



Food: Its preservatives, additives and applications

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Abstract

Foods are substances or mixture of substances both solid and/or liquid, which are intended for human consumption or ingestion for their nutritional of pleasurable benefits. The classification of food, its storage and chemistry were treated in this study. Different methods of food preservations which include drying (spray drying, freeze drying), freezing, vacuum-packing, canning, sugar crystallization, pickling, food irradiation, etc. and its effect were also reviewed. Further, Food additives and its effect, and significance of food preservatives and additives were also explained in this review.

Keywords: preservatives, additives, vacuum-packing, spray drying, Monosodium Glutamate, tartrazine.

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1. Introduction

Food is any substance or material eaten or drunk to provide nutritional support for the body or for pleasure [1]. It usually consists of plant or animal origin, which contains essential nutrients, such as carbohydrates, fats, proteins, vitamins, or minerals, and is ingested and assimilated by an organism to produce energy, stimulate growth and maintain life. Food chemistry is the study of chemical processes and interactions of all biological and non-biological components of foods. The biological substances include meat, poultry, lettuce, beer, and milk as examples. It is similar to biochemistry in its main components such as carbohydrates, lipids, and protein, but it also includes areas such as water, vitamins, minerals, enzymes, food additives, flavors, and colors. This discipline also encompasses how products change under certain food processing techniques and ways either to enhance or to prevent them from happening. An example of enhancing a process would be to encourage fermentation of dairy products with microorganisms that convert lactose to lactic acid; an example of preventing a process would be stopping the browning on the surface of freshly cut Red Delicious apples using lemon juice or other acidulated water [1].

2. Food and its Classification

Historically, people obtained food from hunting, farming, ranching, and fishing, known as agriculture. Today, most of the food energy consumed by the world population

is supplied by the food industry operated by multinational corporations using intensive farming and industrial agriculture methods. Almost all foods are of plant or animal origin. Cereal grain is a staple food that provides more food energy worldwide than any other type of crop. Maize, wheat and rice together account for 87% of all grain production worldwide. Other foods not from animal or plant sources include various edible fungi, especially mushrooms: Fungi and ambient bacteria are used in the preparation of fermented and pickled foods such as leavened bread, alcoholic drinks, cheese, pickles, kombucha and yoghurt, Blue-green algae such as Spirulina. Inorganic substances, baking soda, cream of tartar are also used to chemically alter an ingredient [2].

Many plants or plant parts are eaten as food. There are around 2,000 plant species which are cultivated for food, and many have several distinct cultivars. Seeds of plants are good sources of food for animals, including humans because they contain nutrients necessary for the plant's initial growth, including many healthy fats, such as Omega fats. In fact, the majority of foods consumed by human beings are seed-based foods. Edible seeds include cereals (such as maize, wheat, and rice), legumes (such as beans, peas, and lentils), and nuts. Oilseeds are often pressed to produce rich oils, such as sunflower, flaxseed, rapeseed (including canola oil), and sesame [2]. One of the earliest food recipes made from ground chickpeas is called hummus, which can be traced back to Ancient Egypt times. Seeds are typically high in unsaturated fats and, in moderation, are considered a healthy food, although not all seeds are edible. Large seeds,

such as those from a lemon pose a choking hazard, whereas seeds from apples and cherries contain poison cyanide. Fruits are the ripened ovaries of plants, including the seeds within. Many plants have evolved fruits that are attractive as a food source to animals, so that animals will eat the fruits and excrete the seeds some distance away. Fruits, therefore, make up a significant part of the diets of most cultures. Some botanical fruits, such as tomatoes, pumpkins and eggplants, are eaten as vegetables. Vegetables are second types of plant matter that are commonly eaten as food. These include root vegetables (such as potatoes and carrots), leaf vegetables (such as spinach and lettuce), stem vegetables (such as bamboo shoots and asparagus), and inflorescence vegetables (such as globe artichokes and broccoli). Many herbs and spices are highly flavorful vegetables [2]. Other classifications of food are discussed below:

Fast food is the term given to food that can be prepared and served very quickly. While any meal with low preparation time can be considered to be fast food, typically the term refers to food sold in a restaurant or stored with preheated or precooked ingredients and served to the customer in a packaged form for take-out/take-away. The term “fast food” was recognized in a dictionary by Merriam-Webster (1951). Outlets may be stands or kiosks, which may provide no shelter or seating [3] or fast food restaurants (also known as *quick service restaurants*). Franchise operations which are part of restaurant chains have standardized foodstuffs shipped to each restaurant from central locations [4].

Junk food is an informal term applied to some foods which are perceived to have little or no nutritional value, or to products with nutritional value but which also have ingredients considered unhealthy when regularly eaten, or to those considered unhealthy to consume at all. The term was coined by Michael Jacobson, Director of the Center for Science in the Public Interest, in 1972 [5]. Junk foods are typically ready to eat convenience foods containing high levels of saturated fats, salt, or sugar; and little or no fruit, vegetables, or dietary fibre, and do not provide any health benefits. Junk food includes foods such as soft drinks, hamburgers, hot dogs, ice cream, cake, French fries, chocolate, confectionery, pizza, cookies, fried chicken, onion rings and doughnuts.

Whole foods are foods that are unprocessed and unrefined, or processed and refined as little as possible before being consumed. Whole foods typically do not contain added ingredients, such as sugar, salt, or fat. Examples of whole foods include unpolished grains; fruits and vegetables; unprocessed meat, poultry, and fish; and non-homogenised milk. The term is often confused with organic food, but whole foods are not necessarily organic, nor are organic foods necessarily whole. Because of the lack of basic processing, some whole foods have a very short shelf life [6].

Organic foods are made in a way that complies with organic standards set by national governments and international organisations. For the vast majority of human

history, agriculture can be described as organic; only during the 20th century was a large supply of new synthetic chemicals introduced to the food supply. This more recent style of production is referred to as “conventional.” Under organic production, the use of conventional non-organic pesticide (including insecticides, fungicides, and herbicides) is precluded.

