Super-oxidized soups and the health risks to poor South Africans

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POOR COMMUNITIES IN SOUTH AFRICA regularly ingest large quantities of highly oxidized abused fats also known as super-oxidized soups (SOS). These increase the level of oxidized lipids in human plasma and may result in additional stress on endogenous anti-oxidative agents, which, in turn, can reduce the immune system's ability to fight viral attack. Re-used fats and SOS smoke more easily than new, unused fats when heated, and the number of meals cooked by deep-frying and the frequency of smokiness during cooking has, in studies on Chinese women, been associated with the risk of contracting lung cancer. Extensive animal studies have shown that ingesting oxidized fats can cause oxidative stress and a variety of diseases. We recommend South African studies, therefore, to assess the risks to exposed local communities, especially in relation to HIV/AIDS and cancer.

Introduction

The poor health, especially related to HIV/AIDS,[1] of many South Africans makes it imperative to minimize exposure to harmful substances. Of concern is the widespread practice by frying establishments of distributing such substances to poor South African communities in the form of large quantities of heavily oxidized edible fat waste (called super-oxidized soups or SOS). More than 100 000 tons of unstable oxidized fats and SOS (the highest levels ever recorded) is estimated to be consumed annually by these communities.

As the global demand for fast foods[2] and, consequently, for vegetable fats increased (especially since the early 1980s),[3] so did the amounts of oxidized unstable used fat and SOS distributed to impoverished South Africans. In a first survey of its kind that we conducted in this country in 1994, we found that most frying establishments habitually distributed their unstable, used, and often SOS waste to the poor for re-use in frying food.[4-6] (This fat waste contrasts with the high-quality frying fats used in developed countries.) Such establishments were ignorant of the health-related dangers,[7] as there were no regulations or available information about fat abuse in the country before 1995.[5]

This widespread malpractice and the resulting dark, overused unstable fats nicknamed 'fish oils' (due to their fish-like taste deriving from repeated frying of fish) — became part of everyday life for the poor. The health risk is not limited to people ingesting food that has been fried in these unstable fats but may also compromise the health of those who inhale volatile, potentially harmful compounds readily liberated from these fats when heated.

By 1994, many countries had regulations in force to ensure that fats remain free of these potentially harmful products. They prohibited the use of fats containing around 25% total breakdown products (also known as polar compounds) or 16% polymers (that is, more or less equivalent to 25% total breakdown products). No such regulations existed at that time, however, in any African country.[8,9]

This situation changed when South Africa introduced regulations on 16 August 1996,[10] but extensive surveys conducted by our team show that many frying establishments still use SOS in frying processes, and unstable fats, frequently containing breakdown products far above the regulatory limits, are still being distributed by these businesses to the uninformed poor for re-use in food preparation.[10]

The literature reveals that some South African frying establishments abuse fats up to levels unheard of elsewhere in the world,[11] and that their products can contain as much as 75% polymers. (This figure contrasts dramatically with 1996 survey results from northeastern Australia, in which Somerset *et al.* highlight two samples containing what were regarded as unacceptably high levels of 26.6% and 28.7% total breakdown compounds.[10,12])

Fat breakdown

New unused fats contain mainly triacylglycerols (approximately 98%). When heated, the fats start to break down, producing free fatty acids, diacylglycerols, and monoacylglycerols. When the fats are re-heated, these compounds break down further, mainly through thermal oxidation,[7,13] to produce large amounts of hydroperoxides that are eventually transformed into polymers, characteristic of SOS. Polymers are produced through intra- and intermolecular reactions of alkoxyl-, alkyl- and peroxyl radicals, leading to the formation of dimers, trimers, and polymers of high molecular weight. Free radical reactions may be accelerated and propagated further via chain-branching or homolytic fission of hydroperoxides to generate more free radicals. By combining radicals to form non-radical dimers or polymers, the free radical chain reaction is terminated. It can also be terminated by anti-oxidants such as vitamin E (tocopherols), which react competitively with peroxy radicals, for example, to remove free radicals from the reaction. Consequently, SOS, where large amounts of polymers are produced, are normally characterized by high free radical activities.

