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# Comparative Analysis of the Effects of packaging types on Some Selected Edible Oils in Egypt

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**Abstract** Recent research has shown that storage of edible oils in different packaging materials at ambient temperature with exposure to daylight in conditions similar to those stored in local stores may affect negatively on their physiochemical properties producing unacceptable characteristics taste or odour. in this study; five edible oils: sunflower, corn, cotton seed, palm, and soybean oils were collected from the local markets in Damnhour city, Al Beheira Governorate, Egypt, were packed at three packaging materials (PET, clear glass and, dark glass bottles), for 18 months storage period. Some of their physicochemical properties were determined and compared to recommended values The effect of storage and packaging materials on these oils was also examined. The results showed that most of these oils have acceptable properties values at the beginning of storage as compared to recommended values except palm oil showed higher acid value and peroxide value. At the end of storage, over18 months, the highest rate of peroxidation was recorded for the palm oil. Whereas, sunflower oil showed the lowest rate of peroxidation and degradation during storage at room temperature. The highest rate of peroxidation, and acid value was observed in edible oils stored in PET bottles while, dark glass bottles showed the lowest values of peroxide and acid values for all oil samples under study. It seems that dark glass bottles, followed by clear glass bottles are suitable containers for selected oils that protect oil against oxidative deterioration, whereas, the PET bottles with the low oxidative stability is unsatisfactory.

**Keywords** packaging materials, edible oils , peroxide value, acid value, saponification value, iodine value

## Introduction

Oils and fats play avital role in the human diet [1], it provides us with energy, and important for some vitamins that only dissolve in fat. The main components of edible oils are triglycerides. While, the minor components, including about 2% of the composition: mono and diglycerides, free fatty acids, sterols, fat-soluble vitamins, tocopherols, pigments, waxes, and fatty alcohols. The free fatty acid content of crude oil differs, widely, based on its source. Chemically, fats or oils are tri esters of glycerol and fatty acids [2]. “Oils” are usually, liquids at room temperature, except palm oil, which is semi-solid in room temperature. Edible oils industry is one of vital industries in Egypt as it is considered astrategic food commodity [3].

The number of edible oils consumed in Egypt is around 2.5 million tons per year [4] about 48.5 thousand tons of which are produced by oilseed extraction in local extraction plants. Egypt produces only 2% of its edible oil consumption needs through the extraction of local and imported oilseeds; the remaining 98% is imported Therefor, there is a gap of 97% in the production of oils in Egypt [5].

The majority of shelf life [6] research has focused on comparative evaluations using oxidative changes of edible oils stored in different packaging materials. Packaging can directly [6] influence edible oil quality by protecting the

product from both light and $O_2$. The shelf life of the oils packaged in PET bottles to be the shorter while oils packaged in glass bottles to be the better to use.

Many different kinds of packaging materials are used for edible oils: glass bottles, PET, plastic bottles, and paper-based cartons. PET is one of the most common type of plastic used in packaging food, and covers awide range of packaging materials [7]. It satisfies many important needs of packaging such as; suitability for coloring; thermal, and chemical resistance; recyclable material; suitability for short storage, and has low weight comparing it to glass bottles Glass is considered a healthy container,even though it has major disadvantages ,e.g. it is fragile and cumbersome [8]. The selection of the type of package to be used is generally done on the basis of marketing and economic puproses; however, proper packaging will in many cases provide conditions to assure convenient shelf life for distribution and marketing, Glass and different types of plastic bottles are all used for packaging of oil in Egypt, while Plastic bottles are considered to be the most famous for bottling oils in Egypt, due to their outstanding functionality.

Few research's published about the effect of packaging type on oil quality have concluded that stability can be enhanced by suitable selection of packaging [9]. The aim of the present work was therefor to examine the effect of selected packaging materials (Glass, and plastic) on the quality of edible oils during storage by studying the physicochemical properties.

vegetable oils selected for this study were; palm olein, corn, soybean, cotton seed and, sunflower. The selection of these oils was due to the high relative reaction rates of their unsaturated fatty acids with oxygen and their common use as cooking purpose [10]. Physicochemical properties [11] like Specific gravity, refractive index, Acid value, peroxide value, and, saponification and iodine values of sunflower, corn, cotton seed, Palm olein and soybean oils samples were studied to evaluate the compositional quality of these oils and also to investigate the effect of different packaging materials on long term storage as it greatly changes the physicochemical, nutritional and sensory properties of these oils.

Due to limited published researches on oils in Egypt and its importance on public health, edible oil quality analysis is required. Therefore, another important aim of the study was to assess qualities of edible vegetable oils accessed in Egypt, regarding physicochemical properties.

## Objective of the Study

### General Objective:

The main objective of this study was to determine the effect of storage and packaging type on the physical and chemical properties of edible oils under study.

### Specific Objectives:

1. To choose a suitable storage method for any edible oils.
2. Comparison of edible oil qualities between different types of oils (soybeans, corn, cotton seed, sunflower and palm olein ) which are the main types of edible oils consumed in Egypt.
3. To examine the stability behaviour of the oils during storage at room temperature.
4. To observe the effect of time on the oxidative stability of the oils.
5. Determination the shelf life of the selected oils.
6. To study oxidation and oxidative stability of the edible oils under study by FTIR tool which is an alternative to other traditional methods.

## Material and Methods

### Oil samples:

15 samples of the selected edible oils (sunflower, corn oil, palm olein oil, cotton seed oil and, soybean oil) were collected from local supermarkets in Damanhur city, El Behrira Governorate, Egypt. Packaging materials, used for storage of oil samples were PET, dark glass and, clear glass bottles. these oils were used in their recommended consumption periods. The initial physicochemical characteristics of the studied oils are shown in table 1.

**Oil packaging and storage period:** The samples were collected randomly using dried and cleaned one litre volume bottles in three different materials of packaging's:

1. Clear glass packages.
2. PET packages (polyethylene terephthalate).
3. Dark glass packages.

The three different types of packages bottles were purchased from local market of Damnhour city.

All of these were stored at room temperature (25 °C) with exposure to daylight in conditions in conditions similar to being stored in a supermarket. until they were required for analysis for the period of 18 months between period, three months interval, the physical and chemical properties of samples ( refractive index, specific gravity, peroxide value, acid value, iodine value, and saponification value ) are examined by standard methods of AOCS [12]: Standard physicochemical analyses American Oil Chemists' Society official methods were used for determining refractive index, acid value, specific gravity, iodine value, peroxide value and saponification value.

**Quality assurance**

For quality assurance, instrument and chemicals calibration and pre-test for functionality of instruments were conducted before analysis. Blank measurements must be involved and all the measurements were done triplicate wise. Standard analysis methods were followed.

**Reagents**

All chemicals and reagent used were of analytical grade. In the present study; Silver nitrate, Ethanol 95%, Diethyl ether, n-hexane, heptane, ph.ph., Hydrochloric acid, Glacial acetic acid, Chloroform, potassium hydroxide, potassium iodide, were obtained from Sigma-Aldrich, USA. Acetic anhydride & Sulphuric acid (Sigma-Aldrich).

**Specific gravity:**

Is defined as the ratio of the weight of edible oil sample to that of equal volume of water. A dry density bottle with its stopper was weighed $W_1$ filled with the oil sample, covered with its stopper and re-weighed $W_2$. The density bottle was washed, drained, filled with water and weighed $W_3$.

Specific gravity of oil $W_2$-$W_1$/$W_3$-$W_1$ where, $W_1$ = weight of density bottle with its stopper (g) $W_2$ = weight of density bottle with its stopper + oil (g) $W_3$ = weight of density bottle with its stopper + water (g).

**Saponification value:**

The saponification value is the amount of alkali necessary to saponify a definite quantity of the test sample. It is expressed as the number of milligrams of potassium hydroxide (KOH) required to saponify 1 gram of the oil sample.

