FOOD ADDITIVES

What are Food Additives

- Food additives may be defined as follows: a substance or mixture of substances, other than a basic foodstuff, which is present in a food as a result of any aspect of production, processing, storage, or packaging. The term does not include chance contaminants.

- Legally, according to the FDA, the term refers to "any substance the intended use of which results or may reasonably be expected to result, directly or indirectly in its becoming a component or otherwise affecting the characteristics of any food."

- This definition includes any substance used in the production, processing, treatment, packaging, transportation or storage of food.

NEED FOR FOOD ADDITIVE

- Preservation
- Nutrition
- Convenience Foods
- Appealing Foods
- To aid in the processing and preparation of foods

TYPES OF FOOD ADDITIVE

- **Direct/ Intentional Additives:** Food additives are those that are added to a food for a specific purpose in that food. For example, xanthan gum -- used in salad dressings, chocolate milk, bakery fillings, puddings and other foods to add texture.

- **Indirect/Unintentional Additives:** They are those that become part of the food in trace amounts due to its packaging, storage or other handling. Examples include radioactive fallout, chemicals used in agricultural production and accidental contaminants during food processing

TYPES OF DIRECT FOOD ADDITIVES

- Preservatives
- Food flavours
- Anti-caking agents
- Food colours
- Bulking agents
- Thickners
- Sweetners
- Stabilizers
- Acidulants
- Humectants
- Emulsifiers

Antioxidants

Antioxidants act as preservatives by inhibiting the effects of oxygen on food, and can be beneficial to health.

Examples - Ascorbic acid (Vit C), Tocopherols (Vit E).

Chelating Agents

They serve as scavengers of metals which catalyze oxidation.

Examples - EDTA (ethylenediaminetetraacetic acid) and citric acid.

❖ FOOD COLORING

- Colorings are added to food to replace colors lost during preparation, or to make food look more attractive.

- **Natural colorants** are Caramel coloring (E150), Annatto (E160b), chlorophyll (E140), Cochineal (E120), Betanin extracted from beets, Turmeric (curcuminoids, E100), Grape Skin Extract etc.

- **Synthetic colorants** are FD&C Blue No.1 (E133), FD&C Green No.3 (E143), FD&C Red No. 40 (E129) etc.

❖ ANTIFOAMING AGENTS

- Antifoaming agents reduce or prevent foaming in foods.
- **Examples**- Polydimethylsiloxane (a type of silicone). Silicone oil is also added to cooking oil to prevent foaming in deep-frying.

❖ CURING AGENTS

- These are additives used to preserve (cure) meats, give them desirable colour and flavor, discourage growth of micro-organisms, and prevent toxin formation.
- **Example**- Sodium nitrite has been used for centuries as a preservative and colour stabilizer in meat and fish products.

❖ EMULSIFIERS

- Emulsifiers allow water and oils to remain mixed together in an emulsion, as in mayonnaise, ice cream, and homogenized milk. E.g Lecithin

❖ FLAVOURS AND FLAVOUR ENHANCERS

- Flavouring additives are the ingredients, both naturally occurring and added, which give the characteristic flavor to foods.

- Flavour enhancers are not flavours themselves but they amplify the flavours of other substance through a synergistic effect.

- **Examples** – Artifical flavours such as MSG and natural flavours e.g extracted from milk, egg,nuts e.t.c

❖ ANTICAKING AGENTS

- Anticaking agents keep powders such as milk powder from caking or sticking.
- **Examples** - Sodium bicarbonate (E500), Calcium silicate (E552), Sodium aluminosilicate (E554), Bentonite (E558)

❖ BULKING AGENTS

- Bulking agents such as starch are additives that increase the mass and volume of a food without affecting its nutritional value.
- **Examples**- Cellulose, Inulin, Polydextrose

❖ FLOUR IMPROVERS

- These are bleaching and maturing agents; usually, they both bleach and “mature” the flour.

- Freshly milled flour has a yellowish tint and yields a weak dough that produces poor bread. Both the colour and baking properties improve by storing the flour for several months before making bread. Example: Benzoyl peroxide.

❖ LEAVENING AGENTS

- Leavening agents produce light fluffy baked goods. Originally, yeast was used almost exclusively to leaven baked products. It is still an important leavening agent in bread making.

- When yeast is used, ammonium salts are added to dough to provide a ready source of nitrogen for yeast growth..

❖ HUMECTANTS

- Humectants prevent foods from drying out by retaining moisture.
- **Examples** – Glycerol/propylene glycol (E1520), and glyceryl triacetate (E1518), sorbitol (E420).

❖ PRESERVATIVES

- Preservatives prevent or inhibit spoilage of food due to fungi, bacteria and other microorganisms.
- **Examples**- Natural preservatives such as vinegar, sugar and artificial preservatives such as Benzoates, Nitrites, Sulphites e.t.c

❖ STABILZERS

- Stabilizers, thickeners and gelling agents, like agar or pectin (used in jam for example) give foods a firmer texture. They help to stabilize emulsions.
- **Examples-** Alginic acid, pectin, gelatin, calcium chloride e.t.c

❖ ACIDULANTS

- Food acids are added to make flavors "sharper", and also act as preservatives and antioxidants.

- **Examples**- vinegar, citric acid, tartaric acid, malic acid, fumaric acid, and lactic acid.

❖ ACID REGULATORS

- Acidity regulators are used to change or otherwise control the acidity and alkalinity of foods.

- Examples - Acetic acid, Citric acid

❖ GLAZING AGENTS

- Glazing agents provide a shiny appearance or protective coating to foods.
  - Stearic acid (E570)
  - Beeswax (E901)
  - Candelilla wax (E902)

❖ FLOUR TREATMENT AGENTS

- Flour treatment agents are added to flour to improve its color or its use in baking.
  - azodicarbonamide (E927)
  - carbamide (E927b)

SWEETENERS

- Sweeteners are added to foods for flavoring. Some sweeteners other than sugar are added to keep the food energy (calories) low, or because they have beneficial effects for diabetes mellitus and tooth decay and diarrhea.

- **Examples– Natural Sweeteners** found in sugar cane, stevia,maltodextrins, sugar beet or corn syrup and **artificial sweeteners such as** aspartame, acesulfame K, sugar alcohols, sucralose, saccharin e.t.c

❖ NUTRIENT SUPPLEMENTS

- Nutrient supplements restore values lost in processing or storage, or ensure higher nutritional value than what nature may have provided.
- When foods are processed, there may be loss of some nutrients and additives may be added to restore the original value.
- **For example**, vitamin C is added to canned citrus fruits to make up the loss of the vitamin during processing.

❖ THICKENERS

- Thickeners are substances which, when added to the mixture, increase its viscosity without substantially modifying its other properties.
- **Exampl**e- arrowroot, cornstarch, potato starch, vegetable gums (guar gum, locust bean gum, and xanthan gum, protein (Proteins used as food thickeners include collagen, egg whites etc.

OTHER FOOD ADDITIVES

- **Clarifying agents** like bentonite, gelatins, synthetic resins (polyamides and poly vinyl pyrrolidone) are used to remove haziness or sediments and oxidative deterioration products in fruit juices, beers and wines.

- **Enzymes** are added to bring about desirable changes; rennin for producing curd and cheese, papain for tenderizing meat, and pectinase for clarifying beverages.

- **Firming agents** like aluminium sulphates and calcium slats are used t keep the tissues of fruits and vegetables crisp.

- **Freezing agents** like liquid nitrogen and dichloro fluoro methane, which are extremely volatile and rapidly evaporate at ordinary temperatures, are used to chill foods.

- **Solvents** like alcohol, propylene glycol and glycerine are used to dissolve suspended flavours, colours, and many other ingredients.

- **Packing gases**, such as inert gases, are added to packets of instant foods to prevent oxidative and many other changes

NUMBERING OF ADDITIVES

- Each additive is assigned a unique number, termed as "**E numbers**" which is used in Europe for all approved additives.

