Effects of repeated deep frying on the peroxide value of edible oils

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Abstract:

Edible oils can be spoiled when exposed to high temperatures during frying several times, which leads to the formation of different compounds such as peroxides.

Peroxides are the main chemical indicator of deterioration in the quality of edible oils. In this study, the peroxide value (PV) was determined for different brands of edible oil, which are purchased from Tripoli supermarkets.

The edible oil samples were divided into two groups. The first group CO is four samples of edible oil that are produced from corn, and the second group SF is five samples that are made from sunflower. The iodometric method was applied for measuring PV, the experiment was repeated three times for each sample, the results showed that there was an increase in the PV for all CO samples after each frying, It was noted that the peroxide value was higher in each frying for samples CO2 and CO5 this may be due to the quality of the oil. As for the SF group, the obtained results indicated that the PV was higher than the CO group for each frying; it reached 8.64 mEq\kg and 11.34 mEq\kg in the 2nd frying for SF2 and SF4, respectively, while in the 3rd the PV in SF4 reached 12.5 mEq\kg.

Keywords- determination, peroxide value, Edible oil, frying, iodometric.

Introduction

Edible oils are produced from vegetable and animal sources; they are essential in cooking and food preparation worldwide. The most common vegetable oils used for cooking purposes are corn oil, peanut oil, palm oil, olive oil, and coconut oil. Edible oils are extracted from the seeds, fruits, or nuts of plants, while animal oils are obtained from animal sources such as fish oil. [1].

The significant increase in the production and consumption of edible oils is due to the growth in the global population and increasing demand for food, including edible oils. Recently, awareness of the health benefits associated with some oils has increased, such as olive oil, avocado oil, and coconut oil, which are being promoted as having good health benefits compared to traditional oils such as vegetable oil or corn oil. Due to the growing global demand for edible oils, the last two decades have seen a significant increase in production of 140% [2]. The increase in demand for edible oils is due to the crucial role they play in human nutrition, as they act as carriers of fat-soluble vitamins such as A, D, E, and potassium, and also contribute significantly to the availability of the basic energy that the human body needs. [3]. the frying, particularly of potatoes, accounts for a significant portion of the oils used in culinary applications. Edible oil has become the main ingredient for the preparation of fries, crisps, or other fried foods in general. Deep-fat frying has a long history of preparing food, cooking oils were used decades ago, dating back to around 1600 BC [4].

The high temperatures of edible oil during frying may cause degradation and changes in the composition of the oil. The recommended temperature for frying foods is 180 °C, but it is always higher than 180 °C in deep-fat frying [4]. This higher temperature allows achieving the desired crispy texture and quick cooking times. However, it also leads to some oil absorption by the food being fried.

Mostly, the surface of fried foods absorbs large amounts of oil, it reaches between 9% and 15% [5]. These oils, which were exposed to high temperatures during cooking, may have a high peroxide value, which may cause some health problems.

In the presence of influential conditions such as heat or light, atmospheric oxygen reacts with the components of oils, causing a change in the chemical composition of the oils due to the formation of off-flavors and changes in color as well as loss in nutritional quality [6]. Hydroperoxides are among the first compounds that are formed during the oxidation of oils, which leads to a loss of food quality and is harmful to human health [7]. Recent studies have indicated some health effects on humans, such as atherosclerosis, liver damage, and intestinal tumors [8,9].

It is important to periodically monitor Edible oils by determining the peroxide value (PV, mEq /Kg). The peroxide value is determined by iodometric titration [10], by adding an excess of potassium iodide to the oil sample. Peroxides react with potassium iodide. The liberated iodine is then titrated with a standard solution of sodium thiosulfate until the dark color disappears [10].

This study aimed to focus on: the determination of the peroxide value in the different brands of edible oil samples purchased from Tripoli markets.

Experiment

Regents

Acetic acid CH_3COOH p.a (WinLab); chloroform p.a (BDH); potassium iodide p.a (Merck), , Sodium thiosulfate (Merck), starch (T-Baker).

Sampling

Nine samples of different types of edible oils were purchased from Libyan markets five types of corn oil (CO) and four types of sunflower oil (SF).

Samples preparation

The procedure consisted of the following steps:

Step 1: The samples were analyzed without any treatment (sample 0).

Step 2: Small amounts of fresh potatoes were added to the 300 mL of heated oil, and the time of frying continued for 8.0 min, 50 ml of oil was collected and kept in the stoppered flask (sample 1^{St}).

Step 3: The frying was repeated for another 8 min. by adding a new amount of potatoes to the same oil in step 2, new 50 mL were collected in the flask (sample 2^{nd}).

Step 4: the frying was repeated for 8.0 min. more by adding a new amount of potatoes to the same oil in step 3, new 50 ml of oil was collected and kept in the stoppered flask as (sample 3^{rd}).

All experiments were conducted at a frying temperature between 180 °C and 190 °C [4].

The PV was determined in all samples by the iodometric method.

