

Determination of Edible Oils Adulteration Using Prism Spectrometer



Mohammed Banata Worako

A Thesis Submitted to the Department of Applied Physics

School of Applied Natural Science

Presented In Partial Fulfillment of the Requirements for the Degree of Master's
in Applied Physics (Laser Spectroscopy)

Office of Postgraduate Studies

Adama Science and Technology University

July 2023

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Advisor Abebe Belay (Professor)

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DECLARATION

I Declare that this Thesis Entitled “**Determination Of Edible Oils Adulteration Using Prism Spectrometer**” is my work and has not been submitted to any University for similar purpose. The References used in this thesis are duly recognized by proper citations.

Mohammed Banata

Name of the student

Signature

Date

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We, The Advisor of this Thesis, here by certify that we have closely advised the Student while developing this thesis and read the draft thesis entitled “**Determination Of Edible Oils Adulteration Using Prism Spectrometer**” prepared under our guidance by Mohammed Banata. Therefore, we recommend the submission of the thesis to the department for further review and evaluation.

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ACKNOWLEDGMENTS

First and foremost, I would like to thank “**Almighty God (Allah)**” for offering me not only the opportunity to pursue graduate studies but also for not letting me go down at any time of misfortune, and for being with me in every way. Next, I would like to express my most heartfelt and deepest gratitude to my Advisor professor Abebe Belay for his encouragement, guidance, constant motivation, engagement, constructive criticism, and useful suggestions that made this thesis a precious learning experience for me and also I am grateful for his kindness and patience towards me and my work. I am proud of this work and I hope that you can find pride in it as well.

I have special thanks to my cute lovely wife Zeynaba Emamu to care, support and sacrifice for my Education and daily life. Again, Also I have a great pleasure to thanks Jebel Haji (PhD candidate) in the Department of Applied Physics at ASTU, for his commitment while I prepared my thesis. I have special thanks to Dar Al-Fiker Foundation that helping me by budget. Finally, my thanks go to the Family and friends I have made along the way, thank you for your support.

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LIST OF ACRONYMS

EVOO	Extra virgin olive oil
CGO	Corn Germ oil
PO	Paraffin oils
MOSH	Mineral oil saturated hydro- carbons
MOAH	mineral oil aromatic hydrocarbons
PCA	Principal Component Analysis
LDA	Linear Discriminant Analysis
HPLC	High Performance Liquid Chromatography
MS	Mass spectroscopy
SFO	Sunflower

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Abstract

In This Research a Simple and Low Cost Effective Prism Spectrometer Applied to Measure the Refractive Index (n) of Different Edible Oils Using Red, Green diode and He-Ne laser. This Applied procedures Enable to Distinguish Sunflower Oil (1.4704), Mustard Oil(1.4702), and Palm Oil(1.4566) and Coconut Oil(1.4469).The Average Refractive Index (n) of Adulterated Sunflower Oils with Palm Oils(1.4637) and Coconut Oil with Palm Oil was (1.4522)respectively.As the Concentration of Edible Oils Increases the Refractive Index(n) Increases and the Wavelength(λ)of the laser light Increases as the Refractive Index(n) of Adulterated Edible Oils Decreases.

Keywords: Adulteration,Edible Oils(EO),Refractive Index (n),Prism Spectrometer

1.INTRODUCTION

1.1 Background of the study

The Term Edible Oils Describe a Group of fatty liquids physically Extracted from several vegetables, some animal tissues or microorganisms. the principal sources of oils, obtained after extraction from seeds, while olive, coconut and palm, are extracted from fruits (Bunaciu et al.,2022). The literature data presents several methods for determination of adulteration of olive oil using infrared spectroscopy (Vancancelous et al. 2015; Menu et al. 2019), while in another review are presented the critical parameters for determination of EVOO purity (Gómez-Caravac et al. 2016).

Vegetable oils are some of the most important and used agricultural products worldwide, existing a great variety of oils that can contribute to the human diet. Edible oils and fats are known to be essential nutritional requirements for humans. An adult needs approximately 5 g daily of linolenic and unsaturated fatty acids, which cannot be manufactured within the body (Pitts et al. 2007).

Corn germ oil (CGO) is a by-product of the corn oil milling process. Most corn that is harvested is used as feed but the proportion of the corn that is milled is increasing due to the bioethanol production (Dijkstra 2016). The literature data presents several methods for CGO determination including a relevant review for determination of adulteration of corn germ oil (Rohman et al. 2020).Mineral oils (such as paraffinum liquidum or white oil, PO), which consist of mineral oil saturated hydro- carbons (MOSH) and mineral oil aromatic hydrocarbons (MOAH), are widely applied in various consumer products such as medicines and cosmetics. Optics is a branch of physics, which deals with the study of light. Refractive index is an important optical parameter to analyze the light rays traversing through materials medium. In laboratory, the refractive index of liquids can be found out by spectrometer using hollow prism. The Abbe's refractometer can also use for finding the refractive index with very good accuracy. Using the two techniques, present study deals with the refractive index and adultration of oils.

Edible oils are a food substance of whatever origin, source or composition that is manufactured for human consumption wholly or in part from a fat or oil other than milk and

dairy product. India is an importer of edible oil due to their less net domestic availability. The greater demand in national and international market adulteration in high price oil with low price oil is a major issue. Therefore there is an urgent need for authentication and prevention of adulteration for the sake of consumers. Purity of edible oils is generally ascertained using saponification value, iodine value, acid value, specific gravity, refractive index etc. but these techniques are not sensitive in sophisticated adulterations so advance techniques are required. Further, it is possible to use oil's both major and minor components as adulteration detection tool. As health of the consumer's detection, we can help to reduce consumer's health risks. an oil are liquid at room temperature and is top priority so the purity of edible items is of utmost concern (Yadav shubham et al.2018).

