6 Oxidative pathways to the formation of off-flavours

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6.1 Introduction

Food oils and fats comprise mainly triglycerides, which are triesters of fatty acids and glycerol. In addition to triglycerides (neutral or simple lipids), they also contain minor components such as free fatty acids, mono- and diglycerides, phospholipids, cerebrosides, hydrocarbons, sterols, triterpene, alcohols, waxes, carotenoids, chlorophylls, naturally occurring antioxidants tocopherols (vitamin E), trace metals, etc. (Swern, 1979; Belitz and Grosch, 1987). The glycerophospholipids (also called phosphatides or gums) are classed as any lipid containing one phosphate and one or two fatty acids attached to the glycerol moiety. Lipids are generally soluble in organic solvents and only sparingly soluble in water. Normal processing (i.e. different stages of refining) of oils and fats removes almost all undesirable minor components such as coloured compounds, free fatty acids, trace metals, etc. but retains the major neutral lipids and most of the natural antioxidants tocopherols present in the oils (Hoffmann, 1989). Freshly refined and deodorised oils have bland flavours but develop unacceptable flavours on storage. In contrast to edible fats, low levels of a wide variety of lipid classes are present in milk and lean meats. Most fruits and vegetables contain only small amounts of simple and compound lipids.

With a few exceptions (e.g. milk, coconut and palm kernel oils, fish oils), the large proportion of fatty acids present (as esterified to glycerol) in oils and food lipids consists of palmitic (C16:0), stearic (C18:0), oleic (C18:1), linoleic (C18:2) and linolenic (C18:3) acids. Small amounts of branched-chain, cyclic, odd-numbered carbon atoms, hydroxy- and oxo-fatty acids are also present in certain edible fats. Fatty acids containing two or more double bonds are termed polyunsaturated fatty acids (PUFAs). Of the PUFAs, linoleic, linolenic, arachidonic, ecosapentaenoic, and docosahexaenoic containing respectively, two, three, four, five and six double bonds are important nutritionally. Linoleic and linolenic acids are essential because they cannot be synthesised by the body and must be provided in the diet. Most vegetable oils and nuts are the principal source of these essential fatty acids (EFAs). The PUFAs containing one or more methylene-interrupted double bonds in the cis configuration are very susceptible to oxidation with atmospheric oxygen (Kochhar, 1993).

In foodstuffs, deterioration of unsaturated lipids can be caused both by enzymic
Unsaturated fat or food lipid

Oxygen

Light, heat, pro-oxidants, certain enzymes (e.g. lipoxygenase)

Hydroperoxides

Breakdown

Secondary and tertiary products such as aldehydes, ketones, lactones, furanes, acids, alcohols, hydrocarbons, epoxides, etc., bringing about off-flavours and odours, destruction of essential fatty acids, browning reactions with proteins, etc.

Polymerisation (dark colour)
possibly toxic compounds

Oxidation of other food components leading to destruction of vitamins, pigments, flavour and aroma compounds, insolubilisation of proteins

Figure 6.1 Overall picture of lipid oxidation in foodstuffs.