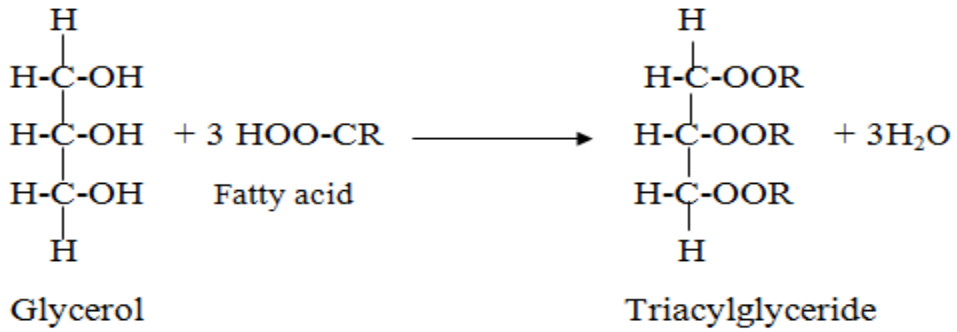
1. Introduction

1.1 Lipids

Many researchers define lipids as a wide variety of natural products including fatty acids and their derivatives, sterols, terepens, carotenoids and bile acids, which have in common a readily solubility in organic solvents as diethyl ether, hexane, benzene, chloroform or methanol (Casimir *et al.*, 2008). The United State Food and Drug Administration, USFDA, defines lipids as sum of components with lipid characteristics that are extracted by association of official analytical chemists (AOAC) methods or by reliable and appropriate procedures, FDA.

Chemically lipids define as substances which consist of glyceryl esters of fatty acids or tri-glyceride. Triglyceride is the condensation product of glycerol with fatty acid to yield water and triglyceride (Bailey *et al.,1979*).



1.1.1 Classification of lipids

Classification of lipids is based on many factors; its classification depends on physical properties at room temperature (oils and fats), their polarity (polar and neutral lipids), their essentiality for humans (essential and non-essential fatty acids), or their structure (simple or complex).

Neutral lipids include fatty acids, alcohol, glycerides and sterols; whereas polar lipids include glycero-phospholipids and glycerol-glycolipids.

Based on structure lipids can be classified as simple, complex or derived. Simple lipids can be hydrolyzed to two different components usually an alcohol and an

acid. Complex lipid includes phospholipids, glycolipids, and sphingolipids. These structures yield three different compounds on hydrolysis**.**

1.2 Fatty acids

Fatty acids contribute from 94% to 96% of the total weight of the molecules and comprise the reactive portion of the molecules, so fatty acids influence the character of glycerides and chemistry of fats and oils. With some exceptions most fatty acids found in nature contain an even number of carbon atoms. The natural occurring of fatty acids can be divided into saturated and unsaturated fatty acids.

1.2.1 Saturated fatty acids

Generally they widely occur in all animal fats and mostly contain straight chain with optical inactivity. Saturated acids higher than C24 don't occur in natural glycerides to any significant extent.

Table 1.1 Shows the most common saturated fatty acids occurring in fats and oils with their boiling points and melting points**, (**Bailey etal., 1997**).**

Table (1.1): Most common saturated fatty acids

No. of carbon	**Acid**	**B.P.**	**M.P.**
4	Butyric	163	- 8
6	Caproic	107	- 3.4
8	Capryic	135	16.7
10	Capric	159	31.6
12	Lauric	182	44.2
14	Myrisitic	202	54.4
16	Palmtic	222	62.9
18	Stearic	240	69.6
20	Arachic	-	75.4
22	Behenic	-	80.0

1.2.2 Unsaturated Fatty Acids

Many unsaturated fatty acids occur naturally and are more difficult to isolate, purify and characterize than the saturated acids because they are less stable and readily converted to position and geometric isomers. The natural occurring acids usually contain an even number of carbon atoms, mostly 18. Frequently the double bond has cis- configuration and frequently the double bond is between ninth and tenth carbon atoms. Fatty acids containing one, two and three double bonds and 18 carbon atoms are the most important unsaturated fatty acids of vegetable and animal fats, while those with four or more double bonds and 20 to 24 carbon atoms are difficult to study and therefor and still have indefinite picture.(Tables 1.2,1.3 and 1.4)

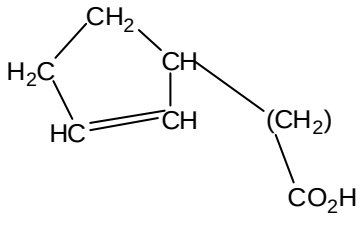
Table (1.2): Fatty acid with one double bond

Formula	**Systematic name**	**Common name**	**Melting. point**	**Principal source**
$C_{10}H_{18}O_2$	4-Decnoic	Obtusilic	-	Lindera Obtusilobo fats
$C_{10}H_{18}O_2$	9-Denoic	Caproleic	-	Animal mir fats
$C_{12}H_{22}O_2$	4-Dodcenoic	Linderic	1.3	Linder obtusilobo
$C_{12}H_{22}O_2$	9-Dodecenoic	Lauroleic	-	Animal milk fat
$C_{14}H_{26}O_2$	4-Teteradecenoic	Tsuzuic	18.5	Litsea glauco fat
$C_{14}H_{26}O_2$	5-Teteradecenoic	Myristoleic	-	Animal milk, sperm whale oil, pycnanthoskombo
$C_{16}H_{30}O_2$	9-Hexadecenoic	Palmitoleic	-	Animal milk, marine oil, beef fat.
$C_{18}H_{34}O_2$	6-Octa decenoic	Petroseliric	30	Umbelliferae especially parsley seed oil
$C_{18}H_{34}O_2$	9-Octadecenoic	Oleic	14.16	Olive oil, all vegetable and animal fats

Table (1.3): Fatty acids with more than one double bond

Formula	Systematic Name	Common Name	M.P	Source
$C_{18}H_{43}O_2$	Cis, Cis, 9-12-Octadecadienoic	Linoleic	-5	Safflower seed oil
$C_{18}H_{30}O_2$	Cis, Cis, Cis, 9, 12, 15 Octadecatrienoic	Linolenic	-11	Lin seed, peril oil
$C_{18}H_{30}O_2$	Cis, Trans, Trans- 9, 11, 13- Octa-decatrienoic	α – Eleo- Stearic	49	Tung oil, Yoke oil
$C_{18}H_{30}O_2$	Trans, Trans, Trans-9, 11, 13-Octadecatrienoic	β-Eleo-Stearic	71	Isomerization of α isomer.
$C18H_{28}O_2$	9,11,13,15- octade-catetraenoic	Parinamic	86(α) 96(β)	Perineum, Laurinum
$C_{20}H_{32}O_2$	5, 8, 11, 14, Eiecosa tetraenoic	Arachidonic	-50	Animal depot fats and phospho tide of liver and brain
$C_{22}H_{34}O_2$	4, 8, 12, 15, 19-Docosa-Pentaenoic	Clupanodonic	-	Marine oil

Table (1.4): Some exceptional structure of fatty acids

Common name	Structure	Source
Isovaleric acid	$(CH_3)_3$-C-CH2CO_2H	Dolphin and porpoise oil.
Chaulmoo-gric acid		Genus hydrocarpus.
Carotonic	CH_3-CH=CHCO_2H	Croton oil

1.3 Non glyceride components of fats and oils

All fats contain small amounts of non-glyceride components ranged between 2 – 8 %. The content of substances varies considerably; it is high in certain oil seeds such as cotton seeds, corn and soybeans, or very little trace in some, such as peanut and coconut oil. Animal fats such as lard and edible tallow contain very low amount of these substances. The non-glyceride substances consist of phosphotide, carbohydrates, carbohydrate derivatives, protein, resinous and mucilaginous materials of uncertain identity. These components have flavor, odor, colour or antioxidants properties. Some of these substances were removed from crude fats and oils during the refining process.

1.4 Refining process

The refining process removes undesirable materials such as phospholipids, mono acylglycerols, diacyglycerol, free acids, pigments, oxidized materials, flavor components, trace metals sulphur compounds and pollutants, but may also remove valuable minor components including antioxidants and vitamins such as carotenes and tocopherols . Some oils such as virgin olive oil are used without further treatment other than filtering, (Frank et *al.*, 1996). Fig (1.1) shows the main steps of refining process in edible oils.

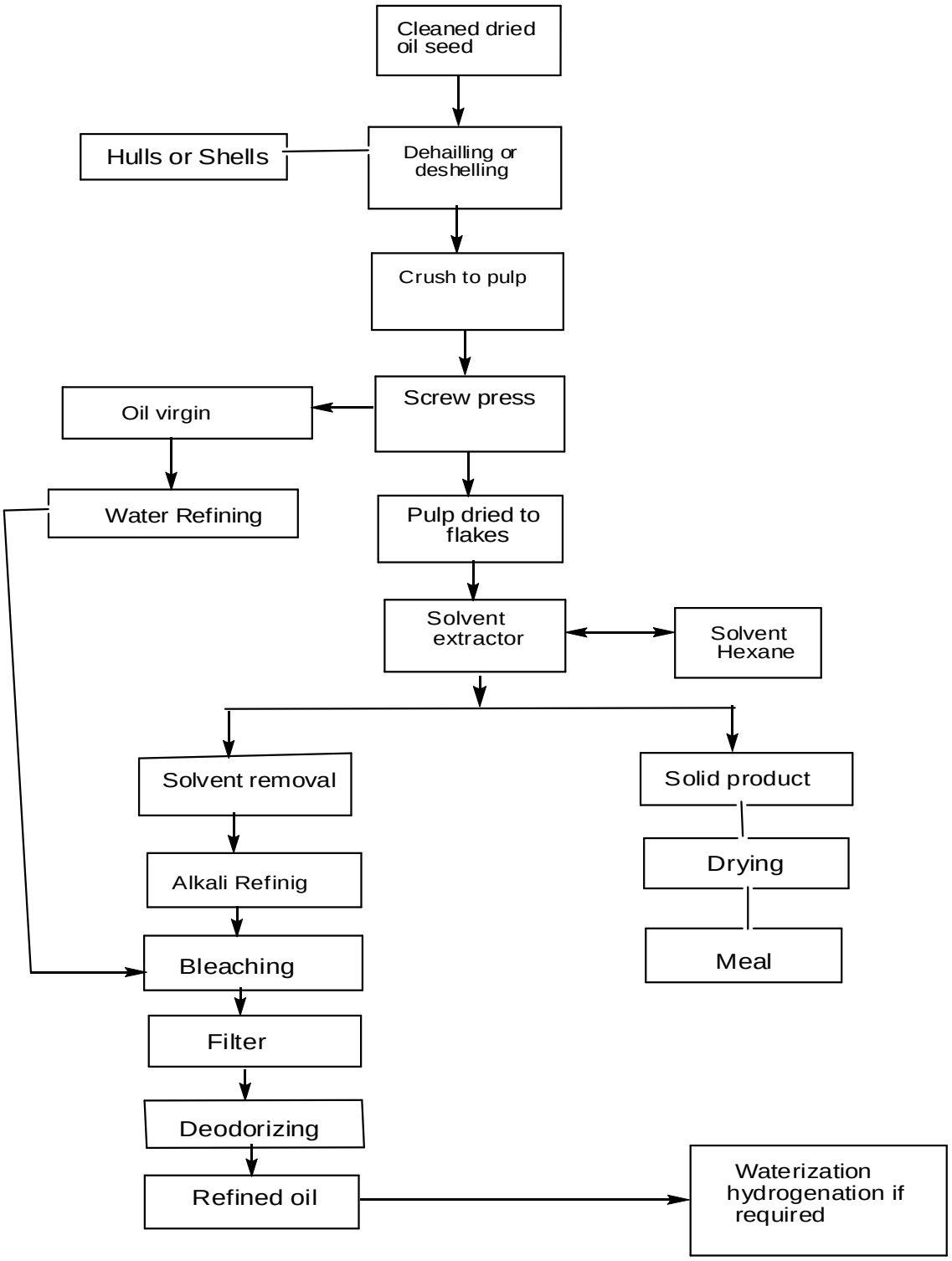


Fig (1.1): The refining steps in edible oils. Devine et al., (1961).

1.5 Rancidity

Rancidity is a term generally used to denote a condition of unpleasant odors and flavors in foods resulting from deterioration in the fat or oil (Michael *et al.*, 2001).

There are three pathways to form rancidity:

• Hydrolytic.

• Oxidative.

• Microbial**.**

1.5.1 Hydrolytic rancidity

It takes place in three steps:

1- Enzyme action or heat or moisturized.
2- Partial or complete hydrolysis.
3- Liberation of free fatty acids (FFA), diacylglycerol (DAG), monoacylglycerl (MAG) and glycerol.

The most common example of the hydrolytic rancidity is the rancid flovour in milk and deep fat frying.

1.5.2 Oxidative rancidity

It is a major cause of food spoilage. Ways of oxidative rancidity:

● Enzymatic oxidation

● Autoxidation

● Photo- oxidation**.**

1.5.3 Autoxidation

It is spontaneous reaction of atmospheric oxygen with lipids. It most commonly occurs in fats and oils; evidences showed that it is free radical mechanism. Abstraction of hydrogen atom by reactive species such as hydroxyl radical may lead to initiation of lipid oxidation; after initiation step propagation reaction occurs in which one lipid radical is converted into different lipid radical. These reactions commonly involve abstraction of hydrogen atom from lipid molecule or addition of oxygen to an alkyl radical. The last steps are termination reactions in which free radicals combine to form molecules with full complement of electrons and are low energy reactions but limited by the low concentration of radicals and by the correct orientation for reaction to collide. In frying oils termination reaction are important, with dimers and higher polymers contributing to the increased viscosity of the oil. Fig (1.2) shows the mechanism of oxidative rancidity in foods.

Initiation $X^{\bullet} + RH \rightarrow R^{\bullet} + XH$

Propagation $R^{\bullet} + O_2 \rightarrow ROO^{\bullet}$

$ROO^{\bullet} + R^{\bullet}H \rightarrow ROOH + R^{\bullet}$

Termination $ROO^{\bullet} + ROO^{\bullet} \rightarrow ROOR + O_2$

$ROO^{\bullet} + R^{\bullet} \rightarrow ROOR$

$R^{\bullet} + R^{\bullet} \rightarrow R\text{-}R$

Fig (1.2): shows the development of oxidative rancidity in foods

Factors influencing the rate of oils and fats oxidation

1-Fatty acids composition

It includes number, position and geometry of double bonds.

2- Free fatty acid

It is found that at lower content, no effect on oxidation occurs, but a higher content, oxidation is enhanced.

3-Temperature

As temperature increases, rate of oxidation increases.

4-Pro-oxidants

Transition metals, particularly those having two or more valence states with suitable oxidation – reduction potential, affect both the speed of oxidation and the direction of hydro peroxide break down to volatile compounds (Grosh , 1982)

5- Oxygen concentration.

6- Surface area.

7- Moisture.

8- Synergists.

9- Antioxidants.

1.6 Measurement of oxidative rancidity

1- Peroxide value.

2- Iodine value.

3- p. anisidine value.

4- Ultra violet spectroscopy.

5- Total polar component.

6- Active oxygen method.

1.7 Antioxidants

Antioxidant in food is defined as any substance which is capable of delaying, retarding or preventing the development in food rancidity or other flavor deterioration due to oxidation. These substances are correctly called oxidation inhibitor (Michael *et al.,* 2001). Antioxidants vary widely in chemical structure, origin and their mechanism of action. Table (1.5) shows the classification of antioxidants depend on the mechanism of antioxidant**.**

Table (1.5): Mechanism of antioxidant activity

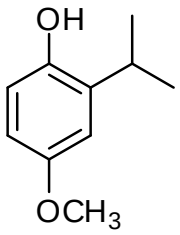
Antioxidant class	Mechanism of Antioxidant	Example of antioxidant
Proper antioxidant.	Preventing lipid free radical formation.	Phenolic compounds
Hydro peroxides stabilizers.	Preventing decomposition of hydro peroxides into free radicals.	Phenolic compounds.
Synergist	Promoting activity of proper antioxidants.	Citric acid, ascorbic acid.
Metal chelates	Binding heavy metal into inactive compounds.	Phosphoric acid, citric acid and maikard acids.
Singlet oxygen quenchers.	Transforming singlet oxygen into triplet oxygen.	Carotenes
Substances reducing hydro peroxides	Reducing hydro peroxide in non-radical way	Protein, amino- acids

1.7.1 Synthetic antioxidant

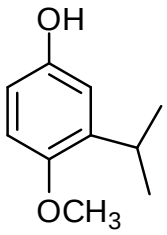
Antioxidants were first used before world war (Π) for food preservation; these early antioxidants were natural substances, but soon they were replaced by synthetic substances, which were cheaper of more consistent purity and possessed more uniform antioxidant properties (Pokorny, 1990).

Synthetic antioxidants were tested for toxicity by range of methods in concentrations at 100- 200 times the level actually consumed to confirm their safe use as additives, but some of them after a long period of use, under heavy pressure as a new toxicological data imposed caution in their use (Valenzuela *et al.*,1996**)** .

The most common synthetic antioxidants used one phenolic compound such as butylated hydroxy anisole (BHA), butylated hydroxy toluene (BHT), tertiary butyl hydroquinone (TBHQ) and esters of gallic acid such as propyl gallate, Fig (1.3) shows the common synthetic antioxidant. Synthetic antioxidants are always substituted by alkyls to improve their solubility in fats and oils (Hudson *et al.*,1990)

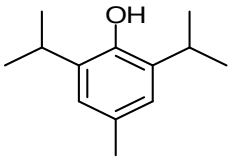


(2-BHA)

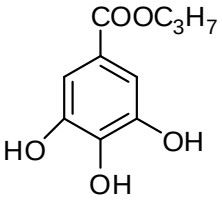


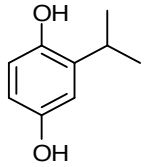
(3-BHA)

Butylated hydroxy anisol



Butyl-p-hydroxy toluene (BHT)





Propyl gallate(PG) **Tertbutyl hydroxyquinon(TBHQ)**

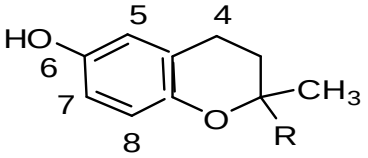
Fig(1.3): Most common syenthetic antioxidants

1.7.2 Natural Antioxidant

Natural antioxidants are defined as substances which occur in and can be extracted from plant or animal tissues and those which may be formed as consequence of cooking processing of plant or animal components for food (Simic *et al.*, 1981). Natural antioxidants are found in almost all plants, microorganism, and fungi and even in animal tissues (Pokorny, 1990). The major natural antioxidants are phenolic, tocopherols, and flavonoid and phenolic acids.

1.7.2.1 Tocopherols

Are the best known and most widely used. They can be classified as tocopherols (Toc) and tocotrienols (Toc -3), within each of these two classes are four isomers (α-β-γ and δ) making total of eight tocopherol isomers, as shown in Fig (1.4).

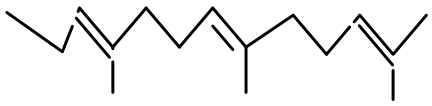


Tocopherols

R =

5, 7, 8- Trimethyl	α-tocopherol
5, 8- D Methyl	β-tocopherol
7, 8- Dimethyl	γ-tocopherol
8-methyl	δ-tocopherol

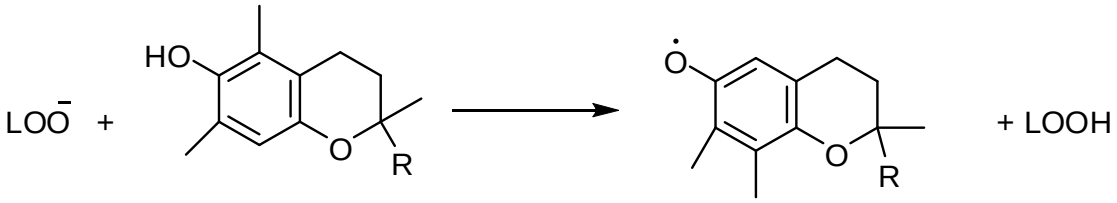
R =



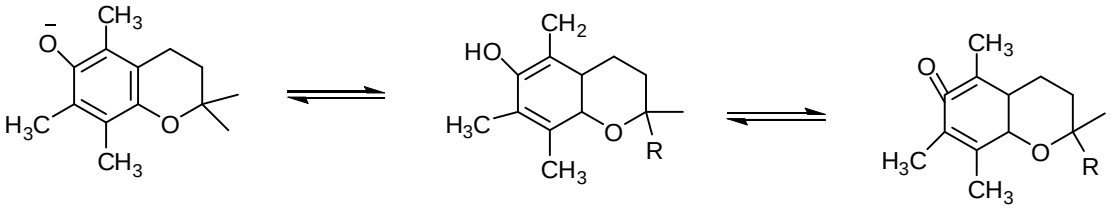
5, 7, 8- Trimethyl,	α-tocotrienol
5, 8- D Methyl	β-tocotrienol
7, 8- Dimethyl	γ-tocotrienol
8-methyl	δ-tocotrienol

Fig (1.4): Most common tocopherols.