Food Storage is both a traditional domestic skill and is important industrially. Food is stored by almost every human society and by many animals. Storing of food has several main purposes: preparation for periods of scarcity or famine, taking advantage of short term surplus of food as at harvest time, enabling a better balanced diet throughout the year, preparing for special events and celebrations, planning for catastrophe or emergency, religious reasons (LDS Church leaders council church members to store food) and protection against predators or others [7].

Domestic food storage

Grain: Grain is stored in a rigid, sealed container to prevent ingress of moisture or attack by vermin. Storage in grain sacks is not effective. Mold and pests destroy a 25kg cloth sack of grain in a year – even if stored off the ground in a dry area. On the ground or damp concrete, the time is as little as three days, and the grain might have to be dried before it can be milled. Food stored under unsuitable conditions should not be purchased or used because of risk of spoilage. To test whether grain is still good, sprout some. If it sprouts, it is still good, but if not, it should not be eaten. It may take up to a week for grains to sprout. When in doubt, throw it out.

Meat: Unpreserved meat has only a relatively short life in storage. Pork should be eaten within one day but beef and venison improve with up to 5 days storage in a cold room. Dry aging techniques are sometimes used to tenderize specialty gourmet meats by hanging them in carefully controlled environments for up to 21 days. Semi-dried meats like salamis and country style hams are processed first with salt, smoke, sugar, or acid, or other “cures” then hung in cool dry storage for extended periods, sometimes exceeding a year.

Fish and shellfish: It is unsafe to store fish or shellfish without preservation. Fresh shellfish and whitefish should be eaten within a few hours of harvesting.

Use of stored food: Guidance for surviving emergency conditions in many parts of the world recommends maintaining a store of essential foods; typically water, cereals, oil, dried milk, and protein rich foods such as beans, lentils, tinned fish and meat. A basic food storage calculator can be used to help determine how much of these staple foods a person would need to store in order to sustain life for one full year [8]. In addition to storing the basic food items, many people choose to supplement their food storage with frozen or preserved garden-grown fruits and vegetables and freeze-dried or canned produce. An unvarying diet of staples prepared in the same way can cause appetite exhaustion. An additional benefit to having a basic supply of

food storage in the home is for the cost savings. Costs of dry bulk foods (before preparation) are often considerably less than convenience and fresh foods purchased at local markets or super-markets. If good food storage guidelines are followed, using and replenishing your food storage should become a commonplace, everyday activity, as normal as preparing meals. Although it does require an initial investment to stock a pantry, eventually it becomes the most economical and convenient way to live. Instead of going to the store when you need something and paying full price for it, you can go to your storage room or pantry to get what you need. Then you replace it next time it is on sale. The best way to rotate your food storage is to prepare meals with it on a daily basis. Of course, that means that you should store what your family will eat. It is wasteful to store products that your family won't eat or that can't be used in your favorite recipes [9]. Grain and beans are stored in tall grain elevators, almost always at a rail head near the point of production. The grain is shipped to a final user in hopper cars. In the former Soviet Union, where harvest was poorly controlled, grain was often irradiated at the point of production to suppress mold and insects. In the U.S., threshing and drying is performed in the field, and transport is nearly sterile and in large containers that effectively suppress pest access, so irradiation is not required. At any given time, the U.S. usually has about two weeks of stored grains. Fresh fruits and vegetables are either packed in plastic cups in cardboard boxes for fresh premium markets, or placed in large plastic tubs for sauce and soup processors. Fruits and vegetables are usually refrigerated at the earliest possible moment, and even so have a shelf life of two weeks or less.

3. Chemistry of Food

Food chemistry or chemistry is the study of chemical processes and interactions of all biological and non-biological components of foods [10]. It also deals with the production, processing, distribution, preparation, evaluation, and utilization of food. Food chemists work with plants that have been harvested for food, and animals that have been slaughtered for food. Food chemists are concerned with how these food products are processed, prepared, and distributed. For example, to address consumer demands, some food chemists are involved with finding fat and sugar substitutes that do not alter food taste and texture. Basic food chemistry deals with the three primary components in food: carbohydrates, lipids and proteins.

Carbohydrates make up a group of chemical compounds found in plant and animal cells. They have an empirical formula $C_nH_{2n}O_n$ or CH_2O . Since this formula is essentially a combination of carbon and water these materials are called "hydrates of carbon or carbohydrates". Carbohydrates are the primary product of plant photosynthesis, and are consumed as fuel by plants and animals. Food carbohydrates include the simple carbohydrates (sugars) and complex carbohydrates (starches and fiber). Lipids include fats, oils, waxes, and cholesterol. In the body, fat serves as a source of energy, a thermal insulator, and a cushion around organs; and it is an important component of the cell. Since fats have 2.25 times the energy content of carbohydrates and proteins, most

people try to limit their intake of dietary fat to avoid becoming overweight. In most instances, fats are from animal products-meats, milk products, eggs, seafood and oils are from plants-nuts, olives, and seeds. We use lipids for flavor, to cook foods, and to improve the texture of foods.

Proteins are important components of food. Every cell requires protein for structure and function. Proteins are complex polymers composed of amino acids. There are 20 amino acids found in the body. Eight of these are essential for adults and children, and nine are essential for infants. Essential means that we cannot synthesize them in large enough quantities for growth and repair of our bodies, and therefore, they must be included in our diet. Proteins consist of long chains of 100-500 amino acids that form into three-dimensional structures, they native state. When you change the native state of the protein, you change the three-dimensional structure, which is referred to as denaturation. Factors that cause denaturation include heating, acid, beating and freezing [11].

