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Food Additives of Cereals, Legumes, and Their By-Products, and the Role of Bioinformatics of Food Sciences

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Abstract

Food additives offer a way to reduce food loss and waste, while simultaneously maintaining the supply of readily available, reasonably priced, and nutrient-dense food for human consumption, thus feeding the globe. Following a century of continuous research and technological advancements in the food industry, more than three thousand naturally occurring and artificially manufactured compounds have been added to food during processing or preparation in order to give it certain, desired qualities. Though the use of food additives has aided in the food industry's explosive expansion, there have also been unintended health effects that raise concerns for the general public's health. In order to encourage safe use and limit detrimental health effects, this paper examines the significant role that food additives play in the food industry, as well as current advancements and trends in the food sector. It also identifies various health hazards that are linked to specific food additives. Bioinformatics can be used to efficiently access all of the genomic, proteome, and metabolomics data that has been found thus far, and to make this data available to any particular industry, group, or corporation in order to improve the nutritional value, taste, and quality of food that is to be produced. The function of bioinformatics and a few methods in the field of food sciences have been covered here.

Keywords: Food additives; Definition; Classification**;** Natural additives; Sensory agents; Processing agents; Preservation.

1. Introduction

Food additives are now widely used and essential to the contemporary food sector. Ready to eat food that is sold in stores and is not made at home frequently contains additives to maintain or improve its quality in terms of appearance, texture, taste, and flavor attributes [1]. Without food additives, a lot of ready-to-eat convenience foods and low-calorie snacks would not be viable. The need for high-quality food has been sustained by the swift population growth and continuous shifts in food habits and tastes, which will also have an impact on the availability of safe, nutrient-rich food. This will further increase the demand for the food sector to employ more food additives and introduce new ones [2].

Food additives are purposefully introduced for technological reasons; they are not often eaten as food or used as a regular food ingredient. With the help of an international scientific committee made up of experts from various nations which establish global standards and guidelines pertaining to food consumption and additive use in processed foods [3].

The primary sources of food additives and the foods that are consumed over time are processed foods. However, it is noted that the scientific method has limits when it comes to analyzing human intake and toxicity of food additives, which results in a lack of evidence in the scientific literature. Additionally, taking into account the body weight of the various age groups, the chemicals have a larger potential for toxicity in consumers. The necessity of adhering to the precautionary principle, which was mandates the prevention of risks of harm [4].

According to Shum and Georgia [5], customers appear to consume this ingredient frequently and occasionally in excess of the suggested levels. They thus highlight the need for research on the possible health effects of sweetener consumption, particularly with regard to the potential risk of type 2 diabetes and other cardio metabolic diseases; they also stress the significance of examining the potential effects of sweetener exposure during uterine development on metabolic outcomes during life.

It is obvious that food additives both pose a substantial health risk and offer consumers significant sensory pleasure and business convenience. As a result, many nations should have rules governing the use of additives in food as the safety of these substances is a significant concern for the food business [6].

2. Definition of Food Additives

Regardless of whether it has nutritional value, any substance that is intentionally added to food in small amounts such that it does not define or comprise a main component of the food in order to accomplish a specific desired effect is regarded as a food additive [1]. Foods additives can be used as improve and preserve certain qualities customers' desire, whether those qualities be chemical, biological, physical, or sensory [7]. Apart from the particular desired effect it produces, a food additive does not meet the requirements to be considered a key ingredient or a distinctive nutritional component of the food in question, even if it is a naturally occurring or artificially made material.

Food additives are defined as "Any substance not usually used as a food itself and not used as a typical ingredient in the food" by the Codex Alimentations, however this definition has evolved over time. They may be added to food for technological or multipurpose purposes, regardless of their nutritional worth. Contaminants, additives added to food to preserve or enhance its nutritional value, and sodium chloride are not included in this definition [8].

3. Classification of Food Additives

Food additives can be categorized as direct, which means they are added to food on purpose during processing, or indirect, which means they are not introduced but are discovered during or after processing and end up in the food during handling, packing, or storage [9]. Certain chemicals are indirectly absorbed into our food through environmental contact with packaging materials or as a consequence of chemical reactions between the food product's constituent parts [10].

3.1. Direct Food Additives

Food additives that are added to food on purpose to achieve a desired quality or characteristic be it physical, chemical, biological, or sensory are either naturally occurring or artificially created [7].

3.2. Indirect Food Additives

Indirect food additives don't have any technical use in food and aren't purposefully added. They may be considered contaminants if they accidentally contaminate food, if food contamination occurs, or if food processing or storage produces higher-than-allowable amounts of them due to chemical and biological interactions [11]. The significant hazards to public health posed by the high concentrations of indirect food pollutants in food and water make them a cause for concern. Consuming contaminated food can lead to inflammation and enteric illnesses, and treating or shielding people from the adverse effects of food contaminants is a difficult undertaking. Chemical contamination is the term used to describe the presence of a chemical in an unsuitable location [10]. Nevertheless, as food pollutants are not considered additives, they are not included in this chapter. By adding unwanted pollutants and substances created in the food. The migration of chemical compounds might result in indirect food contamination [12].This is concerning since elevated concentrations in food and water might have detrimental effects on public health, particularly when migratory chemical levels are high. Globalization and the expansion of agribusiness have contributed to the rising danger and difficulty that has turned into a worldwide issue [13].

4. Categories of Food Additives

Food additives are divided into groups according to their functions. Food additives fall into four broad categories: processing agents, sensory agents, preservatives, and nutritional additions [2]. These divisions are not exact, though, as many additives fit into multiple categories. The five primary categories (Figure 1) are explained in the sections that follow.

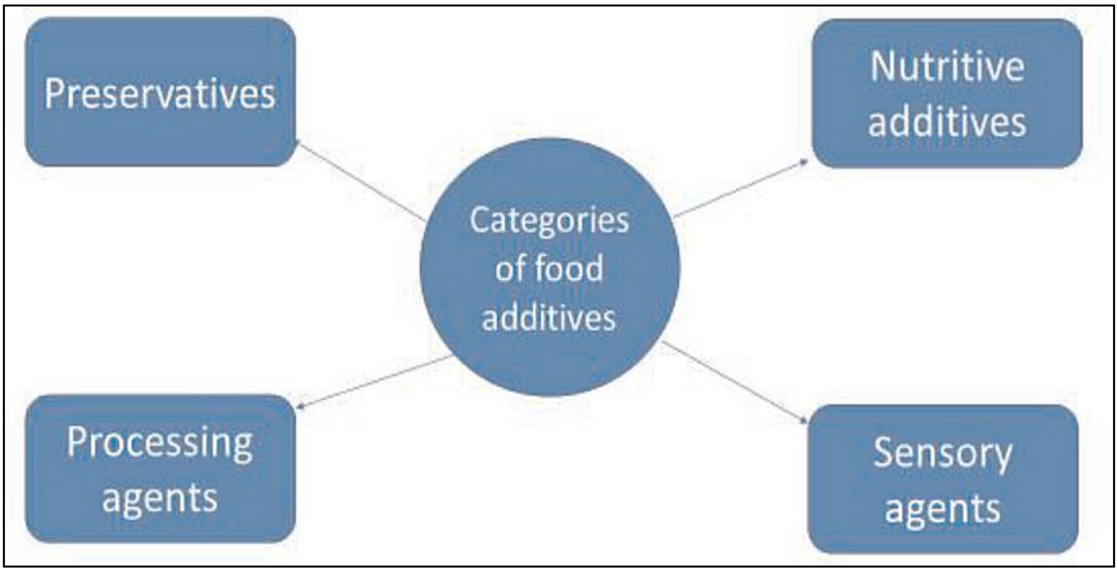

Figure-1. Generalized categories of food additives [2]