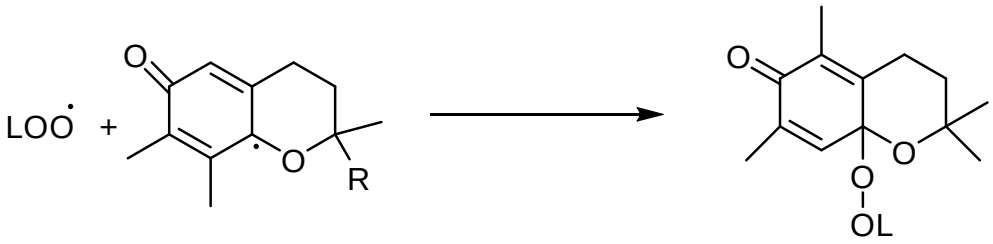
Tocopherols work as antioxidants by donating the hydrogen of the hydroxyl group to the lipid pyroxyl radical. The radical formed from α-tocopherols is stabilized through delocalization of the solitary electron over the aromatic ring structure; this radical forms non- radical product, including stable peroxides, which can be reduced to tocoquinones and tocopherols dimers (Frankel, 1996). Fig (1.5) shows the mechanism of α-tocopherol action.



α-tocopheryl radical

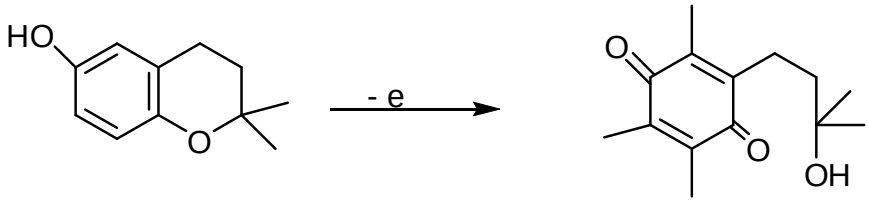


Form α-tocopheryl radical resonance



α-tocopherol peroxide

2 α-tocopheryl radical → α-tocopherol dimer

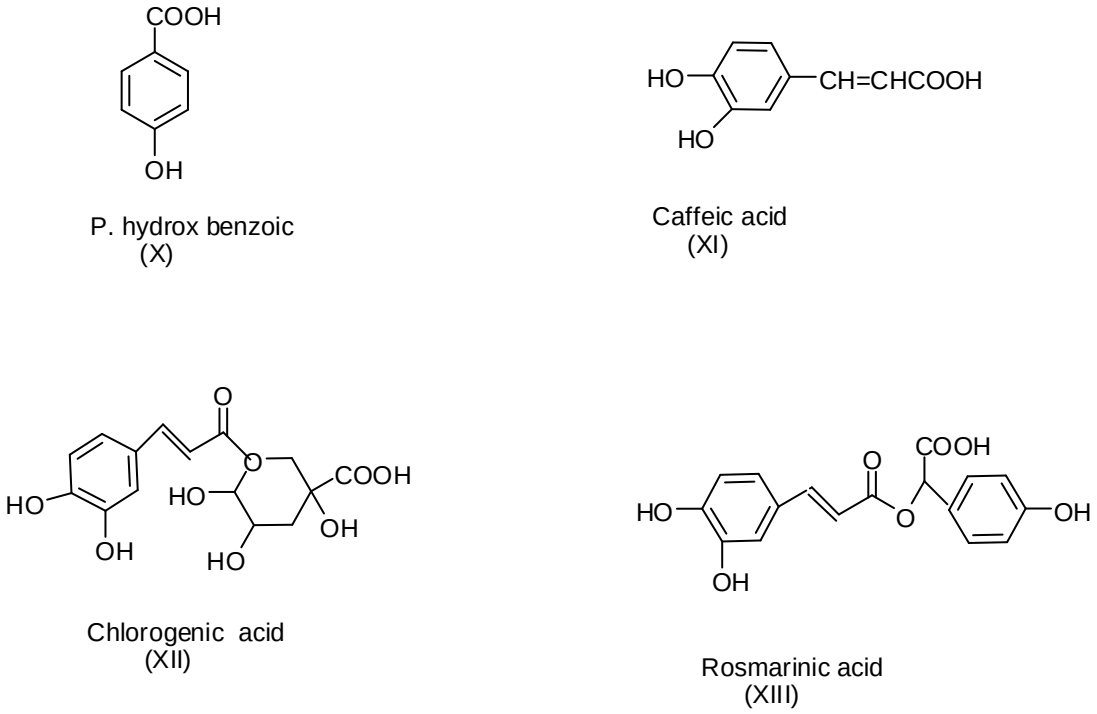


α- pheryl quinone

Fig (1.5) the mechanism of α- tocopherol action .

1.7.2.2 Phenolic acids

Phenolic acids are widely distributed in the plant kingdom. They usually exist as ester of organic acid or glycoside (Hermrnk. 1990). The most common phenolic acids are hydroxybenzoic (X), caffeic acid (XI) chlorogenic acid (XII) and rosmarinic acid (XIII), as shown in Fig (1.6).



P. hydrox benzoic (X)

Caffeic acid (XI)

Chlorogenic acid (XII)

Rosmarinic acid (XIII)

Fig (1.6): The most common phenolic acids.

Cuvelier *et al.(1992*) established the relationship between the structure of many phenolic acids and their antioxidant activity, they concluded that monophenols are less efficient than poly phenols, and introduction of second hydroxy group in the ortho or para position increases the antioxidant activity. The inhibiting effectiveness of monophenols is increased substantially by one or two methoxy substitution. The combination of two acid phenols increases the efficiency so that rosmrinic acid is better antioxidant than caffeic acid. Esterification of caffeic acid by

sugar moiety decreases its activity so that chlorgeric acid is less effective than caffeic acid.

1.7.2.3 Flavonoids

Flavonoids are a group of poly phenolic compounds, differ in chemical structure and character in plants; therefore over 4.000 types of flavonoids have been identified in plant vascular which vary in type and quantity due to variation in plant growth, conditions and maturity (Cook *et al.,* 1997) , table (1.6) shows the occurrence of flavonoid in food . Many scientists proposed that plant have evolved to produce flavonoids to protect them against fungal parasites, herbivores, pathogens and oxidative cell injury (Harbrne *et al.,* 1986). Conversely flavonoids assist plants in pollination and guide insects to their food source, for example, anthocyannins produces the pink, red, mauve, violet and blue colours of flowers fruits and vegetable (Coult *et al.*,1990). Tables (1.7) and (1.8) show different types of flavonoids.

Chemically flavonoids are low molecular weight, the basic structure feature (A and B) linked through hetero cyclic pyran ring (C) as shown in Fig (1.7).

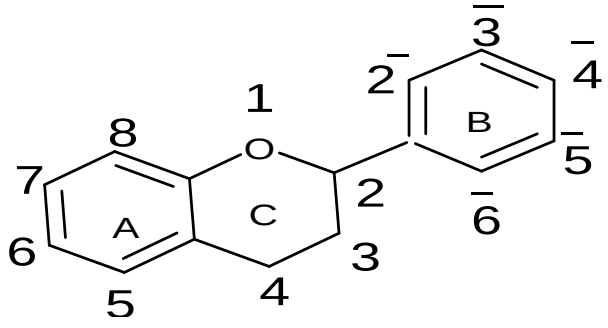


Fig (1.7): Basic molecular structure of flavonoid.

Flavonoid differs in their arrangement of hydroxyl, methoxy and glycosidic side groups and in the conjunction between A and B rings (Heim et *al*., 2002). A variation in C ring provides division of subclasses. According to their molecular structure, they are divided into eight classes as shown in Fig (1.8) and table (1.6).

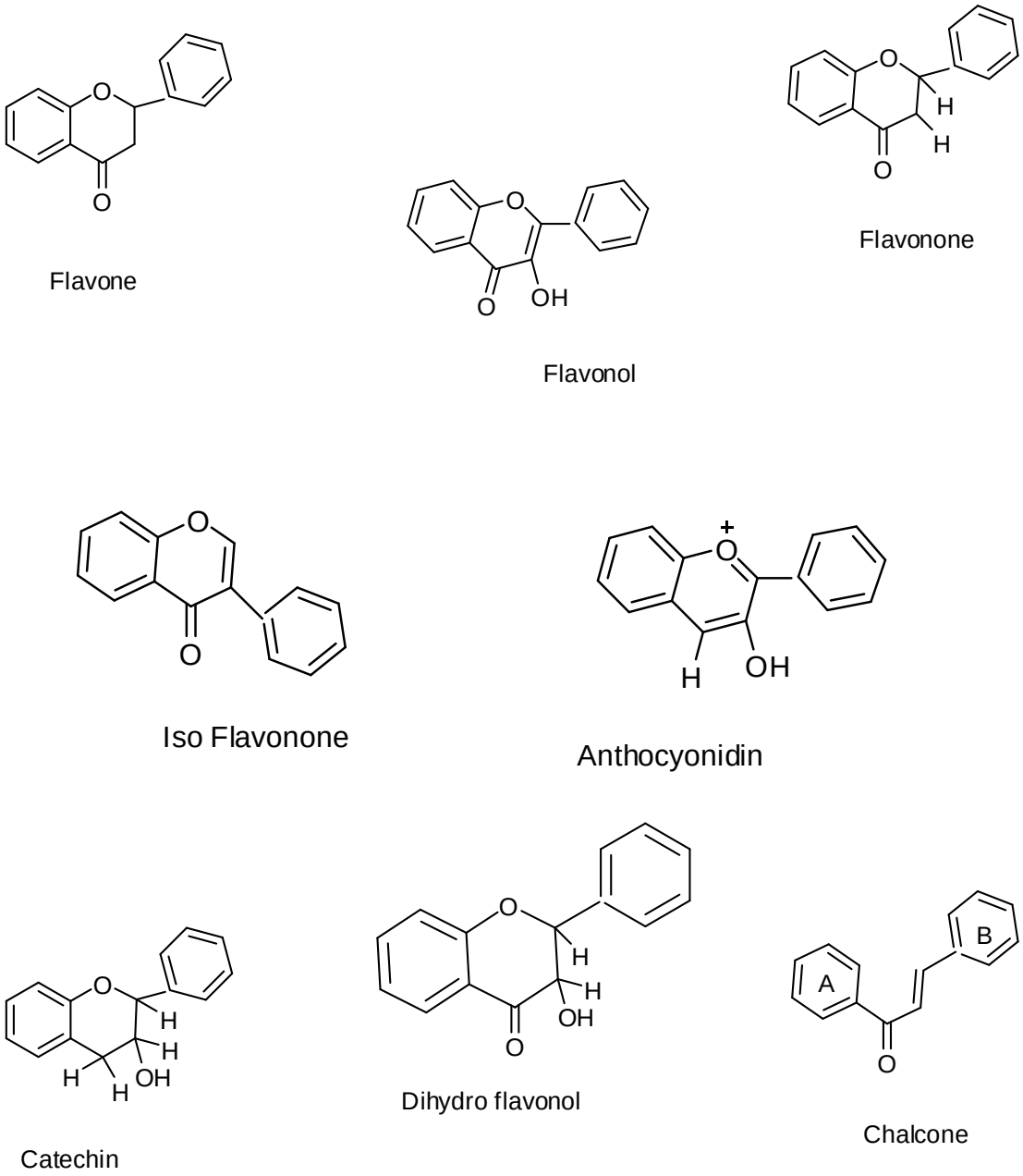


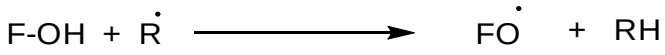
Fig (1.8): Different molecular structure of flavonoids.

Table (1.6): Occurrence of flavonoid in food (Hollman *et al.*, 1990)

Flavonoid subclass	Food source	Representative flavonoid
Flavonol	Onion,Kale,Brocoli, Apple,Cherries,Tea, Red wine	Kaempherol, Myricetin,Quercetin, Rutin
Flanones	Parsley, Thyme	Apigenin, Chrysin, Luteolin.
Flavonones	Citrus	Hesperitin, erodicytol, Naringen.
Catechins	Apple, Tea	Catechin, galocatechin
Antho-cyanidin	Cherries, Grapes	Maluvidin , hydroxyl cinnamate
Iso flavones	Soybean, Legumes	Diadzen, genistein, glyciten, formancntine

1.7.2.3.1 Flavonoid mechanism of action:

Flavonoids are powerful antioxidants against free radicals and are described as free- radicals scavengers (Pal *et al.*, 2009) .This activity attributed to their hydrogen donating ability. The phenolic groups of flavonoid serve as a source of a readily available "H" atom to the radical forming flavonoid radical which in turn reacts with free radical and terminating the propagating chain (Cillard et *al.,1986*).



Some flavonoids act as metal chelating agent and inhibit the superoxide reaction which is an important source of active oxygen radicals. It is found that the inhibition of lipid peroxide (LPO) is influenced by numbers of structural features of flavonoids.

1- The presence of hydroxyl group in position three (3-OH) of C ring. The flavonoids that have 3-OH group such as fisetin (+), catechin, quercetin and morin are potent inhibitors of LPO compared with those that lack a 3 – OH substitution such as hesperetin and diosmetin (Renaud et *al.*, 1992).
2- Double bond between C2-C3 of the C ring. It is found that, the hydrogenation of this bond decreases the antiperoxidative effects (Ratty et *al.*, 1998).
3- The number of hydroxyl groups. It is found that the hydroxy radical scavenging activity of flavonoids increases readily with the number of group substituted on the B ring especially at C-3 (Husain et *al.*, 1987).
4- The presence of sugar moiety. Fraga et al., (1987) found that flavonoids such glycones, as hesperetin and quecetin are more effective inhibiting malondialdehydehyde (MDA) production than their corresponding glycosides. The sugar moiety reduces the antiperoxidation efficiency of adjacent hydroxyl groups due to steric hindrance.
5- Methoxyl group reduces antioxidative efficiency of flavonoids in vitro due to steric hindrance. (Cholbi *et al.*, 1991).

Table (1.7): Diseases treated with flavonoids

Disease	**Flavonoids**
Ulcer	Kaenferol, (+) – cyandidnol – 3, quercetin
Rheumatoid arthritis	Apigenin, rutin
Inflammation	Quercetin, apigeni, catechin, hesperidin, fisetin, kaemferol.
Cancer	Quercetin, Kaemferol, Galeongin, Apigenin Luteolin, catechin
Memory day function	Genistein, Querctin, Fisetin

(Continued)

Depression	Naringenin, 2s-hesperidin, Linarin.
Cardiovascular	Quercetin, Mono-hydroxy ethyl- rutoside, Tri-hydroxy-rutoside.
Diabetes mellitus	Fisetin, Quercetin.
Antiallergic	Quercen, Rutin, Citrin, Disodum cromoglyate.
Hepatoprotective	Quercen, Avicularin, hirustrin, onitin, luteolin .
Thrombosis	Tangeration, hesperidin, quercetin, rutin, catechol, Sinetin.

Table (1. 8): Some antioxidants isolated from herbs and spices

Substances	Systematic name	Species
Carnosic acid carnosol, rosmarinic acid	Rosemainus	Rosemary
Rosmanol, carosol, carnosic acid	Salvia officinlis	Sage
Catechins	Camelia sinesis	Green tea
Theas lavins, theorubigirs	Camelia assamic	Black tea
Oerivatives of phenolic acid, flavonoids, tocophenols	Origanum vulgare	Oregano
Thymol, carvacrol, p-cumene-2,3-diol, biphenyl, flavonoids.	Thymus vularis	Thyme
Gingerol – related compounds Diaryl heptanoids.	Zingiber officinale	Ginger
Curunins	Curum a domestia	Tumeric
Phenolic amides, flavonoids	Piper nigrum	Black pepper
Capsaicin, capsaicinol	Capsicum frutescence	Chili pepper

1.8 Classification of ginger

Kingdom : Plantae (plants)

Subkingdom: Tracheobionta (vascular)

Super division: Spermatopyta (seeds)

Division: Magnoliphyta (flowering)

Class: Liliopsida (monocytoledons)

Subclass: Zingiberidae

Order: Zingiberales .

Family: Zingiberaceae .

Genus: Zingibemill .

Species: Zingiber Offcinale Roscoe

Ginger is indigenous to warm tropical climate, particularly in south eastern Asia, Africa, Jamaica, Mexico and Howii (Evan *et al.*, 1989). The plant is perennial with green-purple flower that occur in terminal spike and resemble orchids (Maurice *et al.*, 2014).The family Zingiberaceae includes 50 genera and over 1200 species. In 1998 Winkler and his co- workers discovered a new species of ginger named smithatris supraneeana .Ginger has been used as spice and natural additive for more than 2000 years (Bartley *et al.*, 2000). It has long been used in traditional fork medicine in various cultures for a wide range of ailments inducing stomach, diarrhea, nausea, asthma, respiratory disorders (Grazanna *et* al., 2005).

Recent studies showed that ginger compounds have variety of biological activities including anticancer, antioxidation, anti-inflammation, antiplatelet aggregation, antifungal, inhibition nitric oxide synthesis, inhibition of cyclooxygenase and protecting neuronal cells (Qing *et al*., 2005).

Chemically the main compounds of ginger classified into gingerol – related compounds and diaryl – heptanoids. The pungent components gingerol, shogaol and zingerone were reported to show high activity. Fig (1.9) shows the structure of these compounds.

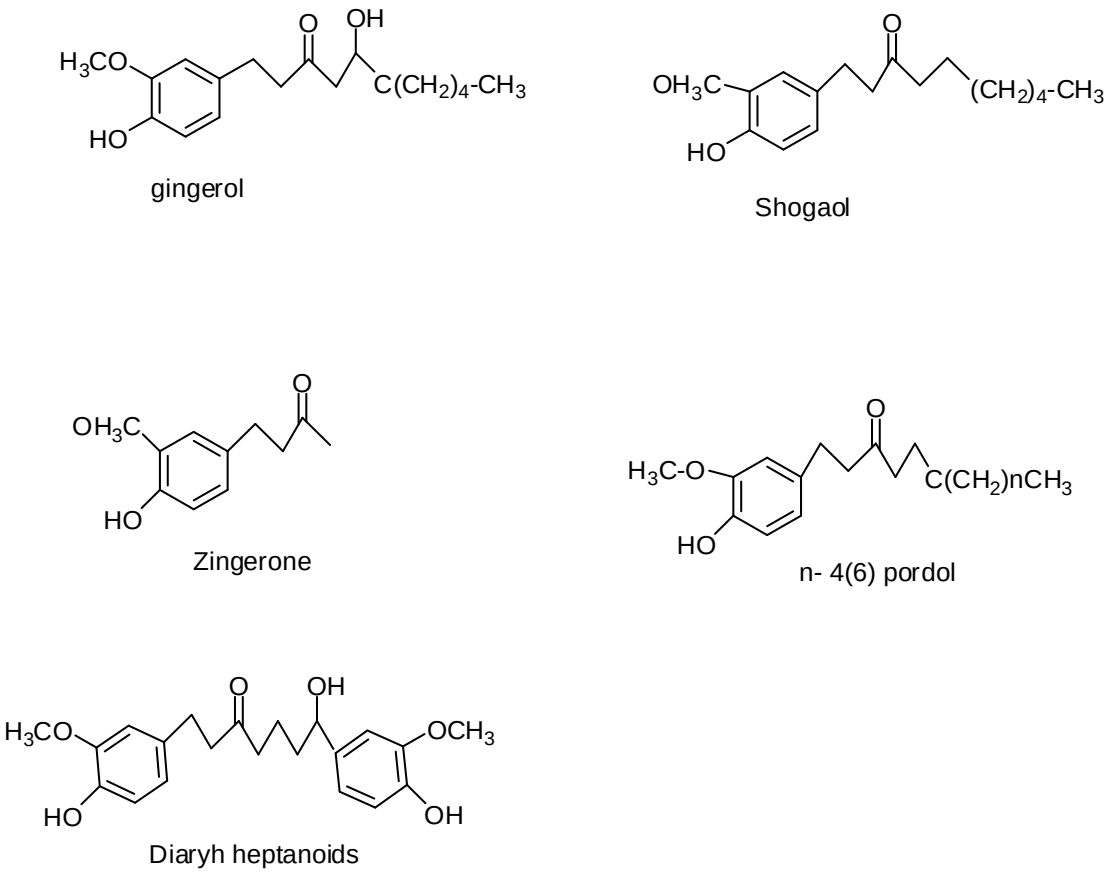


Fig (1.9): Main compounds of ginger

1.9 Sesame

1.9.1 Classification of Sesame

Kingdom : Plantae

Division : Magnoliophyta

Class : Magnoliopsida

Order : Laniales

Family : Pedaliaceae

Genus : Sesanum

Species : S. Indium

Sesanum indicum is an annual herb and attains 2m in height, with divided or palmilobate stem. The leaves are hairy and opposite. The tubular flowers are white or pink with purplish-red spots. It produces erect capsules, 5cm long and a wale shaped. The seeds are non-winged, reticulate or smooth and symmetrical; they are flatted, ovoid, pointed at one end, about 3 to 4 mm long, 2 mm broad and 1mm thick.

