Studying some Physical Properties of some Edible Oils and
Identifying their Metallic Contaminates Through XRF

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Date: January /2017
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Date:     /1/2017
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قال تعالى: ﴿وَلَسَوْفَ يُعْطِيكَ رَبُّكَ رَبِّكَ فَتَرْضَى﴾

صدق الله العظيم

آية (45) سورة الضحى
Dedication

I would like to dedicate this work to

My mother, my brothers
my sister my husband and Children.

To my relatives.

To everyone taught me a letter and

My friends and colleagues
Acknowledgements

Sincere thanks to Allah who gave me the health and strength to complete this work.

Thanks University of Gezira and also for all professors of the Department of Electronic Engineering Faculty of Engineering and Technology.

Thank to Dr. Elfadel Mahmoud Yousif Abdelrahim, my Supervisor and for his unlimited help, he was patient on my questions and support me be the knowledge, he guide me to solve many problems faced me in this work.

Thanks go to Co-Supervisor Dr. Hasab alrasoul Gesmalh Ismail

I would like to thank my family members who supported and helped me to do this work, my friends, and all the teachers’ they taught us all these years.
Studying some physical characteristics of some edible oils and identifying their metallic contaminates by XRF

Tagwa Hassan Abd Allah Awed Kareem

Abstract

Care of human health is one of the most important world’s research areas. Nutrition has the primary care, so food was continuously checked and monitored to discover its nutritional elements and characteristics in order to decide whether the elements are sufficient or insufficient for human body. Consequently, the organizations and institutions have been established to monitor and regulate the food standards. Among the continuously consumed food is oil which is almost used every day. This study aimed to test some physical characteristics of edible oils such as (density, refractive index and viscosity), in addition to measuring the metallic contaminates by using fluorinated X-ray by (X-met 5000) device. Three samples have been selected; sesame oil, peanut oil and mixed oil to identify whether they correspond with the specifications of the Sudanese Standards and Metrology organization (SSMO), and to measure the metallic contaminates concentrations . The results show that the refractive index of sesame oil is (1.4645) which is less compared to the refractive index at the (SSMO), while the density is (0.916 g/ml) which corresponds with the (SSMO) . As for sesame oil’s viscosity, it is (85 mpAs). The refractive index of peanut oil is (1.4777) which is higher than the (SSMO), (0.912, 0.920 g/ml) and the viscosity is (85 mPAs). The refractive index of the mixed oil is (1.4812) which is higher than the (SSMO) (1.4710, 1.4585) and the density is (0.973 g/ml) which is also higher than the (SSMO) (0.925, 0.914) and the viscosity is (55 mPAs). The results of concentrations of metallic contaminates measured by (X-met 5000) are as follows: Sesame oil (Fe 0.05%, Pb 0.00, Ni 0.01%, Cr 0.03%), Peanut oil (Cr 0.03%, Fe 0.05% , Pb 0.01%, Ni 0.00) and Mixed oil ( Ni 0.01%, Pb 0.01%, Fe 0.05%, Cr 0.03%). This study recommends using XRF on other oils to check their metallic contaminates.
دراسة بعض الخصائص الفيزيائية للزيوت وتحديد العناصر الفلزية الموجودة فيها

XRF

تقوى حسن عبد الله عوض الكريم

مستخلص الدراسة

إن الاهتمام بصحة الإنسان من أهم المباحث العالمية واللياقة الأولوية في الاهتمام فهو يأتي في الصدارة ولذلك تتم مراقبة الأغذية والكشف عليها باستمرار فيكشف عن الخصائص والعناصر المكونة للغذاء المحدد لدرجة طبيعة المادة وما إذا كانت عناصرها كافية لحفرة الإنسان وهي أقل من المطلوب ولذلك أنشأت منظمات وهيئات لضبط مواصفات الأغذية ومراقبتها. ومن الأغذية التي يتناولها الإنسان باستمرار الزيوت فهي تكاد تتعامل بصورة يومية. هدفت هذه الدراسة لفحص بعض الخصائص الفيزيائية للزيوت (الكثافة - معامل الانكسار – اللزوجة) وقياس العناصر الموجودة باستخدام الأشعة السينية المفلورة (جهاز X- met5000) ثم اختيار ثلاث عينات من الزيوت (زيت السمسم وزيت الفول وزيت مخلوط) لمعرفة مطابقة خصائصها للمواصفات والمعايير السودانية وقياس نسب العناصر الفلزية. أوضحت النتائج أن معامل الانكسار لزيت السمسم 1.4645 وهو أقل من قيمته في هيئة المواصفات والمقاييس (1.469, 1.465) والكثافة (0.916g/ml) وهي مطابقة للمواصفات (0.924, 0.915) والالزوجة هي (85 mpAs) ومعامل الانكسار لزيت الفول السوداني 1.4777 وهو أعلى من قيمته في المواصفات والمقاييس (1.465, 1.460) والكثافة هي (0.945g/ml) وهي أعلى من قيمتها في المواصفات والمقاييس 85 mpAs (الالزوجة 0.920, 0.912g/ml) بينما الزيت المخلوط فعامل الانكسار له 1.4812 وهو أعلى من قيمته في المواصفات وهي 1.4710 و 1.4585 والكثافة (0.973g/ml) وهي أعلى من قيمتها في المواصفات وهي 0.915 و 0.924, 0.915 والالزوجة 55 mpAs55. أما بالنسبة لتركيز العناصر الفلزية المقاس بواسطة x - met5000 فجاءت النتائج كالتالي:

