Changes of physiochemical characteristics of Al-Gadarif Sunflower Oil (GSFO) during storage and antioxidant vitamins.

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***Abstract*: This study was carried out in order to probe the extent of oxidative alterations in Sunflower Oil (SFO), subjected to light and dark storage conditions with, and without added vitamins, over a period of 16 weeks storage. The magnitude of oxidative changes was monitored by the periodical measurement of acid value, peroxide value, iodine value, Density and color throughout storage time. The acid value of sunflower oil increased from initial value 3.74 mg KOH/g to 4.92 mg KOH/g. kept in light and 4.00 mg KOH/g kept in dark. the acid value for oil samples kept in light and dark with added vitamin C, vitamin E and equal amount mixed from vitamin C and E was decreased for 16 weeks. Like the acid value, the peroxide value of sunflower oil increased from 7.46 meq O2/kg to (9.34 and 8.62) meq O_2/kg, for oil samples kept in the same conditions with that mentioned in acid value. Unlike the acid value, the Iodine value of sunflower oil decreased from 140.5gI2/100g oil to (97.87 and 107.73) gI_2/100g, the initial density 0.9026 g/cm-1 was increase with added antioxidants vitamins The density values was calculated after storage time and observing in the ranges recommended by standard for edible vegetable oils. Like the density, the color of oils was not change because the oil is rich by the color pigments. However, the vitamins added of fresh sunflower oils increase the oxidation stability. Changes in acid value, peroxide value and Iodine value obtained shows that the oxidative deterioration levels of oils were different between storage conditions. The results of the present study show that light acts as a major catalyst in accelerating the development of rancidity in oils. Also, the addition of vitamins to oil can increase the oxidation stability of oils during storage. In conclusion, this study has been able to show storage in the light can affect oil stability and minimizes the potency of vitamins in oils, fats or fat-containing products. Therefore, storing in dark (packaging with material protect light) and supporting with antioxidants is the best way to maintain the quality of oils during storage and domestic uses.**

***Keywords*: Al-Gadarif Sunflower oil; Vitamin C; Vitamin E; antioxidants; Oxidation;**

INTRODUCTION.

Sunflower (Helianthus annuus L.) is one of the important oilseed crops grown throughout the world as a source of premium oil and dietary fiber that significantly contributes to human health (Khan, *et al.;* 2015). Sunflower seed contain a high amount of oil (40% to 50%) which is an important source of polyunsaturated fatty acid of potential health benefits. (Monotti, 2004). Oil is a very important resource, much in demand everywhere in the world and is used in a variety of ways. (Gizachew. 2020).

The physicochemical properties of fats and oils are influenced by the degree of unsaturation, the length of the carbon chain and the type, quantity, distribution on the triglycerol and isomeric form of FA. The oils in sunflower seeds are rich of unsaturated fatty acids, rendering the seeds susceptible to oxidative rancidity this rancidity occurs after prolonged storage and is accelerated when the seeds are stored under inappropriate conditions. The oxidative rancidity affects the quality of both sunflower seeds and sunflower seed oil. (Meng, *et al.*, 2019).

The use of antioxidants as inhibitors of free radical autoxidation is of major importance in preserving polyunsaturated lipids from oxidative deterioration (Frankel, 2005).

Vitamin C or ascorbic acid is vitamin which function as a cofactor in many reaction due to its function as a reducing agent, this property of vitamin C makes it an important antioxidant, vitamin C is especially important as it also function to regenerate other antioxidants including alpha-tocopherol or vitamin E. (Sarkar et al., 2016). Vitamin E is found naturally in some foods, added to others, and available as a dietary supplement. “Vitamin E” is the collective name for a group of fat-soluble compounds with distinctive antioxidant activities .Naturally occurring vitamin E exists in eight chemical forms (alpha-, beta-, gamma-, and delta-tocopherol and alpha-, beta-, gamma-, and delta-tocotrienol) that have varying levels of biological activity.(Traber *et al.*, 2006). Alpha- (or α-) tocopherol is the only form that is recognized to meet human requirements. (Traber, 2007). **Objectives:**

Sunflower oil is considered as a concentrated source of energy for human beings and carriers of oil-soluble Vitamins which supply the essential fatty acids that are required for a wide range of biological and physiological functions. The oxidative changes during storage and domestic use make oils unsuitable for consumption. Oxidative stability is an important indicator of oil quality and shelf-life. This study is expected to increase awareness among the population regarding the influence of storage conditions and added vitamin E and C on the oxidation stability of domestically produced sunflower oil by adapting different oxidation detection methods. Furthermore, the study is important to see the quality and shelf life of domestically produced sunflower oils.

Main objectives:

The general objective of this study is to changes of physiochemical characteristics of Al-Gadarif Sunflower Oil (GSFO) during storage and antioxidant vitamins.

Materials and Methods.

Materials

All chemicals and reagents used in physicochemical analysis were analytical grade and were used with no further purification n-hexane, Ethanol, phenolphthalein, potassium hydroxide (KOH), glacial acetic acid, potassium iodide (KI), sodium thiosulfate (Na2S2O3), potassium bromide, starch were all obtained from Merck and Sigma Co. Chloroform was obtained from WINLAB LIMITED, United Kingdom. Vitamin E and C, was purchased from the SHUANGFENG Industrial China. Distilled water was used throughout the work.

Plants collection:

Fresh Sunflower seed (FSFS), obtained from Al-Gadarif state area in Sudan.