4.1. Nutritive Additives

The goal of class additives was to replenish nutrients primarily vital micronutrientsthat have been lost or deteriorated during the food processing process. The procedure, known as enrichment or fortification, adds nutrients to food supplements or replacements that are intended to prevent or treat dietary deficiencies. It is well acknowledged that fortifying frequently consumed foods and condiments can effectively address certain micronutrient deficiencies over the medium to long term, improving quality of life and accelerating growth at a minimal cost. For example, the germ, bran, and endosperm are separated during the milling of wheat to produce white flour, which removes the portion of the grain that is rich in vitamins and minerals [14].

Eventually, to increase the nutritional value of fats and oils, dairy, and cereal goods, fat-soluble vitamins were added. Vitamins A and D are still added to dairy and cereal products; iron and several B vitamins are found in flour, cereals, baked goods, and pasta; vitamin C is added to fruit drinks, cereals, dairy products, canned citrus fruits, and confections to replenish vitamin C lost during processing. Minerals including calcium and iron, dietary fiber, and the important fatty acid linoleic acid are further nutritional additions [15].

When stored in undamaged containers, food fortification containing water-soluble vitamins can last for at least a year. The most labile vitamins are those that are fat-soluble, which heat, light, and oxygen sensitive. Although vitamin E in its alcohol form is beneficial as an antioxidant, it is best consumed in esterifies form, which is available as vitamin E acetate. The only food additives that contain vitamin K are infant formulas and meal replacements.

A normal and healthy existence depends on micronutrients, and the Codex Alimentarius Commission (CAC) has set safe or tolerated levels for vitamins and critical trace elements [1]. Certain micronutrients might be harmful if used excessively because they can cause toxicity or unpleasant effects when nutrients interact with one another, reducing the nutritional benefits of a regular diet [16]. Codex Alimentarius Commission (CAC) oversees the development of food additive standards and regulations aimed at safeguarding consumer health and promoting equitable practices in the food industry [2]. As a result, food producers must disclose the kinds of additives that are included in their goods.

4.2. Health Risks Associated with Nutritive Additives

Vitamins A, D, E, and K that are fat-soluble can be stored in your liver and adipose tissues, in contrast to water-soluble vitamins. Toxicity may arise from misuse or overindulgence. Many symptoms of micronutrient (vitamins and minerals) toxicity include heart arrhythmias, headaches, nausea, vomiting, and in severe cases, seizures, headaches, general body pain, weakness, shortness of breath, nausea, vomiting, diarrhea, fever, metallic tastes, elevated blood pressure, no urine output, and high doses may result in nutrient-nutrient interactions between iron and copper. Conversely, persistent abuse of fatty acid additions and nutritional sweeteners can lead to obesity and overweight, which are risk factors for numerous associated non-communicable diseases.

4.3. Processing Agents

Food processing agents are substances that are added to food and are primarily used to aid in the processing of a specific food product or to maintain the products desired attributes, safety, consistency, color, and nutritional value [17]. Food-processing agents serve important purposes that make them essential to processing, and when used as directed in modest amounts for safety without changing final product's taste, they are thought to be quite safe. They are frequently used to improve the quality and consistency of a wide range of items, such as confections, jams, jellies, bakery goods, meat, and meat products. They also assist maintain the wholesomeness of the product, extend shelf life, and aid in packing and transportation. Inadvertently adding a "residue" to the final processed material through the use of a processing aid can result in an indirect food additive [18].

Before being used for commercial purposes, a processing aid whether natural or synthetic must have approval from the appropriate institutional body [2]. Every manufacturer should identify, disclose, and investigate the food safety, efficiency, and ethical considerations while evaluating processing agents. The majority of ethical concerns about related to different views around diets like vegetarian and other systems. In order to prevent negative reactions, it is crucial to fully disclose the type of additive processing aid used so that consumers can make an informed decision about a food product from a personal, cultural, religious, or public health perspective. A vegetarian, for example, might wish to steer clear of items that have come into touch derived any similar animal byproduct. Sorts of processing aids are described in the sections below:

4.4. Emulsifying Agents

An emulsifying agent is used to maintain homogeneity, or the uniform dispersion of one liquid into another, and to give food an appealing texture. Emulsifiers keep immiscible liquids, including water and oils, from separating during storage or before use by preventing the coalescence of oil droplets, which encourages the separation of the oil phase from the aqueous phase, as in ice cream or mayonnaise. This results in foods with a good texture and homogeneity. The hydrophilic portion of an emulsifying agent dissolves in the liquid's aqueous phase and can be charged or uncharged, while the hydrophobic portion of the long-chain fatty acid bonds to the oil phase. By distributing microscopic oil droplets, this arrangement produces a stable oil-in-water emulsion.

Additionally, emulsifiers aid in boosting processed baked items' volume, fineness, and uniformity. They can be used to hold in flavor elements and stop meals from forming ice and sugar crystals as the temperature changes, like in sugar-infused ice cream.

A similar mechanism, with the substitution of a gas phase for the oil phase, stabilizes foam in food products. Lecithin is a typical emulsifying agent, and silicone is known to be an antifoaming agent for beverages

4.5. Stabilizers and Thickeners

Stabilizers and thickeners are used as gelling agents to improve the viscosity, smoothness, or consistency of food products, including dressings, frozen desserts, candies, pudding mixes, jams, and jellies. They do this by acting as stabilizing or thickening emulsions. Gums (locust bean, and guar) and pectin are among them. Carrageenan and gelatin are other examples. It's usual practice to remove suspended particles from apple juice by adding gums to gelatin. Agar-agar is used in place of gelatin in dishes intended for vegans. The majority of thickening and stabilizing agents are proteins like gelatin or polysaccharides like starches or gums. The process works by attaching itself to the outside of oil droplets and raising the water phase's viscosity as a result. However, before using a thickening, it can be approved with a recognized food safety regulatory organization [19].

5. Preserving Agents

Preservatives are naturally or synthesized compounds applied to vegetables, fruits, processed food, beauty products, and medicines become better shelf life and preserve quality and efficiency by preventing, delaying, or stopping fermentation, acidification, microbial activity, and breakdown [20].

In order to maintain food safety for an extended amount of time, preservatives are also employed to prevent or lessen food deteriorating brought on by bacterial, fungal, and microorganism contamination [21].

According to Thomas and Adegoke [22], preservatives are substances added to food with the purpose of preventing or delaying undesirable alterations caused by the action of microorganisms, enzymes, and/or physical agents that come into contact with the food. One of the oldest human technologies is food preservation, which has been done for ages using chemicals to perfect the preservation of salt, vinegar, and sugar for extended periods of time [23, 24].

