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Lipid profile of foods fried in thermally polymerized palm oil

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Abstract

Lipids extracted from foods fried in thermally polymerized palm oil were evaluated in *papads,* French fries and fish fry (Bombay duck) with moisture content ranging between 10% and 75%, in an attempt to investigate the effect of moisture content on lipid quality indices such as free fatty acids, conjugated dienes, *p*-anisidine value, viscosity, total polar materials and colour values. The quality of lipids in products with high moisture content (50% or more) was found to be inferior to that of the oil left after frying, as evidenced in Bombay duck and French fries from potatoes with initial moisture content of 52–77%. A reverse trend was observed in *papads* and French fries prepared from dehydrated potatoes with moisture content of 12% or less. The results indicate the moisture content of food plays a definite role in the distribution of the lipid constituents during frying in thermally polymerized oil.

Keywords: French fries; Fish fry; *Papads*; Moisture; Lipid; Quality

1. Introduction

Fats and oils undergo deteriorative changes during deep fat frying such as oxidative, hydrolytic, and polymerization. These are influenced by the temperature of frying, and also by factors such as emulsifiers, trace metals, food scraps, free fatty acids and alkaline-reacting materials in the frying oil. Various compounds are released from the substrate into the frying oil, enhancing discoloration or formation of off-flavors. For instance, fatty fish release fat during frying so that the frying oil becomes contaminated with fish oil (Sanchez-Muniz, Viejo, & Medina, 1992). As fish oil is highly polyunsaturated, the frying oil contaminated with fish oil deteriorates rapidly. During frying of cabbage and other green vegetables, glucosinolates are decomposed, and their decomposition products, such as nitriles, indolyl derivatives or vinyl oxazolidinethione contaminate the frying oil (Rossell, 2001). Chlorophylls and their decomposition products (mainly pheophytins) have been reported to pass into the frying oil producing absorption peaks between 600 and 700 nm (Taha, Helmy, & El-Nokrashy, 1988). On the contrary, pigments present in frying oil may be adsorbed on the surface of the fried substrate.

Maillard browning products and their precursors are the major contributing substances to the discoloration of frying oil; lysine, γ-aminobutyric acid and glycine being the most potent precursors of brown pigments. The discoloration is highly pronounced in fish fried in used frying oil, as polyunsaturated fatty acids of fish oil participate in the formation of brown pigments (Pokorny, 1981). Vitamins, such as thiamin, pyridoxin, riboflavin and ascorbic acid decompose on heating, and some oil-soluble decomposition products dissolve in the frying oil, affecting colour and flavour, the decomposition being accelerated by contact with the oxidation products of the frying oil (Pokorny, 1998). Iron and copper salts released from the substrate during frying accelerate the oxidation of frying oil. Sodium and potassium ions are transported to the frying oil to form alkaline soaps, which in turn stimulate foaming. Foaming increases the interface between oil and air and further promotes oxidation (Blumenthal, Stockier, & Summers, 1985).

Mutagens formed during deep-frying of protein-rich foods belong to the polycyclic aromatic heterocycles of the aminoimidazo-azarene and amine-carbolin series (Hatch, Knize, & Felton, 1991). Creatine and creatinine

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are the most important precursors of these aromatic heterocyclic compounds. Maillard products react with creatinine, producing various imidazoquinolines and imidazoquinoxaline mutagens (Dahlqvisl, 1986). The production of mutagens is much lower in the absence of fat so that frying fat is important for their formation.

Oxidation by aerial oxygen is the most important deterioration reaction of frying oil, which is relatively rapid, especially in the case of polyunsaturated oils, such as soybean or sunflower oil. Free peroxyl radicals are unstable intermediates, and hydroperoxides, the primary oxidation products are rather unstable under frying conditions. They react with the substrate, particularly with thiol, sulphide disulphide, and primary amine groups of proteins, and partially remain attached to the protein moiety (Pokorny et al., 1988). Frying fat adsorbed on the surface of the substrate is generally more oxidized than frying oil as oxidized products are selectively adsorbed on protein molecules (Pokorny, 1998).