Equipment:

The equipment's used in this work are electronic balance (OHAUS, Switzerland), soxthlet apparatus, pycnometer, micro pipettes, burettes, conical flasks, thermometer, stirrer, stands, heating device.

Instruments:

GC-MS spectrophotometry technique model (GC/MS –QP2010-Ultra) from japans (Shimadzu Company) with serial number 020525101565SA, The GC operating conditions were: column Rtx…..length (30m)….Diameter (0.25mn) ,Detector mass spectrometer and carrier gas Helium with flow rate 1.61 ml/min,

Methods.

General methodology.

The samples of sunflower seed was obtained from Al-Gadarif state agricultural area in Sudan. Oil from the seeds was obtained separately using solvent extraction method. Pure oil was separated using rotary evaporation. An oil sample from extract was investigated chemically and physically, the physical tests were density and color. And the chemical tests were acid value, peroxide value, iodine value and saponification value. The oil sample was also subjected to GC-MS. Oil from sample was divided into four portions labelled A, B, C and D. portion A was the control sample, portion B was mixed with vitamin C, portion C was mixed with vitamin E and portion D was mixed with an equal amount of vitamin C and vitamin E. the same physical and chemical tests above were replicate to all portion at an interval of three times, average results was obtained. The same procedure was repeated to an oil samples stored in normal day light and temperature for eight weeks and sixteen weeks separately. Results were recorded and conclusion were obtained.

Extraction of sunflower Oil.

The sample of sunflower seed was extracted by soxhlet method. A total of 50 g sunflower seed sample was weighed and extracted with n-hexane in a Soxhlet Apparatus at a condensation rate of 5 or 6 points per second for 4 hours with 300 ml of hexane at a temperature of 70˚C. The solvent was evaporated to dryness using a rotary evaporator at 40˚C. (A. O. A. C., 2005).

Physiochemical analysis of sunflower Oil.

Determination of Specific Gravity

Specific Gravity was determined by the standard method of A.O.A.C 17^{th} edn, 2000.

$$\text{Specific gravity at 30 0C/ 30 0C} = \frac{A-B}{C-B}$$

Where

A = weight in gm of specific gravity bottle with oil at 30 0C

B = weight in gm of specific gravity bottle at 30C

C = weight in gm of specific gravity bottle with water at 30 0C

Determination of Acid Value

The acid value was determined by directly titrating the oil/fat in an alcoholic medium against standard potassium hydroxide/sodium hydroxide solution describe by A.O.A.C, 2000).

$$\text{Acid value} = \frac{56.1VN}{W}$$

Where

V = Volume in ml of standard potassium hydroxide or sodium hydroxide used

N = Normality of the potassium hydroxide solution or Sodium hydroxide solution; and

W = Weight in g of the sample.

Determination Peroxide value.

Peroxide value (PV) was evaluated according to (AOCS, 2003).

Determination of Iodine Value

Iodine value was determined according to the Hanus method as described in A.O.A.C. 2000)

$$\text{Iodine value} = \frac{12.69\,(B-S)\,N}{W}$$

Where,

B = volume in ml of standard sodium thiosulphate solution required for the blank.

S = volume in ml of standard sodium thiosulphate solution required for the sample.

N = normality of the standard sodium thiosulphate solution.

W = weight in g of the sample

Preparation of methyl ester of fatty acid

The fatty acid methyl esters were prepared as described in the International Olive Council (IOOC, 2009).

Fatty acid profile

Fatty acid profile was analyzed by GC according to the method described by (IOOC, 2009).

Determination of fatty acid methyl Easters

Gas chromatography has been used for the qualitative and quantitative analysis of the fatty acids reported in the relative area percentage, the GC/MS technique model (GC/MS –QP2010-Ultra) from japans (Shimadzu Company) with serial number 020525101565SA and capillary column (Rtx -5ms -30m x 0.25mm x 0.25µm). The sample was injected by using split mode, helium as the carrier gas passed with flow rate 1.61 ml/min, the temperature program was started from 60◦C with rate 10◦C /min to 300◦C as final temperature degree with 6 minutes hold time, the injection port temperature was 300◦C the ion source temperature was 200 ◦C and the interface temperature was 250 ◦C. the sample was analyzed by using scan mode in the range of 40 to 500 m/z charge to ratio and the total run time was 30 min. Identification of components for the samples was achieved by comparing their retention times and mass fragmentation patents with those available in the library, the National Institute of Standards and Technology (NIST). The results were recorded.

Statistical analysis

The statistical analysis was performed with the SPSS package software, version 20 (SPSS). Results were presented as means ± standard deviation of the two triplicates of each experiment. Analysis of variance (ANOVA) was performed. Significant differences among the means ($p < 0.05$) were determined by Duncan's multiple tests.

Results and Discussion.

Characterization Analysis of Al-Gadarif state sunflower Oil.

The chemical and Physical parameters are usually used for the identification of oils. Normally more than one character is determined so that the identification can be made with more assurance since the oils vary in their properties. The composition is not constant it depends upon certain factors such as climatic conditions, nature of soil, type of plant and variety of edible oil.

Physiochemical Characterizations Analysis.

Physicochemical properties of oils are determined to know the quality, purity and identification. Characteristic properties are properties that depend on the nature of the oil. These are used to characterize oil, irrespective of location or sources of origin

The initial determined of Physiochemical characterization for sunflower oil sample have been made before the storage and antioxidants vitamin added Table 1. Shown the results of some characteristics of sunflower oil such as density, color, AV, FFA, PV and IV.