**The refractive index:**

The refractive index of the selected oils in the study was determined according to the AOCS [12] official method using an Abbe Refractometer at 20 °C.

**Peroxide value:**

Edible Oil samples were examined for peroxide value using AOCS Cd 8b-90 method [13]. In 250 mL conical flask 5 g oil sample was weighed firstly. The conical flask was then filled with 30 mL solution (3:2) of glacial acetic acid: chloroform and rapidly shaken. Then 0.5 mL of saturated KI solution was added into the flask and shaken for 1 min. After adding 30 mL of distilled water, the solution was titrated with 0.1 N $Na_2S_2O_3$. The flask was shaken vigorously until the yellow colour of the solution got disappeared. The colour changed to blue after a few drops of 1% starch solution as (indicator) were added. The mixture was again shaken until the blue colour got disappeared. Blank titration was done twice using the same method. The Peroxide value was calculated using the formula below:

Peroxide Value = $[(V\ sample - V\ blank) \times N \times 1000]/W$ where, N is normality of $Na_2S_2O_3$, W weight of oil sample.

**Acid value (AV) (free fatty acid):**

The acid value (calculated as oleic acid percentage) was determined according to the AOCS official methods [12]. Free Fatty Acid (Acid Value): Weigh 10 g of edible oil, Dissolve the sample in hot 100 ml of neutralized ethyl alcohol (95%) and titrate using 0.1 N KOH using ph.ph. as indicator. Shake vigorously during titration and keep the solution warm.

$$\text{Acid value} = \text{ml of alkali} \times N \text{ of alkali} \times 56.1/W \text{ of oil sample (gm.)}.$$

**Iodine value:**

A 0.01gm of oil sample was weighed into a 500mL volumetric flask. 15mL of carbon tetrachloride was added to the oil sample and swirled to ensure that the sample is completely dissolved. 25mL of Wijs solution was then dispensed into the flask containing the sample using a pipette. The flask was stoppered and swirled to ensure complete mixing. The sample was then placed in the dark for 30 minutes at room temperature. The flask was removed from storage and 20mL of 10% potassium iodide (KI) solution added, followed by 150 mL of distilled water. The mixture was titrated with 0.1N sodium thiosulphate (Na2 S2 O3) solution, adding gradually and with constant and vigorous shaking until the yellow colour had almost disappeared. 1.5mL of starch indicator solution was added and the titration was continued until the blue colour disappeared. A blank determination was conducted simultaneously. The iodine value was calculated using the formula below:

$$\text{Iodine number} = 12.69x(v2 - v1)xN/W$$

Where, N = normality of sodium thiosulphate solution, V1 = volume of sodium thiosulphate solution used in test, V2 = volume of sodium thiosulphate solution used in blank, W = weight of sample

**Spectral Studies:**

The infrared spectra of the selected edible oils were obtained using The Bruker Tensor 37 FTIR instrument which is located in the central lab, Alexandria University, covering frequency range of 400 - 4000 $cm^{-1}$ and the data recorded and refined by OPUS Data Collection Program.

**Statistical Analysis:**

Three bottles of each oil type were independently analysed in each interval period (3, 6, 9, 12, 15, and 18 months). The results are expressed as mean.

**Determination of the chemical and physical parameters of edible oils:**

The chemical and physical parameters were performed for edible oil samples using titrimetric and titration method following standard procedures described for the determination of acid value, saponification value, and peroxide value, the physical parameters were detected also.

**Results and Discussion**

**Table 1:** Initial quality of some selected edible oils in Egypt.

| Parameter | Sunflower oil | Corn oil | Cotton seed oil | Palm olein oil | Soybean oil |
|---|---|---|---|---|---|
| RI | 1.467 | 1.468 | 1.472 | 1.458 | 1.470 |
| Sp.gr | 0.920 | 0.922 | 0.925 | 0.910 | 0.921 |
| Acid value (mg KOH/g oil) | 0.08 | 0.11 | 0.15 | 0.21 | 0.13 |
| PV (meq$O_2$/Kg) | 2.12 | 2.50 | 3.22 | 3.55 | 3.00 |
| Saponification value ((mg KOH/g) | 190 | 188.00 | 194.00 | 198.00 | 193.00 |
| Iodine value (g I2/100g oil) | 120 | 130.03 | 123.00 | 58.00 | 128.00 |

- Storage at average room temperature 25°C for at zero time of storage.

Some chemical and physical characteristics of sunflower, corn, cotton seed, palm olein and soybean oils before storage process have been extensively investigated in Table 1. The data of specific gravity values, refractive index values, iodine values, saponification value, peroxides values, acid values as showed in Table 1. The initial physicochemical characters of the selected vegetable oils used in this study indicated that all the oils were of relatively good quality [14].

**Refractive index:**

Refractive index is a crucial quality for edible oil [15], refractive index for edible oils may be used to identify edible oils that are rancid as well as to give information about the purity of the oil. This value has a specific range for each oil, and a departure from the established specification may signify oil adulteration [16]. Initially, according to the obtained data in Table 1, refractive index was determined at the beginning of storage of the selected oils were in rang of recommended values listed in codex [17]. These variations in refractive indices of the corresponding oils under study were due to their structure, chain length and the differences in fatty acid composition of these edible oils, especially linoleic acid (C18:2) content [18].

Refractive index (RI) of the edible oils under study were increased at the end of storage period as shown in Table 2, The amount of RI increment in sunflower oil (0.017, 0.015, 0.012 unit from initial) for samples stored in PET, clear glass and dark glass bottles respectively. was similar to that corn oil samples 0.021, 0.016, and 0.014 unit from initial for samples stored in PET, clear glass and dark glass bottles respectively, while The amount of RI increment in cotton seed oil (0.019, 0.018, and 0.015 unit from initial, was similar to that soybean oil samples 0.02, 0.017, 0.011 unit from initial for samples stored in PET, clear glass and dark glass bottles respectively and the amount of RI increment in palm oil samples 0.017, 0.015, 0.014 unit from initial for samples stored in PET, clear glass and dark glass bottles respectively. However, due to storage conditions in 3 different packages for 18 months, at all stages, a gradual increase was observed in RI values, highest refractive index was observed for oil samples stored in PET packages (1.484, 1.489, 1.491, 1.475, and 1.490) followed by samples stored in clear glass (1.482, 1.484, 1.490, 1.473, and 1.487). This means that the packaging with the longest shelf life for oils is glass packaging.

**Table 2:** Change of refractive index during storage period as a function of packaging type.

| Edible oil | Storage period(months) | PET | Clear glass | Dark glass |
|---|---|---|---|---|
| Sunflower oil | 3 | 1.468 | 1.467 | 1.468 |
| | 6 | 1.470 | 1.468 | 1.470 |
| | 9 | 1.473 | 1.471 | 1.472 |
| | 12 | 1.478 | 1.475 | 1.473 |
| | 15 | 1.480 | 1.478 | 1.475 |
| | 18 | 1.484 | 1.482 | 1.479 |
| Corn oil | 3 | 1.472 | 1.470 | 1.469 |
| | 6 | 1.478 | 1.475 | 1.473 |
| | 9 | 1.480 | 1.477 | 1.479 |
| | 12 | 1.482 | 1.480 | 1.481 |
| | 15 | 1.484 | 1.482 | 1.482 |
| | 18 | 1.489 | 1.484 | 1.479 |
| Cotton seed oil | 3 | 1.473 | 1.474 | 1.472 |
| | 6 | 1.476 | 1.477 | 1.474 |
| | 9 | 1.484 | 1.482 | 1.479 |
| | 12 | 1.488 | 1.486 | 1.484 |
| | 15 | 1.490 | 1.489 | 1.487 |
| | 18 | 1.491 | 1.490 | 1.487 |
| | 3 | 1.460 | 1.459 | 1.458 |

| | | | | |
|---|---|---|---|---|
| Palm olein oil | 6 | 1.464 | 1.460 | 1.461 |
| | 9 | 1.468 | 1.463 | 1.464 |
| | 12 | 1.470 | 1.465 | 1.466 |
| | 15 | 1.471 | 1.468 | 1.469 |
| | 18 | 1.475 | 1.473 | 1.472 |
| Soybean oil | 3 | 1.476 | 1.473 | 1.471 |
| | 6 | 1.479 | 1.477 | 1.473 |
| | 9 | 1.484 | 1.481 | 1.478 |
| | 12 | 1.487 | 1.485 | 1.478 |
| | 15 | 1.489 | 1.487 | 1.480 |
| | 18 | 1.490 | 1.487 | 1.481 |

- At average room temperature ($25^0$C), storage period 18 months.