Preservation of Food is the process of treating and handling food to stop or greatly slow down spoilage (loss of quality, edibility or nutritive value) caused or accelerated by micro-organisms. Some methods, however, use benign bacteria, yeasts or fungi to add specific qualities and to preserve food (e.g. cheese, wine). Maintaining or creating nutritional value, texture and flavour is important in preserving its value as food. This is culturally dependent, as what qualifies as food fit for humans in one culture may not qualify in another culture. Preservation usually involves preventing the growth of bacteria, fungi, and other micro-organisms, as well as retarding the oxidation of fats which cause rancidity. It also includes processes used to inhibit natural ageing and discolouration that can occur during food preparation such as the enzymatic browning reaction in apples after they are cut [12].

4. Classification of Food preservation: Some preservation methods require the food to be sealed after treatment to prevent recontamination with microbes; others, such as drying, allow food to be stored without any special containment for long periods. Common methods of applying these processes include drying, spray drying, freeze drying, freezing, vacuum-packing, canning, preserving in syrup, sugar crystallization, food irradiation, and adding preservatives or inert gases such as carbon dioxide. Other methods that not only help to preserve food, but also add flavour, include pickling, salting, smoking, preserving in syrup or alcohol, sugar crystallization and curing.

Preservation processes include:

- Heating to kill or denature micro-organisms (e.g. boiling)
- Oxidation (e.g. use of sulfur dioxide)
- Toxic inhibition (e.g. smoking, use of carbon dioxide, vinegar, alcohol etc)
- Dehydration (drying)
- Osmotic inhibition (e.g. use of syrups)
- Low temperature inactivation (e.g. freezing)
- Ultra high water pressure (e.g. freshised, a kind of "cold" pasteurization, the pressure kills naturally occurring pathogens, which cause food deterioration and affect food safety). These methods include:

- i. **Drying:** One of the oldest methods of food preservation is by drying, which reduces water activity sufficiently to prevent or delay bacterial growth. Drying also reduces weight.
- ii. **Freezing:** Freezing is also one of the most commonly used processes commercially and domestically for preserving a very wide range of food including prepared food stuffs which would not have required freezing in their unprepared state. For example, potato waffles are stored in the freezer, but potatoes themselves require only a cool dark place to ensure many months' storage. Cold stores provide large volume, long-term storage for strategic food stocks held in case of national emergency in many countries [13].
- iii. **Vacuum packing:** Vacuum-packing stores food in a vacuum environment, usually in an air-tight bag or bottle. The vacuum environment strips bacteria of oxygen needed for survival, slowing spoiling. Vacuum-packing is commonly used for storing nuts to reduce loss of flavour from oxidation.
- iv. **Salt:** Salting or curing draws moisture from the meat through a process of osmosis. Meat is cured with salt or sugar, or a combination of the two. Nitrates and nitrites are also often used to cure meat and contribute the characteristic pink color, as well as inhibition of *Clostridium botulinum*.
- v. **Sugar:** Sugar is used to preserve fruits, either in syrup with fruit such as apples, pears, peaches, apricots, plums or in crystallized form where the preserved material is cooked in sugar to the point of crystallization and the resultant product is then stored dry. This method is used for the skins of citrus fruit (candied peel), angelica and ginger. A modification of this process produces glace fruit such as glace cherries where the fruit is preserved in sugar but is then extracted from the syrup and sold, the preservation being maintained by the sugar content of the fruit and the superficial coating of syrup. The use of sugar is often combined with alcohol for preservation of luxury products such as fruit in brandy or other spirits [14].
- vi. **Pickling:** Pickling is a method of preserving food in an edible anti-microbial liquid. Pickling can be broadly categorized as chemical pickling for example, in chemical pickling, the food is placed in an edible liquid that inhibits or kills bacteria and other micro-organisms. Typical pickling agents include brine (high in salt), vinegar, alcohol, and vegetable oil, especially olive oil but also many other oils. Many chemical pickling processes also involve heating or boiling so that the food being preserved becomes saturated with the pickling agent. Common chemically pickled foods include cucumbers, peppers, corned beef, herring, and eggs, as well mixed vegetables such as piccalilli. In fermentation pickling, the food itself produces the preservation agent, typically by a process that produces lactic acid. Fermented pickles include sauerkraut, nukazuke, kimchi, surstromming, and curtido. Some pickled cucumbers are also fermented.
- vii. **Lye:** Sodium hydroxide (lye) makes food too alkaline for bacterial growth. Lye will saponify fats in the food, which will change its flavour and texture. Lutefisk uses lye in its preparation, as do some olive recipes. Modern recipes for century eggs also call for lye. Masa harina and hominy use agricultural lime in their preparation and this is often misheard as 'lye'.
- viii. **Canning and bottling:** Canning involves cooking food, sealing it in sterile cans or jars, and boiling the containers to kill or weaken any remaining bacteria as a form of sterilization. It was invented by Nicolas Appert [11]. Foods have varying degrees of natural protection against spoilage and may require that the final step occur in a pressure cooker. High-acid fruits like strawberries require no preservatives to can and only a short boiling cycle, whereas marginal fruits such as tomatoes require longer boiling and addition of other acidic elements. Low acid foods, such as vegetables and meats require pressure canning. Food preserved by canning or bottling is at immediate risk of spoilage once the can or bottle has been opened. Lack of quality control in the canning process may allow ingress of water or micro-organisms. Most such failures are rapidly detected as decomposition within the can causing gas production and the can will swell or burst. However, there have been examples of poor manufacture (underprocessing) and poor hygiene allowing contamination of canned food by the obligate anaerobe *Clostridium botulinum*, which produces an acute toxin within the food, leading to severe illness or death. This organism produces no gas or obvious taste and remains undetected by taste or smell. Its toxin is denatured by cooking, though, cooked mushrooms, handled poorly and then canned, can support the growth of *Staphylococcus aureus*, which produces a toxin that is not destroyed by canning or subsequent reheating [15].
- ix. **Jellying:** Food may be preserved by cooking in a material that solidifies to form a gel. Such materials include gelatine, agar, maize flour and arrowroot flour. Some foods naturally form a protein gel when cooked such as eels and elvers, and sipunculid worms which are a delicacy in the town of Xiamen in Fujian province of the People's Republic of China. Jellied eels are a delicacy in the East End of London where they are eaten with mashed potatoes. Potted meats in aspic, (a gel made from gelatine and clarified meat broth) were a common way of serving meat off-cuts in the UK until the 1950s. Many jugged meats are also jellied. Fruit preserved by jellying is known as jelly, marmalade, or fruit preserves. In this case, the jellying agent is usually pectin, either added during cooking or arising naturally from the fruit. Most preserved fruit is also sugared in jars. Heating, packaging and acid and sugar provide the preservation.
- x. **Potting:** A traditional British way of preserving meat (particularly shrimp) is by setting it in a pot and sealing it with a layer of fat. Also common is potted chicken liver.
- xi. **Jugging:** Meat can be preserved by jugging, the process of stewing the meat (commonly game or fish) in a covered

