Effect of Storage on physico-chemical Characteristics and Quality of some Vegetable Oils from Sudan

Asrra Mohammed Elamin Elmosbah Mohammed
B.Sc.( Honors ) in Food Science
Faculty of Agricultural Sciences
University of Gezira (2001)

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Department of Food Science and Technology
Faculty of Engineering and Technology

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<td>Prof. Dr. Ali Osman Ali</td>
<td>Main Supervisor</td>
<td>...............</td>
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<tr>
<td>Dr. Ahlam Ahmed Hussein</td>
<td>Co-supervisor</td>
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<tr>
<td>Prof. Dr. Abu Alhassan Salih Ibrahim</td>
<td>Internal Examiners</td>
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Date of Examination: 24 / 9 / 2014
Dedication

To my parents, source of love and source of Permanent exertion efforts.

To my beloved brother and sisters And their families.

To my friends, colleagues, and my relatives.

To all, I present this simple work being The fruit mind.
Thanks and grate fullness, firstly and lastly to “Allah” who gave me health, strength and patience to carry out this study successfully.

I would like to express my deep thanks and gratitude with special respect to my major supervisor Prof. Ali Osman Ali for his fatherly advise, useful guidance, encouragement, cooperation supervision and for the moral and professional support with which he provided me via the study.

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My thanks also to the Food Research Center and oil lab. Staff and special thanks to Mona Abas.

Thanks and deep gratitude to my family for encouragement and support during my study period.

I am also very grateful to all others who helped me during this work.
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M.Sc. in Food Science and Technology ( December , 2014 )

Department of Food Science and Technology
Faculty of Engineering and Technology
University of Gezira

Abstract
Vegetable oils are very important in human nutrition. They act as some of energy and provide essential nutrients such as essential fatty acids and fat soluble vitamins to our bodies. Samples of three types of main Sudanese vegetable oils were obtained from the local markets "peanut, sesame, sunflower". The aim of this study was to determine the quality characteristics of these oils and study the changes that occurred after storage at room temperature for six month. The physical properties results showed that peanut oil has a colour of 25 yellow units, 4.5 red units and 2.2 blue units, sesame oil has 25 yellow unit, 6.1 red unit and 4.8 blue unit while sunflower oil showed 7.9 yellow units, 1 red unit and zero blue unit. Density of peanut oil was 0.91, sesame oil 0.913 and sunflower 0.914. The refractive index of peanut oil was 1.471, sesame oil 1.474 and sunflower oil was 1.475. Viscosity of peanut oil was 25.99 cps sesame oil 21.78 cps and sunflower oil was 22.95 cps. The fatty acids composition of peanut oil (palmitic acid 15.37% oleic acid 42.82% linoleic acid 35.2% linolenic acid 1.84% stearic acid 0.01% arachidic acid 45.23% lignocenic acid 0.53%). Sesame oil fatty acids was composed of myristic 0.61% palmitic acid 12.85% palmitoleic acid 0.2% oleic acid 44.08% linoleic 37.72% linolenic acid 0.92 arachidic acid 2.89% behenic 0.75%. Sunflower oil composition was palmitic acid 11.59% oleic acid 41.85% linoleic acid 40.18 linolenic acid 6.38% . Free fatty acids of peanut oil were 0.809% sesame oil 1.045% and sunflower oil 1.020 %. The iodine value of peanut, sesame and sunflower oils were 94, 155 and 136, respectively. The peroxide value of peanut oil was 5.57, sesame oil 5.2 and sunflower oil was 4.443meqO₂/Kg fat . Saponification value of peanut oil was 193.20, and sesame oil 195 sunflower oil 188.2 mgKOH/g oil . After storage at room temperature the result of physical properties (Density of peanut oil is 0.914 sesame oil 0.916 sunflower 0.919 and refractive index of peanut oil was 1.471, sesame oil 1.474 and sunflower oil was 1.475 and viscosity of peanut oil was 27.98cps, sesame oil 27.04cps and sunflower oil was 25.38cps ).Free fatty acids content : peanut oil was 0.98%, sesame oil 1.41% and sunflower oil 2.82% . Peroxide Value of peanut oil was 6.82, sesame oil 6.16 and sunflower oil was 14.03 meqO₂/Kg fat. Generally the fresh oils quality parameters are within the range required by the Sudanese
Standards and Metrological Organization. This study recommend that, consideration should be given to storage condition e.g. storage of the oils in a cool place and away from the sunlight.
ผลกระทบ التخزين على الخواص الفيزيوكيميائية والجودة لبعض الزيوت النباتية في السودان

اسراء محمد المصباح محمد

ماجستير العلوم في علوم الأغذية (ديسمبر 2014)
قسم علوم وتكنولوجيا الأغذية - كلية الهندسة والتكنولوجيا - جامعة الجزيرة

ملخص الدراسة

الزيوت النباتية ذات أهمية كبيرة في تغذية الإنسان إذ تمده بالطاقة والمغذيات الأخرى مثل الأملاح الدهنية الأساسية والفيتامينات الدقيقة في الدهن. تم الحصول على ثلاثة أنواع من زيت الطعام السوداني من السوق المحلي: زيت الفول السوداني، زيت السمسم، و زيت زهرة الشمس. تم تحليل الخواص الفيزيائية والكيميائية للزيوت ودراسة التغيرات التي حدثت أثناء تخزينها عند درجة حرارة الغرف لمدة ستة أشهر المتعارف عليها وكانت نتائج التحاليل كما يلي:

الخواص الفيزيائية: اللون الأصفر لزيت الفول السوداني و الأحمر 4.5 و الأزرق 2.2 وزيت السمسم اللون الأصفر 25 و الأحمر 6.1 و الأزرق 4.8 ولون الأصفر زيت زهرة الشمس 7.9 و الأحمر 1.0 و الأزرق 0.0

الكثافة النوعية لزيت الفول السوداني 0.914 وزيت السمسم 0.913 وزيت زهرة الشمس 0.918.

معامل الانكسار لزيت الفول السوداني 1.471 وزيت السمسم 1.474 وزيت زهرة الشمس 1.475.

اللزوجة لزيت الفول السوداني 25.99 سنتيبويز وزيت السمسم 21.78 سنتيبويز وزيت زهرة الشمس 22.95 سنتيبويز.

الخواص الكيميائية: الأحماض الدهنية لزيت الفول السوداني: حامض الباليتيك 15.37% حامض الوليك 42.82% واللينونيك 35.2% والبيهنيك 4.23% والأحماض الدهنية لزيت السمسم حامض الباليتيك 15.37% حامض الوليك 44.08% واللينونيك 37.72% والبيهنيك 40.18% والأحماض الدهنية لزيت زهرة الشمس حامض الباليتيك 15.37% حامض الوليك 41.85% واللينونيك 37.72% والبيهنيك 40.18% والأحماض الدهنية لزيت زهرة الشمس حامض الباليتيك 15.37% حامض الوليك 44.08% واللينونيك 37.72%.

قيمة البيروكسيد لزيت الفول السوداني 6.82 وزيت السمسم 1.045 وزيت زهرة الشمس 1.41.