Table. 1: Physical Characterization of Sunflower Oil.

Sample	Density at 20°C (g/cm-^{1})	Color	Acid value (mg KOH/g oil)	Free Fatty Acid (%)	Peroxide value (meq O2/kg oil)	Iodine value (gI2/100g oil)
SFO	0.9026± (0.001)	13.35 ± (0.00)	3.74 ± (0.14)	1.87 ± (0.07)	7.46 ± (0.05)	140.50 ± (0.71)

The above results show that density of sunflower oil are always greater than the refined oil. Therefore oil may provide more protection for human health than refined oil.

Changes in Specific Gravity.

Specific gravity is considered as a good index of purity of oils, the increase in chain length of fatty acid present in oil tends to increase the specific gravity of oils. (Table 1) Shown the specific gravity value of oils samples were within the FAO/WHO standard for edible vegetable oils. The specific gravity of Al-gadarif sunflower oil shows that the oil is less dense than water because the impurities are not present in oil.

Changes in Color.

Change in color indicates the deterioration of oil due to oxidation. Color of oils depends upon the nature of coloring material like chlorophyll and carotene present in oil. Sunflower oil samples have pale yellow color indicating the presence of color pigments, so the color of oils was not change because the oil is rich by the color pigments, according the color of Al-gadarif sunflower oils became stable.

Changes in acid value (AV).

AV is a measure of the FFAs in oil. Normally, FAs are found in the TAG form, however; during processing, the FAs may be hydrolyzed into FFA. Production of FFA is the best predictor of fat deterioration and the presence of FFA could be used to monitor the extent of oils abused (Atta *et al.*, 2008). Table 1. Shows the lower AV found, the lower the level of FFA which results in increased oil quality. The initial AV of SFO presented in this study show a lower value than Codex Standard for Named Vegetable Oils (CODEX-STAN210-1999) (4.0 mg KOH/g). The observation of low initial AV for Al-gadarif sunflower oil (3.74 ± 0.14mg KOH/g of oil) indicates a low formation of FFAs. Probably, this is due to oil seeds without moisture content. The acceptability level of virgin sunflower oils is below 4.0 mg KOH/g (measured in potassium hydroxide per gram). (Alimentarius, 1999).

Changes in Fatty Acid Composition of Oils.

Change in free fatty acid values were determined for sunflower oils (Table.1). Although the initial free fatty acid value for the sample of the SFO was almost insignificantly different so the value was found in the sample.

Changes in Peroxide value (PV).

Determination of peroxide value can give an idea about the early stages of oil oxidation. PV is a measure of oxidation during storage and the freshness of the lipid matrix. The PV indicates the level of oxidation during production and storage. One of the most important parameters that influence lipid oxidation is the degree of unsaturation of its FAs. When double bonds of unsaturated fats are oxidized, peroxides are among the oxidation products formed. The peroxide values for the fresh oils were very low which indicate the high quality of the SFOs used in this work. Change in PV without storage was shown in (Table. 1).

Peroxides are possibly (not directly) responsible for the taste and odor of rancid fats, their concentration as represented by the PV is often useful in assessing the extent to which the rancidity has advanced. Rancid taste often begins to be noticeable when the PV is above 20 meq O2/kg (Food Adulteration, 1954). At the beginning of the experiment, the PV of SFO was (7.46 ± 0.05meq O2/kg. Which is less than 10 meqO2/Kg, and therefore within the acceptable value range for fresh oil. This value within the range considered as satisfactory and in agreement with the maximum Codex standard PV (15 meq O2/Kg). (Alimentarius, 1999). For virgin vegetable oil.

Changes in Iodine value (IV).

The iodine value is a measure of the unsaturation of the oils, it is one of the parameters used to measure the oil quality, Table 1. Demonstrates the initial iodine value of SFO is (140.50 ± 0.71 gI2/100g oil). Bending sunflower oil with various levels of oils caused increase in iodine values (degree of oil unsaturation), this increase was due to the increase in the predominance of monounsaturated fatty acids of sunflower oil in the blended oils.

Characterization and Identification of AL-Gadarif sunflower oil by using GC-MS.

The oil from Al-Gadarif sunflower was analyzed. Fig 2. And table 2. Reflect the profile of fatty acids presence in oil.

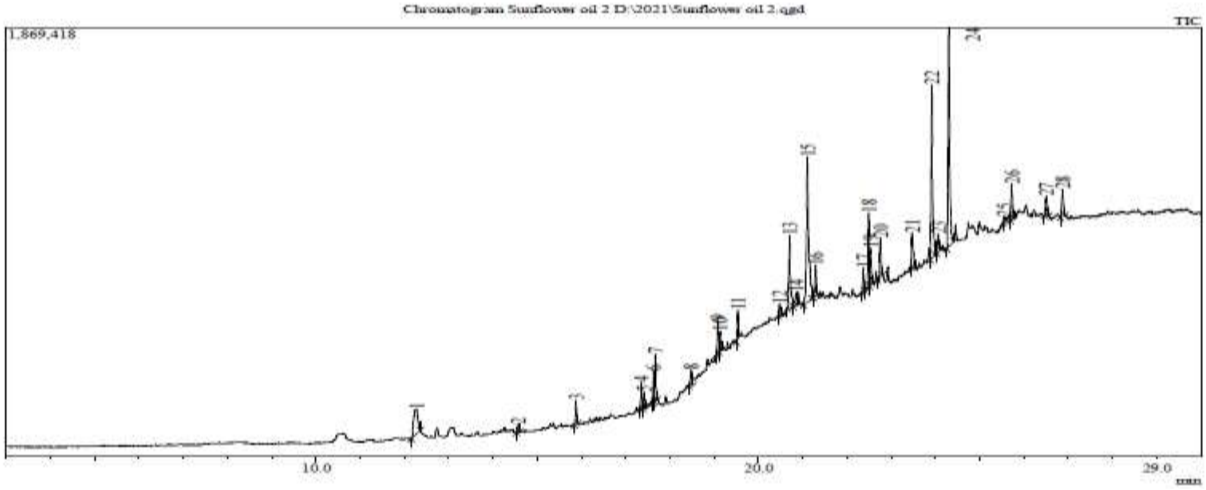

Figure 1. GC/MS Chromatogram of Al-Gadarif sunflower oil.