earthenware jug or casserole. The animal to be jugged is usually cut into pieces, placed into a tightly-sealed jug with brine or gravy, and stewed. Red wine and/or the animal's own blood is sometimes added to the cooking liquid. Jugging was a popular method of preserving meat up until the middle of the 20th century.

xii. Irradiation: Irradiation of food [16] is the exposure of food to ionizing radiation; either high-energy electron X-rays from accelerators, or by gamma rays (emitted from radioactive sources as Cobalt-60 or Caesium-137). The treatment has a range of effects, including killing of bacteria, molds and insect pests, reducing the ripening and spoiling of fruits, and at higher doses including sterility. The technology may be compared to pasteurization; it is sometimes called 'cold pasteurisation', as the product is not heated. Irradiation is not effective against viruses or prions; it cannot eliminate toxins already formed by microorganisms, and is only useful for food of high initial quality. The radiation process is unrelated to nuclear energy, but it may use the radiation emitted from radioactive nuclides produced in nuclear reactors. Ionizing radiation is hazardous to life (hence its usefulness in sterilization); for this reason irradiation facilities have a heavily shielded irradiation room where the process takes place. Radiation safety procedures ensure that neither the workers in such facility nor the environment receive any radiation dose from the facility. Irradiated food does not become radioactive, and national and international expert bodies have declared food irradiation as wholesome. However, the wholesomeness of consuming such food is disputed by opponents [17] and consumer organisations [14]. National and International expert bodies have declared food irradiation as 'wholesome', UN-organisations as WHO and FAO are endorsing to use food irradiation. International legislations on whether food may be irradiated or not varies worldwide from no regulation to full banning [18]. It is estimated that about 500,000 tons of food items are irradiated per year worldwide in over 40 countries. These are mainly spices and condiments with an increasing segment of fresh fruit irradiated for fruit fly quarantine [19,20].

xiii. Modified atmosphere: Modifying atmosphere is a way to preserve food by operating on the atmosphere around it. Salad crops which are notoriously difficult to preserve are now being packaged in sealed bags with an atmosphere modified to reduce the oxygen (O₂) concentration and increase the carbon dioxide (CO₂) concentration. There is concern that although salad vegetables retain their appearance and texture in such conditions, this method of preservation may not retain nutrients, especially vitamins. Grains may be preserved using carbon dioxide. A block of dry ice is placed in the bottom and the can is filled with grain. The can is then "burped" of excess gas. The carbon dioxide from the sublimation of the dry ice prevents insects, mold, and oxidation from damaging the grain. Grain stored in this way can remain edible for five years. Nitrogen gas (N₂) at concentrations of 98% or higher is also used effectively to kill insects in grain through hypoxia. However, carbon dioxide has an advantage in this respect as it kills organisms through both hypoxia and

hypercarbia, requiring concentrations of only 80%, or so. This makes carbon dioxide preferable for fumigation in situations where a hermetic seal cannot be maintained [21].

xiv. Burial in the ground: Burial of food can preserve food due to a variety of factors: lack of light, lack of oxygen, cool temperatures, pH level, or desiccants in the soil. Burial may be combined with other methods such as salting or fermentation. Many root vegetables are very resistant to spoilage and require no other preservation other than storage in cool dark conditions, for example by burial in the ground, such as in a storage clamp. Century eggs are created by placing eggs in alkaline mud (or other alkaline substance) resulting in their "inorganic" fermentation through raised pH instead of spoiling. The fermentation preserves them and breaks down some of the complex, less flavourful proteins and fats into simpler more flavourful ones. Most foods can be preserved in soil that is very dry and salty (thus a desiccant), or soil that is frozen.

xv. Controlled use of micro-organism: Some foods, such as many cheeses, wines, and beers will keep for a long time because their production uses specific micro-organisms that combat spoilage from other less benign organisms. These micro-organisms keep pathogens in check by creating an environment toxic for themselves and other micro-organisms by producing acid or alcohol. Starter micro-organisms, salt, hops, controlled (usually cool) temperatures, controlled (usually low) levels of oxygen and/or other methods are used to create the specific controlled conditions that will support the desirable organisms that produce food fit for human consumption.

xvi. High Pressure Food Preservation: High pressure food preservation refers to high pressure used for food preservation. "Pressed inside a vessel exerting 70,000 pounds per square inch or more, food can be processed so that it retains its fresh appearance, flavour, texture and nutrients while disabling harmful microorganism and slowing spoilage". By 2001, adequate commercial equipment was developed so that by 2005 the process was being used for products ranging from orange juice to guacamole to deli meats and widely sold [22].