رقم التصبن لزيت الفول السوداني 193.5 وزيت السمسم 195 وزيت زهرة الشمس 188.2. بعد تخزين هذه الزيوت عند درجة حرارة الغرفة لمدة ستة أشهر كتبت تحليل الخواص الفيزيائية كالتالي: كنتيات زيت الفول السوداني 0.914 وزيت السمسم 0.916 وزيت زهرة الشمس 0.919 معامل الانكسار زيت الفول السوداني 1.474 وزيت السمسم 1.475 وزيت زهرة الشمس 1.475. ووزارة زيت الفول السوداني 27.91 وزيت السمسم 25.38 وزيت زهرة الشمس 25.38. التغييرات في الأملاح الدهنية الحرة في زيت الفول السودان 0.98 وزيت السمسم 1.41 وزيت زهرة الشمس 2.82 وقيمة البيريكسيد لزيت الفول السودان 2.82 وزيت السمسم 1.41 وزيت زهرة الشمس 2.82. وقيمة البيريكسيد لزيت الفول السودان 2.82 وزيت السمسم 1.41 وزيت زهرة الشمس 2.82. وقيمة البيريكسيد لزيت الفول السودان 2.82 وزيت السمسم 1.41 وزيت زهرة الشمس 2.82. وقيمة البيريكسيد لزيت الفول السودان 2.82 وزيت السمسم 1.41 وزيت زهرة الشمس 2.82. وقيمة البيريكسيد لزيت الفول السودان 2.82 وزيت السمسم 1.41 وزيت زهرة الشمس 2.82. وقيمة البيريكسيد لزيت الفول السودان 2.82 وزيت السمسم 1.41 وزيت زهرة الشمس 2.82. وقيمة البيريكسيد لزيت الفول السودان 2.82 وزيت السمسم 1.41 وزيت زهرة الشمس 2.82. وقيمة البيريكسيد لزيت الفول السودان 2.82 وزيت السمسم 1.41 وزيت زهرة الشمس 2.82. وقيمة البيريكسيد لزيت الفول السودان 2.82 وزيت السمسم 1.41 وزيت زهرة الشمس 2.82. وقيمة البيريكسيد لزيت الفول السودان 2.82 وزيت السمسم 1.41 وزيت زهرة الشمس 2.82. وقيمة البيريكسيد لزيت الفول السودان 2.82 وزيت السمسم 1.41 وزيت زهرة الشمس 2.82. وقيمة البيريكسيد لزيت الفول السودان 2.82 وزيت السمسم 1.41 وزيت زهرة الشمس 2.82. وقيمة البيريكسيد لزيت الفول السودان 2.82 وزيت السمسم 1.41 وزيت زهرة الشمس 2.82. وقيمة البيريكسيد لزيت الفول السودان 2.82 وزيت السمسم 1.41 وزيت زهرة الشمس 2.82. وقيمة البيريكسيد لزيت الفول السودان 2.82 وزيت السمسم 1.41 وزيت زهرة الشمس 2.82. وقيمة البيريكسيد لزيت الفول السودان 2.82 وزيت السمسم 1.41 وزيت زهرة الشمس 2.82. وقيمة البيريكسيد لزيت الفول السودان 2.82 وزيت السمسم 1.41 وزيت زهرة الشمس 2.82. وقيمة البيريكسيد لزيت الفول السودان 2.82 وزيت السمسم 1.41 وزيت زهرة الش
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CHAPTER ONE
INTRODUCTION

Oils and fats are important parts of human diet and more than 90 percent of the world production from vegetable, animal and marine source is used as food or as an ingredient in food products. Oils and fats are rich source of dietary energy and contain more than twice the caloric value of equivalent amount of sugar. Their functional and textural characteristics contribute to the flavour and palatability of natural and prepared foods. They contain certain fatty acids which play an important role in nutrition and also carries fat soluble vitamins (FSSAI, 2012).

Each year the world consumes close to 120 million MT of edible fat and oils (Siraj ,2002) Oils and fats of vegetables origin are in great and increasing demands in the world markets. Vegetable oils are produced in Sudan from cotton seed (Gossypium barbadense.L) and (Gossypium Hirsutum.L), sesame (Sesamum indicum.L) peanut (Arachis hypogaea.L) and sunflower (Helianthus annuus. L).

In Sudan the production of oil is variable to changes in climatic condition. Sudan is the biggest producer of annual oil seeds among the Arab countries and a major world export of sesame seed and peanut. (OCDP, 1995).

Peanut is principally used for food products, e.g., eaten as peanut butter used for confectionary, snack food and peanut are used for oil making. Peanut fifth largest source of vegetable oil in the world( Lack et al., 2003).

Peanut is an important cash crop in the Sudan it is grown mainly for it’s oil, large areas of more than one million hectares both under rainfed and irrigation are devoted to this crop annually (Ahmed, 2002). The nuts are economically important as a food crop due to their high content of digestible protein, unsaturated oil and exceptional roasted nutty flavour. They have substantial value and flavorful food commodity. Overall more than 50% of all peanut produced are crushed for oil (Gunston, 2002).

Yagoub (2008) reported that the sesame seeds are an important source of oil (50- 60% ) and protein (18- 25%) and therefore plays an important source of edible oil in human nutrition. Most of the sesame seeds are used for oil extraction and the rest used for edible purposes (Elleuch et al ,2007). Sesame oil has pleasant flavour and is regarded as a superior vegetable oil, it ranks second with regard to nutritional value after olive oil (Alpaslan et al, 2001). The oil has mild colour and pleasant taste and as such is natural salad oil (Abou- Gharbia et al., 2000). The
Sesame oil have multiple physiolocal functions such as estrogenic activity (Coulman et al., 2005).

Hus et al. (2005) reported that the sesame oil providing anti-inflammatory function, and it also increases anti oxidative ability and 8-tocopherol bioavailability,(Lemcke-Norojavi et al., 2001). Sunflower seed is also considered as a new promising source of high quality oil for cooking and salads it is used in the manufacture of shortenings and margarine. Sunflower oil was high linoleic acid content next to safflower oil in having high levels of linoleic acid which was required for the cell membrane structure, cholesterol transportation in the blood and for prolonged blood clotting.(Adams, 1982). Sunflower oil is considered to reduce the serum cholesterol levels.(Deosthale, 1972).

General objective:
To study the quality characteristics of some sudanese vegetable oils and the effect of the storage on it.

Specific objectives:
1- To determine the physical and chemical characteristics of three types of oils before and after storage
2- To evaluate the sensory properties of the three oils.
CHAPTER TWO

LITERATURE REVIEW

2.1 Physical properties of oil:

2.1.1 Colour:

Colour is an important quality factor, and in order to maintain a bright colour in the final product, chemical treatment and additives are often used in place of blanching by heat to inactivate enzymes (Luch et al., 1986).

Neiwiadom, et al. (1965) stated that the natural colour in vegetable oils and fats is due to presence of the natural pigments or of their decomposition and their a companying substance e.g. Zanthophyll and the colour substances related to them.

Cocks and Van Rede (1966) pointed out that the determination of colour of oils were based on visual comparison of standard by using lovibond tintometer.

Peanut oil of the first grade for cooking should not exceed 2 lovibond red with fixed lovibond yellow 20 according to Chinese national standard GB 5525-85, and for salad use, it should be no more than 1.5 lovibond red with fixed lovibond yellow 15 (Fengxia et al., 2001).

As peanut mature oil colour becomes lighter as β carotene and lutelin, which are responsible for the yellow colour, become more diluted (Gunstone, 2002).

Cobbe and Johnson (1973) indicated that the colour of peanut oil using lovibond as maximum yellow 16-25 and 2 for red. In Codex Alimentarius (1993) the colour of peanut oil was mentioned to depend on the characteristics of the designated product.