Table. 2: GC-MS analysis of the Al-Gadarif sunflower oil extract.

R. T	Area %	IUPAC Name	Formula
12.277	5.55	Phthalic acid, diethyl ester	C12H14O4
14.569	0.51	Cyclononasiloxane, octadecamethyl-	C18H54O9Si9
15.876	1.48	Hexadecanoic acid, methyl ester	C17H34O2
17.350	1.47	1-Nonadecene	C19H38
17.413	0.99	Heptadecyl heptafluorobutyrate	C21H35F7O2
17.628	1.70	Methyl 9-cis,11-trans-octadecadienoate	C19H34O2
17.672	2.51	9-Octadecenoic acid (Z)-, methyl ester	C19H36O2
18.483	1.57	Androstan-17-one, (5.beta.)-	C19H30O
19.085	2.06	Pentadec-7-ene, 7-bromomethyl-	C16H31Br
19.130	1.35	Hexadecanoic acid, 2-hydroxy-1-(hydroxymethyl	C19H38O4
19.537	1.65	Hexadecanoic acid, 1-(hydroxymethyl)-1,2-ethane	C35H68O5
20.474	0.86	9-Octadecenal, (Z)-	C18H34O
20.703	6.17	Oleoyl chloride	C18H33ClO
20.853	1.27	Pentadec-7-ene, 7-bromomethyl-	C16H31Br
21.105	15.81	9-Octadecenoic acid, 1,2,3-propanetriyl ester, (E,	C57H104O6
21.292	2.12	Octadecanoic acid, 2-hydroxy-1,3-propanediyl este	C39H76O5
22.370	1.38	cis-9-Hexadecenal	C16H30O
22.489	4.31	Pentadec-7-ene, 7-bromomethyl-	C16H31Br
22.528	2.70	Heptanoic acid, docosyl ester	C29H58O2
22.757	2.38	9-Octadecenoic acid, 1,2,3-propanetriyl ester,	C57H104O6
23.473	2.92	18.alpha.-Olean-3.beta.-ol, acetate	C32H54O2
23.918	12.83	cis-13-Docosenoyl chloride	C22H41ClO
24.062	1.29	Octadecanoic acid, 2,3-dihydroxypropyl ester	C21H42O4
24.301	17.34	9-Octadecenoic acid, 1,2,3-propanetriyl ester, (E	C57H104O6

25.545	1.03	Oleyl oleate	C36H68O2
25.725	2.83	Heptanoic acid, docosyl ester	C29H58O2
26.505	1.62	Stigmastan-3,5-diene	C29H48
26.871	2.28	Olean-12-ene-3, 28-diol, (3.beta.)-	C30H50O2
	100		

The GC-MS analysis of Al-Gadarif sunflower oil revealed some fatty acid with high concent1rations, Table 4.6. Were

Table .3: The major fatty acids of Al-Gadarif sunflower oil

IUPAC Name	Common name	Formula	Content (%)
Hexadecanoic acid	palmitic acid	C15H30O2	6.36
9- Hexadecenoic acid	palmitolic acid	$C16H30O_2$	8.02
Octadecanoic acid,	steric acid	$C18H36O_2$	9.28
9-Octadecenoic acid,	Oleic acid	$C18H34O_2$	46.10
9-12, Octadecenoic acid,	linoleic acid	$C18H32O_2$	21.05

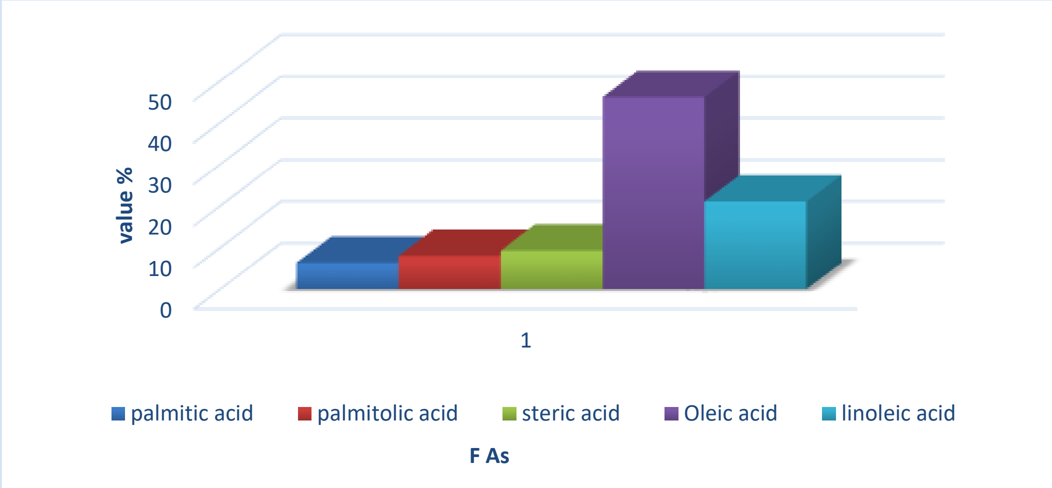

Fig. 2. Fatty acid contents of Al-Gadarif sunflower oil.