- This numbering scheme has now been adopted and extended by the Codex Alimentarius Commission

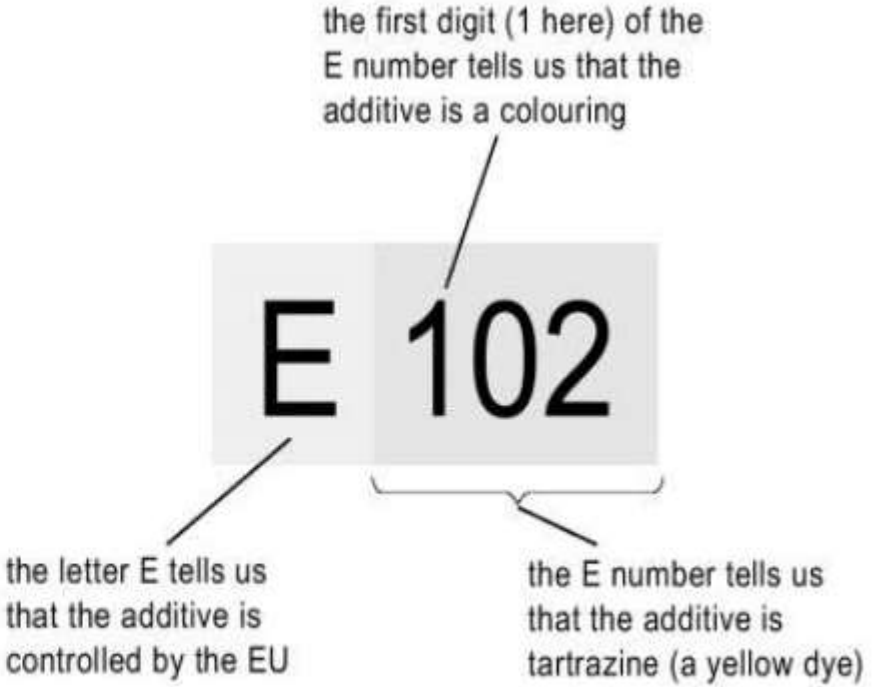
E 100 – Curcumin, turmeric
E 123 – Amaranth
E 140 – Chlorophylls, Chlorophyllin
E 210 – Benzoic acid
E 224 – Potassium metabisulphite
E 300 – Ascorbic acid
E 330 – Citric acid

Type of additive	First digit of the E number	Purpose	Example
Colourings 	1	to improve colour	tartrazine (E 102), a synthetic yellow dye added to sweets, fizzy drinks and packet food
Preservatives 	2	to preserve food so that it goes bad less quickly	benzoic acid (E 210) added to beer, sauce and jam
Flavourings 	(*not* numbered)	to add or enhance flavour	ethyl ethanoate, a synthetic ester, add to give a pineapple flavour in drinks and sweets
Anti-oxidants 	3	to stop fats and oils getting oxidized, changing colours and tasting bad	BHA (E 320) added to biscuits, butte margarine and oils
Emulsifiers and stabilizers 	3 or 4	to make oil and water mix, and alter the texture of food	lecithin (E 322) added to ice cream, salad dressings and margarine
Acid and bases 	5	to control pH	citric acid added to soft drinks; sodium hydrogencarbonate (E 500) added to canned custard etc.
Sweeteners 	4 or 6	to sweeten food without using sugar	sorbitol (E420) added to certain drink and sweets (suitable for diabetics and those on d
Nutrients 	(*not* numbered)	to increase the nutritive value	vitamin C added to soft drinks; minerals added to milk powder

LABELING

- Federal government regulations generally require that all food ingredients, including direct additives, be listed on the package label by their common names in order of weight.
- The EU (European Union) countries have drawn a list of 314 safe food additives. Each of them is given an E number.

100-199	colors
200-299	preservatives
300-399	antioxidants and acidity regulators
400-499	thickeners, stabilizers and emulsifiers
500-599	ph regulators, anti-caking agents
600-699	flavor enhancers
700-799	antibiotics
900-999	miscelaneous
1100-1599	Additional chemicals



Permissible Limits of Food Additives

ESTABLISHING PERMISSIBLE LIMITS OF FOOD ADDITIVES

The limit is established with due importance to following factors:

- The estimated level of consumption of the food product by the consumers for which the additive is proposed.
- Finding out minimum levels which would produce significant deviation from physiological behavior.
- Legal control over the use of food additives. This can be accomplished only when a list of permitted additives exists with specified safe levels and toxic levels.
- Stringent labeling on foods i.e. declaring the usage of additives in food and their quantities.
- Employing trained food inspectors, food control laboratories and reliable analytical methods are of utmost important for regulation / control over usage of food additives.

Some of the permitted GRAS Additives and Tolerances

Additive	Food Used	Function	Tolerance
Al, Ca silicate	Table Salt	Anti-caking agent	2.0 %
BHA	Various foods	Antioxidant	0.3%
≤0.02%	Various foods		
BHT			
Caffeine	Cola type beverages	Multi-purpose	0.02%
Ca. Silicate	Table	Anti-caking	2.0 %
	Baking powder	Fumigants	5.0 %
	Cashew nuts	Flavouring agents	
Ethyl formarate	Baked goods	Flavouring agents	0.03%
	Pudding fillings		0.05%
KMS	General preservative	Antimicrobial	GMP
Sodium bisulphite	Various foods	Antimicrobial	GMP
SO_2	Wines, fruit juices, dehydrated foods	Antimicrobial	GMP
Stearyl citrate	Various fruits	Sequestrants	0.15%
Thiodipropionic acid	Various fat containing foods	Antioxidants	0.02 %

ADI'S (ACCEPTABLE DAILY INTAKE) OF SOME FOOD ADDITIVES:

Addtive	ADI Mg/kg	Function
EDTA	2.5	Preservative Sequestrant
BHA	0.5	Antioxidant
BHT	0.5	Antioxidant
Sodium nitrate	5.0	Curing, Colour fixation
Sodium stearyl formal	0.2	Stabilizing is non-yeast leavened. Conditioning agent is yeas leavened
Glycine	25	Stabilizer
Succinylated monoglyceride		Emusifier, dough conditione
Polysorbate	25	Emulsifies
Polypropyl glycoaginate	25	Stabilizer Emulsifier

Toxicity and adverse effects of food additives

- **Digestive disorders** – diarrhoea, stomach pain
- **Nervous disorders** – hyperactivity, insomnia and irritability
- **Respiratory problems** – asthma and sinusitis
- **Skin problems** – hives, itching, rashes and swelling


Sodium propionate
Annatto
Sodium metabisulphite
Sodium benzoate
Sunset yellow FCF
Allura red AC
Brilliant blue FCF
Tartrazine
Sunset yellow FCF
Monosodium glutamate
Sodium benzoate
Aspartame
Cyclamate
Sulphur dioxide
Tartrazine
Sunset yellow FCF
Carmoisine
Brilliant blue FCF
Sunset yellow FCF
Allura red AC
Brilliant blue FCF
Sodium sulphite
Potassium metabisulphite
Annatto
Tartrazine
Sunset yellow FCF
Carmoisine
Ponceau 4R
Erythrosine
Cyclamate
Saccharin
Sunset yellow FCF
Allura red AC
Brilliant blue FCF
Annatto
Monosodium glutamate

FSSAI

FSSAI,2006

- **The Food Safety and Standards Authority of India (FSSAI)** has been established under Food Safety and standards 2006 which consolidates various acts & orders that have either to handled food related issues in various ministries and departments.
- It has been created for laying down science based standards for articles of food and to regulate their manufacture, storage, distribution, sale and import to ensure availability of safe and wholesome food for human consumption.

FEATURES OF FSSAI

- It would lay down the guidelines for the accreditation of the bodies that are engaged in the certification of food safety management system for food businesses.
- It would lay down guidelines for accreditation of laboratories and notification of the accredited laboratories.
- It would provide scientific advice and support to the central and state governments in framing rules for food safety and nutrition.
- It would collect and compare data on food consumption, incidence and prevalence of biological risks, contaminants in food and its products, residues of various, recognition of emerging risks and introduction of alert systems. To establish a network that would provide information to all the people in the society regarding food safety and the related issues.
- To provide training programs to the people who are or plan to get involved in the food business. To contribute in the development of international technical standards for food and sanitation.

- There are **7 main acts** under the FSSAI act,2006. They are :

1.)Prevention of Food Adulteration Act,1955

2.) Fruit Product Order, 1955

3.) Meat Product Order,1973

4.) Vegetable Oil Product(Control) Order,1947

5.) Edible Oils Packaging(Regulation) Order,1988

6.) Solvent Extracted Oil, De-oiled Meal and Edible Flour(Control) Order, 1967

7.) Milk and Milk Product Order,1992

The Prevention of Food Adulteration act, 1954:

- The act seeks to prevent the adulteration of any article used as food or drinks for human consumption excluding drugs and water.
- The act gives the power to the central government to set up at Central Committee for Food Standards and Central Food Laboratory for testing and analyzing food items.
- Additionally, the act also states that no persons shall import into India any food which has been adulterated or misbranded.
- The act also provides penalties for contravening provisions of this act.

The Fruit Products Order, 1955

- Fruit Products Order -1955 was declared under Section 3 of the Essential Commodities Act – 1955.
- Its objective is to manufacture fruit & vegetable products, maintain sanitary and hygienic conditions in the premises and to ensure that the quality standards are laid down in the Order.
- All manufacturers of fruit and vegetable products including some non fruit products like non fruit vinegar, syrup and sweetened aerated water are supposed to obtain a license under this Order.
- **There are a few minimum requirements laid down in the Fruit Product Order for hygienic production and quality standards and that are as follows:**
  Location and surroundings of the factory, Sanitary and hygienic conditions of premises, Personnel hygiene, Portability of water, Machinery & Equipment with installed capacity, Quality control facility & Technical staff, Product Standards, Limits for preservatives & other additives.