Preservatives contribute to the safety and/or healthfulness of food. The food business uses a lot of preserving agents because consumers want meals that are safe, long-lasting, and chemically stable [22]. According to Lennerz, *et al.* [25], sulfur dioxide, potassium and sodium nitrates, ascorbic acid, sodium benzoate, and nitrites are the most widely used preservatives. Antioxidants and antimicrobials are the two main classes of food preservatives.

5.1. Natural Food Preservatives

Before introducing preservatives, food was stored in clay jars to prevent spoilage. Food storage maybe dates back to early Egyptian, Greek, Roman, Sumerian, and Chinese civilizations. As most germs and fungi need moisture to develop, drying food was a common preservation technique. Fruits, vegetables, and meats were mostly dried for preservation purposes. The early preservatives included sugar and salt, which created food conditions with high osmotic pressure, denying bacteria the aquatic environment they need to survive and multiply. As high-sugar solutions, jams and jellies are preserved, while many types of meat and fish are still salted. Spices were also employed to preserve food by the Eastern Civilizations of India and China. Pickling vegetables with salt, vinegar, lemon juice, or mustard oil was a common preservation technique. Canning, in combination with pasteurization, revolutionized food preservation in the early nineteenth century [26]. Also, salt, sugar, and vinegar can be used as natural food preservatives [23].

5.2. Artificial Food Preservatives

It is the most efficient method for long-term preservation [23]. Current toxicological investigations suggest that certain levels and/or prolonged usage of synthetic preservatives may be significantly mutagenic [27]. Natural chemicals with antimicrobial and antioxidant action are being investigated as alternatives to commonly used artificial preservatives, lowering their quantity in foods and their potential health hazards [28].

5.3. Antioxidants

There is a similarity between preservatives and antioxidants as they contribute to food preservation. Antioxidants primarily avoid or minimize food deterioration by preventing or inhibiting oxidation [29]. Natural antioxidants are often used in producing meat, fish, nuts, vegetables, fruits, drinks, and canned foods.

Chemical substances are known as antioxidants work to postpone or stop food deterioration caused by oxidative processes. They function as metal chelators, enzyme inhibitors, and scavengers of free radicals. Consequently, they lessen the damage that fat foods inflict to certain amino acids and vitamins, prevent fresh produce from browning when exposed to air, and slow down food auto-oxidation to maintain flavor and appearance. Potatoes, several baked goods, and processed meats all employ tocopherols instead of nitrites.

Butylated hydroxyanisole (BHA) is a white substance that dissolves in fat and water and is volatile. It is rather alkaline and heat stable (Figure 2).

According to Schaefer [30], TBHQ is as an antioxidant prolongs their shelf life and inhibition discoloring and lipids from going rancid. Light-colored and crystalline, TBHQ has a faint smell and is present in many processed foods, such as vegetable and animal fats, noodles, snack crackers, frozen and fast meals, and fish products. It is frequently used with other chemicals. Because of their tight relationship, the compounds are frequently addressed together. The body metabolizes BHA to create TBHQ. But as of late, TBHQ has developed a dubious reputation [30].

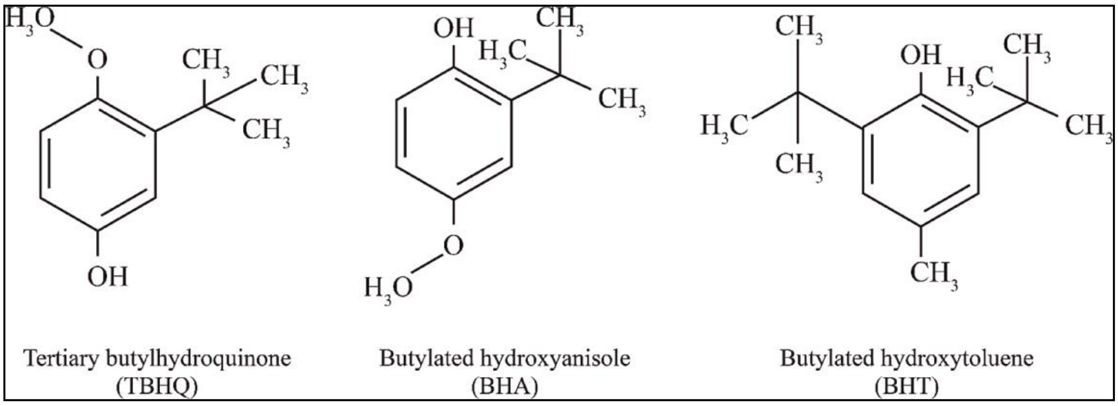

Figure-2. Molecular structure of TBHQ, BHA and BHT

5. Antimicrobials

Antimicrobials are preservatives that stop harmful and spoilage germs from growing in food. Foods containing too much water may encourage the growth of bacteria, fungus, molds, and yeasts that take on unpleasant traits. According to Topuz and Uyar [31] antimicrobials inhibit the growth of pathogenic microorganisms or lessen the activity of spoilage microorganisms in order to preserve the food's nutritional content, wholesomeness, and overall quality and consistency. In addition, it gives food color and leavening, regulates pH fluctuations, and improves flavor.

To regulate the growth of microbes in low-PH meals, organic acids such as ascorbic acid, propionic acid, benzoic acid, and acetic acid are employed. Since their introduction to the market, chemical preservative compounds have outperformed natural antimicrobials in terms of effectiveness [32]. To stop the bacterium *Clostridium botulinum* from growing in meats and meat products like bacon and ham, for example, nitrates and nitrites are commonly utilized. Sulfites and sulfur dioxide (SO2) have antibacterial, structural-modifying, antioxidant, and enzyme-inhibiting properties. They are used to control the decaying microorganisms in dried fruits and vegetables, pickles, juices, and sugar syrups. Some microbes produce nisin, which inhibits the growth of bacteria, and natamycin, which combats yeast and mold. Potassium and sodium salts, together with propionates, benzoates, and sorbates, act against spore-forming bacteria and bread molds that create mycotoxins in flour and ropiness in bread.

Their mode of action involves binding sterol groups in fungus, mold, yeast, and certain bacteria's cell membranes, disrupting cell membrane function, or inhibiting enzymatic processes. They also prevent spore germination in yeast, mold, and some bacteria. To stop microbiological activity, cold water is treated with ozone, an antibacterial.

6. Sensory agents

6.1. Sweetening Agents

Sweetener, often known as a sugar replacement, is an ingredient in food that imparts a sweet flavor similar to sugar but has zero or very few calories [33]. In the late 1800s, non-nutritive sweeteners (NNSs), also called non-artificial sweeteners or high-intensity sweeteners (e.g., saccharin), were brought into the food supply and first authorized their use as a food additive [33]. NNSs make meals and drink more palatable without adding more calories to them. It has been suggested that the sweeteners' low-calorie content may aid in weight reduction [34].