5. Food Preservatives

Preservatives may be added to food to prevent the growth of fungi. Preservative food additives can be used alone or in conjunction with other methods of food preservation. Preservatives may be antimicrobial preservatives, which inhibit the growth of bacteria or fungi, including mold, or antioxidants such as oxygen absorbers, which inhibit the oxidation of food constituents. Common antimicrobial preservatives include calcium propionate, sodium nitrate, sodium nitrite, sulfites (sulfur dioxide, sodium bisulfite, potassium hydrogen sulfite, etc.) and disodium. The benefits and safety of many artificial food additives (including preservatives) are the subject of debate among academics and regulators specializing in food science, toxicology, and biology. Natural substances such as

salt, sugar, vinegar, alcohol, and diatomaceous earth are also used as traditional preservatives. Certain processes such as freezing, pickling, smoking and salting can also be used to preserve food. Another group of preservatives targets enzymes in fruits and vegetables that continue to metabolise after they are cut. For instance, citric and ascorbic acids from lemon or other citrus juice can inhibit the action of the enzyme phenolase which turns surfaces of cut apples and potatoes brown. Most foods contain enzymes or natural chemicals, such as acids or alcohols that cause them to begin to lose desirable characteristics almost immediately after harvest or preparation. In addition, a host of environmental factors, such as heat and the presence of microorganisms, acts to change foodstuffs in ways that may harm the food product. Food preservation traditionally has three goals: the preservation of nutritional characteristics, the preservation of appearance, and a prolongation of the time that the food can be stored. Traditional methods of preservation usually aim to exclude air, moisture, and microorganisms, or to provide environments in which organisms that might cause spoilage cannot survive [23]. Among the earliest preservatives were sugar and salt (NaCl), which produced food environments of high osmotic pressure that denied bacteria the aqueous surroundings they needed to live and reproduce. Jams and jellies are preserved as solutions of high sugar content, and many meats (e.g., hams) and fish are still preserved by salting. Unlike other microorganisms, molds can often withstand the effects of high salt or sugar concentrations in foods. Fortunately, they seldom cause illness. Early methods of air removal included the sealing of foods inside containers (such as jars), or the covering of food surfaces with hot paraffin. The invention of canning by Nicolas Appert enabled commercial preparations of foodstuffs. In response to a prize offered by Napoleon in 1795, Appert developed a method of canning and preserving fruits and vegetables in glass containers for sea voyages. His process was used commercially in 1910 by Peter Durand in England, using metal cans. During the earliest days of canning, some persons (including some Arctic explorers) probably died as a result of exposure to the lead that was once used to solder cans. Modern techniques of air removal include vacuum sealing and the use of plastic wrappings. Chemical preservatives include free radical scavengers (also known as antioxidants), such as vitamin C and compounds such as BHA (butylated hydroxyanisole), and bacterial growth inhibitors, such as benzoic acid, sulfur dioxide, and sodium nitrite (NaNO₂). Ethanol (CH₃CH₂OH) has long been used as a preservative, both of itself (as in wine), and of other foods (e.g. fruits stored in brandy). Some chemical preservatives may be harmful: Sulfur dioxide (often used to preserve wines) is irritating to the bronchial tubes of persons who have asthma, and nitrites have been implicated as carcinogens. After Louis Pasteur proved that it was the presence of bacteria that caused food to spoil, there was a tendency to consider all microorganisms harmful. But in fact, microbial action is responsible for the production and preservation of some foods. The action of microbes is a part of the production of cheese and some flavouring agents. Sauerkraut is both processed. The irradiation of foods has the advantage of enabling food packaging and preparation in which there is less person-to-food contact, thus decreasing the possibility of contamination and decreasing the need for

chemical preservatives, some of which may be harmful. The ionizing radiation that is used to irradiate foods, wherein the foods are exposed to bursts of high-intensity x-rays or streams of electrons, disrupts bacterial DNA. Some persons have objected to the irradiation of foods because of an (unfounded) fear of radioactivity. As pathogens such as virulent strains of coliform bacteria have caused food poisoning, the irradiation of animal carcasses and, in particular, of hamburger during its preparation has become more desirable. Irradiation currently extends the shelf life of foods such as strawberries. Irradiation does not make foods radioactive, but may cause changes in food color or texture [24].

6. Chemical Reactions of Food and its Preservatives

Since it is probable that many reactions to food additives are not diagnosed, the exact rate of reactions is not known. However, various studies estimate that the rate is probably less than 1% of adults, and up to 2% of children. There are many types of reactions that can occur as a result of food additives. Some of these reactions suggest an allergic cause while many others do not appear to be allergic, but rather an intolerance. Reports of reactions to food additives have included the following: Skin, urticaria/angioedema, atopic dermatitis, sweating, itching, flushing, gastrointestinal, abdominal pain, nausea/vomiting, diarrhea, respiratory, asthma symptoms, cough, rhinitis, musculoskeletal, muscle aches, joint aches, fatigue, weakness, neurologic, behavior and mood changes, attention deficit and hyperactivity disorder, migraine headaches, numbness, cardiac, palpitations and arrhythmias. A diagnosis of allergy to food additives is suspected when a person experiences various reactions to prepared foods or when eating at restaurants, but not from foods prepared at home. Various seemingly unrelated foods might in fact have common ingredients, such as food colorings or preservatives. Once a food or food additive is suspected, allergy testing (using skin testing or RAST) may be possible to certain natural substances such as annatto, carmine, and saffron. Testing for synthetic substances is not possible or reliable, and therefore a trial of a preservative-free diet may support a diagnosis of food additive reactions. In many instances, the only way to truly diagnose an adverse reaction to food additives is for the person to undergo an oral challenge with the suspected additive under close supervision of an allergist. Tartrazine also known as FD&C Yellow #5, tartrazine has been suspected as the cause of many reactions, including urticaria (hives), asthma and other illness. Recent studies have disproven the thought that aspirin-allergic asthmatics were especially sensitive to tartrazine. Other studies suggest a role of tartrazine as worsening atopic dermatitis [25]. Carmine is a red food coloring made from a dried insect called *Dactylopius occus* Coasta, which can be found on prickly pear cactus plants. This coloring is also found in various cosmetics, drinks, red yoghurt and popsicles. Reactions to carmine are probably due to allergic antibodies. Annatto is a yellow food coloring made from the seeds of a South American tree, *Bixa orellana*. This additive has been found to cause allergic reactions, including anaphylaxis and urticaria / angioedema.