- زيت السمسم (Cr 0.05%, Pb 0.00, Ni 0.01%, Cr 0.03%), Fe 0.04%, Pb 0.00, Ni 0.01%
- زيت الفول السوداني (Ni 0.01%, Pb 0.03%, Fe 0.05%, Pb 0.01%, Ni 0.00)
- الزيت المخلوط (Fe 0.01%, Cr 0.03%, Fe 0.05%, Pb 0.01%, Ni 0.00)

أوصت هذه الدراسة باستخدام جهاز الأشعة السينية المفلورة على المزيد من الزيوت لفحص العناصر الفلزية الموجودة فيها.
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CHAPTER ONE

INTRODUCTION

1.1 Overview

Fats and oils are recognized as essential nutrients in both human and animal diets. Nutritionally, they are concentrated sources of energy (9 cal/gram); provide essential fatty acids which are the building blocks for the hormones needed to regulate bodily systems; and are a carrier for the oil soluble vitamins A, D, E, and K. They also enhance the foods we eat by providing texture and mouth feel, imparting flavor, and contributing to the feeling of satiety after eating. Fats and oils are also important functionally in the preparation of many food products. They act as tenderizing agents, facilitate aeration, carry flavors and colors, and provide a heating medium for food preparation. Fats and oils are present naturally in many foods, such as meats, dairy products, poultry, fish, and nuts, and in prepared foods, such as baked goods, margarines, and dressings and sauces. To understand the nutritional and functional importance of fats and oils, it is necessary to understand their chemical composition (Brian, 2004).

The concentration of heavy metals in vegetable oils is an important criterion for the assessment of oil qualities with regard to freshness, keeping properties, storage and their influence on human nutrition and health. Trace heavy metals in vegetable oils are known to have an effect on the rate of oil oxidation. (Leila and other 2014).
1.2 Problem Statement

Some Elements are needed to be added in different concentration in our daily food such as oil, but it will be dangerous for human health if it added more than the recommended concentration.

1.3 Objectives

The objects of this study are:

1. Study the metallic in three samples of edible oil.
2. Study some physical properties of the samples
3. Compare the results with the results in Sudanese Standards and Metrology Organization (SSMO)

1.4 Methodology:

In this study XRF used to measuring the concentration of different metallic elements in edible oil such as iron (Fe) lead (Pb) nickel (Ni) chrom (Cr), the experiment examined three samples of food oil and also calculates the physical properties for these oils samples using an laboratory apparatus,

1.5 These outline

This study organized into five chapters, the first Chapter is an introduction chapter two provides the previous study of XRF oil and literature review chapters three present the methodology of study. Chapter four provide the results and discussion. Chapter five conclusion and future works.
CHAPTER TWO

BACKGROUND AND PREVIOUS STUDIES

2.1 Background

Vegetable oils are very important in human nutrition. They act as a some of energy and provide essential nutrients such as essential fatty acids and fat soluble vitamins to our bodies.

This chapter will deals with the reviewed literature and other writing on sesame Sesame, Peanut, Peanut oil X Rays and XRF

2.1.1 Sesame

Sesame (Sesamum indicum) is a flowering plant in the genus Sesamum, also called benneNumerous wild relatives occur in Africa and a smaller number in India. It is widely naturalized in tropical regions around the world and is cultivated for its edible seeds, which grow in pods or "buns". The world harvested 4.2 million metric tons of sesame seeds in 2013, with India and China as the largest producers.

Sesame seed is one of the oldest oilseed crops known, domesticated well over 3000 years ago. Sesame has many species, most being wild and native to sub-Saharan Africa. Sesame indicum, the cultivated type, originated in India and is tolerant to drought-like conditions, growing where other crops fail. Sesame has one of the highest oil contents of any seed. With a rich, nutty flavor, it is a common ingredient in cuisines across the world. Like other nuts and foods, it can trigger allergic reactions in some people. Sesame in Nepal Sometimes
sold with its seed coat removed (decorticated), this variety is often present on top of baked goods in many countries. (D. Langham et al, 2008).

2.1.2 Peanut

Peanut, also known as groundnut and goober (Arachis hypogaea) is a legume crop grown mainly for its edible seeds. It is widely grown in the tropics and subtropics, being important to both smallholder and large commercial producers. It is classified as both a grain legume and, because of its high oil content, an oil crop. World annual production of shelled peanuts was 42 million tons in 2014. Atypically among crop plants, peanut pods develop under the ground. It is this characteristic that the botanist Linnaeus used to assign the specific name hypogaea, which means "under the earth". Peanuts As a legume, peanut belongs to the botanical family Fabaceae (also known as Leguminosae, and commonly known as the bean or pea family). Like most other legumes, peanuts harbor symbiotic nitrogen-fixing bacteria in root nodules. This capacity to fix nitrogen means peanuts require less nitrogen-containing fertilizer and improve soil fertility, making them valuable in crop rotations. Peanuts are similar in taste and nutritional profile to tree nuts such as walnuts and almonds, and are often served in similar ways in Western cuisines. The botanical definition of a "nut" is a fruit whose ovary wall becomes very hard at maturity. Using this criterion, the peanut is not a nut, but rather a legume. However, for culinary purposes and in common English language usage, peanuts are usually referred to as nuts. The Plant List: A Working List of All Plant Species". (Wikipedia. 2016)
2.1.3 Peanut oil

