

What are Food Additives?

The pursuit of happiness through the enjoyment of food is a centuries old human endeavor. Taste, texture, freshness and eye appeal are major contributors to such enjoyment, made possible in our modern lifestyle through the use of highly specialized ingredients known as food additives.

The broadest practical definition of a food additive is any substance that becomes part of a food product either directly or indirectly during some phase of processing, storage or packaging. Direct food additives, which are discussed in this publication, are those that have intentionally been included for a functional purpose by the food processor, whereas indirect additives are those migrating into food products in very small quantities as a result of growing, processing or packaging.



Food additives afford us the convenience and enjoyment of a wide variety of appetizing, nutritious, fresh, and palatable foods. Their quantities in food are small, yet their impact is great. Without additives, we would be unfortunately lacking in the abundant and varied foods that we enjoy today.

Food Additives – Ingredients with a Purpose

Direct food additives serve four major purposes in our foods:

1. **To provide nutrition** – to improve or maintain the nutritional quality of food. For example, the addition of iodine to salt has contributed to the virtual elimination of simple goiter. The addition of Vitamin D to milk and other dairy products has accomplished the same thing with respect to rickets. Niacin in bread, cornmeal and cereals has helped eliminate pellagra, a disease characterized by central nervous system and skin disorders. Other nutritional food additives (such as thiamine and iron) are used for further fortification in the diet and as a result, diseases due to nutritional deficiencies, common in lesser developed countries, are now very rare in the United States.
2. **To maintain product quality and freshness** – fresh foods do not stay that way for long periods of time; they rapidly deteriorate, turn rancid and spoil. Food additives delay significantly this deterioration and prevent spoilage caused by growth of microorganisms, bacteria and yeast and also by oxidation (oxygen in air coming into contact with the foods). For example, if you were to cut slices of fresh fruits such as apples, bananas or pears, they would rapidly turn brown as a result of this oxidation process. However, placing these slices in juice from lemons, limes or oranges can stop this process. Food processors do the same thing by using ascorbic acid – the principal active ingredient in citrus juice – when packaging fruit slices. Propionates, which naturally occur in cheese, are used similarly in bakery goods to prevent the growth of molds.

3. **To aid in the processing and preparation of foods** – additives impart and/or maintain certain desirable qualities associated with various foods. For example, we expect salad dressings to stay mixed once they have been shaken. Emulsifiers such as lecithin from soybeans maintain mixture and improve texture in dressings and other foods. They are used in ice cream where smoothness is desired, in breads to increase volume and impart fine grain quality, and in cake mixes to achieve better consistency. Pectin, derived from citrus peels and used in jellies and preserves when thickening is desired, belongs in the category of stabilizers and thickeners. Leaveners used to make breads, biscuits and rolls rise, include yeast, baking powder and baking soda. Humectants, like sorbitol that naturally occurs in apples, are used when moisture retention is necessary, such as in the packaging of shredded coconut.
4. **To make foods appealing** – the majority of food additives are most often used for this purpose. Unless foods look appetizing and appeal to our senses, they will most likely go uneaten and valuable nutrients will be lost. Food additives such as flavoring agents and enhancers, coloring agents and sweeteners are included by food processors because we demand foods that look and taste good.



There are many other food additives than those listed here (over 2300, in fact). However, most of them fall into the four functional classes described.

Technology and Food Additives – A History of Improvement

The use of food additives is not a modern-day invention. The practice probably started when man first discovered that fire would cook and thereby preserve his meat. Later he realized that the addition of salt would preserve without cooking. In ancient times, cloves were placed in hams to inhibit the growth of bacteria; the Egyptians used food colors and seasonings, spices, flavors and condiments were considered so valuable as to serve as items of trade and, at times, objects of war. The worth of spices during the Middle Ages was measured in livestock and even, in some instances, in human lives. The search for spices was the driving force behind many explorations including those of Columbus who was seeking the spices of India when he discovered America.

But food additives were not an integral part of the Spartan life most Americans lived in the late 1700's: a rural, farm-type existence with each family growing and eating its own foods. This lifestyle was one that exemplified immediacy - most of the work done on a farm revolved around food (planting, cultivating, harvesting, etc.) and when it came time to sit down for a meal, the food on the table came right from the field. One ate what was available, what was in season, and what was fresh at that moment. Not too many items found their way to "tomorrow's table."

