakoff syndrome**
B2 (riboflavin)	Supports energy metabolism, normal vision and skin health	Spinach, Broccoli, Mushrooms, Eggs, Milk, Liver, Oysters, Clams	**Ariboflavinosis**
B3 (niacin)	Supports energy metabolism, skin health, nervous system and digestive system	Spinach, Potatoes, Tomato juice, Lean ground beef, Chicken breast, Tuna (Canned in water), Liver, Shrimp	**Pellagra**
Biotin	Energy metabolism, fat synthesis, amino acid metabolism, glycogen synthesis	Widespread in foods	**Dermatitis, Enteritis**
B5 Pantothenic Acid	Supports energy metabolism	Widespread in foods	**Paresthesia**
B6 (pyridoxine)	Amino acid and fatty acid metabolism, red blood cell production	Bananas, Watermelon, Tomato juice, Broccoli, Spinach, Acron squash,	**Anemia peripheral neuropathy**

		Potatoes, White rice, Chicken breast	
Folate	Supports DNA synthesis and new cell formation	Tomato juice, green beans, Broccoli, Spinach, Asparagus, Okra, Black-eyed peas, Lentils, Navy, Pinto and Garbanzo beans	**Deficiency during pregnancy is associated with birth defects, such as neural tube defects**
B12	Used in new cell synthesis, helps break down fatty acids and amino acids, supports nerve cell maintenance	Meats, Poultry, Fish, Shellfish, Milk, Eggs	**Megaloblastic anemia**
C (ascorbic acid)	Collagen synthesis, amino acid metabolism, helps iron absorption, immunity, antioxidant	Spinach, Broccoli, Red bell peppers, Snow peas, Tomato juice, Kiwi, Mango, Orange, Grape fruit juice, Strawberries	**Scurvy**
D	Promotes bone mineralization	Self- synthesis via sunlight, Fortified milk, Egg yolk, Liver, Fatty fish	**Rickets in children and Osteomalacia in adult**
E Antioxidant,	regulation of oxidation reactions, supports cell membrane stabilization	Polyunsaturated plant oils (soyabean, corn and canola oils), Wheat germ, Sunflower seeds, Tofu, Avocado, Sweet potatoes, Shrimp, Cod	**Deficiency is very rare; mild hemolytic anemia in newborn infants**
K	Synthesis of blood- clotting proteins, regulates blood calcium	Brussels sprouts, Leafy greens vegetables, Spinach, Broccoli, Cabbage, Liver	**Bleeding diathesis Increases clotting time of blood**

MINERALS

Dietary minerals are the chemical elements required by living organisms, other than the four elements carbon, hydrogen, nitrogen, and oxygen present in common organic molecules. The dietary focus on dietary minerals derives from an interest in supporting biochemical reactions with the required elemental components. Appropriate intake levels of certain chemical elements are thus required to maintain optimal health.

Essential dietary minerals

Some sources state that sixteen dietary minerals are required to support human biochemical processes by serving structural and functional roles as well as electrolytes. Sometimes a distinction is drawn between this category and micronutrients. Most of the dietary minerals are of relatively low atomic weight. Our body needs larger amounts of some minerals, such as calcium, to grow and stay healthy. Other minerals like chromium, copper, iodine, iron, selenium, and zinc are called trace minerals because we only need very small amounts of them each day.

Functions, Food Source and Deficiency diseases of major Minerals

Mineral	Functions	Significant food sources	Deficiency Diseases
Potassium	Maintains fluid and Electrolyte balance, cell integrity, muscle contractions and nerve impulse transmission	Potatoes, acron squash, antichoke, spinach, broccoli, carrots, green beans, tomato juice, avocado, grapefruit juice, watermelon, banana, strawberries, cod, milk	Nausea, anorexia, muscle weakness, irritability. (Occurs most often in persons with prolonged diarrhea).
Calcium	Formation of bones and teeth, supports blood clotting	Milk, yoghurt, cheddar cheese, Swiss cheese, tofu, sardines, green beans, spinach, broccoli	Rickets in children and Osteomalacia in adult
Phosphorus	Formation of cells, bones and teeth, maintains acid-base balance	All animal foods (meat, fish, poultry, eggs, milk)	Weakness; bone pain; Anorexia
Magnesium	Supports bone mineralization, protein building, muscular contraction, nerve impulse transmission, immunity	Artichoke, parsley, spinach, broccoli, green beans, tomato juice, navy beans, pinto beans, black-eyed peas, sunflower seeds, tofu, cashews, halibut	Nausea, irritability, muscle weakness; twitching; cramps, cardiac arrhythmias
Iron	Part of protein hemoglobin (carries oxygen throughout body‘s cells)	Artichoke, parsley, spinach, broccoli, green beans, tomato juice, tofu, clams, shrimp, beef liver	Skin pallor; weakness; fatigue; headaches; shortness of breath (all signs of iron-deficiency anemia)
Zinc	A part of many enzymes, involved in	Spinach, broccoli, green peas, green beans, tomato juice, lentils, oysters,	Slow healing of wounds; loss of taste; retarded growth and delayed