Palm olein oil exhibited the highest increase in refractive index value, at 25°C after 18 months storage time, while sunflower oil exhibited the lowest increase in refractive index value, at 25°C after 18 months storage period.

**Specific Gravity:**

Specific gravity is the heaviness of a substance compared to that of water, and it is expressed without units. The specific gravity obtained for all oil samples are less than 1 when measured at 20°C [19].

The specific gravity of the selected edible oils before storage process is as shown in Table 1. it shows that the specific gravity of the selected oils ranges from 0.910 g/ml to 0.925 g/ml with palm olein oil having the least before storage and cotton seed oil having the highest sp.gr. The specific gravities of the edible oils were related to the standard range

The increasing in values of the specific gravities at the end of storage period 18 months as compared with the values at initial time may however be due to the pie (π) bonds that make the bonding more rigid and rotation between C-C becomes more strenuous. as showed in Table 3 Specific gravity values in oil stored in different packaging materials at room temperature increased from 0.920, 0.922, 0.925, 0.910 and 0.921 to 0.924, 0.934, 0.944, 0.921 and 0.940 for sunflower, corn, cotton seed, palm olein and soybean oils stored in PET package which showed the highest increase in specific gravity after 18 months .while, increased to 0.922, 0.934, 0.941, 0.921 and 0.936 for oils stored in clear glass packaging in contrast 0.922, 0.932, 0.941, 0.919 and 0.934 for sunflower , corn, cotton seed, palm olein and soybean oils stored in dark glass packaging.

**Table 3:** change of specific gravity during storage period as a function of packaging type.

| **Edible oil** | **Storage period(months)** | **PET** | **Clear glass** | **Dark glass** |
|---|---|---|---|---|
| Sunflower oil | 3 | 0.920 | 0.919 | 0.920 |
| | 6 | 0.921 | 0.920 | 0.921 |
| | 9 | 0.922 | 0.921 | 0.921 |
| | 12 | 0.923 | 0.923 | 0.922 |
| | 15 | 0.925 | 0.922 | 0.923 |
| | 18 | 0.924 | 0.922 | 0.922 |
| Corn oil | 3 | 0.923 | 0.922 | 0.921 |
| | 6 | 0.924 | 0.923 | 0.924 |
| | 9 | 0.925 | 0.927 | 0.926 |
| | 12 | 0.928 | 0.930 | 0.929 |
| | 15 | 0.932 | 0.934 | 0.931 |
| | 18 | 0.934 | 0.932 | 0.932 |
| | 3 | 0.927 | 0.925 | 0.926 |
| | 6 | 0.931 | 0.931 | 0.928 |

| | | | | |
|---|---|---|---|---|
| Cotton seed oil | 9 | 0.935 | 0.933 | 0.931 |
| | 12 | 0.938 | 0.936 | 0.934 |
| | 15 | 0.942 | 0.938 | 0.937 |
| | 18 | 0.944 | 0.941 | 0.941 |
| | 3 | 0.912 | 0.911 | 0.910 |
| | 6 | 0.913 | 0.912 | 0.911 |
| Palm olein oil | 9 | 0.915 | 0.914 | 0.913 |
| | 12 | 0.917 | 0.918 | 0.916 |
| | 15 | 0.918 | 0.920 | 0.918 |
| | 18 | 0.921 | 0.921 | 0.919 |
| | 3 | 0.923 | 0.922 | 0.923 |
| | 6 | 0.926 | 0.925 | 0.924 |
| Soybean oil | 9 | 0.930 | 0.927 | 0.927 |
| | 12 | 0.933 | 0.930 | 0.928 |
| | 15 | 0.937 | 0.933 | 0.931 |
| | 18 | 0.940 | 0.936 | 0.934 |

- At average room temperature (25 $^0$C), storage period 18 months.

**Peroxide Value (PV):**

Peroxide value (PV), a measure of total peroxides [20] in edible oil (meq.$O_2$ $kg^{-1}$ oil or fat) is a major guide of edible oil quality [21]. The Peroxide Value is a measure of the active oxygen bound by the oil which reflects the peroxide value, and measures the degree of oil peroxidation.

Peroxide value is used as a measure of the extent to which rancidity reactions have occurred during storage. The Peroxide value before storage ranges for all selected edible oils under investigation are closely related to the standard add to that sunflower oil and corn oil showed lower mean peroxide values 2.12 and 2.50 meq.$O_2$/kg oil, for recently refined edible oils, the peroxide value should be close or equal to zero and should not 0.5 meq.$O_2$ /kg [22]. The results showed that some fresh refined oils had exceeded that limit (Table .1). This can be attributed to the time gap between production process of oils and analysis, The low mean peroxide values in sunflower and corn oils indicated the relative initial quality of these oils than the others oils while, cotton seed, soybean and, palm olein oils showed a little increase in initial mean peroxide values, in the ranges 3.00 -3.50 meq $O_2$/kg oil which indicates a relatively lower quality of these oil although agreement with the standard. In case of storage the samples at room temperature for 18 months it was noticed that gradual increase in peroxide value for all samples until the nine month storage then peroxide values decreased to show increasing again at the end of storage, the peroxide values reached 10.78, 11.43, 12.06, 15.21, and 14.00 for, sunflower, corn, cotton seed, palm olein, and soybean oils ( in case of dark glass) which considered to be lower than peroxide values of contrast samples stored in PET package obtained 10.43, 11.31, 11.70, 14.40, and 13.31 meq$O_2$/kg oil Similar results have been obtained before [23]. A remarkable gradual increase in the peroxide value was observed in all types of packaging materials at the nine storage month to 9.00, 9.04, and 8.44 meq$O_2$ /kg for sunflower oil at PET, clear glass, and dark glass bottles, 9.55, 9.34, and 9.02 meq$O_2$ /kg corn oil at PET, clear glass and dark glass bottles, 10.00, 9.33, and 9.14 meqO2 /kg cotton seed oil at PET, clear glass and dark glass bottles, 9.02, 8.90, whereas peroxides values reached to13.54, 13.22, and 13.17 meq$O_2$ /kg edible oil after nine storage months for palm olein oil, and, 13.48, 13.11, 13.44 meq$O_2$ /kg edible oil for soybean oil this is may be due to the relative temperature in this months of storage.

It was observed that the peroxide value decreased noticeably at the end of storage 18$^{th}$ storage months and it exceeds the limits recommended in the codex standard (10 meq$O_2$ /kg edible oil).

Results in Table 4 showed that the lowest increase between the initial and final peroxide values were at glass dark glass, then both plastic and clear glass for all samples of oil offered the same level in their low ability to keep the quality of edible oil.

the lowest mean peroxide value was reported in oil stored in dark glass, while the other containers maintained similar values, this makes it the most suitable packaging for storing oils.