Yermanos et al. (1972) correlated the sesame plant height and oil colour and concluded that short plants had clear oil while tall plants had green oil. Andraos et al. (1950) stated the colour of sesame oil as blue 0.0 tintometer, yellow 35.0 tintometer, and 4.3 red tintometer. Lyon (1972) studied the pigments of sesame oil using spectrophotometrically, sesame oil obtained from first cold pressing has a light colour, contains a suspended meal, which is removed by settling and filtering to get oil varies from yellow to dark amber colour. Oil of second heated pressing is coloured because it contains colouring matters, which are removed by alkali-refining. Refined sesame oil is pale yellow in colour used commercially as salad oil. Sesame is bleached with a less quantity of bleaching earth (Salunkhe et al., 1992; Hui, 1996).
Bashir (1986) found that, Lovibond values recorded ranged between 4.0 and 5.0 for yellow tint, 0.55 and 0.70 for red tint, and 0.2 for blue tint for sunflower seed oil from Alabama and Minnesota, respectively, also he stated that, the colour of three sunflower oil cultivars grown in Sudan ranged between 4.7 - 4.4 yellow tint, 0.16 - 0.58 red tint and 0.2 blue tint.

The crude sunflower oil is yellow in colour, and when refined, it becomes very light yellow or pale. Although crude oil contains sufficient tocopherols to confer some antioxidant activity, a large proportion of it is removed during the process of refining. The presence of Iron derivatives intensifies colour development, increases the concentration of deoxypolymers (Sedlacek, 1972) Robertson and Russell (1972) reported that the colour of sunflower oil from Alabama and Minnesota as 1.0 yellow tint and 0.1 red tints, 2.0 yellow tints and 3.0 red tints, respectively.

2.1.2 Density:

Determination of the contents of tanks or flow rates are usually based on methods of volumetric dosing. These methods are used to facilitate equipment automation. However, mass determination based on volume measurements will depend on the nature and temperature of oil. Wiess (1983) reported that density of peanut at 15 °C was 0.917 – 0.921 and at 25 °C was 0.910 - 0.915 . While the relative density of peanut oil was reported by Codex Alimentarius (2001) varying from 0.914 to 0.917 at 20 °C.

density of sesame oil reported by Bernardini (1986) was 0.889 - 0.894 at temperature 60 °C. Salwa (2009) reported that the standard for edible sesame oil from recommended international codex relative density at 20 °C / water at 20 °C was 0.915 - 0.923 . Bailey (1996) reported that density of sesame at 20°C is 0.915 – 0.924.

Hui (1996) reported that relative density of regular sunflower oil in the range of 0.909 - 0.915 (20°C /water at 20°C ).The Codex Alimentarius indicates a relative density of regular sunflower oil in the range of 0.918 - 0.923 (20°C /water at 20°C) the values suggested by the codex don’t differ appreciably from the expected values for must vegetable oils. Bashir (1986) reported the density of sunflower oil ranged between 0.9082 and 0.9169.
2.1.3 Refractive index:

It is characteristic properties of fat and oil and may be used as a fast measurement of the advance of a hydrogenation operation. FSSAI (2012), Eckey and Lawrence (1954) defined it as the ratio of velocity of light in vacuum to the velocity of light in the oil or fat. Refractive index of oils increases with the increase in unsaturation and also chain length of fatty acids (AOAC, 2000). Refractive index values ranging from 1.4658 to 1.4690 were recently reported for refined oil extracted from five different peanut species (Nkafamiya et al., 2010).

The Sudanese Standards Metrological Organization (SSMO, 2009) proposed that the range of refractive index of peanut oil was 1.460 – 1.465, matched with the value that was reported by Mansour (2007). Also a value of 1.449 was reported for the natural peanut oil. Atasie et al., (2009). Jacob and Krishnamurthy (1990) reported that the refractive index of peanut oil at 40°C ranged between 1.4620 - 1.4640. Codex Alimentarius (1993) was mentioned 1.4600 - 1.4650 at 40°C, and reported that the refractive index varies with the specific gravity. Also indicted the high RI value are obtained with larger molecular weight.

Hui (1996) reported that refractive index (RI) of sesame oil at 40°C is range 1.465-1.469. Pearson (1981) found the RI of sesame oil was 1.465-1.469 at 40°C. Sauzacletus and Ramaiah (1978) indicated that the RI of sesame seed oil at 25°C was 1.469. Lyon (1972) gave values of 1.471 - 1.474 for the RI of sesame oil at 40°C.

Jar Elnabi (2001) reported the R.I. of crude sunflower oil as 1.4700. Bashir (1986) found that, the R.I. of three fresh sunflowers oil grown in Sudan is 1.4706, 1.4723 and 1.4720. The Codex Alimentarius indicates a refractive index of regular sunflower oil in the range of 1.461 -1.468 at 40°C, Merrien (1998) reported that it range between 1.474 -1.476 at 20°C.

Richard (1986) reported the R.I of crude sunflower oil at 25°C was 1.4742 Yousuf (1979) reported that refractive index of sunflower oil at 32°C was 1.460 - 1.530. Parvathi and Geervani (1976) reported that the R.I of fresh sunflower oil as 1.4656 - 1.4685 at 40°C. Pearson (1988) reported that, R.I of sunflower oil ranged between 1.4670 - 1.4690.
2.1.4 Viscosity:

Balla (2001) reported that the viscosity of oil decreased with rise in temperature while saturation and large molecules such as a long chain fatty acids or polymerized oil increased the viscosity. Eugene, (1991) defined the viscosity as the measure of resistance to flow. Viscosity is the measure of the internal fraction in the oil and is important index for the study of oil and their intermolecular forces, and its useful criterion for degradation or depolymerization such as that occurs in initial stage of hydrolysis of fats and oils during storage (Joslyn, 1970).

Balla (2001) found that the viscosity of three peanut cultivars ranged between 46.0 and 52.43 centipoises at 30°C. Prasad and Dutt (1989) found to be influenced by changes in temperature, and it’s generally decreased exponentially with increase in temperature, and slightly decreased with increase in unsaturation and reported the viscosity of peanut oil ranged between 16.22 - 76.67 cp. Rock and Poth (1966) found that unsaturation reduces viscosity of fats, e.g. linoleic acid is less viscous than oleic and oleic is less viscous than stearic acid. Also, Wakeham (1954) reported that hydrogenation of oil increase its viscosity as it decrease with its unsaturation. In (1976) Koman and Kotuc showed that, viscosity of peanut oil ranged between 71.07 to 68.15 centipoise.

Sabah El Khier et al. (2008) reported that the viscosity of different samples of sesame oil ranged between 18.94 to 26.40 centipoises. Murwan (1994) reported that the viscosity of sesame seed oil ranged between 18.90 - 26.43 centipoises at 40°C.