	production of genetic material and proteins, transports vitamin A, taste perception, wound healing, sperm production and the normal development of the foetus	shrimp, crab, turkey (dark meat), lean ham, lean ground beef, lean sirloin steak, plain yoghurt, Swiss cheese, tofu, ricotta cheese	sexual development in children
Selenium	Antioxidant, works with vitamin E to protect body from oxidation	Seafood, meats and grains	Impaired thyroid function, impaired cardiac function, enlarged heart, Necrosis of liver
Iodine	Component of thyroid hormones that help regulate growth, development and metabolic rate	Salt, seafood, bread, milk, cheese	Goitre – enlargement of thyroid gland
Copper	Necessary for the absorption and utilization of iron, supports formation of haemoglobin and several enzymes	Meats, water	Rare in adults. Infants may develop a type of anemia marked by abnormal development of bones, nerve tissue and lungs

Effects of Food Processing on Food Nutrition

Freezing, Drying, Cooking, and Reheating

Nearly every food preparation process reduces the amount of nutrients in food. In particular, processes that expose foods to high levels of heat, light, and/or oxygen cause the greatest nutrient loss. Nutrients can also be "washed out" of foods by fluids that are introduced during a cooking process. For example, boiling a potato can cause much of the potato's B and C vitamins to migrate to the boiling water. You'll still benefit from those nutrients if you consume the liquid (i.e., if the potato and water are being turned into potato soup), but not if you throw away the liquid. Similar losses also occur when you broil, roast, or fry in oil, and then drain off the drippings.

Consuming raw foods

The amount of nutrient loss caused by cooking has encouraged some health-conscious consumers to eat more raw foods. In general, this is a positive step. However, cooking is also beneficial, because it kills potentially harmful microorganisms that are present in the food supply. In particular, poultry and ground meats (e.g., hamburger) should always be thoroughly cooked, and the surface of all fruits and vegetables should be carefully washed before eating.

Grilling meats

Outdoor grilling is a popular cooking method, primarily because of the wonderful taste it imparts on meats. It can also be a healthy alternative to other cooking methods, because some of the meat's saturated fat content is reduced by the grilling process. However, grilling also presents a health risk. Two separate types of carcinogenic compounds are produced by high-temperature grilling:

- **Heterocyclic Amines (HCAs)**

HCAs form when a meat is directly exposed to a flame or very high-temperature surface. The creatine-rich meat juices react with the heat to form various HCAs, including amino-imidazo-quinolines, amino-imidazo-quinoxalines, amino-imidazo- pyridines, and aminocarbolines. HCAs have been shown to cause DNA mutation, and may be a factor in the development of certain cancers.

- **Polycyclic Aromatic Hydrocarbons (PAHs)**

PAHs form in smoke that's produced when fat from the meat ignites or drips on the hot coals of the grill. Various PAHs present in the resulting smoke, including benzo pyrene and dibenzo anthracene, adhere to the outside surface of the grilled meat. PAH exposure is also believed to be linked to certain cancers.

Effect of Food Processing on Vitamins and Minerals

The freshness, appearance, and nutritive value of foods changes when they are stored for long time. People in food industry work for procedures which make the foods retain their nutritive value even after a long time. The conversion of raw food materials into the acceptable food product by a variety of means is referred to as food processing. The techniques followed include, dehydration, freezing, heating at high temperatures, exposure to radiation (i.e., irradiation), fermentation, chemical preservation etc.

Processing of food has advantages and disadvantages both. We know that it results into desirable changes like enhancement of flavors, improvement of texture, and increase in shelf life etc. However, it may lead to some undesirable changes too. These include changes in colour, flavour, nutritional properties and development of toxicity.

Effect of Food Processing on Vitamins

Dehydration i.e., removal of water under controlled conditions is one of the ways of lowering water activity and preserving foods. However, dehydration results in decrease of vitamin levels. In fruits, β-carotene and B-group vitamins do not get altered significantly but vitamin C is lost to a good extent. However, pickling of vegetables leads to acidic pH, which stabilizes vitamin C. Freezing fruits, and vegetables also do not result in a substantial loss of vitamin A and β-carotene. The B-group vitamins also remain unaffected.