The Meat Food Products Order, 1973

- Processing of meat products are licensed under the meat food products order.
- It encompasses the regulation of the production and sale of meat food products through licensing of manufacturers, enforcement of sanitary and hygienic conditions laid down for production of wholesome meat food products and implementation of strict quality control at all stages of production of meat food products, fish products including chilled poultry etc.
- Under MFPO, all manufacturers of meat food products engaged in manufacturing, packing, repacking, relabeling meat food products meant for sale are licensed except those who manufacture meat products for consumption on the spot like in restaurants, hotels etc.

The Vegetable Oil Products (Control) Order, 1947

- Vegetable Oil Products (Control) Order, 1947 along with Vegetable Oil Products (Standards of Quality) Order, 1975 has been replaced by a single Order called “Vegetable Oil Products (Regulation) Order, 1998.
- This was done for proper regulation of manufacture, distribution and sale of Vegetable Oil Products. This order has lead to a huge reduction in the overlapping of jurisdiction of multiple authorities and agencies.
- The Directorate of Vanaspati, Vegetable Oils and Fats holds the responsibility for implementation of the standards of quality of the vegetable oil product mainly at the manufacturing stage.
- The provision for proposal of BIS Certification has been removed. This order has laid down the standards of quality and there has been some easing in vegetable oil product prices.

The Edible Oils Packaging (Regulation) Order, 1998

- This order was promulgated under the Essential commodities act, 1955 in order to make the packing of edible oils at predetermined prices, sold in retail, mandatory with an exception of being exempted by the concerned state government. Its objective was to ensure the availability of safe and quality edible oils.

- **Salient features of this order are as follows:**

1.) All the packers have to compulsorily get registered with the registering authority as well as have their own analytical facilities for the samples of edible oils to be tested to the government's satisfaction.

2.) Only those oils will be allowed to be packed which conform to the standards of quality specified in the Prevention of Food Adulteration Act, 1954 and Rules made thereunder.

2.) Only those oils will be allowed to be packed which conform to the standards of quality specified in the Prevention of Food Adulteration Act, 1954 and Rules made thereunder.

3.) Each container or pack will have to show the relevant particulars in order to avoid the consumer being misled and to state the clear identity of the packer.

4.) The packing of Edible oils shall conform to the Standards of Weights and Measures (Packaged Commodities) Rules, 1977 and the Prevention of Food Adulteration Act, 1954 and Rules made thereunder.

5.) The power to relax the requirements of the packaging order to meet special circumstances will be under the control of the State Governments.

The Solvent Extracted Oil, De oiled Meal, and Edible Flour (Control) Order, 1967

- This Order has been formulated to ensure that the solvent extracted oils do not reach the consumers for consumption before they are refined and conform to the quality standards specified in the Order for the same.
- In order to eliminate the contamination of oil from the solvent used, Standards for the solvent (hexane), used for extraction of oil from the oil-bearing materials, have also been specified.

The features of this order are as follows:

- It controls the manufacture, quality and movement of solvent extracted oils, de-oiled meal and edible flour.

- It offers consumer protection through quality assurance of solvent extracted oils, de-oiled meal and edible flour.
- It decimates the possibility of diversion of the oils for unintended uses.
- It prohibits by, offers to buy, use or stock for use any solvent that does not comply with the quality standards for extraction of vegetable oils and states the particulars that need to be declared on the label attached to the container.

The Milk and Milk Products Order, 1992

- The milk and milk products order, 1992 was promulgated under the section 3 of the Essential commodities act, 1955 by the department of AH, dairying and fisheries because of the de-licensing of Dairy Sector in 1991 under Industrial Development & Regulation Act.
- The main objective of the order is to maintain and increase the supply of liquid milk of required quality and to regulate the production, processing and distribution of milk and milk products.
- According to this order it is mandatory for a person or a dairy plant handling more than 10,000 liters per day of milk or 500 MT of milk solids per annum, to get registered with the Central government appointed Registering Authority.

The Essential Commodities Act, 1955

- Its objective is to ensure that the essential commodities are available to the consumers and to protect them from being exploited by corrupted traders.
- It regulates and controls the production, distribution and pricing of commodities which are considered essential for maintaining or increasing supplies. It also ensures their equitable distribution and availability at fair prices.
- At present the number of essential commodities has been brought down to 7. After an agreement with the state governments, the Central Government has the power to add, remove and modify any essential commodity in the public interest.
- The addition/modification of any essential commodity will depend on the scarcity or non-availability of the commodity during war, natural calamities, disruption or threat of disruption of supply of essential commodities, requiring Central Government's intervention under the Act.

Livestock Importation Act, 1898:

- This Act has established procedures and regulates the import of livestock which are prone to be affected by infectious or contagious disorders.
- It makes a sanitary import permit mandatory from the department of Animal Husbandry, dairying and fisheries at the ministry of agriculture, during the import of meat products, eggs and egg powder and milk products.
- An import risk analysis is performed considering the disease scenario in the exporting country in comparison to the disease situation in India.

Export (quality control and inspection) Act, 1963

- All the operations of this Act fall under the responsibility of the Export Inspection Council. Its salient features are as follows:
  - A number of exportable commodities have been notified for compulsory pre-shipment inspection.
  - The quality control and inspection of export products is administered through fifty offices located around major production centers and ports of shipment.
  - Organizations may be considered as agencies for inspection and /or quality control.
  - Agriculture, food products, fruit products, fish and fishery products have been exempted by the government from pre-shipment inspections. There is one condition to the above clause, that the exporter should have a firm letter from the overseas buyer mentioning that the overseas buyer does not require pre-shipment inspection from official Indian inspection agencies.

SUMMARY

- These Laws and regulations ensure the development of a wholesome food processing sector. They have been laid down for standardization of all the food procedures resulting in a conducive environment sustaining healthy growth.

Active compounds in functional foods and antioxidants

ACTIVE COMPOUNDS IN FUNCTIONAL FOODS

Functional foods offer specific benefits that enhance life and promote longevity, and the active compounds responsible for these favorable effects can be analyzed through a range of techniques. Bioactive compounds are present in small quantities in foods, mainly in fruits, vegetables, and whole grains, and provide health benefits beyond the basic nutritional value (Gökmen, 2016). Bioactive compounds are molecules that can present therapeutic potential with influence on energy intake, while reducing pro-inflammatory state, oxidative stress, and metabolic disorders (Siriwardhana et al., 2013).

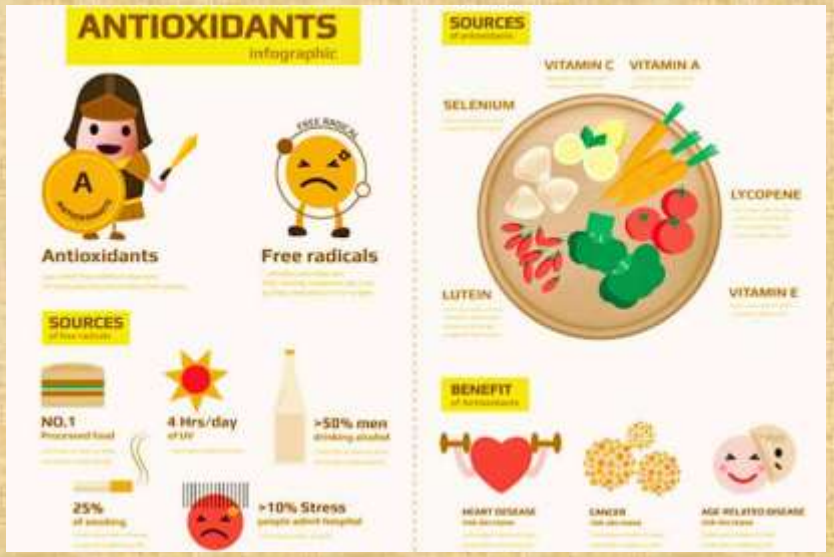
Epidemiological studies indicate that high consumption of foods rich in bioactive compounds with antioxidant activity, including vitamins, phytochemicals, and mainly phenolic compounds, such as flavonoids and carotenoids, has a positive effect on human health and could diminish the risk of numerous diseases, such as cancer, heart disease, stroke, Alzheimer's, diabetes, cataracts, etc.

Functional components include phytochemicals which are plant-derived, non-nutritive and biologically active chemicals that function in the body to prevent the onset of certain non-communicable diseases (Murano 2003). There are over 900 phytochemicals found in foods. One serving (about 120 g) of a fruit or vegetables may have as many as 100 different phytochemicals (Srividya et al. 2010).
Previously, it was thought that functional components occur predominantly only in plant foods including whole grains, fruits, and vegetables as phytochemicals. However, probiotics, conjugated linolenic acid, long-chain omega-3, −6 and −9 polyunsaturated fatty acids, and bioactive peptides are equally found in animal products such as milk, fermented milk products and cold-water fish.