**Table 4:** Change of peroxide value ($meqO_2/Kg$) during storage period as a function of packaging type.

| Edible oil | Storage period(mon.) | PET | Clear glass | Dark glass |
|---|---|---|---|---|
| | | Packaging types | | |
| Sunflower oil | 3 | 3.44 | 3.08 | 3.11 |
| | 6 | 5.08 | 5.22 | 5.04 |
| | 9 | 9.00 | 9.34 | 9.14 |
| | 12 | 10.33 | 11.00 | 10.51 |
| | 15 | 11.20 | 11.16 | 11.00 |
| | 18 | 10.78 | 10.54 | 10.43 |
| Corn oil | 3 | 4.08 | 4.21 | 3.61 |
| | 6 | 5.11 | 5.30 | 5.20 |
| | 9 | 9.55 | 9.34 | 9.20 |
| | 12 | 11.70 | 11.68 | 10.52 |
| | 15 | 11.51 | 11.52 | 11.00 |
| | 18 | 11.43 | 11.40 | 11.31 |
| Cotton seed oil | 3 | 3.70 | 3.46 | 3.24 |
| | 6 | 5.12 | 5.00 | 5.05 |
| | 9 | 10.00 | 9.33 | 9.14 |
| | 12 | 13.78 | 13.08 | 13.22 |
| | 15 | 13.10 | 12.53 | 12.63 |
| | 18 | 12.06 | 11.77 | 11.70 |
| Palm olein oil | 3 | 5.70 | 5.40 | 5.22 |
| | 6 | 7.00 | 7.04 | 6.86 |
| | 9 | 13.54 | 13.22 | 13.17 |
| | 12 | 15.00 | 14.00 | 14.11 |
| | 15 | 15.21 | 14.63 | 14.79 |
| | 18 | 15.21 | 14.50 | 14.40 |
| Soybean oil | 3 | 5.00 | 4.84 | 4.33 |
| | 6 | 7.12 | 7.00 | 6.82 |
| | 9 | 13.48 | 13.11 | 13.44 |
| | 12 | 14.88 | 14.42 | 0.928 |
| | 15 | 14.54 | 14.08 | 0.931 |
| | 18 | 14.00 | 13.39 | 13.31 |

- At average room temperature (25 $^0$C), storage period 18 months.

**Acid value:**

Acid value is a key feature linked with the quality and commercial value of oils and fats [24,25]. Acid value of the edible oils gives us information about the amount of free fatty acids present in oil sample due to hydrolysis and oxidation of double bonds of the unsaturated acyl chains which produced free fatty acids. Acid value used to understand whether oils have decomposed or oxidized due to inappropriate storage conditions or any other factors that led to such heat or by action of lipase enzyme.

the initial mean acid values for sunflower oil, corn oil, cotton seed oil, palm olein oil, and soybean oil are shown as 0.08, 0.11, 0.15, 0.15, 0.21, and 0.13 (expressed as mg KOH/g), The observed low acidity in sunflower and corn oils indicated that these oils did not undergo hydrolytic processes and may have a relative long shelf life than the others edible oils. Acid value of edible oils is indicative of free fatty acid content of the oil or fat expressed as mg KOH/g, its mains that the initial mean acid value for all edible oils ranges under investigation are closely related to the

standard before storage process. Palm oil has the highest acid value (0.21 mg KOH/g), while sunflower oil has the lowest acid value (0.08 mg KOH/g).

**Table 5:** Change of acid value (mg KOH/g) during storage period as a function of packaging type.

| Edible oil | Storage period (months) | PET | Clear glass | Dark glass |
|---|---|---|---|---|
| | 3 | 0.14 | 0.12 | 0.12 |
| | 6 | 0.21 | 0.18 | 0.18 |
| Sunflower oil | 9 | 0.32 | 0.26 | 0.26 |
| | 12 | 0.48 | 0.42 | 0.42 |
| | 15 | 0.87 | 0.81 | 0.81 |
| | 18 | 1.08 | 1.00 | 1.19 |
| | 3 | 0.17 | 0.16 | 0.17 |
| | 6 | 0.22 | 0.20 | 0.21 |
| Corn oil | 9 | 0.47 | 0.42 | 0.37 |
| | 12 | 0.60 | 0.57 | 0.55 |
| | 15 | 0.92 | 0.85 | 0.84 |
| | 18 | 1.14 | 1.09 | 1.07 |
| | 3 | 0.24 | 0.22 | 0.20 |
| | 6 | 0.33 | 0.31 | 0.29 |
| Cotton seed oil | 9 | 0.47 | 0.44 | 0.45 |
| | 12 | 0.58 | 0.51 | 0.54 |
| | 15 | 1.00 | 1.06 | 1.10 |
| | 18 | 1.31 | 1.22 | 1.40 |
| | 3 | 0.38 | 0.35 | 0.34 |
| | 6 | 0.45 | 0.43 | 0.40 |
| Palm olein oil | 9 | 0.54 | 0.51 | 0.47 |
| | 12 | 0.68 | 0.64 | 0.60 |
| | 15 | 1.44 | 1.37 | 1.33 |
| | 18 | 1.74 | 1.60 | 1.54 |
| | 3 | 0.18 | 0.15 | 0.14 |
| | 6 | 0.24 | 0.20 | 0.19 |
| Soybean oil | 9 | 0.36 | 0.34 | 0.32 |
| | 12 | 0.44 | 0.43 | 0.40 |
| | 15 | 0.63 | 0.61 | 0.57 |
| | 18 | 1.25 | 0.19 | 1.00 |

- Storage at average room temperature 25°C for 18 months.

The acid values of sunflower, corn, cotton seed, palm, and soybean oils stored in containers made from three types of packaging materials (PET, clear glass, and dark glass) during 18 months are shown in Table 5 as expected, a gradual increase in acid values as time of storage increased from zero to 18 month can be observed in all type of storage containers, which was in agreement with the observations recorded by Rababah [23]. The acidity increase could be due to the development of rancidity as the result of free fatty acid hydrolysis. also, it can be noticed that the acid value of palm olein oil before and after storage process had the highest mean values 0.21mgKOH/g (before storage) and 1.74, 1.60, 1.54 mg KOH/g (after 18 months) oil samples stored in PET, clear glass and dark glass bottles compared with sunflower oil had the lowest values at the end of storage 1.08, 1.00, 1.19 mg KOH/g for samples stored in PET, clear glass and dark glass bottles. And corn oil samples at the same range recorded 1.14, 1.00 and 1.07 mg KOH/g for samples stored in PET, clear glass and dark glass bottles.

According to the data obtained in (Table 5), acid values continuously increase during the storage period at ambient temperature in all of the edible oils samples by the end of storage time 18 months, acid values of all oil samples exceeds the limits recommended in the codex standard [17] (0.6 mg KOH/g). The highest mean values were produced by samples stored at PET packages, It was observed that acid value of all samples stored in PET, clear glass and dark glass increased as storage period increased for the samples stored at ambient temperature. But for samples stored at PET package has showed the highest increase. These values were comparable with the values reported in previous studied [26]. In all the selected oils, palm oil samples has the highest peroxide values in comparison to other oil samples, palm oil has the highest increase in acid value after storage period 18 months These values were comparable with the values reported.

**Iodine value:**

The iodine value is an identity characteristics nature of edible oils. The iodine value of an oil or fat is defined as number of grams of iodine absorbed by 100g oil sample. The iodine number gives us information about the degree of unsaturation, the number of C=C double bonds in fats and oils [27]. Iodine value could be used to quantify the amount of double bond present in edible oil which reflects the susceptibility of oil to oxidation process during storage as the iodine no. is a measure for unsaturation of the fatty acids in the fat, the number of double bonds of a pure substance.