Heating at high temperatures, another important food process, results into a number of changes. For example, the heating process employed in industry for the sterilization of milk-based formulations greatly reduces their vitamin B6 content, thiamin may be lost to the extent of 30-50%. Baking of cereals and cereal products also cause loss of B-group vitamins to different extent. For example, the baking of white bread may result in thiamin loss of about 20%. The vitamin B12 on the other hand is not destroyed to a great extent by cooking, unless boiled in alkaline solution. The vitamin like vitamin A, vitamin B, thiamin, riboflavin, pantothenic acid and nicotinic acid do not get affected by frying of egg.

The heat treatment and leaching are the factors affecting vitamin C destruction during processing. Further, the rate of destruction of vitamin C is increased by the action of metals especially Cu and Fe and also by the action of enzymes. Considerable vitamin C is lost by cooking, preservation, drying and storage of the food's commodities. On irradiation the nutrients in meats and poultry are also affected. It has been found that thermal processing and radiation sterilization of pork have comparable losses of thiamine. Blanching of vegetables and cooking of meat do not cause folic acid losses. Vitamin A is relatively stable to heat in the absence of oxygen. Vitamin A and carotenoids have good stability during various food processing operations. Losses may occur at high temperatures in the presence of oxygen.

Vitamin D is extremely stable and little or no loss is experienced in processing and storage.

Vitamin D in milk is not affected by pasteurization, boiling or sterilization. Frozen storage of milk or butter also had little or no effect on vitamin D levels.

Substantial tocopherol losses may occur on processing and storage of foods. Baking of white bread results in a loss of ~50% of the tocopherols in the crumb.

Effect of Food Processing on Minerals

Minerals are comparatively stable under food processing conditions such as heat, light, use of oxidizing agents and extremes in pH. Therefore, processing does not usually reduce the mineral contents. However, these minerals can be removed from foods by leaching or by physical separation. Cooking in water would result in some losses of minerals since many minerals have significant solubility in water. In general, boiling the vegetables in water causes greater loss of minerals from them as against steaming them. Canned foods such as fruit juices may take up metals from the container-tin and iron from the tin plate and tin and lead from the soldering.

During cooking sodium may be lost but the other minerals are well retained. Many selenium compounds are volatile and can be lost by cooking or processing. Further, it has been found that milling of cereals cause considerable loss of minerals. Since minerals are mainly concentrated in the bran layers and in the germ, during milling after removal of bran and germ, only pure endosperm remains, which is poor in minerals. For example, when wheat is milled to obtain refined flour, the losses in mineral content are to the extent of 76% in case of iron, 78% in zinc, 86% in manganese, 68% for copper, and 16% for selenium. Similar losses occur during milling of rice and other cereals.

As mentioned above, the minerals are quite stable to heat and pH during processing. However, change in temperature, pH and concentration or dehydration may lead to the change in the status in food system. For example, in milk 1/3rd 1/4th of the calcium and phosphorous is associated with casein while 66 to 80% are present as dissolved calcium and phosphorous. On heating these minerals change from the dissolved to the colloidal state. On the other hand, cooling of milk shift the colloidal calcium and phosphorous to the dissolved state. Decrease in pH from the normal value towards isoelectric side (pH 4.6) will caused the solubilization of these minerals while an increase in pH will causes a shift of colloidal calcium, magnesium and phosphorus to the dissolved state. The minerals in meat products are in the non-fatty portions, when liquid is lost from meat, the maximum loss is of sodium and calcium, phosphorus and potassium are lost to a lesser extent. During cooking also, sodium is lost but other minerals are well retained. In fact, cooking dissolves some calcium from bone and enriches the meat with this mineral.

The table below compares the typical maximum nutrient losses for common food processing methods.

Typical Maximum Nutrient Losses (as compared to raw food)					
Vitamins	**Freeze**	**Dry**	**Cook**	**Cook+Drain**	**Reheat**
Vitamin A	5%	50%	25%	35%	10%
Retinol Activity Equivalent	5%	50%	25%	35%	10%
Alpha Carotene	5%	50%	25%	35%	10%
Beta Carotene	5%	50%	25%	35%	10%
Beta Cryptoxanthin	5%	50%	25%	35%	10%
Lycopene	5%	50%	25%	35%	10%
Lutein+Zeaxanthin	5%	50%	25%	35%	10%
Vitamin C	30%	80%	50%	75%	50%
Thiamin	5%	30%	55%	70%	40%
Riboflavin	0%	10%	25%	45%	5%
Niacin	0%	10%	40%	55%	5%
Vitamin B6	0%	10%	50%	65%	45%
Folate	5%	50%	70%	75%	30%
Food Folate	5%	50%	70%	75%	30%
Folic Acid	5%	50%	70%	75%	30%
Vitamin B12	0%	0%	45%	50%	45%
Minerals	**Freeze**	**Dry**	**Cook**	**Cook+Drain**	**Reheat**
Calcium	5%	0%	20%	25%	0%
Iron	0%	0%	35%	40%	0%
Magnesium	0%	0%	25%	40%	0%

