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The Effect of Heating Simulated by Rancimat and Evaluating Fatty Acids Profile of Corn Oil after Exceeding Oxidative Stability

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ABSTRACT

Corn is one of the plants whose seed oils are conventionally used for food frying processes. Since corn oil contains high oxidation stability, the present study aimed at reviewing stability and the effect of heating on fatty acids compositions when it goes beyond the stability point. In this study, pure corn oils that were imported to Bushehr were simulated for heating condition using Rancimat system under a determined temperature. Additionally, the spectrum of thermal oxidative stability was plotted and evaluated by determining the stability point, deformation oil in methyl ester and considering fatty acids profiles. Comparing the spectrums of unheated corn and heated corn in similar conditions, it was found that the amount of saturated fatty acids in the heated corn reached 25.36% after exceeding over the oxidative stability point. The obtained values for mono unsaturated and poly unsaturated fatty acids were 66.31 and 5.35, respectively. In the composition of the profile, the percentage of oleic acid increased considerably while a sharp drop in linoleic acid was revealed. After going over the oxidative stability, the saturated components increased and unsaturated components generally decreased. The drop in the composition of poly unsaturated compounds was associated to linoleic acid. The observed drop was significant. The ratio of Omega 6 to Omega 3 changed from about 56 to 6.33 that is relatively close to the desired amount of 4. Therefore, exceeding over the oxidative stability point for corn oil is not necessarily considered as a negative point. Since the amount of fatty acid in oleic increased and this acid can decrease the risk of heart attacks; therefore, there are other factors than oxidative stability point that should be considered in the process of heating in corn oil. It should be carefully investigated for the patients with the related problem.

KEYWORDS: oxidative stability, corn oil, unsaturated fatty acid, fatty acids profile, Rancimat

1. INTRODUCTION

Using oil for frying some foods is one of the methods of food preparation. The effect of heating different food oils is obvious based on previous studies and heating frying oils can produce undesirable cases that may be risky for the individuals' health. The composition and properties of the frying oil, transport and storage conditions, type and size of the food being fried, frying machine design and the process of quality control of the frying oil while using are the most important factors influencing the quality of the fried foods (Takeok et al., 1997).

Frying is the most common methods of preparing food that is done superficially and deeply (oil immersion). The deep method is mostly used in preparing the food quickly with desirable sensory properties (Mellema, 2003). This is a process of transferring heat and mass simultaneously. It means that heat is transferred from oil to food and the water in food is evaporated and will be absorbed into the food (Debnath et al., 2003; Lisinska&Leszczynski, 1989). In fact, frying food in hot oil (160-180 C°) is a way of fast drying (Beuthien-Baumann & Escher, 1995). This process of fast drying is highly important in improving the mechanical and structural properties of the product. In this case, we can have speedy transfer of heat into food, quick cooking, browning, and texture, flavor and taste improvements. Basically, during the process of frying different changes such as physical occur including increased viscosity, surface tension reduction, increased density and chemical changes including increased levels of free fatty acids, peroxide index increase, oil stability drop and the growth of compounds with high molecular weight that can overshadow the health of the foods (Sangdehi, 2005;Mackay, 2000). In this field, Oxidative Stability Index (OSI) can be used to determine the amount of oxidative resistance of oil against heating and oxidation processes and the required time for the endurance of oil can be determined as well. Overall, based on the fatty acids composition in oils their physical properties change. This is due to the difference in melting point, carbon chain length and the degree of saturation of fatty acids within the oils. Unsaturated fatty acids are susceptible to oxidative degradation under the heating condition. The generated radicals due to heating are atherogenic factors and lead to cardiovascular

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diseases (Al-Saghir et al., 2004). Corn oil is one of the dominant oils used for frying. Since corn fields after wheat farmlands are the largest all over the world and world's highest amount of crop is corn, oil corn can be greatly noted and its healthy consumption is also evaluated in a high position. Consumption of corn oil can reduce cholesterol absorption by more than 25% which cause a significant reduction in heart diseases that are largely a function of cholesterol (Lands, 2005;Okuyama et al., 2007).

Oil corn has a high nutritional value and its germ oil is rich in linoleic acid (Omega 3) which is an essential fatty acid (Lands, 2005;Ohlson, 1983). Since corn oil oxidation stability is high and it is used for frying foods and preparing salads, this research focused on its stability and the effect of heat on other aspects of the oil quality that is the composition of fatty acids so that the appropriateness of this composition after exceeding over the stability point and the following variations is examined. Mirmira et al. (2001) determined the effect of corn oil on physical growth, blood lipid concentration and the body composition of mouse. In 2003 and 2004, the effect of corn oil on serum lipids levels in diabetic patients was studied and compared with another oil called fish oil by Rashidi and Arian pour. Farhoosh et al. in 2009 and 2010 measured relative stability of corn oil compared to canola, soybean and olive oils based on accelerated methods of Rancimat at 120C°. From the structural point of view, the highest ratio of poly unsaturated to saturated fatty acids (PUFA/SFA) belonged to corn oil (4.74). Corn oil had lower values of phenolic compositions (Farhoosh et al., 2009). Therefore, the present study aims to examine nutritional value of corn oil after exceeding over the oxidative stability and to determine the process of quality degradation for this popular frying oil where possible the frying procedures are revised. Moreover, with regard to high consumption of corn oil in community it should be used with greater care.

