The Study of Frying Oils Properties


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ABSTRACT
Frying is the oldest, fastest and the simplest method of cooking foods in which foods are submerged or flipped into the hot oil using cooking oils or edible fats. Since the combination of fried food and frying environment is constantly changing, the process is one of the most difficult processes to sort out the interactions taking place; because several reactions occur in it. Hence, the characteristics of the oil during frying, discussed in this study, are of the utmost importance. Therefore, the oil extraction and refining happened in pilot unit. Experiments were performed according to the national standard and AOCS and IUPAC. Researchers suggest that the proper frying oil should be resistant to high temperatures, And to ensure the health of the oil at temperatures above 200 °C, while having a mild flavor and bright Hue, smoke and flash points must be above 200 and 315 °C respectively. The amount of fresh oil added while frying, frying time and temperature, heating method, initial quality of oil, Food constituents, fryer type, type and concentration of the anti oxidant such as oxygen, are factors affecting oil quality during frying. Mentioning the advantages of frying oil, it can affect the taste and texture of the food, while creating a cover and coloring up the product, and it can help in increment of product's oil, heat transfer, blanching and deactivation of microorganisms or inhabitation of pathogens. From the starting point to the time it becomes inedible, analysis and quality variation of frying oil is a 5-step process in which, food quality alters following the change in oil quality during the process of frying. Physical changes happening during the frying process includes increment of Hue, foam and viscosity. Damaging chemical reactions during the frying process include hydrolysis, oxidation and polymerization. The chemical structure of the compounds generated during frying, depends on many factors including the type of oil and food, frying conditions and oxygen availability.

Keywords - Edible oil, Frying, Oxidation

I. INTRODUCTION
In ancient times, frying foods were one of the most common processes in cooking; So that Chinese people in 3000 years before Christ, and Jews 1300 years before Christ, consumed meat and bread in hot fried oil. The background of frying technology is mainly connected to Mediterranean areas due to the effect of olive oil, back to 1600 years before Christ. But in recent half decades, this process has come into the consideration of most scientific conventions. Some believe that the start point of these studies was first held in 1950. More often, the attention of food science researchers was drawn to this chemical process. Oils and edible fats take a large proportion of daily intake and these categories of foods provide essential nutrition, energy, vitamins, and essential fatty acids and play important role in health protection and life endurance. Oils and fats are means of heat transfer that provide the heat needed for cooking and cause delicate flavors and improve taste and texture of foods.(Fenema1996) Frying is the oldest, fastest and the simplest method of cooking foods in which foods are submerged or flipped into the hot oil using cooking oils or edible fats. In other words, deep frying is the process of baking and drying the food in the hot oil while heat and mass are transferred at the same time. In this process of preparation, delicate flavor, crunchy texture and a desired golden Hue is seen in foods. Since consumers prefer the appearance and texture of this kind, and the food is quickly and easily prepared, this method of cooking has become a special opportunity in food production industry and is highly and frequently applied at homes, restaurants and factories. Since the combination of fried food and frying environment is constantly changing, the process is one of the most difficult processes to sort out the interactions taking place; because several reactions occur in it. Using different frying oils with different fatty acid structure has brought up some troubles with the clear understanding of this oxidation reactions. So far, only few compounds of hundreds were detected. While deep frying the foods in presence of oxygen, some chemical reactions such as hydrolysis, oxidation, polymerization, isomerization, and
cycling take place. Therefore, frying oil is discomposed and then the formation of volatile oxidation products, Oxidized derivatives of non-volatile material and polymeric or cyclic dimers, occur; through which these compounds on affect the oil quality and the quality of the final product. There's the evidence that some products of triacylglycerol oxidation reactions, particularly those that cause chemical changes, may be dangerous to human health. (Dobarguesn, 2003).