As the United States moved from the late 1800's into the 20th century, sweeping changes took place throughout the country as Americans moved from a rural environment to a more industrialized society. Advances in farm mechanization and specialization, cross-country transportation systems, the advent of canning, and later the development of refrigeration, all had an impact on increasing this country's food productivity to levels unheard of in previous times. At

the same time, America was demanding more from her food supply, including increased availability and uniform quality.

As the 20th century progressed, the public's demands for foods of high quality and convenience increased and could only be met by reasonably priced, packaged food. It is a result of the consumer demand that food additives have found their present place in our food supply. Technology has been able to meet demands that today we think of as imperative – variability, accessibility, freshness, palatability, uniformity – qualities that simply did not exist hundreds of years ago for even the richest, but are available for all today in the nearest supermarket.

Industry continues to satisfy consumer demands as we advance technologically. With an ever-increasing portion of our population employed in the working world, these qualities take on further importance, as we require high-quality, readily available foods.

Composition of Food Additives

With well over 2300 food additives currently approved for use, it would be staggering to list the components of each of these substances. However, every additive – like every food we consume – no matter what its source or intended purpose, is composed of chemicals. Everything, including the clothes we wear, the cars we drive, the foods we eat, even our own bodies, is made up of chemicals.



There is much discussion regarding “natural” and “synthetic” chemicals. Many of those synthesized in the laboratory are also found naturally-occurring in foods. Chemicals are chemicals; the distinction between a “natural” and “synthetic” chemical is itself artificial. The molecular structure of each is exactly the same and the human body does not discriminate based upon the source. For example, sugar found in sugarcane (sucrose) is no different in composition and function than refined sugar. Monosodium glutamate or MSG (a food additive used for its flavor enhancing qualities) and glutamate (a naturally-occurring amino acid found in many foods such as mushrooms and tomatoes) are metabolized by the body using the same normal biochemical pathways of digestion. The Vitamin C (ascorbic acid) found in an orange is the same as ascorbic acid added to canned and frozen food. Similarly, citric acid produced commercially by enzymatic fermentation, is the same naturally-occurring chemical that makes lemons tart. To say one chemical is safer than another because of its origin simply does not make sense.

Consumption of Food Additives

With the ready availability of thousands of food additives, one would naturally wonder to what extent they appear in our food supply. We have already discussed the impact advanced technology has had on increased use of food additives and we are also aware of their beneficial use in our food supply. However, an important question is in what quantity these additives are to be found in our foods.

In 1979 the United States Department of Agriculture (USDA) determined that each person consumed about three quarters of a ton of food each year (1463 pounds). Sugars and salt made up about 9% of that amount and all other additives contributed less than 1%. USDA no longer

provides data on food additive consumption. If one were to increase the amount of food consumed in 1979 by one-third, however, the consumption of food additives other than sugar and salt, but including black pepper, yeast, baking soda, citric acid, and mustard, would be about 14 pounds per year, or a little over half an ounce per day.

While food additives offer a major contribution to the palatability and appeal of a wide variety of foods, their levels of use are relatively insignificant to our total diet. This is because they are used in the lowest possible quantity necessary to achieve the desired effect.

Labeling

Federal government regulations generally require that all food ingredients, including direct additives, be listed on the package label by their common names in order of weight. Nutrition information is also required. The Nutrition Facts Panel on the food label includes content information on calories, fat, sodium, carbohydrates, protein, vitamins and minerals while the ingredient statement lists the product's ingredients in order of predominance by weight.



An exception to the FDA's labeling requirements relates to "standardized" foods – a number of very common foods – for which the FDA specifies ingredients. For example, to be "macaroni" a product must contain water and certain flours. While these required ingredients do not have to be listed on the label, food additives permitted in these "standardized" foods will be listed on the label.

Food Additive Safety

The question of food additive safety is one that has received widespread attention in recent years. While literally thousands of studies, conducted throughout the world, attest to the overall safety of additives as they are used in the food supply, it is important to understand the relativity of safety and be careful when using the words "toxic," "harmful" and "safe." Any substance whatsoever has the potential for being harmful. The controlling factor in determining the safety of substances in our diet is quantity. Anything consumed in excessive amounts will be toxic, even those substances with which we are most familiar and in daily contact. There are no exceptions; anything from vitamins to water, if consumed in large enough quantities, will cause illness, and sometimes fatal effects. The age-old adage, "solo dosis facit venenum" or "Only the dose makes the poison" is well worth noting here.