Some examples of functional foods are - Beta Carotene, Lutein, Lycopene, Fiber, Omega 3, Anthocyanin, Flavonoids, Selenium, Isoflavones, Lignans, Vitamin A, Vitamin C, Vitamin E, Biotin, Plant sterols etc.

Some functional ingredients of food, their sources and potential benefits: -
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4397330/table/Tab1/?report=objectonly

ANTIOXIDANTS



Antioxidants are compounds that inhibit oxidation. Oxidation is a chemical reaction that can produce free radicals, thereby leading to chain reactions that may damage the cells of organisms. In biological systems, removal or addition of electrons is the most frequent mechanism known as redox reactions. The reduction is the addition of an electron to an acceptor molecule, which stores energy, while oxidation is removal of an electron from a molecule to release energy. During, the process of release of energy to perform normal activities of life, electrons are transferred between the molecules resulting in many ***REACTIVE OXYGEN SPECIES*** and the non- oxygen free radicals in the body.

Free radicals are waste substances produced by cells as the body processes food and reacts to the environment. If the body cannot process and remove free radicals efficiently, oxidative stress can result. This can harm cells and body function.

Oxidative stress has been linked to heart disease, cancer, arthritis, stroke, respiratory diseases, immune deficiency, and other inflammatory or ischemic conditions.

Factors that increase the production of free radicals in the body can be internal, such as inflammation, or external, for example, pollution, UV exposure, and cigarette smoke.

They are sometimes called ***"free-radical scavengers."***

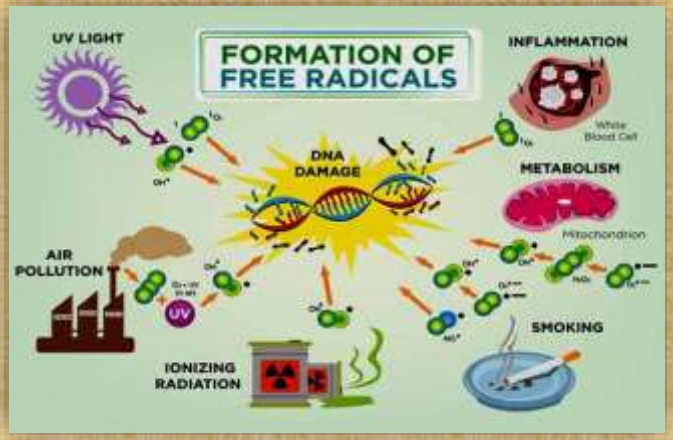
The sources of antioxidants can be natural or artificial. Certain plant-based foods are thought to be rich in antioxidants. Plant-based antioxidants are a kind of phytonutrient, or plant-based nutrient.

The body also produces some antioxidants, known as endogenous antioxidants. Antioxidants that come from outside the body are called exogenous antioxidants.

Antioxidants are said to help neutralize free radicals in our bodies, and this is thought to boost overall health.

FACTORS THAT INCREASES FREE- RADICAL FORMATION

BODY FACTORS	ENVIRONMENTAL FACTORS
Energy metabolism	Air pollution
Diabetes	Asbestos
Exercise	High levels of vitamin C
Acute illness	High levels of oxygen
Immune response	Radioactive emissions
Injury	Some herbicides
Obesity	Tobacco smoke
Other diseases	Trace minerals
Other metabolic reactions	Ultra-violet rays
Xenobiotics	



Selenium (Se)

Selenium is a chemical element with the symbol **Se** and atomic number 34. It is a nonmetal (more rarely considered a metalloid) with properties that are intermediate between the elements above and below in the periodic table, sulfur and tellurium, and also has similarities to arsenic. It rarely occurs in its elemental state or as pure ore compounds in the Earth's crust.

Selenium (Se) is an essential trace element, and its low status in humans has been linked to increased risk of various diseases, such as cancer and heart disease. In recent years, Se research has attracted tremendous interest because of its important role in antioxidant selenoproteins for protection against oxidative stress initiated by excess reactive oxygen species (ROS) and reactive nitrogen species (NOS).

However, excess Se intakes through supplementation and its potential misuse as health therapy could also pose a risk of adverse health effects if its use is not properly regulated.

FOOD SOURCES OF SELENIUM

In foods, Se is predominantly present as *selenomethionine*, which is an important dietary source. Foods are major natural source of Se, The amount of selenium in different foods depends on the amount of selenium in the soil where the food was grown. Rain, evaporation, pesticides, and pH levels can all affect selenium levels in soil. Its deficiency has caused serious health effects in humans, such as Keshan disease.

- The riches sources of selenium are organ meats and seafood- such as FISH, HAM, BEEF, TURKEY, CHICKEN, EGGS etc.
- The variation in the selenium content of cereals vegetable and grains is due to the fact that plants do not appear to require selenium and thus contain variable amounts, depending upon how much soil selenium is available for uptake (Phyto availability)- various sources are BRAZIL NUTS, BROWN RICE, SUNFLOWER SEEDS, BAKED BEANS, MUSHROOMS, OATMEAL SPINACH, LENTILS, CASHEW, BANANAS.
- The milk and milk products also contain good amount of selenium- such as yogurts. Cottage cheese and milk .

FUNCTIONS OF SELENIUM

- **Acts as a powerful antioxidant-** Selenium is a powerful antioxidant that fights oxidative stress and helps defend your body from chronic conditions, such as heart disease and cancer.
- **May reduce the risk of certain cancers-** Selenium has ability to reduce DNA damage and oxidative stress, boost your immune system, and destroy cancer cells. selenium may reduce side effects in people undergoing radiation therapy.
- **May protect against heart disease-** Selenium may also lower markers of inflammation in the body – one of the main risk factors for heart disease such as atherosclerosis, or the buildup of plaque in arteries.
- **Helps prevent mental decline-** A diet rich in selenium may help prevent mental decline and improve memory loss in people with Alzheimer's disease.
- **Important for thyroid health-** Selenium protects the thyroid gland from oxidative stress and is necessary for thyroid hormone production. Selenium may help people with Hashimoto's disease and other types of thyroid disease, but more research is needed.
- **Boosts the immune system-** Selenium is crucial for the health and proper functioning of your immune system. Higher levels of selenium may help boost the immune systems of people with HIV, influenza, tuberculosis, and hepatitis C.

ISOFLAVONS

Isoflavones are part of the human diet all over the world. They are a type of polyphenol.
They are produced almost exclusively by the members of the bean family particularly in soy, black beans, green split peas, chickpeas, lima beans, split peas, alfalfa sprouts, sunflower seeds and clover sprouts.

Moreover their natural distribution in raw materials, their presence as an ingredient in the composition of several foods, soy products in infant foods, vegetarian formulations, etc. lead to their ubiquitous presence in foodstuffs. Due to their ubiquitous distribution in food and the claimed beneficial health effects as in renal disease protection, learning memory behavior during aging, prevention of some types of cancer, bone metabolism etc.

Soybeans are the richest source of isoflavones, and soy foods and ingredients contain varying concentrations of isoflavones. Isoflavone content is affected to some extent by processing, with the highest levels in whole-bean products, such as tofu and cooked soybeans.
Soyabeans are implicated to improve cognitive abilities, prevent osteoporosis and various cancers, improve immune function and maintenance of menopausal health in women, and also suppress CVD by lowering total cholesterol and LDL cholesterol and raising HDL in the blood vessels

LIGNANS

LIGNANS are fiber-associated compounds found in many plant families and common foods, including grains, nuts, seeds, vegetables, and drinks such as tea, coffee or wine. The highest concentrations of dietary lignans are found in flaxseed. Some examples of lignans are enterolignans, enterodiol and enterolactone.

When a part of the human diet, some plant lignans are metabolized by intestinal bacteria to mammalian lignans enterodiol. Lignans are antioxidants that may also support the immune system. Additionally, lignans are excellent for balancing hormone levels in the body. In women, they help balance estrogen levels; in men, they help balance the testosterone.

SOURCES OF LIGNANS-

- Flax seed and sesame seed contain higher levels of lignans than most other foods. The principal lignan precursor found in flaxseed ***is secoisolariciresinol diglucoside.***
- Other sources of lignans include cereals (rye, wheat, oat and barley - rye being the richest source), soybeans, cruciferous vegetables such as broccoli and cabbage, and some fruit, particularly apricots and strawberries.

VITAMINS

Vitamins are a group of unrelated organic in many foods in small amounts and necessary in trace amounts for the normal metabolic functioning of the body. They may be water soluble or fat soluble.

