



Changes in Unsaturated Fatty Acid Profiles of Some Vegetable Oils during Frying at Medium Frying Temperature

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ABSTRACT

The use of cooking oils in the deep fat frying of food has increased significantly in the modern day living. During heating and frying the unsaturated fatty acids undergo isomerization and chemical reactions resulting in the formation of trans isomers and several other toxic compounds. During frying fatty acids are gradually depleted to form other products. The aim of this project is to study the changes in unsaturated fatty acid profiles in four different vegetable oils. Fatty acid profiles of soybean, rapeseed, olive and corn oil samples that were heated at medium frying temperature 175°C in the presence of air were analyzed by gas chromatography after derivatization. Fatty acid profiles of the oils revealed that there is no significant formation of trans isomers at this temperature and time interval. The reduction percentages of unsaturated fatty acids are high in rapeseed oil. Furthermore, the results clearly show that the stability of fatty acids decrease with increasing number of double bonds in the molecule. Olive oil seems to be the stable oil at this frying temperature.

Keywords: Fatty acid; Isomers, Gas chromatography; Unsaturated fat

INTRODUCTION

Fatty Acids in Vegetable Oils

Edible oils have achieved a significant remark in food industry as well as in domestic cooking. Most of edible oils are of plant origin and are obtained from fruit pulp or seeds. Nine vegetable oils such as palm, soybean, rapeseed and sunflower, coconut, palm kernel, cotton seeds, olive, and groundnut are among the several edible oils consumed by people [1]. Most of these vegetable oils are consumed directly, or indirectly as ingredients in food – a role that they share with some animal fats [2]. The oils give texture and flavor to food prepared in or with oil. Most of the edible oils have saturated fatty acids such as myristic (C14:0), palmitic (C16:0) and stearic acids (C18:0); and unsaturated fatty acids such as oleic (C18:1, 9c), linoleic (C18:2 9c12c) and linolenic (C18:3 9c12c15c) acids. These fatty acids have their respective health benefits when they are consumed in their natural state.

Saturated fats play a key role in cardiovascular health by reducing lipoprotein and help incorporate calcium into bones. Furthermore, it has been shown to protect liver from alcohol and medications and drugs used for pain and arthritis [3]. Oleic acid controls the serum lipoprotein concentrations and regulates plasma LDL and cholesterol content in blood. It plays also a role in the control of blood pressure and viscosity and the transportation of cations in the erythrocytes. Furthermore, oleic acid modulates lipid metabolism and the binding of glucocorticoid receptors in the lungs by negative feed -back. More over oleic acid can affect signal transduction by activating the iso-enzyme of protein kinase [4]. Linoleic acid reduces the serum cholesterol level. Consumption of linoleic acid reduces the coronary heart disease (CHD) risk factor. Furthermore, higher linoleic acid intake may improve insulin resistance and reduces the incidence of diabetes. It also helps in lowering blood pressure. Linolenic acid is an essential fatty

acid and human body cannot synthesize the acid and is taken through food consumption. High intake of linolenic acid can lower the risk of Coronary Artery Disease (CAD) and other cardiovascular diseases [5].

However, when food is prepared by deep frying at a temperature over 170°C, several changes take place due to chemical reactions. These changes include isomerization [6], oxidation, intra cyclization and polymerization [7-13]. The products formed from mono unsaturated fatty acids can reach up to a concentration of 60% in oils heated at 300°C. These products are toxic [11,13] and may cause health problems in humans. Formation of these products reduce the fatty acid contents in edible oils during frying and the quality of the oil decreases. Our intention in this article is to determine the fatty acid profiles of four different vegetable oils used in deep frying to understand how the fatty acid profiles change during deep frying so that consumers are aware about these changes.

METHODS AND METHODOLOGY

Sample Preparation

Four different vegetable oil samples were collected from the local vendors. Sets of 10 samples were prepared from each of the oil. Portions of 1ml oil samples were placed in 10 ml glass vials. The vials containing the oil samples were placed in an oven set at 170°C. The vials were not covered so that the oil was open to interact with the atmosphere. Oil samples were then removed. Samples were removed at 0.5 h time intervals until all the 10 samples were exhausted. After cooling three drops of each oil sample were transferred into a test tube and the weight was recorded. The experiment was repeated in the same manner with other vegetable oils (rapeseed oil, olive oil, corn oil and soya oil).

Derivatisation and GC Analysis

Each test tube containing an oil sample was added 1 ml of heptadecanoic acid (2 mg/ml) and 1 ml of 0.5 M methanolic NaOH. The test tubes were then placed in a water bath at 65°C for 10 minutes. After cooling, 1 ml of BF₃/methanol was added to each test tube and placed in the water bath for 5 minutes at 65°C. The test tubes were placed to cool down to room temperature and 1 ml of heptane and 1 ml of saturated NaCl were added. The test tubes were shaken well to get better separation and dissolution of fatty acids methyl esters (FAMES) in organic layer. The test tubes were placed to stand for few minutes and anhydrous MgSO₄ was added into the top layer. The organic layer from each test tube was extracted using a plastic syringe and filtered through a 45 µm ethyl acetate filter into a brown colour GC vial and kept in dark until GC analysis.