Also, Classification of oils and fats as drying, semi drying and non-drying is given as follows according the value of iodine number: Drying oils: Iodine value in range of 200-130, Semi drying: Iodine value in rang of 130-100 and, Non-drying: Iodine value lower than 100 [28]. The iodine values of sunflower oil, corn oil, cotton seed oil, palm olein oil and soybean oil at the initial time of storage were found to be 61.91, 142.96 and 89.86 (g $I_2$/ 100 g oil), respectively. According to Codex standard [17] sunflower oil, corn oil, cotton seed oil, palm olein oil and, soybean oil should have an IV of 118-141, 103-135, 100-123, ≥ 56 and, 124-139 g $I_2$/100g edible oil, respectively.

At zero time of storage (Table 1) corn oil was found to have higher mean iodine value while palm olein oil was found to have lower mean iodine value compared to the standard requirements (codex standard).

**Table 6:** Change of iodine value (g $I_2$/100g edible oil) during storage period as a function of packaging type.

| Edible oil storage | Storage period(months) | PET | Clear glass | Dark glass |
|---|---|---|---|---|
| | 3 | 119.14 | 119.33 | 119.44 |
| | 6 | 117.44 | 118.20 | 119.15 |
| Sunflower oil | 9 | 115.12 | 115.04 | 116.33 |
| | 12 | 113.46 | 113.58 | 115.42 |
| | 15 | 112.11 | 112.84 | 112.68 |
| | 18 | 111.00 | 111.86 | 112.02 |
| | 3 | 129.00 | 129.27 | 129.33 |
| | 6 | 128.06 | 127.66 | 128.33 |
| Corn oil | 9 | 125.84 | 125.00 | 126.14 |
| | 12 | 124.44 | 124.06 | 125.28 |
| | 15 | 122.72 | 120.00 | 123.26 |
| | 18 | 120.54 | 118.12 | 120.11 |
| | 3 | 122.18 | 121.08 | 122.29 |
| | 6 | 119.00 | 119.15 | 120.40 |
| Cotton seed oil | 9 | 118.44 | 118.12 | 119.30 |
| | 12 | 115.04 | 115.88 | 116.16 |
| | 15 | 112.40 | 112.22 | 114.05 |
| | 18 | 110.22 | 110.20 | 111.48 |
| | 3 | 57.00 | 57.26 | 57.20 |
| | 6 | 56.12 | 56.44 | 55.20 |

| | | | | |
|---|---|---|---|---|
| Palm olein oil | 9 | 52.11 | 53.12 | 53.74 |
| | 12 | 47.27 | 48.25 | 49.04 |
| | 15 | 45.90 | 46.22 | 46.18 |
| | 18 | 42.04 | 42.90 | 42.45 |
| | 3 | 126.12 | 126.44 | 127.88 |
| | 6 | 123.18 | 124.07 | 124.28 |
| Soybean oil | 9 | 120.43 | 122.40 | 201.11 |
| | 12 | 119.00 | 120.28 | 213.00 |
| | 15 | 118.28 | 119.65` | 218.42 |
| | 18 | 117.24 | 117.28 | 117.44 |

- Storage at average temperature 25°C for 18 months.

The changes in the iodine value (IV) of the selected edible oils stored in different packaging materials at the end of storage period 18 months at ambient temperature are shown in Table 6. It was observed that IV decreased during the storage and was lowest for the samples stored in dark glass bottles followed by those stored in clear glass bottles. Maximum (IV) was 130.03 initially in corn oil, which decreased to 120.54 and 118.12 by the end of the storage period in PET bottles, clear glass bottles, whereas (IV) decreased to 120.11 dark glass bottles. Minimum (IV) 58.00 was observed in palm olein oil initially which decreased to 42.04 for the sample stored in PET bottle, 42.90 for the sample stored in dark glass bottles and 42.45 for the samples stored in clear glass bottles. The decrease in iodine number of olein oil is considered the greatest, as it decreased by 15.96 units in PET samples 15.1 units in clear glass samples and decreased by 15.55 units in olein oil samples stored in dark glass bottles.

Decrease in the mean iodine values in all edible oil samples under study at the end of storage in the different packaging material types occurs in conjunction with increase in acid value (free fatty acid). The obtained results are in agreement with the previous studies [29, 30].

**Saponification value:**

The determination of the saponification value is based on the breakdown of the oil into its components in glycerol and free fatty acids. Saponification value gives us the information about the average chain length and molecular weight of the fatty acid in the edible oil., the higher the saponification value mains The shorter the average chain length of the fatty acids in oils and vice versa [31]. Initially, from data in Table 1, saponification values of oil samples fall into the permitted standard level by Codex.

**Table 7:** Change of saponification value (mg KOH/g) during storage period as a function of packaging type.

| **Edible oil** | **Storage period(months)** | **PET** | **Clear glass** | **Dark glass** |
|---|---|---|---|---|
| | 3 | 193.00 | 191.64 | 192.21 |
| | 6 | 195.13 | 193.08 | 194.00 |
| Sunflower oil | 9 | 197.06 | 195.00 | 196.22 |
| | 12 | 200.21 | 198.44 | 198.32 |
| | 15 | 204.11 | 201.74 | 203.24 |
| | 18 | 210.00 | 208.00 | 208.75 |
| | 3 | 190.75 | 190.44 | 189.31 |
| | 6 | 193.00 | 191.17 | 192.00 |
| Corn oil | 9 | 193.76 | 192.53 | 192.82 |
| | 12 | 195.06 | 194.32 | 194.00 |
| | 15 | 196.31 | 195.44 | 195.67 |
| | 18 | 198.00 | 197.00 | 197.11 |
| | 3 | 195.53 | 195.66 | 193.38 |
| | 6 | 197.22 | 199.11 | 200.00 |
| Cotton seed oil | 9 | 204.00 | 202.05 | 201.44 |

| | | | | |
|---|---|---|---|---|
| | 12 | 207.33 | 203.91 | 203.17 |
| | 15 | 208.00 | 206.20 | 206.00 |
| | 18 | 211.04 | 207.13 | 207.16 |
| | 3 | 216.11 | 211.74 | 211.98 |
| | 6 | 223.62 | 221.30 | 219.69 |
| Palm olein oil | 9 | 229.05 | 223.44 | 221.00 |
| | 12 | 230.21 | 227.31 | 225.26 |
| | 15 | 232.11 | 231.00 | 229.05 |
| | 18 | 244.00 | 240.11 | 240.22 |
| | 3 | 195.13 | 195.42 | 194.00 |
| | 6 | 199.11 | 197.75 | 198.21 |
| Soybean oil | 9 | 203.12 | 200.77 | 201.11 |
| | 12 | 214.04 | 212.44 | 213.00 |
| | 15 | 220.10 | 217.05 | 218.42 |
| | 18 | 223.15 | 220.02 | 220.62 |

- Storage at average room temperature 25°C for 18 months

The highest saponification value for palm olein oil is 198.00 mg KOH/g due to its high content of short chain fatty acids compared with other oils, so that palm olein oil can be considered as potential to be used for cosmetic industry [32]. The obtained data are relatively in accordance with that data obtained by El Sayed Sadek found that palm oil was characterized by having higher saponification value than soybean oil and sunflower oil [33].

The result of changes in saponification values of sunflower, corn, cotton seed, palm olein and soybean oils stored in different packaging containers PET, clear glass and dark glass bottles under storage conditions at room temperature is shown in Table 7, it can be observed from the results obtained that the saponification values increased gradually in all edible oil samples stored in different packaging types: PET, clear glass and dark glass bottles as storage period increased. The rate of increase in Saponification value was affected by packaging materials and storage period. The highest increase in the (S.V.) was recorded in oil samples stored in PET bottles which changed from 190.00 mg KOH/g, 188.00 mg KOH/g, 194.00 mg KOH/g, 198.00 mg KOH/g, and 193.00 mg KOH/g, to 210.00 mg KOH/g, 198.00 mg KOH/g, 211.04 mg KOH/g, 244.00 mg KOH/g, and 223.15 mg KOH/g, for sunflower, corn, cotton seed, palm olein and soybean oils respectively, stored for 18 months, palm olein oil recorded the greatest increase in saponification value at the end of the 18$^{th}$ month giving values 244.00, 240.11 and 240.22 in PET, clear glass and dark glass packages respectively, while corn oil recorded 198.00, 197.00 and 197.11 mg KOH/g for PET, clear glass and dark glass packaging, increase saponification values during storage at average room temperature as indicate a lower molecular weight, usually due to presence of lower fatty acids i.e. breakdown of oil molecule, This occurs in conjunction with an increase in the acid value during storage period.