Sesame seeds are one of the oldest oil seed crops, known domesticated well over 3000 years ago. Sesame has many species, most being wide and native to sub- sahra Africa and highly tolerant to drought – like conditions, and it grows where other crops may fail.

1.9.2 Lipid composition of sesame oil

Like most vegetable oil, sesame oil is composed mainly of neutral triacyl glycerol (≈ 90%) with small quantities of diacyl glycerol (6%), free fatty

acids, phospholipids and unsaponifiable material. Table (1.9) shows the main constituents of sesame oil.

Compared with other vegetable oils, sesame oil is highly resistant to oxidative deterioration, and has been used as health food to slow down ageing and prevent several ailments. Lemck *et al*., (2001) suggested that sesame oil can reduce significantly the total bad cholesterol and the good cholesterol level unchanged and increase the concentration of 1 – tocopherol in plasma and tissue, this contributed to the presence of un saponifiable matter ; sesamin , sesamolin, sesamol and sesamolinol , as shown in (Fig 1.10) .

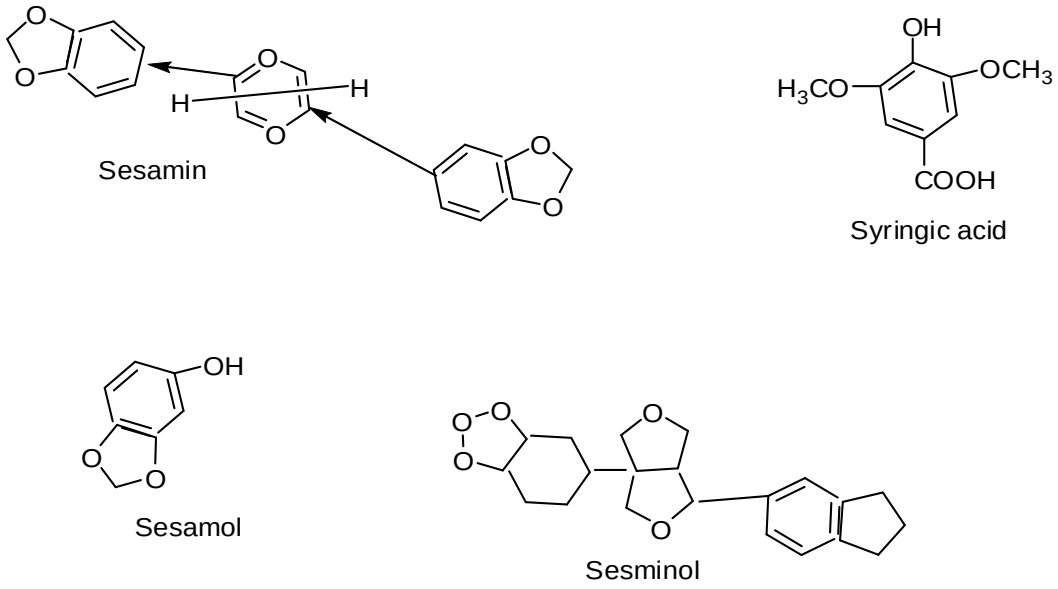


Fig (1.10): Main active compounds of sesame

Table (1.9) Fatty acids and codex ranges of some parameter of sesame oil

Parameters	Codex range
Specific gravity	0.915 – 0.924
Refractive index	1.466 - 1.469
Iodine value	104 - 120
Saponification value	186 - 95
Unsaponifiable matter g/100g	2
Fatty acid (%)	
14: 0	nd – 0.1
16 : 0	7.9 - 12
16 : 1	nd -0.2
18 : 0	4.5 - 6.7
18 :1	34.4 – 45.5
18 : 2	36.9 – 47.9
18 : 3	0.2 – 1.0
20 : 0	0.3 – 0.7
20 :1	nd- 0.3
22 : 0	nd- 1.1
other	nd- 0.7
Sterolcomposition of total sterol (%)	
Cholesterol	0.1 - 0.5
Brassicasterol	0.1- 0.2
Campesterol	10.1- 20.0
Sigma sterol	3.4- 12.6
β - Sitoserol	57.7-61.9
Tocopherols (mg /kg)	400 - 700

Source (Codex Stan 1993)

1.10 Sunflower

1.10.1 Classification of sunflower

Kingdom : Plantae

Subkingdom : Tracheobionta

Superdivision : Spermatophyta

Division : Magnoliphyta

Class : Magnoliospida

Subclass : Asteridae

Order : Asterales

Family : Asteraceae

Genus : Helianthus. L.

Species : Helianthus annuus L.

(Source: United State Department of Agriculture, USDA, 2004).

Cultivated sunflower (Helianthus annuus L.) is an unusual plant. It can be distinguished from all other cultivated plants by its single stem with conspicuously large inflorescence. Quantitative characteristics such as plant height, head diameter, a chene size and days to flowering vary greatly depending on the environment in which plant grow (USDA, 2004).

The sunflower is considered to be somewhat of drought to lerant plant and will grow in a variety of soil types from sands to clays and a wide

range of soil pH from 5 – 7 to 8. The world's largest sunflower oil producer is Russia, Kuraine and Argentina.

Sunflower (Helianthus annuus) was introduced early in The Sudan but commercial production on large scale started in late 1980s by the private sector. Sunflower in Sudan is grown in two seasons winter and summer and is recognized as a crop with high potential that can successfully meets future oil requirements (Rahmtalla, 2015).

1.10.2 Composition of sunflower oil

Like most vegetable oil sunflower composed of triacyl glycerols (98-99%) and a small proportion of phospholipids. The unsaponifiable matter contains tocophenols, sterols and waxes, beside other substances.

There are three commercial types of sunflower oil differing in their oleic and linoleic acid content, but having nearly equal content of palmitic acid.

Table (1.10): The percentage of fatty acid composition of sunflower oil

Fatty acid	**Regular**	**High - oleic**	**Mild - oleic**
Palmatic (16:0)	5.0 – 7.6	2.6 – 5.0	4.0 – 5.5
Oleic (18:1)	14.0 – 39.4	75.0 – 90.7	43.1 – 71.8
Linoleic (18:2)	48.3 – 74.0	2.1 – 17 .0	18.7 – 45.3
Arachidic (20:0)	0.1 – 0.5	0.2 – 0.5	0.2 – 0.4
Behenic (22:0)	0.3 – 1.5	0.5 – 1.6	0.6 – 1.1
Lignoceric(24:0)	Nd – 0.5	Nd – 0.5	0.3 – 0.4

The percentage composition of major triacyl-glycerol not exceeds 1%. The phospholipids content of crude regular sunflower between 0.5% and 1.2, which consists mainly of phosphatidyl cholines, phosphatidyl ethanolamines, phosphatide linositols and phosphatidic acid. Most of which is removed from the crude oil by water degumming. The unsaponifiable matter of crude sunflower oil amounts to less than 15 g /kg, it is composed of sterols tocopherols, tocotrinols and minor components.

1.11 Soybean

1.12.1 Scientific classification of Soybean

Kingdom : Plantae

Division : Angiosperm

Class : Eudicots

Sub class : Fabales

Family : Leguminaceae

Sub family : Faboideae

Genus : Glucine

Species : G. max

Soybeans are globally important crop, providing oil and protein. Man knows soybean since early decays in East Asia and from there spreads to all over the world. Soybean introduced to Africa from China in the late 19th century. During World War (1) soybean became important in North America and Europe chiefly as substituted protein food and as a

source of edible oil. The main producers are United States (36%), Brazil (36%), Argentine (8%), (China 5%) and India (4%). Cultivation of soya bean grows successfully in climates with hot summers. The standard for measuring protein quality of soybean is the nutritional equivalent of meat and eggs for human growth and health. Natural soybean seeds are oval shaped and consist of three major parts: seed coat or hull, Cotyledon and germs or hypocotyl. Table (1.11) shows the approximate composition of the seeds of soybean.

Table (1.11): the approximate composition of the seeds of soybean

Components	Yield	Protein	Carbohydrate	Oil	Ash
Whole seed	100.0	40.3	33.9	21.0	4.9
Catyledon	90.3	42.8	29.4	22.8	5.0
Hull	7.3	8.8	85.9	1.0	4.3
Hypocotyl	2.4	40.8	43.4	11.4	4.4

1.11.2 Oil composition

Crude oil recovered by solvent extract or mechanical pressing contains various classes of lipid. It consists primarily of neutral lipids, which include tri, di and mono acyl glycerols, free fatty acids and polar lipids such as phospholipids .It also contains a minor amount of unsaponofiable matter that includes phyto-sterols, tocopherols and hydro carbons such as squealers. Trace metals are found in ppm concentration (Wang *et al.*, 2001). Table (1.12) shows the composition of crude and refined soybean oil.

Table (1.12) Composition of crude and refined Soy bean oil

Composition	**Crude oil**	**Refined oil**
Triacylglycerol (%)	95 – 97	>99
Phospholipids (%)	1.5 – 2.5	0.003 – 0.045
Unsaponifiable matter (%)	1.6	0.3
Phytosterols	0.33	0.13
Tocopherols	0.15 – 0.21	0.11 – 0.18
Hysrocarbons	0.014	0.01
Free fatty acids (%)	0.3 – 0.7	< 0.05
Trace metals (ppm)		
Iron	1 - 3	0.1 – 0.3
Copper	0.03 – 0.05	0.02 – 0.006

Source: Pryde, (1980).

Fatty acids of soy bean oil consist mainly of linoleic acid, oleic acid, palmitic acid, beside others in low concentrations. Table (1.13) illustrates the fatty acids composition of soybean oil.

Table (1.13) The fatty acids composition (wt. %) of oil from soybean oil .

Fatty Acid	**(Wt. %)**
Lauric (12:0)	-
Myristic (14: 0)	0.1
Palmitic (16: 0)	11.0
Palmitoleic (16 : 1)	0.1
Stearic (18 : 0)	4.6
Oleic (18 : 1)	23.4

(Continues)

Linoleic (18 : 2)	53.2
Linolenic (18 : 3)	7.8
Arachidinic (20 : 0)	0.3
Gadoleic (20 : 1)	-
Eicosadieroic (20 : 2)	-
Behenic (22 : 0)	0.1
Lignoceric (24 : 0)	-

Source: Orthoef (1996)

1.12 Objectives

1.12.1 General objectives

1- To study the chemistry of edible oils in general with especial focus on sunflower oil and soybean oil because soybean is promising oil in Sudan.

2- To study the chemistry of natural antioxidants with especial concern on sesame oil and ginger roots.

1.12.2 Special objectives

1- To investigate use of natural antioxidants to increase the shelf life of vegetables oils.

2-To study the application of sesame oil and ginger roots extract as antioxidants for soybean and sunflower oils.

2.0 Materials and methods

2.1 Materials

2.1.1 Plant materials

Fresh ginger root (Zingiber Officinale) were procured from Khartoum local market, washed with distilled water, dried with air, ground and stored in a container in a refrigerator.

Sunflower oil under study procured from Arabian Company for oils. Soybean seeds (Sudan 1) were procured from Agriculture Research Centre (Gezira State) .The crude soybean oil was extracted by cold pressing extraction in local market.

The sesame seeds were purchased from local market (Ommdrman). The crude oil of sesame oil was extracted by cold pressing extraction.

2.1.2 Chemicals

All chemicals used in this study were obtained from LOBA company (India), for an analytical grade.

2.1.2.1 Reagents

Sulphuric acid , hydrochloric acid, boric acid , glacial acetic acid, sodium hydroxide potasium hydroxide ,sodium thiosulphate , potassium iodide , sodium chloride ,Wij, s reagent , Kjeldal catalyst (copper sulphate + sodium sulphate) , diphenyl Picryl Hydrazide (DPPH) , phenolphthalein , methyl red and starch .

2.1.2.2 Solvents

Dichloromethane , diethyl ether , chloroform , methanol , ethanol , hexane dimethyl sulphoxide (DMSO) .

2.1. 2.3 Instrumentation

1- Rotary evaporator type KRVUD 56/45, Buch.

2- Oven (Herus), 230 V- 50/60Hz.

3- Furnace (Herus electronic/ muffle furnace).

4-Atomic absobtion photometer, model Perkin Elemer version 220.

5- Viscometer (HAAKE 6 plus type 387- 0100) thermo electronic.

6- Refractometer (D-22296 Hamburg, type KRUSS- Germany.

7- Digital tintometer type lovibond House, SP4752, UK.

8- Spectrophotometer (multiplayer reader).

9- Gas chromatography –mass spectroscopy, type QP2010 ultra, column: RTX - 5m, length: 20 m, diameter: 0.25 mm, carrier gas : Helium.

2.2 Methods

2.2.1 Extraction of ginger oil

A sample of 50g of ground ginger was dissolved in 400cm^3 of distilled water in conical flask and connected to the Clevenger apparatus. The system was heated in boiling water for 5-6 hours .The oil was then collected from the upper layer (Kamaliroosta *et al*. 2013).

The percentage of oil = $\frac{wt.of\ oil}{wt.of\ sample} \times 100$

2.2.2 Extraction by dichloromethane solvent (DCM)

Accurately 50 g of ground ginger was dissolved in 250 cm^3 of dichloromethane. The mixture was shacked and left over night at room temperature, filtered with whatman No.1 filter paper. The filtrate was evaporated below 40℃ in rotary evaporator and then was kept in a container in a refrigerator.

The percentage of dichloromethane extract = $\frac{wt.of\ extract}{wt.of\ sample} \times 100$.

2.2.3 Addition of natural antioxidants to sunflower and soybean oils

The dichloromethane extract of ginger or sesame oil was added to make different concentrations of 200ppm, 300ppm, 400ppm, 500ppm or 600ppm, each, to refined sunflower or crude soybean oil.

2.2.4 Approximate analysis of ginger roots

All approximate analysis of ginger roots were done according to official methods of the Association of Official Agriculture Chemist, 1990.

2.2.4.1 Moisture content

An accurately 0.2 g of sample was placed, in an oven at 105°C for 5 hours , cooled in desiccator and weighed . The procedure was repeated to obtain constant weight .The percentage of the moisture content was calculated according to the following equation:

$$\text{Moisture content} = \frac{(wt.of\ sample - wt.of\ dry\ sample)}{wt.of\ sample} \times 100$$

2.2.4.2 Ash content

Accurate weighed 2.0 g of sample was placed in dry crucible, heated in muffle furnace at 550°C for 6 hours, cooled in desiccator and weighed .The percentages of the total ash content were calculated according to the following relation:

$$\text{Total ash content} = \frac{wt.of\ ash}{wt.of\ sample} \times 100$$

2.2.4.3 Determination of protein content

The protein content was obtained by using Kjeldahl method. 0.5 g of sample was weighed in a peace of filter paper. Kjeldahl was added. The mixture (Kjeldahl catalyst and the sample) was dissolved in concentrated sulphuric ($10cm^3$) in a Kjeldahl flask .The solution was heated till the colour became pale yellowish- green. After cooling, it was diluted with distilled water, $15cm^3$ of sodium hydroxide (30%) were added and mounted into a distillation system. The distillate containing ammonia was received in a conical flask containing $25cm^3$ of 2% boric acid with drops of methyl red as indicator. When all ammonia had been collected, the

distillate was titrated against a standard solution of 0.02 N HCl. A blank was also titrated without adding the sample.

Nitrogen = $\frac{(V2-V1)\times N\times 0.01401\times 100}{wt.of\ sample}$

Where $v_2 \equiv$the volume of titrant.

$V_1 \equiv$ the volume of blank.

Protein % = nitrogen content $\times$ 6.6

Where 6.6 is nitrogen conversation factor.

2.2.4.4 Determination of fiber content

About 5.0g of sample was dissolved in 200 cm³ sulphuric acid (0.225 N), boiled for 30 min. and filtered. 200 cm³ of sodium hydroxide (0.313 N) was added to the precipitate, boiled for 30 min, filtered and washed the filtrate with hot distilled water and alcohol. The filtrate was dried, weighed and ashed at 500-600°C for 2 hours; then the fiber content was calculated by subtracting the weight of ash from the weight of precipitate.

Fiber % = $\frac{wt.of\ fiber}{wt.of\ sample} \times 100$

2.2.4. 5 Carbohydrate content

The percentage of carbohydrate content was calculated by subtracting the summation of moisture, ash, protein, and fiber from the weight of sample.

2.2.4.6 Determination of essntional elements

Accurately 1.0 g of sample was placed in crucible, heated in a furnace at 550° C for 5 hours , cooled , dissolved in concentrated hydrochloric acid and filtered . The solution was transferred to 100 cm³ distilled water.

Atomic absorption photometer , was used for determining sodium , iron , chromium , manganese , copper ,zinc , calcium, lead and alminium .

2.2.5 Determination of Physiochemical properties of sesame, sunflower and soybean oils

2.2.5.1 Peroxide Value (PV)

The peroxide value was performed according to (AOAC, 1990).

Procedure:

0.5 g of oil sample was dissolved in 30 cm^3 of mixture of acetic acid and chloroform (3:2). 0.5 cm^3 of saturated potassium iodide solution was added. The solution was shaked for one min, kept in the dark (10 – 30 min.) and then titrated against 0.01N sodium thiosulphate, using 0.5 cm^3 starch as indicator.

Peroxide Value (PV) = $\frac{S-B \times N \times 1000}{wt.of\ sample}$

B ≡ volume of titrant, cm^3 of blank

S ≡ volume of titrant, cm^3 of sample

N ≡nolarity of sodium thio sulphate

2.2.5.2 Iodine value (IV)

This experiment was carried out according to (AOAC, 1990).

Procedure:

2.0 g of oil sample was dissolved into 10 cm^3 of chloroform and 20 cm^3 of wij's reagent was added. The mixture was shaked well and then allowed to stand in the dark for 30 minutes; 15 cm^3 of potassium iodide solution (1%) and100 cm^3 of water were added and then titrated against 0.1N sodium thiosulphate using starch as indicator.

$$IV = \frac{(B-A)\times 126.9 \times 100}{wt.\ of\ sample}$$

B ≡ volume of titrant, cm^3 of blank

A ≡ volume of titrant, cm^3 of sample

2.2.5.3 Acidity (AVand FFA)

Procedure:

2.0 g of oil was dissolved in 50 cm^3 of mixture of ethanol and ether (1:1%). Then the solution neutralized with 0.1N sodium hydroxide and ph.ph. as indicator.

$$(Av) = \frac{\text{volume of (titrant x 0.1 x 5.61}}{\text{wt of sample}}$$

$$\text{Free Fatty Acid (FFA)} = \frac{Av}{2}$$

2.2.5.4 Viscosity (V)

The viscosity was done according to (AOAC, 1990).