Saffron is a yellow food coloring, obtained from the flower of the *Crocus sativa* plant, has been reported as a

cause of anaphylaxis [26]. Many other food colorings are less common, but possible, causes of adverse reactions. These include sunset yellow (yellow #6), amaranth (red #2), erythrosine (red #3), and quinoline yellow, among others. Antioxidants such as BHA (butylated hydroxyanisole) and BHT (butylated hydroxytoluene) are added to prevent the spoilage of fats and oils. Both BHA and BHT are suspected of causing urticaria and angioedema. Lecithin is an emulsifier made from soybeans and eggs, and may contain soybean proteins. Reactions to soy lecithin are rare, even in soy-allergic people, since the level of this additive is usually very low in most foods [27]. Various gums are used as food additives and function as emulsifiers and stabilizers. Major gums include guar, tragacanth, xanthan, carageenan, acacia (Arabic) and locust bean. Many of these gums are known to worsen asthma, particularly in the occupational setting, when airborne, others are known to cause allergic reactions when present in foods. Monosodium Glutamate (MSG) is a flavor enhancer added to various foods, and also occurs naturally. Reactions to MSG have been called the “Chinese Restaurant Syndrome,” and symptoms include numbness on the back of the neck, shoulders and arms, weakness and palpitations. Other symptoms include facial pressure/tightness, headaches, nausea, chest pain and drowsiness. MSG is also suspected of worsening asthma symptoms. Spices are the aromatic part of various weeds, flowers, roots, barks and trees. Because they are derived from plants, spices have the ability to cause allergic reactions, just like pollens, fruits and vegetables. The most common spices used include chili peppers, celery, caraway, cinnamon, coriander, garlic, mace, onion, paprika, parsley and pepper. Aspartame is a sweetener used in many sugar-free foods and drinks. This food additive has been suspected of causing such symptoms as headaches, seizures and urticaria.

7. What Preservatives Cause Reactions?

- Sulfites are common preservatives used in various foods, and are well known to cause a variety of symptoms.
- Nitrates and Nitrites: These additives are used as curing agents in meat products. Few reports of reactions to nitrates and nitrites exist, and include urticaria, itching and anaphylaxis.
- Benzoates are used in foods as antimicrobial preservatives, and have been responsible for worsening asthma, allergic rhinitis, chronic urticaria, and flushing in some people.
- Sorbates/sorbic acid are added to foods as antimicrobial preservatives. Reactions to sorbates are rare, but have included reports of urticaria and contact dermatitis [28].

8. Effects of Food Preservatives

Many foods available in the market contain different types of preservatives. These chemicals can give rise to certain health problems. Additives consistently maintain the high quality of foods. Food preservatives are the additives that are used to inhibit the growth of bacteria, molds and yeasts in the food. Some of the additives are manufactured from the natural sources such as corn, beet

and soybean, while some are artificial, man-made additives. Many people are allergic to certain food additives or colors. When someone has a reaction after eating certain foods, such an allergy is suspected. Unfortunately, some people do not have a reaction until a day or two later, so it is difficult to know what is causing the problem. When a certain food additive is believed to cause an allergic reaction, the blood is mixed with materials known to trigger allergies. The test measures the level of allergy antibodies in the blood that are present with an allergic reaction. Such test for synthetic additives is not reliable. Thus, people have to go on an elimination diet. They stop eating all foods that might be problematic and introduce one at a time to see if a reaction occurs. It is best to eat a preservative-free diet if at all possible. The reaction from these additives can be very mild to life-threatening. They can be immediate or build up in the body over time. Only in recent years have researchers seriously considered the physical impact of these additives over the long term [29].

9. Food Additives

In its broadest sense, a food additive is any substance added to food. Legally, the term refers to any substance the intended use 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 [30]. Food additives are also substances added to food to preserve flavor or enhance its taste and appearance. Some additives have been used for centuries; for example, preserving food by pickling (with vinegar), salting, as with bacon, preserving sweets or using sulfur dioxide as in some wines. With the advent of processed foods in the second half of the 20th century, many more additives have been introduced, of both natural and artificial origin [31]. Food Additives are defined by the United States Food and Drug Administration (FDA) as “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”. In other words, an additive is any substance that is added to food. Direct additives are those that are intentionally added to foods for a specific purpose while indirect additives are those to which the food is exposed during processing, packaging, or storing [31]. If a substance is added to a food for a specific purpose, it is referred to as a direct additive. For example, the low-calorie sweetener aspartame, which is used in beverages, puddings, yoghurt, chewing gum and other foods, is considered a direct additive. Many direct additives are identified on the ingredient label of foods. Indirect food additives are those that become part of the food in trace amounts due to its packaging, storage or other handling. For instance, minute amounts of packaging substances may find their way into foods during storage.

Food additives may be classified as:

- a) Antimicrobial agents, which prevent spoilage of food by mold or micro-organisms. These include not only vinegar and salt, but also compounds such as calcium propionate and sorbic acid, which are used in products

such as baked goods, salad dressings, cheeses, margarines, and pickled foods.