The Toxic Substances Strategy Committee (members include representatives from all federal agencies with programs relating to potentially hazardous chemicals) in its May 1980 report discussed the topic of toxicity as follows:

“ 'Toxic' is a relative term. The effects of any chemical substance or mixture depend not only on its composition and basic properties, but also on dosage, route and conditions of exposure, susceptibility of the organism exposed and other factors. It is not possible to categorize all chemical substances as 'toxic' or 'non-toxic' although some are more toxic than others during normal conditions of use and exposure and some are generally innocuous.”

One advantage of the wide variety of products available in our current food supply is that we can eat well-balanced, diverse foods. Besides being appetizing and appealing to our senses, this

diversity affords us the opportunity of avoiding excess consumption of any one particular food, or food additive. This is an important point since it is the “dose” or quantity of an item consumed that impacts on safety. There are those who encourage us to eat only “natural” not “processed” food or “synthetic” food ingredients. Consider, however, the toxins that appear in the following “natural” foods, which, *in quantities typically found in the diet, are routinely handled by the body without harm:*

“Natural Toxins in Food”		
Food	Toxin	Potential Reactions from Concentrated Non-Dietary Doses
Potatoes	Solanine*	Interferes with transmission of nerve impulses
Spinach	Oxalic acid	Imbeds in mucous membranes of throat, causes swelling. Interferes with calcium metabolism
Lima beans	Hydrogen cyanide	Results in difficulty in breathing, discoloration of skin, eventual death
Peanuts	Aflatoxin**	Most potent liver carcinogen known
Carrots	Myristicin Carotatoxin	Hallucinogenic nerve poison Neurotoxin
*Average per capita human consumption of potatoes is 119 lbs. per year. This amount contains 9700 mg. of solanine - a single dose injection of which would kill a horse.		
**Aflatoxin is produced from molds, which may grow on the peanut. However, at the very low levels sometimes present on peanuts, aflatoxin is not harmful to humans.		

Again, the important thing to remember when reviewing these substances is the quantity we consume in our daily diet. Certainly, potatoes and carrots will continue to remain part of our diet and there is no need to restrict our intake of these and other generally used foods and food additives since our widely varied diet nearly rules out the possibility of “too much.”

As a result of the demand for quality and convenience placed upon the food industry over the last 50 years, there has been a significant increase in the use of additives in our food supply. Although some charge additives are harmful, it is interesting to note that the growth in food additive use in concurrent, perhaps coincidentally, with a major increase in the average life expectancy rate during the same time span. In fact, from 1940 to 2005 the average life expectancy in the United States increased nearly 15 years (from 63.6 to 77.9 years) while the total age adjusted death rate decreased 45%. Americans are living longer and healthier lives; more so than at any time in the past.

Additive Review

Government and private industry have come a long way in achieving high standards for pure, unadulterated foods. A century ago, the standards simply did not exist in the United States for insuring even sanitary conditions in the handling of foodstuffs. Government became involved in cleaning up unsanitary factories when the public, becoming aware of the practices of meat

packing and slaughter houses, demanded action be taken to correct the atrocities revealed by Upton Sinclair's famous book, The Jungle. The initial legislative acts passed by Congress helped insure sanitary conditions and removal of adulterated and poisonous food from the marketplace. Since then it is illegal to conceal inferiority, or to mislead the consumer by untruthful labeling.



Following these initial laws (Pure Food and Drug Act and Meat Inspection Act of 1906 and the current, Food, Drug and Cosmetic Act of 1938), a number of amendments were adopted to cover situations created by advances in scientific evaluation. The Food Additives Amendment of 1958 (including the Delaney Clause) and the Color Additives Amendment of 1960 place the burden of proof of an additive's safety upon industry. The Delaney Clause states:

“That no additive shall be deemed to be safe if it is found to induce cancer when ingested by man or animal, or if it is found, after tests which are appropriate for the evaluation of the safety of food additives, to induce cancer in man or animal.”

In view of developments in scientific analysis since the Delaney Clause was adopted in 1958, there is now some controversy over the precise meaning of certain words such as “safe,” “appropriate” and “induce” in this amendment.

These amendments created three legal categories of additives: (1) those requiring governmental approval in order to be used (“food additives” and “color additives”); (2) those approved by the Government prior to 1958 (“prior-sanctioned” substances); and (3) those not requiring government approval (Generally Recognized As Safe – GRAS – substances). Each direct and indirect additive is classified into one of these legal categories.