2. MATERIALS AND METHODS

2.1. Sample Preparation

40 imported oils to Bushehr port were collected in four categories of 0.5 to 2 liters. Then, the samples were transferred to toxicology laboratory under laboratory temperature condition. The experiments were performed on oil similarly with several replications.

2.2. Determining Oxidative Stability Index

Rancimat system (version 743) equipped with a software including conditions in the range of 50 to 220C° and the AOCS 12b-92 Cd method was used to determine the status of corn oil regarding its oxidative stability point. The associated diagram was plotted using the software. For providing samples of the device, 3 grams of each imported oil was weighed and adjusted in software programming, and air flow rate of 22 L/h and the device temperature was set at 110C°.

2.3. Fatty Acid Components

The fatty acids components were determined using a gas chromatograph device (version Varian cp-3800) equipped with FID detector and capillary column with a length of 3m that was programmed for the following condition for the study of fatty acid:

Hellium was used as the carrier gas; the detector temperature and the injection temperature were considered as 270 and 255C°, respectively. The program set for the column temperature was as the following: first, the columns temperature was increased into 125C° within 30 seconds, then, the temperature reached to 25 degree per minute. Then, the temperature reached 200C° during 90 minutes at the same speed. Flow of nitrogen as Makeup, and air and hydrogen were adjusted as 25, 30 and 300 ml/m. The standards and necessary chemicals were purchased from Merck Company in Germany.

AOCS Ce 2-66 method was used for the process of fatty acids methylestration (FAME). 0.02 gram from each corn oil was weighed with laboratory scales having 3 decimal weighing precision and then, 2cc of methanol and 1 cc of hexane solvent were added to them. Next, 0.02 cc concentrated sulfuric acid was added as a catalyst and the reflex process was done for about 3 hours at 75C°. So, the formed methyl esters were injected to Gas Chromatography (GC) device using 10 ml syringes and their fatty acid profiles were determined. On the other hand, a similar method was applied to compare fatty acids of each sample oil that were processed by Rancimat system or a certain program and had passed over the oxidative stability point.

3. Findings

Figure 1 illustrated the fatty acid spectrum of corn oil that is presented in Table 1 with respect to the measured spectra, the amount and the components of these fatty acids.

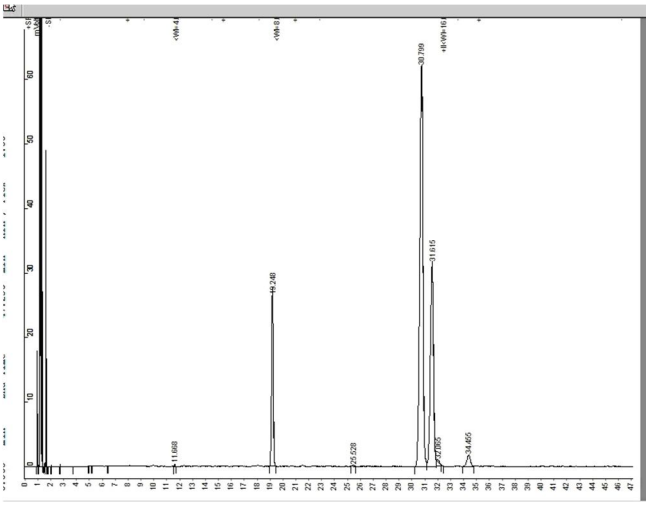

Figure1-Fatty acids spectrum for corn oils

Table 1-The amount and components of fatty acids of corn oil

Fatty acids composition	Fatty acid %
Capric acid	1.4
Myristic acid	ND
Palmitic acid	19.57
Margaric acid	ND
Stearic acid	4.39
Oleic acid	66.31
linoleic Acid	4.62
Linolenic acid	0.73

Rancimat system was used to simulate oil heating process and their condition after the oxidative stability point. The diagram in Figure 2 represented the state of the oils after the oxidative stability point, the time for oil stabilization against heat and the oxidation process.

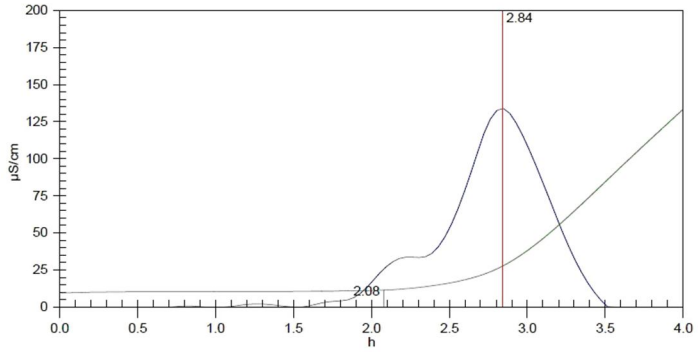

Figure 2-Oxidative Stability of Corn Oil at 110C°

Figure 3 showed the composition of fatty acids after the stability point. Table 3 also showed the composition of fatty acids after stability point. Table 2 indicated the percentage of fatty acids regarding the mentioned oil saturated comparison.