- b) Antioxidants, which prevent rancidity in foods containing fats and damage to foods caused by oxygen. Examples of antioxidants include vitamin C, vitamin E, BHA (butylated hydroxyl anisole), BHT (butylated hydroxytolene), and propyl gallate.
- c) Artificial colors, which are intended to make food more appealing and to provide certain foods with a colour that humans associate with a particular flavor (e.g. red for cherry, green for lime).
- d) Artificial flavors and flavor enhancers are the largest class of additives; its function is to make food taste better, or to give them a specific taste. Examples are salt, sugar, and vanilla, which are used to complement the flavor of certain foods. Synthetic flavoring agents, such as benzaldehyde for cherry or almond flavor, may be used to simulate natural flavors. Flavor enhancers, such as monosodium glutamate (MSG) intensifying the flavor of other compounds in a food.
- e) Bleaching agents, such as peroxides, are used to whiten foods such as wheat flour and cheese [31].
- f) Chelating agents, which are used to prevent discoloration, flavor changes, and rancidity that might occur during the processing of foods. Examples are citric acid, malic acid, and tartaric acid.
- g) Nutrient additives, including vitamins and minerals are added to foods during enrichment or fortification. For example, milk is fortified with vitamin D, and rice is enriched with thiamin, riboflavin, and niacin.
- h) Thickening and stabilizing agents, which function to alter the texture of a food. Examples include the emulsifier lecithin, which, keeps oil and vinegar blended in salad dressings, and carrageen, which is used as a thickener in ice creams and low-calorie jellies.

10. Classification of food additives

Food additives can be divided into several groups, although there is some overlap between them.

Acids: Food acids are added to make flavors “sharper”, and also act as preservatives and antioxidants. Common food acids include vinegar, citric acid, tartaric acid, malic acid, fumaric acid, and lactic acid.

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

Anticaking agents: Anticaking agents keep powders such as milk powder from caking or sticking.

Antifoaming agents: Antifoaming agents reduce or prevent foaming in foods.

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

Bulking agents: Bulking agents such as starch are additives that increase the bulk of a food without affecting its nutritional value.

Food coloring: Colorings are added to food to replace colors lost during preparation, or to make food look more attractive and appealing [32].

Color retention agents: In contrast to colorings, color retention agents are used to preserve a food’s existing color.

Emulsifiers: Emulsifiers allow water and oil to remain mixed together in an emulsion, as in mayonnaise, ice cream, and homogenized milk.

Flavors: Flavors are additives that give food a particular taste or smell, and may be derived from natural ingredients or created artificially.

Flavor enhancers: Flavor enhancers enhance a food’s existing flavors. They may be extracted from natural sources (through distillation, solvent extraction, maceration, among other methods) or created artificially.

Flour treatment agents: Flour treatment agents are added to flour to improve its color or its use in baking.

Glazing agents: Glazing agents provide a shiny appearance or protective coating to foods.

Humectants: Humectants prevent foods from drying out.

Tracer gas: Tracer gas allows for package integrity testing preventing foods from being exposed to atmosphere, thus guaranteeing shelf life.

Stabilizers: Stabilizers, thickeners and gelling agents, like agar or pectin (used in jam for example) give foods a firmer texture. While they are not true emulsifiers, they help to stabilize emulsions.

Sweeteners: Sweeteners are added to foods for flavoring. 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.

Thickeners: Thickeners are substances which, when added to the mixture, increase its viscosity without substantially modifying its other properties [33].

Nowadays, most people tend to eat the ready-made food available in the market, rather than preparing it at home. Such foods contain some kind of additives and preservatives, so that their quality and flavor is maintained and they are not spoiled by bacteria and yeasts. More than 3000 additives and preservatives are available in the market, which are used as antioxidants and antimicrobial agents. Salt and sugar are the most commonly used additives. Some of the commonly used food additives and preservatives are

aluminum silicate, amino acid compounds, ammonium carbonates, sodium nitrate, propyl gallate, butylated hydroxytoluene (BHT), butylated hydroxyanisole (BHA), monosodium glutamate, white sugar, potassium bromate, potassium sorbate, sodium benzoate, etc. Some artificial colors are also added to the foods to give them an appealing look. These coloring substances are erythrosine (red), cantaxanthin (orange), amaranth (Azoic red), tartrazine (Azoic yellow) and annatto bixine (yellow orange). When the food is to be stored for a prolonged period, use of additives and preservatives is essential in order to maintain its quality and flavor. The excess water in the foods can cause the growth of bacteria, fungi and yeasts. Use of additives and preservatives prevents spoiling of the foods due to the growth of bacteria and fungi. Additives and preservatives maintain the quality and consistency of the foods. They also maintain palatability and wholesomeness of the food, improve or maintain its nutritional value, control appropriate pH, provide leavening and color, and enhance its flavor.

11. Chemistry of Food Additives

When we need to store any food for a longer time, it should be properly processed. During this processing, some substances and chemicals, known as additives, are added to the food. In addition, we also need to add some preservatives in order to prevent the food from spoiling. Direct additives are intentionally added to foods for a particular purpose. Indirect additives are added to the food during its processing, packaging and storage [34]. Food additives require the appropriate machinery, dispensing and storing equipment, whether one produce the chemical food additives, or rely on food preservative suppliers to deliver additives and preservatives for baked goods or beverages. In the food preservatives industry, the industry considers supplies that align with the need for using food additives in food products. In other words, supplies and other equipment for food additives must be beneficial in maintaining freshness, consistency, texture, taste, color and nutrient levels that help sell food products. Supplies for food additives include liquid and solid separation equipment, food preservation presses, industrial mixers, homogenizers, pasteurizers and dispensers. Conveyors, storage and processing tanks, and vacuum tumblers that marinate or cure meats are also common equipment used for preservatives in food. Chemical food additives such as corn starch, potassium sorbate and sodium nitrate are usually available as syrup, crystals or powders that must be ordered from food preservative suppliers.