The fatty acids presence in Al-gadarif sunflower oil were oleic (C18:1), linoleic (C18:2), Stearic (C18:0), palmitoleic (C16:1), palmitic (C16:0), and acid which together composed about 90.81% of the total fatty acids and 09.19% other component.

For Al-gadarif sunflower oil, saturated fatty acids represent 15.64% of the total fatty acids while the unsaturated fatty acid represents 75.17%.

The oil extracted from Al-gadarif sunflower was analyzed using GC-MS, the result obtained showed high content of fatty acids, rich in oleic acid 46.10%, followed by linoleic acid which was 21.05%. For palmitoleic acid the result showed that the content was 8.02%. Al-gadarif sunflower oil contain also palmitic acid which was 6.36%.Stearic acid also found in considerable amount which was 9.28%.

Changes of physiochemical characteristics during storage and antioxidant vitamins.

Effects of Density (g/cm^{-1})

Table.4. Changes in Density (g/cm-1) of SFO during storage (light and dark) with and without antioxidant vitamin.

storage time (week)	**Density** (g/cm^{-1}) storage condition (Light and Dark)								standard value
	SFO^L A	SFO^L+ Vit. C	SFO^L+ Vit. E	SFO^L+ Mix Vit.	SFO^{D}A	SFO^D+ Vit. C	SFO^D+ Vit. E	SFO^D+ Mix Vit.	
0	0.9026±0.001				0.9026±0.001				
8	0.9208±0.002	0.9182±0.001	0.9181±0.001	0.9192±0.001	0.9185±0.001	0.9202±0.003	0.9203±0.002	0.9213±0.003	0.918
16	0.9214±0.002	0.9253±0.01	0.9214±0.001	0.9265±0.01	0.932±0.001	0.9227±0.001	0.9316±0.001	0.9255±0.01	0.923

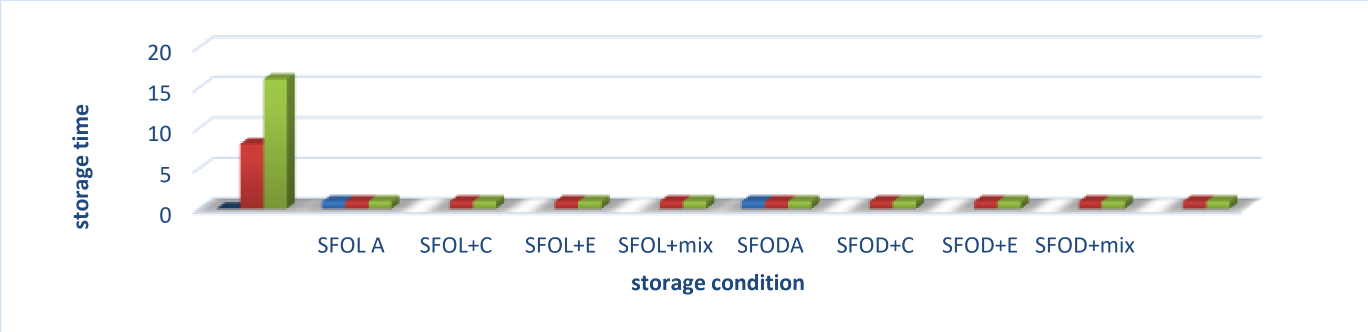

Fig.3: effect of light and dark on the Density (g/cm-1) of Al-gadarif sunflower oil during storage with and without antioxidant vitamins.

Specific gravity is determined and calculated at temperature 20°C as a ratio of mass in air of a given volume of the oil or fat to that of the same volume of at 20°C (Theodore, 1983). It can reveal the extent of adulteration and may be used as a means of acceptance of oils, during the storage time, the density of Al-gadarif sunflower oil (SFOL and SFOD) samples stored with and without added vitamins increased slowly and steadily with increase storage time in Table.1. Show the initial density (0.9026 g/cm-1) this value increase with added antioxidants vitamins the density values was calculated after storage time Table.4. And observing in the ranges recommended by the (FAO/WHO, 1993-1994). Standard for edible vegetable oils, probably. This is due to the effect of vitamins on the oils. These results of density are the acceptability of oil quality.

Effects of AV (mg KOH/g of oil).

Table.5: Changes in AV (mg KOH/g of oil) of Al-gadarif sunflower oil during storage (light and dark) with and without antioxidant vitamin.