The calculated physicochemical parameters such as refractive index, peroxide value, iodine value, acid value, relative density and saponification values are qualitative properties of the edible oils and do not give us information about exactly the position of the double bonds but rather it provides an overall status of unsaturation of the edible oils so it is not possible to point out the position of double bond(s) which are more susceptible to oxidation.

**Evaluation the change during storage of the selected edibles oils by FTIR:**

FTIR spectroscopy is an efficient method for studying the classification, adulteration, of edible oils [34, 35]. FTIR spectroscopy is currently used more frequently in oils and fats research, Triglycerides predominate the FTIR spectra of fats and oils because they are responsible for most of the spectrum's peaks found in fatty acid and triglyceride profiles. Furthermore, variations in the number of fatty acids in triglyceride molecules produce peak shifts because the fatty acid structure of fats and oils affects the exact placements and shape of the peak FTIR spectra of the selected edible oil samples before and after storage were recorded with the help of a Fourier Transform Spectroscopy Model The Bruker Tensor37 FTIR instrument in the region of 4000–500 $cm^{-1}$ which is located in the

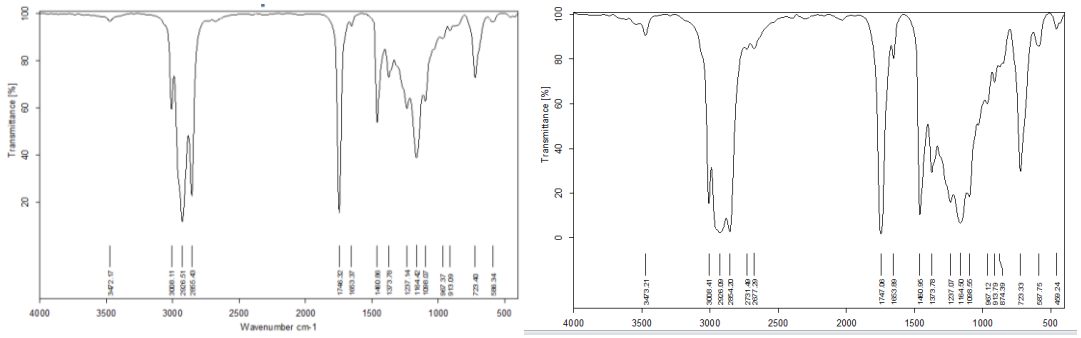
central lab, Alexandria university. It is used to study both saturation and unsaturation degree of the selected oils samples before storage and after storage at average room temperature $25^0$C for monitoring the oxidation process in oils under the study. In addition, this method protects us from danger of chemicals that may take place in case of monitoring the oxidation of oils by traditional methods.

The frequency regions of 3472 to 2677 $cm^{-1,}$ 1746 to 723 $cm^{-1}$ were picked up to study oxidation of sunflower, corn, cotton seed, palm olein and soybeans oils.

The wavenumber which corresponds to 3474 $cm^{-1}$ was attributed to (O-H), the wave numbers at 3007 $cm^{-1}$ and 3008 $cm^{-1}$ were ascribed to C-H stretching vibration of the cis-double bond (=CH), 1746 cm-1 was ascribed to –(C=O) group and 1655 $cm^{-1}$ was related to (C=C) stretching vibration of cis-olefins, 1418 $cm^{-1}$ was assigned to Rocking vibrations of CH bonds of cis-distributed olefins. 1239 $cm^{-1}$ was attributed to (C=C) and 1163, 1164, 1098$cm^{-1}$ were due to –C-O (ester) vibrations in finger print region.

As shown in Figures 1(a) and 1(b) which noticed FTIR spectrum of sunflower oil before storage at average room temperature ($25^0$C) for 18 months.it was shown the comparison between sunflower oil before the storage and after storage for period time 18 months at room temp. There were two interesting spectral regions from 3472 to 2677 $cm^{-1}$, where the activity of stretching vibrations of fatty acids and peroxides was observed and from 1746 to 723$cm^{-1}$, where the vibrational activity of conjugated bonds and of bending vibrations of aliphatic compounds were observed

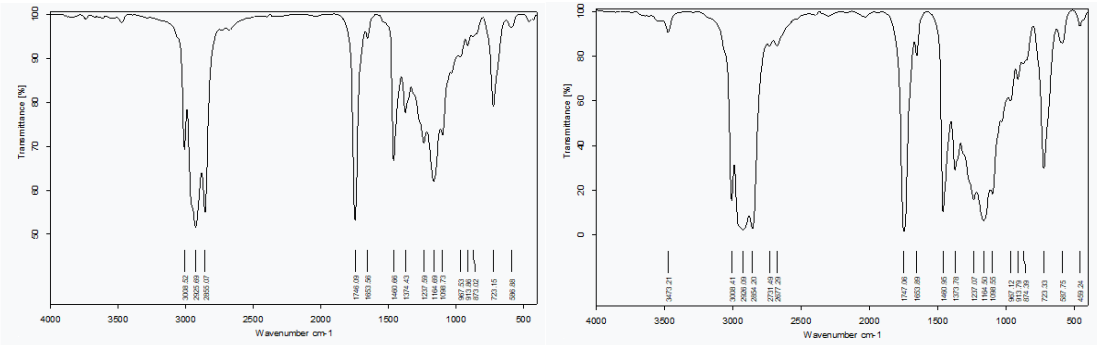
As mentioned before, storage edible oils for long time periods or in unsuitable storage conditions of oils may leads to oxidation of these edible oils [36], oxidation process occurs via two steps; the first step involved increase in the peroxide content and of some secondary oxidation compound; next steps involved breaking of the ester bonds between the fatty acids and glycerol, leading to decrease the unsaturation degree of edible oils and cis isomers converted to trans isomer leading to increase in concentration of trans isomers [37]. We can consider the band at 3474 $cm^{-1}$ as a fingerprint of the oxidation process associated to the C–H stretching vibration of the cis double bond (CH).




**1(a)** **1(b)**

*Figure 1(a): FTIR spectrum of sunflower oil before storage at room temperature ($25^0$C).*

*Figure 1(b): FTIR spectrum of sunflower oil after storage at room temperature ($25^0$C) for 18 months.*

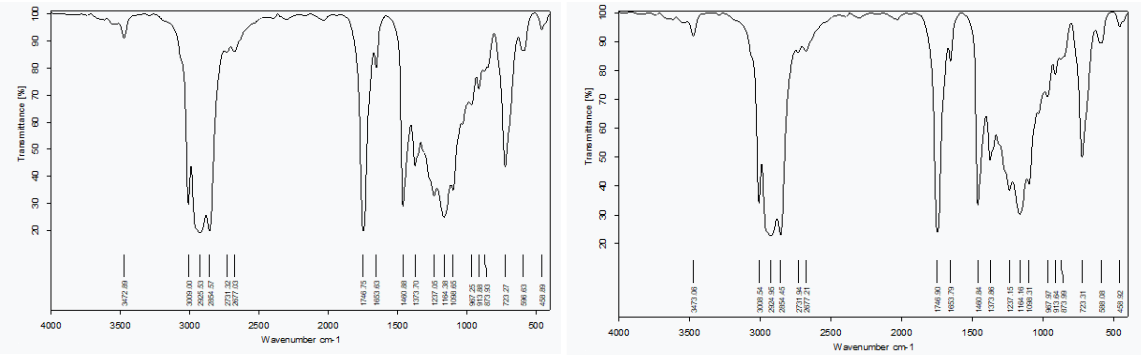



2(b) 2(a)

