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Review Article

# Fats and Oils: Effects of Processing and Its Oxidation

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**Abstract**

Fats and oils are soluble in organic solvents and insoluble in water and made up of fatty acids. Fatty acids can be saturated and unsaturated containing MUFA and PUFA which are good to health playing an important role in an individual's growth and development. Different processing methods are used for the fats and oils to improve its shelf life and nutritional quality. Factors like humidity, water, air, temperature and micro-organism can affect the stability of the oils and fats. The use of proper storage methods like air tight containers and suitable antioxidants can help to improve their storage life.

**Keywords:** Fats, oils, MUFA, PUFA, peroxide value, free fatty acids and heat treatment

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## Introduction

Lipids are wide variety of natural products including fatty acids and their derivatives soluble in organic solvents like benzene, hexane or chloroform [1]. Based on their physical properties at room temperature they are classified as oils and fats. Fats are solids at room temperature and are of two types, saturated fats are molecules with no double bonds and hydrogen bonds which are present in butter, milk, pork, beef. Trans fats were made through hydrogenation and mostly found in foods like French fries, burgers and vanaspati ghee. Oils are liquid at room temperature which is of two types mono unsaturated which contain double bond and tends to become solid when they are chilled found in olive and canola oil. Poly unsaturated oils more than one double bond found in soyabean, corn and sunflower oil [2].

## Brief history of findings

Cooking oils can be in liquid or solid state as with coconut and palm oils due to high amounts of saturated fat at room temperature. It can be of animal or plant origin and used in food preparation. They act as a medium which helps to transfer the heat, imparts flavour and texture to foods [3]. Different types of oils support growth of fungi and bacteria in the presence of moisture in such conditions lipolytic enzymes of oils were active and produce free fatty acid (FFA) content of less than 2.0% as such oils are not harmful for consumption [4].

Vegetable oil is the main dietary component in food consumption and is used in nearly all types of food preparations. The triglycerides are main component and serve as sources of fat which contains three fatty acids and one glycerol [5]. Deep frying is most common method where temperature ranges between 170º to 220ºC thereby causing physicochemical changes such as oxidation, hydrolysis, cyclization, and polymerization and eventually degradation of volatile compounds occurs [6]. During cooking, hydrolysis occurs when moist food is fried in hot oil which enhances acid value due to fatty acid production from triglycerides due to oxidation. Auto-oxidation occurs due to external temperatures or UV exposure [7].

Various factors influence quality of cooking oil during heating, includes aeration, temperature, duration of the heating, the type of oil, the saturation ratio of the oil, and the presence of a catalyst. The reused cooking oils produce acrolein due to breakdown of glycerol with an unpleasant smelling compound and visible fumes are produced which causes irritation to eyes and nasal passage. It also acts as an immunosuppressor thereby preventing generation of allergic reactions and increase the risk of cancers [8, 9].

Polyunsaturated fatty acids (PUFAs) are abundance in vegetable oils like sunflower oil that play an integral part in mitochondrial membranes [10]. The anti-atherogenic properties of PUFA can reduce serum cholesterol and triglycerides along with playing an important role in electron transport chain [11]. The docosahexaenoic acid (DHA) is usually synthesized by α-linolenic acid (ALA) found in soybeans, flax seeds, walnuts, and spinach [12]. γ-linolenic acid (GLA) inhibits tumours and cardiovascular diseases [13].

Diets rich in fats induces obesity leading to mediobasal hypothalamus (MBH) and can cause metabolic inflammation [14]. Saturated fatty acids when consumed in excess deposits in hypothalamus and the microglia of it is sensitive to saturated fats and causing inflammation in them leading to this progressive degeneration [15].

The repeated heating of oils reduces the viscosity, froth, smoke point and darkening of its colour occurs and becomes harmful for the consumption causes carcinogenic and mutagenic problems [16-18]. Consumption of reused oils results in variety of symptoms like reduced appetite, growth depression, diarrhoea, histological changes in tissues and even death [19]. Due to the presence of unsaturated bonds, PUFA's are more susceptible to oxidation which generates reactive oxygen species based on non-enzymatic and enzymatic oxidation [20].

Non-enzymatic oxidation includes auto-oxidation were free radicals produce lipid hydroperoxide which is a primary oxidation product that are further oxidized to ketones and malonaldehyde. PUFA's are sensitive to light undergoing oxidation when exposed to it [21].