Storage time (week)	Acid value (mg KOH/g oil)								standard value
	storage condition (light and Dark)								
	SFO^LA	SFO^L+ Vit. C	SFO^L+ Vit. E	SFO^L+ Mix Vit.	SFO^DA	SFO^D+ Vit. C	SFO^D+ Vit. E	SFO^D+ Mix Vit.	
0	3.74 ± 0.14				3.74 ± 0.14				
8	3.96 ± 0.14	0.39 ± 0.07	0.36 ± 0.07	0.30 ± 0.02	3.80 ± 0.14	0.31 ± 0.06	0.37 ± 0.11	0.28 ± 0.20	
16	4.92 ± 0.15	0.62 ± 0.03	0.71 ± 0.04	0.59 ± 0.19	4.00 ± 0.16	0.62 ± 0.05	0.69 ± 0.03	0.62 ± 0.02	4

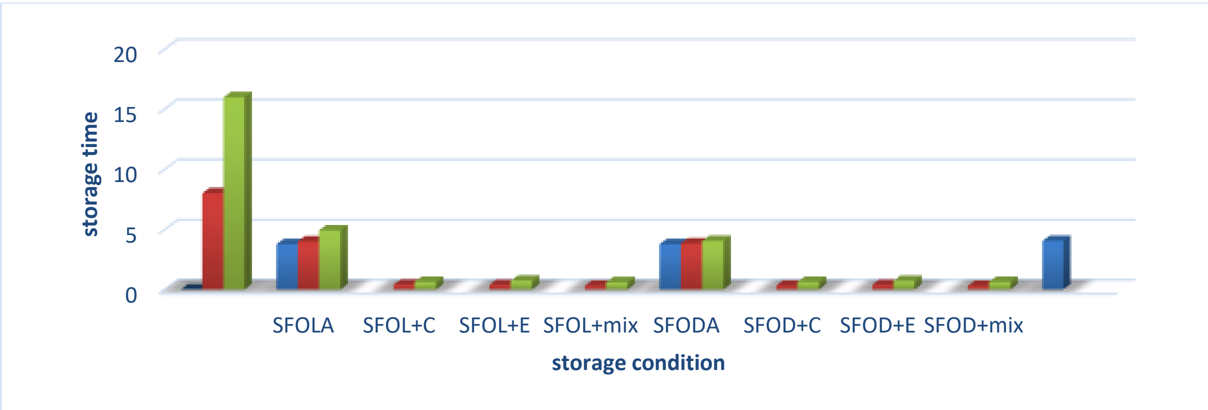

Fig.4: effect of light and dark on the AV of Al-gadarif sunflower oil during storage with and without antioxidant vitamins.

Effect of light on AV of Al-gadarif sunflower oil sample stored with added vitamins. During the storage time, the AV of Al-gadarif sunflower oil (SFOL and SFOD) samples stored with vitamins decreased slowly and steadily Table.5. The effect of vitamins was high in maintaining the formation of FFA during the eight weeks of mixed vitamins for SFOL and SFOD samples (0.30 ± 0.02and 0.28 ± 0.20) mg KOH/g respectively. And it starts to more capacity as storage time increased. The vitamins E, C and mixed were decreased the AV of Al-gadarif sunflower oil (SFOL and SFOD) samples kept at light by compared to SFOL and SFOD control samples stored in light without added vitamin. Similarly, the AV of control samples were presented in this study. Fig.4. Shown higher value than Codex Standard Oils (CODEX-STAN210-1999). The observation of SFOL high values of AV more than SFOD (4.92 ± 0.15 and 4.00 ± 0.16 mg KOH/g of oil) respectively indicates a formation of FFAs. Probably, this is due to the effect of light on the oils. The acceptability level of virgin sunflower oils is below 4.0 mg KOH/g. These results of AV decreased oil quality.

The Al-gadarif sunflower oil sample kept at dark place show a decrease in the FFA content by (0.28 ± 0.20 and 0.62 ± 0.02) mg KOH/g compared to samples exposed to light. From the samples stored in a dark place, higher change in AV was noted for SFOD than SFOL. This might be related to the presence of high PUFAs in SFO, especially linoleic acid (18: 2), which is susceptible to oxidation, hydrolysis, and thermal degradation. It may be postulated that light absorption (effect of photosensitizers) was greater in

SFOL as compared to darkness. This result is in line with works reported on sunflower and rapeseed oil under dark storage by (Abramovic and Abram, 2005).
The Vitamins functions as an antioxidant by serving as free-radical terminators and scavenging singlet oxygen molecules. The ascorbic acid and α-tocopherol concentration is an important factor that influences antioxidant activity in bulk oils. Studies in purified TAGs obtained from Al-gadarif SFO showed that antioxidant activity α-tocopherol was greater at concentrations (200 ppm) and it loses efficacy at higher concentrations due to its participation inside reactions. Figure5. Shows the AV changes of oils stored under light and dark after the addition of 200 mg/kg vitamin E and C.
At the dark place by (3.74 ± 0.14and 4.00 ± 0.16) mg KOH/g from SFOD and stored in similar condition without added vitamins by protecting them against deterioration caused by oxidation which leads to rancidity. This effect shows the antioxidant activity of vitamins in increasing the shelf life of Al-gadarif sunflower oil. The lower AV found, the lower the level of FFA which results in increased oil quality.

Effects of PV (meq O2/kg oil).