Peanut oil is one of the healthiest oils. It is a vegetable oil that is naturally Tran's fat-free, cholesterol free, and low in saturated fats. Peanut oil is high in unsaturated fats, especially monounsaturated fat, like the one found in olive oil. It is also a source of the antioxidant vitamin E and phytosterols, which benefit heart health. © (The Peanut Institute, 2013)

2.2 Electromagnetic Radiation, Quanta

From a physical point of view, X-rays are of the same nature as visible light. Visible light can be described as electromagnetic wave radiation whose variety of colors (e.g. the colors of the rainbow) we interpret as different wavelengths. The wavelengths of electromagnetic radiation reach from the kilometer range of radio waves up to the picometer range (10-12 m) of hard gamma radiation (Table 1).

Table (2.1): Energy and wavelength ranges of electromagnetic radiation

<table>
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<th>Energy range (keV)</th>
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<td>&lt; 10-7</td>
<td>cm to km</td>
<td>Radio waves (short, medium, long waves)</td>
</tr>
<tr>
<td>&lt; 10-3</td>
<td>μm to cm</td>
<td>Microwaves</td>
</tr>
<tr>
<td>&lt; 10-3</td>
<td>μm to mm</td>
<td>Infra-red</td>
</tr>
<tr>
<td>0.0017 – 0.0033</td>
<td>380 to 750 nm</td>
<td>Visible light</td>
</tr>
<tr>
<td>0.0033 – 0.1</td>
<td>10 to 380 nm</td>
<td>Ultra-violet</td>
</tr>
<tr>
<td>0.11 – 100</td>
<td>0.01 to 12 nm</td>
<td>X-rays</td>
</tr>
<tr>
<td>10 – 5000</td>
<td>0.0002 to 0.12 nm</td>
<td>Gamma radiation</td>
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</table>
In the following text, the unit nanometer (\(\text{nm} = 10^{-9} \text{ m}\)) is used for the wavelength, \(\lambda \) (=\(\text{Lambda}\)), and the unit kilo electron volts (keV) for energy, \(E\).

### 2.2.1 Characteristic Radiations

Every element is clearly defined by its atomic number \(Z\) in the periodic table of elements or by the number of its electrons in a neutral state. The binding energies or the energy levels in every element are different and characteristic for every element as a result of the varying number of electrons (negative charges) or the number \(Z\) of the positive charges in the atomic nucleus (= atomic number). If an electron of an inner shell is now separated from the atom by the irradiation of energy, an electron from a higher shell falls into this resultant “hole” which releases an amount of energy equivalent to the difference between the energy levels involved. The energy being released can be either emitted in the form of an X-ray or transferred to another atomic shell electron (Auger effect). The probability of an X-ray resulting from this process is called the fluorescence yield \(w\). This depends on the element’s atomic number and the shell in which the “hole” occurred. \(w\) is very low for light elements (approx. 10^{-4} for boron) and almost reaches a value of 1 for the K-shell of heavier elements (e.g. uranium). However, since the energy or wavelength of the X ray is very characteristic for the element from which it is emitted; such radiation is called characteristic X-rays. This provides the basis for determining chemical elements with the aid of X-ray fluorescence analysis. (BRUKER .2006)
2.2.2 X Rays

Wilhelm K. Roentgen, who in 1901 was the first man to receive the Nobel Prize in physics, first observed x rays in 1895. He was studying the light produced when electricity was passed through a gas in a tube at low pressure. He noted that a paper screen coated with a fluorescent material glowed when it was in the vicinity of the tube under operation. We now know that x rays are produced if electrons are accelerated through a potential of the order of 104 or more volts and then allowed to strike a metal target. Classical electromagnetic theory indicates that the deceleration of an electric charge causes it to radiate energy. In this case the form of electromagnetic radiation is called x rays. Early observations showed that this newly detected radiation had greater penetration power than any other electromagnetic radiation known at that time. It was also observed that these x rays affected a photographic film and would ionize atoms. These effects are utilized in detecting devices for x rays. Since x rays are electromagnetic waves, they are not deflected by either an electric or a magnetic field. The usual way of producing x rays involves the use of the thermionic x-ray tube as

![Fig. (2.1) x-ray tube](image-url)
Diagram of an x-ray tube is heated filament emits electrons. Which are accelerated through a potential of more than 10000 V. The electrons strike the anode and cause it to emit energy as x-ray photons. The anode serves as transducer changing the kinetic energy of the electron into heat energy and electromagnetic radiation energy in the x-ray region of the spectrum (Jan Kybic 2014).