The GC analysis of the samples was carried out using Hewlett- packed 5890 gas chromatograph. With a 120m capillary column with 0.25 internal diameter coated with 0.25 thick, 70% cyanopropyl polysilphenylene-siloxane stationary phase. A temperature program with initial temperature of 170°C with 2 minutes equilibrium time, a temperature gradient of 1°C/min up to 180°C with 50 minutes holding time, then a temperature gradient of 1°C/min up to 190°C with 15 minutes holding time, finally 10°C /min up to 250°C with 20 minutes holding time was used. The total running time was 83 minutes. The peak identification in the gas chromatograms was carried out by comparing the peaks with the peaks from a standard Fatty Acid Methyl Ester (FAME). The peak heights of the fatty acid methyl esters were determined. The mass of the fatty acids in the heated mixtures were then determined by comparing the peak height of the fatty acid methyl esters with the peak height of the reference standard (margaric acid methyl ester). The mass of a fatty acid methyl ester in the mixture was then converted into percentage by using the total mass of the oil used in the experiment.

RESULTS AND DISCUSSION

Oxidation of Vegetable Oils and Fatty Acid Profiles in Selected Edible Oils

The vegetable oils were kept at 170°C in the presence of air to mimic the medium frying temperature. Oxygen in the air initiates autoxidation and the fatty acids undergo a series of reactions leading to the degradation of fatty acids. The oxygen in air auto-oxidizes the fatty acid moieties in tri acyl glycerols and the fatty acid contents in tri acyl glycerols decrease. The rate of depletion of fatty acids varies depending on the fatty acids nature. Fatty acids with multiple double bonds are depleted faster than the saturated and mono unsaturated fatty acids.

The changes in the major unsaturated fatty acid profiles of olive oil, corn oil, soya bean oil and rapeseed oil are shown in Figure 1. Changes in individual fatty acid profiles are shown in Figure 2.

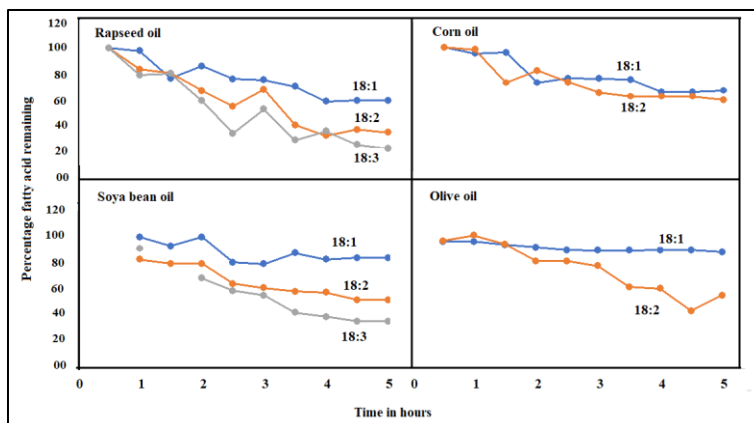


Figure 1: Fatty acid profiles of the vegetable oils against heating time

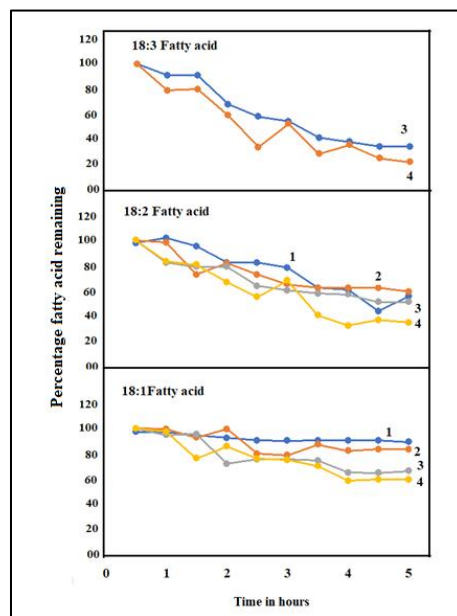


Figure 2: Changes in individual fatty acid profiles in heated vegetable oils. 1-olive oil, 2-corn oil, 3-soya bean oil and 4-rapeseed oil

These figures clearly illustrate the degradation of fatty acids with temperature. The 18:3 fatty acids degrade faster than the 18:2 and 18:1 fatty acids. Furthermore, all the unsaturated fatty acids in rapeseed oil degrade faster than the unsaturated fatty acids in other oils. A 40% reduction in 18:1, 65% reduction in 18:2 and 70% reduction in 18:3 fatty acids in rapeseed oil. Olive oil has an 8% reduction in 18:1 and 42% reduction in 18:2 fatty acids at the same frying temperature and time interval. These facts clearly show that olive oil is more stable than the other three vegetable oils. Furthermore, it can be easily concluded that the stability of these oils follows the order olive oil > corn oil > soya bean oil > Rapeseed oil.

CONCLUSION

The fatty acid profiles of four vegetable oils indicate that the concentration of fatty acids decrease during frying at medium frying temperature. There is no evidence for the formation of trans fatty acids during the time interval and temperature selected in this study. The percentages of fatty acids are different in each of the oils. Only soybean and rapeseed oil contain linolenic acid (18:3). The reduction percentages of oleic (18:1), linoleic (18:2) and linolenic (18:3) acids are high in rapeseed oil and shows that the oil is unstable for frying purpose at medium frying temperature. Olive oil has high stability towards heat (medium frying temperature) and the reduction in fatty acids contents is low compared to the reduction in fatty acids contents in other three vegetable oils. Therefore, if one had to choose a vegetable oil with high unsaturated fatty acids for medium temperature frying purpose, olive oil is the best choice among the four vegetable oils.

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