Procedure**:**

An appropriate cylinder of the instrument was chosen and then filled with 5 cm^3 of oil sample and placed inside the instrument. The switch bottom was opened, to readily the oil, and then displays the viscosity directly in poise.

2.2.5.5 Refractive Index (RI)

Refractive index was determined by, refractometer at 28°C as described by (AOAC, 1984).

Procedure:

The source of light was opened, the place of the sample was washed by a drop of ethanol and the temperature of instrument was measured .Then the instrument was adjusted with distill water by turning the scale adjustment to move along the measuring range until light / dark division appeared and the refractive index of was measured ,then the place of the sample was dried by apiece of cotton on which the oil sample was put , and refractive index of sample was determined .

2.2.5.6 Determination of colour Intensity (CI)

The colour intensity was recorded in livobond tintometer units of red, yellow and blue by the digital tintometer .

2.2.6 Gas Chromatography –Mass Spectroscopy (GC-MS)

2.2.6.1 Sample preparation (methylation)

2.0 cm^3 of oil sample was taken in a test tube, and 7cm^3 alcoholic sodium hydroxide was added. 7 cm^3 of mixture of sulphuric acid and methanol (1% v/v) was added, shaked well and left over night. 2 cm^3 of super

saturated sodium cholloride was added, and 2 cm^3 of normal hexane also was added and shaked well; then organic layer was collected, diluted with 5cm^3 of diethyl ether. 1g. of sodium thiosulphate was added as drying agent, filtered by syringe filter paper 0.45µm and transferred directly to GC-MS vial.

2.2.7 Diphenylpicrylhydrazyl (DPPH) radical scavenging assay

The antioxidant and radical scavenging of sesame oil and DCM extract of ginger roots was evaluated according to the method of Shimada *et al.*, (1992) with some modification. In 96-wells plate, the test samples were allowed to react with 2.2 di (4-tert-octylphenyl)-picryl-hydrazyl stable free radical (DPPH) for half an hour at 37°C. The concentration of DPPH was kept at 300 µm. The test samples were dissolved in DMSO (Dimethyl sulphoxide) while DPPH was prepared in ethanol. After incubation, decrease in absorbance was measured at 517 nm using multiplate reader spectrophotometer. Percentage radical scavenging activity by samples was determined in comparison with a DMSO treated control group. All tests and analysis were run in triplicate**.**

3.0 Results and discussion

3.1 A pproximate analysis of ginger

The results of the approximate analysis of ginger are illustrated in Table (3.1.1). The moisture and protein contents were found to be 12. 5% and 3.24%, respectively, these results are in a good agreement with those reported by Goplan *et al.* (2004). The ash content was found to be 5.98%. The concentration of essential elements was determined by AAS: sodium , iron ,chromium, manganese , copper , zinc , calcium and lead were found to be 10.92 , 15.24 , 0.02 , 11.03 , 0.65, 10.96 , 111.23 and 0.27 ppm, respectively ; these results are very close to those reported early by Adel *et al., (*2010).

Table (3.1.1): Approximate analysis of ginger:

Constituents	Resuts
Moisture	12.5 %
Ash	5.98 %
Protein	3.24 %
Carbohydrate	21.51 %
Fiber	56.86 %
Oil content	1.5 %
Sodium	0.001 %
Iron	0.001%
Chromium	0.02 ppm
Manganese	0.001 %
Copper	0.65 ppm
Zinc	0.001%
Calcium	0.0111%
Lead	0.27 ppm
Alminum	N.D.

N.D. = not detected

Table (3.1.2) provides chemical composition and percentages of compounds present in ginger oil .It shows that zengerben is the major compound (19.96 %); this result is in agreement with those reported by several earlier investigators ; Kamaliroosta et al., (2013) , Sultan et al., (2005) and Pino et al., (2004). Beside, zengerben , there are wide range of compounds: α – curamene (10.93%) , α –farnesene (9.5%) , β – bisabolene (7.45%) , methyl heptadiene (5%) , phallandrene (3.93%) ,citral (3%) ,eucalypol (2.9%) , camphen (2.2%) ,citronellal(1.26%) and alloarmomadendrene (0.48%) .

Table (3.1.2): Chemical composition in percentage for ginger oil

Peak	R.time (min)	Area	Area%	Name
1	4.81	367860	0.06	2-Heptanol.
2	5.46	3545598	0.58	Alpha-pinene.
3	5.77	13444629	2.2	Camphene.
4	6.23	212046	0.03	Bicyclo(3.1.)Hexane, 4-methylene-methyl ester.
5	6.32	784311	0.13	Bicyclo(3.1.1)heptane,6,6-dimethyl ester.
6	6.45	1129788	0.19	5-Heptane-2-one, 6 –methyl ester.
7	6.52	2981737	0.49	Beta-myrcene.
8	6.77	219279	0.04	Octanal.
9	6.85	965353	0.16	Apha-phellandrene.
10	6.98	118205	0.02	3-Carene.
11	7.27	534055	0.9	P-Cymene.
12	7.39	23934562	3.93	Beta-phellandrene.
13	7.44	17748207	2.91	Eucalyptol.
14	7.55	1199391	0.03	Acetic acid, 5-methylhex yl-2-methyl ester.

(Continued)

15	7.85	144102	0.02	Cyclopropane, 11-dimethyl-2-propenyl -methyl ester.
16	7.99	225987	0.04	Gamma-terpinene.
17	8.65	2278103	0.37	2-Carene.
18	8.78	4153987	0.68	Bicyclo (3.1.1) hept-3-en-2-one, 4, 6, 6-trimethyl ester.
19	8.85	6634054	1.09	1, 6-Octadien-3-ol, 3, 7-dimethyl, 2-aminobenzen.
20	9.18	248370	0.04	Neryllnitrile.
21	9.23	335022	0.05	Isoborncol.
22	9.41	315596	0.05	2-Cyclohexen-1-ol, 1-methyl-4-1-methyl ester.
23	9.44	408202	0.07	Traans-2-pinanol.
24	9.82	342324	0.06	1, 4-Hexadiene, 3, 3, 5-tri methyl ester.
25	9.95	722560	0.22	(+)-2-Bornanone.
26	9.99	815795	0.13	6-Octenal, 3, 7-dimethyl ester.
27	10.05	461871	0.08	Bicyclo(2.2.1)heptan-2-ol,2,3,3,-trimethyl ester.
28	10.23	603839	0.1	Bicyclo(2,2,1)heptan-2-ol,1,7,7-trimethyl ester .
29	10.42	13165450	2.16	Endo-borncol.
30	10.49	2444062	0.4	2, 6-Dimethyl-1-nonen-3-yn-5-ol –methyl ester.
31	10.63	1739300	0.29	Terpinen-4-ol-methyl ester.
32	10.91	6046164	0.99	L-alpha-terpincol .
33	11.61	7703032	1.26	Citronellol.
34	11.93	19134365	3.14	Citral.
35	12.55	30965795	5.08	2-Octene, 2-methyl-6-methylene-methyl ester.
36	12.66	1872895	0.31	Cinnamaldehyde .
37	12.92	2607570	0.43	Bornyl acetate.
38	12.96	3095902	0.51	2-Dodecanone.
39	13.97	395623	0.06	Delta elmene.

(Continued)

40	14.14	1718815	0.28	Citronyl n-proprionate.
41	14.64	1407569	0.23	Cyclosativene.
42	14.76	5875684	0.96	Geranyl acetate.
43	14.79	2711904	0.44	Alpha-cubene .
44	15.08	6019697	0.99	Cyclohexane.
45	15.26	1776453	0.29	Beta-curcumene .
46	15.88	6149326	1.01	1, 5-Cyclodecadiene, 1, 5-dimethyle-8-methylidene.
47	16.2	2750553	0.45	(E)-Beta-famesene.
48	16.27	2170830	0.36	Cyclohexene, 3-(1, 5-dimethyl-4-hexenyl)-6-methylene.
49	16.52	2927073	0.48	Alloaromadendrene.
50	16.8	66665595	10.93	Alpha-curcumene.
51	16.88	6981700	1.14	1, 6-Cyclodecadiene, 1-methyl-5-methylethyl ester.
52	17.05	121694885	19.96	Zingiberen.
53	17.19	57918130	9.5	Alpha-farnesene.
54	17.28	45404414	7.45	Beta-bisabolene.
55	17.71	3171765	0.52	Alpha-beranotene
56	18.1	13018756	2.14	Cyclohexane methanol, 4-ethenyl-alpha4-trimethyl ester.
57	18.21	9815313	1.61	Trans-nerolidol.
58	18.77	8793461	1.44	7-Epi-cis-sesquisabinene hydrate.
59	19.17	13711644	2.25	Cis-sesquisabinene hydrate.
60	19.45	12598106	2.07	7-Epi-trans-sesquisabinene hydrate.
61	19.58	7176046	1.18	Beta-eudesmene.
62	19.94	16678244	2.74	Beta-eudesmol.
63	20.51	9413919	1.54	6, 10,-dodecadien-1-yn-3-ol, 3, 7, 11-trimethylester.

(Continued)

64	22.09	2842122	0.47	Tetramethyl-4-methylene chromen
65	23.84	1709008	0.28	Geranyl-p-cymene
66	24.8	5616539	0.92	Verticillol
		609762542	100	

Tables (3.1.3) provide the main chemical constituents of ginger DCM extract. The table shows that gingerol -3-decanone-5-hydroxyl –phenyl (27.4%) and capaicin (8.49%) are the most abundant of DCM extract , beside other compounds in different ratios including dimethyl ethyl phenyl (3.48%) , behenic alcohol (3.47%) , hexahydro-plotaxene (3.1%) , pelargonic acid (2.99%), paradol (2.93 %) and carinol (2.08 %).These results are in agreement with those reported in earlier papers investigating the structure –activity relationship Gurdip et al. (2008), Ali et al. (2010).

Table (3.1.3): The Chemical constituents of ginger DCM extract

peak	R.time(min)	Area	Area%	Name
1	4.14	122720	0.08	Camphene.
2	4.81	751425	0.48	Octanal.
3	5.33	159655	0.1	Beta-Phellandrene.
4	7.91	233610	0.15	Endo-Borneol.
5	8.17	1326786	0.85	1-Dodecene.
6	8.33	741513	0.48	Dodecane.
7	8.5	2964	1.91	Decanal.
8	8.95	122450	0.08	Citronellol.
9	9.49	169103	0.11	Geraniol.
10	10.24	276873	1.18	2-Undecanone.

(Continued)

11	10.81	286972	0.18	2-Methoxy-4-vinylphenol.
12	12.08	2860286	1.84	1-Tridecene.
13	12.23	1157936	0.75	Tetrad cane.
14	13.9	670499	0.43	Beta-Curcumene
15	13.95	1856783	1.19	Benzene,1-(1,5-dimethyl-4-hexenyl)-4methyl ester .
16	14.18	3717188	2.39	1,3Cyclohexadiene, 1, 5 dimethyl ester.
17	14.33	1261024	0.81	Alpha-Farnesene .
18	14.46	5410649	3.48	Phenol,2,4-bis1,1-dimethyl ester .
19	14.72	2250980	1.45	Cyclohexene,3-1,5dimethyl ester .
20	15.36	538955	0.35	1,6,10-Dodecatrien-3-ol,3,7,11-trimethyl ester.
21	15.75	4817158	3.1	1-Heptadecene.
22	15.87	1332154	0.86	Nonadecane .
23	16.32	378824	0.24	7-Epi-cis-sesquisabinenehydrate.
24	16.61	678732	0.44	8-Decen-2one,9-methy,-5-methyl ester .
25	16.93	6059400	3.9	Butan-2-one,3-hydroxy-2-methoxyphenyl.
26	17.09	1361169	0.88	Beta-Eudesmol .
27	18.42	1127072	0.73	Phenol, 2-methyl1, 2, 2-trimethylcyclopentyl.
28	18.81	5175066	3.33	1-Nonadecene.
29	18.89	1277436	0.82	Octadecane.
30	19.24	2565165	1.65	Cyclohexane, 1, 1-dimethyl ester.
31	20.96	4407161	2.84	n-Hexadecanoic acid .
32	21.27	5396963	3.47	Behenic alcohol.
33	21.33	9772373	0.63	Heneieosane.

(Continued)

34	22.78	670978	0.43	Furan, 2, 5-dibutyl, methyl ester.
35	22.86	1936734	1.25	Linoleic acid.
36	23.14	1796085	1.16	Geranyl linallol.
37	23.35	3598392	2.32	N-Tetracosanol-1.
38	23.91	3519153	2.26	(4-Methoxy-phenyl)-2-nitrocylohexyl)-methanol.
39	23.98	2159964	1.39	3-Hydroxycarbofuran.
40	24.57	42328199	27.24	Gingerol.
41	24.95	4648089	2.99	Noni amide.
42	25.21	2616734	1.68	1-Heptacosanol.
43	25.47	4554793	2.93	Parado.
44	26.22	3233827	2.08	Carinol.
45	26.4	1300539	8.49	Capsaicin.
46	26.51	2737011	1.76	(+)-Lariciresinol .
47	26.76	2861080	1.84	Dihydrocapsicin.
48	26.88	3116221	2.01	9-Tricosene, (Z).
		155406478	100	

3.2 Fatty acids of edible oils

Fatty acids composition of edible oils under study (sunflower oil and soybean Oil) in addition to sesame oil was investigated by GC-MS.

The fatty acids of crude sesame oil are shown in Table (3.2.1). The table shows that linoleic is the most abundant (42. 69%), followed by oleic

acid (25.2 %), palmitic (16.0%) and stearic (11.45%), in this decreasing order.

Table (3.2.2) shows the fatty acids of sunflower oil. The fatty acids of refined sunflower oil consist mainly of leinolic (53.50 %), followed by oleic acid (15.66 %), palmitic acid (12.51 %) and stearic acid (9.21 %), in this decreasing order .

Table (3.2.3) shows the fatty acids of soybean oil .The main constituents of fatty acids composition of crude soybean oil are leinolic acid (38.66 %), followed by oleic acid (18.88%), palmitic acid (13.12 %) and stearic acid (8.24%), in this decreasing order .

These results of fatty acids composition of edible oils conform with values reported in the codex, (1993).

Table (3.2.1): Fatty acids composition of crude sesame oil

Peak	R.Time (min)	Area	Area %	Name
1	13.575	245464	0.04	Methyl tetradecanoate.
2	15.435	402524	0.07	9-Hexadecenoic acid , methyl ester .
3	15.480	2134043	0.36	7-Hexadecenoic acid , methyl ester .
4	15.698	94349292	16.01	Hexadecnoic acid , methyl ester .
5	16.444	533006	0.09	Cis -10-Heptadecenoic acid , methyl ester .
6	16.652	941597	0.16	Hexadecanoic acid , 15- methyl , methyl ester.
7	17.408	251531969	42.69	9,12- Octadecadienoic acid (Z,Z)-, methyl ester
8	17.463	148499159	25.20	9-Octadecenoic acid (Z)-, methyl ester .
9	17.617	67469100	11.45	Methyl stearate.

(Continued)

10	19.144	3561246	0.60	Cis-11 –Eicosenoic acid , methyl ester.
11	19.344	13720784	2.33	Eicosanoic acid , methyl ester .
12	20.963	3492990	0.59	Docosanoic acid methyl ester.
13	21.729	496176	0.08	Tricosanoic acid, methyl ester .
14	22.467	1875467	0.32	Tetracosanoic acid , methyl ester .
		5892522853	100.00	

Table (3.2.2): Fatty acids composition of refined sunflower oil

Peak	**R.Time (min)**	**Area**	**Area %**	**Name**
1	5.93	131984	0.02	Octanoic acid , methyl ester .
2	13.568	1469979	0.22	Methyl tetradecanoate .
3	14.643	327670	0.05	Pentadecenoic acid , methyl ester .
4	15.431	382410	0.06	7- –Hexadecenoic acid , methyl ester .
5	15.476	1878766	0.28	9-Hexadecenoic aci ,methyl ester .
6	15.691	83715876	12.51	Hexadecenoic acid , methyl ester .
7	16.439	885628	0.13	cis-10-Heptadecenoic acid, methyl ester .
8	16.649	944866	0.14	Hexadecanoic acid , 15-methyl ester .
9	17.437	357897324	53.50	9,12- Octadecadienoic acid (Z,Z)-,methyl ester
10	17.473	104789465	15.66	9-Octadecenoicacid (Z,Z) -,methyl ester .
11	17.616	61592380	9.21	Methyl stearate .
12	18.152	3996639	0.60	Methyl 9-cis ,11-trans-octadecadienote .
13	18.980	3074883	0.46	9,12-Octadecadienoyl chloride,(Z,Z) .
14	19.105	1455241	0.22	Oxiraneoctanoic acid , 3-octyl-,methyl ester .

(Continued)

15	19.141	4232898	0.63	Cis-11-Eicosenoic acid , methyl ester .
16	16.339	8649847	1.29	Eicosenoic acid , methyl ester .
17	20.164	162183	0.02	Heneicosanoic acid , methyl ester .
18	20.256	153677	0.02	Phenol , 2,2,-methylenebis {6-(1,1-dimethyl ester)
19	20.960	21531989	3.22	Docosanoic acid ,methyl ester .
20	21.723	933628	0.14	Tricosanoic,methyl ester .
21	22.461	7824312	1.17	Tetracosanoic acid ,methyl ester .
22	23.791	2911743	0.44	Stigmasterol .
		668943388	100.00	

Table (3.2.3): Fatty acids composition of crude soybean oil

Peak	R.Time (min)	Area	Area %	Name
1	3.356	35328	0.00	Hexanoic acid , methyl ester .
2	4.647	20698	0.00	p- Cymen .
3	5.936	53264	0.00	Octanoic acid , methyl ester .
4	11.256	78703	0.01	Dodecnoic acid , methyl ester .
5	11.576	42979	0.00	Nonanedioic acid , dimethyl ester .
6	13.571	2558260	0.21	Methyl tetradecanoate .
7	14.379	403098	0.03	6- Octadecenoic acid , methyl ester .
8	14.484	350589	0.03	5-Octadecenoic acid , methyl ester .
9	14.644	479290	0.04	Pentadecanoic acid , methyl ester .
10	15.373	225939	0.02	7,10-Hxadecadienoic , methyl ester .
11	15.436	778673	0.06	7-Hexadecenoic acid , methyl ester .
12	15.479	3151653	0.26	9- Hexadecenoic acid , methyl ester .

(Continued)

13	15.519	264593	0.02	9,12 Hexadecadienoic acid , methyl ester .
14	15.572	434469	0.04	Methyl 11-hexadecenoate .
15	15.710	158022850	13.12	Pentadecanoic acid , 14-methyl -,methyl ester
16	16.440	2060512	0.17	Methyl 9- heptadecenoate .
17	16.651	2601766	0.22	Heptadecanoic acid , methyl ester .
18	17.437	465594169	38.66	9,12 –Octadecandienoic acid (Z,Z)methyl ester
19	17.484	227323979	18.88	9-Octadecenoic acid (Z) -,methyl ester .
20	17.625	99176560	8.24	Mrthyl stearate .
21	18.988	7467507	0.26	8, 11,14 –Docosatrienoic acid , methyl ester .
22	19.151	36433692	3.03	11-Eicosenoic acid , methyl ester .
23	19.198	6192025	0.51	Methyl 9- eicosenoate .
24	19.343	18311389	1.52	Eicosanoic acid, methyl ester .
25	19.397	2729345	0.23	PGH I, methyl ester .
26	19.506	1162789	0.10	9,12-Octadecadienoyl chloride ,(z,Z)
27	19.845	906163	0.08	Tricyclo{20.8.0.0(17,16) }triacontane .
28	19.982	938777	0.08	Octadecanoic acid ,9,10-dihydroxy-,methyl ester
29	20.165	851797	0.07	Heneicosanoic acid , methyl ester .
30	20.261	261467	0.02	Phenol 2,2-methylene bis{ 6-(1,1,methyl ester)
31	20.812	121467211	1.09	13-Docosenoic acid, methyl ester.
32	20.964	18876365	1.57	Docosanoic acid, methyl ester.
33	21.723	1763044	0.15	Tricosanoic acid, methyl ester.
34	22.308	8620140	0.72	15-Tetracosenoic acid, methyl ester.
35	22.462	8782274	0.73	Tetracosanoic acid, methyl ester.