These are the ingredients that give food its sweet flavor. Carbohydrate sweeteners, also known as nutritive sweeteners, are the most often used because they offer a superior sweet flavor, are usually well-tolerated, and have a suitable texture and form. Often referred to as "table sugar," sucrose is the most widely used food sweetener and is crucial to several bodily processes. The two molecules that make up sucrose, a naturally occurring nonreducing disaccharide, are merely glucose and fructose. In addition to being naturally occurring in fruits, vegetables, and nuts, sucrose is also manufactured commercially through a refining process from sugar cane, sugar beets, and other plants (Figure 3).

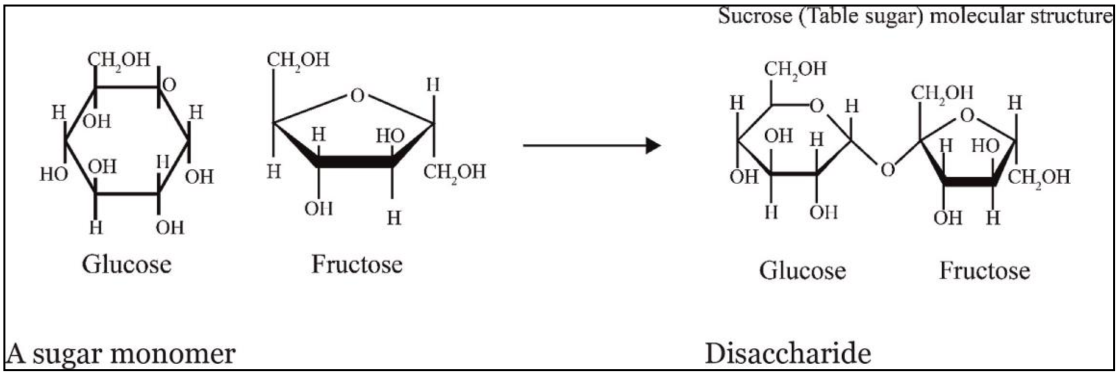

Figure-3. Molecular structures of sucrose and fructose monomers and disaccharides

6.2. Nutritive Sweeteners

The most common sweetener is sucrose, a white, odorless, solid with a sweet flavor. One molecule each of fructose and glucoseare produced when sucrose is broken down. The glucose molecule is directly used by human body cells. Upon initial absorption into the bloodstream, glucose is either stored as glycogen or utilized to directly produce ATP (adenosine triphosphate), an energy source. Through the hepatic portal, fructose is absorbed. In the liver, it is transformed to fat, which can then be further processed chemically to produce energy as needed [35].

Sweeteners classified as nutrients belong to the food group carbs. The three components of carbon, oxygen, and hydrogen are present in all carbohydrates, including sugar. The most basic saccharides are monosaccharides and disaccharides, which are regarded as simple sugars and have one or two monomers, respectively. Sucrose is a disaccharide with the chemical formula C12H22O11, which is made up of 12 carbon atoms, 11 oxygen atoms, and 22 hydrogen atoms.

Oligosaccharides, which have three to ten monomers joined together, are in between simple sugars (mono-saccharine) and polysaccharides (starches). Complex carbohydrates made up of several monomers are called polysaccharides. A kind of carbohydrate called oligosaccharides serves as a prebiotic, giving the good bacteria in the stomach something to eat [36]. According to Liang, *et al.* [37], a balanced population of gut bacteria can strengthen the immune system and improve general health.

6.3. Artificial Sweeteners (sugar substitutes)

Artificial sweeteners are chemical molecules with minimal or no calories that are used to sweeten food and beverages in place of table sugar [38]. A food ingredient that has a sweet flavor that is stronger than table sugar is called a sugar replacement. Though they are low in calories and several times sweeter than table sugar, artificial sweeteners also known as "intense sweeteners" are not carbs. Certain artificial sweeteners are so strong that they need to be balanced with maltodextrin or dextrose (Figure 4) [35].

Aspartame, a popular artificial sweetener, is a methyl ester of dipeptide that is generated from phenylalanine and aspartic acid. Compared to sucrose, it is roughly 100,100 times sweeter. Aspartame can be used as a sugar substitute for cold dishes and soft beverages because it becomes unstable at boiling temperatures. Compared to aspartame, aflatame has a higher potency and is more heat stable; nonetheless, it can be challenging to regulate how sweet the dish is once it has been added. Sucralose is a colorless trichloro derivative of sucrose that is stable at cooking temperatures and resembles table sugar in both look and flavor.

In addition to being created from synthetic sugar substitutes, natural materials like sugars or herbs can also be used to make artificial sweeteners. Because the sweeteners are so highly water soluble and heat stable, they are employed directly in a wide variety of foods and beverages, including puddings, dairy products, candies, soft drinks, baked goods, jams, and many more. The sweetness of a food product or artificial sweetener is due to the interaction between the receptor and the sweetener [39].

Since artificial sweeteners are soluble in water and do not raise blood sugar levels or add a substantial amount of calories to food, they are a desirable alternative to sugar. They can also be combined with starch-based sweeteners without changing the food's nutritional composition.

