Rancidity and Antioxidants

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Types of Rancidity

The term "rancidity" is used to describe two entirely different processes:

- **Oxidative rancidity** is a condition caused by fat oxidation
- **Hydrolytic rancidity** is a condition caused by fat hydrolysis

Oxidative rancidity of fats such as lard, shortenings, salad and cooking oils refers to the undesirable odors and flavors which develop when such products are exposed to the oxygen in the air. Products containing these fats, including but not limited to food products such as fish, poultry, meat, frozen vegetables and dry milk can become rancid as the fats in the products react to air. The poly-unsaturated fatty acid portions of these foods react with oxygen to form peroxides. The peroxides decompose to yield a complex of mixtures, including aldehydes, ketones, and other volatile products. These products are responsible for "rancid" odors and flavors. It is important to note that fish contain highly unsaturated (poly-unsaturated and mono-unsaturated) fatty acids which make some fish products particularly susceptible to oxidative deterioration. Highly saturated products, such as butter, are not as prone to oxidative rancidity due to the absence of poly-unsaturated fatty acid compounds. These products also tend to be more solid at room temperature.

Hydrolytic rancidity refers to the odor that develops when triglycerides are hydrolyzed and free fatty acids are released. This reaction of lipid with water sometimes requires a catalyst but results in the formation of free fatty acids and salts from free fatty acids (soaps). In particular, short chain fatty acids, such as common butter fats, are odorous.

Rancidity in foods may be very slight, indicated by a loss of freshness to very severe, indicated by objectionable odors and/or flavors. Slight degrees of rancidity are much more common in foods than severe rancidity, yet slight rancidity is a much more a practical concern. A slight degree of rancidity may not be objectionable to consumers, but products which do not seem fresh will not attract repeat purchases. If customers do not return to a product, the long-term effects of a slight degree of rancidity can be very serious.

Even though meat is held under refrigeration or in a frozen state, the poly-unsaturated fat will continue to oxidize and slowly become rancid. The fat oxidation process, potentially resulting in rancidity, begins immediately after the animal is slaughtered and the muscle, intra-muscular, inter-muscular and surface fat becomes exposed to oxygen of the air. This chemical process continues during frozen storage, though more slowly at lower temperatures. Airtight packaging will slow rancidity development.

Factors Influencing Fat Oxidation

Temperature. The rate of fat oxidation is highly dependent on temperature. Considerable improvement in storage stability can therefore be gained by lowering the storage temperature. As an example, it has been found that the storage time for frozen raw, lean meat can be extended approximately by 3 times by lowering the temperature from 5 to -13°F (-15 to -25°C). Temperature fluctuations during storage should also be minimized.

Oxygen. Oxygen in the air may be displaced by an inert gas such as nitrogen or carbon dioxide to retard oxidative rancidity, or the products may be packed under vacuum. These methods require the use of packaging materials with low oxygen permeability.

Type of fat. In general, the softer the fat, the more unsaturated are the fatty acids and the more susceptible they are to oxidation and oxidative rancidity. However, vegetable fats, although unsaturated, are usually more stable than animal fats because they contain natural antioxidants. The most common antioxidant found in vegetable fats is vitamin E. Coconut oil is more saturated and, therefore, more stable than most other vegetable oils. Fish oils are highly unsaturated, and therefore more susceptible to oxidative rancidity and off odors and flavors. The process of Hydrogenation, which involves the addition of hydrogen to unsaturated bonds, effectively hardens fat and increases its saturation, therefore providing additional resistance to oxidation.

It is important to note that the susceptibility to oxidation of a product may be dependent on factors other than the degree of un-saturation of the fat. One important factor influencing oxidation, other than level of saturation, is the possibility for contact between the fat and pro-oxidants, antioxidants, or oxygen. For this reason, ground or minced flesh products are less stable than whole flesh products, since the muscle surface area has been increased through mincing or grinding, and oxygen has been mixed throughout the product as part of the mechanical process. This is why further processed products may be more prone to oxidative rancidity than whole-muscle cuts.

Light. Packages that exclude light can be used to protect the products against fat oxidation.

Metals. Metals such as copper, iron, manganese, and chromium increase the rate of fat oxidation. As a result, the preferred storage containers are steel drums, tin, or nonmetallic materials such as plastic. Stainless steel is commonly used in processing plants to avoid excessive contact with metals that increase fat oxidation. It is important to note that water with trace metal is often a cause of rancidity in food products.

Products from fat oxidation. Traces of oxidized fat in ingredients can accelerate oxidative rancidity in the remainder of the products. Blending oxidized products with unoxidized products is not recommended. Steam treatment under vacuum conditions has been effective in removing products of deterioration (odorous substances) from some oils and fats.

Antioxidants

Food antioxidants are compounds that increase the resistance of fats to oxidation and consequent deterioration or rancidity. Only specifically approved antioxidants can be added to lard, tallow, and other foods susceptible to rancidity. In the United States, authorization of antioxidants for use in meat products is a responsibility of the Food Safety Inspection Service (FSIS) of the United States Department of Agriculture (USDA). Antioxidants used in dairy products, salad dressings and oils are regulated by the Food and Color Additives Division of the U.S. Food and Drug Administration (FDA). Antioxidant inclusion is restricted to specific limits and must be declared on product labels. Some of the approved antioxidants are butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), propyl gallate, and tocopherols.

These primary antioxidants are often used in combination with citric or phosphoric acid. Use of one or more of the primary antioxidants in combination with one of the acids is common because combinations are much more effective than single antioxidants. Many food grade combinations are possible. It is important to note that antioxidants cannot be expected to stop rancidity. Their effectiveness lies only in slowing down the rate of oxidation and varies with the antioxidant combination used and with the food product to be protected.

Natural antioxidants, such as those contained in some spices, such as rosemary, sage, and marjoram, have met acceptance for the retardation of rancidity in meat products. These and other natural antioxidants not only retard the warmed-over flavor (WOF) in precooked meat products but provide an agreeable aromatic aroma and flavor. Some spice extracts, particularly rosemary, are prepared primarily for their antioxidant activity and do not include strong flavor components.

Natural antioxidants from fruit products, including but not limited to pear and plum extracts, have also been shown to effectively reduce oxidative rancidity in ground meat products while providing additional sources of nutrients and flavor.

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