Table.6. Changes in PV (meq O2/kg oil) of Al-gadarif sunflower oil during storage (light and dark) with and without antioxidant vitamin.

storage time (week)	Peroxide value (meq O_2/kg oil)								standard value
	storage condition(light and Dark)								
	$SFO^{L}A$	SFO^{L}+ Vit. C	SFO^{L}+ Vit. E	SFO^{L}+ Mix Vit.	SFO^{D}+ A	SFO^{D}+ Vit. C	SFO^{D}+ Vit. E	SFO^{D}+ Mix Vit.	
0	7.46 ± 0.06				7.46 ± 0.06				
8	6.87 ± 0.40	2.91 ± 0.13	2.59 ± 0.20	2.16 ± 0.18	5.3± 0.05	3.78± 0.50	3.03± 0.57	2.64± 0.68	
16	9.34 ± 1.07	6.03 ± 0.21	7.06 ± 0.67	6.25 ± 0.07	8.62± 0.32	4.89± 0.55	5.16± 0.27	5.63± 0.63	15

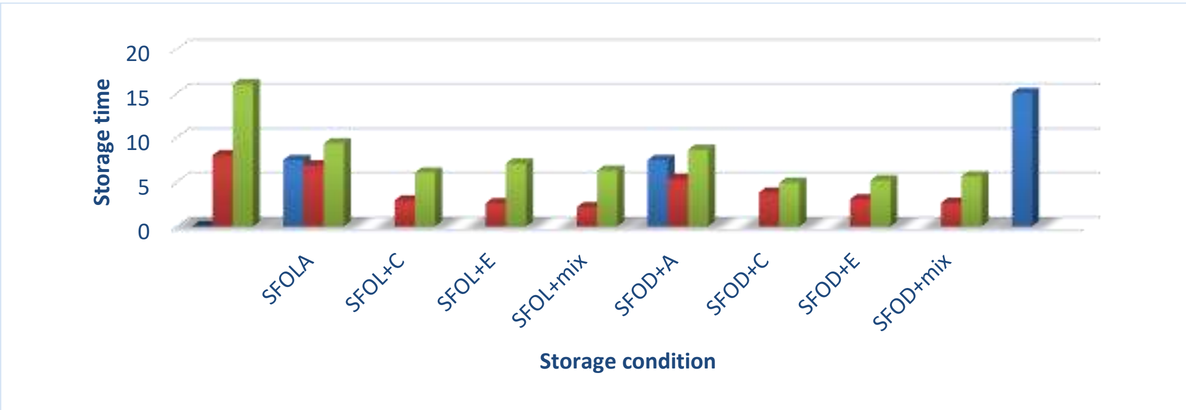

Fig.5: effect of light and dark on the PV of Al-gadarif sunflower oil during storage with and without antioxidant vitamin.
At the beginning of the experiment, the PV of SFOL and SFOD is (7.46 ± 0.06, 6.87 ± 0.40, 9.34 ± 1.07 and 7.46 ± 0.06, 5.3± 0.05, 8.62± 0.32) meq O_2/kg. This value falls in the range considered as satisfactory and in agreement with the maximum Codex standard PV (15 meq O2/Kg) (Atta *et al.*, 2008). For virgin vegetable oil. The PV of oil samples stored for 16 weeks registered a progressive increase with the increment of storage period. From Table6 it was observed that changes in PV of SFOL and SFOD stored under different conditions with and without added vitamins were significant ($p<0.05$). At the end of 16 weeks of storage, the Table.6. Shows the PV of SFOL and SFOD samples stored at control light > control dark > light vitamin C > dark vitamin C > light vitamin E > dark vitamin E > dark Mixed of vitamin > light Mixed of vitamin storage condition. Light accelerates oxidation more than dark. The change in PV of Al-gadarif SFO kept at light was significantly ($p<0.05$) higher than the PV value of Al-gadarif SFO stored at dark. Lower change in PV of Al-gadarif compared to SFOD dark vitamin during light storage was probably due to higher content of saturated palmitic acid, which is less prone to oxidation than unsaturated fatty acids, linoleic acid, Oleic acid and etc. (Paul, *et al.*, 1992)
The higher PV of control SFOL and SFOD is mostly because Al-gadarif SFO has an appreciable amount of unsaturated FA to fix oxygen and easily oxidized. These findings are similar to the work of Huang *et al.* 1981) who reported that high PUFAs, especially linoleic acid (18:2), are prone to oxidation, hydrolysis, and thermal degradation.
The absence of light lowered the PV of SFOD by (7.46 ± 0.06 and 2.64± 0.68) meq O2/kg the first eight weeks storage when compared to SFOL stored in light, this finding shows the oxidation process during periods of storage was affected by light. Figure 5. Shows the PV changes of oils stored under light and dark after the addition of 200 mg/kg vitamin E and C.
A lot of literature states that faster oxidation occurs due to exposure to light (Khan and Shahidi 2002). The absence of light minimized the hydroperoxide formation and also synergistically supported by minor components found in oils which acts as an antioxidant in the dark ((Khan and Shahidi, 2000). Such decreases in PVs had been reported by Neff *et al.*, 1994).

Effects of iodine value (IV).

Table.7. Changes in IV (gI_2/100g oil) of Al-gadarif sunflower oil during storage (light and dark) with and without antioxidant vitamin.

storage time (week)	Iodine value (gI_2/100g oil) storage condition (Light and Dark)								standard value
	SFO^L A	SFO^L+Vit. C	SFO^L+ Vit. E	SFO^L+ Mix Vit.	SFO^D A	SFO^D+ Vit. C	SFO^D+ Vit. E	SFO^D+mix Vit.	
0	140.5 ± 0.71				140.5± 0.71				**110**
8	102.9 ± 0.76	112.65± 4.80	111.38±7.03	108.76±7.17	107.73±6.55	106.01±5.80	111.13±1.20	96.59±9.20	**143**
16	97.87 ± 1.31	94.05± 4.13	96.71±1.65	98.25±1.89	98.18±0.53	98.5±1.09	98.4±0.81	98.21±0.95	