The extent of hydrolysis of oil triacylglycerols during deep-fat frying is influenced by the moisture from the substrate. When the food material, usually at room temperature, comes in contact with the frying oil preheated to 130–200 °C, the water within the substrate is almost immediately heated to boiling point. The steam so produced partially hydrolyzes the triacylglycerols into free fatty acids and partial glycerol esters (diacylglycerol, monoacylglycerol and even glycerol) in a relatively short period of about 5–10 min of deep fat-frying (Pokorny, 1998). In a study, addition of water to coconut or niger seed oil before frying was found to increase the formation of epoxy acids and stimulate the formation of free fatty acids during subsequent heating (Ramanna & Sen, 1983). The water evaporated was proportional to the square root of frying time, and the difference between the temperature of oil and boiling water (Ashkenazi, Mizrahi, & Berk, 1984). More than the other components, the water present in the substrate was found to greatly affect the quality of frying oil (Barbanti, Pizzirani, & Dalla Rosa, 1994).

The quality of oil in a fried product depends upon pyrolytic degradation of frying oil and interactions that take place within a product between degraded components of frying oil and free functional groups of the ingredients of a product. Assessment of the quality of frying oil and that picked up by the fried product is relevant from the nutritional point of view.

Food processors in unorganized sectors often continue to fry foods in heat-abused oils in batch processes without replenishing with fresh oils. Consumers do experience discomfort on consumption of such foods. However, such foods are poorly characterized. In the present investigation, three fried foods that are very popular in the Indian sub-continent *viz*. fried fish, *papads* and French fries that differ vastly in their composition and moisture content were selected. These were fried in heat-abused palm oil, and evaluated for the quality of the lipid extracted from the said foods, and that left behind in the fryer. Palm oil is used commonly for preparation of fried foods due to its availability and better stability than other vegetable oils and hence was used in this study.

2. Materials and methods

2.1. Oil samples

Heat-abused frying oil (palm oil used for continuous frying of legume-based snacks for 36 h at 170–180 °C without any fresh oil-makeup, and labeled as P36) was obtained from a local processor from a small-scale unorganized sector of Mumbai city.

2.2. Food samples

The raw materials, *papads,* potatoes and fish were obtained from a local market of Mumbai city. The products prepared were diced potato fingers for French fries of initial moisture content of 72.7%, which were dehydrated to 63.09%, 52.05% and 10.14%, respectively, fried *papads* (initial moisture content, 11.84%), and fish fry (Bombay Duck having an initial moisture content of 74.52%).

2.3. Frying of the selected foods

Raw *papads* were deep-fried in the frying oil. Potatoes were peeled, thin-sliced (0.95 cm wide, 4–5 cm long, straight-cut), and further dipped in 4% salt water to prevent browning. The slices were drained and divided into four portions, of which three portions were subjected to drying at 60 °C to achieve the required moisture levels as stated above, and one portion was air-dried at room temperature. All the four portions after the respective treatments were deep-fried. Fish (100 g) was cleaned, dipped in 150 ml of a 9% solution (comprising of 1% turmeric, 7% chilli powder, and 2% salt) for 10 s, well drained and deep-fried for 90 s.

For frying, 200 ml of oil were heated to smoke point (180 °C) and about 100 g of each of the materials were fried separately in P36 for times, as judged subjectively to be sufficient for completion of frying. The oil left behind in the fryer and the products were stored at −18 °C until further analysis.

2.4. Sampling procedures

Fifty grams of the products were cut into small pieces and macerated to obtain a uniform mass, which was dried in a hot air oven at 60 °C for 30 min and subjected to fat extraction. The extracted fat was stored at −18 °C until analysis.

2.5. Analytical methods

2.5.1. Total lipid content

Total lipid content of the fried food was determined by the Soxhlet extraction using petroleum ether (60–80 °C) as the solvent.