2.2.3 X-ray Advantages / disadvantages

- Advantages
- Widely used and available
- Experts available
- High-spatial resolution
- Excellent imaging of hard tissues (bones)
- Disadvantages
- Radiation exposure
- Difficulty in imaging soft-tissues
- 2D projection, hidden parts (Jan Kybic 2014)

2.3 Generating the Characteristic Radiation

The purpose of X-ray fluorescence is to determine chemical elements both qualitatively and quantitatively by measuring their characteristic radiation. To do this, the chemical elements in a sample must be caused emit X-rays. As characteristic X-rays only arise in the transition of atomic shell electrons to lower, vacant energy levels of the atom, a method must be applied that is suitable for releasing electrons from the innermost shell of an atom. This involves adding to the inner electrons amounts of energy that are higher than the energy bonding them to the atom. This can be done in a number ways:
• Irradiation using elementary particles of sufficient energy (electrons, protons, a-particles, etc.) that transfer the energy necessary for release to the atomic shell electrons during collision processes
• Irradiation using X- or gamma rays from radionuclide's
• Irradiation using X-rays from an X-ray tube Using an X-ray tube here proves to be the technically most straightforward and, from the point of view of radiation protection, the safest solution (an X-ray tube can be switched off, a radionuclide cannot).( BRUKER .2006)

2.3.1 XRF

X-Ray Fluorescence is defined as “The emission of characteristic "secondary" (or fluorescent) X-rays from a material that has been excited by bombarding with high-energy X-rays or gamma rays. The phenomenon is widely used for elemental analysis.”

When high energy photons (x-rays or gamma-rays) are absorbed by atoms, inner shell electrons are ejected from the atom, becoming “photoelectrons”. This leaves the atom in an excited state, with a vacancy in the inner shell. Outer shell electrons then fall into the vacancy, emitting photons with energy equal to the energy difference between the two states. Since each element has a unique set of energy levels, each element emits a pattern of X-rays characteristic of the element, termed “characteristic X-rays”. The intensity of the X-rays increases with the concentration of the corresponding element. The same underlying physics produces the optical emission spectra which are often observed in high school or college labs and used in quantitative analysis. Some typical optical spectra are shown below. The inner shells of
heavier elements involve higher binding energies so produce photons in the X-ray wavelength range.

2.3.2 XRF advantages:

- Non-destructive: The X-radiation has absolutely no lasting influence on the material; it fully retains its quality.
- Fast: The XRF method needs very simple sample preparation and short measurement times range in the seconds, rarely longer than one minute.
- Clean: No chemicals are used.
- Safe: Method without the use of environmentally hazardous chemicals, X-radiation poses no risk for operator due to the protective instrument design.
- Universally applicable: The XRF method is suitable for material analysis and counting thickness measurement in a very broad range of applications.

2.3.3 X-MET5000

This light-weight, hand-held EDXRF analyzer provides rapid, non-destructive, point and shoot screening of plastics, PCBs, cables, plastic housings, solder material, fasteners, sheet metal and other electronic components. When used in combination with the powerful user interface it provides information for quick and reliable Go/No-Go decisions. When testing non-uniform components, the X-MET5000 averaging feature will give additional confidence to screening. A fully configurable user interface allows the user to specify alarm limits and testing criteria. Data measured with the X-MET5000 can be easily transferred to a PC for further inspection and report generation. Rapid
analysis and reporting avoids delays generally associated with laboratory based analysis, allowing quick screening of a large number of samples. The X-MET5000 can be taken to the sample wherever it is located. It can also be used as a quick, on-site, quality control tool to analyze other elements such as Sn, Ag, Cu, Sb, Bi, etc., in solder and Cl, Ca, Sb, Ni, Sr, Zn, As and Ba in plastics and components. It can sort PVC and Br or Sb containing plastics in seconds and helps to support the Waste Electrical and Electronic Equipment (WEEE) recycling. Industries with high reliability exempt applications, like aerospace, medical equipment and military systems, may use the X-MET5000 to ensure the presence of adequate lead in their product components, especially in finishes and solder joints for reasons of product safety and reliability. (Oxford Instruments, 2008). Show fig(2.2).
2.4 Physical Property

A physical property is any property that is measurable, whose value describes a state of a physical system. The changes in the physical properties of a system can be used to describe its transformations or evolutions between its momentary states. Physical properties are often referred to as observables. They are not modal properties. Quantifiable physical property is called physical quantity. Physical properties are often characterized as intensive and extensive properties. An intensive property does not depend on the size or extent of the system, nor on the
amount of matter in the object, while an extensive property shows an additive relationship. These classifications are in general only valid in cases when smaller subdivisions of the sample do not interact in some physical or chemical process when combined.

Properties may also be classified with respect to the directionality of their nature. For example, isotropic properties do not change with the direction of observation, and anisotropic properties do have spatial variance.

It may be difficult to determine whether a given property is a material property or not. Color, for example, can be seen and measured; however, what one perceives as color is really an interpretation of the reflective properties of a surface and the light used to illuminate it. In this sense, many ostensibly physical properties are called supervenient. A supervenient property is one which is actual, but is secondary to some underlying reality. This is similar to the way in which objects are supervenient on atomic structure. A cup might have the physical properties of mass, shape, color, temperature, etc., but these properties are supervenient on the underlying atomic structure, which may in turn be supervenient on an underlying quantum structure. Physical properties are contrasted with chemical properties which determine the way a material behaves in a chemical reaction (Wikipedia. 2016)

2.4.1 The density

The density, or more precisely, the volumetric mass density, of a substance is its mass per unit volume. The symbol most often used for density is \( \rho \) (the lower case Greek letter rho), although the Latin letter \( D \)
can also be used. Mathematically, density is defined as mass divided by volume:

\[ \rho = \frac{m}{v} \]  

(2.1)