1.2 Statement of the problems

Adulteration represents unhealthy and unethical act of adding prohibited substances to food with a profit motive. In these conditions it is necessary to ensure the authenticity of the food that we consume has intensified more and more in the last period of time all over the world. Usually, low priced oils are mixed with premium oils. Many analytical techniques, such as: chromatographic methods, differential scanning calorimetry, Fourier transform infrared spectroscopy, etc. can be used to discriminate different oils as well as to detect adulteration (Libish et al. 2011; Rohman 2017; Valand et al. 2019; Jamwal et al. 2021). This reveals that the simple laboratory measurement of refractive index (n) can also be used as a quality control technique for finding the adultration of oil.

Edible oils are used as cooking or frying medium, salad oil or in food products formulation. They are important from nutritional point of view but ensuring their purity is a concern since old times. Because of their greater demand in national and international market adulteration in high price oil with low price oil is a major issue. It can affect the health of consumers adversely. Mustard oil adulterated with argemone oil and butter yellow has been reported to cause gall bladder cancer. Similarly, argemone oil mixed with edible oils can lead to epidemic dropsy, glaucoma and loss of eyesight. Therefore there is an urgent need for authentication and prevention of adulteration for the sake of consumers. A spectrophotometric method for detection and quantification of adulteration of sunflower, corn and soybean oils in olive oil was developed. ESI-MS fingerprinting analysis has also been applied to differentiate olive oil from the five other edible oils. GC/MS is used to classify five kinds of edible oils into five groups for authenticity assessment. Argemone oil adulteration in mustard oil can be determined by HPTLC. The HPTLC fingerprinting can also be used for

identification and estimation of mineral oil in various vegetable oils. The presence of palm kernel olein as adulterant in virgin coconut oil can be successfully detected by using FTIR spectroscopy. As health of the consumers is top priority so the purity of edible items is of utmost concern. Utilizing advance techniques for adulteration detection, we can help to reduce consumer's health risks (Yadav shubham et al.2018). In this research a simple and cost effective techniques were applied to detect adulteration using prism spectrometer by different wavelength laser light.

1.3 Objectives of the study

1.3.1 General Objective

The General Objective of this thesis is Determination Of Edible Oils Adulteration Using Prism Spectrometer.

1.3.2 Specific Objectives

The Specific Objective Of This Thesis is:-

To Determine the Refractive Index(n) of Edible Oil and Adulterated with Palm oil.

To Compare the Refractive Index(n) of Pure Edible Oil with Adulterated Palm oil.

To Examine the Effect of Concentration(% C) and Wavelength (λ) on Refractive Index(n) of Adulterated oil.

1.4. Significance of the Study

Adulteration is a common problem everywhere. It has been confirmed from different people that the palm oil is mostly used for Adulteration of Edible Oils because of its lower cost and odorless property. The Refractive indices of five oils will be determined. The percentage of adulteration of these oils will be deduced by using Refractive Index as a tool. This reveals that the simple Laboratory Measurement of Refractive Index(n) can also be used as a quality control technique for finding the adulteration of oils.

2. REVIEW OF THE LITERATURE

The Refractive Index(n) is a Basic Optical property of Materials and its Accurate value is often needed in many branches of physics and chemistry and has also several applications in many industries and materials to know the clarity of glasses and solid plastics (Bunaciu et al., 2022).

Coconut oil is frequently adulterated with substances like liquid paraffin, palm oil, palm kernel oil, etc. Liquid paraffin addition poses a serious threat to human health because it can eventually result in a number of illnesses like cancer or liver ailments. Coconut oil can readily be combined with up to 20% paraffin oil, and neither the coconut oil's flavor nor color will be noticeably altered (Bunaciu et al., 2022).

(Libish 2011).stipulated that different oils can be distinguished from one another and adulteration can be found using a variety of analytical techniques. Chromatographic techniques, differential scanning calorimetry, Fourier transform infrared spectroscopy, photopyroelectric detection, and other techniques are among them. These methods have the drawbacks of being costly, time-consuming, requiring a high level of analytical ability, and producing dangerous chemical waste.

The demand for more reliable, quick, and affordable monitoring and quality checking of paraffin oil is continuously rising due to growing public concern and legal obligations. Due to its inherent advantages, such as high sensitivity,small size,immunity to electromagnetic interference, high performance, and quick reaction, fiber-optic sensors are particularly appealing alternatives in this regard.

A separate class of devices for measuring the refractive index of transparent liquids consists of systems designed for examining liquids in cuvettes made of glass, quartz or other transparent materials. During the last decade, numerous practical devices based on the principle described above using various cuvettes have been constructed for determining the refractive index (Libish al.2022).

In this research very sensitive laser light sources (Red and Green Diode, He-Ne) to determine the concentration and wavelength dependent refractive index of edible oils solution (sunflower, coconut, mustarad, and Palm oil) using Snell's law.an empirical expression was also derived for the wavelength dependent refractive index of Edible oil solution by fitting Cauchy's equation to the experimental data using non-linear curve at the minimum discrepancy (Issaoui and Delgado 2019).

To better understand the detection techniques and processes of paraffin oil adulteration, on

this paper employs a qualitative content and thematic analysis method. Following a qualitative content and thematic analysis of the retrieved documents, the data for the role of energy-efficient buildings in sustainable development goals was analyzed. The fundamental goal of this procedure was to get a thorough grasp of the phenomena under investigation (Creswell, 2014).

2.1.1 General Overview of Paraffin Oil

Crude oil processing yields paraffin oil, often known as liquid paraffin oil (Parkash, 2003; Gary et al., 2007; Speight, 2014, 2017, 2019; Hsu and Robinson, 2017). It is flavorless, colorless oil that serves a variety of uses. Paraffin oil and mineral oil are sometimes used interchangeably. In other situations, there are minute, frequently imperceptible variations in composition and characteristics that can only be discovered via meticulous and in-depth research of the pair (Speight, 2019).