**Oil extraction and refining**

Oil extraction and refining occurs in pilot unit. Seed oil is extracted using continuous press with a capacity to process 400 kg per hour. The extracted pure oil is refined 200 kg per batch in the pilot, discontinuously. The oil is degummed in a reactor tank equipped with a mixer with 0/2% phosphoric acid for 30 min at 25 °C. The neutralizing phase is carried out in the reactor as well with 18 degrees of alkaline at room temperature for 40 minutes. When the gum and soap are eliminated, Oil is washed 3 times with water at 80 °C. Then it is bleached with 0/1% of silica gel and 1% of bleaching soil at 70 °C under vacuum condition for 10 minutes. 3% of steam at 240 °C during 3 h session under a vacuum condition of less than 3 mm Hg is performed to remove the odors. General Information on refined frying oils and national standard of frying oil production in Iran is as shown in the table (Malek, 2007).

**Determination of fatty acid composition**

Fatty acid composition was determined, using GC after conversion to the methyl esters of fatty acids with KOH in methanol according to the IUPAC standard method 2.301 and 2.302. GC 6890 system is equipped with various injectors while capillary column and ionization detectors have also been used. Hydrogen was used as carrier gas. Detector and injector temperature was 250 °C. The initial oven temperature was 180 °C and a temperature gradient from 180 to 220 °C at 3 °C min was applied. Injection was done using a split ratio of 1 to 50.

**Smoke point and flash point**

The smoke point is the temperature at which the fat or oil is heated to high temperatures. Smoke is made up of a continuous loop. The smoke point is used as a useful indicator for determining the suitability of frying oils. The specified smoke point for frying oil is 200 °C at minimum. Flash point is the temperature at which the decomposition products of the oils heated to high temperatures can be ignited. These temperatures ranging from 275 to 330 °C vary in different oils. Increment in the amount of unsaturated fatty acids usually reduces smoke point and flash point oils.

**Iodine value**

Iodine value indicates the unsaturation intensity of oils and fats and it is expressed as Grams of iodine absorbed by 100 grams of fat. The maximum acceptable Iodine number is 100 in frying oils. (Malek, 2007).

**Melting point and stability of oil**

These tests are carried out according to standard methods of AOCS.

**II. THE PROCESS OF FRYING**

In frying food process, water penetrates into the oil and brings it to evaporate. Steam causes the hydrolysis of oil into fatty acids and glycerol; then fatty acids are oxidized more rapidly than triacylglycerol. With increasing the solubility of metal catalysts in oil, lipid oxidation is doubled. On the other hand, Steam covers the oil surface and oxidation rate of oils is equilibrated through reduction control of oxygen. The steam removes the released volatile matters of hydrolysis covering the oil level and delays the deterioration of the oil. During the process of frying, foods absorb oil, 5 to 40 percent of their weight. Stable structure of the oils used in frying food is altered by foods. Proper performance of this process requires controlled temperature, time and fresh oil substitution, to obtain desirable sensory characteristics of the food due to minimization of products accumulation resulting from lipid oxidation (Saguay et al, 2003).

**Frying oil selection**

This selection is based on the structure of fatty acids in frying oils, commercial applications, the amount of oil absorbed by fried food, fried food shelf life, speed of oil penetration into food, type of food and oil price. The suitable oil for frying should be resistant to high temperatures and to ensure the safety of oils at temperatures above 200 °C, while having a mild flavor and bright Hue, smoke and flash points are respectively, expected to be higher than, 200 and 315 °C (Morira 1999).

**Benefits of frying**

Frying benefits include improvement of taste and texture, formation of coating, dying the product, increment in the amount of product's oil, heat transfer, Blanching, deactivation of micro organisms or
destruction of pathogens (Bosque et al, 2006; Morira, 1999)

**Taste and texture**
Fried foods have a good Hue and flavor, and a tender texture, which result in appreciation of consumers. The combination of these properties cannot be achieved through other cooking methods.

**Formation of coating**
Fast food frying provides a large tender skin and coating in the final product.

**Increasing the oil content of the product**
Frying causes the absorption of oil by the fried food. Oil absorbed by food products varies from 4 percent to 40 percent for nuts, potato chips, which causes the release of large deal of energy, and served as a lubricant and eases the act of swallowing. The amount of oil absorbed during frying, is influenced by frying time, food surfaces and moisture, food pulp or coatings and the type of frying oil.

**Hueing up the product**
Frying creates a pleasant golden brown Hue on fried coated products and can be used for roasting foods.