VITAMIN A

Vitamin A was discovered in 1909, when McCollum and Davis observed that a fat-soluble vitamin substance was necessary for the growth of animals. Its chemical name is retinol. In the body, vitamin A can also function in the slightly different aldehyde (retinal) or acid (retinoic acid) forms. Retinol and retinal (retinaldehyde) can be readily inter converted but retinoic acid cannot be converted back into retinol or retinal. The two other members of the vitamin A family compounds are retinyl esters (produced when retinol combines with an organic acid, usually palmitic acid) and β-carotene. Retinol can be converted into all major members of the vitamin A except the β-carotene.

Carotenoids serve as precursors of vitamin A and these are structurally related to β-carotene.

RETINOIDS

The term retinoid is used to include retinol and its derivatives and analogues either naturally occurring or synthetic, with or without the biological activity of the vitamin. The main biological active retinoids until late 1990s, only retinol, retinaldehyde, all trans-retinoic acid and 9-cis-retinoic acid known to be biologically active. However, a number of other retinoids are now also known to have important functions, including 4-oxo-retinol, 4-oxo-retinoic acid and a variety of retro retinoids.

Units- 1μg of retinol = 3.7 μg of β-carotene

= 2 μg of carotenoids

= 0.3 μg of retinol equivalents

FUNCTIONS –

- Vision- vitamin A plays a critical role in dim light, in the retina of the eye. Retinol, supplied to the retina in blood is converted to retinal, which then combines with a protein called opsin to produce a purple pigment known as rhodopsin. Rhodopsin is located in the light sensitive rod cells of the retina. When light strikes the rod cells are bleached as the rhodopsin splits to form retinal and opsin. As this occurs, a nerve stimulus is transmitted through the optic nerve fibres to the visual centre of the brain, where the sensation of vision is created. The eye contains only 0.01% of the total vitamin A in the body.
- GROWTH- It is well established that vitamin A is essential for the normal growth of bones. In vit A deficiency bones become weak, although thicker than normal. The cavities in the skull and spinal column do not enlarge to make room for the growing nervous system. As, a result of vit A deficiency, bone remodeling does not occur properly retinoic acid can support growth but will not maintain normal vision.
- CELL DIFFERENTIATION AND GENE EXPRESSION – epithelial cells are found in many locations, including the skin, the eye and in the lining of the digestive system, genitourinary system and respiratory tract. Those within the body normally secrete mucus and are covered by hair like cilia. The cilia are involved in protecting the body against infection by sweeping the cell surfaces clear of invading micro-organisms. In vit A deficiency keratinized cells the cilia are lost, and leave the body more vulnerable to the infection. Hence, vit A is known as “anti-infective” vitamin.

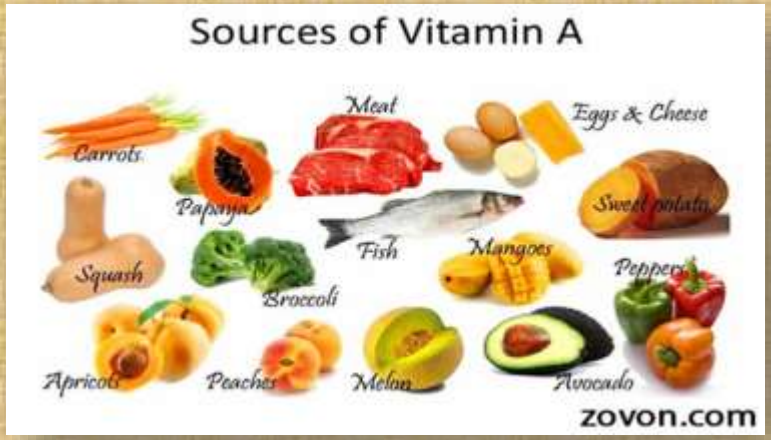
CAROTENE-

Carotenes are important due to 3 attributes; their colour, their vit A activity and their potential as anti-cancer agents. Common pro-vitamin A carotenoids in foods are α-carotene, β-carotene, γ- carotene and β-crypto xanthinin. All the trans isomer of each of these carotenoids is more biologically active than any of the cis isomers.

HEALTH BENEFITS OF β- CAROTENE

- CANCER- β-carotene has been associated with reduced risk of cancer of the female reproductive system, gastro-intestinal system and mouth, gums, and trachea. These all are the cancers of epithelial cells. It has been suggested that β-carotene may act by enhancing the immune defense mechanism.
- CARDIOVASCULAR DISEASES- β-carotene may also be an important nutritional weapon in the fight against cardiovascular disease. Supplementation intake of β-carotene has been shown to reduce the incidence of CV diseases among men who had previously had heart attacks.
- CATARACTS- Cataracts are areas of opacity in the lens of the eyes. Their formation has been linked to damage by oxidising agents and free radicals. People with low serum carotenoid levels had more than 5 times the risk of developing cataracts than those with high carotenoids levels. It has been suggested that β-carotene may protect against cataracts simply by decreasing the level of oxidative damage in the body.
- GASTRIC INFLAMMATION- carotenoids have inhibitory effect on gastric inflammation induced by *helico bacter pylori* by inhibiting the activation of transcription factor.

SOURCES-



SPIRULINA – blue green algae, spirulina is used as a nutrient dense food. Spray dried spirulina is a rich source of β-carotene. About 70% of the β-carotene is absorbed. 1gm of spirulina contains carotenoids equivalent to 1kg of vegetables and yellow fruits.

VITAMIN C

The chemical name for vit C is ascorbic acid and it is also known as hexuronic acid and anti-scorbutic acid.

Ascorbic acid is a simple compound containing 6-C atoms, related to the monosaccharide glucose. It is stable to acid but easily destroyed by oxidation, light, alkali and heat. the oxidised form of ascorbic acid is known as dehydroascorbic acid which has no vit C activity.

Vit C is susceptible to oxidation because it is a reducing agent that functions in the body as antioxidant.

FUNCTIONS –

- **COLLAGEN FORMATION-** Collagen is a major structural protein of connective tissue, bone, teeth, cartilage, skin and scar tissue. It is estimated that collagen constitutes about one quarter of all the protein in the body. Any deficiency in vit C results in defective collagen synthesis, associated with wound healing, disruption of capillaries and faulty bone and tooth formation. If the collagen synthesis is impaired, the matrix formation is defective and it becomes less able to accumulate the calcium and phosphorus required for proper bone mineralisation. As a result, the bone becomes weakened and sometimes distorted.
- **CARNITINE TRANSPORTER-** vit C is required for the synthesis of carnitine. Carnitine is a N-containing compound involved in the transport of fatty acids into mitochondria to be oxidised to release energy for use by cells.

- **NEURO -TRANSMITTER SYNTHESIS-** vit C is required to sustain the activity of copper containing enzyme dopamine oxygenase, which catalyses the oxidation of dopamine to form the neuro-transmitter.
- **ACTIVATION OF HORMONES-** vit C is essential for the activation of calcitonin, gastrin, oxytocin, thyrotropin, corticotropin, vasopressin, growth hormone- releasing factor.
- **ANTIOXIDANT-** A variety of damaging oxidising agents occur in the body, as a result of both normal metabolic processes and exposure to drugs and environmental pollutants. Vit C can combine with and so "scavenge" many types of oxidising free radicals. It can also regenerate the reduced form of vit E converting that vitamin back into the form in which it can act as an antioxidant.

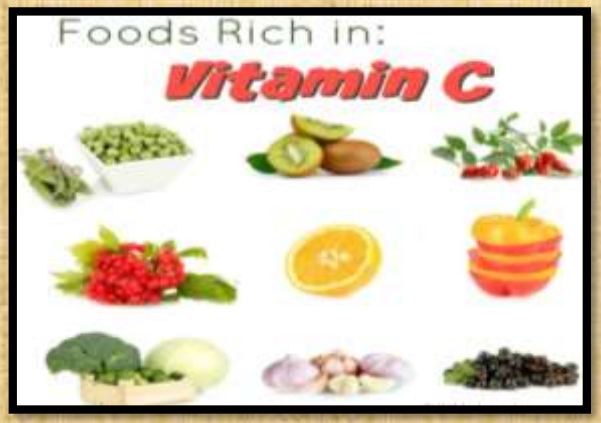
Vit C is known to be involved in regulating cholesterol metabolism and in maintaining the structure of blood vessels and the antioxidant effects of the vitamin might prevent tissue damage that leads to cardiovascular disease.

- **IRON METABOLISM-** vit C acts as a reducing agent, that is, able to keep ferric ions in ferrous form and facilitate absorption. Vit C also assists in the transfer of iron from blood plasma into ferritin for storage in the liver as well as the release of iron from ferritin when required. The role of ascorbate in iron metabolism is related not only to enhanced absorption but also to intracellular metabolism of iron binding protein.

Vit C also aids calcium absorption by preventing the incorporation of calcium into insoluble complexes. Vit C alleviates allergic reactions, enhances immune function, stimulates formation of bile and facilitate the release of some steroid hormones.