The product of distilling crude oil is liquid paraffin oil, a type of mineral oil. It is clear, tasteless, colorless, odorless oil that is mostly made of high-boiling alkane derivatives. It goes by several names, including nujol, adepsine oil, alboline, glymol, medical paraffin, or saxol, and is a blend of higher molecular weight alkane derivatives. About 0.8 g/cm³ is about how dense it is. It is reported to have little reactivity and is not soluble in water. Modern times have seen a wide range of industrial, medical, and cosmetic uses for paraffin oil and paraffin wax. There are typically two types of liquid paraffin oil: high-boiling liquid paraffin oil and low-boiling liquid paraffin oil (Speight, 2019).

From making candles to creating cosmetics or beauty goods, liquid paraffin oil has a wide range of uses. Liquid paraffin is used to treat digestive tract issues, but it doesn't enter the body because it goes through the tract. When employed in the food sector, where paraffin oil is sometimes referred to as wax, it can be used as a lubricant in mechanical mixing, as a coating on fruit or other foods that need to look polished for sale, and as a release agent for baked goods when applied to baking tins (Parkash 2003).

Furthermore Parkash (2003) stated that paraffin oil can provide some health risks, particularly if it is inhaled or consumed as well as when exposed repeatedly or for an extended period of time to the skin. The inhalation of paraffin oil can irritate the respiratory tract, resulting in coughing, wheezing, and, in rare cases, hydrocarbon pneumonitis. On the other hand, prolonged skin contact with this oil might irritate the skin and result in contact dermatitis, particularly in people who already have skin conditions or diseases. Paraffin oil use might disturb the digestive system. Unrefined paraffin oil is frequently regarded as a carcinogen or cancer-causing substance. Therefore, utilizing paraffin oil requires taking the necessary precautions. Liquid paraffin oil should ideally be kept in a tightly closed container and kept in a cold, well-ventilated area.

2.1.2 Paraffin Oil Adulteration

Adulteration represents unhealthy and unethical act of adding prohibited substances to food with a profit motive. In these conditions it is necessary to ensure the authenticity of the food that we consume has intensified more and more in the last period of time all over the world. Usually, low priced oils are mixed with premium oils. Many analytical techniques, such as: chromatographic methods, differential scanning calorimetry, Fourier transform infrared spectroscopy, etc. can be used to discriminate different oils as well as to detect adulteration (Libish et al. 2011; Rohman 2017; Valand et al. 2019; Jamwal et al. 2021).

The density of paraffin oil, a thin, colorless mineral oil, is between 0.75 and 0.85 g/cm³. It has been described as a combination of carbon molecules with six to sixteen carbon atoms. Paraffin oil is miscible in petroleum-based solvents but not in water. Paraffin oil has a flash point between 37 and 65 degrees Celsius and an auto ignition temperature of 220 degrees Celsius. Paraffin oil is relatively low in volatility. Consequently, if a lit match is dropped into a pool of it, it will extinguish. It produces an offensive odor and releases fumes when improperly burned indoors as fuel; these gases can become hazardous in low concentrations (Lawal, 2011).

The addition of additional liquids, whether miscible or immiscible, can taint paraffin oil. For instance, depending on the price differential between the product and the adulterant, paraffin oil in Nigeria is adulterated by adding water, Premium Motor Spirit (PMS), Automotive Gas Oil (AGO), or gas condensate (Lawal, 2011).

According to Meira et al (2011) by adding poor value-added goods to fuel, adulteration is done for nefarious purposes. In Brazil, this practice is common, and using contaminated fuel frequently can lead to engine heat and acceleration, higher fuel consumption, particle and

exhaust gas emissions, fuel pump blockage, and fuel system corrosion. Among other things, the accumulation of waste inside the engine and electronic injection. Additionally, the article also mentioned that fuel adulteration leads to tax avoidance and unfair market rivalry, indicating a bad scenario for the nation's economy. A sort of adulteration that is simple to use because of its good miscibility with diesel is the addition of vegetable oil that has not undergone transesterification or the addition of waste oils in place of biodiesel.

For instance, Meira et al. (2011) noted that the National Agency of Petroleum, Natural Gas and Biofuels (ANP) in Brazil establishes the requirements for the sale of vehicle fuels over the entire national territory as well as the duties of economic agents with regard to product quality control. The ANP's methods for determining diesel adulteration typically involve several sample preparation steps, are expensive, call for expensive equipment and constant calibration and gauging, and take a lot of time to collect, transport, prepare, and analyze the samples. This information was also reported in the article.

2.1.3 The Process and Detection Techniques of Paraffin Oil Adulteration

Oil products are becoming more and more crucial to the vehicle industry as society and the economy expand. Due to the significant economic benefit, some dishonest traders have recently sold low-quality or adulterated oil goods instead of high-quality oil products (Han Z et al. 2015). To increase their earnings, many oil refinery facilities in China are producing contaminated oil. According to Han et al to create 93# blend oil, they combine 90# gasoline, naphtha, aromatics, and other additives. In addition to harming consumer benefits, adulterated oil also poses a concern to public safety. Therefore, it is crucial to distinguish between qualified oil goods and adulterated oil products in order to ensure and enhance the quality of oil products.

Mass spectroscopy (MS) and High Performance Liquid Chromatography (HPLC) are well-known chemical detection techniques, and HPLC has benefits in terms of precision and sensitivity (Han et al 2016). Although HPLC produces accurate results, the process is time-consuming, ineffective, and damaging. Highly skilled and qualified people are also needed. Additionally, the identification is ineligible for online use in the industrial sector. In order to identify certified oil products and adulterated products, a method based on spectral approach and pattern classification technique has been proposed. It is regarded as an alternate method for oil detection because it is quicker, less expensive, and nondestructive. Kim et al (2000) researched the classification of oil products of six types using near-infrared spectra and were the first to apply real-time classification method for petroleum products detection.