The enzymatic oxidation includes cyclooxygenases (COXs), lipoxygenases (LOXs) and cytochromes P450 (CYPs) that oxidize PUFAs and generate various metabolites [22]. Phospholipases A2 is the major one which cleaves phospholipids resulting in free PUFAs and lysophospholipids [23]. In foods lipid peroxidation mainly depends on lipid composition, presence of prooxidants, antioxidants, oxygen levels, temperature, light and processing methods and their oxidation that results in the development of off-flavours in food products [24]. In humans, oxidation of fats causes various problems like carcinogenesis, free radical and mutagenic problems of genes and to avoid such oxidation co-supplementation with antioxidants like vitamin C and vitamin E may reduce autoxidation of PUFA's as shown in **Figure 1** [25].

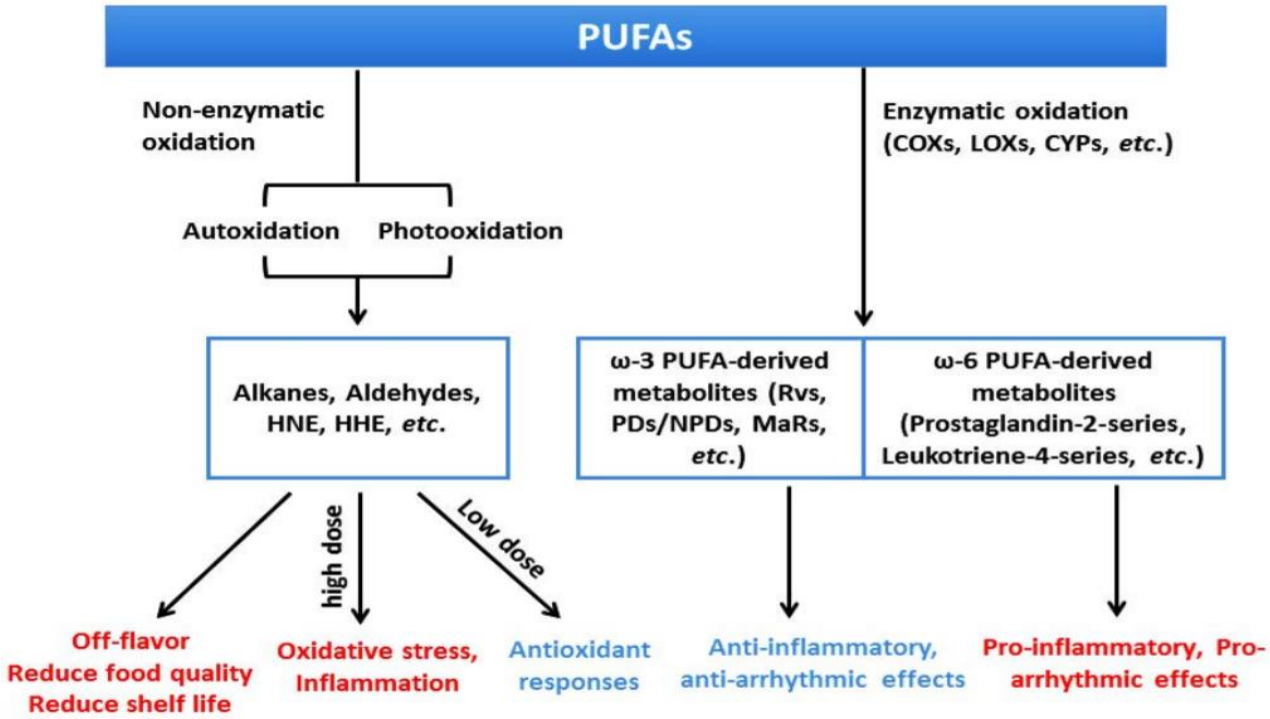


**Figure 1** Non enzymatic and enzymatic oxidation of PUFAs – Their effects

The oxidative changes in different types of oils like palm, soyabean and corn were observed at 150ºC for five rounds and the changes recorded. Thermal oxidation of oils occured when they were repeatedly subjected to heating process which is harmful for health [26]. The oxidation level can be determined by the presence of free fatty acids, peroxide value and fatty acid composition. Oils with higher unsaturation are more prone to oxidation and have negative effects. Palm oil showed high oxidative stability due to more saturated bonds than corn oil and followed by soyabean oil [27].

The oil deterioration was characterized by peroxide value and FFA as parameters. It was showed that the average time between production and consumption of unbranded cooking oil is three weeks. Cooking oil with a high initial peroxide value has a very short shelf life and quickly becomes unfit for human consumption [28]. The fortification of cooking oils can be done at lower peroxide levels that otherwise associated with health-related issues [29].