*Figure 2(a): FTIR spectrum of corn oil after storage at room temperature ($25^0$C) for 18 months.*

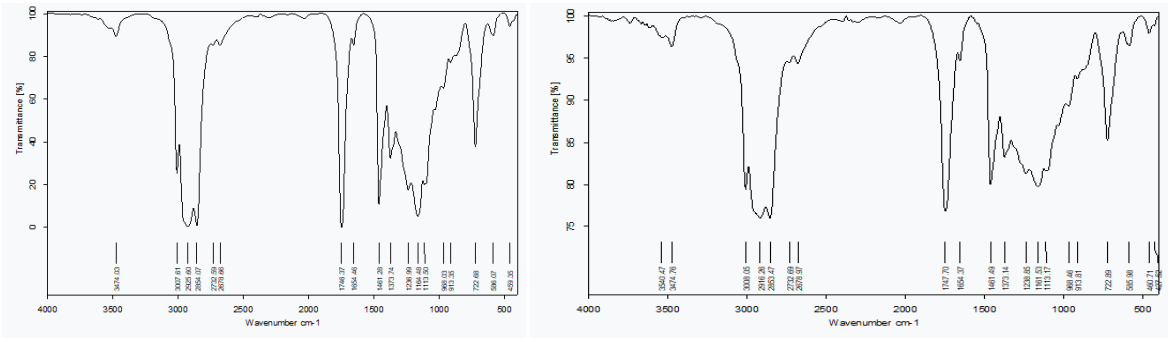
*Figure 2(b): FTIR spectrum of corn oil before storage at room temperature ($25^0$C).*

Figures 2(a) and 2(b) show the FTIR spectra recorded for corn oil before storage and after storage for 18 months. The inset shows the shift of the band recorded at 3008 cm−1 to higher wave number as a result of oxidative change happened at the end of storage. Rather than, a weak broad peak appeared at 3473cm$^{-1}$ which may related to O-H stretching vibration of peroxides (primary oxidation product), this coincides with shift in peak at 1747 cm$^{-1}$(C=O). The two peaks at 2955 and 2925 cm$^{-1}$, only two changes in Figures 3(1) and 3(b), the band at 3009 cm$^{-1}$ shifted to 3008 cm$^{-1}$ and a band at wavenumber 3473 cm$^{-1}$ also shifted to a lower wavenumber 3472 cm$^{-1}$due to oxidation daring storage of cotton seed oil at room temperature for 18 months.



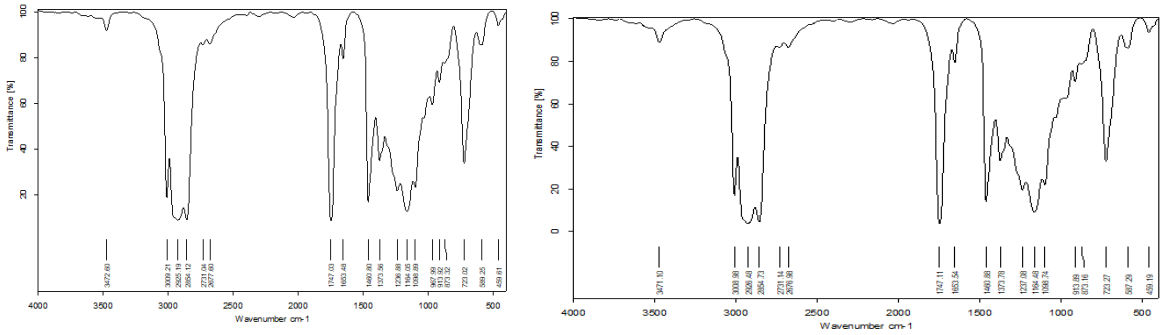

3(a) 3(b)

*Figure 3(a): FTIR spectrum of cotton seed oil before storage at room temperature (25$^0$C),*
*Figure 3(b): FTIR spectrum of cotton seed oil after storage at room temperature (25$^0$C) for 18 months.*




*4(a)* *4(b)*

*Figure 4(a): FTIR spectrum of palm olein oil before storage at room temperature (25$^0$C).*
*Figure 4(b): FTIR spectrum of palm olein oil after storage at room temperature (25$^0$C) for 18 months.*




5(a) 5(b)

*Figure 5(a): FTIR spectrum of soybean oil before storage at room temperature (25$^0$C).*
*Figure 5(b): FTIR spectrum of soybean oil after storage at room temperature (25$^0$C) for 18 months.*

As noticed in Figures 4(a) and 4(b) which showed FTIR spectrum of palm olein oil before and after storage at room temperature for 18 months, a noticeable increase in a band at 3472 $cm^{-1}$ as a result of oxidative degradation of palm olein oil and formation new O-H group of peroxides as result of oxidation, a band at 722 $cm^{-1}$ belongs to the cis double bonds of unsaturated fatty acids [38].

A noticeable increase in a band at 3472 $cm^{-1}$ as shown in Figure 5(b) wavenumber which correspond to 3474 $cm^{-1}$ was attributed to (O-H).

Generally, the changes in FTIR for the edible oils under the study can be summarized as : the wave numbers at 3007 $cm^{-1}$ and 3008 $cm^{-1}$ were ascribed to C-H stretching vibration of the cis-double bond (=CH), 1746 $cm^{-1}$ was ascribed to –(C=O) group and 1655 $cm^{-1}$ was related to (C=C) stretching vibration of cis-olefins, 1418 $cm^{-1}$ was assigned to Rocking vibrations of CH bonds of cis-distributed olefins. 1239 $cm^{-1}$ was attributed to (C=C) and 1163, 1164, 1098$cm^{-1}$ were due to –C-O (ester) vibrations in finger print region.

A band at 3473 $cm^{-1}$ gradually increased at the end of storage as a result of oxidative degradation of polyunsaturated lipids. This band was attributed to the newly formed hydroxyl groups of hydro peroxides as result of oxidation of the selected edible oils.

The results showed that the absorbance changes of peaks 3473$cm^{-1}$ were increased. This suggested that the hydro peroxides were found in the selected oils during storage at ambient temperature as a result of oxidation process. The ratio between the absorbance band at 2854 $cm^{-1}$ and the absorbance band at 3600-3100 $cm^{-1}$ (A2854/A3600–3100) could be determined the oxidation of oil [39]. the lower peak amplitude at wave number 2853 $cm^{-1}$ was found. The amplitude in peak 2853 $cm^{-1}$ indicated the amounts of aldehyde in the edible oil samples. The absorption of ester carbonyl group of triglyceride was presented at range of 1743-1746 $cm^{-1}$. Triglyceride peak of oil was considered at wave number 1743 $cm^{-1}$. After18 months of storage, intensities of this peak became lower. This change was in accordance with a slight increase in peak at wave number 17653 $cm^{-1}$, which represents the C=O carboxylic group of free fatty acids [38].