However, Han et al also stated that there is little study on detecting oil adulteration, particularly when utilizing hyperspectral imaging. Due to its benefits, hyperspectral imaging (HSI), which combines spectral and imaging techniques, has received substantial research in a variety of fields. In their study of sesame oil, Xie et al (2014), used near-infrared hyperspectral imaging to achieve classification performance by SPA-LS-SVM and CARS-LDA of 95.59% and 98.53%, respectively.

Under 365nm UV light, samples of oil products show intense fluorescence, as noted by Kessler et al. (2011) in Science. Actually, the phenomenon's mechanism is far more intricate. Different fluorescence is produced by different oil components and percentages. The color and luminosity of fluorescence will be altered in contaminated oil products. Imaging in the hyperspectral range can demonstrate it. Wu et al. (2020) classified six oil kinds into four classes using a wavelet of a three-dimensional fluorescence spectrum under halogen lighting. UV lighting is another potential stimulation method in addition to halogen illumination. When employing a hyperspectral imaging system to analyze aflatoxin-infected chili peppers under UV fluorescence; Atas et al. were able to classify the samples with 90% accuracy (Ataş et al. 2012).

Furthermore, Miera et al (2012) stipulated that analytical chemistry pertains to the adulteration of such as paraffin or diesel oil by comparable substances like waste or vegetable oils, which uses spectrofluorometric as the basic approach. The technique of the invention which involves a colored chemical to vegetable or waste oils, biodiesel, or oil mixtures, allows for the determination of the chlorophyll compound in these substances. (Miera et al 2018) also stated that in order to identify paraffin oil or diesel adulteration by vegetable or residual oils, the invention more precisely pertains to a method for boosting the characteristic

fluorescence of chlorophyll contained in vegetable oils and biodiesel created from them. Intensity of the chlorophyll compound's fluorescence.

Due to its high level of sensitivity and broad dynamic range, fluorescence spectrometry, also known as spectrofluorimetry, is the optical spectroscopic technique that is employed the most in analytical media and scientific investigations. Additionally, the instrument can be bought for a reasonable price and used for the majority of functions (Gómez-Rioja 2019).

Paraffin or diesel tampering is detected using total spectrofluorimetry in conjunction with PCA (Principal Component Analysis) by injecting used frying oil in place of biodiesel (Miera et al, 2012). Principal Component Analysis (PCA), Linear Discriminant Analysis (LDA), and Partial Least Squares Synchronized Spectrofluorimetry (PLS) were also employed to detect and measure the presence of residual oil in 2% biodiesel (B2) diesel (Corgozinho et al, 2008). Matrix emission excitation fluorescence (EEM) and spectral matrix emission excitation (EEMSS) were used as background approaches in a study on the contamination of paraffin oil or diesel oil by a number of typical adulterants, including kerosene, crude hexane, cyclohexane, turpentine oil, and others (Patra, & Mishra, 2002).

According to Ribeiro et al (2008) Spectrofluorimetry is an analytical technique used to determine the quantity or quality of compounds that can emit fluorescence. The advantages of spectrofluorimetry are its ease of use, sensitivity, affordability, little usage of harmful solvents, and lack of device interaction with these solvents. Ribeiro have also stipulated that various studies have looked into diesel adulteration, but none have the sensitivity, utility, and affordability that spectro fluorimetry provides.

2.2 Spectroscopy

Spectroscopy is the study of interaction between matter and radiated energy. Historically spectroscopy originated through the study of visible light dispersed according to its wavelength by a prism. Latter the concept was expanded greatly to comprise any interaction with radiant energy as a function of its wavelength or frequency. Electromagnetic radiation was the first source of energy used for spectroscopic studies, there are different type of spectroscopy such as microwave spectroscopy, UV spectroscopy, IR spectroscopy, Gamma ray spectroscopy NMR, MRI, acoustic spectroscopy etc. Spectrometers are used as spectral measurement devices (Dongarge, 2015).

In principle, a spectrometer is the simplest of scientific instruments. Bend a beam of light with a prism or diffraction grating. If the beam is composed of more than one color of light, a spectrum is formed, since the various colors are refracted or diffracted to different angles.

Carefully measure the angle to which each color of light is bent. The result is a spectral "fingerprint" which carries a wealth of information about the substance from which the light emanates. In most cases, substances must be hot if they are to emit light. But a spectrometer can also be used to investigate cold substances. Pass white light, which contains all the colors of the visible spectrum, through a cool gas. The result is an absorption spectrum. All the colors of the visible spectrum are seen, except for certain colors that are absorbed by the gas (Dongarge, 2015).

The importance of the spectrometer as a scientific instrument is based on a simple but crucial fact. Light is emitted or absorbed when an electron changes its orbit within an individual atom. Because of this, the spectrometer is a powerful tool for investigating the structure of atoms. It's also a powerful tool for determining which atoms are present in a substance. Chemists use it to determine the constituents of molecules, and astronomers use it to determine the constituents of stars that are millions of light years away (Dongarge, 2015).

2.2.1 Refractive Index Measurement Principle

2.2.1.1 Snell's Law

Snell's law (also known as Descartes' law or the law of refraction), a formula used to describe the relationship between the angles of incidence and refraction, for light or electromagnetic waves, passing through a boundary between two different transparent medias, such as air and glass or others (Tinashe, 2008). Snell's law states that the ratios of the Sine of the angle of incidence to the Sine of the angle of refraction are a constant that depends on the properties of the media (Henderson, 2004). When a light ray incident on an interface point of the two medias with different refractive indices at an angle of incident θ_i which is the angle between the ray of incident and the normal line which is perpendicular to the surface, it becomes refract either towards or away from the normal depending on the optical density of the two medias at an angle of refraction θ_r which is the angle formed between ray of refracted and the normal line as shown in figure 2.1.