SOURCES OF VITAMIN C

- Amla is the richest source of vitamin C.
- Guava, orange, lime are also good sources of vit C.
- Drumsticks, agathi
- Dry pulses and beans are allowed to germinate vit C is formed in the grain and the growing sprout.
- Sprouted green gram contains 3 times more vit C than sprouted Bengal gram.



Heating and drying of fresh fruits and vegetables usually leads to destruction of most of the vitamin C. amla is an exception because it contains substances which partially protects the vitamin from destruction.

On of the characteristic properties of this vitamin is its intense reducing action and hence, it is oxidised rapidly in the air. It is for this reason that when vegetables become dry and stale and exposed to air most of the vit C originally present is destroyed.

VITAMIN E

Vit E is a generic term that includes all compounds that exhibit the biological activity of α-tocopherol. 8 compounds with vitamin E activity are found in nature; 4 are tocopherols and other 4 are tocotrienols. α-tocopherol is the most active form. Much of the vit E used in supplements is naturally occurring α-tocopherol concentrated from vegetable oils.

FUNCTIONS-

It is generally agreed that the main function of vitamin E within the body is to act as an antioxidant.

- Vit E is a fat-soluble vitamin, it is able to mix with and protect lipid molecules from oxidation. It is considered as the body's first line defense against a specific form of lipid oxidation known as peroxidation. In this role vit E protects the cell membrane against oxidising free radicals.
- Free radicals are produced during the normal oxidation of energy yielding nutrients in the cell. When the free radicals attack the lipids of cell membranes, they can initiate a highly damaging chain reaction, leading to damage to the structure and function of the membranes. Vit E is the main "***chain blocking***" antioxidant in the body that is able to prevent these chain reactions from the starting.
- Vitamin E may be required for the normal functioning of the immune system and by regulating the production of prostaglandins may control the aggregation of blood platelets during the formation of blood clots.
- The antioxidant properties of vit E are believed in inhibiting the formation of lipofuscin, a pigment that accumulates within tissues during ageing. Brown spots in a variety of tissues caused by the accumulation of lipofuscin are one of the characteristic indicators of ageing.
- Vit E protects the organism against the damage likely to be caused by nitrosamines which are strong tumour promoters.

SOURCES OF VITAMIN E

- Vegetable oils, nuts and whole grams are the richest natural sources of vitamin E.
- Rice bran oil contains a high amount of unsaponifiable compounds such as tocotrienols and oryzanol which have antioxidant activity.
- Vitamin E content of vegetable oils is found to be higher than many other foodstuffs.

Table 15.3: Vitamin E content of foods

Name of the foodstuff	Vitamin E mg%
Wheat flour	6.5
Bajra flour	8.8
Jowar flour	2.2
Maize flour	6.2
Rice flakes	3.4
Rice	3.7
Red gram dal	10.2
Green gram whole	12.4
Moth beans	10.0
Onion	1.1
Yam	3.2
Cluster beans	11.6
French beans	8.3
Cauliflower	6.8
Butter	5.1
Ghee	2.8
Vanaspati	6.7
Mustard oil	66.2
Groundnut oil	35.9
Sesame oil	53.1

BIOTIN

Biotin a water-soluble vitamin that our bodies need to provide us with energy and maintain the health of our hair, nails and skin. Originally called ***vitamin H***, biotin is now classified as one of the B vitamins (B7) and has gained commercial popularity for its proposed benefits for healthier hair and nails. It helps the body metabolize fats, carbohydrates, and protein. Water-soluble vitamins are not stored in the body so daily intake is necessary.

Biotin functions in cells covalently bound to enzymes. Acetyl CoA carboxylase is a biotin dependent enzyme. It helps in the biosynthesis of fatty acid from acetyl CoA.

FUNCTIONS OF BIOTIN-

- It helps the body metabolize fats, carbohydrates, and protein.
- It is a coenzyme for carboxylase enzymes. These enzymes are involved in: Synthesis of fatty acids, Synthesis of the amino acids- isoleucine and valine, gluconeogenesis.
- **Maintaining a healthy pregnancy-** Mild biotin deficiency is often seen during pregnancy. It can lead to abnormal development in the fetus.

Folic acid supplementation is recommended both the year before and during pregnancy. It is sensible to obtain a multivitamin that provides at least 30 mcg of biotin per day, in addition to folic acid, to decrease the risk of a deficiency.

- **Nails, hair, and skin-** biotin may improve the strength and durability of fingernails and enhance hair and skin health. Researchers have concluded that "brittle nail syndrome appears to abate with supplementation with a 2.5-mg dose of biotin daily.
- **Lowering blood glucose-** biotin was shown to stimulate the secretion of insulin from the pancreas and subsequently to lower blood glucose. Researches indicate that biotin may assist with glycemic control in people with type I diabetes.
- **Controlling neuropathy -** It may also help reduce nerve damage in people who have diabetes or who are undergoing dialysis for kidney disease. Biotin is necessary for the activity of pyruvate carboxylase. Without this, high levels of pyruvate and aspartate may arise, and this can adversely affect the nerves.

- Biotin-responsive basal ganglia disease -This is a rare, inherited disorder. It affects a part of the nervous system that controls movement. It can lead to involuntary tensing of muscles, muscle rigidity, muscle weakness, and other problems. The condition appears to respond to treatment with thiamine and biotin.
- Treating multiple sclerosis- Studies have suggested that high-dose biotin therapy might help improve symptoms in people with multiple sclerosis (MS), an autoimmune disease that affects the nervous system, leading to muscle weakness and a range of other problems. Researches suggested that biotin was a safe therapy. In some participants, a high dose, taken three times daily, reduced symptoms after 9 months of use.

SOURCES OF BIOTIN-

Biotin is found widely distributed in foods. Good food sources of the vitamin are liver, soybeans, egg yolks. Cereals, legumes and nuts also contain relatively high amounts of biotin. Within many foods, biotin is found bound to protein or as a biocytin, which is also called biotinyllysine. Biotin is produced by bacteria within the colon.

Avidin, a glycoprotein in raw egg whites, may irreversibly bind in a non- covalent bond and prevent biotin absorption. Because avidin is heat- liable, ingestion of cooked egg does not compromise biotin absorption.

PLANT STEROLS

Plant sterols are an essential component of the membranes of all eukaryotic organisms. Plant sterols are cholesterol-like substances that occur naturally at low levels in fruits, vegetables, nuts and cereals. When eaten at the recommended amount, between 2 -3 grams a day, plant sterols can reduce low-density lipoprotein (LDL), bad cholesterol levels in our blood.

As, they resemble cholesterol, they are absorbed instead of LDL cholesterol. However, eating more than three grams per day does not reduce your LDL cholesterol any further.

The Food and Drug Administration (FDA) has even approved a health claim on phytosterols, which states: “Foods containing at least 0.65 gram per serving of vegetable oil plant sterol esters, eaten twice a day with meals for a daily total intake of at least 1.3 grams, as part of a diet low in saturated fat and cholesterol, may reduce the risk of heart disease.”

They are either synthesised de novo or taken up from the environment. Their function appears to be to control membrane fluidity and permeability, although some plant sterols have a specific function in signal transduction.

The commonly consumed plant sterols are sitosterol, stigmasterol and camp sterol which are predominantly supplied by vegetable oils.

FUNCTIONS OF PLANT STEROLS -

- Reducing cholesterol levels in people with familial hypercholesterolemia- Plant sterols are effective for reducing cholesterol levels in children and adults with high cholesterol levels due to familial hypercholesterolemia. When taken in people who are also following a low-fat or cholesterol-lowering diet, plant sterols can reduce total and "bad" low-density lipoprotein (LDL) cholesterol more than the diet alone. Plant sterols don't decrease blood fats called triglycerides or increase "good" high-density lipoprotein (HDL) cholesterol levels.
- High cholesterol- Taking plant sterols lowers total and low-density lipoprotein (LDL or "bad") cholesterol levels by about 3% to 15% in people with high cholesterol who are following a cholesterol-lowering diet. When added to a cholesterol-lowering prescription medication, such as certain "statins", plant sterols reduce total cholesterol by an additional 12-22 mg/dL and LDL cholesterol by another 11-16 mg/dL.
- Plant sterols can be incorporated in margarines, dairy products, and breads and cereals, or taken in pill form. Research suggests a dose of about 2-3 grams daily lowers cholesterol the most. But plant sterols may stop working as well when taken for more than 2-3 months. Plant sterols don't raise "good" high-density lipoprotein (HDL) cholesterol levels.
- Colon and rectal cancer- People who eat more plant sterols as part of their diet don't have a lower risk of colon cancer compared to people who eat less plant sterols. Also, women who eat more plant sterols don't have a lower risk of rectal cancer compared to women who eat less plant sterols. But men who eat more plant sterols might have a lower risk of rectal cancer compared to men who eat less plant sterols.