**Blanching**
Frying temperatures (typically exceeding 177 degrees of Celsius) can bring about blanching. Usually blanching is applied to activate enzymes, reduce intercellular air, reduce the volume and destroy some microorganisms. Manufacturers of fries, consider frying as an act of blanching.

**Deactivation of microorganisms or destruction of pathogens**
Frying can also cause the deactivation of microorganism and destruction of pathogens.

**Heat Transfer**
The fried oil acts as a heat carrier to quickly prepare the food for consumption (Bosque et al, 2006; Morira, 1999).

Factors affecting oil quality during frying is as listed below:

1. The amount of fresh oil added during frying
2. Time and temperature of frying
3. Method of heating
4. Initial Quality of Oil
5. Nutrient constituents
6. Type of Fryer
7. The type and concentration of anti oxidants
8. The amount of oxygen

**Re-filling or adding fresh oil**
If adding a larger proportion of the fresh oil to the total oil, the quality of frying oil is improved. Frequent addition of fresh oil decreases the formation of polar compounds, di-acyl glycerol and free fatty acids and enhances the quality and duration of frying oils. Researchers showed that refilling the fryer with fresh oil improves the quality of oil, only up to the 30th frying time. (Romero and et al, 1998; Sánchez et al, 1993).

**Time and temperature frying**
As the frying time increases, free fatty acids, triacylglycerols, and more polar compounds such as acyl oxidized dimers, dimers, and polymers increases. With increment of frying temperature, there is an increment in thermal oxidation and polymerization of oils. Meanwhile, the formation of polymers with peroxide connections is reduced and the formation of peroxide polymers bearing ether or carbon - carbon links increases. Alternate heating and cooling of oil, due to the increased solubility of oxygen in cold oil causes more corruption than continuous oil heating. Because when the temperature of the frying oil falls lower than the temperature of frying, the solubility of oxygen increases. Investigations revealed that from the first time of frying to the 20th time, the formation of polar compounds increased rapidly but no significant increase of polar compounds was observed after the 30th time of frying. The higher temperature of frying accelerated the oxidation and polymerization of oils. (Tompkins and Perkins, 2000; Kim et al, 1999).

To select the proper oil for frying, oils with higher withstanding of temperature are of outmost importance. Some methods of stabilizing frying oils are functional; such as mixture of polyunsaturated frying oils with saturated or monounsaturated type, hydrogenation, genetically modifying fatty acids structure, using antioxidants as well as the processing and storage of the product under any conditions of oxidative degradation. Hydrogenation of unsaturated oils is a common process in this area of work, but this process endangers consumer health. Genetic modification of fats is the latest correction method of edible polyunsaturated oils. Polyunsaturated oils contain fatty acids, mainly linoleic (18:2) and linolenic (18:3). Genetical modification causes reduction in the amount of linoleic and linolenic...
acids and enhancement in the oleic acid (18:1) levels. Canola oil with low linolenic acid and high oleic acid content is one of those kinds. Those types of oils can be frying sustainable, though have no Trans fatty acids (Warner and Knowlton, 1997).

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**Oxygen level**

Fresh fried oil contains large amounts of oxygen and some more of it will make its way from the oil level through the nutrients while adding the food to it. Oxygen is one of the main factors in the formation of compounds including free radicals, hydro peroxides, aldehydes, ketones and conjugated dien acids. Oxidative reactions lead to a wide range of volatile and non-volatile compounds. The primary products of lipid oxidation in frying temperatures (over 180 ° C), rapidly break into secondary oxidation products such as aldehydes and ketones. Secondary products such as aldehydes, which are volatile, notably participate in formation of oil odor and taste of fried products. Polyunsaturated oils that are unstable against oxidation, create more unpleasant fried products. Therefore, Oils containing acids, such as linoleic and linolenic, like soybean, sunflower and canola would lead to more tangible off-flavors and unpleasant taste, during the frying condition. (Baileys, 2005).