Suppose a light ray is incident on an interface separating two transparent media. The incident ray is then partially reflected to the first medium and partially transmitted (reflected) to the second medium. The refractive ray makes an angle θ_r with the normal ray and the incident ray makes an angle with the normal. If n_1 is the refractive index of the first medium and n_2 is that of the second medium, then Snell's law states that:

$\frac{\sin \theta_i}{\sin \theta_r} = \frac{n_2}{n_1}$ Moreover, if v_1 is speed of light in the first, medium and v_2 is speed in the second

medium, the Snell's law is expressed as: $\frac{\sin\theta_i}{\sin\theta_r} = \frac{v_1}{v_2}$

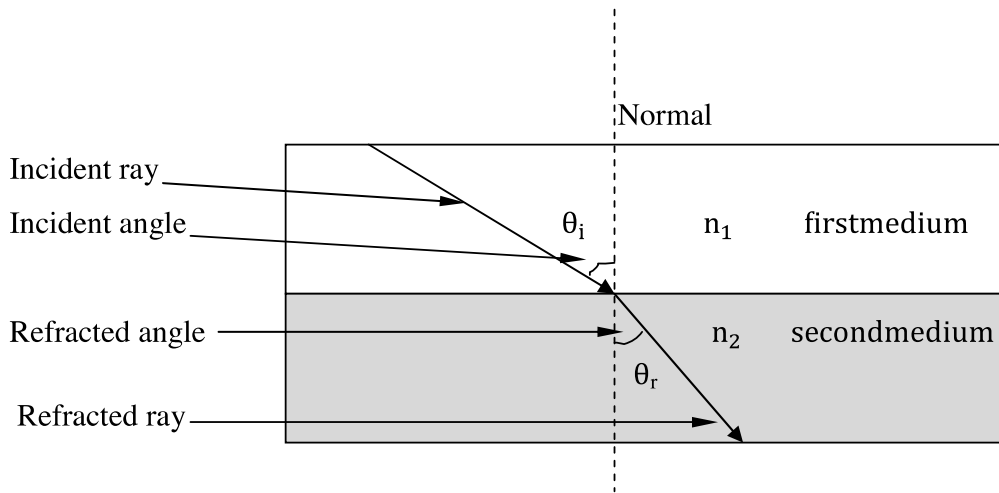


Figure: 2.1 Graphic of Snell's law

Mathematically Snell's law also can be rewired as;

$$n_1 \sin\theta_i = n_2 \sin\theta_r \quad (2.1)$$

$$\frac{\sin\theta_i}{\sin\theta_r} = \frac{n_2}{n_1} = \text{constant (n)} \quad (2.2)$$

Where θ_i and θ_r are angle of incidence and angle of refraction respectively. n_1 and n_2 are the refractive indices of the first and second medium respectively and $n = \frac{n_2}{n_1}$ is the relative refractive index .

As light passes the border between the two Medias, depending upon the relative refractive indices of the two Medias, the light will either be refracted to a lesser angle or a greater one. These angles are measured with respect to the normal line, line perpendicular to the boundary at the point of incidence.

Snell's law used to determine the direction of light rays through refractive media with varying indices of refraction. The indices of refraction of the media, labeled n_1 and n_2 , are used to represent the factor by which light is "slowed down" with in a refractive medium, such as glass or water, compared to its velocity in a vacuum.

2.2.1.2 Angle of Minimum Deviation

Angle of deviation is the angle through which an incident ray deviates. By measuring the angle of deviation from various angles of incident, we can determine the angle of minimum deviation and refractive index of the prism.

Figure 2.2 shows the set up to determine the angle of minimum deviation using a prism.

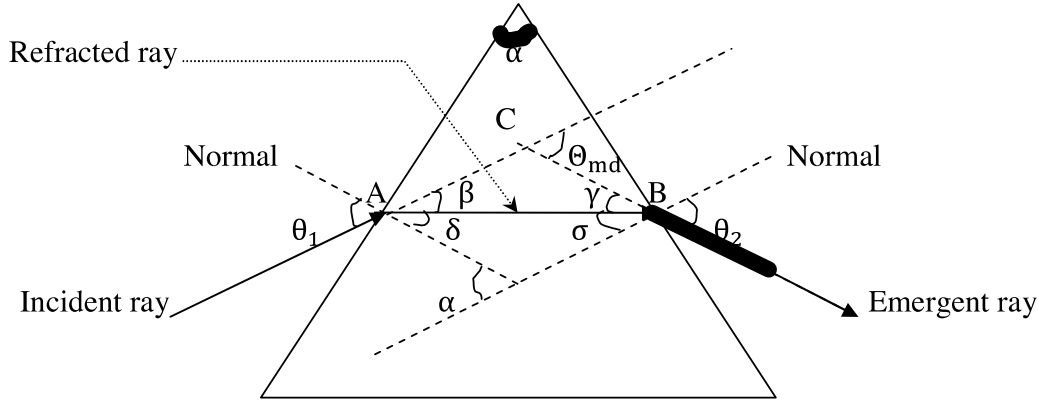


Figure: 2.2 The geometry of a light rays passing through a prism

Where: α is the apex angle; θ_1 and δ are the angles of incidence and angle of refraction on surface A, respectively. σ and θ_2 are the angle of incidence and angle of refraction on surface B, respectively. Θ_{md} is the angle of minimum deviation. If light of ray is incident on the first surface of the prism at an angle of θ_1 , then the refraction at both surfaces obeys Snell's law (Jenkins, 2004). Then due to the refraction at surface A, we can write Snell's law as:

$$\frac{\sin\theta_1}{\sin\delta} = \frac{n_g}{n_a} \quad (2.3)$$

Where: n_g and n_a are refractive indices of the glass and air respectively. Application of Snell's law at point B yields:

$$\frac{\sin\delta}{\sin\theta_2} = \frac{n_a}{n_g} \quad (2.4)$$

$$\frac{\sin\theta_2}{\sin\delta} = \frac{n_g}{n_a} \quad (2.5)$$

Equates equation (2.3) and (2.5) yields:

$$\frac{\sin\theta_1}{\sin\delta} = \frac{n_g}{n_a} = \frac{\sin\theta_2}{\sin\delta} \quad (2.6)$$