Jar Elnabi (2001) reported that, the viscosity of both refined and crude sunflower seed oil was 21.4 and 24.3 (cps), respectively. Richard (1986) reported the normal value of viscosity for crude sunflower seed oil at 25°C to be 50 centipoises (cps). Mohammed, (1998) reported that the viscosity of sudanese refined sunflower seed oil was 31 (cps) measured at 30°C.
2.2 Chemical characteristics:

2.2.1 Fatty acids composition:

Vegetables oils differ in their composition and fatty acids, fatty acids are saturated or unsaturated with one double bond (mono unsaturated) or more than one double bond (poly unsaturated). The major unsaturated fatty acids are oleic acid (C18:1), linoleic acid (C18:2) and linolenic acid (C18:3) oil resistance to oxidation in the frying process depends mainly on the fatty acids composition and antioxidant content of the oil. (Rossell, 2001; Sanches- Silva et al., 2003; Nogala-Kalncka et al., 2005; Przybylski and Eskin, 2006). The physicochemical properties of oil are directly related to their lipids and glyceride composition (Rahman et al., 2007).

About 96% of peanut oil triglycerides are composed of palmitic, stearic, oleic, and linoleic acids (Koman and Kotuc ,1976). Cobbe and Johnson (1973) stated that the fatty acids composition of peanut oil have included 14 different fatty acids to be present in peanut oil of which oleic (18:1) and linoleic (18:2) contributed 47.8 and 30.7% of the total fatty acids, respectively. Other minor fatty acids include behenic (22:0), stearic (18:0), and arachidic (20:0) acids. Shitole (1987) found 17 to 22% saturated and 78 to 83% unsaturated fatty acids in peanut oil. Fatty acids composition of peanut oil as influenced by cultivar, maturity storage, processing treatments and environmental conditions has been investigated by several workers, Hamilton (1987); Knauf et al. (1986) and Kamaladevi et al. (1984).

Sesame oil contains about 80% unsaturated fatty acids. Oleic and linoleic acids are the major fatty acids and are present in approximately equal amounts (Lyon, 1972). The saturated fatty acids account for less than 20% of the total fatty acids. Palmitic and stearic acids are the major saturated fatty acids in sesame oil. Smith (1971) reported that 44% and 42% linoleic and oleic acids, respectively and 13% saturated fatty acids in sesame oil. Arachidic and linolenic acids are present in very small quantities (Rao and Rao, 1981). Arachidic and linolenic acids are present in very small quantities heptadecanoic acid (0.2 – 0.3%) and hexadecenoic acid 0.0 – 0.5% have also been reported from some sesame oil. (Weiss, 1971; Swern 1979).

Sunflower oil is primarily composed of palmitic, stearic, oleic and linoleic acids. It contains more unsaturated fatty acids than other oil seeds like soybean, peanut and cotton seed. sunflower oil is characterized by its high concentration of linoleic acid (60-70%) followed by oleic acid (
Earle et al., (1968). It’s low in saturated fatty acids and contains only small amounts of palmitoleic, linolenic, arachidic, behinic, lignoceric acids.

2.2.2 Free fatty acids:

The acid value is defined by as the number of milligrams of potassium hydroxide required to neutralize the free fatty acids present in one gram of fat. It is a relative measure of rancidity as free fatty acids are normally formed during decomposition of oil glycerides. The value is also expressed as percent of free fatty acids calculated as oleic acid. (FSSAI, 2012). The pro-oxidant effect of free fatty acids in vegetable oils is widely known. (Crapiste et al., 1999). The free fatty acids percentage of the fresh peanut oil was 0.155% as oleic acid. Much higher FFAs contents ranging between 0.25 to 0.98% were earlier reported for different peanut species (Nkafamiya et al., 2010).

Jacob and Krishnamurthy, (1990) stated that free fatty acids as oleic acid of peanut oil should be less than 3%. Codex Alimentarius (1993) reported that acid value for peanut oil (virgin) should not be more than 4mg KOH/g oil and for non-virgin oil not more than 0.6 mg KOH/g oil, while, Branseome and Young (1972) mentioned that the free fatty acids, as oleic acid, of peanut oil should have a maximum value of 0.05%. While Davies and Tom (1994) mentioned that, rancidity can arise in two quite distinct ways e.g. butter goes rancid when it is kept for too long time. Over time some of the triglycerides break down to release their fatty acids components including butyric acid and caproic acid.

Seegeler (1983) and Weiss (1983) reported free fatty acids of sesame oil ranged between 1.0% to 3.0% as oleic acid, Andraos et al. (1950) gave an acidity of 1.5% as oleic acid, while Instituto Centeromercano de Investigation (1974) gave an acidity of 2% oleic acid. On the other hand, Pearson (1981) reported about 0.99% free fatty acids in sesame seeds oil.

Jar Elnabi (2001) reported that, the F.F.As for refined and crude sunflower oil were 0.5 and 2%, respectively.

The development of free fatty acids in oil is usually considered to be one of the main parameters to use in evaluating the quality of oil, specially the state of storage and heat. (El Harith, 1999).

Youssef, et al. (1979) and Richard, (1986). reported a value of 1.8% and 1.0% F.F.As for crude sunflower oil respectively, and 3% by Mohammed (1998), for Sudanese refined sunflower oil. The percentage of F.F.As reflects the efficiency of the refining process.
2.2.3 Iodine value:

The iodine value of an oil or fat is the number of grams of Iodine absorbed by 100g of the oil/fat, when determined by using Wijs solution. Ali (2002) reported that the measurement of iodine value (IV) was found to be one of the most convenient methods to determine saturation and unsaturation oil the initial iodine value for peanut oils was reported to be 97.5 mg/iodine /100g / fat. Jacob and Krishnamurthy (1990) found that iodine value of peanut oil ranged between 85 to 95. Norden *et al.* (1987) stated that iodine value of the Florida breeding lines varied from 74 to 107 and all the oil quality factors studied were highly affected by genotype. Cobbe and Johnson, (1973) found that iodine value of peanut oil were 82 to 107. Similarly Codex Alimentarius (1993) reported that iodine value for peanut oil range from 80 up to 106. Eckey (1954) found that do not all unsaturated bonds are similar in their reactivity. Unsaturated bonds in the conjugated relationship react more slowly than that are unconjugated. Sauzacletus and Ramaiah (1978) found that the iodine value (IV) of sesame oil was 116, however, Seegeler (1983) reported a range of 103 - 130, whereas, Weiss (1983) stated that the (IV) of the sesame oil varied from 102 - 116. Lavachev *et al.* (1987), mentioned that, the sunflower oil showed a higher iodine number when stored for 18 months in tanks with heat solution than the oil that stored without heat solution. Scincalepore (1975) reported that iodine number ranged between121 - 139. Although the iodine number gives an indication of the number of double bonds in any particular oil or fat it however also indicates the total amount of unsaturation. Robertson and Russell (1972) reported the iodine number ranged between130 - 138 for sunflower seed oil grown in northern U.S.A and Canada. The standard value of iodine number of sunflower oil in 110 -143 reported by Pearson (1988). Jar Elnabi, (2001) reported that, the iodine number is 129.4 and 126.9 for crude and refined sunflower oil, respectively.

2.2.4 Peroxide value:

This is an indication of the extent of oxidation suffered by oil. Peroxide value was ranging from 1.5 to 6.7 meqO2 /kg were earlier reported for crude and refined peanut oil OZcan (2003a) and (2003b), Atasie ,(2009). Also, Nkafamiya *et al.* , (2010) reported PV ranging between 1.30 -1.73 and 22.06- 25.30 Meq O2 /Kg sequentially for refined
and crude oil. Balla (2001) reported that the peroxide value of crude peanut oil range from 0.7 to 1.2 milli equiv o₂/kg of oil and 2.9 to 4.1 milli equiv o₂/kg of oil for the refined oil.