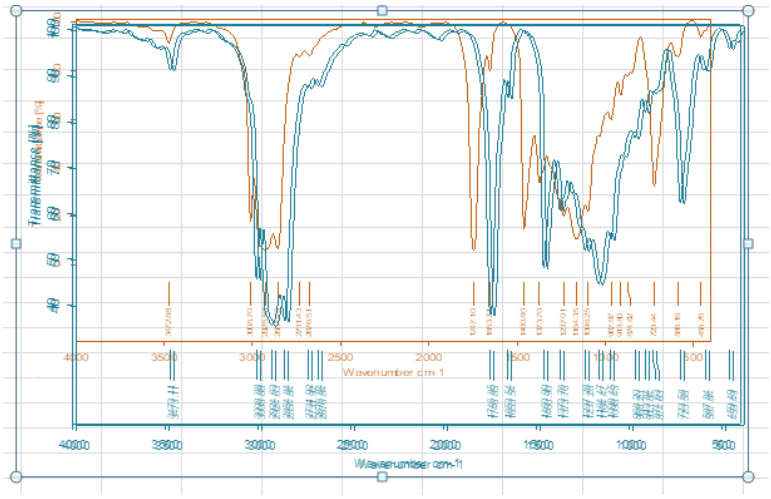



*Figure 6: FTIR for palm olein oil samples stored in PET, clear glass and dark glass bottles at the end of storage 18 months at ambient tem.*

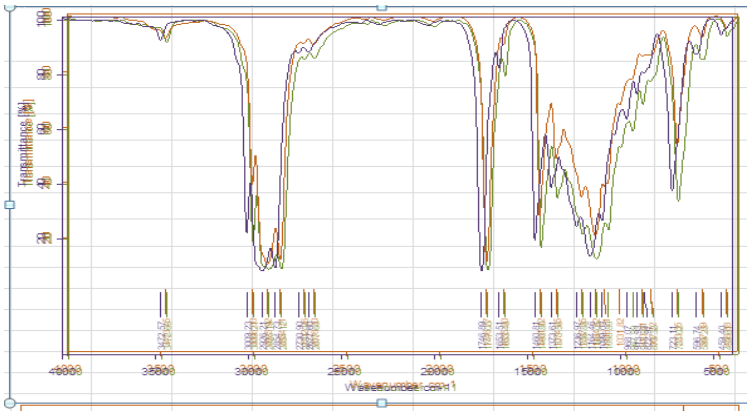


*Figure 7: FTIR for soybean oil samples stored in PET, clear glass and dark glass bottles at the end of storage 18 months at ambient tem.*

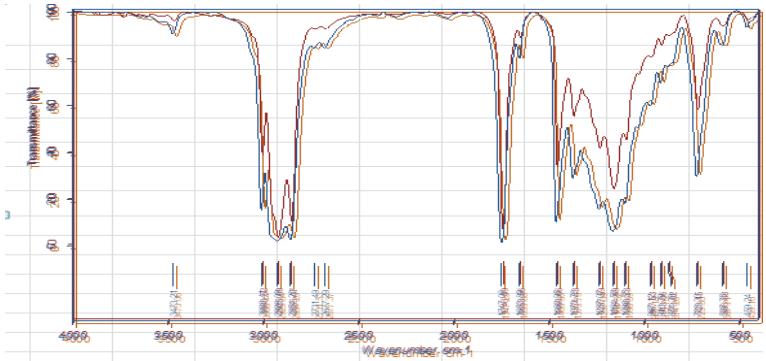


*Figure 8: FTIR for corn oil samples stored in PET, clear glass and dark glass bottles at the end of storage 18 months at ambient temp.*

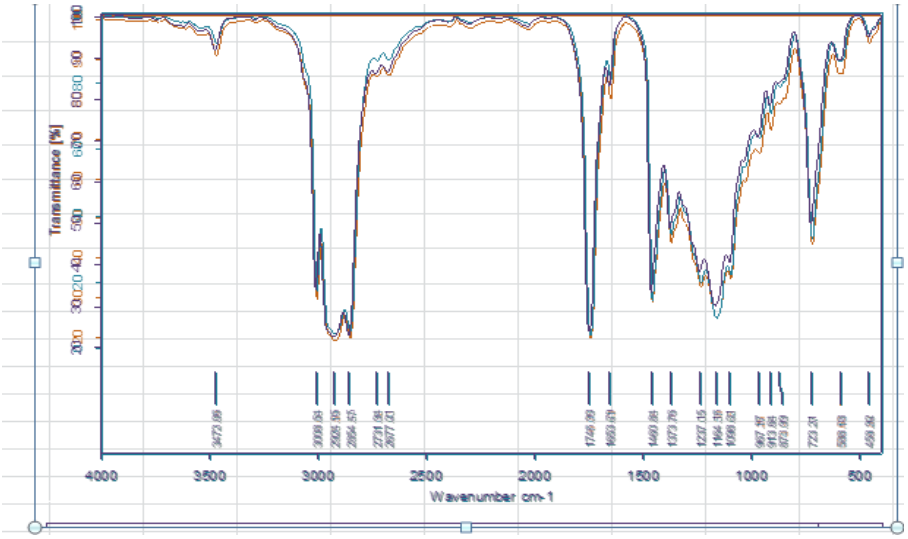



*Figure 9: FTIR for cotton seed oil samples stored in PET, clear glass and dark glass bottles at the end of storage 18 months at ambient temp.*

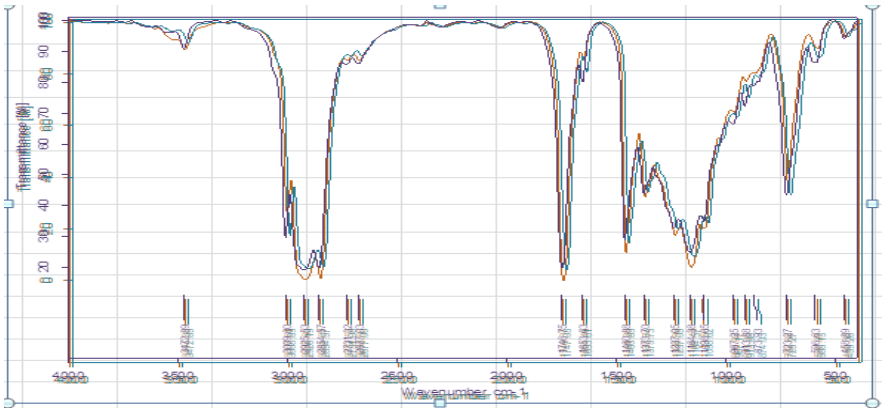


*Figure 10: FTIR for sunflower oil samples stored in PET, clear glass and dark glass bottles at the end of storage 18 months at ambient temp.*

The change of the absorbance ratio 2853/3008 was attributed to disappearance of cis-double bonds of the selected oils and formation of saturated bonds during oxidation. The intensity of ratio 2850/3008 $cm^{-1}$ could give information about the degree of saturation or unsaturation of the edible oils under the study band trend are in good agreement with the decreased in the iodine value for these oils.

Figures from 6 to 10 showed as light and varying changes between the three types of packaging used in the study (clear, dark glass bottles and PET bottles), the inset showed that the three types of bottles did not have the same effect on the properties of the edible oils during the storage period.

**Conclusion and Recommendations:**

Based on the results of the present study, the following conclusions may be drawn:

- The selected edible oils analysed in this study presented relatively good initial quality, in accordance with current legislation on acid value, peroxide value and iodine value.
- During the storage period, changes took place in peroxide value, acid value, iodine value and refractive index which considered the main parameters. From the results obtained it can be deduced that all the oils have similar properties.
- All these vegetable oils can storage at room temperature as liquid at room temperature. Oil stored in PET packing showed the great changes in their properties upon long storage. So Recommendation drawn from this study is that edible oils used for cooking and dressing purposes should be best stored in clear and dark glass,
- Peroxide values and acid values obtained from such oils are lower than the other means of storage as at the research time.
- Sunflower oil is the most suitable edible oil for consumption as it maintains its quality with increase in storage time.
- Dark glass container seemed to be the best choice to prolong oil edibility.
- Researches should be conducted regularly to know more necessary area of improvement in production of vegetable oils for both consumers and producer.
- Storage at conditions similar to being stored in a supermarket may have negative effects on edible oils.
- In accordance with this study, it is recommended that palm oils be stored under refrigeration not in room temperature.

**Acknowledgment**

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