Testing Methods

The ability to test for relative safety has progressed a long way since the early 1900's and Dr. Wiley's (then Chief Chemist, Department of Agriculture) “poison squad” – a group of twelve men who tested, by consumption, the safety of foods and food additives. Now both industry and government evaluate safety through comprehensive testing and accepted scientific procedures.



No longer do we base safety considerations on “poison squads” or only upon the safe and effective use of a substance over a long period of time.

For direct additives, the first step is for the manufacturer (and/or others seeking approval) to conduct a battery of tests and chemical analyses to determine that a substance does what it is intended to do, and that it can be measured accurately in minute quantities. These tests assure that the usage can be checked, and that unwanted manufacturing by-products are adequately removed.

A wide variety of animal tests are used to estimate the safety of a direct additive in the human diet. Because no animal is a perfect model, a number of different tests are used and the totality of scientific evidence must be evaluated and cautiously interpreted as to its relevance to man. Studies on metabolism, genetic toxicity, carcinogenicity and reproduction are among those required.

Then further animal testing is conducted on at least two different types of laboratory animals. Large doses over extended periods of time are administered to determine whether an additive may be harmful over a lifetime of use. While rats and mice are commonly used, often a non-rodent is also studied. In addition to animal research, “in vitro” – test tube – studies are conducted: however, their results, although useful, are difficult to interpret and extrapolate to man. Of course, adequate human studies, when available are most significant.

Detection of indirect additives and impurities has reached incredibly precise proportions allowing for identification of infinitesimally minute amounts of substances in foods. Just a few years ago the ability to test for one part per million concentration was considered quite a scientific feat, while now we can not only test for 1 part per million (1 ppm) but 1 part per billion (1 ppb) and even 1 part per trillion (1 ppt)! It is hard to envision the infinitesimally small quantities involved. For example, 1 ppt equals one grain of sugar in an Olympic-sized swimming pool.



The reason for developing such refined methods of testing is to be able to determine margins of safety. As discussed earlier, the quantity consumed is the important factor in determining a potential hazard of any food substance. Therefore, if we know a substance may be hazardous at a particular dose and can determine the quantity of use to achieve the desired effect, we can regulate its presence at that level. This avoids the possibility of risk due to excessive amounts.

While we now know that many foods and food additives may contain potentially toxic substances, we can also determine they do not contain enough to produce harmful effects in typical preparation and ordinary, even exaggerated, consumption. Increasing attention is now being given to chemical substances occurring naturally in foods, in an effort to further evaluate the safety of our food supply. It is interesting to consider that the unknowns regarding the toxic potential of our naturally-occurring food substances seem more numerous and extensive than those related to food additives.

Additive Approval Process

The testing required for a new additive petitioned for use in the marketplace is extremely detailed and rigorous. The approval process takes many years to complete and requires the expenditure of millions of dollars by the manufacturer and food processors for technical and safety evaluation. Again, the burden of proof of safety is incumbent upon industry and it is the industry – not the federal taxpayer – dollar that goes toward this approval process.

The procedure begins when a person interested in an additive (the additive manufacturer or the additive user) submits the results of functionality and animal feeding studies to the FDA for review to decide if the additive is safe. Then a public notice is published by the FDA announcing the name of the additive and its proposed use. If after reviewing the data, FDA feels there remains an issue of risk, further testing may be required. If FDA concludes that an additive will be safe for its proposed use, a regulation permitting its use will be issued. This regulation may specify the amount of the substance that may be present in or on the foods, the foods in which it is permitted, the manner of use and any special labeling required.

A common rule used by FDA in determining levels of use is the “Philosophy of the Minimum.” First, the FDA determines the lowest limit at which a substance will produce its desired effect and also the maximum level at which it does not produce harmful effects, and it then requires the use level of the additive to be no more than 1/100th of the “no effect” level of safety. Therefore, generally, there is a minimum 100-fold margin of safety imposed on the additive.

Food Additives for a Better Food Supply

In looking toward the future, increases in population will have a tremendous effect on the world’s food supply. There is much discussion regarding advances that must be made in order to meeting this growing demand. Food additives are making a major contribution to the goal of assuring a better supply of food through increased food production, improved nutritional quality, improved packaging, preservation, and distribution techniques, and replacement of dwindling supplies of natural resources.

Food additives are largely responsible for the food supply to which we have grown accustomed. The consumer demands placed on technology have resulted in the development of additives that afford us abundant, convenient, nutritious, appetizing and economical foods. While the levels of use of food additives compared to our total diet are minor, their contributions have proven to be major.