- Stomach cancer - People who eat at least 82.5 mg of plant sterols daily as part of their diet seem to have a lower risk of gastric cancer compared to people who eat less than 45.5 mg daily.
- Metabolic syndrome- Metabolic syndrome is a group of conditions that increase the risk of having heart disease, stroke, and diabetes. These conditions include high cholesterol, high blood pressure, high blood sugar, and excess fat. Some research shows that taking 2 grams of plant sterols twice daily reduces cholesterol levels in people with metabolic syndrome.
- Heart attack- Men who eat more plant sterols as part of their diet have a 29% lower risk of having a heart attack compared to men who eat less. But women who eat more plant sterols don't seem to have a lower risk of having a heart attack compared to women who eat less.
- Obesity- Early research shows that eating a snack bar containing 1.8 grams of plant sterols lowers total cholesterol levels by about 10% compared to eating the snack bar alone in people who are obese and trying to lose weight. But eating the snack bar containing plant sterols doesn't increase weight loss, reduce "bad" low-density lipoprotein (LDL) cholesterol levels, or improve blood sugar levels compared to eating a snack bar that doesn't contain plant sterols.

RESEARCHES-

1. ***Spices and herbs: Natural sources of antioxidants – a mini review***

Milda E. Embuscado: *Applied Research, McCormick & Company, Inc., Hunt Valley, MD, USA. Tel.: +410-527-6009; fax: +410-527-6527*

Spices and herbs are rich sources of powerful antioxidants. Spices and herbs have been used for flavour, colour and aroma for more than 2000 years. They have also been used for preservation of foods and beverages primarily due to their phytochemicals. The antioxidants in spices and herbs are very effective because they possess excellent antioxidant activity. The spices and herbs have been used as antioxidants as whole or ground spice/herb, extracts, encapsulated or as emulsions. Aside from their efficacy as antioxidants, spices and herbs are classified as all natural, an attractive quality for consumers. Thus, spices and herbs may be used as a means to control lipid oxidation in foods.

2. Tomato powder and crude lycopene as a source of natural antioxidants in whole wheat flour cookies

Department of Food Science & Technology, University of Kashmir, Srinagar, 190006, India

The present study demonstrated that considerable improvement in the physical characteristics and antioxidant properties of whole wheat flour cookies could be attained by the addition of tomato powder and crude lycopene. Results revealed that spread ratio of the cookies decreased after incorporation of tomato powder and crude lycopene thereby indicating a better rising ability of the enriched cookies. Texture analysis of the cookies showed that the cookies supplemented with tomato powder and crude lycopene were hard as compared to control cookies. The Hunter colour values a and b* of the enriched cookies were also comparable to control cookies. The results of this study suggest that novel cookies with added tomato powder and crude lycopene can be produced with improved antioxidant properties without having any adverse effect on their physical and organoleptic properties.*

UNDERSTANDING FOOD SAFETY MEASURES IN THE FOOD INDUSTRY- **HACCP**

HACCP

- HACCP, or the Hazard Analysis Critical Control Point system, is a process control system that identifies where hazards might occur in the food production process and puts into place stringent actions to take to prevent the hazards from occurring.
- By strictly monitoring and controlling each step of the process, there is less chance for hazards to occur.

Why is HACCP important?

- HACCP is important because it prioritizes and controls potential hazards in food production.
- By controlling major food risks, such as microbiological, chemical and physical contaminants, the industry can better assure consumers that its products are as safe as good science and technology allows.
- By reducing foodborne hazards, public health protection is strengthened.

GUIDELINES FOR APPLICATION OF HACCP PRINCIPLES

- HACCP is designed for use in all segments of the food industry from growing, harvesting, processing, manufacturing, distributing, and merchandising to preparing food for consumption.
- Prerequisite programs such as current Good Manufacturing Practices (cGMPs) are an essential foundation for the development and implementation of successful HACCP plans.
- Food safety systems based on the HACCP principles have been successfully applied in food processing plants, retail food stores, and food service operations.
- The seven principles of HACCP have been universally accepted by government agencies, trade associations and the food industry around the world.

Prerequisite Programs

- The production of safe food products requires that the HACCP system be built upon a solid foundation of prerequisite programs.
- Each segment of the food industry must provide the conditions necessary to protect food while it is under their control.
- Prerequisite programs provide the basic environmental and operating conditions that are necessary for the production of safe, wholesome food.
- Many of the conditions and practices are specified in federal, state and local regulations and guidelines (e.g., cGMPs and Food Code).
- The Codex Alimentarius General Principles of Food Hygiene describe the basic conditions and practices expected for foods intended for international trade.
- HACCP plans are narrower in scope, being limited to ensuring food is safe to consume.

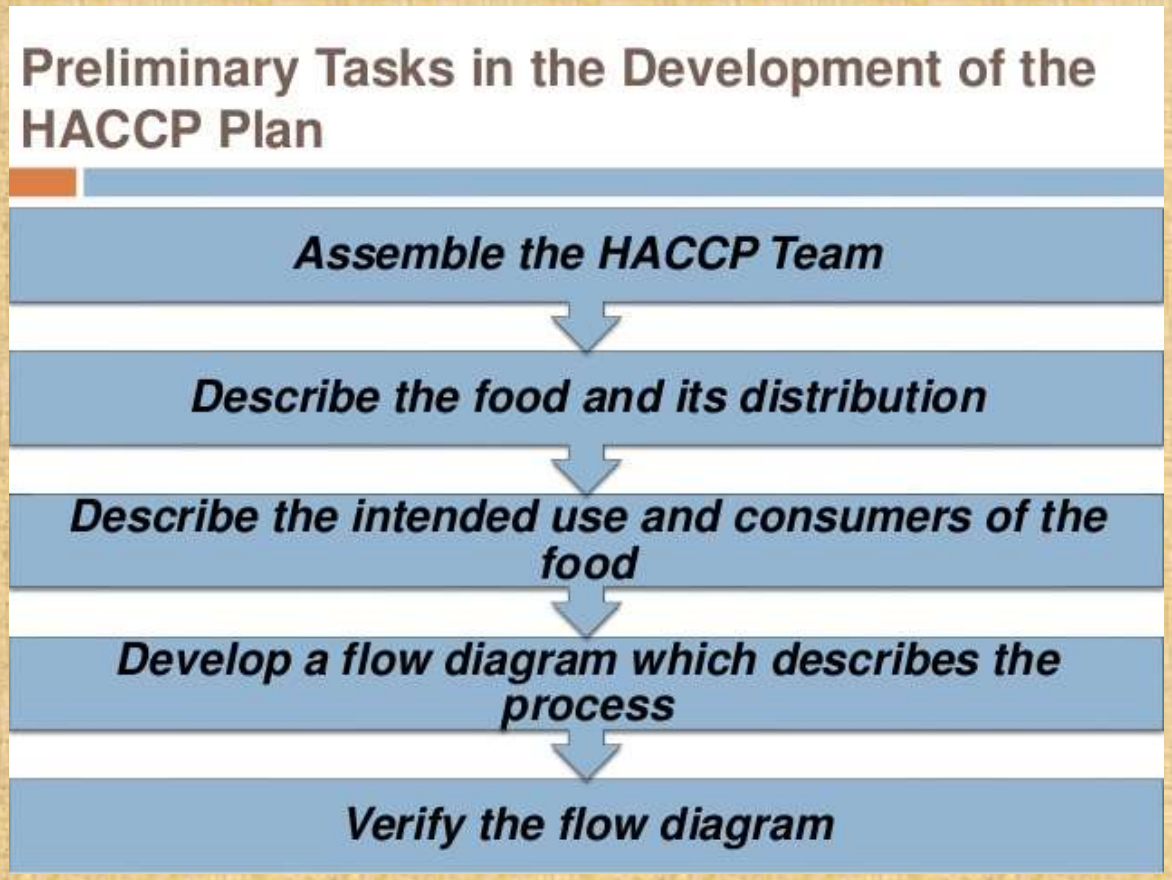
Education and Training

- The success of a HACCP system depends on educating and training management and employees in the importance of their role in producing safe foods.
- This should also include information the control of foodborne hazards related to all stages of the food chain.
- It is important to recognize that employees must first understand what HACCP is and then learn the skills necessary to make it function properly.
- Specific training activities should include working instructions and procedures that outline the tasks of employees monitoring each CCP.

Developing a HACCP Plan

- The format of HACCP plans will vary.
- In many cases the plans will be product and process specific. However, some plans may use a unit operations approach.
- Generic HACCP plans can serve as useful guides in the development of process and product HACCP plans; however, it is essential that the unique conditions within each facility be considered during the development of all components of the HACCP plan.