The angle of deviation produced by the first surface is:

$$\beta = \theta_1 - \delta \quad (2.7)$$

And the angle of deviation produced by the second surface is:

$$\gamma = \theta_2 - \delta \quad (2.8)$$

The total angle of minimum deviation is thus:

$$\Theta = \beta + \gamma \quad (2.9)$$

Now substitute equation 2.7 and 2.8 into 2.9 and it yields:

$$\Theta = \theta_1 + \theta_2 - (\delta + \sigma) \quad (2.10)$$

$$\text{But, } \delta + \sigma = \alpha$$

Therefore, equation (2.10) becomes: -

$$\Theta_d = \theta_1 + \theta_2 - \alpha \quad (2.11)$$

2.2.1.3 Condition for Minimum Deviation

The angle of minimum deviation occurs at a particular angle of incidence where the refracted ray inside the prism makes equal angles with the two prism faces. This occurs when the path of the light inside the prism is parallel to the base of the prism. Therefore, it means that in Figure 2.2

$$\theta_1 = \theta_2, \quad \gamma = \beta, \quad \delta = \sigma$$

On account of equation (2.11) we can thus write the minimum angle of deviation as:

$$\Theta_{md} = 2\theta_1 - \alpha \quad \text{Or} \quad \Theta_{md} = 2\theta_2 - \alpha \quad (2.12)$$

This implies that:

$$\theta_1 = \frac{1}{2}(\Theta_{md} + \alpha) \quad \text{Or} \quad \theta_2 = \frac{1}{2}(\Theta_{md} + \alpha) \quad (2.13)$$

And from equation (2.10) it follows that:

$$\delta = \frac{1}{2}\alpha \quad \text{Or} \quad \sigma = \frac{1}{2}\alpha$$

2.2.2. Determining Concentration of a Solution using a Hollow Prism

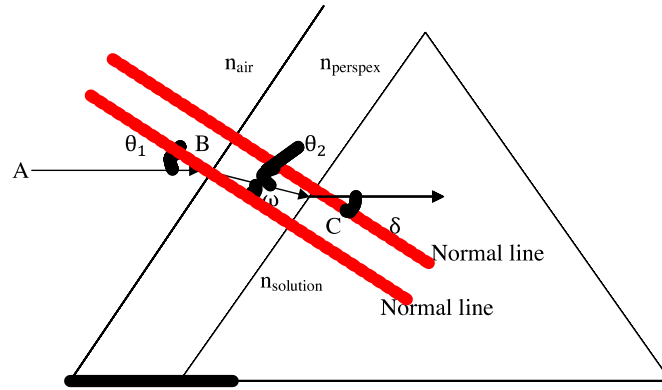


Figure: 2.3 The geometry of a light ray passing through a hollow prism

From A to B, light is travelling in air. It is refracted at B and travels in the Perspex up to C. At C it is refracted again and we assume it travels parallel to the base of the prism to achieve minimum deviation.

By applying Snell's law at B:

$$n_{air} \sin \theta_1 = n_{per} \sin \omega \quad (2.15)$$

Where: n_{air} and n_{per} are the refractive indices of air and Perspex respectively. The only unknown parameter in equation (2.15) is the angle of refraction, ω .

It can be obtained by rearranging Eq. (2.15)

$$\sin \omega = \frac{n_{air}}{n_{per}} \sin \theta_1 \quad (2.16)$$

Again by applying Snell's law at C,

$$n_{per} \sin \theta_2 = n_{sol} \sin \delta \quad (2.17)$$

Was n_{sol} – refractive index of

Solution. Because $\theta_2 = \omega$, we see that

$$n_{per} \sin \omega = n_{sol} \sin \delta$$

$$\text{Or } \sin \omega = \frac{n_{sol}}{n_{per}} \sin \delta \quad (2.18)$$

Now, equates equation (2.16) and (2.18), we note that

$$\frac{n_{air}}{n_{per}} \sin \theta_1 = \frac{n_{sol}}{n_{per}} \sin \delta$$

$$n_{air} \sin \theta_1 = n_{sol} \sin \delta \quad (2.19)$$

Now substitution of equation (2.14) into (2.19) leads to:

$$n_{air} \sin \frac{1}{2}(\alpha + \Theta_{md}) = n_{sol} \sin(\frac{1}{2}\alpha) \quad (2.20)$$

Since the refractive index of the air is 1, the refractive index of the solution can be written as:

$$n_{sol} = \frac{\sin(\frac{1}{2}(\alpha + \Theta_{md}))}{\sin(\frac{1}{2}\alpha)} \quad (2.21)$$

For this research the angle of apex $\alpha = 60^\circ$. Therefore, equation (2.21) becomes:

$$n_{sol} = \frac{\sin(\frac{1}{2}(\alpha + \Theta_{md}))}{\sin 30^\circ} \quad (2.22)$$

It then follows that:

$$n_{sol} = 2 \sin(\frac{1}{2}\Theta_{md} + 30^\circ) \quad (2.23)$$

Where: Θ_{md} is determined experimentally using a prism spectrometer.

2.3. Concentration of the Components of the Liquids, Density and Refractive Index

Refractive Index (RI) is an Important characteristic of liquid substances for analyzing, monitoring, and identification of liquids in several industries now days. Accurate determination of the concentration of the solution by measuring the RI is widely used in chemical and physical studies, food technology, materials processing, medical diagnostics, monitoring systems, fuel cells directly measuring pollution, and many other fields. In general, the measured refractive index of a multicomponent mixture is a function of its temperature T , concentration C , and the wavelength of the incident light λ (Fan, 1998).

$$n = n(T, C, \lambda) \quad (2.24)$$

From Eq. (2.24), the change of RI Δn of a multicomponent mixture is:

$$\Delta n \approx \frac{\partial n}{\partial T} \Delta T + \frac{\partial n}{\partial C} \Delta C + \frac{\partial n}{\partial \lambda} \Delta \lambda \quad (2.25)$$

Changes in the density of matter are always accompanied by some change of RI. Usually RI increases with increasing density. Theoretical study of the relationship between the density of matter and its RI, as well as the experimental data shows that there is a direct proportion between some RI function $f(n)$ and density d :

$$f(n) = rd \quad (2.26)$$

The constant factor r that is specific for this substance is called as specific refraction. As distinct from n and d the specific refraction does not depend on external conditions (temperature, pressure) and very slightly depends on the state of aggregation of matter.