Ramsden (1995) pointed out that amount of which oxygen was taken up to peroxides and a measure of freshness. The peroxide value is used as an indicator of the oxidation of oil. Narasimhan, et al (1986). However the peroxide value of 10 as recommended by Codex Alimentarius is not valid for evaluating the quality of peanut oil. Applewhite (1982) pointed out that the effects of atmospheric oxidation apply to all fats and oils regardless of their stage of processing.

SSMO (2002) reported that the peroxide value of unrefined sesame oil as 15 meq/kg oil and refined sesame oil is 10 meq/kg oil. Instituto Centromericano de Investigacion (1974) reported the peroxide value (PV) of sesame seed oil is 6.0 meq/Kg. Generally PV of sesame seed oil is totally dependent on the storage state of the oil (Pearson, 1981).

Morrison (1981) reported that sunflower oil was strong-flavored at P.V8m.Eq/kg or was off-flavored at P.V of 13 m.Eq/kg. the change of P.V of oils and fats during storage under normal or controlled condition is an important for detecting their quality (Hoffmann, 1962).

Izzo et al. (1974) reported sunflower oil of sixty-two varieties had P.V between 2.92 - 8.54 m.Eq/kg depending on variety. Robertson and Russell (1972) found that sunflower oil had P.V between 0.21- 0.41 m.Eq/kg. Yousuf et al. (1979) reported a P.V of 5 m.Eq/kg for crude sunflower oil, Jar Elnabi (2001) found that a P.V for refined and crude sunflower oil as 4.4 and 6.1 m.Eq/kg, respectively. The P.V of oil reflects the quality of the raw material used in the extraction of the oil. luckadoo and Sherwin (1972) reported that treatment of sunflower oil with 0.02 % tertiary butyl hydroquinone (TBHQ) reduced the development of peroxides during storage.

2.2.5 Saponification value

Yagoub (2008) reported that saponification value of oils as the number of milligrams of potassium hydroxide need to neutralized the fatty acids formed by the complete hydrolysis of one gram of oil. A high saponification value indicated that the lipid has fatty groups of low relative molecular mass.

Jacob and Krishnamurthy (1990) found that saponification value of peanut oil varied refining a considerable amount of oil was lost because of saponification of neutral oils. Sreenivsan (1968) indicated that saponification value of peanut oil were equi to194.1, Codex Alimentarius (1993)
mentioned that the saponification value as mg KOH/g oil should range between 187 to 196. Sawsan (2001) reported that the higher S.V indicated shorter chain fatty acids found that in chemical refining a considerable amount of oil was lost because saponification of neutral oil and indicated that S.V of sesame oil were equal to 194.1 mg/100g.

Hui (1996) reported that saponification values for sesame seed oil is 186–195 mgKOH/g oil saponification values (SV) of 185, 187-193 and 187-195 mgKOH/g oil that reported by Andraos et al. (1950); Lyon (1972) and Pearson (1981). Sauzacletus and Ramaiah (1978) indicated that (SV) of the edible sesame seed oil was as high as 270 mgKOH/g oil. Seegeler (1983) reported a range of 186-199 mgKOH/g oil (SV) of sesame seed oil.

Codex Alimentarius (1993) mentioned that, the S.V. as mg/KOH/g oil of sunflower oil should range between 187-196. Richard (1986) reported the S.V. of crude sunflower oil as 190. Pearson (1988) reported a range of 188-194 for S.V of edible sunflower oil. Jar Elnabi (2001) reported that, the S.V. of refined and crude sunflower oil were 187.9 and 189.6, respectively.

The saponification value is a measure of the free and esterified acids present in fats and oils and is the formation of metallic salt of a fatty acids (soap). Moreover, saponification is a reaction that occurs in food.

### 2.3 Sensory evaluation analysis:

Sensory evaluation commonly use in quality assurance and new product development. A sensory evaluation is made by the senses of taste, smell, touch, and hearing when food is eaten. The complex sensation that results from the interaction of our senses is used to measure food quality in program quality control and new product development. This evaluation may be carried out by one person or several hundred quality can be measured by sensory panels. More tightly, food quality and acceptance can be indicated by correlating the quantitative and qualitative measurement of the various sensory characteristics contributing to the overall appreciation of food, with the consumer assessment or preference ratings (Larmond, 1982).
CHAPTER THREE

MATERIALS AND METHODS

3.1 Materials

3.1.1 Source of oils
The oils were collected from the Khartoum state local market, Sudan.

3.1.2 Chemicals and reagents
Chemicals and reagents used in this study were of analytical grade.

3.2 Methods

3.2.1 Physical properties methods
3.2.1.1 Colour:
The colour intensity of oils was recorded using a lovibond tintometer as units of red, yellow and blue according to AOCS (2005) where sample of oils were filtered through filter paper immediately before testing. An appropriate cell (2or5.25” cell) was filled with the oil and placed in tintometer near-by a window for light. The instrument was switched on and looked through the eyepiece. The yellow colour was adjusted, and the slides were adjusted until a match colour was obtained from a combination of red and blue. The values obtained by matching were recorded as red, yellow and blue.

3.2.1.2 Density:
The oil density was determined according to AOAC (2005) methods, using psycho-meter. An empty stoppard. Psycho-meter was weighted, filled with water and kept at constant temperature of 25°C in a bath water for 30 min. The weight of water at 25°C was determined by subtracting weight of empty psycho-meter from its weight when filled with water. Psycho - meter was adjusted to proper level, dried with a cloth, filled with oil and weighted. In the same manner, the weight of the oil at 25°C was determined. The density was calculated as follows:
The density at 25°C = W₁/ W₂
where:
W₁= Weight of oil at 25°C
W₂ = weight of water at 25°C
3.2.1.3 Refractive index:

The refractive index (RI) was determined by Abbe 60 Refractometer as described by the AOAC method (2005). A double prism was opened by means of screw head, few drops of oil were placed on the prism. The prism was closed firmly by tightening the screw head and the instrument was then left to stand for few minutes before reading in order to equilibrate the sample temperature with that of the instrument (32±2°C). The prisms were cleaned between readings by wiping of the oil with soft cloth, then with petroleum ether and left to dry.

3.2.1.4 Viscosity:

The viscosity of the oil samples was recorded using an Ostwald U-Tube viscometer according to Cocks and Van Rede (1966). The viscometer was suspended in a constant temperature bath water (32 ±2°C) so that the capillary was vertical. The instrument was filled by means of pipette inserted into the side arm to the mark at the top of the lower reservoir with the oil. So that the tube above the mark was not wetted. The instrument was then left to stand for few minutes before reading in order to equilibrate the sample temperature with that of the instrument (32±2°C). By means of the pressure on the respective arm of the tube, the oil moved into the other arm so that the meniscus was 1cm above the mark at the top of the upper reservoir. The liquid was then allowed to flow freely through the tube and the time required for the meniscus to pass from the mark above the upper reservoir to that at the bottom of the upper reservoir was recorded.

Calculation

Relative Viscosity of the oil = \( \frac{T - T_0}{T_0} \)

where:

\( T = \) is the flow-time of the oil.
\( T_0 = \) is the flow-time of the distilled water.
3.2.2 Chemical characteristics

3.2.2.1 Fatty acids composition

A gas chromatograph from Shimadzu hyphenated to a mass spectrometer QP 2010 plus (Tokyo, Japan) equipped with an auto-sampler (AOC-20S) and auto-injector (AOC-20i) was used. After methylation, sample was injected in the column of GC/MS and left to run for about 52 min. Identification of the compounds were carried out by comparing the mass spectra obtained with those of standard mass spectra.