(Continued)

36	23.171	1330994	0.11	Pentacosanoic acid , methyl ester .
37	23.372	3620319	0.30	Lanosta-8,24-dien-3-ol,acetate ,(3-beta) .
38	23.860	954624	0.08	Hexacosanoic acid , methyl ester .
		1204321294	100.00	

3.3 Effects of addition of antioxidant on shelf life of the refined sunflower oil and crude soybean oil

3.3.1 Peroxide value

Peroxide value is defined as milli equivalent of peroxide per kilogram of oil (meq O_2/kg). Peroxide value is a measure of a transient product of oil and fat which break down to form peroxide, hydro peroxide and other products, and it is determined by a redox titration. The assumption is made that the compounds reacting under the condition of test are peroxide or similar product of lipid oxidation (Nielson, 2009).

$$ROOH + KI \xrightarrow{H+} ROH + KOH + I_2$$

$$I_2 + Starch + 2Na_2S_2O_3 \rightarrow 2NaI + Starch + Na_2S_4O_6$$

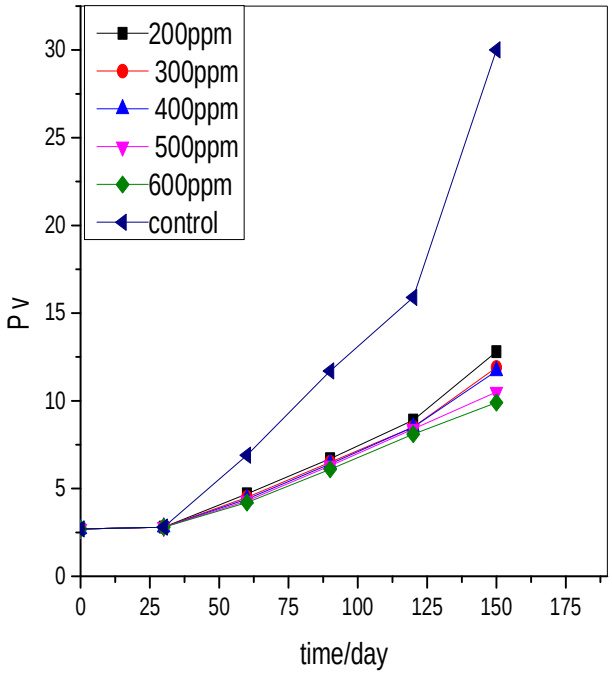
High quality, freshly deodorized fats and oils will have nil or close nil of peroxide value; so PV is important as decisive value that oil or lipid has no longer nutritional value.

Table (3.3.1.1) and Fig (3.3.1.1) illustrate the changes in PV of refined sunflower oil, treated with sesame oil as antioxidant in different concentrations (0,200,300,400,500 and 600ppm) through five months (150 days) as storage period at room temperature (28°C) . Samples free of antioxidant (control) showed clear increase in PV from 2.7 to 30 meq O_2/kg of oil by the end of storage period. Meanwhile samples containing different concentrations of antioxidant showed remarkable decrease in PV in direct proportion to the concentration of antioxidant from 2.7 to 12.8 and 11.9 meq O_2/kg at 200 and 300ppm of sesame oil, respectively; so

500 and 600ppm showed less increase in PV from 2.7 to 10.5 and 9.9, respectively .Several earlier investigations (Hassnein *et al.* 2003) and (Chu et al. 1998) reported just such a correlation .

Table (3.3.1.1) Effect of the addition of sesame oil as antioxidant on peroxide values of refined sunflower oil during its storage period.

Storage period(days)	**Concentration (ppm)**					
	200ppm	**300ppm**	**400ppm**	**500ppm**	**600ppm**	**Control**
0	2.7	2.7	2.7	2.7	2.7	2.7
30	2.8	2.8	2.8	2.8	2.8	2.8
60	4.7	4.5	4.4	4.3	4.2	6.9
90	6.7	6.5	6.4	6.3	6.1	11.7
120	8.9	8.5	8.5	8.4	8.1	15.9
150	12.8	11.9	11.7	10.5	9.9	30



Fig(3.3.1.1): Curves of peroxide values of sunflower oil treated with sesame oil as antioxdant against storage time .

Table (3.3.1.2) and Fig (3.3.1.2) show the changes in PV of refined sunflower oil , treated with DCM extracted from ginger roots as antioxidant in different concentrations (0,200 ,300 ,400 ,500 ,and 600ppm) through five months (150 days) at room temperature (28° C). Samples free of antioxidant have high PV from 2.7 to 30 meq O_2/kg of oil. Samples which were treated with DCM extract showed slightly increase in PV from 2.7 to 13.7 and 12.5 meq O_2/kg for 200 and 300 ppm, respectively. Samples with 500 and 600ppm showed tenuous increase in PV compared with control from 2.7 to 10.9 and 9.5meq O_2/ kg of oil, respectively .These results agreed with those obtained in previous studies of Kikuzaki *et al*. (1993) , Xuesong et .al. (1997) and Rehman et al. (2003) .

Table (3.3.1.3) and Fig (3.3.1.3) explain the changes in PV for crude soybean oil which was treated with sesame oil as antioxidant in different concentrations (0,200,300,400, 500 and 600ppm). Samples free of antioxidant (control) showed remarkable increase in PV from 4.0 to 20.5 meqO_2/kg of oil, in contrast samples which were treated with antioxidant showed clearly shift in PV of samples with 200 and 300ppm from initial PV 4.0 to 12.5and 12.0 meq O_2 /kg of oil, respectively. Samples with 500 and 600ppm showed less increasing in PV from 4.0 to 11.5 and 11.0, respectively. These results are in a good agreement with previous studies of Hassnein *et al. (*2012).

Table (3.3.1.4) and Fig (3.3.1.4) show the changes in PV for soybean oil which was treated with DCM extracted from ginger roots in different concentrations (0,200,300, 400, 500 and 600ppm) through five months (150 days). Samples free of antioxidant showed clearly increasing in PV from 4.0 to 20.5meq O_2/kg of oil .Sample which were treated with DCM showed clearly shift in PV

even with slight concentrations, samples with 200 and 300ppm of DCM had increasing from 4.0 to 14.8 and 13.9 meq O_2/kg of oil, respectively, samples which were treated with 500 and 600ppm of DCM had less increasing in PV from 4.0 to 13.2 and 12.7 meq O_2/ kg of oil, respectively.

Table (3.3.1.2): Effect of the addition of dichloromethane (DCM) extract from ginger roots as antioxidant on peroxide values of sunflower oil during its storage period.

Time (days)	Concentration (ppm)					
	200ppm	300ppm	400ppm	500ppm	600ppm	Control
0	2.7	2.7	2.7	2.7	2.7	2.7
30	2.8	2.7	2.8	2.8	2.8	2.8
60	5.7	5.4	5.2	4.9	4.7	6.9
90	6.5	6.1	5.9	5.7	5.5	11.7
120	9.0	8.7	8.5	8.2	7.9	15.9
150	13.7	12.5	11.7	10.9	9.5	30.0

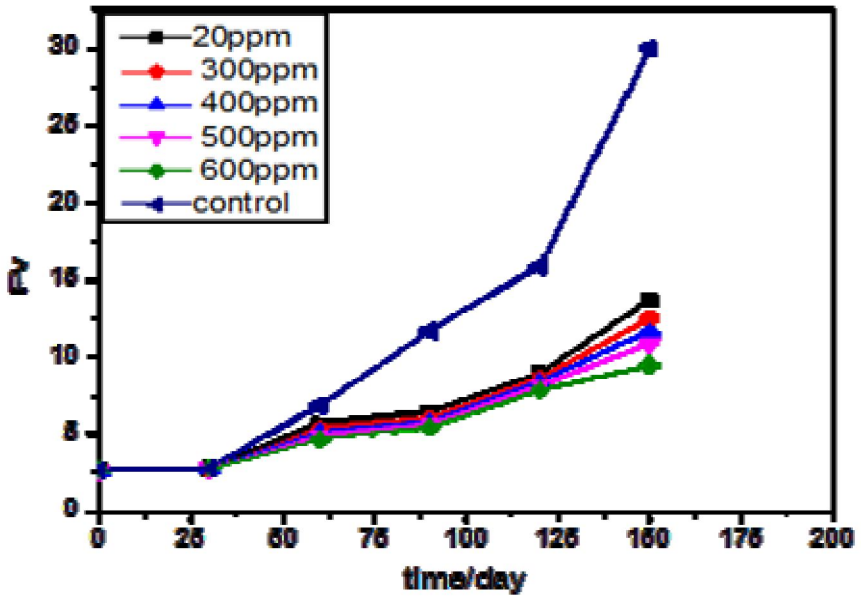


Fig (3.3.1.2): Curves of peroxide values of sunflower oil treated with DCM extract as antioxidant against storage time

Table (3.3.1.3) Effect of the addition of sesame oil as antioxidant on peroxide values of soybean oil on its storage period.

Storage period(days)	Concentration (ppm)					
	200ppm	300ppm	400ppm	500ppm	600ppm	Control
0	4.0	4.0	4.0	4.0	4.0	4.0
30	4.2	4.1	4.0	4.0	4.0	4.3
60	5.4	5.0	4.8	4.6	4.2	7.9
90	6.5	6.3	6.3	6.2	6.0	10.9
120	7.8	7.6	7.6	7.4	7.2	14.7
150	12.5	12.0	11.9	11.5	11.0	20.5

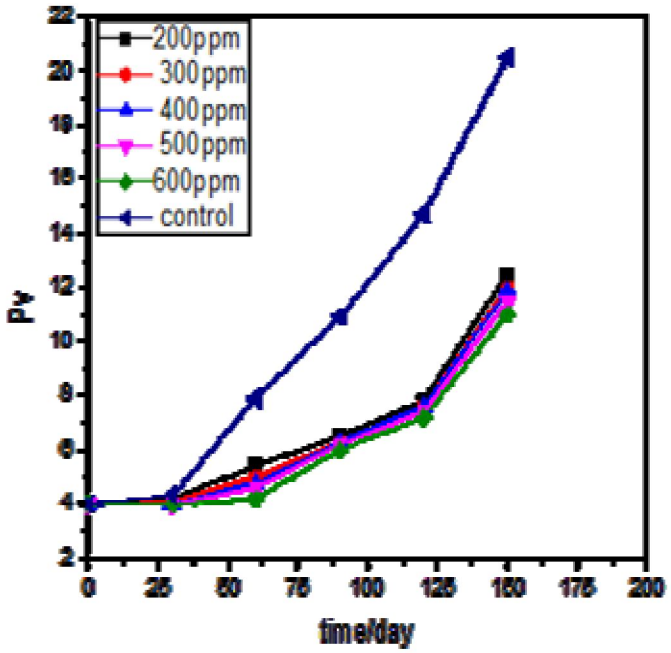


Fig (3.3.1.3): Curves of peroxide values of soybean oil treated with sesame oil as antioxidant against storage time .

Table(3.3.1.4) Effect of the addition of DCM extract from ginger roots as antioxidant on peroxide values of crude soybean oil on its storage period .

Storage period(days)	Concentration (ppm)					
	200ppm	300ppm	400ppm	500ppm	600ppm	Control
0	4.0	4.0	4.0	4.0	4.0	4.0
30	4.7	4.5	4.3	4.2	4.2	4.3
60	6.9	6.4	6.4	6.2	6.1	7.9
90	7.9	7.7	7.5	7.2	7.2	10.9
120	8.9	8.8	8.5	8.3	8.1	14.7
150	14.8	14.0	13.9	13.2	12.7	20.5

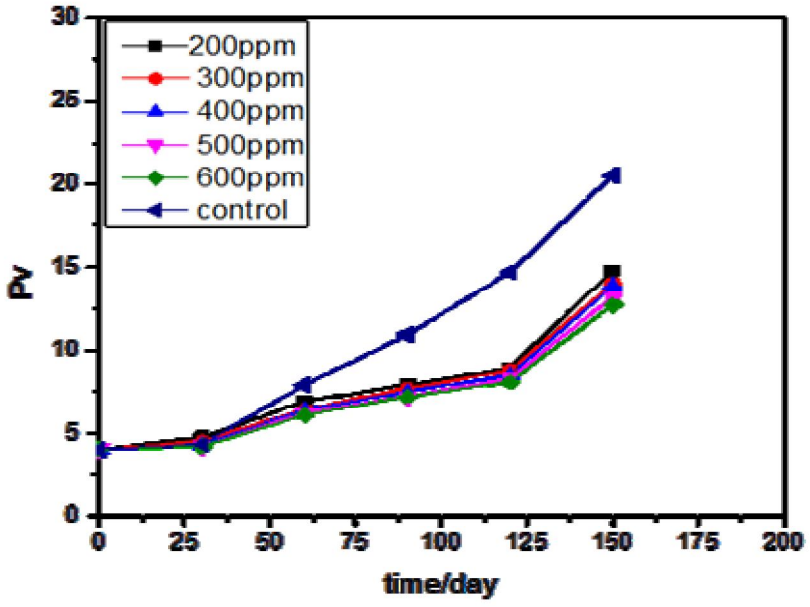


Fig (3.3.1.4): Curves of peroxide values of soybean oil treated with DCM extract from ginger roots as antioxidant against storage time.

3.3.2. Iodine value (IV)

The iodine value IV (iodine number) is a measure of degree of unsaturation, so IV is defined as the grams of iodine absorbed per 100g of oil sample.

$$2ICl + R\text{-}CH{=}CH\text{-}R \rightarrow R\text{-}CHI\text{-}CHCl\text{-}R + ICl$$

(excess) (remain)

$$ICl + 2KI \rightarrow KCl + KI + I_2$$

$$I_2 + Starch + 2Na_2S_2O_3 \rightarrow 2NaI + Starch + Na_2S_4O_6$$

(Blue) (colorless)

The decrease in IV is a result of unsaturation as the triglyceride π – bond becomes oxidized; so slight changes in IV may indicate that oil and its quality remains unchanged (Bukola *et al.*, 2015).

Table (3.3.2 .1) and Fig (3.3.2 .1) show changes in IV of sunflower oil treated with sesame oil as antioxidant in different concentrations (0,200,300,400,500 and 600pm), through 150days. Samples which were free of antioxidant show clear decrease in IV from 120 to 109.7 g I_2/100g of oil , while samples which were treated with antioxidant showed slight changes in IV from 120.0 to 112.0, 112.4, and112.6 I_2/100g of oil for 200,300 and400ppm, respectively. Samples with higher concentrations of 500 or 600 ppm antioxidants showed minimum decrease in IV from 120.0 to 112.8 or 113.0 of I_2/100g of oil sample, respectively. Previous study of Ngassapa *et al.* (2012) reported just such a correlation.

Table (3.3.2.2) and fig (3.3.2.2) show changes in IV of sunflower oil treated with DCM extracted from ginger roots as antioxidant in different concentrations (0,200,300,400,500 and 600ppm). It's found that the IV after the end of storage period is proportion to the concentration of antioxidant in sunflower oil, so samples with 200 or 300ppm had less IV from 120.0 to115.7 or 116.5, respectively. Samples with higher concentrations of 500 or 600ppm DCM had higher of IV from 120.0 to 117.5 or 118.0 g of I_2/100g of oil, respectively.

Table (3.3.2.3) and Fig (3.3.2.3) show changes in IV of crude soybean oil treated with sesame oil as antioxidant in different concentrations (0,200,300,400,500and 600ppm). Sample free of antioxidant (control) showed obvious decrease in IV from 130.0 to 110.0g of I_2/100g of oil, while samples with 200 or 300ppm were changed from 130.0 to 117.0 or 119.9 g of I_2/100g of oil, respectively, and samples which were treated with 500 or 600ppm of sesame oil the IV slightly changed from 130.0 to123.0 or 125.0g of I_2/100g of oil, respectively.

Table (3.3.2.4) and Fig (3.3.2.4) illustrate changes in IV for crude soybean oil treated with DCM extracted from ginger roots as antioxidant in different concentrations (0,200,300,400,500and 600ppm), through 150days as storage periods. Its found that, the decreases in IV proportion inversely with concentration of DCM in oil sample, thus samples with 200 or 300 ppm DCM had IV from 130.0 to 118.0 or 119.0g of I_2/100g of oil and samples with 500or 600ppm DCM from 130.0 to 122.0 or 125.0g of I_2/100g of oil, respectively . Earlier studies Bukola *et al.* (2015) and Chebet *et al.* (2016) reported just similar correlation.

Table (3.3.2.1): Effect of the addition sesame oil as antioxidant on iodine values of sunflower oil during its storage period.

Storage period(days)	Concentration (ppm)					
	200ppm	300ppm	400ppm	500ppm	600ppm	Control
0	120.0	120.0	120.0	120.0	120.0	120.0
30	119.5	119.5	119.5	119.5	119.5	119.0
60	118.0	118.0	118.3	118.5	118.7	117.0
90	115.0	115.0	115.5	117.7	117.9	114.6
120	113.0	113.2	113.4	113.5	113.8	110.0
150	112.0	112.4	112.6	112.8	113.0	109.7

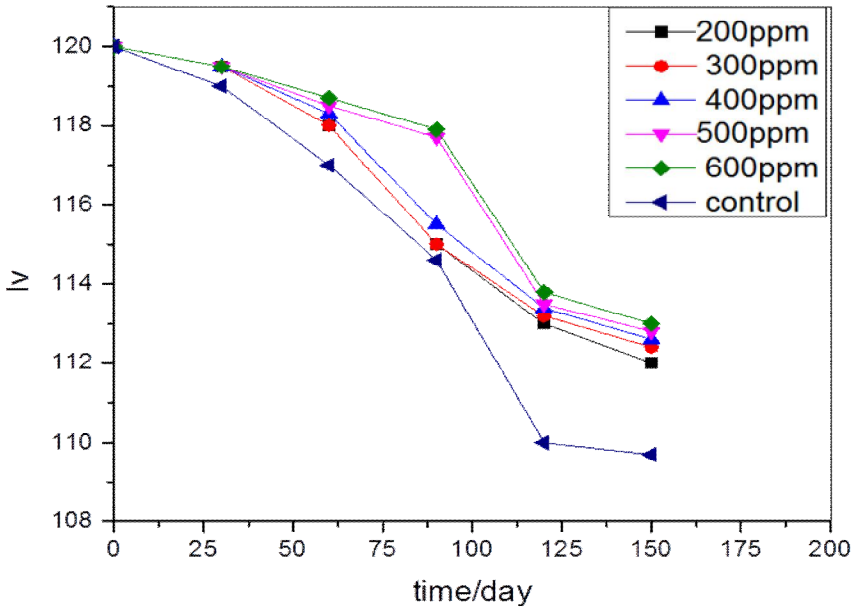


Fig (3.3.2.1): Curves of iodine values of sunflower oil treated with sesame oil as antioxidant against storage time.

Table (3.3.2.2): Effect of the addition DCM extract from ginger roots as antioxidant on iodine values of sunflower oil on its storage period

Storage period(days)	Concentration (ppm)					
	200ppm	300ppm	400ppm	500ppm	600ppm	Control
0	120.0	120.0	120.0	120.0	120.0	120.0
30	119.5	119.5	120.0	120.0	120.0	119.0
60	118.0	119.0	119.0	119.0	119.5	117.0
90	117.5	118.0	118.5	118.5	119.0	114.6
120	117.0	117.5	118.0	118.0	118.5	110.0
150	115.7	116.5	117.0	117.5	118.0	109.7

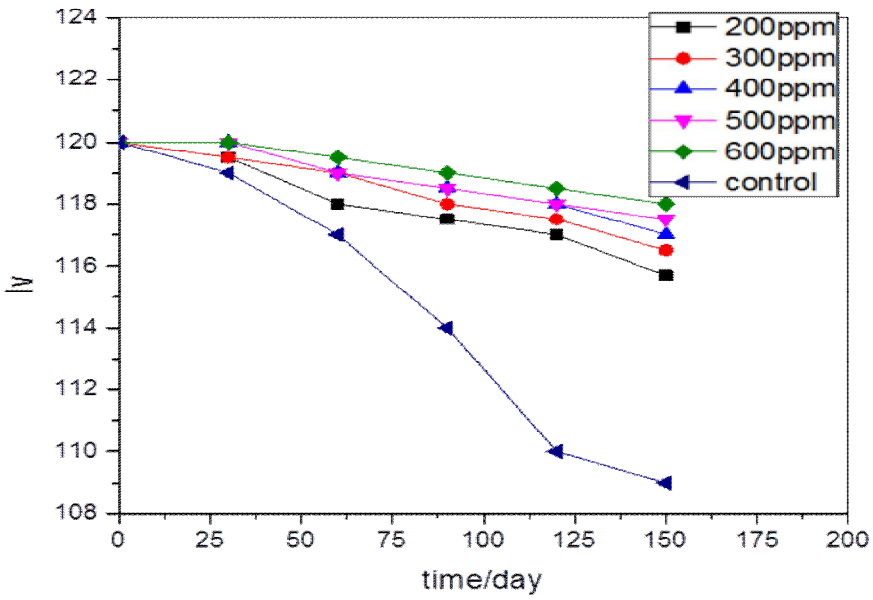


Fig (3.3.2.2):Curves of iodine values of sunflower oil treated with DCM extract of ginger roots as antioxidants againist storage time .

