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4-Hydroxynonenal: A Parameter of Quality and Safety of Vegetable Oils

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COLUMN ARTICLE

Due to several factors, namely social, economic and technical, people have less time to spend in food preparation. Consequently, the consumption of fried and pre-fried foods has been increasing due to its easy preparation. This behaviour has been linked to an increase in the intake of fats and oils subjected to high temperatures [1]. Oils and fats are previously processed (refining) to improve their quality, stability and safety. Despite the removal of a large amount of impurities from the oil that influence negatively their quality, some processing conditions can often originate new compounds with additional health hazards.

(E)-4-hydroxy-2-nonenal (HNE) is a secondary lipid peroxidation product derived from the oxidation of n-6 polyunsaturated fatty acids, namely linoleic acid (C18:2). This compound belongs to the class of α, β-unsaturated aldehydes, which are able to perform two type of reactions, Michael addition and Schiff base formation [2]. Compounds such as HNE are a consequence of fatty acids degradation in the presence of oxygen, and when vegetable oils are exposed to high temperatures [3]. From a health impact point of view, HNE is appointed as a cytotoxic and mutagenic compound, related with several diseases, such as atherosclerosis, low density lipoprotein oxidation, stroke, Parkinson's and Alzheimer's diseases, among others [4]. Acute effects, including the inhibition of catabolic and anabolic functions that lead to cell death were observed at a cellular level even with low HNE concentrations (>100 μM). HNE is also considered a mediator of the damage induced by oxidative stress, being involved in inflammation and cell signalling [5].

In the last years, great attention has been devoted to this subject, since new routes of hazard compounds formation, as well as new data on their occurrence in vegetable oils and their potential impact on health have arisen. When vegetable oils, particularly those that are rich in polyunsaturated fatty acids, are subjected to high temperatures (frying, for example), the risk of formation of secondary products such as HNE is increased. Due to the toxicity of HNE, which can be absorbed by food, information regarding its mechanisms of formation, particularly in fats and oils subjected to high temperatures, is very important from the point of view of public health.

The data found in the literature regarding HNE content in vegetable oils is scarce, and sometimes it is only presented in charts, making it impossible to know precisely the amount of these compounds. Between oils from different origin (e.g. sunflower oil and corn oil) there are great differences for HNE content, but also among the oils of the same type. For instance, in olive oil, HNE content can vary from 0.057 to 2.66 mg/kg of sample [6,7]. In 2002, Seppanen and Csallany have studied the formation of HNE in soybean oil at frying temperature. To perform these experiments authors have monitored the content of HNE in soybean oil that was heated at 185 °C for 2, 4, 6, 8 and 10 h. According to the obtained results, after 2 h of frying, HNE was already formed and its concentration continued to increase until 6 h of heating [3]. Later, the same authors have studied what

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happens to the food fried in oxidized soybean oil, expecting that the fried food contained this toxic aldehyde [8]. The reported results indicated that HNE was readily incorporated into the fried food, and similar concentrations of HNE were found in the oil prior to and after frying, and in the oil extracted from the fried potatoes (5.75, 5.24 and 5.96 mg/kg of oil, respectively) [8].

Afterwards, Han and Csallany have studied the formation of HNE at a higher frying temperature, 218 °C for short periods of time, and compared it to a lower frying temperature, 190 °C for longer periods of time. In this study, authors have included three types of oils: butter, corn and soybean [4]. HNE concentration at the higher frying temperature was 4.9, 3.7, and 8.7 times higher than at the lower temperature. The concentration of HNE at 30 min reached the maximum of 15.5, 10.7 and 6.7 mg/kg of oil for corn, soybean and butter oils, respectively [4]. Recently, Papastergiadis., *et al.* have determined the HNE content in some foodstuffs commercialized in Belgium including vegetable oils [6]. From the analysed vegetable oils, the highest values of HNE were determined in the soybean oil extracted from fried potatoes (596 mg/kg) and in frying oil ω-3 enriched (0.520 mg/kg).

In conclusion, there is a lack of data regarding HNE content in vegetable oils, but it was possible to confirm that, vegetable oils, especially those subjected to temperature treatment (e.g. frying) can contain considerable amounts of this cytotoxic and mutagenic compound. For the appointed reasons, it is urgent to perform more studies considering different variables and to find mitigation strategies. Future trends should also include studies that suppress the lack of data regarding the formation of this toxic compound in the presence of food and using real frying conditions, considering the different types of fryer, duration and temperature, and also the different types of food matrices and oils. Moreover, some studies in the literature, reported data on HNE, under unrealistic frying conditions, such as temperatures above 185 °C, which is the recommended frying temperature. Therefore, to investigate what occurs during the different stages of frying is also another challenge that should be considered in further studies.

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