3.2.2.2 Free fatty acids:

Free fatty acids were determined according to AOAC (2005) about 5 to 10 g of cold oil sample was weighted into a 250 ml conical flask and 50 ml to 100 ml of freshly neutralized hot ethyl alcohol and about 1 ml of phenolphthalein indicator solution were added. The mixture was warmed about 5 minutes and titrated with hot against standard alkali solution shaking vigorously during the titration the weight of the oil was taken for the estimation and the strength the alkali used for titration shall be in such a way that volume of alkali required for the titration must not exceed 10 ml.

The formula used to calculate (FFA) was

\[
\text{FFA\%} = \frac{V \times N \times M}{W}
\]

where :
V: Volume (in ml) of NaOH used.
N: Normality of NaOH.
M: Molecular weight of fatty acids (282 as oleic acid).
W: Weight (in gm) of sample.

3.2.2.3 Iodine value:

The iodine value of the oil was determined according to AOAC (2005). Approximately 0.2g of oil was accurately weighed and placed in a dry and clean flask specially offered for the test. To 10 ml of chloroform was used for dissolving the oil, 25 ml of pyridine sulphate dibromide solution was added and finally 20 ml of KI (0.1N) was added to the contents of the flask. Then the flask was Stoppard and the mixture was allowed to stand for 10 minutes in a dark place. The stopper and the side of the flask were rinsed with enough amount of distilled water,
and the flask content was shaken and titrated against 0.01N sodium thiosulphate solution using starch liquid as an indicator. A blank determination was carried out simultaneously.

Calculation

\[
\text{Iodine value} = \frac{(b-a) \times 0.01269 \times 100}{S}
\]

where :
b: Volume (ml) sodium thiosulphate in blank solution.
a: Volume (ml) sodium thiosulphate in active test solution.
S: weight (g) of the oil sample used.

0.01269: Iodine factor.

3.2.2.4 Peroxide value :

The Peroxide value of the oil samples was determined according to the AOAC (2005). One gram of the oil was weighed into 250ml stopper conical flask. Thirty ml of a mixture of glacial acetic acid and chloroform (3:2) were added and the solution was swirled gently to dissolve the oil. About 0.5 ml of 0.1N KI was added to the flask, and the content of the flask were left to stand in dark with occasional shaking for one minute before adding 30ml of distilled water. Slowly the liberated Iodine was, titrated with 0.01 N sodium thiosulphate until the yellow colour almost disappeared. About 0.5ml of 1% starch solution was added. The titration continued with vigorously shaking until the blue colour completely disappeared. The number of ml 0.01 N sodium thiosulphate required (a) were recorded. The same process was repeated for blank. The number of ml of 0.01 Sodium thiosulphate required by the blank (b) was recorded.

Calculation

\[
\text{Peroxide value} = \frac{(b-a) \times N \times 1000}{S}
\]

Where:
b: reading of blank (ml).
a: reading of oil sample (ml).
S: weight of oil sample used (g).
N: normality.
3.2.2.4 Saponification value

The determination of the saponification value was carried out according to AOAC (2005). Accurately 2 g of oil sample were introduced into a 200 ml conical flask. Then 25 ml of 0.5 N alcoholic KOH solutions was added, and the contents of the flask were boiled under reflux for 1h with frequent rotation. One ml of phenolphthalein indicator was added, while the solution was still hot, and the excess alkali was titrated with 0.5N HCl. The ml of HCl required (a) was noted. A blank was determined at the same time and condition and the required volume of the acid (b) was also recorded.

Calculation

\[
\text{Saponification value} = \frac{(b - a) \times 28.05}{S}
\]

Where:

- a: ml of HCL for sample.
- b: ml of HCL for blank.
- S: Weight of oil (g).
CHAPTER FOUR
RESULTS AND DISCUSSION

4-1 Physical properties of fresh oils:

Table (1) shows the physical properties of the fresh vegetable oils of peanut, sesame and sunflower as follows:

4-1-1 Colour

colour of peanut oil was determined using lovibond tinotometer units has 25, 4.5 and 2.2 for yellow, Red and Blue, respectively.

Which is higher than that reported by Fengxia et al., (2001) peanut oil colour of the first grade for cooking should not exceed 2 red unit lovibond with fixed lovibond yellow units of 20, and for salad use, it should be no more than 1.5 red units with fixed yellow units of 15.

The yellow colour of peanut oil is similar to the maximum limit that was reported by Cobbe and Johnson (1973) yellow 16 - 25, but the red colour 4.5 units was high than his red 2 units.

colour of sesame oil was consists of 25 yellow units, 6.1 red units and 4.8 blue units. Which is different from that reported by Andraos et al., (1950) that the blue 0.0 tintometer yellow 35 tintometer and 4.3 red tintometer.

The colour of sunflower oil consists of 7.9 yellow units, 1 red unit, this result was higher than that reported by Robertson and Russell (1972). The colour of sunflower oil from Alabama and Minnesota as 1.0 yellow units and 0.1 red units, 2.0 yellow units and 3.0 red units, respectively and also higher than that of Bashir (1986) who found the lovibond values ranging between 4.0 and 5.0 for yellow units, 0.55 and 0.70 for red units, and 0.2 for blue units for sunflower seed oil from Alabama and Minnesota, respectively. Also he stated that, the colour of three sunflower oil cultivars grown in Sudan ranged between 4.7 – 4.4 yellow unit, 0.16 – 0.58 red unit and 0.2 blue unit. (in the study result blue is 0 it is small than that reported).
4-1-2 Density:

Table (1) shows density of the oils peanut, sesame and sunflower. Density of peanut oil is 0.91 within the value reported by Wiess (1983) the density of peanut oil at 25°C was 0.910 - 0.915. In Codex Alimentarius (1993) the density of peanut oil vary from 0.914 to 0.917 at 20°C. Density of sesame oil is 0.913 less than that reported by Salwa, (2009). The density of sesame oil at temperature of 20°C/water 20°C is 0.915 - 0.923 and in the range that Bailey (1996) reported at 30°C is 0.915 – 0.924. Density of sunflower oil is 9.14 it is in the range that reported by Codex Alimentarius (1993) which vary from 0.914 to 0.917 at 20°C, and reported by Bashir (1986) which is 0.9082 to 0.9169.

4-1-3 Refractive index (RI):

Table (1) shows the refractive index of oils peanut, sesame and sunflower. Refractive index of peanut oil is 1.471 which was higher than the value found by Nkafamiya et al. (2010) ranging from 1.4658 to 1.4690 were recently reported for refined oil extracted from five different peanut species and also it is highest than the Sudanese Standards (SSMO, 2009). That proposed the range of refractive index from 1.460 – 1.465, the same value was reported by Mansour (2007). Also it is higher than the value of 1.449 which was reported by Atasie et al. (2009) for the natural peanut oil and also than that reported by Jacob and Krishnamurthy (1990) who reported the Refractive Index of peanut oil at 40°C ranging between 1.4620 and 1.46. However, it is in the range that reported by salunkhe et al., (1992) as 1.4697 – 1.4790. The refractive index of sesame oil is 1.474 it is in the range that reported by Lyon (1972) which is 1.171 – 1.474 at 40°C and it is higher than the value reported by Pearson (1981) which was 1.465 – 1.469 at 40°C. Sauzacletus and Reamaiah (1978) indicated that the RI of sesame oil at 25°C was 1.469. Refractive index of sunflower oil was 1.475 which is similar to that reported by Jar Elnabi (2001) (1.4700), by Merrien (1998) (1.474) at 20°C and higher than the range of Codex Alimentarius (1999) (1.461 – 1.468) at 40°C. Also within the range reported by Parvathi and Geervanti (1976). Who reported 1.4670 - 1.4690 and that reported by Richard (1986) at 25°C as
1.4742 and also Bashir (1986) who found that RI of three fresh Sunflower oil grown in Sudan are 1.4706, 1.4723, 1.4720 which are less than the sample of study.