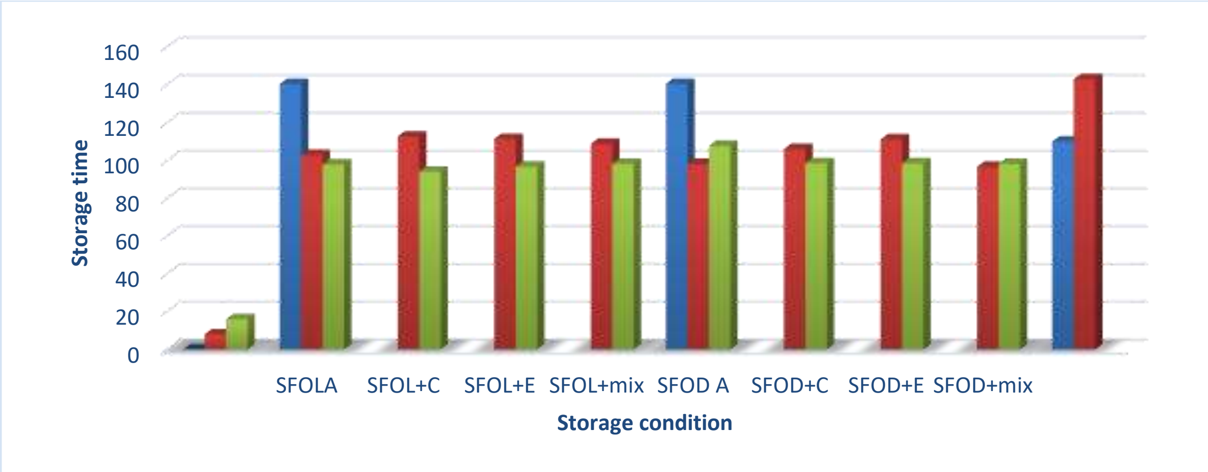

Fig.6. effect of light and dark on the IV of Al-gadarif sunflower oil during storage with and without antioxidant vitamin.

Changes in Iodine Value (IV) during storage.

For Sunflower Oil, the high iodine value portrays that it is rich in unsaturated fatty acid which implies that it will have short oxidative storage stability because according to Perkins the oxidative and chemical changes in oils during storage are characterized by increase in FFA content and a decrease in the total unsaturation of oils. (Perkins, 1992). Iodine value is a measure of the degree of unsaturation or double bonds among the fatty acid present in the oil therefore it does not tell precisely the fatty acids composition of any oil. Iodine value or number is useful as a guide to check adulteration of oil and also as a process control of oil. Free Fatty Acid values was lower for the oil as compared to the value recommended by FAO/WHO which may be attributed to the variation in variety, and climatic conditions which is evident in the iodine value. Fig.6. the effect of vitamin E and C, was high in maintaining the formation of FFA during the Sixteen weeks.

The different results for storage conditions of SFO significantly differed in iodine values due to the insignificant variation in their fatty acid composition Table.7. Iodine values showed significant and positive correlations with FAs and other polyunsaturated content. Data indicated that the SFOL and SFOD had the lower in iodine values. The iodine values were in the ranges recommended by the (Codex Standard, 2003). The PUFA ratios as well as iodine values were indicative of unsaturation levels and as a result,

The oil has a tendency to undergo autoxidation (Farhoosh, *et al.*, **2008**). Decreased levels of unsaturation linoleic acid will result in increased levels of oxidative stability. Therefore the high oleic sunflower oil with their lower levels of unsaturation should be more resistant to oxidation than the high linoleic acid sunflower oil.

CONCLUSION AND RECOMMENDATION

Conclusion

Oxidative stability is an important indicator of oil quality and shelf-life. The oxidative changes during storage and domestic use make oils unsuitable for consumption. The present investigation is an overview of changes in acid value, peroxide value and Iodine Value of sunflower oil from 16 weeks of storage. The results observed during the study show that prolonged storage of sunflower oil at ambient (25-33) °C temperatures can lead to oxidative deterioration of oil samples. Initially, both oil samples show acceptable acid value from the recommended value and significantly increased during storage. Higher change in acid value observed for a sample stored in light than dark. Also, additions of vitamins decreased the formation of free fatty acids in sunflower oil. The initial peroxide value of both oil samples is in agreement with Codex standard guideline value. The peroxide value significantly increased during storage. Higher peroxide value was observed for samples stored in light than samples stored in dark. Also, the addition of vitamins decreased the change in the peroxide value of sunflower oil. The added vitamins prohibited the formation of hydroperoxide more in the dark than daylight storage.

The high content of primary oxidation products and the presence of FFAs might profoundly lower the oxidative stability of the oil. Even if the oxidation stability of SFOL was found to be higher than oxidative stability of sunflower oil in the dark from the acid value, peroxide value obtained, both SFOL and SFOD are acceptable during storage with added vitamins as antioxidants. In general, the results of the present study show that light acts as a major catalyst in accelerating the development of rancidity in oils. However; the addition of vitamins to oil can increase the oxidation stability of oils during storage. Storing in dark (packaging with material protect light) and supporting with antioxidant vitamins is the best way to maintain the quality of oils during storage and domestic uses.

Recommendation

The investigations presented in this study suggest:

•Better packing and storage conditions can lead to an improvement in the oxidative stability of vegetable oils and other related products containing fats and oils

•Lipid oxidation products make the oil unfit for human health; therefore, to minimize the oxidation phenomenon, some antioxidants should be added to increase the storage and shelf life of oils and oil products

•Producers, shopkeepers, and users should store oils and oil products in dark places protected from light

•The government or any responsible body should follow that local oil producers have put the production and expiry dates of domestically produced oils to safeguard the health of people

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