Where \( \rho \) is the density, \( m \) is the mass, and \( V \) is the volume. In some cases (for instance, in the United States oil and gas industry), density is loosely defined as its weight per unit volume, although this is scientifically inaccurate – this quantity is more specifically called specific weight. For a pure substance the density has the same numerical value as its mass concentration. Different materials usually have different densities, and density may be relevant to buoyancy, purity and packaging. Osmium and iridium are the densest known elements at standard conditions for temperature and pressure but certain chemical compounds may be denser. To simplify comparisons of density across different systems of units, it is sometimes replaced by the dimensionless quantity "relative density" or "specific gravity", i.e. the ratio of the density of the material to that of a standard material, usually water. Thus a relative density less than one means that the substance floats in water. The density of a material varies with temperature and pressure. This variation is typically small for solids and liquids but much greater for gases. Increasing the pressure on an object decreases the volume of the object and thus increases its density. Increasing the temperature of a substance (with a few exceptions) decreases its density by increasing its volume. In most materials, heating the bottom of a fluid results in convection of the heat from the bottom to the top, due to the decrease in the density of the heated fluid. This causes it to rise relative to more dense unheated material. The reciprocal of the density of a substance is occasionally called its specific volume, a term sometimes used in thermodynamics. Density is an intensive property in that increasing the amount of a
substance does not increase its density; rather it increases its mass (Wikipedia. 2016)

2.4.2 Viscosity

Viscosity is a measure of the resistance of a fluid which is being deformed by either shear stress or tensile stress. In everyday terms (and for fluids only), viscosity is "thickness" or "internal friction". Thus, water is "thin", having a lower viscosity, while honey is "thick", having a higher viscosity. Put simply, the less viscous the fluid is, the greater its ease of movement (fluidity). Viscosity describes a fluid's internal resistance to flow and may be thought of as a measure of fluid friction. For example, high-viscosity felsic magma will create a tall, steep stratovolcano, because it cannot flow far before it cools, while low-viscosity mafic lava will create a wide, shallow-sloped shield volcano. All real fluids (except super fluids) have some resistance to stress and therefore are viscous but a fluid which has no resistance to shear stress is known as an ideal fluid or in viscid fluid. The study of flowing matter is known as rheology which includes viscosity and related concepts (Symon, Keith 1971).

2.4.3 Viscosity measurement

Viscosity is measured with various types of viscometers and rheometers. A rheometer is used for those fluids which cannot be defined by a single value of viscosity and therefore require more parameters to be set and measured than is the case for a viscometer. Close temperature control of the fluid is essential to accurate measurements, particularly in materials like lubricants, whose viscosity can double with a change of only 5 °C. For some fluids, viscosity is a constant over a wide range of shear rates
(Newtonian fluids). The fluids without a constant viscosity (non-Newtonian fluids) cannot be described by a single number. Non-Newtonian fluids exhibit a variety of different correlations between shear stress and shear rate. One of the most common instruments for measuring kinematic viscosity is the glass capillary viscometer. In paint industries, viscosity is commonly measured with a Zahn cup, in which the efflux time is determined and given to customers. The efflux time can also be converted to kinematic viscosities (centistokes, cSt) through the conversion equations. Also used in paint, a Stormer viscometer uses load-based rotation in order to determine viscosity. The viscosity is reported in Krebs units (KU), which are unique to Stormer viscometers. A Ford viscosity cup measures the rate of flow of a liquid. This, under ideal conditions, is proportional to the kinematic viscosity. Vibrating viscometers can also be used to measure viscosity. These models such as the Dynatrol use vibration rather than rotation to measure viscosity. Extensional viscosity can be measured with various rheometers that apply extensional stress. Volume viscosity can be measured with an acoustic rheometer. Apparent viscosity is a calculation derived from tests performed on drilling fluid used in oil or gas well development. These calculations and tests help engineers develop and maintain the properties of the drilling fluid to the specifications required (Frank, 2007).

2.4.4 Refractive Index (Index of Refraction)

Refractive Index (Index of Refraction) is a value calculated from the ratio of the speed of light in a vacuum to that in a second medium of greater density. The refractive index variable is most commonly symbolized by the letter n or n' in descriptive text and mathematical equations.
a wave front incident upon a plane surface separating two media is
refracted upon entering the second medium if the incident wave is
oblique to the surface. The incident angle ($\theta(1)$) is related to the
refraction angle ($\theta(2)$) by the simple relationship known as Snell’s law:

$$n_1 \times \sin(\theta_1) = n_2 \times \sin(\theta_2) \quad (2.2)$$

Where $n$ represents the refractive indices of material 1 and material 2
and $\theta$ are the angles of light traveling through these materials with
respect to the normal. There are several important points that can be
drawn from this equation. When $n(1)$ is greater than $n(2)$, the angle of
refraction is always larger than the angle of incidence. Alternatively
when $n(2)$ is greater than $n(1)$ the angle of refraction is always smaller
than the angle of incidence. When the two refractive indices are equal
($n(1) = n(2)$), then the light is passed through without refraction.