**4-1-4 Viscosity:**

Table (1)- shows the viscosity of peanut, sesame and sunflower oil.

Viscosity of peanut oil is 25.99 centipoise. This value is lower than that reported by Balla (2001) who found that the viscosity of three peanut cultivars ranges between 46.0 and 52.43 cp at 30 °C and by Koman and Kotuc (1976) which ranges between 71.07 to 88.15 cp and within the range of Prasad and Dutt (1989) who reported 16.22 – 76.67 cp.

Viscosity of sesame oil is 21.78 it is in the range that reported by Sabah El Khier et al (2008) which ranged between 18.94 to 26.40 cp and Murwan (1994), who reported a range 18.90 – 26.43 centipoises at 40 °C.

the viscosity of sunflower oil is 22.95 cp it is within the range that who Jar Elnabi (2001) reported for both refined and crude sunflower oil as(21.4 and 24.3 cp, respectively). The result was lower than those obtained by Bashir (1986) and Mohammed (1998) who reported 50 cps at 25°C and 31 cps at 30°C, respectively.
Table 1: Physical properties of some Sudanese vegetable oils

<table>
<thead>
<tr>
<th>Type of oil</th>
<th>Colour ((tintometer))</th>
<th>Density</th>
<th>Refractive index</th>
<th>Viscosity((Cps))</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yellow</td>
<td>red</td>
<td>Blue</td>
<td></td>
</tr>
<tr>
<td>Peanut</td>
<td>25</td>
<td>4.5</td>
<td>2.2</td>
<td>0.910</td>
</tr>
<tr>
<td>Sesame</td>
<td>25</td>
<td>6.1</td>
<td>4.8</td>
<td>0.913</td>
</tr>
<tr>
<td>Sun flower</td>
<td>7.9</td>
<td>1</td>
<td>0.0</td>
<td>0.914</td>
</tr>
</tbody>
</table>
4-2 Chemical composition of fresh oils:

4-2-1 Fatty acids composition:

Table (2) shows fatty acids composition of peanut, sesame and sunflower oil.

Fatty acids composition of peanut oil which was is in the range of Shitole (1987) who found 17% - 22% saturated fatty acids and 83%-78% unsaturated fatty acids. Koman and Koutuc (1976) reported about 96% of peanut oil is triglycerides composed of palmitic, stearic, oleic and linoleic acids.

And also show that fatty acids of sesame oil within the range that reported by Lyon (1972) which was about 80% unsaturated fatty acids (oleic and linoleic). The saturated fatty acids account for less than 20% but was different from that reported by Smith (1971) who reported 44% and 42% linoleic and oleic acid respectively and 13% saturated fatty acids. The result agreed with that of Rao and Rao (1981) who reported arachidic and linolenic acid are present in very small quantities.

the fatty acids composition of sunflower oil was 82.03% unsaturated and 17.97% saturated fatty acid which is lower than that reported by Earile et al (1968) who found linoleic acid of sunflower oil is 60 - 70%.
Chemical composition:

Table 2: Fatty acids composition of some vegetable oils

<table>
<thead>
<tr>
<th>Fatty acids %</th>
<th>Peanut</th>
<th>Sesame</th>
<th>Sunflower</th>
</tr>
</thead>
<tbody>
<tr>
<td>Myristic (14:0)</td>
<td>00</td>
<td>0.61</td>
<td>00</td>
</tr>
<tr>
<td>Palmitic (16:0)</td>
<td>15.37</td>
<td>12.85</td>
<td>11.59</td>
</tr>
<tr>
<td>Palmitoleic (16:1)</td>
<td>00</td>
<td>0.2</td>
<td>00</td>
</tr>
<tr>
<td>Stearic (18:0)</td>
<td>1.01</td>
<td>00</td>
<td>00</td>
</tr>
<tr>
<td>Oleic (18:1)</td>
<td>42.82</td>
<td>44.08</td>
<td>41.85</td>
</tr>
<tr>
<td>Linoleic (18:2)</td>
<td>35.2</td>
<td>37.72</td>
<td>40.18</td>
</tr>
<tr>
<td>Linolenic (18:3)</td>
<td>1.84</td>
<td>0.92</td>
<td>6.38</td>
</tr>
<tr>
<td>Arachidic (20:0)</td>
<td>4.23</td>
<td>2.89</td>
<td>00</td>
</tr>
<tr>
<td>Behenic (22:0)</td>
<td>00</td>
<td>0.75</td>
<td>00</td>
</tr>
<tr>
<td>Lignocenic (24:0)</td>
<td>0.53</td>
<td>00</td>
<td>00</td>
</tr>
</tbody>
</table>
4-2-2 Free fatty acids:

Table (3) shows that the free fatty acids of peanut, sesame and sunflower oil. The free fatty acids of peanut is 0.809 which within the limit recorded by Nkafamiya et al. (2010), which is ranging between 0.25 to 0.98 %. The free fatty acids of peanut oil is lower than that pointed out by Codex Alimentarius (1993) (2%) for crude oil. However, Jacob (1990) reported that it should be less than 3%.

The free fatty acids of sesame oil is 1.045 which is lower than that reported by Pearson (1981) who reported a value of about 2% but within the range reported by Seegeler (1983) and Weiss (1983) who found a value 1.0% to 3.0% as oleic acid.

The free fatty acids of sunflower oil is 1.020% more than that reported by Jar Elnabi (2001) (0.5%) Mohammed (1998) for Sudanese refine sunflower oil was 0.3%.

4-2-3 Iodine value:

Table (3) shows that the Iodine value of peanut, sesame sunflower oil.

The iodine value of peanut oil is 94 mg/iodine/1g of oil less than that found by Ali (2002) who reported a value of 97.5 mg/iodine/1g of fat. But was in the range that Jacob and Krishnanurthy (1990) and Norden et al (1987) found (85 - 95 and 74 - 107), respectively the iodine value of Peanut oil under study is within the limits of codex Alimentarius 80 - 106 mg/iodine/1g of fat.

Iodine value of sesame oil is 115 within the range reported by Seegeler (1983) and Weiss (1983) (103 - 130 and 102 - 116, respectively), but approximately equal to that recorded by Sauzacletus and Ramaiah (1973) who reported a value of 116 mg/iodine/1g of fat.