Procedure

The iodometric titration method was applied according to [11], to accurately weigh 10–12 g of oil sample in an Erlenmeyer flask, 30 ml of acetic acid – chloroform mixture was added to the sample, shaken well, and then 1 ml of saturated potassium iodide was added, shake for 1 min., after that added 30 ml distilled water and mix well again for 1 min, finally start titration by adding sodium thiosulfate, using 0.5 ml of 1% starch solution. The procedure was repeated three times for each frying.

Result and Discussion

Two groups of edible oils available in the Libyan markets, corn oil (CO group) and sunflower oil (SF group), which are commonly used for frying, were selected, for determining peroxide values (PV).

- The results in Table 1 showed that the PV of all samples of the CO group were increased after each frying, it was noted that the increase in the peroxide value was almost acceptable, as it was close to between 3.0 and 5.0 mEq\kg in the sampled CO1, CO3, and CO4.

Table 1:- The peroxide value of the CO group, before and after each frying batch.

PV (mEq\kg)				
Sample	**0**	**1st**	**2nd**	**3rd**
CO 1	0.633±0.0506	1.0845±0.0022	1.4171±0.0544	2.9515±0.0043
CO 2	2.386±0.0126	2.9582±0.0027	5.692±0.0077	7.391±0.02757
CO 3	1.934±0.146	1.975±0.0042	3.016±0.0537	3.112±0.378
CO 4	2.142±0.056	2.267±0.0032	3.918±0.0201	4.933±0.0066
CO 5	2.932±0.00764	5.599±0.00151	8.636±0.0402	9.211±0.0278

* 0.0 – Before Frying, 1st – After frying the first batch of finger potatoes, 2nd - After frying the second batch of finger potatoes, 3rd - After frying the third batch of finger potatoes.

While the PV in the CO2 and CO5, were increased after each frying, as the concentration reached between 7 mEq\kg and 9 mEq\kg respectively in the third fry, it was close to the maximum permissible limit of 10 mEq\kg. This is an indication of the importance of paying attention to the quality of the oil and avoiding re-frying more than twice**.** In cases of high concentrations of peroxide, a rancid taste is usually perceptible [12]. However, the PV value of all CO samples before and after frying was acceptable and did not exceed the maximum permissible limits in edible oils, as shown in Figure 1. The experiments were repeated three times for each sample, and the relative standard deviation (RSD) was between 0.026 % - 12.15 %.

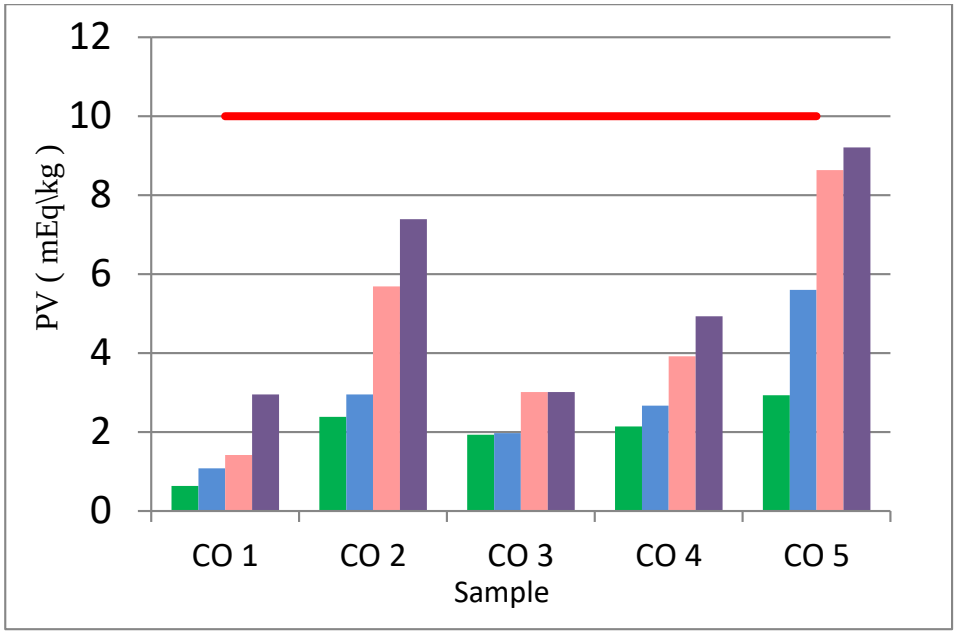

Figure 1. Comparing the results of the CO group with the permissible limits of PV.

- The results of the SF group are presented in Table 2. The results obtained demonstrate a rise in PV after each frying of all samples, this is normal as a result of the exposure of oils to the heat several times.

Table 2:- The peroxide value of the SF group, before and after each frying batch.