Table (3.3.2.3): Effect of the addition of sesame oil as antioxidant on iodine values of soybean oil during storage time .

Storage period(days)	Concentration (ppm)					
	200ppm	300ppm	400ppm	500ppm	600ppm	Control
0	130.0	130.0	130.0	130.0	130.0	130.0
30	129.0	129.0	129.5	129.5	130.0	129.0
60	122.0	125.0	127.0	129.0	129.0	120.0
90	120.0	122.0	125.0	127.0	128.0	119.0
120	119.0	120.0	122.0	125.0	126.0	110.8
150	117.0	119.0	120.	123.0	125.0	110.0

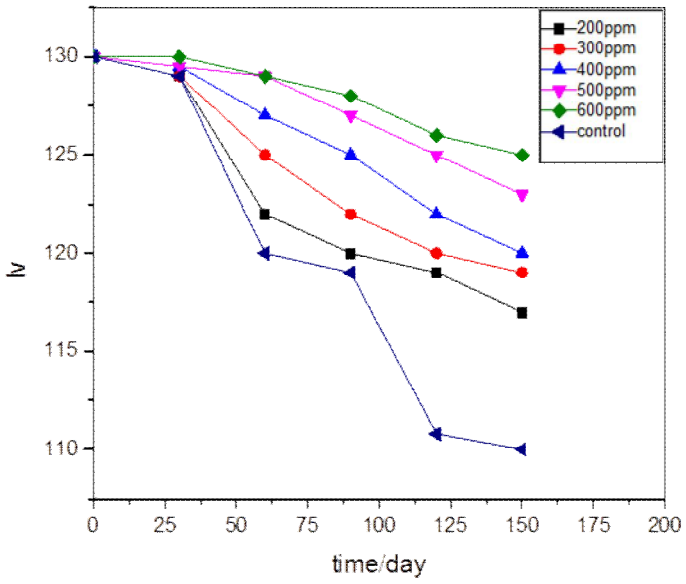


Fig (3.3.2.3): Curves of iodine values of soybean oil treated with sesame oil as antioxidant against storage time.

Table (3.3.2.4): Effect of the addition of dichloromethane (DCM) extract from ginger roots as antioxidant on iodine values of soybean oil on its storage time

Storage period (days)	Concentration (ppm)					
	200ppm	300ppm	400ppm	500ppm	600ppm	Control
0	130	130	130	130	130	130
30	129	129	129	129	130	129
60	125	127	127	128	129	120
90	122	124	125	125	127	119
120	120	120	122	124	125.9	110.8
150	118.5	119	120	122	125	110.0

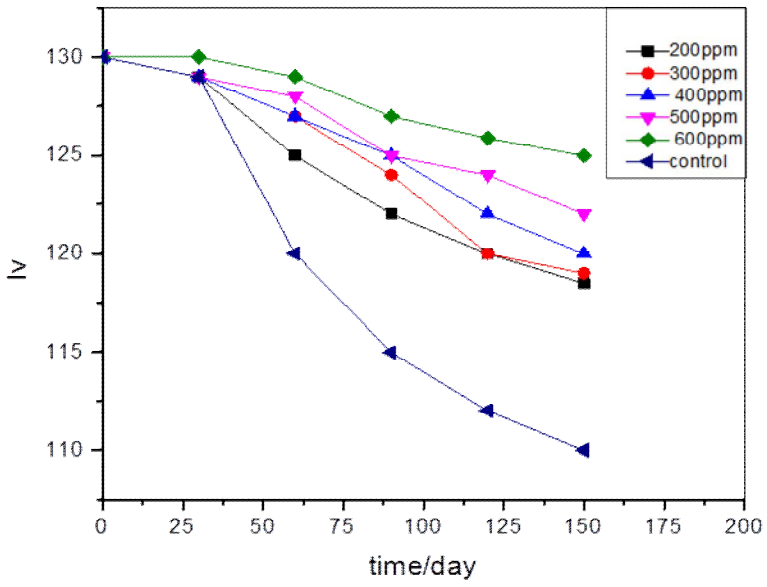


Fig (3.3.2.4) :Curves of iodine values of soybean oil treated with DCM extract as antioxidant against storage time .

3.3.3 Acidity

Is a measure of acid value (Av) in percentages of free fatty acid as oleic acid. Acid value is the number of milligrams (mg) of potassium hydroxide that neutralized the free acid present in 1g of fat or oil .It is a measure of fatty acids hydrolyzed from triacylglycerols. The level of acidity contributed in breakdown of fat or oil after storage or use is a measure of hydrolytic rancidity.

Tables (3.3.3.1) and (3.3.3.2) with Figs (3.3.3.1) and (3.3.3.2) show the changes in acidity (Av and FFA) of sunflower oil treated with sesame oil as antioxidant in different concentrations (0,200,300,400,500and 600ppm) .Samples free of antioxidant (control) showed increase in Av from 1.2 to 2.7 mg of KOH/g of oil and in FFA from 0.6 to 1.35% of oleic acid . Samples treated with 200 or 300ppm sesame oil showed tenuous increase in acidity from 1.2 to 2.5 or 2.3 mg of KOH/g of oil correlated to 1.21or 1.15% of oleic acid . Samples with 500 or 600ppm have AV from 1.2 to 2.1 or 2.0 mg of KOH/g of oil and in 1.05 or 1.0 % of oleic acid , respectively .

Almost identical results were given in Tables (3.3.3.3) and(3.3.3.4) and Figs (3.3.3.3) and (3.3.3.4) for samples of sunflower oil treated with DCM extracted from ginger roots as antioxidant in different concentrations (0,200,300,400,500 and 600ppm).These results were close to those reported earlier by Hassnein, *et .al.*, (2003).

Tables (3.3.3.5) and (3.3.3.6) and Figs (3.3.3.5) and (3.3.3.6) show the changes in acidity (Av and FFA) for soybean oil treated with sesame oil as antioxidant in different concentrations (0,200,300,400,500 and 600ppm) through 150 days as storage period .Samples free of antioxidant showed clearly increase in acidity from 0.9 to 3.0 mg of KOH/g of oil corresponding to form 0.45to 1.5 % of

oleic acid. The same results given by samples of 200 or 300ppm of sesame oil. Samples with 500 or 600ppm showed inconsiderable increase in acidity from 0.9 to 2.4 or 2.3 mg of KOH/g of oil corresponding from 0.45 to 1.2 or 1.15 % of oleic acid, respectively, similar results were given in Tables (3.3.3.7) and (3.3.3.8) and Figs (3.3.3.9) and (3.3.3.9) for crude soybean oil treated with DCM extracted from ginger roots as antioxidant.

Table (3.3.3.1) Effect of the addition sesame oil as antioxidant on acid values of sunflower oil during its storage period

Storage period (days)	Concentration (ppm)					
	200ppm	300ppm	400ppm	500ppm	600ppm	Control
0	1.20	1.20	1.20	1.20	1.20	1.20
30	1.25	1.24	1.24	1.22	1.20	1.30
60	1.40	1.37	1.35	1.33	1.30	1.50
90	1.49	1.45	1.43	1.42	1.40	2.0
120	2.20	1.80	1.70	1.70	1.50	2.50
150	2.50	2.30	2.10	2.10	2.0	2.70

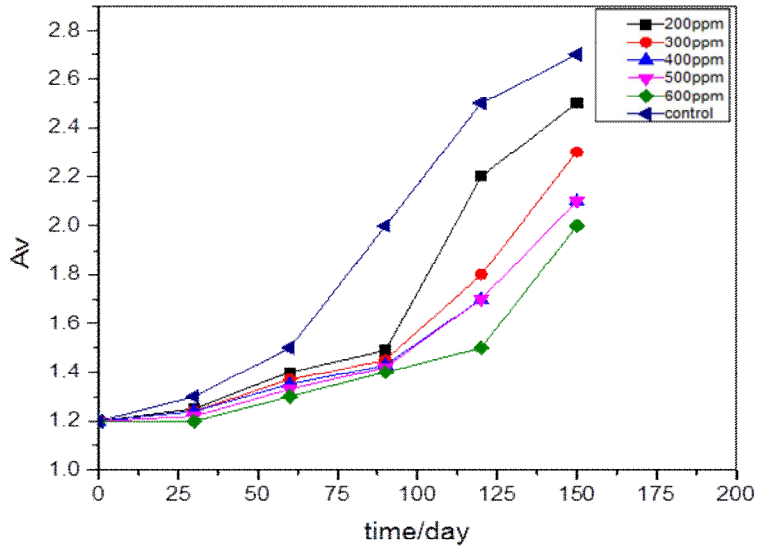


Fig (3.3.3.1): Curves of acid values of refined sunflower oil treated with sesame oil as antioxidant against its storage time .

Table (3.3.3.2): Effect of the addition sesame oil as antioxidant on free fatty acids of sunflower oil against storage period

Storage period(days)	Concentration (ppm)					
	200ppm	300ppm	400ppm	500ppm	600ppm	Control
0	0.60	0.60	0.60	0.60	0.60	0.60
30	0.63	0.62	0.62	0.61	0.60	0.65
60	0.70	0.69	0.68	0.67	0.65	0.75
90	0.75	0.73	0.72	0.71	0.70	1.0
120	1.1	0.90	0.85	0.85	0.75	1.25
150	1.21	1.15	1.05	1.05	1.0	1.35

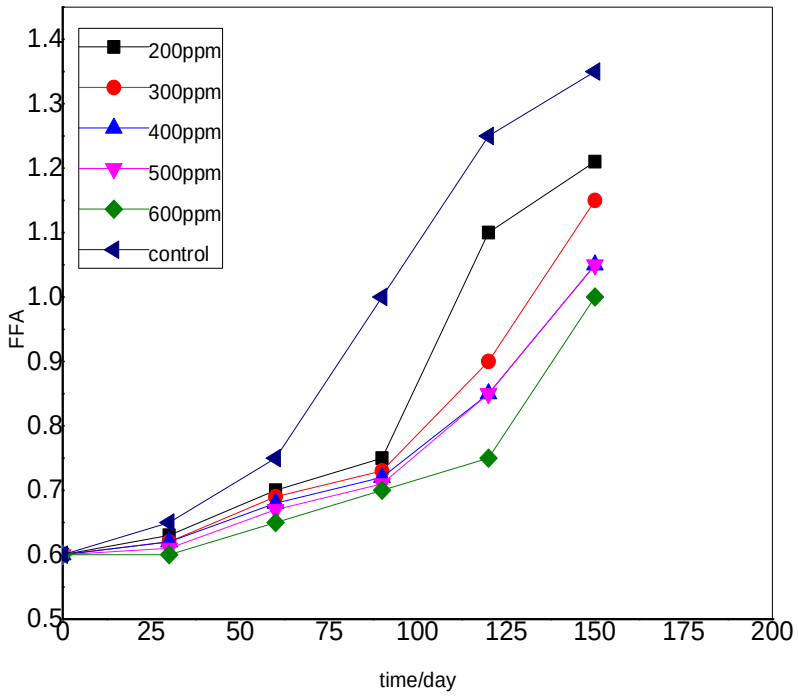


Fig (3.3.3.2):Curves of FFA of sunflower oil treated with sesame oil as antioxidant against storage time

Table (3.3.3.3): Effect of the addition dichloromethane (DCM) from ginger roots as antioxidant on acidvalues of sunflower oil during its storage time

Storage period(days	Concentration (ppm)					
	200ppm	300ppm	400ppm	500ppm	600ppm	Control
0	1.20	1.20	1.20	1.20	1.20	1.20
30	1.30	1.25	1.24	1.22	1.20	1.30
60	1.40	1.35	1.34	1.32	1.30	1.50
90	1.50	1.48	1.45	1.44	1.40	2.0
120	1.80	1.70	1.60	1.50	1.50	2.50
150	2.50	2.30	2.20	2.10	2.0	2.7

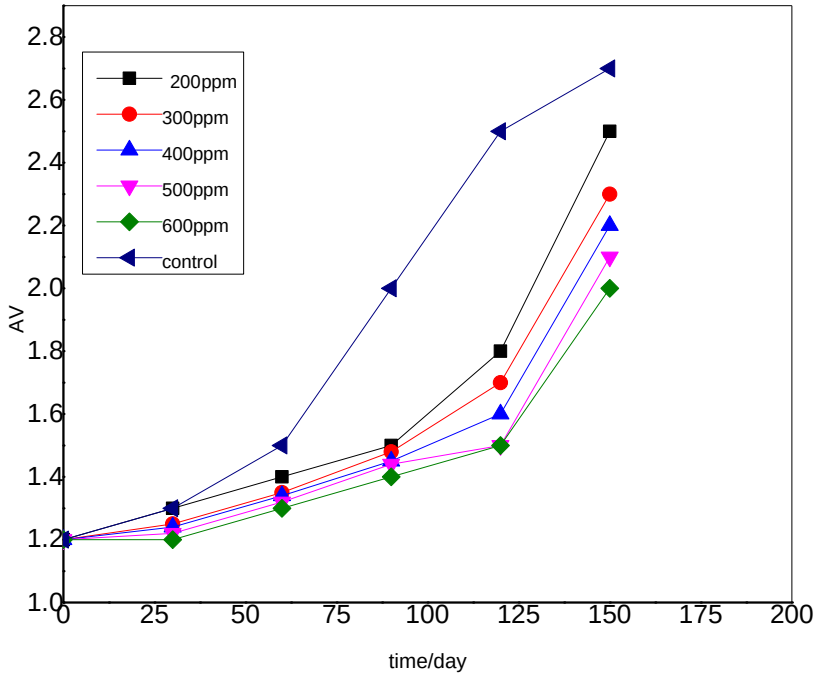


Fig (3.3.3.3): Curves of acid values of sunflower oil treated with DCM extract as antioxidant against its storage time .

Table (3.3.3.4): Effect of the addition of DCM extract from ginger roots as antioxidant on free fatty acids of Sunflower oil during its storage period

Storage period/day	Concentrations (ppm)					
	200ppm	300ppm	400ppm	600ppm	Control	
0	0.60	0.60	0.60	0.60	0.60	0.60
30	0.65	0.63	0.62	0.61	0.60	0.65
60	0.70	0.66	0.67	0.66	0.65	0.75
90	0.75	0.73	0.73	0.72	0.72	1.0
120	0.90	0.85	0.80	0.75	0.75	1.25
150	1.25	1.15	1.10	1.05	1.0	1.35

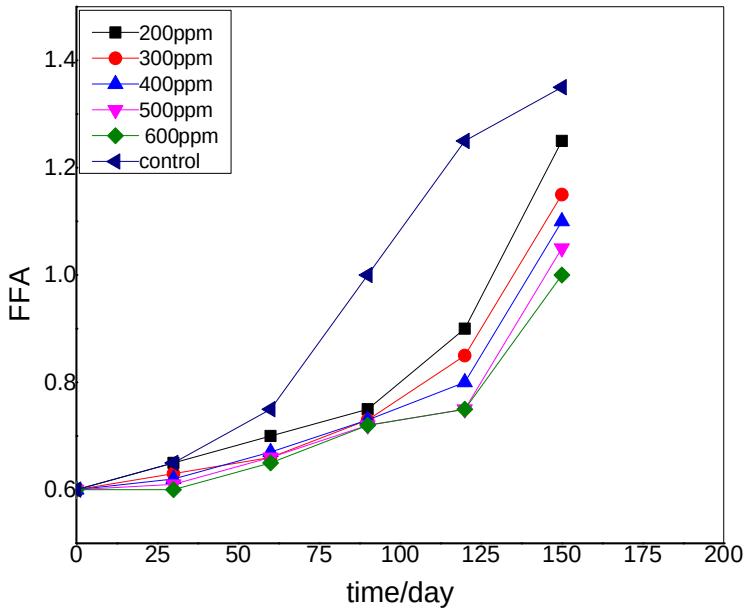


Fig (3.3.3.4): Curves FFA of sunflower oil treated with DCM as antioxidant against storage time

Table (3.3.3.5): Effect of the addition sesame oil as antioxidant on acid value of crude soybean oil during its storage period

Storage period/day	Concentration (ppm)					
	200ppm	300ppm	400ppm	500ppm	600ppm	Control
0	0.9	0.9	0.9	0.9	0.9	0.9
30	1.2	1.2	1.1	1.0	1.0	1.4
60	1.5	1.3	1.2	1.1	1.1	2.1
90	2.5	2.3	2.0	1.7	1.5	2.7
120	2.6	2.4	2.3	2.2	2.0	2.9
150	2.7	2.6	2.5	2.4	2.3	3.0

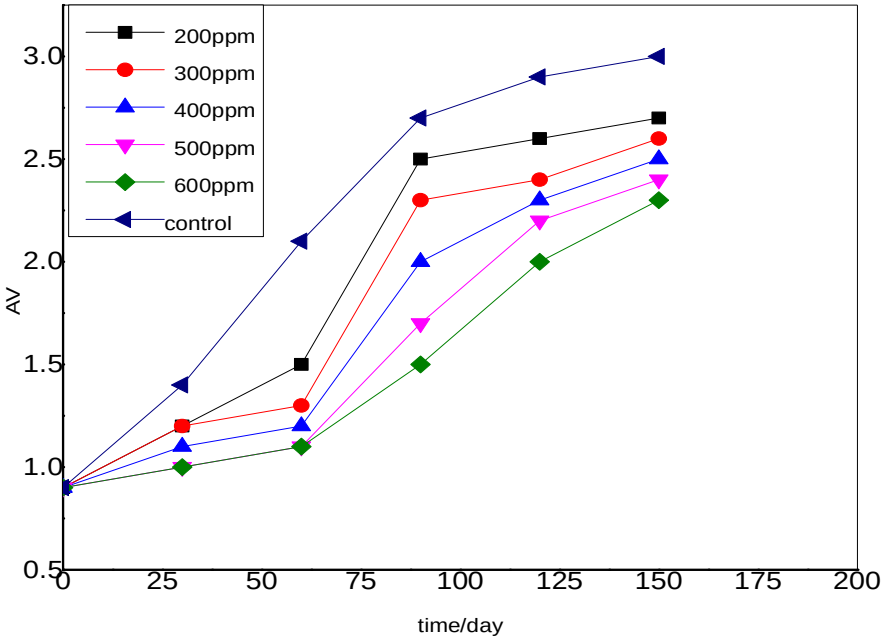


Fig (3.3.3.5): Curves of acid values soybean oil treated with sesame oil as antioxidant against its storage period

Table (3.3.3.6): Effect of the addition sesame oil as antioxidant on free fatty acids of crude soybean oil during storage period

Storage period/days	Concentration (ppm)					
	200ppm	300ppm	400ppm	500ppm	600ppm	Control
0	0.45	0.45	0.45	0.45	0.45	0.45
30	0.6	0.6	0.55	0.5	0.5	0.7
60	0.75	0.65	0.6	0.55	0.55	1.05
90	1.25	1.15	1.0	0.85	0.75	1.35
120	1.3	1.2	1.15	1.1	1.0	1.45
150	1.35	1.3	1.25	1.2	1.15	1.5

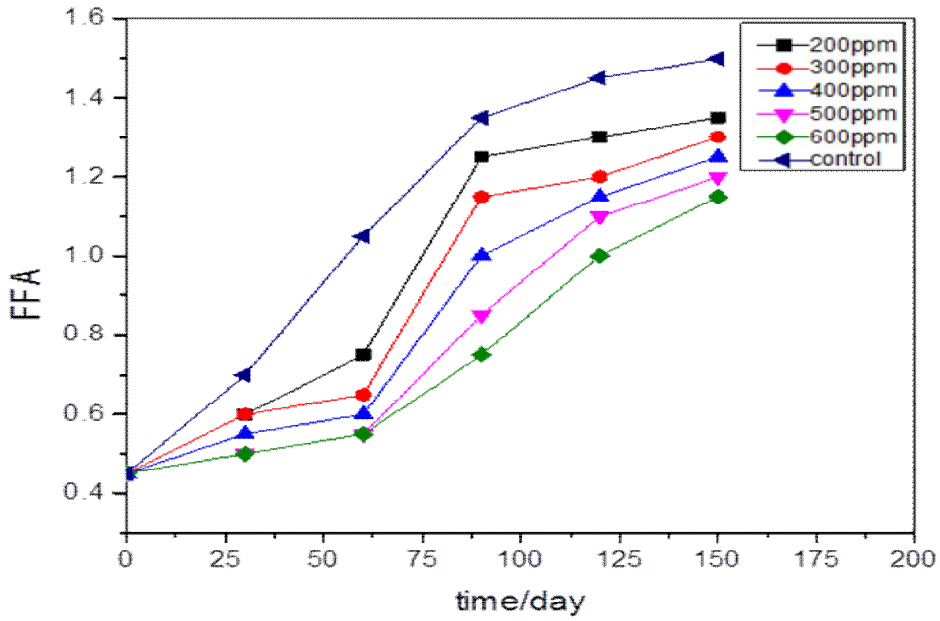


Fig (3.3.3.6): Curves of FFA of soybean oil treated with sesame oil as antioxidant against storage time.