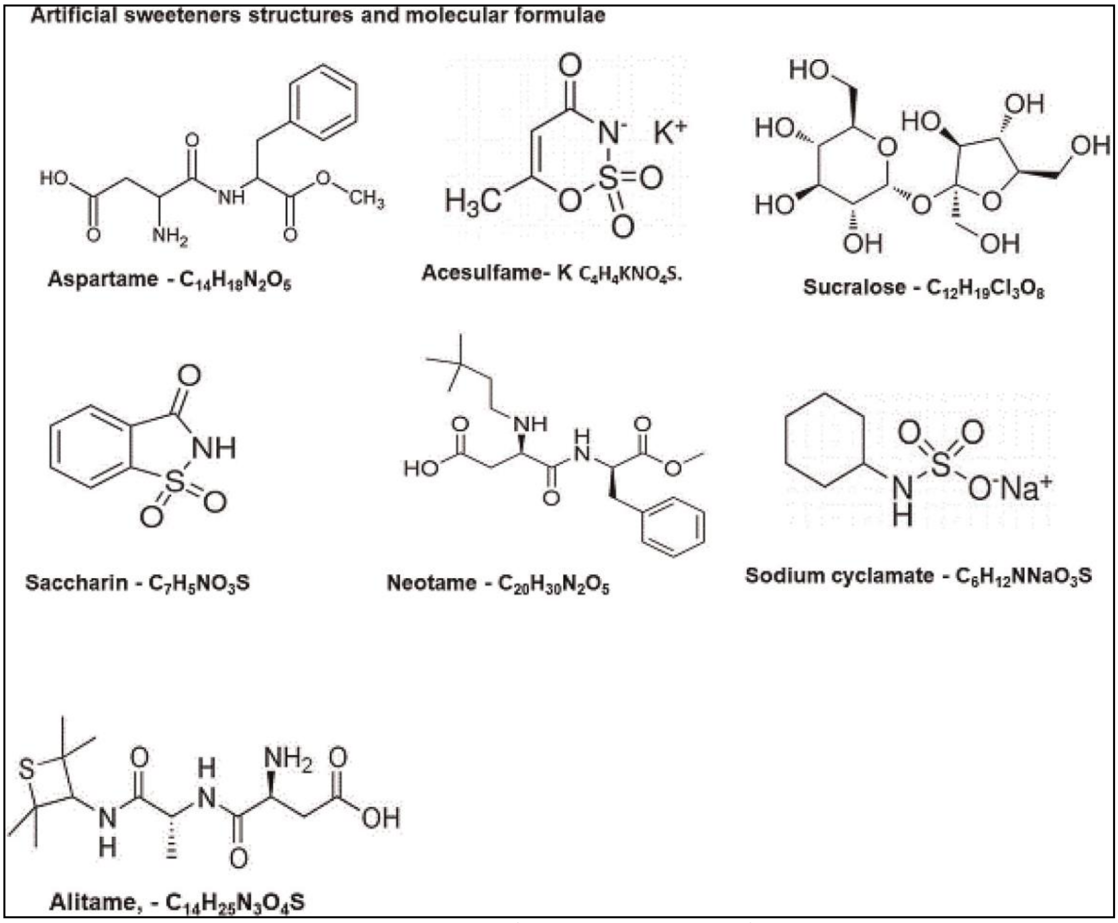

Figure-4. Molecular structures of some commonly used artificial sweeteners

6.4. Flavoring Agents

Food acquires its flavor through the activation of specialized cells called taste buds, which are located on the tongue, lips, and throat, as well as olfactory cells in the nasal cavity, which are capable of detecting over 10,000 different stimuli [39]. Taste cells are specific to five flavor molecules and are responsible for the fine-tuning and expression of the taste sensations of sweet, salty, bitter, sour, and umami [39]. Relatively small amounts of flavoring ingredients are employed in great range meals, confections, to add taste and/or scent.

A single chemical or a mixture of artificial or natural chemicals added to food to enhance the flavor already there, introduce a new flavor, or restore flavor that may have been lost during food preparation is known as a flavor addition. Natural flavorings come from plants, spices, herbs, animals, or microbial fermentations; artificial flavorings are created from synthetic molecules that have been chemically altered to mimic natural flavorings.

With over 1200 identified flavoring compounds, they represent the largest class of food additives used in the food industry on a commercial basis. Because natural flavorings are more expensive, harder to find, and have less power, artificial flavorings are chosen for commercial application.

Seaweed was discovered to improve the flavors of normally bland soup stocks, which is where flavor enhancers got their start in Far East Asia. The sodium salt of glutamic acid present in seaweed, known as monosodium glutamate (MSG) or monosodium L-glutamate, gives food an umami flavor that is different from bitter, salty, sour, or sweet. Since then, adding monosodium glutamate (Figure 5) to a variety of meals has been a standard practice for boosting their flavor. These foods mostly include broths, soups, canned and frozen vegetables, spice mixes, gravies, meats, poultry, seafood, and sauces.

MSG is now produced commercially by bacterial fermentation of starch and molasses followed by a reaction with ammonium salts. Yeast extract, hydrolyzed vegetable protein, inosine monophosphate (IMP), guanosine monophosphate (GMP), and 50-ribonucleotides are further compounds used as flavor enhancers.

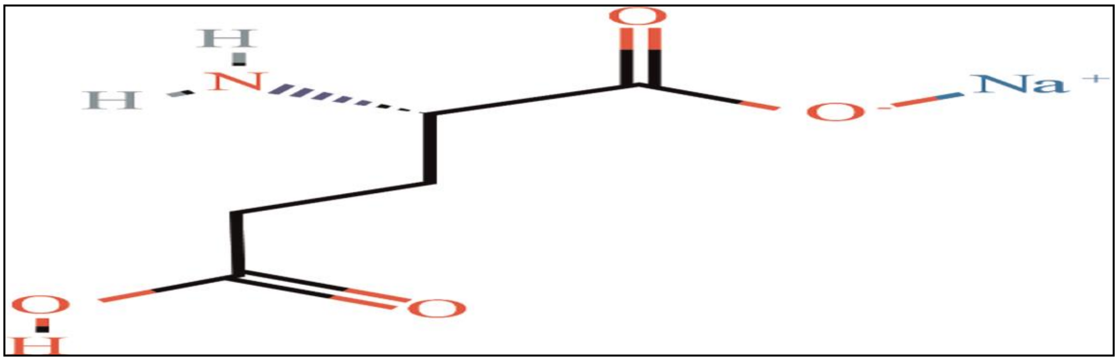

Figure-5. MSG formula is $C_5H_8NO_4Na$ and molecular weight, 169.11

7. Food Colorants

Colorants are food additives that restore colors lost during food preparation, improve flavor perception, or make food more visually appealing [40].

Because humans have evolved to notice food color, it matters. In addition to taste, sound, and scent, color is a crucial aspect of food since it affects how flavors are perceived, how a food product tastes, and how it makes people feel hungry by enhancing flavors. The usage of natural food colorings derived from mulberries, flowers, carrots, beets, pomegranates, saffron, and wine dates back to the Romans circa 1500 B.C. While coal tar was the first artificial food coloring developed in 1856, petroleum is now the primary ingredient in the majority of food colors today [41]. The simplest method of identifying if food is fresh, rotten, or poisonous is to look at its color. Nonetheless, food colorants are frequently added to food in order to change the color, intensify the color, or create a more consistent final product from the basic ingredients [41]. Although they can be used to, colorants are occasionally included as a desirable feature to enhance the appearance of food.

A food dye is a chemical compound that adds artificial color to food to make it look prettier, especially for kids. The vivid hues and alluring appearance of candies, sports drinks, baked goods, and other meals like pickles, smoked salmon, and salad dressing are caused by artificial food coloring. Food products' inherent color pigmentation or deterioration may occasionally be altered by food processing, handling, or storage. Manufacturers usually utilize food dyes to simulate natural foods, restore food and food product natural looks, or mask food preparation or processing flaws. This is the primary driving force behind the coloring of baked goods, drinks, snacks, candies, and ice cream to increase their appeal.
Food coloring can be synthetic derived from molecules based on petroleum or natural extracted from minerals, plants, or animals. However, because artificial food dyes are less expensive, produce more bright hues, and have a longer shelf life than natural ones, producers prefer them.

7.1. Natural Colorants

Refers to naturally occurring colors were derived from plants, animals, or minerals. For example, curcumin is mostly used to color foods such as drinks and sauces [42].

7.2. Synthetic Colorants

The majorities of artificial colorants are soluble in water and can be purchased in commercial quantities as pastes, powders, solutions, or granules to be mixed with food. Synthetic colorants are soluble in organic solvents and water; their stability can be affected by light, heat, pH, and reducing agents. Numerous synthetic dyes and colorants have been produced chemically and approved for use in various countries. The colorants are identified using unique numbering schemes that are national in nature. For instance, colorants approved by the EU use E numbers, and colorants approved by the FDA use FD&C numbers. Before being permitted, all synthetic colorants are subjected to thorough analysis and toxicological testing; however, approval is not granted in every nation.

8. Advantage of Additives

The food industry commonly employs food additives to extend product shelf life and improve foods' specific properties [43].