**III. OTHER FACTORS AFFECTING THE QUALITY AND STABILITY OF OIL**

The quality and stability of oils are largely related to unsaturated fatty acids in triacylglycerol structures, and the more they appear in the structure, the less stability is expected. Linolenic acid content affects oil stability and flavor of fried foods. Oil used for frequent frying should contain below 2% of linolenic acid content to minimize the occurrence of undesirable flavors. During frying, by presence of oxygen and moisture in food, lots of oxidation and hydrolysis reactions take place which leads to the creation of undesirable substances that negatively affect the flavor and the Hue of the product so that they even may threaten human health (Choe et al, 2007).

Frying oil durability and the destruction stages
Blumenthal (1991) showed that from the start point to the time it becomes inedible, the analysis and transformation of quality in frying is a five-stage process. Various stages of oil and fried food quality change are as listed:

1. **Primary stage:** Food stuff are Hueless, with raw kernel and non-gelatinized starch, and crispy surface, while oil absorption is low.
2. **Fresh oil stage:** The edges of fried products are brown; kernels are partially cooked and relatively brittle. Oil absorption increases.
3. **Optimum oil stage:** Hue of food is golden, the texture is crunchy and a rigid surface has been
observed, product smells pleasant and is fully cooked and the taste of oil is felt.
4. Beginning of oil degradation stage: The Hue of the product has become dark, and the tissue became loose with rigid surfaces, while oil absorption is increased.
5. Inedible oil stage: Hue is quite dark, with hard surface, absorbing oil has exceeded the limit, product surface is indented, and brains are half cooked, with bad smell and flavor (it is burnt).

The indicator of frying oil analysis
Stability of oils is defined as the resistance of oils and fats under the process conditions and corruption caused by, which creates off-flavors and undesirable odors. In other words, oxidative stability is the time it takes to reach the point where one of the quantities, such as peroxide oxidation or carbonyl dramatically rises after their sudden increment flow. The time required to reach this point is called the induction period. There are relatively many oxidative stability evaluation methods, but the results are difficult to interpret because the induction periods of the tests are different from each other. Selection of the appropriate method for interpreting the data on the stability of oxidation conditions is critical fact. Oxidative stability of unsaturated fat can be estimated by determination of oxidation rate, under defined conditions and existing standards. Since unsaturated hydro peroxides are decomposed to their aldehyde shapes in high temperatures, both carbonyl and peroxide value can be used to assess the lipid oxidation. When the oil is heated to a temperature of frying, and the food is fried, a part of the triacylglycerol is decomposed to the products of dissolution.
Total polar compounds, are chemical criterion for the breakdown of oil and since it includes deformed ingredients, by determination of TPC percentage, total degradation products accumulated in the frying oil, can be measured (firestone, 2007).

Physical and chemical changes of oil during the process of frying
Deep frying of fats stimulates the production of desirable or undesirable flavor compounds with changes in the quality and consistency of flavor and Hue and texture of fried foods. Hydrolysis, oxidation and polymerization of oils are produced during general or ordinary chemical reactions taking place in frying oil and produce volatile or non-volatile compounds. Deep frying of fats can cause reduction in unsaturated fatty acids and increment in foam, hue viscosity, density, content of free fatty acids, polar substances and polymeric compounds (Choe et al, 2006)
Physical changes in oil include the growth in Hue, foam and viscosity. These qualitative changes can be simply checked visually, although there are ways to measure these changes. (Choe et al, 2006). Physical and chemical changes during the process of frying are illustrated in Fig1.

IV. RE-FILLING OR ADDING FRESH OIL
If adding a larger proportion of the fresh oil to the total oil, the quality of frying oil is improved. Frequent addition of fresh oil decreases the formation of polar compounds, di-acyl glycerol and free fatty acids and enhances the quality and duration of frying oils. Researchers showed that refilling the fryer with fresh oil improves the quality of oil, only up to the 30th frying time. (Romero et al, 1998; Sánchez et al, 1993).
Foam: As the oil degradation increases, formation of foam happens. While deep frying, with increment of the viscosity, bubbles o foam are enlarged. Air and oil are more in touch and oxidation is intensified. Polymerization of oil decreases the surface tension causing the bubbles to be trapped in water vapor and reach the stability.
Hue: determining the hue in oils can be an effective method to be used as an index. Considering the right time to change the oil for frying can provide information on oil changes.Viscosity: Viscosity demonstrates relative oil resistance against flow. In other words, viscosity is defined as internal friction of a given molecule, at specified temperature and pressure. Viscosity is a indicator for detection of the oil. It is also proved to be an important factor in assessing the quality of the oil used in the frying process, because in the final stages of frying, the oil viscosity increases due to oxidation and polymerization. Generally, the viscosity of saturated fatty acids is more than the viscosity of unsaturated fatty acids. Thus, oils containing higher amounts of saturated fatty acids, they are expected to show a higher viscosity(Haddad Khodaparast,1994).

