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Commentary

Development of Aldehydes from Lipid Oxidation

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DESCRIPTION

Lipids in food are a source of vital fatty acids and are also important in the production of flavour and off flavours. Autoxidation, photooxidation, and enzymatic oxidation are the main methods used to break down lipids, and they all result in the production of a variety of volatile compounds. Unsaturated fatty acid oxidation results in hydroperoxides, which later decompose into odor-active secondary lipid oxidation products such aldehydes, alcohols, and ketones. In addition to providing food energy, texture, and mouthfeel, lipids also contribute significantly to the development of the odour and flavour of food. Lipids are responsible for both the good and disagreeable flavours of food; lipid oxidation primarily causes the creation of off-flavors and lipid-based volatiles formed from lipoxygenase, which are flavor-generating compounds. Food flavour is the result of interactions between scent, taste, and oral sensations; whereas taste is linked with non-volatile high-molecular-weight components, aroma is linked with predominantly volatile molecules.

Raw foods, especially meat, typically have a mild flavour and minimal odor, but this can alter during processing to a powerful flavour and perfume. For instance, cis-1,5-octadien-3-one (geranium-like), 4-ethyloctanoic acid (mutton-like), trans-4,5-epoxy-2-decenal (metallic), and trans-2,4-decadienal have all been implicated in the odorants of raw and cooked meat (deep-fried). Additionally, cooking clearly raised the Flavour Dilution (FD) factors of aroma compounds as 2-acetyl-1-pyrroline, 4-hydroxy-2,5-dimethyl-3(2H)-furanone, and 2-aminoacetophenone. Aquatic foods are a little unusual since they have a somewhat potent flavour when they are raw. This is brought on by the presence of amines, lipid-based volatile components produced by lipoxygenase, and the emergence of secondary oxidation products during the raw stage. However, due in part to their non-polar nature, lipids with low and high volatility has essentially no odour or taste, respectively.

Food lipid oxidation results in the loss of some bioactive substances and fat-soluble vitamins as well as the development of an off-flavor. Unsaturated fatty acid oxidation is a complicated process that can take place in the presence of oxygen, as well as through enzymatic (lipoxygenase) and non-enzymatic (autoxidation and photooxidation) routes. Light, heat, oxygen, photosensitizers, and transition metal ions (such Fe^{2+} and Cu^{2+}) catalyse lipid oxidation and the creation of off-flavor chemicals. When triplet oxygen ($^3O_2$) is present, autoxidation takes place while singlet oxygen ($^1O_2$) causes photooxidation. The formation of primary oxidation products during autoxidation, such as hydroperoxides, and their subsequent breakdown into volatile secondary lipid oxidation products, including ketones, alcohols, and aldehydes, are thought to be the key contributors to the emergence of an off-flavor. Polyunsaturated Fatty Acids (PUFAs) have several methylene-interrupted cis-double bonds, which make them extremely vulnerable to oxidation. For instance, fish lipids and edible oils are abundant in omega-3 fatty acids, while propanal and acrolein serve as reliable indicators for determining the level of oxidation. Hexanal is a reliable predictor of flavour deterioration, and meat and meat products are high in omega-6 fatty acids.

Lipid oxidation is an extremely complicated process that involves numerous reactions and yields a variety of chemicals. In general, fatty acids-primarily PUFAs-react with molecular oxygen to form primary oxidation products (hydroperoxides) through free radical processes. Although it is thought that these compounds have little effect on the production of odour and scent and are highly unstable due to a weak oxygen-oxygen link, they decompose quickly and produce a wide range of secondary constituents that are in charge of creating off-flavors. Since the overall perception of scent is primarily influenced by the olfactory threshold, concentration, and type of products, not all of these ingredients, however, contributes in the same way to the flavour profiles. Aldehydes appear to be the main flavor-developing chemicals among them because of their low odour threshold and larger concentration. The most prevalent aldehydes produced by lipid oxidation are Malondialdehyde (MDA), 4-hydroxy-2-alkenals, 2-alkenals, and n-alkanals. Thus, lipid oxidation can take place *via* a number of different mechanisms, including enzyme-catalyzed oxidation, autoxidation, photooxidation, thermal oxidation, and others. The very frequent lipid oxidation process known as autoxidation is brought on by an ongoing free-radical chain reaction. The fundamental distinction between the photo and enzymatic oxidation mechanisms is that hydroperoxides are produced during the start step of autoxidation.

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The formation of volatile components in different foods mostly depends on the compounds that make them up and how they react during processing. The Maillard reaction, lipid oxidation chemicals, and interactions between these compounds and the Maillard reaction are the main factors in the production of taste volatiles. Lipid oxidation is mostly caused by processing techniques like gradual cooking, whereas Maillard reaction products are produced during quick cooking. Thus, by comprehending the intricate mechanisms at play and including physiologically active substances, one can prevent the formation of off-taste and create a flavour that consumers would enjoy.