In addition to serving as a means of food preservation, food additives also aid in improving the nutritional value of food by enhancing its color, flavor, and flexibility [42].

Assist in preventing contamination that might result in foodborne illnesses, such as lethal botulism [44]

Healthy food Nutrient enhancers may be added to compensate for nutrition lost during food preparation, preventing malnutrition and nutrient deficit and improving nutrition balance. Many foods have added vitamins, minerals, and fibers to compensate for those missing in a particular food or lost during manufacturing or to improve the nutritional value of a product [42].

Preservatives suppress the development of molds, yeasts, and bacteria in sauces, beverages, and juices, among other goods [45].

Antioxidants may avoid or reduce the deterioration of food caused by unstable particles and free radicals [42].

Antioxidants inhibit rancidity and off-flavor development in fats, oils, and meals containing them. Additionally, they keep fresh foods like apples from browning if exposed to the air [46].

Foods' expected texture and consistency are provided by emulsifiers, stabilizers, and thickeners [47].

During baking, leavening chemicals cause produced goods to FAO and WHO [46].

While some substances assist preserve the flavor and attractiveness of meals with low fat content, certain additives help regulate the acidity and alkalinity of foods [24].

9. Disadvantages of Food Additives

Despite their widespread usage, they are compounds that, like any other medicine, may cause adverse effects such as allergic reactions, behavioural abnormalities, and carcinogenic effects [48].

Abnormal responses in the gastrointestinal, respiratory, dermatologic, and neurological systems may result from excessive doses of synthetic food additives [49].

When taken over the ADI, some preservatives, notably antimicrobial compounds, may be toxic and genotoxic as well as induce urticaria and behavioural disorders such as hyperactivity and Attention-deficit/hyperactivity disorder (ADHD) [32].

Children that consumed too much sodium benzoate were hyperactive, had urticaria, and their Deoxyribonucleic Acid (DNA) was also severely harmed (DNA) [50].

Potential health risks from high dosages of propyl gallate include apoptosis and DNA breakage [51].

10. Regulation of Use of Food Additives

Many additives are widely utilized and serve to improve the quality of food. However, most food safety accidents result from illicit activity, particularly the misuse and unlawful use of food additives, which has sparked global alarm. Consequently, legislation and monitoring additives are the two most efficient means of standardizing market activity and enhancing safety. We must ensure that only safe additives are used in foods. Therefore, several regulations on the safety of food additives should be addressed in order to bring new, safer chemicals and eliminate those of dubious safety [42].

Strict rules controlling the licensing and management of food additives have been created by regulatory bodies and law enforcement organizations. Regulation is employed to ensure that there are no dangers or malicious intent. Nevertheless, given the circumstances of use and the release of fresh scientific information, the use of food additives should continue to be closely monitored and evaluated when necessary [52]. For example, extremely small amounts of humectants and anti-caking agents are employed to protect food supply and preserve quality during shelf life. According to studies, these additives are safe to use as long as you stick to the recommended dosages. Research and development in this field are still ongoing in an effort to find safer, natural substitutes and technologies that can improve human health and food systems even further. Food additives can occasionally be misused to cover up food adulteration or poor processing or preparation techniques. They can be used to cover up or mask deterioration, damage, subpar quality, or faulty ingredients, or they can take the place of a drawn-out, laborious procedure.

In order to safeguard consumers, processing aids that show signs of allergies, intolerances, or religious concerns must follow food labeling laws regulating food additives.

11. Assessment of Food Additives

Illegal food additives or the misuse of food additives are typically evaluated in two ways: constituent identification and content estimation under laws, regulations, and standards. The first seeks to determine if additives are being used unlawfully, and the second seeks to determine whether additives are being used excessively. From this perspective, identifying food composition and additive content is a crucial problem in informing legislation and guaranteeing the population is fed with safe food consequently, it is crucial to develop sensitive and trustworthy analytical techniques for examining food additives (Figure 6).

Over the past 50 years, human risk assessments of additives for a wide range of substances have been conducted by numerous international and national organizations that deal with food safety and consumer safety [53].

The international evaluation of food additives is supported by the Acceptable Daily Intake (ADI) regulatory system, which was designed by the Food and Agriculture Organization of the United Nations [54]. Awareness of the potential toxicological concerns posed by frequent and/or excessive exposure to these compounds is essential. ADI is described as a quantitative measure of the additive that a person may consume every day without posing a danger to their health, assessed in proportion to body weight. It has been designed to safeguard consumers against potential harmful health impacts [45].

A food additive or its derivatives must undergo testing and a proper toxicity evaluation in order to evaluate any potential negative effects [8].Every food additive should continue to be monitored and evaluated as necessary, taking into account the use circumstances and any new scientific.

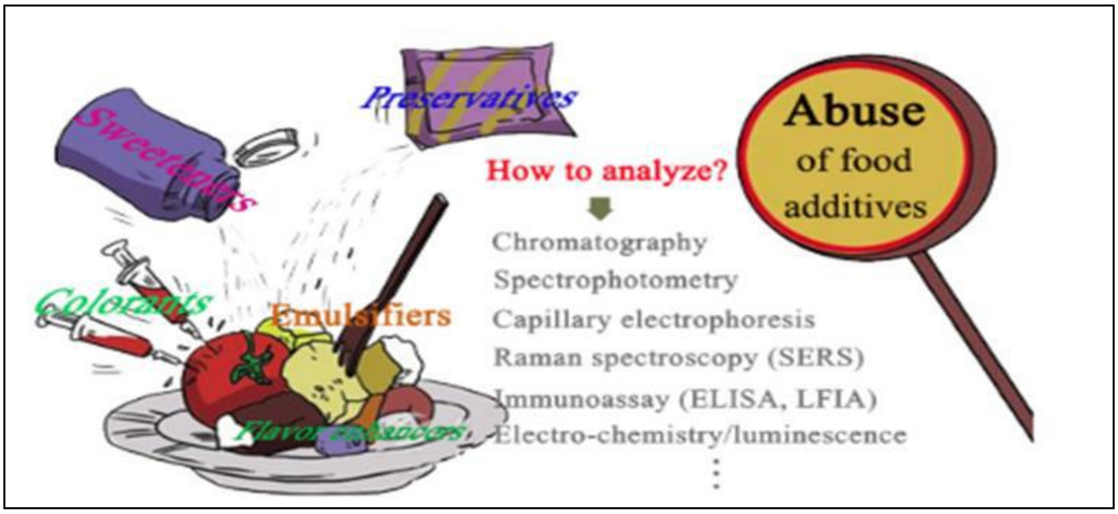

Figure-6. The plan for the misuse of food additives and the associated analytical procedures Safety evaluation of food additives

The Food Additives Amendment exempts two categories of substances from regulation [55].

Group I: Prohibited substances that, before to the 1958 amendment, the FDA or USDA had determined were safe for use in food, such as potassium and sodium nitrate.

Group II consists of all compounds that, based on published scientific data or their extensive history of usage in food before 1958, have been deemed safe by specialists. These chemicals include monosodium glutamate (MSG), sugar, and salt, for which various maximum allowed limits have been set depending on the product and additive type.