Table (3.3.3.7): Effect of the addition DCM extract from ginger roots as antioxidant on acid values of soybean oil during its storage period

Storage period/days	Concentration (ppm)					
	200ppm	300ppm	400ppm	500ppm	600ppm	Control
0	0.9	0.9	0.9	0.9	0.9	0.9
30	1.3	1.2	1.2	1.1	1.1	1.4
60	1.8	1.7	1.5	1.4	1.4	2.1
90	2.5	2.4	2.3	2.1	2.1	2.7
120	2.7	2.6	2.4	2.2	2.2	2.9
150	2.9	2.8	2.7	2.5	2.5	3.0

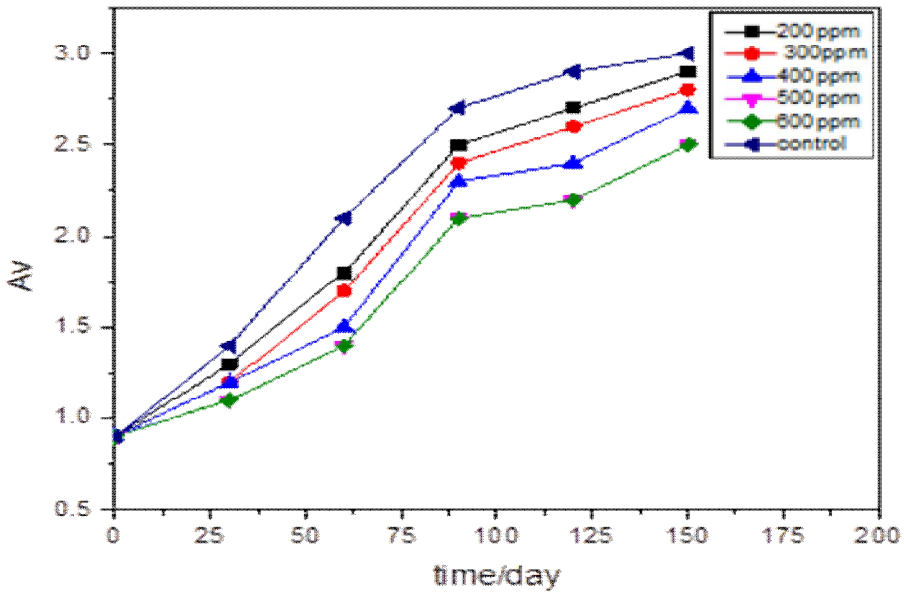


Fig (3.3.3.7): Curves of AV of soybean oil treated with DCM extract from ginger roots as antioxidant against storage time

Table (3.3.3.8) Effect of the addition DCM extract as antioxidant on free fatty acid of soybean oil during its storage period

Storage period/days	Concentration (ppm)					
	200ppm	300ppm	400ppm	500ppm	600ppm	Control
0	0.45	0.45	0.45	0.45	0.45	0.45
30	0.65	0.6	0.55	0.55	0.55	0.7
60	0.9	0.85	0.75	0.7	0.6	1.05
90	1.25	1.2	1.15	1.05	1.0	1.35
120	1.35	1.3	1.2	1.1	1.05	1.45
150	1.45	1.4	1.35	1.25	1.2	1.5

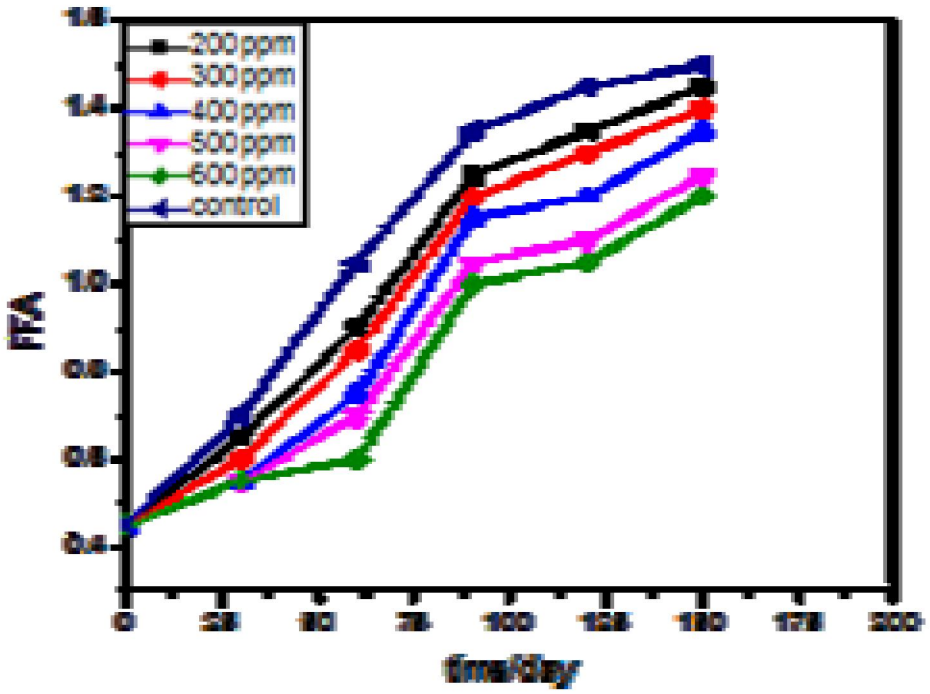


Fig (3.3.3.8): Curves of FFA of soybean oil treated with DCM extract as antioxidant against storage time.

3.3.4 Viscosity

It's a measure of inter action between molecules or of the extent at which fluid resist flow, and it is one of the important properties of an oil which needs to be determined as it influences the ease of handing, transport, and nature of storage Anupama *et al.*, (2007*)* .Viscosity of oil affected by degree of unsaturation, free fatty acids and temperature. Many investigators found that the viscosity of oil decreased proportionally to the raised of temperature Lang *et al.*, (1992), Nouredini *et al*, (1997).

Table (3.3.4.1) and Fig (3.3.4.1) show the changes in viscosity in poise for sunflower oil treated with sesame oil as antioxidant in different concentrations (0,200,300,400,500 and 600ppm) through 150days as storage period. Samples free of antioxidant (control) showed considerable decrease in viscosity from 54 to 35.5 poise at the end of storage period. Samples with 200 or 300ppm of sesame oil showed slightly change in viscosity comparable with control from 54 to 40 or 45 poise, respectively. Samples with 500 or 600ppm of sesame oil showed inconsiderable decrease in viscosity from 54 to 47.5 or 47.8 poise, respectively. Similar behavior for samples of sesame oil shown in Table (3.3.4.2) and Fig (3.3.4.2) was obtained when they were treated with DCM extracted from ginger roots as antioxidant in different concentrations (0,200,300,400,500 and 600ppm). Samples with 200 or 300ppm of DCM showed decrease in viscosity from 54 to 37.5 or 40.5 poise, respectively. Samples with 500 or 600ppm of DCM were decreased in viscosity from 54 to 44 or 45 poise, respectively.

Table (3.3.4.2) and Fig (3.3.4.2) show the changes in viscosity for crude soybean oil treated with sesame oil as antioxidant in different concentrations (0,200,300,400,500 and 600ppm) through 150 days as storage period. Samples free of antioxidant (control) showed clearly decrease in viscosity from 52 to 40 poise at the end of storage period. Samples with 200 or 300 ppm of sesame oil showed results close to those of the control from 52 to 40 or 42 poise, respectively. Samples with 500 or 600ppm of sesame oil showed slight decrease in viscosity from 52 to 43 or 44 poise, respectively.

Samples of soybean oil treated with DCM extract shown in Table (3.3.4.3) and Fig (3.3.4.3) show almost identical viscosity results to those of sesame oil antioxidant. The significant value between using sesame oil and DCM extract antioxidants in soybean oil on viscosity was inconsiderable.

Table (3.3.4.1): Effect the addition sesame oil as antioxidant on viscosity of sunflower oil during its storage time

Storage period(days)	Concentration (ppm)					
	200ppm	300ppm	400 ppm	500ppm	600ppm	Control
0	54	54	54	54	54	54
30	54	54	54	54	54	54
60	50.9	52.7	53	53	53.3	50.0
90	45.7	48.5	49.0	49.5	50.0	45.0
120	40.5	46.5	47.5	48.0	48.0	40.0
150	40.0	45.0	45.8	47.5	47.8	35.5

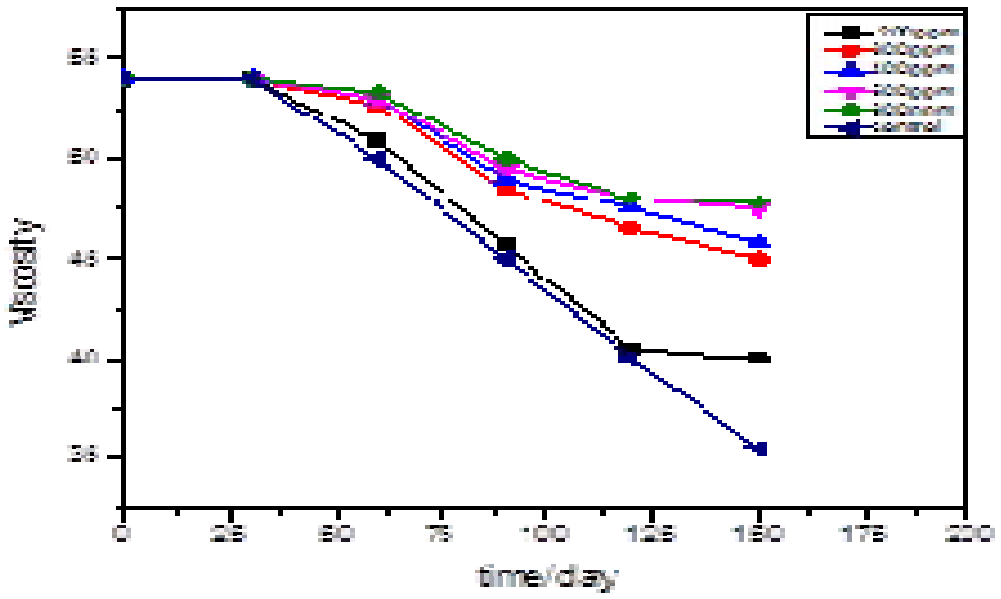


Fig (3.3.4.1): Curves of viscosity of sunflower oil treated with sesame oil as antioxidant during storage time.

Table (3.3.4.2): Effect of the addition DCM extract of ginger roots as antioxidant on viscosity of sunflower oil during its storage period

Storage period(days)	Concentration (ppm)					
	200ppm	300ppm	400ppm	500ppm	600ppm	Control
0	54.0	54.0	54.0	54.0	54.0	54.0
30	53.4	53.6	53.6	53.7	53.8	54.0
60	50.7	52.5	52.7	53.5	53.6	50.0
90	45.0	45.5	45.5	45.7	45.9	45.0
120	40.0	40.9	42.5	44.5	45.5	40.0
150	37.5	40.5	42.0	44.0	45.0	35.5

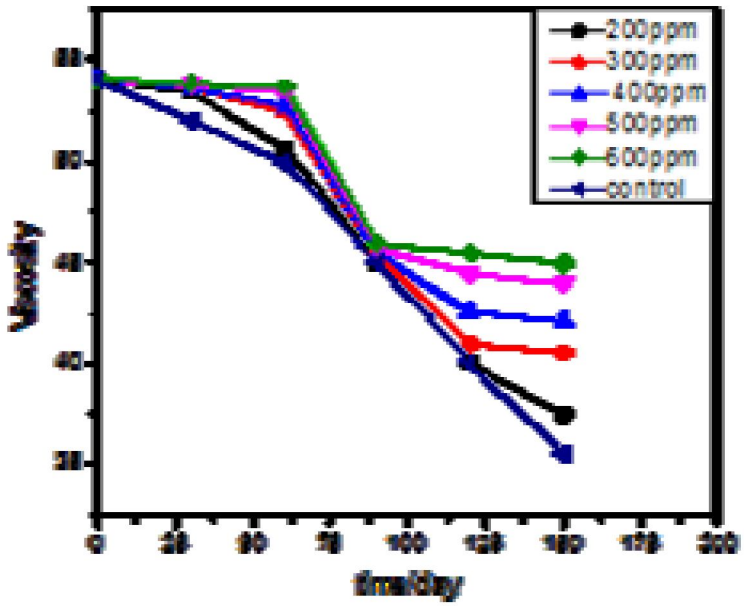


Fig (3.3.4.2): Curves of viscosity of sunflower oil treated with DCM extract as antioxidant against its storage time.

Table (3. 3.4.3): Effect of the addition sesame oil as antioxidant on viscosity of soybean oil during its storage period

Storage period(days)	Concentration (ppm)					
	200ppm	300ppm	400ppm	500ppm	600ppm	Control
0	52	52	52	52	52	52
30	50	50	51	51	52	50
60	45	47	47	48	50	44
90	43	45	46	47	48	43
120	42	43	44	45	45	42
150	40	42	42	43	44	40

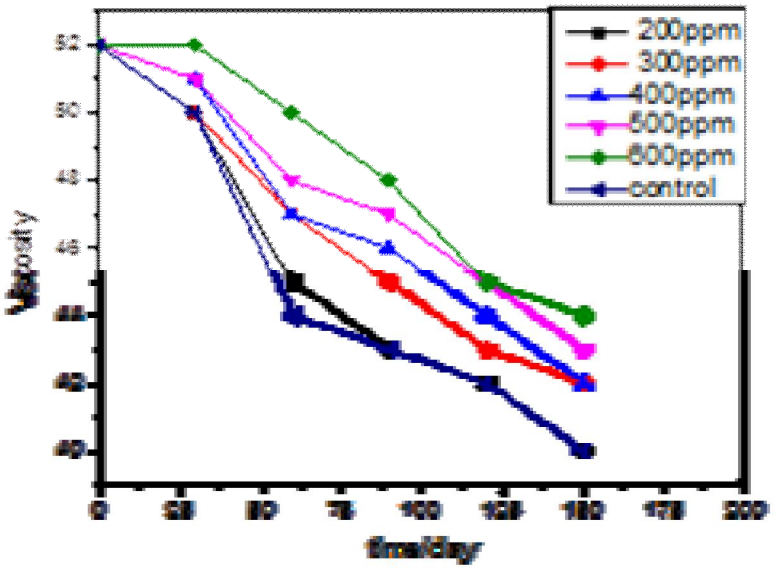


Fig (3.3.4.3): Curves of viscosity of soybean oil treated with sesame oil as antioxidant against storage time.

Table (3.3.4.4): Effect of the addition DCM extract from ginger roots as antioxidant on viscosity of soybean oil during its storage period.

Storage period(days)	Concentration					
	200ppm	300ppm	400ppm	500ppm	600ppm	Control
0	52	52	52	52	52	52
30	50	50	51	51	52	50
60	45	47	47	50	52	44
90	43	45	46	48	48	43
120	42	43	44	45	45	42
150	40	42	42	43	44	40

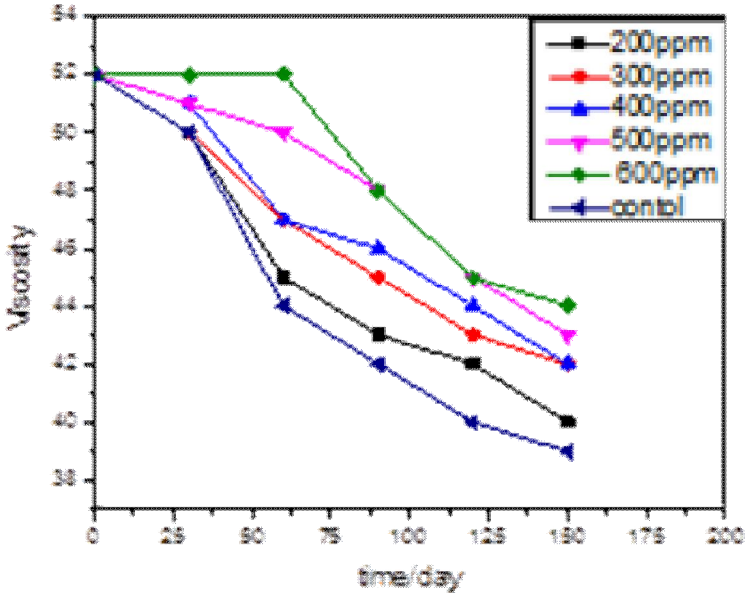


Fig (3.3.4.4): Curves of viscosity of soybean oil treated with DCM extract as antioxidant against storage time.

3.3.5 Refractive index (RI)

The refractive index (RI) of oil is defined as the ratio of speed of light in air (vacuum) to the speed of light in the oil (Nielson , 2009), and it is related to the amount of saturation, free fatty acids content, oxidation and heating of the oil; so refractive index is used as a measure of purity and the degree of oxidation, it is found that refractive index of oil is directly proportional to the increase of temperature (Gulla , *et al.*, 2012) .

Table (3.3.5.1) and Fig (3.3.5.1) show the changes in RI for refined sunflower oil treated with sesame oil as antioxidant in different concentrations(0, 200, 300, 400, 500 and 600ppm) through 150days as storage period .Samples free of antioxidant showed tenuous increase in RI from 1.467 to 1.478 . Samples treated with 200 or 300ppm of sesame oil did not show considerable increase in RI from 1.467 to 1.476 or 1.474, respectively. Samples treated with 500 or 600ppm of sesame oil also showed slight increase in RI from 1.467 to 1.472 or 1.471, respectively. These results confirmed the reported studies of Hassnein *et al.* (2012).

Table (3.3.5.2) and Fig (3.3.5.2) show the changes in RI for refined sunflower oil treated with DCM extracted from ginger roots as antioxidant in different concentration (0,200,300,400,500 and 600ppm) through 150 days as storage period .Samples treated with 200 or 300ppm of DCM showed each similar results from 1.467 to 1.476 . Samples treated with 500 or 600ppm of DCM showed slight increase in RI from 1.467 to 1.472 or 1.470, respectively.

Table (3.3.5.3) and Fig (3.3.5.3) show changes in RI for crude soybean oil treated with sesame oil as antioxidant in different concentrations (0,200, 300,400,500 and 600ppm) through 150 days as storage period. Samples free of

antioxidant (control) show slight changes in RI values from 1.470 to 1.488 at the end of storage period. Samples treated with 200 or 300ppm of sesame oil showed slight increase in RI from 1.470 to 1.484 or 1.482, respectively. Samples treated with 500 or 600ppm of sesame oil showed tenuous increase in RI from 1.470 to 1.479 or 1.477, respectively.