PV (mEq\kg)				
Sample	**0**	**1st**	**2nd**	**3rd**
SF 1	0.498±0.001	2.661±0.0072	5.879±0.0036	7.584±0.0213
SF 2	2.928±0.0068	5.602±0.0066	8.644±0.0218	9.2413±0.0105
SF 3	2.704±0.00665	4.809±0.0185	5.067±0.0503	6.699±0.0142
SF 4	1.346±0.0584	7.2148±0.646	11.34±0.7448	12.503±0.4438

* 0.0 – Before Frying, 1st – After frying the first batch of finger potatoes, 2nd - After frying the second batch of finger potatoes, 3rd - After frying the third batch of finger potatoes.

The increase in the PV in the samples SF1 and SF3 is almost normal and can be overlooked because the peroxide values did not exceed approximately 7.5 mEq\kg in the **3rd** frying, which is less than the maximum permissible limit.

While, the increase in the PV is evident in the sample SF2, where it reached 8.64 mEq\kg in the second fry and 9.24 mEq\kg in the third fried. These results give us an indication to pay attention to this brand of oil and avoid using it for frying more than once. For sample SF4, the results showed an increase in PV from 1.3 mEq\kg before the first frying to 12.5 mEq\kg after the third frying. In this case, the PV increased, which is attributed to the oil quality [13] which is capable of changing the chemical composition [14]. The changes in the chemical and physical composition of edible oil during frying several times affect the surface area of food, and the absorption of large amounts of oil on the surface of foods [7, 12,15]. When edible oil is exposed to high heat due to use several times, hydroperoxide compounds form, which release the flavor in the oil[13, 16],

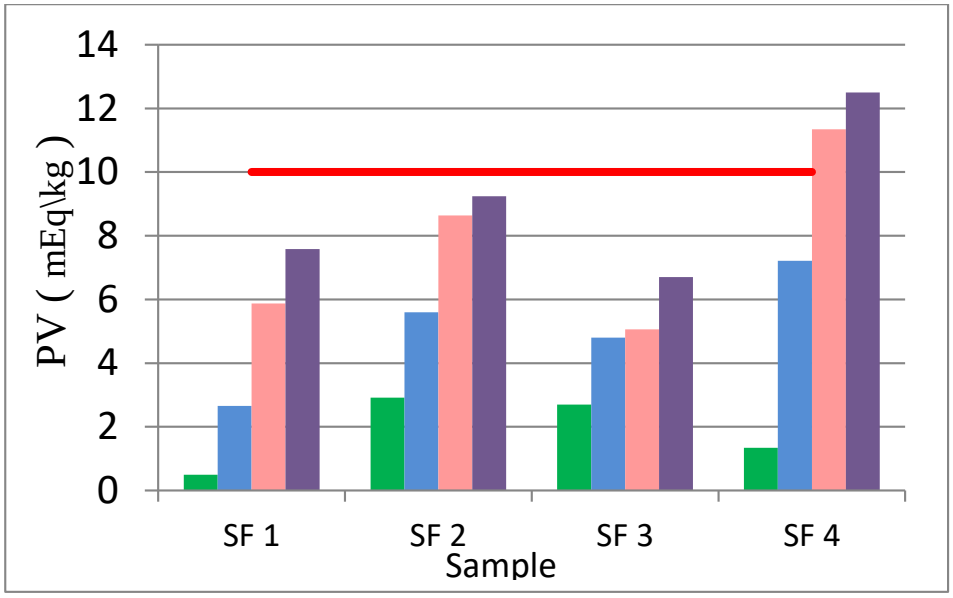

Figure 2. Comparing the results of the SF group with the maximum permissible limits of PV

In Figure 2, the peroxide values for each sample and the maximum allowable value are compared, the results indicated that sample SF5 was higher than the permissible limit. The RSD of SF group was between (0.06 % - 9.07 %). it's important to exclude this brand from the market or avoid using it multiple times to fry, as several volatile and non-volatile products from the degradation of edible oil during cooking were described [17,18], Such as glycerol-bound, alcohol, aldehydes, acids, and ketones [19].

Conclusion

In this study, the peroxide value was estimated as a main factor to identify the change in the chemical properties of edible oil, which is produced due to the degradation of oil during cooking. It caused important changes, such as the release of odors.

Nine different samples of edible oils were divided into two groups, the first, group five samples of oils produced from corn (CO), and the second group, four samples of oils produced from sunflower (SF). All samples were purchased from the supermarket. The results obtained from the CO group showed that the PV of samples CO1, CO3, and CO4 were within the permissible limits, while the PV of samples CO2 and CO5 were also within the permissible limits, but the peroxide values were significantly higher after each frying, where the PV reached very close to the 10 mEq/Kg.

Whilst the results obtained from the second group (SF), indicate that the PV is incrementally increasing in all samples, it was noted that the PV of the 3rd frying for samples SF1 and SF3 is very close to the maximum permissible. The results of the second frying of SF4 showed that the PV exceeded the limit, reaching 11.34 mEq/Kg, and then continued to increase the PV in the third frying, exceeding 12.0 mEq/Kg. However, it was observed that the PV of the edible oil samples produced from sunflowers was higher than samples of edible oil produced from corn.

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