There are many attempts to derive a general formula for the function of all substances $f(n)$, but a universal function that is independent of the properties of matter does not exist (Vilitis O, 2004).

2.4. Classical Description of Refractive Index Using Electron Oscillator Model

From classical electron oscillator model the Lorentz force is given by

$$\vec{F} = e \left(\vec{E} + \vec{v} \times \vec{B} \right) \quad 2.27$$

Where: $\mathbf{F}$ is Lorentz force, $\mathbf{v}$ is velocity, e is electron charge, $\mathbf{E}$ is electric field and $\mathbf{B}$ is magnetic field.

We assume that Eq. (2.27) applies to the individual protons and electrons in atoms. Although these particles and their interactions can be properly treated only using quantum theory, their interaction with light can be treated very accurately in most cases with classical laws and concepts.

If the electron has mass m_e and charge e and nucleus has mass m_n and charge $+e$. The nucleus exerts a binding force $\mathbf{F}_{en}$ on the electron, depending on the relative separation $\mathbf{r}_{en} = \mathbf{r}_e - \mathbf{r}_n$. The electron also exerts a force $\mathbf{F}_{ne}$ on the nucleus, and according to Newton's third law,

$$F_{en}(r_{en}) = -F_{ne}(r_{ne}) \quad (2.28)$$

The Newton equations of motion for the electron is therefore

$$m \frac{d^2 x}{dt^2} = eE(x, t) + F_{en}(x) \quad (2.29)$$

Assume x is the electron coordinate relative to the nucleus, $x = r_{en}$ and m = mass of electron in the absence of external force, the atom has a certain equilibrium position. Under the influence of an electromagnetic field, the electron experiences the Lorentz force Eq. (2.27) and is displaced from its equilibrium position; according to Lorentz “the displacement will immediately give rise to a new force by which the particle is pulled back towards its original position, and which we may therefore appropriately distinguish by the name of elastic force”

(Lorentz, 1952). Lorentz's assertion is equivalent to the replacement $\mathbf{F}_{en}(x)$ by $-k_s x$, where: k_s is the "spring constant" associated with the hypothetical elastic force. This leads to the equation,

$$\left. \begin{aligned} m \frac{dx^2}{dt^2} &= eE(R, t) - K_s x \\ \left(\frac{dx^2}{dt^2} + \omega_o^2 \right) x &= \frac{eE(R, t)}{m} \end{aligned} \right\} \quad (2.30)$$

Where: $\omega_o = \sqrt{\frac{K_s}{m}}$ is the electron's natural frequency of oscillator, R-for the position of the stationary nucleus.

If we take a frictional force for granted and explore its consequences, we simply amend the Newton force law Eq. (2.30) to be written as:

$$m \frac{dx^2}{dt^2} = eE(R, t) - K_s x + F_{fric} \quad (2.31)$$

This frictional (drag) force can be given as:

$$F_{fric} = -bv = -b \frac{dx}{dt} \quad (2.32)$$

For an electron oscillator in a linearly polarized monochromatic plane wave Eq. (2.36) takes the form (Milonni ,2010):

$$\frac{dx^2}{dt^2} + 2\beta \frac{dx}{dt} + \omega_o^2 x = \hat{e} \frac{e}{m} E_o \cos(\omega t - kZ) \quad (2.33)$$

Where: $\beta = \frac{b}{2m}$ the unit vector $\hat{e}$ defines the polarization of the applied field. And then Eq. (2.31) For the electron oscillator with frictional damping is most easily solved by first writing it in complex form as

$$\frac{dx^2}{dt^2} + 2\beta \frac{dx}{dt} + \omega_o^2 x = \hat{e} \frac{e}{m} E_o e^{-i(\omega t - kz)} \quad (2.34)$$

Where: we follow the convention of writing: $E_o \cos(\omega t - kZ)$ as $E_o e^{-i(\omega t - kz)}$
 $E_o \cos(\omega t - kZ)$ Is real part of $E_o e^{-i(\omega t - kz)}$

This means that $x(t)$ in Eq. (2.34) is also regarded mathematically as a complex quantity in our calculations, but only its real part is physically meaningful. In other words, we may submit the process of taking the real part of (2.34) until after our calculations, at which point

the real part of our solution for $x(t)$ is the (real) electron displacement. This approach is used frequently in solving linear equations such as Eq. (2.34). We solve Eq. (2.34) by writing;

$$X(t) = ae^{-i(\omega t - kz)} \quad (2.35)$$

and after inserting this into Eq. (2.34) we obtain

$$(-\omega^2 - 2i\beta\omega + \omega_o^2)a = \hat{e} \frac{e}{m} E_o \quad (2.36)$$

Therefore, the assumed solution Eq. (2.35) satisfy Eq. (2.34)

$$a = \frac{\hat{e} \frac{e}{m} E_o}{(-\omega^2 - 2i\beta\omega + \omega_o^2)} \quad , \quad (2.37)$$

And the physically relevant solution is therefore

$$X(t) = Re \left[\frac{\hat{e} \left(\frac{e}{m} \right) E_o}{(\omega_o^2 - \omega^2 - 2i\beta\omega)} e^{-i(\omega t - kz)} \right] \quad (2.38)$$

Note that Eq. (2.38) actually gives only the steady-state solution of Eq. (2.33).