In optical microscopy, refractive index is an important variable in
calculating numerical aperture, which is a measure of the light-gathering
and resolving power of an objective. In most instances, the imaging
medium for microscopy is air, but high-magnification objectives often
employ oil or a similar liquid between the objective front lens and the
specimen to improve resolution. The numerical aperture equation is
given by:

$$\text{NA (numerical aperture)} = n \times \sin(\theta) \quad (2.3)$$

Where $n$ is the refractive index of the imaging medium and $\theta$ is the
angular aperture of the objective. It is obvious from the equation that
increasing the refractive index by replacing the imaging medium from
air (refractive index = 1.000) with a low-dispersion oil (refractive index
= 1.515) dramatically increases the numerical aperture.
2.5 previous studies

2.5.1 Used X-ray fluorescence device (XRF) to see original spare and counterfeit car

In this research we have used X-ray fluorescence device (XRF) to see original spare and counterfeit car and distinguish between the two part as well as knowledge of the Concentration of elements in the samples and then analyze the results for each individual sample through this study it become that the original samples is where the iron Concentration of 90% ration and more counterfeit and less than 90%. As the study showed that exposure time increase the Concentration in the samples until you reach atoms saturation after seven seconds and in that time have all fall the atom have been raised as well as the change in the fall of radiology and distance angle (yet) device of the sample gives reading by the angle and dimension, if the scan falling vertically identical device with sample atoms will all be raised, but the distance is set, the number of excited atom at least as swell focus (Alfadel, Yousf 2015).

2.5.2 Chemical Composition on the Seeds and Oil of Sesame (Sesamum indicum L.) Grown in Congo-Brazzaville

Proximate composition and physicochemical analyses were carried out on the seed and Sesame oil (Sesamum indicum L.). The results showed that the seed contained 5.7% moisture, 20% crude protein, 3.7% ash, 3.2% crude fiber, 54% fat and 13.4% carbohydrate. The seeds were found to be good sources of minerals. Potassium (851.35 ± 3.44 mg/100g) was the highest, followed in descending order by Phosphorus (647.25 ± 3.52 mg/100g), Magnesium (579.53 ± 0.42 mg/100g), Calcium (415.38 ± 3.14 mg/100g) and Sodium (122.50 ± 4.21 mg/100g). The
physical properties of the oil extracts showed the state to be liquid at room temperature. The oil was found to contain high levels of unsaturated fatty acids, especially oleic (up to 38.84%) and linoleum (up to 46.26%). *Sesamum indicum* L. oil can be classified in the oleic-linoleic acid group. The dominant saturated acids were palm tic (up to 8.58%) and stearic (up to 5.44%). The oil extracts exhibited good physicochemical properties and could be useful as edible oils and for industrial applications (Nzikou, 2009).

### 2.5.3 Determination of Metal Contents in Edible Vegetable Oils Produced in Iran Using Microwave-assisted Acid Digestion

In this work, the contents of lead (Pb), cadmium (Cd), nickel (Ni), manganese (Mn), zinc (Zn), copper (Cu), iron (Fe), calcium (Ca) and magnesium (Mg) in four varieties of edible vegetable oils (olive oil, canola oil, sunflower oil and soybean oil) collected from Iran were determined using atomic absorption spectrometry (AAS). The samples were digested in microwave digestion system. The concentration of nickel, manganese, zinc, copper, iron, calcium and magnesium were observed in the range of 0.91–2.17, 0.14–1.76, 3.58–9.54, 0.18–0.68, 7.78–28.93, 21.42–78.52, 5.34–36.49 μg/g, respectively. Lead and cadmium were found to be 4.56–15.82 and 1.87–8.58 μg/kg. We found that the content of the heavy metals in all of the tested oils was lower than the maximum values recommended for FAO/WHO. (Leila and Mohammad, 2014).
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 oil 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 mgK oH/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.(Esraa, 2014)
CHAPTER THREE

MATERIAL AND METHOD

3.1 Introduction

We use three sample of edible oil (sesame oil, peanut oil and a mixture of oil) to study some properties in laboratory.

3.1.1 Viscosity Methodology:

Two marks a and b, a measure distance d apart, are scratched on each of the tube. Mark a should be sufficiently well down the tubes to ensure that the sphere acquires its terminal velocity before passing A. This will be so if the sphere falls through equal successive distance in equal intervals of time before passing A the times of descent between A and B of several of before sphere are taken, the temperature being maintained uniform throughout by constant stirring. The experiment is repeated, using several tubes of different diameters, and a graph is plotted of the mean time of descent against a/R. The internal radii of the tubes are found by calipers, and the mean radius of the sphere is obtained by weighing a known number, and calculating a from the weight obtained, and the density of steel. Alternatively, the mean radius of the spheres can be found using a screw gauge.

3.1.2 Determination of the density of using a loaded test – tube Methodology:

Sufficient lead shot is placed the tube to make it float vertically in the liquid, and the level (x0) at which is float in noted.
Weights are then placed in the tube and in each case the reading \( x \)
The scale \( a \) against the liquid level is noted. A graph is then drawn of depth of immersion

\[
(d) = x * x0 \tag{3.1}
\]

Against additional load the external radius of the tube is found by using calipers taking four readings.

### 3.1.3 Determination of the refractive index of liquid

An ink spot \( p \) is marked on a piece of white paper placed on the bench. A traveling microscope arranged to move vertically is placed on the paper and adjusted so as to bring the point \( p \) in focus the reading of the vernier is taken the glass block is now placed over the mark \( p \) and microscope readjusted to bring \( p \) in focus again (at \( p \)). Again the vernier is read. Finally, an ink spot is made on the top surface of the glass block and reading of the vernier is taken when this mark is in focus in the microscope.