12. Identification System of Food Additives

Due the extensive range usage for food additives, a system of identifying coding was required; therefore e-numbers are utilized to facilitate simple identification and application. Based on the E-system, the Codex Alimentarious Commission created the International Numbering system (INS), which is more inclusive and meant for food additives that have received approval in one or more nations. The E system, minus the numerals, was adopted by the INS.

13. Principles of Using Food Additives

Food additives should only be used when necessary and shouldn't have any negative effects when consumed or used frequently. It is not appropriate to employ food additives to achieve any kind of technological or physical malfunction. Based on anticipated servings, the amount added should be as small as feasible and within safe bounds for people. It must maintain its nutritional content, not have any negative effects when consumed, and adhere to established norms and laws. Ad additives should be continuously regulated, even after approval. Labeling is required and needs to be listed with specific names or INS on the list of ingredients. Food labeling can assist consumers in avoiding particular food additives if they are sensitive to them.

14. Recent Developments and Trends in the Food Sector

The need for food additives in the food processing industry has grown dramatically as a result of customer preferences and the financial benefits they offer food goods, such as ease of processing, consistent quality, and extended shelf life. But food science and technology have advanced quickly in recent decades, which have resulted in an increase in the number and variety of food additives. The question of whether food additives are safe to use has become more and more contentious over time as a result of some damages involving threats to the public's health.

Despite all of these achievements, food manipulation has had a significant impact on the distinct biochemical equilibrium of our bodies. Notably, a number of food additives have been linked to unfavorable outcomes that raise questions about public health. Natural or artificial food additives have the same function or goal when used in food preparation. But some consumers of foods containing additives mostly synthetic food additives have reported allergies and unfavorable side effects, which have left them unhappy.

Several studies have linked some artificial food additives to a variety of health risks, including multiple sclerosis (MS), asthma, allergies, cancer, metabolic abnormalities, and attention deficit hyperactivity disorder (ADHD) in children. Inattention, impulsivity, and hyperactivity are the hallmarks of ADHD, which is thought to have a range of neurobehavioral symptoms and intensities [56]. Certain dietary additives cause hormonal imbalances that interfere with a child's natural growth and development by upsetting their endocrine system [57].

According to Agarwal and Rakhra [58], food additives can also interfere with the body's normal metabolic processes, resulting in hormonal imbalances, chemical reactions, and/or physiological responses that can cause brain damage, nausea, heart disease, and childhood obesity in addition to other health problems [59]. A child's growth and development may be stunted by some food additives and their metabolites because they block specific growth hormones [58]. While the majority of food additives that are sold commercially are thought to be harmless, some are known to be poisonous or carcinogenic. Knowing these compounds' characteristics is crucial to ensuring their safe application or restrictions because they are purposefully added to food [21]. Therefore, before being approved, food additives must undergo proper toxicity assessments or studies to rule out any potential negative effects [60].

Because it can bind to the estrogen receptor and cause the body to react as though there is estradiol present, BPA is categorized as an endocrine disruptor [61]. Human epidemiologic studies have demonstrated the association between BPA exposure and a range of endocrine-related consequences, such as altered puberty timing, decreased fertility, changes in mammary development, and neoplasia progression [62].

15. Bioinformatics in Food Sciences

Food is a vital component in controlling the body's numerous functions. As the "omics" era advances, bioinformatics has become increasingly integrated into many life sciences disciplines, including food sciences, as a result of its ability to computationally organize and interpret biological data. The field of bioinformatics has the potential to enhance the quality, flavor, and nutritional value of food production by providing efficient access to all genomes, proteomics, and metabolomics data that has been discovered thus far. This data may then be made available to any industry, group, or company [63].

Food additives are thought to be the driving forces and cornerstones of the contemporary food industry, having an impact on the entire food production, processing, and storage process. In response to the urgent need for a comprehensive curation of food additives, including their molecular structures, biological activities, and precise toxicity ratings, the Additive Chem database (http://www.rxnfinder.org/additivechem/) was developed in response to the pressing need for a thorough curation of food additives, including their molecular structures, biological activities, and accurate toxicity evaluations. In order to create an effective search platform for in silico preliminary evaluations, this database has carefully selected over 9064 different types of food additives, along with information about their molecular structure, chemical and physical properties, absorption, distribution, metabolism, excretion, and toxicity properties, as well as usage specifications, toxicological and risk assessment data, and targets in the human body from 16 databases. An investigation of the connection between the structure and function of food additives will be made possible by the Additive Chem database [64].

The multidisciplinary field of bioinformatics has gained recognition as a significant scientific field. It introduces a paradigm change in a number of fields, such as biotechnology, drug discovery, microbial genome applications, comparative genomics, molecular medicine, and molecular evolution [65]. Although this topic has received less attention, many bioinformatics methodologies have acknowledged the potential for a significant contribution to food sciences.

In order to meet the needs of food production, food processing, enhancing the quality and nutritional content of food sources, and many other areas, bioinformatics plays a significant role in forecasting and evaluating the intended and undesired impacts of microorganisms on food, genomes, and proteomics research. Furthermore, bioinformatics techniques can be applied to produce crops with high yields and disease resistance, among other desirable qualities. Additionally, there are numerous databases with information on food, including its components, nutritional value, chemistry, and biology [63].

To guarantee food additives are used safely, a number of organizations carry out safety evaluations. The abundance of food additives has made in silico early analyses and virtual screening based on massive data sets of food additive molecular structure suitable techniques. Computational prediction algorithms are able to anticipate the possibility for each food additive to interact with and change the biological activity of its selected targets, assuming a human target and utilizing a molecular data set of food additives. Following initial in silico filtering, food additives that are recognized as possible binders or as active substances in other ways can undergo additional in vitro testing for functional investigations or more thorough risk assessments [66-68].

16. Bioinformatics Tools to Understand Human Diseases

Identifying connections between diseases broadens our knowledge of disease biology and facilitates the search for common mechanisms or the creation of novel treatments, such as medication repurposing. Thus, discovering new connections among illnesses is highly intriguing from a biology and pharmacological standpoint. In the past, diseases were classified according to their origin, symptoms, or the area of the body they impact [69]. However, the emergence of innovative bioinformatics tools has made it possible to quantify and associate diseases in a variety of new ways. A deeper understanding of disease at the molecular level is made possible, in particular, by (-omics) data, which link diseases through pathways [69]**,** gene expression [70], protein interaction networks [71], disease-associated genes [72, 73], and biological processes [74].

Within the field of research, bioinformatics has emerged as a vital instrument for managing and producing information. The application of computer science (informatics) to molecular biology is known as bioinformatics. Biomedical informatics, or informatics applied to health challenges, is closely related to bioinformatics [75]. Bioinformatics can be used to map sequences to databases [76], generate molecular interaction models [77], assess structural compatibility [78], identify conservation motifs in protein structure [75], and find differences between host and pathogen DNA [79]. Furthermore, bioinformatics offers a fresh approach to deepen our understanding of diseases, establish a connection between genotypes and phenotypes, clarify the etiology of polygenetic diseases, and pinpoint new treatment targets. Utilizing information from databases and analyzing information with data mining methods are the two main subfields of bioinformatics.