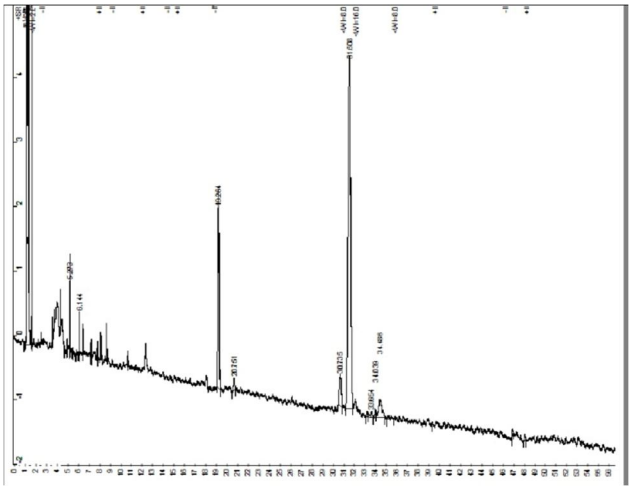

Figure 3 -Fatty acids spectrum of corn oil after the oxidative stability point

Table 2-Saturated fatty acids of corn oil after the oxidative stability point

Fatty acids composition	Fatty acid %
Capric acid	0.22
Myristic acid	0.081
Palmitic acid	12.94
Margaric acid	0.11
Stearic acid	1.81
Oleic acid	28.5
linoleic Acid	56.36
Linolenic acid	0.2

4. RESULTS AND DISCUSSION

In this research, the amount of unsaturated corn oils was the property of the applied oils. The maximum amount of it was observed in oleic linoleic and palmitic acids, respectively and an insignificant amount was formed by stearic and linoleic acids. Totally, saturated fatty acids were 15% of the whole fatty acids. The obtained values for fatty acids with mono-unsaturated, polyunsaturated and the total unsaturated degrees were 28.5, 56.56 and 85, respectively. The high degree of unsaturated fatty acids can question the health of this oil to some extent. The high ratio of omega-6 to omega-3 should be approximately 4 to 1, but the ratio was about 56 times greater as it is shown in Table 1 and Figure 1. This has caused the consumption of this oil unclear since according to some of medical researchers, high values of Omega-6 compared to Omega-3 may cause depression and some other diseases (Conklin et al., 2007; Tanskanen et al., 2001), so it should be more carefully consumed. As it is displayed in Figure 2, oxidative stability of corn oil at 110C° continued until 2.08 and from this moment on the structure of oil changed and at 2.84 the structure was distorted and its structure was fundamentally changed. After this point, the health of fatty acids in corn oils had to be studied carefully so that the issue of health and quality of oil were researched and the required measures need to be considered.

According to Table 2, the amount of saturated fatty acids in this oil reached to 25.36% after the oxidative stability and this value for mono unsaturated fatty acids was 66.31% and for poly unsaturated fatty acid this value reached 5.35. The total unsaturated fatty acids were 71.66% of the whole fatty acids. Table 3 illustrated the comparison between fatty acids before and after the stability point. As it was observed, the saturated compounds increased and the unsaturated compounds dropped after the oxidative stability point. On the other hand, mono unsaturated composition increased considerably and the poly unsaturated composition decreased inversely. The observed reduction in poly unsaturated composition is basically due to linoleic acid. This significant reduction changed the ratio of omega-6 to omega-3 approximately from 56 times value to a value of 6.33 which is closed to the desirable value of 4. Since the value of oleic acid increased, this oil can be utilized as a source of oleic acid and can be considered in specified and targeted applications. As oleic acid reduces the risk of heart attack and cardiovascular diseases and in some cases can be applied as an inhibition for some patients with ADL (a fatal diseases that influences the brain and adrenal glands); therefore, the increase in heating process should be noted and

investigated as a generated source for the associated patients. Higher values of saturated fatty acids in oils and their thermal oxidation increase the cholesterol plasma, while higher rates of linoleic acid in oils increase plasma cholesterol lowering effect (Sun et al., 1986;Rizzo et al., 1986). In this oil, after thermal stability point high values of saturated fatty acids may endanger the oil health. In other cases, high levels of capric acid are noticeable which can meet the required needs of corn oil in this condition by passing the oil stability through the stability point.

Therefore, according to the above-mentioned cases passing through the oxidative stability point in corn oil cannot be essentially regarded as negative, because the ratio of omega-6 to omega-3 has improved and major changes has occurred to oleic acid though the amount of saturated composition naturally increased.

Table 3-Comparing different ratio fatty acids in corn oil before and after passing through the oxidative stability point

	Saturated fatty acids %	Unsaturated fatty acids %	Omega-3 %	Omega-6 %
Oil before the stability point	15	85	0.2	56.36
Oil after the stability point	25.36	71.66	0.73	4.62

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