Table (3.3.5.4) and Fig (3.3.5.4) illustrate the changes in RI for crude soybean oil treated with DCM extracted from ginger roots as antioxidant in different concentrations (0,200,300,400,500and 600ppm) through 150 days as storage period. Samples treated with 200 or 300ppm of DCM extract showed inconsiderable increases in RI values from 1.470 to 1.477 or 1.475, respectively. Samples treated with 500 or 600ppm of DCM extract showed each negligible increase in RI values from 1.470 to 1.474.

The insignificant RI changes obtained during the studied storage period suggested that they could not be used to determine the deterioration of the oil during storage but though it could be used initially to identify its type . These findings confirmed those obtained by earlier investigators including Hassnein *et al.* (2012), Gulla *et al.* (2012), Mordret *et al.* (1985) *and* Ngassapa *et al.* (2012)

Table (3.3.5.1): Effect of the addition sesame oil as antioxidant on refractive index of sunflower oil during its storage period .

Storage period(days)	Concentration (ppm)					
	200ppm	300ppm	400ppm	500ppm	600ppm	Control
0	1.467	1.467	1.467	1.467	1.467	1.467
30	1.468	1.468	1.468	1.468	1.468	1.468
60	1.470	1.469	1.469	1.468	1.468	1.470
90	1.472	1.469	1.470	1.469	1.469	1.472
120	1.474	1.472	1.470	1.470	1.470	1.476
150	1.476	1.474	1.472	1.472	1.471	1.478

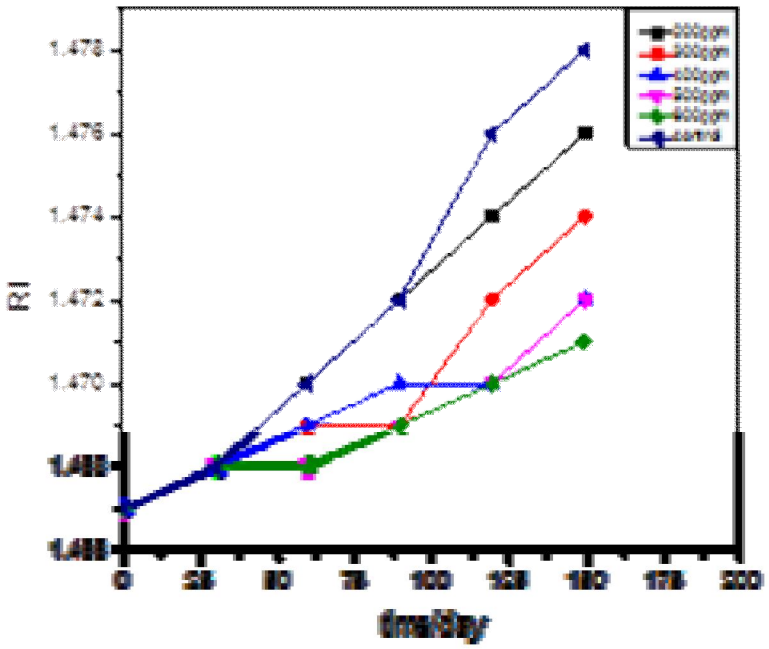


Fig (3.3.5.1): Curves of RI of sunflower oil treated with sesame oil as antioxidant against its storage time .

Table (3.3.5.2): Effect of the addition DCM extract of ginger roots as antioxidant on RI of sunflower oil during storage period

Storage period(days)	Concentration (ppm)					
	200ppm	300ppm	400ppm	500ppm	600ppm	Control
0	1.467	1.467	1.467	1.467	1.467	1.467
30	1.468	1.468	1.468	1.468	1.467	1.468
60	1.470	1.470	1.469	1.469	1.468	1.470
90	1.473	1.472	1.471	1.470	1.469	1.472
120	1.474	1.474	1.472	1.470	1.470	1.476
150	1.476	1.476	1.474	1.472	1.470	1.478

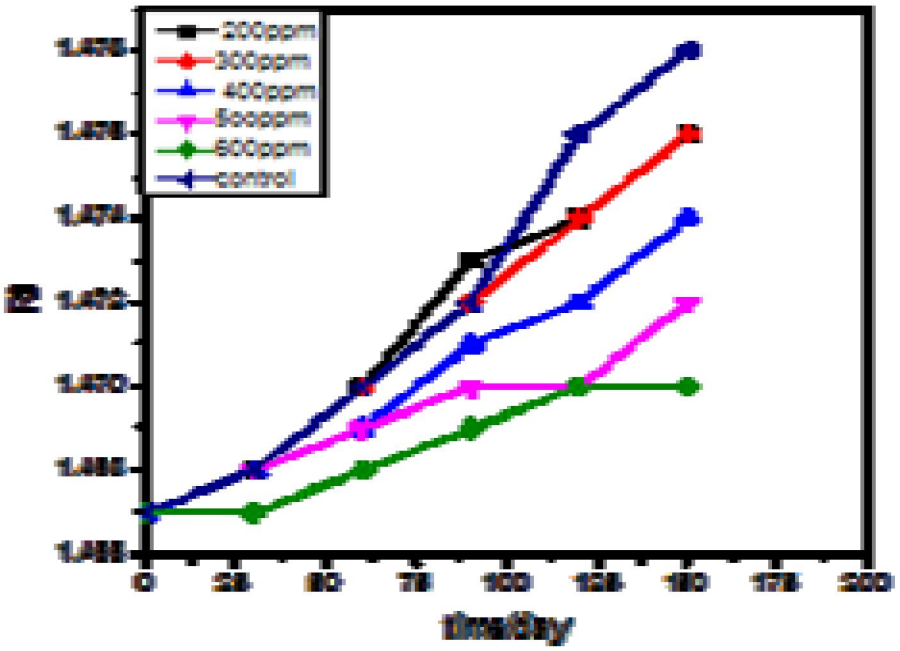


Fig (3.3.5.2): Curves of RI of sunflower oil treated with DCM extract as antioxidant against storage time.

Table (3.3.5.3): Effect of the addition sesame oil as antioxidant on refractive index of soybean oil during its storage time

Storage period(days)	Concentration (ppm)					
	200ppm	300ppm	400ppm	500ppm	600ppm	Control
0	1.470	1.470	1.470	1.470	1.470	1.470
30	1.474	1.473	1.472	1.471	1.470	1.474
60	1.476	1.475	1.474	1.473	1.472	1.478
90	1.479	1.479	1.477	1.475	1.474	1.479
120	1.482	1.480	1.479	1.477	1.475	1.485
150	1.484	1.482	1.480	1.479	1.477	1.488

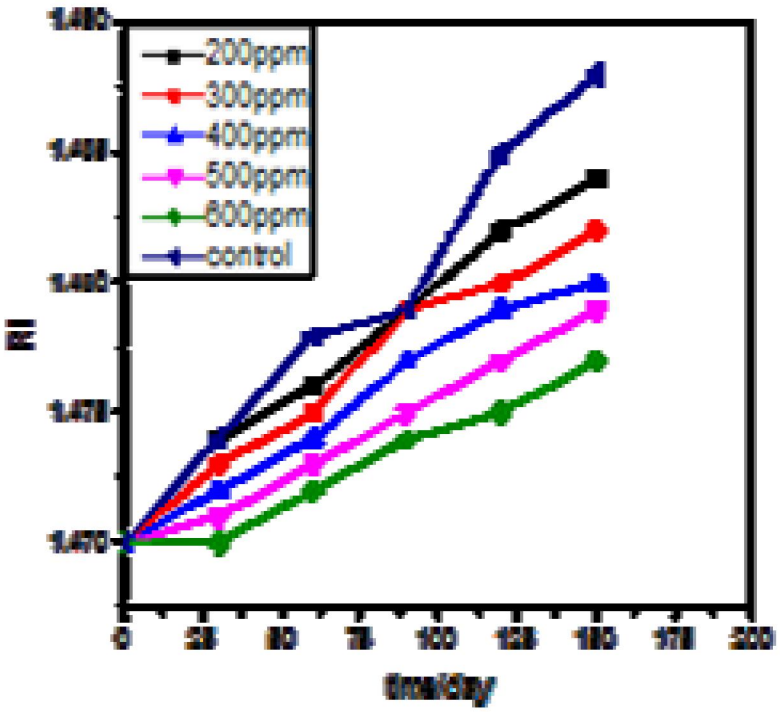


Fig (3.3.5.3): Curves of RI of soybean oil treated with sesame oil as antioxidant against storage time.

Table (3.3.5.4): Effect of the addition DCM extract from ginger roots as antioxidant on RI of soybean oil during its storage period

Storage period(days)	Concentration (ppm)					
	200ppm	300ppm	400ppm	500ppm	600ppm	Control
0	1.470	1.470	1.470	1.470	1.470	1.470
30	1.470	1.470	1.470	1.470	1.470	1.474
60	1.474	1.473	1.472	1.472	1.471	1.478
90	1.475	1.474	1.472	1.473	1.472	1.479
120	1.476	1.475	1.474	1.473	1.473	1.485
150	1.477	1.475	1.475	1.474	1.474	1.488

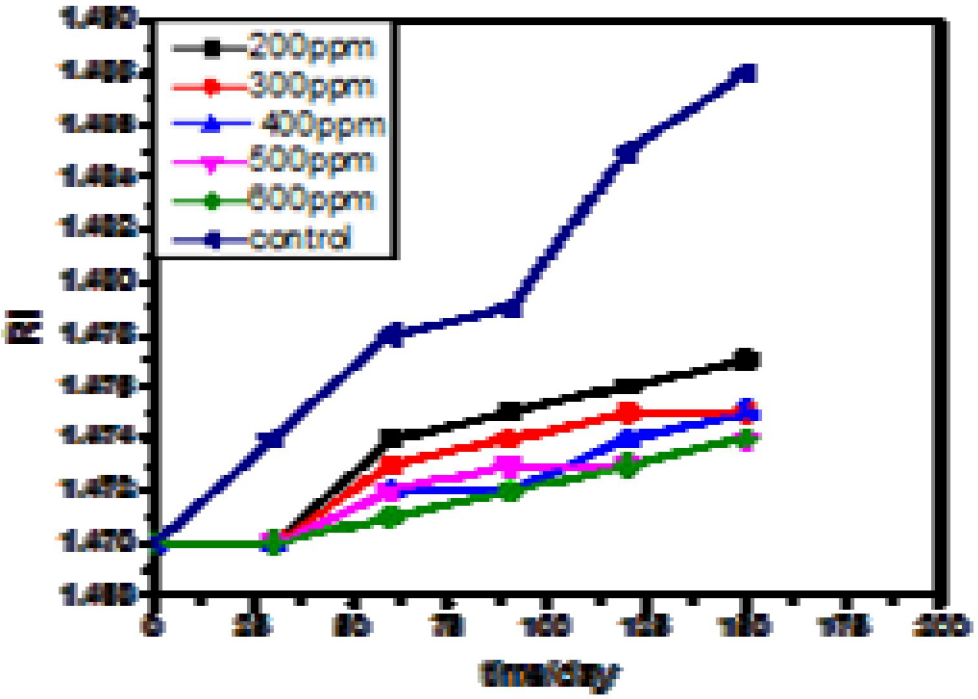


Fig (3.3.5.4): Curves of RI of soybean oil treated with DCM extract as antioxidant against its storage time.

3.3.6 Colour Intensity (CI)

Carotenoids and chlorophylls are the most abundant lipochromes of vegetable oils. The carotenoid and chlorophyll contents of fully refined oil are considerably lower than crude oil; hence the light amber coluor of refined sunflower oil turns to pale yellow on bleaching and the reddish coluor of crude soybean contributed to β-carotene.

Tables (3.3.6.1) and (3.3.6.2) show the changes in CI of sunflower oil both cases treated with sesame oil or DCM extracted from ginger roots as antioxidants, respectively , each in different concentrations (0,200,300,400,500 and 600ppm) , the results were almost identical . The yellow colour in all samples remained unchanged at 1.3. The red colour in all samples changed slightly from 0.4 initially time to 0.2 finally at the end of storage period. The difference in CI between samples which was treated with antioxidants (sesame /or DCM) and control insignificant.

Tables (3.3.6.3) and (3.3.6.4) illustrate the changes in CI of crude soybean oil treated with sesame oil or DCM extracted from ginger roots as antioxidants ,respectively, in different concentrations (0,200,300,400,500 and 600ppm) , through 150 days as storage period . The yellow colour in all samples remained unchanged at 7.0. The red colour in samples free of antioxidants (sesame oil and/or DCM extract) changed slightly from 3.1 at initially to 3.0 at the end of storage period. Samples treated with antioxidants (sesame oil and/or DCM extract) showed inconsiderable change in red colour from 3.1 to 3.0.

Table (3.3.6.1): Effect of the addition of sesame oil as antioxidant to sunflower oil on livobond colour readings

Storage period(days)	Concentration (ppm)											
	200ppm		300ppm		400ppm		500ppm		600ppm		Control	
	Y	R	Y	R	Y	R	Y	R	Y	R	Y	R
0	1.3	0.4	1.3	0.4	1.3	0.4	1.3	0.4	1.3	0.4	1.3	0.4
30	1.3	0.4	1.3	0.4	1.3	0.4	1.3	0.4	1.3	0.4	1.3	0.3
60	1.3	0.3	1.3	0.4	1.3	0.4	1.3	0.4	1.3	0.4	1.3	0.3
90	1.3	0.3	1.3	0.3	1.3	0.3	1.3	0.3	1.3	0.4	1.3	0.2
120	1.3	0.2	1.3	0.3	1.3	0.3	1.3	0.3	1.3	0.3	1.3	0.2
150	1.3	0.2	1.3	0.2	1.3	0.2	1.3	0.2	1.3	0.2	1.3	0.2

Table (3.3.6.2): Effect of the addition of DCM extract from ginger roots as antioxidant on livobond colour readings of sunflower oil during storage period

Storage period(days)	Concentration (ppm)											
	200ppm		300ppm		400ppm		500ppm		600ppm		Control	
	Y	R	Y	R	Y	R	Y	R	Y	R	Y	R
0	1.3	0.4	1.3	0.4	1.3	0.4	1.3	0.4	1.3	0.4	1.3	0.4
30	1.3	0.4	1.3	0.4	1.3	0.4	1.3	0.4	1.3	0.4	1.3	0.4
60	1.3	0.4	1.3	0.4	1.3	0.4	1.3	0.4	1.3	0.4	1.3	0.3
90	1.3	0.4	1.3	0.3	1.3	0.3	1.3	0.3	1.3	0.4	1.3	0.3
120	1.3	0.3	1.3	0.3	1.3	0.3	1.3	0.3	1.3	0.3	1.3	0.2
150	1.3	0.2	1.3	0.2	1.3	0.2	1.3	0.2	1.3	0.2	1.3	0.2

Table (3.3.6.3): Effect of the addition of sesame oil as antioxidant to soybean oil onlivobond colour reading during its storage time

Storage period(days)	Concentration (ppm)											
	200ppm		300ppm		400ppm		500ppm		600ppm		Control	
	Y	R	Y	R	Y	R	Y	R	Y	R	Y	R
0	7.0	3.1	7.0	3.1	7.0	3.1	7.0	3.1	7.0	3.1	7.0	3.1
30	7.0	3.1	7.0	3.1	7.0	3.1	7.0	3.1	7.0	3.1	7.0	3.1
60	7.0	3.1	7.0	3.1	7.0	3.1	7.0	3.1	7.0	3.1	7.0	3.1
90	7.0	3.0	7.0	3.1	7.0	3.1	7.0	3.1	7.0	3.1	7.0	3.0
120	7.0	3.0	7.0	3.0	7.0	3.0	7.0	3.0	7.0	3.0	7.0	3.0
150	7.0	3.0	7.0	3.0	7.0	3.0	7.0	3.0	7.0	3.0	7.0	3.0

Table (3.3.6.): Effect of the addition of DCM extract from ginger roots as antioxidant to soybean oil on livobond colour readings during storage time

Storage period(days)	Concentration (ppm)											
	200ppm		300ppm		400ppm		500ppm		600ppm		control	
	Y	R	Y	R	Y	R	Y	R	Y	R	Y	R
0	7.0	3.1	7.0	3.1	7.0	3.1	7.0	3.1	7.0	3.1	7.0	3.1
30	7.0	3.1	7.0	3.1	7.0	3.1	7.0	3.1	7.0	3.1	7.0	3.1
60	7.0	3.1	7.0	3.1	7.0	3.1	7.0	3.1	7.0	3.1	7.0	3.1
90	7.0	3.0	7.0	3.1	7.0	3.1	7.0	3.1	7.0	3.1	7.0	3.0
120	7.0	3.0	7.0	3.0	7.0	3.0	7.0	3.0	7.0	3.1	7.0	3.0
150	7.0	3.0	7.0	3.0	7.0	3.0	7.0	3.0	7.0	3.0	7.0	3.0

3.3.7 2, 2-Diphenyl-1-picrylhydrazyl (DPPH)scavenging

2, 2-Diphenyl-1-picrylhydrazyl (DPPH) is a stable free radical and has been commonly used to screen phenolic compounds containing high free radical scavenging ability (Wettasingh *et al.,* 2000). When hydrogen atom or electron was transferred to the single electron in DPPH, the absorbance at 515-517 nm decreased proportionally to the increase of non-radical form of DPPH. Conventionally, high free radical scavenging ability is regarded as high antioxidant activity (Lee *et al.,* 2007).

Table (3.3.7.1) shows the measure of DPPH scavenging of sesame oil or DCM extracted from ginger roots comparable with propyl gallate as standard antioxidant scavenger. It showed that DCM ginger extract is very strong scavenger (80%) close to the standard (94.7%). Despite sesame oil showed weak affinity to scavenging (4.9%) yet its result contrasted with that of the practical and also with previous results of sesame oil as antioxidant reported by Hassnein *et al.* (2012) .The controversy might be attributed to the modification of the applied method.

Table (3.3.7.1): The scavenging ability DPPH,Seseame oil and DCM ginger extract

Sample	% RSA ± (SD)
DCM extracted from ginger roots	80 ± .01
Sesame oil	4.0± 0.04
Standard (Propyl gallate)	94.7 ± 0.26

4.0 Conclusions and recommendations

4.1 Conclusions

This work was aimed to study in depth the chemistry of oils to surmount the problem of their rancidity by replacing the addition of synthetic antioxidants with that of natural antioxidants for their safety. Several natural products were investigated including ginger rhizome and sesame oil as antioxidants for common edible oils.

The following findings have been obtained:

1- Ginger rhizome as well as sesame oil have rich natural antioxidant constituents.

2-The DCM extract from ginger roots could be classified as a proper antioxidant.

3-Not only the crude soybean oil but also the refined sunflower oil from Arabian Company for Oils had only a maximum shortage life of two months.

4-The physiochemical properties were less significant and were useless in the identification of stored oil .They were useful only in the initial identification the oil. Peroxide and iodine values, however, could be used in the determination of quality and nutritional values of even moderately stored oil.

5- As chemical investigations of stability of stored oil treated with as much as 600ppm natural antioxidant , did not reveal any significant difference in the results from that oil treated with 500ppm , the later concentration was chosen as effective concentration of the natural antioxidant .

4.2 Recommendations

The critically needed:

1- Sudan land is a vast country with various natural vegetation and rich in natural products containing various antioxidants. Vast research work is critically need to extract, purify and apply these natural antioxidants.

2- Several organic solvents including methanol, ethanol, chloroform, acetone and tetracarboncholoride have been adopted to extract the constituents of ginger rhizomes. Further investigations are needed to determine the most efficient solvent in extracting the required antioxidant to be added to vegetable oils to increase their storage period.

3- Crude sesame oil, one of the important vegetable oils produced in Sudan, contains uninutrients such as sesamin, sesamol and sesamolin. These constituents can also extract, purified and tested as antioxidant additive for edible oils.

4- Chemistry can greatly serve the society in detecting harmful constituents on edible oils. More cooperation is critically needed between Sudanese chemical society and the society of protecting consumers to decrease the health hazards of harmful food materials.

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