Iodine value of sunflower oil is 136 mg/iodine/1g of fat it is in the range that reported by Scincalepoe (1975) and Ropertson (1972) and Pearson (1988) (130 - 138, 121 - 139 and 100 - 143 respectively), it is higher than that reported by Jar Elnabi (2001) who reported a value of 126.9 mg/iodine/1g of fat.
<table>
<thead>
<tr>
<th>Type of oil</th>
<th>Free fatty acid( %)</th>
<th>Iodine value</th>
<th>Peroxide value (m.eq/kg)</th>
<th>Saponification Value mg koH/g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peanut</td>
<td>0.809</td>
<td>94</td>
<td>5.75</td>
<td>193.20</td>
</tr>
<tr>
<td>Sesame</td>
<td>1.045</td>
<td>115</td>
<td>5.2</td>
<td>195</td>
</tr>
<tr>
<td>Sunflower</td>
<td>1.020</td>
<td>136</td>
<td>4.443</td>
<td>188.2</td>
</tr>
</tbody>
</table>
4-2-4 Peroxide Value:

Table (3) shows the peroxide value of peanut, sesame and sunflower oil. Peroxide value of peanut oil is 5.75 m eq/kg, within the range of Özcan (2003a) and (2003b). Atasie (2009) reported 1.5 to 6.7 meqO₂/kg, but lower than Nkafamiya et al. (2010) who reported PV 22.06 - 25.30 Meq O₂/Kg and higher than Balla (2001) who reported 0.7 to 1.2 milli equiv O₂/kg of oil.

Peroxide value of sesame oil is 5.2 Meq/kg oil, a value lower than that reported by Institute Centromericano de Investigation (1974) of 6.0 mg/kg oil.

Peroxide value of sunflower oil is 4.443 Meq/kg within that reported by Morrison (1981) who reported a value of 2.92 - 8.54mg Meq/kg depending on variety and it is higher than that reported by Robertson and Russell (1972) (0.21 – 0.41 meq/kg) and agrees with Jar Ehnabi (2001) who reported 4.4 mEq/kg.

4-2-5 Saponification Value:

Table (3) shows that the result of saponification value of peanut, sesame and sunflower oil. Saponification value of peanut oil was 193.20 mg KOH/g oil and within the range of Codex Alimentarius (1993) found (187 to 196 mg KOH/g oil) and around that found by Sreenivsan (1968) (194.1 mg KOH/g oil).

Saponification value of sesame oil is 195 mg KOH/g oil, higher than that found by Sawsan (2001) (194.1 mg/1g), but in the range reported by Seegeler (1983), Pearson (1980) and Lyon (1972) 186 – 199,187 to 195 and 187 – 193 mg KOH/g oil, respectively.

Saponification value of sunflower oil is 188.2 mg KOH/g oil, it was within the range of the Codex Alimentraius (1993) (187 – 196). Also, the result is within the range found by Pearson (1988) and Jar Ehnabi (2001) (188 to 194 and 187.9 – 189.6 mg KOH/g oil), respectively.
4-3 Characteristics of oils after storage:

4-3-1 Physical characteristics:
4-3-1-1 Density

The result reported in table (4) shows the effect of storage on densities of peanut, sesame and sunflower oils. It indicates that after storage of six-months the oils densities increased and highest increase was in the sunflower oil followed by peanut oil and the sesame oil.

4-3-1-2 Refractive index

It was found that no change in refractive index of these oil has occurred after six- months of storage.

4-3-1-3 Viscosity

The result reported in table(4) shows that the viscosity of the three oils increased after storage period of 6-months and an increase in viscosity of 5.26 cps, 2.43cps and 1.99cps occured in sesame oil, sunflower oil and peanut oil, respectively.
Table 4: The effect of storage on physical characteristics of some vegetable oils

<table>
<thead>
<tr>
<th>Type of oil</th>
<th>Density</th>
<th>Refractive index</th>
<th>Viscosity (cps)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before</td>
<td>After</td>
<td>Before</td>
</tr>
<tr>
<td>Peanut</td>
<td>0.910</td>
<td>0.913</td>
<td>1.471</td>
</tr>
<tr>
<td>Sesame</td>
<td>0.913</td>
<td>0.916</td>
<td>1.474</td>
</tr>
<tr>
<td>Sunflower</td>
<td>0.914</td>
<td>0.919</td>
<td>1.475</td>
</tr>
</tbody>
</table>
4-3-2- Chemical characteristics

4-3-2-1 Free fatty acids

Table (5) shows that the free fatty acids% of three oils increased after six month of storage. The free fatty acids of the sunflower oil highly increased during storage followed by sesame oil and lastly the peanut oil.

4-3-2-2 Peroxide Value

Table (5) and figure (6) show the effect of storage on peroxide value of the three oils after six month of storage. The peroxide value of sunflower oil highly increased by 9.63meqO\textsubscript{2}/kg of fat followed by peanut oil 1.07 meqO\textsubscript{2}/kg of fat and lastly the same oil by 0.96 meqO\textsubscript{2}/kg of fat.
Table 5: The effect of storage on free fatty acids and peroxide value of some vegetable oils after six month of storage.

<table>
<thead>
<tr>
<th>Type of oil</th>
<th>Free fatty acids %</th>
<th>Peroxide meqO₂/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before storage</td>
<td>After storage</td>
</tr>
<tr>
<td>Peanut</td>
<td>0.809</td>
<td>0.98</td>
</tr>
<tr>
<td>Sesame</td>
<td>1.045</td>
<td>1.41</td>
</tr>
<tr>
<td>Sunflower</td>
<td>1.020</td>
<td>2.82</td>
</tr>
</tbody>
</table>

4-4 Sensory evaluation:
Figure (1) show the colour of some oils before and after storage the result show there is No clear difference in colour of oils before and after storage.

Figure (2) show the taste of some oils before and after storage the result show

There is clear difference, of taste of Sunflower oils and No clear difference in taste of peanut oil and sesame oil.

Figure (3) show the odour of some oils before and after storage the result show there is difference, in oduor of oils
Figure (1) Sensory evaluation of the colour of oils used before and after storage

Scores

Samples

Sunflower oil  Peanut oil  Sesame oil

Before  After
Figure (2) Sensory evaluation of the taste of oils before and after storage:

- Sunflower oil
- Peanut oil
- Sesame oil

Scores

Samples

Before  After
Figure (3) Sensory evaluation of the odour of oils before and after storage:

- Sunflower oil
- Peanut oil
- Sesame oil
CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5-1 Conclusions:

From the results obtained in this study, it could be concluded that:

- The storage of oils at room temperature for six months resulted in an increase in density, viscosity, free fatty acids and peroxide value of these oils. This can be used to determine the shelf life of these vegetable oils.

- Sensory evaluation and chemical characteristics are match.

5-2 Recommendation:

- According to the change that occurred during the storage it can be recommended that, before storage conditions should be performed so that the quality of the oil can be maintained for vegetable period of storage i.e. one year can be achieved by storing the oil in a cool place and away from sunlight special condition should be given to these oil should be moisture free as for possible before storage.

- The crude peanut and sesame oils are stable after storage but the refined sunflower oil was more affected by storage this study recommended to regard the storage of sunflower oil special condition showed be given to sunflower oil e.g. storage the oil in a cool place and away from the sunlight due to its high degree of unsaturation fatty acids.
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(1) Fatty Acids composition of Peanut, Sesame and Sunflower oils (%)
(2) **Iodine number and saponification number of some oil**

![Graph showing iodine number and saponification number for different oils](image)
(3) Density of peanut, sesame and sunflower oils before and after storage.
(4) Viscosity of peanuts, sesame and sunflower oils before and after storage
(5) Free fatty acids in peanut, sesame and sunflower oils before and after storage.
(6) Peroxide value of peanut, sesame and sunflower oils before and after storage