When fats are re-used for frying, more breakdown products are formed, some of which may be harmful when consumed or inhaled. They not only influence the organoleptic character of fried foods, but may cause fats containing these compounds to smoke more easily at lower temperatures, thereby exposing people to volatile breakdown compounds such as aldehydes, ketones, alcohols, hydrocarbons, lactones, and substituted furans. The principal volatile constituents identified in frying fats derive from the decomposition of lipid oxidation products and include 1-pentanol, hexanal, furfuryl alcohol, *trans*-2-heptenal, 5-methylfurfural, 1-octen-3-ol, octanal, 2-pentylfuran, *trans*-2-nonenal and hexadecanoic acid.[13] Prolonged heating accelerates the production of oxidized breakdown compounds, resulting not only in the formation of potentially unhealthy volatile chemicals, but also in a greater absorption of the deteriorated fried fat by the fried food.[6]

Public health implications

Animal studies. The biological and toxicological properties of oxidized fats have been studied extensively, and there is general agreement that undesirable or harmful materials are formed during the abuse of fats.[7,8,14,15] Most research has been performed on animals, however, and shows experimental subjects to be resistant to the adverse effects of fats that have been heated under conditions that approximate human culinary practices,

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that is, containing less than 16% polymers. Extensive thermally oxidized fats or isolated fractions containing oxidation and degradation products have caused adverse biological effects in laboratory animals, however, including growth retardation, diarrhoea, teratogenicity, tissue damage and increased mass of liver and kidneys, cellular damage to the testes and epididymides, increased peroxidation of membrane and tissue lipids, induction of cytochrome P-450 activities in the liver and colon, enhanced urine mutagenicity, raised cell proliferation in the oesophagus, and even death. Hageman *et al.*[14] concluded that short-term consumption of heated deep-frying fats containing as little as 15% of breakdown products can cause increased cell proliferation in the gastrointestinal tract and induce oxidative stress (in particular the depletion of anti-oxidant agents such as vitamin E[7]). In these studies, the deteriorated fats used were far less degraded than those commonly found at South African frying establishments, where fats can be abused till they contain some 75% of free-radical-induced polymers.

Human studies. Although there is little in the literature that describes the effects of thermally oxidized fats on humans, studies have been conducted on the influence of mildly thermally oxidized fats when ingested and inhaled by people. When thermally oxidized soya bean oil (peroxide value 4.8 mEq/kg oil) was fed orally to men aged 25 to 38 years,[16] the level of lipid peroxides in human plasma increased within four hours, thereby adding to their oxidative stress levels. No such increases were observed after the intake of fresh oil (peroxide value 1.6 mEq/kg oil). Results from various experiments suggest that chronic oxidative stress can affect the immune system's fight against HIV.[17]

A study, conducted by the Shanghai Cancer Institute in collaboration with the US National Cancer Institute,[18] was based on interviews with 672 female lung cancer patients and 735 controls, and investigated the high rates of lung cancer among Shanghai women. Associations were found between lung cancer and measures of exposure to cooking oil vapour. Risks increased with: the numbers of meals cooked by stir-frying or deep-frying; the presence of smokiness during cooking; and the frequency of eye irritation during cooking. A similar study, which included interviews with 965 female patients and 959 controls in the industrial cities of Shenyang and Harbin, also found that the number of deep-fried meals consumed and the incidence of smokiness during cooking were associated with a higher than normal risk of lung cancer.[19]

The future

Since 1995, in collaboration with our group, the Department of Health as well as industry are actively addressing the problem countrywide,[10] but more investment from government and the private sector is required, to effect a change of culture in poor communities accustomed to frying with 'fish oil'. The consumption of used oils should be stopped immediately through increased policing of frying establishments and improved public awareness campaigns.

Urgent epidemiological studies are needed throughout sub-Saharan Africa to investigate possible links between SOS exposure over extended periods of time and disease, oxidative stress, and the progression of HIV/AIDS and afflictions such as tuberculosis. The database (obtainable from the authors) and expertise developed in South Africa since 1994 can be used to benchmark such a study.

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