Food antioxidants
Natural or synthetic antioxidants affect frying oil quality during the deep frying process. Antioxidants are compounds that are capable of preventing or delaying the rapid expansion of off-flavors and undesirable tastes which are products of oxidation. Induction period of
edible fats and oils is delayed in the presence of antioxidant compounds. Antioxidants function varies under certain conditions, including food processing and storage environment. One of the efficient methods of Stabilization of frying oils is addition of synthetic antioxidants in it. In addition to natural antioxidants like rosemary extract tocopherols, synthetic types such as ascorbil palmitate (AP unauthorized) and authorized synthetic antioxidants such as Butyl hydroxy toluene (BHT), Butyl hydroxy anisole (BHA), Propyl gallate (PG) and Tetra butyl hydroquinone (TBHQ) and citric acid are also used. (Lilon et al, 2008)

The mechanism of function

1. Primary antioxidants: These types of antioxidants cut off free radical chain reactions with providing hydrogen and produce stable free radicals that cannot participate in the initial stage or release of oxidative reactions.

2. Secondary antioxidants: These antioxidants protect the fats against non-radical compounds by trapping oxygen, inhibiting ion - metal and decomposing the peroxide (Lilon et al,2008).

The general conclusions
Therefore we conclude that proper oil for frying should be resistant to high temperatures. The amount of fresh oil added while frying, frying time and temperature, heating method, initial quality of oil, Food constituents, fryer type, type and concentration of the anti oxidant such as oxygen, are factors affecting oil quality during frying. Mentioning the advantages of frying oil, it can affect the taste and texture of the food, while creating a cover and coloring up the product, and it can help in increment of product's oil, heat transfer, blanching and deactivation of microorganisms or inhabitation of pathogens. Damaging chemical reactions during the frying process include hydrolysis, oxidation and polymerization. The chemical structure of the compounds generated during frying, depends on many factors including the type of oil and food, frying conditions and oxygen availability.

Table 1 .properties of different edible oil

<table>
<thead>
<tr>
<th>oil</th>
<th>Consolidation</th>
<th>Melting point(degrees of centigrade)</th>
<th>durability (AOM hour)</th>
<th>Unsaturated fatty acids (percent)</th>
<th>Satureted fatty acids (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Refined oil</td>
<td>Bright liquid</td>
<td>liquid</td>
<td>10 to 25</td>
<td>34 to 61</td>
<td>13 to 27</td>
</tr>
<tr>
<td>Salad oil</td>
<td>Bright liquid</td>
<td>liquid</td>
<td>16 to 20</td>
<td>54 to 60</td>
<td>14 to 21</td>
</tr>
<tr>
<td>Shortening liquid</td>
<td>Turbid liquid</td>
<td>33 to 37</td>
<td>35</td>
<td>35 to 40</td>
<td>15 to 20</td>
</tr>
<tr>
<td>shortening</td>
<td>Plastic solid</td>
<td>46</td>
<td>40</td>
<td>15 to 20</td>
<td>20 to 30</td>
</tr>
<tr>
<td>Animal fat</td>
<td>solid</td>
<td>46 to 52</td>
<td>75</td>
<td>2 to 4</td>
<td>45 to 50</td>
</tr>
<tr>
<td>Plant oil</td>
<td>solid</td>
<td>41 to 43</td>
<td>200</td>
<td>4 to 8</td>
<td>2 to 25</td>
</tr>
</tbody>
</table>

REFERENCES