At elevated temperatures oils undergo many physical and chemical changes. Physical changes include increased viscosity, darkening of oil color, and increased foaming as frying time increases and smoke point decreases [30]. Oxidation stability of oil not only depends on the degree of unsaturation, but also on the antioxidant content present in it [31]. Smoke is an indication of chemical breakdown of fatty acids to glycerol and FFAs whereas oils with short chain fatty acids has low smoke point compared to long chain fatty acids. While cooking, the water and steam which comes from the food being cooked aids the process of hydrolysis resulting in degradation of oil quality [32].

Peroxide value is used to determine the amount of oxidation that takes place in frequently heated oils and usually repeated heating increased the peroxide value [33]. The oils heated repeatedly increased the amount of plasma cholesterol, triglycerides, LDL-cholesterol and VLDL-cholesterol as shown in **Figure 2** [34]. The consumption of heated oils increased the oxidization of cell membranes and oxidised ghee consumption increased lipid peroxidation of cells [35].

Oxidative stress and lipid peroxidation are the major reasons for pathogenesis of many diseases including hypertension [36]. The oxidative stress induced endothelial injury caused vasodilation by vascular reactivity due to nitric oxide and free radical [37].

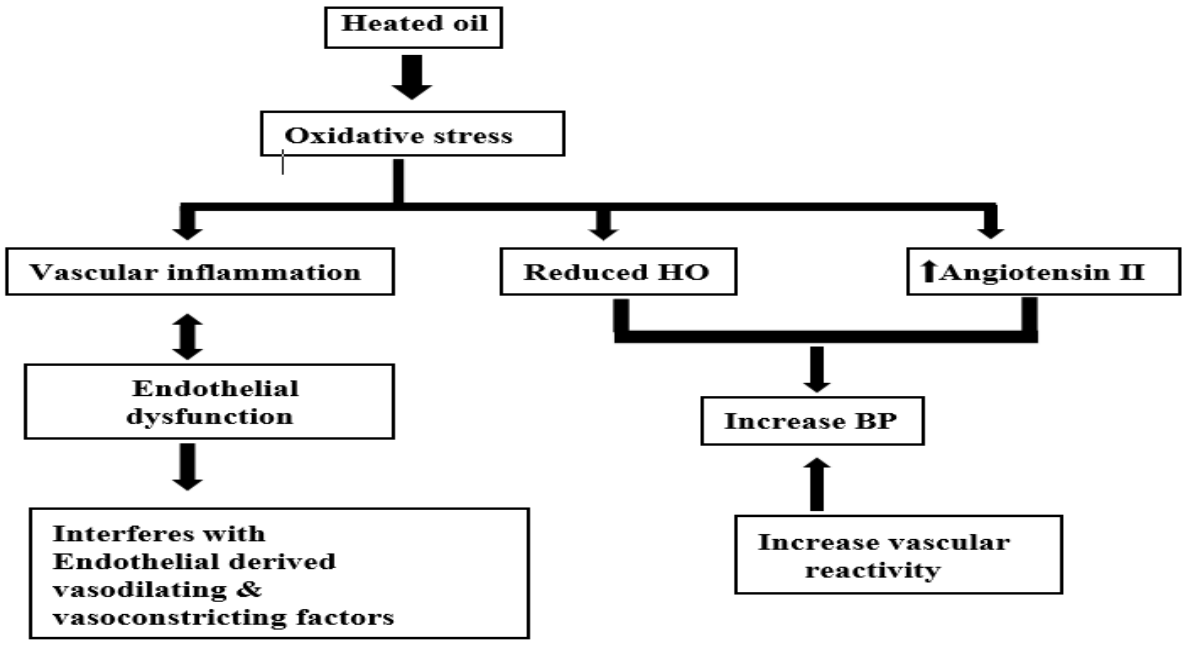


**Figure 2** Use of heated oils and oxidative stress in the body [38]

The repeated use of the fried oils can cause lung, breast, prostate and colorectal cancers because of somatic mutation involved in the formation of the atherosclerotic plaque [39].

## Future perspectives

Fortification of the oils can be done with the antioxidants so that the oxidation can be reduced and shelf life improved.

## Conclusion

In conclusion PUFA's are good sources of fatty acids which reduce the LDL levels in the body. They have important role in the body such as reducing the oxidative stress, and influencing the inflammatory cascade which helps in neuroprotection and cardiovascular protection. The repeated use of the oils can cause oxidation causing increased free fatty acids and peroxide. The increase of them makes the fats unfit for consumption as they have adverse effects on the humans like cardiovascular diseases, hypertension, microglial damage and obesity related problems. So, the repeated use of cooking oils should be avoided and awareness should be created though mass media and awareness campaigns.

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