The procedure here is exactly the same as above except that the first reading is taken by focusing on some particles of fine sand on the bottom of the tank, and the third reading by focusing on a little I ycopodium powder on the top of the liquid.

In first I tests were implemented on the three samples using Stocks low to determine the density and Viscosity of the liquids (different type of oil) and the results were observed and assembled in table (1) using the following equation

\[
\eta = \frac{2}{9} \frac{gr^2}{(v[\rho_1 - \rho_2])} \tag{3.2}
\]
Where

\[ g = \text{Gravity} = 98 \text{ cm/s}^2 \]

\[ v = \text{velocity of the metal ball} \]

\[ r = \frac{1}{2}\text{diameter of the metal ball} = 0.0567 \text{ cm} \]

\[ \rho_1 = \text{metals density} = 7.8 \text{ g/cm}^3 \]

\[ \rho_2 = \text{fluid density} \]

\[ \eta = \text{fluid viscosity} \]

This experiment is one of the simplest tests to calculate the viscosity in laboratory.

In the second to calculate the density we use the 10 cm\(^3\) sample and following low

\[
Density = \frac{\text{weight}}{\text{volume}}
\] (3.3)

The weight was calculated from the sample and substituted in the low and the results were observed and assembled in table (2).

At last to calculate the refraction index for the samples we forest calculate the real distance and the superficial distance using the traveling microscope and substituting in the low

\[
Refractive \ Index = \frac{\text{Real distance}}{\text{superficial distance}}
\] (3.4)

We obtained the following table (3)
3.2 Introduction

The second addition the working principle and circumstance of study of XRF

3.2.1 Working principle:

The Working principle of XRF analysis is the measurement of wavelength or energy and intensity of the characteristic X-ray photons emitted from the sample. This allows the identification of the elements present in the analyse and the determination of their mass or concentration. All the information for the analysis is stored in the measured spectrum, which is a line spectrum with all characteristic lines superimposed above a certain fluctuating background. Other interaction processes, mainly the elastic and inelastic scattering of the primary radiation on sample and substrate, induce the background.

3.2.2 Circumstance of Study:

The sample was demonstrated to XRF for six second and the experiment proceedings three time and then we calculating the average from the result.
CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This chapter includes the data analysis that collected to achieve the objective of the research, beside the most important findings of the study.

4.2 Physical Properties Results

The following results in table 4.1 up to table 4.3 shows the physical proprieties such as density viscosity and refraction index

Table (4.1) : Viscosity Results

<table>
<thead>
<tr>
<th>Sample</th>
<th>Density (g/mL) at 25°C</th>
<th>Viscosity η (m PAs) at 25°C</th>
<th>Velocity (cm/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sesame oil</td>
<td>0.916</td>
<td>85</td>
<td>25.64</td>
</tr>
<tr>
<td>Peanuts oil</td>
<td>0.945</td>
<td>85</td>
<td>28.08</td>
</tr>
<tr>
<td>Mixed oil</td>
<td>0.973</td>
<td>55</td>
<td>24.04</td>
</tr>
</tbody>
</table>

Table (4.2): Calculate Density of samples

<table>
<thead>
<tr>
<th>Sample</th>
<th>Weight(g)</th>
<th>Density (g/ml) at 25°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sesame oil</td>
<td>9.16</td>
<td>0.916</td>
</tr>
<tr>
<td>Peanuts oil</td>
<td>9.45</td>
<td>0.945</td>
</tr>
<tr>
<td>Mixed oil</td>
<td>9.73</td>
<td>0.973</td>
</tr>
</tbody>
</table>

Table (4.3) Calculated the Refraction Index of the samples
<table>
<thead>
<tr>
<th>Sample</th>
<th>Real distance (cm)</th>
<th>Superficial distance (cm)</th>
<th>Refractive Index (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sesame oil</td>
<td>6.01975</td>
<td>4.1105</td>
<td>1.4645</td>
</tr>
<tr>
<td>Peanuts oil</td>
<td>7.630205</td>
<td>5.1637</td>
<td>1.4777</td>
</tr>
<tr>
<td>Mixed oil</td>
<td>5.910085</td>
<td>3.9907</td>
<td>1.4812</td>
</tr>
</tbody>
</table>

### 4.3 XRF results:

The three samples of oil were impacted by the XRF to measure the elements on it. The outcomes were:

**Table (4.4): Sesame oil**

<table>
<thead>
<tr>
<th>Elem</th>
<th>Concentration %</th>
<th>Mlgm/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ni</td>
<td>0.01</td>
<td>100</td>
</tr>
<tr>
<td>Cr</td>
<td>0.03</td>
<td>300</td>
</tr>
<tr>
<td>Fe</td>
<td>0.05</td>
<td>500</td>
</tr>
<tr>
<td>Pb</td>
<td>0.00</td>
<td>000</td>
</tr>
</tbody>
</table>

![Fig (4.1): Sesame oil](image)

**Table (4.5): Peanuts oil**
<table>
<thead>
<tr>
<th>Elem</th>
<th>Concentration %</th>
<th>MI g/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fe</td>
<td>0.05</td>
<td>500</td>
</tr>
<tr>
<td>Pb</td>
<td>0.01</td>
<td>100</td>
</tr>
<tr>
<td>Cr</td>
<td>0.03</td>
<td>300</td>
</tr>
<tr>
<td>Zn</td>
<td>0.00</td>
<td>000</td>
</tr>
<tr>
<td>Ni</td>
<td>0.01</td>
<td>100</td>
</tr>
</tbody>
</table>