The analysis of next-generation sequencing (NGS) data using bioinformatics tools and methodologies is becoming more and more common in the diagnosis and surveillance of infectious illnesses. A review of the use of NGS data, widely used databases, and bioinformatics tools in clinical microbiology is interesting, with particular attention to molecular identification, genotyping, microbiome research, analysis of antibiotic resistance, and identification of pathogens associated with unknown diseases in clinical specimens [80].

It can also concentrate on the links inside a particular disease by using the disease map. We analyze psoriasis and associated illnesses as a case study, as they comprise a highly interconnected area on the map. According to Boehncke and Schön [81], psoriasis is categorized as a skin condition in Disease Ontology, but it is also known to contain immunological and genetic components. This is illustrated by the disease map (Figure 7), which connects psoriasis to a variety of autoimmune disorders in addition to other skin conditions. Examples of these disorders include Crohn's disease (CD) and ulcerative colitis (UC), two inflammatory bowel diseases. It's interesting to note that these situations are known to co-occur to some extent [82]. Interleukin family genes IL12B and IL23R, involved in cytokine-mediated immune response, STAT3, which is activated by the shared interleukin IL6 to produce inflammatory T-cells [83], and (in psoriasis and UC) human leukocyte antigen HLA-B, which also plays an important role in the immune system, are among the genetic associations shared by UC, CD, and psoriasis. A number of genes, including those that are upregulated in the pro-inflammatory S100 family (S100A8, S100A9) and the CXC chemokines CXCL8, CXCL9, and CXCL10 (linked to immune system activation), are dysregulated in psoriasis, CD, and UC. Significantly, some of these commonalities relate to the medications used to treat these conditions: according to Park and Jeen [84], the monoclonal antibodies infliximab and adalimumab are TNF antagonists, and these antibodies' corresponding gene variations are linked to a variety of conditions, including psoriasis, UC, and CD.

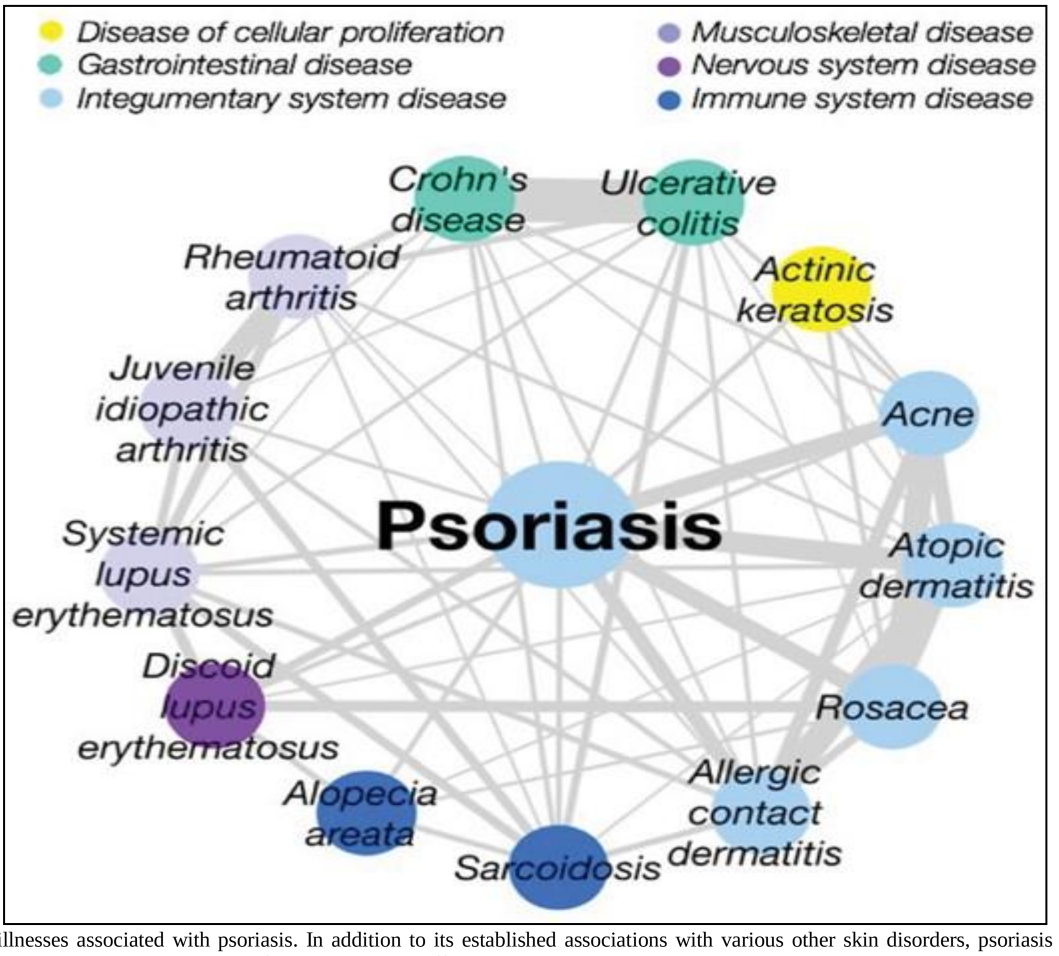

Figure-7. illnesses associated with psoriasis. In addition to its established associations with various other skin disorders, psoriasis also shares genetic characteristics with a number of phenotypically different autoimmune diseases, including lupus, alopecia, and arthritis, as well as inflammatory bowel disorders that can be treated with medication. This collection of illnesses is highly interconnected, making it one of the network's densestly connected regions.

17. Conclusion

Certain food additives, such as sugar, salt, spices, vinegar, and sulfites, have been employed as preserving agents since ancient times. However, the use of preservatives and chemicals is crucial when food is to be kept in storage for an extended length of time in order to preserve its flavor and quality and stop bacteria become distinctive elements of the dish. For a variety of reasons, a large number of individuals consume prepared foods from the market, which may include additives and preservatives of some form. Regulations on food labeling have been put in place to make sure that customers are aware of the ingredients in processed meals so they can make informed decisions.

Numerous health hazards, including allergies, asthma, cancer, irritable bowel syndrome, mood swings, skin irritations or responses, constipation, migraines, autism, sleep disturbances, and nasal congestion, have been linked to food additives. This means that even while the use of food additives in industry is unavoidable because to their low cost, low calorie content, low tailor-made foods, and long shelf life, more study and stringent regulations are needed. For these reasons, in order to prevent negative impacts, food safety monitoring authorities operating under the auspices of the World Health Organization (WHO) should constantly oversee and direct the regulation and supervision of national and international health authorities. Whenever possible, switching to organic foods has been a long-term method to halt or reverse these impacts. But without the means to organize, mine, and produce hypothesis-based laboratory research, all this data would be useless. Bioinformatics has emerged as a vital instrument for managing and producing data in the scientific domain. The application of computer science (informatics) to molecular biology is known as bioinformatics. Biomedical informatics, or informatics applied to health challenges, is closely related to bioinformatics.

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