12. Effect of Additives in Food

Some modern synthetic preservatives have become controversial because they have been shown to cause respiratory or other health problems. Some studies point to synthetic preservatives and artificial coloring agents aggravating ADD & ADHD symptoms in those affected [35]. Older studies were inconclusive, quite possibly due to inadequate clinical methods of measuring offending behaviour. Parental reports were more accurate indicators of the presence of additives than clinical tests [36]. Several

major studies show academic performance increased and disciplinary problems decreased in large non-ADD student populations when artificial ingredients, including preservatives were eliminated from school food programs [37]. Allergic preservatives in food or medicine can cause an anaphylactic shock in susceptible individuals, a condition which is often fatal within minutes without emergency treatment. It is almost a certainty that few really know what it is, that is part of their foodstuffs, and yet may present threats and danger. Essentially, there are two main sources of dangerous or threatening additives. The first is those that are put in as part of the processing operation. These include the colorings, preservatives, flavors and flavor enhancers, sweeteners, texture agents and processing agents. Details of these must be included on the labelling and can be identified with a little knowledge and some attention to the information provided by the manufacturer. Ideally, food that has no additives at all is to be preferred and especially if it is to be used to feed children. Far too many of our young are sensitized through these additives and this can lead to allergies and such conditions as Attention Deficit Disorder and Hyperactivity [37].

13. Significance of Food Preservatives and Additives

The importance of preserving food is that, it lengthens the shelf life of a food and it slows down the spoilage of food which is caused by microorganisms present in the container or the hands that held it before putting it inside a container. The importance of food preservation is so that the food cannot be spoiled or can cause illness. Although preservatives are essential to maintain food safety, too much of a good thing is not healthy. Besides allergies, these foods may cause stomach pains, vomiting, breathing problems, hives and skin rashes. Some of the worst additives include benzoates, which can cause skin rashes, asthma and perhaps brain damage. Bromates can cause nausea and diarrhea. Saccharin may lead to toxic reactions that impact the gastrointestinal tract and heart, as well as cause tumors and bladder cancer. Red Dye 40 may result in certain birth defects. Sodium chloride can lead to high blood pressure, kidney failure, stroke and heart attack. Such problems are why some doctors are now saying it is better to have a soda with sugar than a diet soda with additives [38].

14. Advantages of Food Additives

Food additives play a vital role in today's food supply. They allow our growing urban population to have a variety of foods year-round. And, they make possible an array of convenience foods without the inconvenience of daily shopping. Food additives perform a variety of useful functions in foods that are often taken for granted. Since most people no longer live on farms, additives help keep food wholesome and appealing while en route to markets sometimes thousands of miles away from where it is grown or manufactured. Additives also improve the nutritional value of certain foods and can make them more appealing by improving their taste, texture, consistency or colour [39].

Additives are used in foods for five main reasons:

- i) To maintain product consistency. Emulsifiers give products a consistent texture and prevent them from

separating. Stabilizers and thickeners give smooth uniform texture. Anti-caking agents help substances such as salt to flow freely.

- ii) To improve or maintain nutritional value. Vitamins and minerals are added to many common foods such as milk, flour, cereal and margarine to make up for those likely to be lacking in a person's diet or lost in processing. Such fortification and enrichment has helped reduce malnutrition among the U.S. population. All products containing added nutrients must be appropriately labeled.
- iii) To maintain palatability and wholesomeness. Preservatives retard product spoilage caused by mold, air, bacteria, fungi or yeast. Bacterial contamination can cause foodborne illness, including life-threatening botulism. Antioxidants are preservatives that prevent fats and oils in baked goods and other foods from becoming rancid or developing an off-flavor. They also prevent cut fresh fruits such as apples from turning brown when exposed to air.
- iv) To provide leavening or control acidity/alkalinity. Leavening agents that release acids when heated can react with baking soda to help cakes, biscuits and other baked goods to rise during baking. Other additives help to modify the acidity and alkalinity of foods for proper flavor, taste and color.
- v) To enhance flavor or impact desired color. Many spices, natural and synthetic flavors enhance the taste of foods. Colors, likewise, enhance the appearance of certain foods to meet consumer expectations [39].

Additives and preservatives are used to maintain product consistency and quality, improve or maintain nutritional value, maintain palatability and wholesomeness, provide leavening, control pH, enhance flavor, or provide color.

15. Disadvantages of Food Additives

Although additives and preservatives are essential for food storage, they can give rise to certain health problems. They can cause different allergies and conditions such as hyperactivity and Attention Deficit Disorder in some people who are sensitive to specific chemicals[40]. The foods containing additives can cause asthma, hay fever and certain reactions such as rashes, vomiting, headache, tight chest, hives and worsening of eczema. Some of the known dangers of food additives and preservatives are as follows:

- Benzoates can trigger the allergies such as skin rashes and asthma as well as believed to be causing brain damage.
- Bromates destroy the nutrients in the foods. It can give rise to nausea and diarrhea.
- Butylates are responsible for high blood cholesterol levels as well as impaired liver and kidney function.
- Caffeine is a colorant and flavorant that has diuretic, stimulant properties. It can cause nervousness, heart palpitations and occasionally heart defects.
- Saccharin causes toxic reactions and allergic response, affecting skin, gastrointestinal tract and heart. It may also cause tumors and bladder cancer.

- Red Dye 40 is suspected to cause certain birth defects and possibly cancer.
- Mono and di-glycerides can cause birth defects, genetic changes and cancer.
- Caramel is a famous flavoring and coloring agent that can cause vitamin B6 deficiencies. It can cause certain genetic defects and even cancer.
- Sodium chloride can lead to high blood pressure, kidney failure, stroke and heart attack.

To minimize the risk of developing health problems due to food additives and preservatives, one should avoid the foods containing additives and preservatives. Before purchasing the canned food, you must check its ingredients. You should buy organic foods, which are free from artificial additives. Try to eat the freshly prepared foods as much as possible rather than processed or canned foods [40].

16. Conclusion

This study has examined the chemistry of food. Food chemistry has been defined as the study of chemical processes and interactions of all biological and non-biological components of foods. The most essential aspects of food chemistry are the additives and preservatives. Additives have been used for many years to preserve, flavor, blend, thicken and color foods, and have played an important and essential role in reducing serious nutritional deficiencies. Additives help to assure the availability of wholesome, appetizing and affordable foods that meet consumer's demands from season to season. In summary, a food needs to be looked at in its totality-is it gluten free or not? The presence or absence of additives in a specific food product can only be supplied by the food manufacturer.

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