Phosphorus	0%	0%	25%	35%	0%
Potassium	10%	0%	30%	70%	0%
Sodium	0%	0%	25%	55%	0%
Zinc	0%	0%	25%	25%	0%
Copper	10%	0%	40%	45%	0%

Effect of Food Processing on Carbohydrates

Food processing or cooking can have significant effect on the constituent carbohydrates. During cooking soluble carbohydrates are dissolved e.g., sucrose. Some polysaccharides get hydrolyzed. This may alter the rate and extent of digestion of starch and the properties of dietary fibre.

Effect on Starch

Heating the food to cook it and cooling thereafter before consuming have a significant effect on the starchy components of the food. These can be understood in terms of two important phenomena.

These are as follows.

Gelatinization: On heating starch in the presence of water, the crystalline structure of the starch granules is lost irreversibly by a process called gelatinization. It is due to absorption of water by starch granules and turning into a jelly like substance. In this process, amylopectin forms the gel and amylase comes into solution. When heating is continued in excess water, more soluble components of starch come into solution and a paste result. In the food processing, the starch granules are not completely dissolved however, their partial gelatinization is sufficient to allow a good part of the starch to be digested rapidly. In the steaming of food, the process of gelatinization occurs to a small extent whereby a large proportion of slowly digestible starch is preserved.

Retrogradation: The process of re-association of the starch granules on cooling of the gelatinized starch or the starch paste is called retrogradation. It depends on the relative proportions of amylose and amylopectin in starch as linear amylose molecules re-associate faster than the highly branched amylopectin. Reheating starchy foods also influences this process. The digestibility of starch in the small intestine is reduced by the degree of processing and retrogradation. The staling of bread is due to retrogradation of starch and the rate of staling is temperature dependent.

Effect on Dietary Fiber

The cereal grains are usually milled to form refined flours, which are processed to prepare food products. The milling process removes the fiber-rich outer layers of the grain, and diminishes the total fiber content. The flours of wheat, rye, and maize contain large amounts of cellulose and hemicelluloses. Oat and barley also lose some dietary fiber in the process of milling. Besides the heat treatment can also influence the physical structure and the functional properties of the dietary fiber. The pectic substances cause thickening of juices, also these are also responsible for mushy nature of vegetables.

Deteriorative Changes in Fats and Oils and their Prevention

Food processes like heating and frying lead to polymerization of fats that leads to change in molecular weight, colour, viscosity and refractive index of the fat or the oil used. The presence of enzymes, atmospheric oxygen and application of high temperature are the factors responsible for such changes. The deteriorative changes in fats and oils are termed rancidity. In some cases, containing high content of PUFA (Linolenic acid) lose the flavour giving a taste to it. This is called flavour reversion. It is of great economic concern to the food industry because it leads to the development of various off-flavours and off-odours in edible oils and fat-containing foods, which render these foods less acceptable.

Lipid oxidation is one of the major causes of food spoilage. Oxidative reactions can decrease the nutritional quality of food and certain oxidation products are potentially toxic. On the other hand, under certain conditions, a limited degree of lipid oxidation is sometimes desirable, as in aged cheeses and in some fried foods.

Auto-oxidation, Lipolysis and Thermal Decomposition

Oxidation via a self-catalytic mechanism is the main reaction, which takes place in oil becoming rancid. This is called the oxidative deterioration of lipids or '**auto-oxidation'**. The auto-oxidation follows a free radical mechanism and can be visualized to be consisting of three stages as follows.

a) Initiation

In the first step of auto-oxidation process called initiation, hydrogen is removed from the fatty acid chain to yield a free radical. The reaction can be shown as below.

RH ------------------> R˙ + H˙ (R and H are free radicals)

b) Propagation

Once a free radical is formed, it combines with oxygen to form a peroxy free radical which can remove hydrogen from another unsaturated molecule yielding a peroxide and a new free radical. This is called propagation reaction' and may repeat up to several thousand times in a kind of chain reaction

R˙ + O2 --------> RO2˙

RȮ 2 + RH -------> ROOH + R˙

(peroxide)

c) Termination

The propagating chain reactions are terminated through a reaction between the free radicals to yield non-active products

R˙ + R˙ -----> R - R

R˙ + RO2 -----> RO2R

nRO2 -----> (RO2)n