Fig (4.2): Peanuts oil
Table (4.6): Mixed oil

<table>
<thead>
<tr>
<th>Elem</th>
<th>Concentration %</th>
<th>Mlgm/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pb</td>
<td>0.01</td>
<td>100</td>
</tr>
<tr>
<td>Cr</td>
<td>0.03</td>
<td>300</td>
</tr>
<tr>
<td>Fe</td>
<td>0.05</td>
<td>200</td>
</tr>
<tr>
<td>Ni</td>
<td>0.01</td>
<td>100</td>
</tr>
</tbody>
</table>

Fig (4.3): Mixed oil
4.4 Discussion:

The basic objective of this chapter is to present and discuss the results obtained from the experimentalist work of this study. Some of the results were measured and the others were calculated to determine the characterize oil samples Sesame oil, Peanuts oil and mixed oil. In general, each some characterized liked density, Viscosity, refractive index (n), and concentration of element on the sample. In this work different samples were give and all data for these samples are listed in tables and plotted in figures, while for the samples results will be presents the measured values of concentration element.

- One of the important points of this work is the measurement of Viscosity of Oil samples, using the Stocks low (see chapter three ). The measured Viscosity of Oil samples are tabulated in table (4.1). Show that the viscosity for Sesame oil is 85 and Peanuts oil is 85 m PAs at 25°C and Viscosity of mixed oil is 55 m Pas at 25°C . (in (SSMO)no result to compare with it ).

- By noting t o calculate the density of samples we following low in Equation (2), because the density of samples Sesame oil, Peanuts oil and Sabah oil liked the density of liquated. Show on the table (2) the values of density for the samples Sesame oil, Peanuts oil and Sabah oil. From this table the value of density of Sesame oil is 0.916(g/ml) is good with the values of the density in Sudanese Standards and Metrology Organization (SSMO) the values is (the highest rate 0.924 and the minimum is0.915) , Peanuts oil is 0.945(g/ml) is high than the values of the density in Sudanese Standards and Metrology Organization (SSMO) the values is (the highest rate 0.920 and the minimum is0912) , and Sabah oil equal 0.973(g/ml) ) is high than the values of the
density in Sudanese Standards and Metrology Organization (SSMO) the values is (the highest rate 0.925 and the minimum is 0.914).

By noting to calculate the Refractive Index (n) of samples we following low in Equation (3), Show on the table (3) the values of Refractive Index (n) for the samples Sesame oil, Peanuts oil and Sabah oil. From this table the value of Refractive Index (n) of Sesame oil is 1.4645 is less than the values of the Refractive Index (n) in Sudanese Standards and Metrology Organization (SSMO) the values is (the maximum is 1.469 and the minimum is 1.465). Peanuts oil is 1.4777 is high than the values of the Refractive Index (n) in Sudanese Standards and Metrology Organization (SSMO) the values is (the maximum is 1.465 and the minimum is 1.460) and Sabah oil is 1.4812 is high than the values of the Refractive Index (n) in Sudanese Standards and Metrology Organization (SSMO) the values is (the maximum is 1.4710 and the minimum is 1.4585). (Physical characteristics vary depending on the type of oil and the value affected by several factors: method of oil extraction, The degree of purity of the oil, Storage, Sun light and so on)

The Concentration of metallic elements of samples see table (4.3) up to table (4.6) and figure (4.1) up to figure (4.3) the element Fe, Cr, Pb and Ni detect like contaminates and measuring by mlgm/kg. in (SSMO) measure the Fe, Cu, Pb and As but by XRF we found a new element like Cr and Ni in all samples. In sesame the ratio of Fe (0.05)% it equal (500) mlgm/kg it very higher than the stander (5 mlgm/kg) and Cr (0.03% = 300 mlgm/kg) and Ni (0.01)% equal 100 mlgm/kg
In sample tow peanut oil the ratio of Fe and Pb (0.05-0.01)%it equal (500-100) mlgm/kg it very higher than the stander(5-0.1 mlgm/kg) respectfully ,Cr (0.03%=300mlgm/kg) , Ni (0.01)% equal 100mlgm/kg and Zn=0.00 The last sample mixed oil the ratio of Fe and Pb (0.05-0.01)%it equal (500-100) mlgm/kg it very higher than the stander(105-0.1 mlgm/kg) respectfully ,Cr (0.03%=300mlgm/kg) , Ni (0.01)% equal 100mlgm/kg
CHAPTER FIVE

Conclusion and Recommendations

5.1 Conclusion

In this study three sample of edible oil calculated their physical properties and measuring the Metallic elements of the oils are often measured by a very complicated methods and difficult methods and instrumentations to use readings these are affected by the factors surrounding. temperature reveals the individual components. Devices as X MET 5000 which works on the principle of XRF is small and easy to use and metallic items appear in a single measurement. Oils might match specifications ,but affected by some factors (contaminates).

5.2 Recommendations

The recommendations of this study are that:

- using XRF on other oils to check their metallic contaminates.
- Sample should be selected by different ways ,
- more sophisticated tests on edible oils. Such as the use of UV for the use of the optical properties.

5.3 References


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