Preliminary Tasks in the Development of the HACCP Plan



Preliminary Tasks in the Development of the HACCP Plan

- **Assemble the HACCP Team**
  - The team should be multi disciplinary
    - Engineering
    - Production
    - Sanitation
    - Quality Assurance
    - Microbiology
    - Note: The team should also include local personnel who are involved in the operation as they are more familiar with the variability and limitations of the operation

Preliminary Tasks in the Development of the HACCP Plan

- **Individuals should have the knowledge and experience to correctly**
  - Conduct a hazard analysis.
  - Identify potential hazards.
  - Identify hazards which must be controlled.
  - Recommend controls, critical limits, and procedures for monitoring and verification.
  - Recommend appropriate corrective actions when a deviation occurs.
  - Recommend research related to the HACCP plan if important information is not known.
  - Validate the HACCP plan.

Preliminary Tasks in the Development of the HACCP Plan

- **Describe the food and its distribution**
  - The HACCP team first describes the food.
  - General description of the food, ingredients, and processing methods.
  - Distribution of the food (whether the food is to be distributed frozen, refrigerated, or at ambient temperature.)
- **Describe the intended use and consumers of the food**
  - Describe the normal expected use of the food.
  - The intended consumers may be the general public or a particular segment of the population.

Preliminary Tasks in the Development of the HACCP Plan

- ***Develop a flow diagram which describes the process***
  - Clear, simple outline of the steps involved in the process.
  - Flow diagram must cover all the steps in the process which are directly under the control of the establishment.
  - The flow diagram should be simple that everyone in the team could understand it properly.

Preliminary Tasks in the Development of the HACCP Plan

- **Verify the flow diagram**
  - Perform an on-site review of the operation to verify the accuracy and completeness of the flow diagram.
  - Modifications should be made to the flow diagram as necessary and documented.
    - After these five preliminary tasks have been completed, the seven principles of **HACCP** are applied

How Does HACCP Work in Food Production?

- There are seven principles, developed by the National Advisory Committee on Microbiological Criteria for Foods, that serve as the foundation for a HACCP system. They are:
- **Conduct a hazard analysis** to identify potential hazards that could occur in the food production process.
- **Identify the critical control points** (CCPs) -- those points in the process where the potential hazards could occur and can be prevented and/or controlled.
- **Establish critical limits for preventive measures associated with each CCP**. A critical limit is a criterion that must be met for each CCP. Where appropriate, critical limits may reflect relevant FSIS regulations and FDA tolerances.
- **Establish CCP monitoring requirements to ensure each CCP stays within** its limit. Monitoring may require materials or devices to measure or otherwise evaluate the process at CCPs.
- **Establish corrective actions** if monitoring determines a CCP is not within the established limits. In case a problem occurs, corrective actions must be in place to ensure no public health hazard occurs.
- **Establish effective recordkeeping procedures** that document the HACCP system is working properly. Records should document CCP monitoring, verification activities and deviation records.
- **Establish procedures for verifying** that the HACCP system is working properly. Verification procedures may include reviewing the HACCP plan, CCP records, critical limits as well as conducting microbial sampling. Both plant personnel and FSIS inspectors will conduct verification activities.

1. **Hazard Analysis**
   - Identify the hazards that affects the process.
   - Identify the steps that hazards likely to occur.
   - Decide which hazards are significant.
   - Determine the measures that are necessary to control the hazards.

FOOD HAZARDS

- **Physical**
  - Accidental Contamination/ Cross contamination.
  - Food Handling.
    - Metal, glass, wood, insects, stones, soil, dirt, jewelry, hair, fingernails, plasters, personal items, bone, nuts / bolts, wire, plastic, paper and cardboard.
- **Chemical**
  - Cleaning chemical residues
  - Factory contaminants
  - Agricultural residues
  - Food allergens
  - Naturally occurring harmful chemicals
  - Industrial heavy metals
- **Biological**
  - Bacterial, Viral/ fungal Contamination
    - Food Infection and Intoxications

2. Critical Control Points (CCPs)

- Control that can be applied and is essential to prevent or eliminate a food safety hazard or, reduce it to an acceptable level.
- **Control Point (CP)** is a step where hazards are at acceptable level and will be eliminated on itself by the following step in the process of production.
- The number of **CCP**s in a process will depend on the complexity of the process itself and the Scope of the study**.**
- **CCP**s should be determined through **experience** and **judgment**; this may be aided by the use of a **decision tree**.

Process Steps	Identifying the level of hazard	Reason for identification
Delivery	CP	Hazard present here is eliminated later in the process during cooking
Chilled Storage	CP	Hazard present here is eliminated later in the process during cooking
Preparation	CP	Hazard present here is eliminated later in the process during cooking
Marinating chilled Storage	CP	Hazard present here is eliminated later in the process during cooking
Cook > Service	CCP	This is final step in production so hazard needs to controlled /eliminated, to make food safe for consumption.

3. CRITICAL LIMIT

- A critical limit is the maximum or minimum value for the control measure at a CCP to prevent, eliminate, or reduce the hazard to an acceptable level.
- It separates acceptable (safe) product from unacceptable (unsafe) product.

- **Critical limits should be for the control measure and not the hazard. They should be**:
  - Measureable.
  - Observable.
  - Able to monitor in “real time” (quickly)
  - Some critical limits are defined in:
  - Legislation.
  - Industry guidelines and codes of practice.

- **Others can be determined from**:
  - Collection of experimental data during trials
  - Advice from specialists with expert knowledge
- **Criteria often used to set a critical limit include measurements of:**
  - Temperature
  - Time
  - Moisture level
  - pH (level of acidity)
  - Aw (level of water available to support the growth of a hazard such as bacteria)
- **Chemical analyses**
  - Available chlorine
- **Subjective data**
    - e.g. visual observations/assessments.

4. MONITORING SYSTEM

- The monitoring system describes the methods by which the business is able to confirm that all CCPs are operating within the defined critical limit.
- Monitoring actions must be able to detect a loss of control at the CCP and provide rapid results. This should be in time to allow corrective action to be taken, to regain control of the process whilst the product is still under your control.
- Generally microbiological testing is not considered to be suitable as a monitoring activity because the results are not quick, even with the most rapid methods results are not instant.

Process Steps	Temperature Checks	Visual Checks
	Cooking	Cooking
Hazards	Microbiological survival of Salmonella sp. Campylobacter sp.	Microbiological survival of Salmonella sp. Campylobacter sp.
Control Measures	Thorough cooking	Thorough cooking
CCP	Yes	Yes
Critical Limits	80℃ for 6 sec. Target 85℃ for 6 sec Tolerance +/-5℃	Meat should not be pink or red and neither the juices.
Monitoring procedures	Insert disinfected probe thermometer to the thickest part of leg of each chicken. Responsible – Asst. Chef.	Check that each chicken is properly cooked in the thickest part of the leg and the juices are 100% clear of blood.

5. CORRECTIVE ACTIONS

- Decide What to do when a CCP is breached
- Actions taken again to make food safe and to get the process back under control. immediate actions taken if processes fail to achieve food safety.

Temperature check	Visual check
Cooking	Cooking
1) If critical limit not met, cook for longer and repeat check. 2) If problem due to operating procedure, adapt as required (e.g. increase cooking time/or oven temperature) 3) If problem due to oven repair/replace as necessary. 4) If problem due to staff, retain in operating procedure and increase supervision. 5) If unable to achieve critical limit, isolate and arrange disposal.	1) If meat pink/red and juices have any pink or red in them, cook for longer and repeat checks. 2) If problem due to operating procedure, adapt as required (e.g. increase cooking time or oven temperature) 3) If problem due to oven, repair/replace as necessary. 4) If problem due to staff, retain in operating procedure and increase supervision. 5) If unable to achieve critical limit, isolate and arrange disposal.

6. VERIFICATION

- Verification is the principle which confirms that the HACCP plan if followed will produce safe food for the final consumer.
- Verification is split into three parts
  - **Validation** – "Will the HACCP plan ensure that safe food will be produced"?
  - **Verification** – "Is the HACCP plan working, is it producing safe food"?
  - **Review** - "Is the HACCP plan up to date"?

VALIDATION

- Obtain evidence that the elements of the HACCP plan are effective.
- Prior to implementing HACCP the contents of the plan must be validated to ensure that the HACCP plan will ensure safe food is produced.
- The main focus is to ensure that the hazards identified are complete, correct and have suitable controls in place (effectively managed if the specified controls are followed) i.e. confirmation that the CCPs have been correctly identified and can assure safe

- **REVIEW**
  - Your HACCP plan should be up-to-date at all times and reflect any change. A change is anything in the HACCP plan that is different to when the study was last carried out.
  - A review should be both scheduled and triggered.

7. DOCUMENTATION

- Efficient and accurate record-keeping is essential to the application of a HACCP system.
- In the unfortunate event of a food safety incident that is connected to your products you may have to show that you have taken all reasonable precautions to produce food safely.
- Demonstrating that the principles of HACCP have been correctly applied as required by law and that documentation and records are kept, may provide evidence of due diligence in the event of legal action.