Recall the classical oscillator formula Eq. (2.38) the electron displacement due to an applied electric field $\hat{e} E_o (\cos(\omega t - kZ))$:

$$X(t) = \hat{e} \frac{e}{m} E_o \left\{ \frac{\omega_o^2 - \omega^2}{(\omega_o^2 + \omega^2)^2} e^{-i(\omega t - kz)} (\cos(\omega t - kZ)) + \frac{2\beta\omega}{(\omega_o^2 + \omega^2)^2 + 4\beta^2\omega^2} \sin(\omega t - kz) \right\} \quad (2.39)$$

The first term in brackets is in phase with the electric field, whereas the second term is “in quadrature,” that is, its phase differs by $\frac{\pi}{2}$ from that of the field. The in-quadrature part of the induced electric dipole moment $d = ex$ is responsible for absorption (or stimulated emission) of light (Lorentz, 1952). If the medium consists of N particles per unit volume, each of which has a dipole moment p , the polarization density is Np . We assume that the medium has no polarization in the absence of a field, so that the only dipole moments p in the medium are induced by the field, that is, the electric field causes charge displacements that result in an induced dipole moment given by the formula:

$$P(r, \omega) = \alpha(\omega) \varepsilon(r, \omega) \quad (2.40)$$

Where the polarizability $\alpha(\omega)$ is defined by writing the in-phase component of $\mathbf{d}$ as $\alpha \hat{e} E_o (\cos(\omega t - kZ))$. Thus, from Eq. (2.39),

$$\alpha(\omega) = \frac{e^2}{m} \left[\frac{\omega_o^2 - \omega^2}{(\omega_o^2 - \omega^2)^2 + 4\beta^2\omega^2} \right] \quad (2.41)$$

$$\text{And } n^2(\omega) - 1 = \frac{Ne^2}{m\epsilon_0} \left[\frac{\omega_o^2 - \omega^2}{(\omega_o^2 - \omega^2)^2 + 4\beta^2 \omega^2} \right] \quad (2.42)$$

As in the case of spontaneous emission and absorption, this result of the classical oscillator model must be modified to include the oscillator strength f :

$$n^2(\omega) - 1 = \frac{Ne^2 f}{m\epsilon_0} \left[\frac{\omega_o^2 - \omega^2}{(\omega_o^2 - \omega^2)^2 + 4\beta^2 \omega^2} \right] \quad (2.43)$$

Unlike absorption, the refractive index is usually attributable to non-resonant transitions, that is, transitions such that, $|\omega_o^2 - \omega^2| \gg \beta\omega$. In this case:

$$n^2(\omega) - 1 = \frac{Ne^2}{m\epsilon_0(\omega_o^2 - \omega^2)} \quad (2.44)$$

In this no resonant situation, however, no one transition is necessarily dominate, and so we must add the contributions of all transitions connected to the ground state in which the atoms are presumed (for now) to reside. Thus, if the transitions from the ground state have oscillator strengths f_j and transition frequencies ω_j , the refractive index at the radiation frequency ω is given by the formula:

$$n^2(\omega) - 1 = \frac{Ne^2}{m\epsilon_0} \sum_j \frac{f_j}{\omega_o^2 - \omega^2} \quad (2.45)$$

This result applies when there is one type of atom or molecule in the medium; more generally we simply add the contributions of the different species. In a gas, furthermore, the density N is generally sufficiently low that $n(\omega) \approx 1$ and therefore

$n^2 - 1 = (n - 1)(n + 1) \approx 2(n - 1)$ Thus, for a gas consisting of a single type of atom or molecule with number density N , the formula for the refractive index is approximately:

$$n(\omega) = 1 + \frac{Ne^2}{m\epsilon_0} \sum_j \frac{f_j}{\omega_o^2 - \omega^2} \quad (2.46)$$

It is interesting to relate this result to a formula that is often used in tabulations of the refractive index of gases. For this purpose, we first rewrite Eq.(2.46) in terms of radiation wavelength $\left(\lambda = \frac{2\pi c}{\omega}\right)$ and transition wavelengths $\left(\lambda_j = \frac{2\pi c}{\omega_j}\right)$:

$$n(\omega) = 1 + \frac{Ne^2}{8\pi\epsilon_0 mc^2} \sum_j \frac{f_j \lambda^2}{1 - \frac{\lambda_j^2}{\lambda^2}} \quad (2.47)$$

Hence Permittivity ϵ correlated with refractive index (n) where total Permittivity (ϵ total) was summation of both real (ϵ') and Imaginary (ϵ'') as Eq (2.48) below:

$$\epsilon = \sqrt{n^2 - 1} \quad (2.48)$$

As noted, electronic resonance in molecules (and in many atoms) tends to lie in the ultraviolet, in which case $\lambda_j \ll \lambda$ for optical wavelength λ . In this case we can approximate

$\left(1 - \frac{\lambda_j^2}{\lambda^2}\right)^{-1}$ by the first two terms of its binomial series expansion, $1 + \frac{\lambda_j^2}{\lambda^2}$ then

$$n(\lambda) - 1 \approx A_1 \left(1 + \frac{B_1}{\lambda^2}\right) \quad (2.49)$$

$$\text{Where } A_1 = \frac{Ne^2}{8\pi\epsilon_0 mc^2} \sum f_i \lambda_j^2 \quad (2.50)$$

$$B_1 = \sum \lambda_j^4 \quad (2.51)$$

An empirical relation of the form Eq. (2.48) was proposed by Cauchy in 1830, before the electromagnetic theory of light. Our derivation of Cauchy's formula gives explicit expressions for the coefficients A_1 and B_1 . Unfortunately, it is difficult to calculate the numerical values of A_1 and B_1 for a given atom or molecule because we require the transition wavelengths and the oscillator strengths of all transitions connected to the ground state, including transitions to "continuum" states in which the electrons are unbound, that is, in which an atom is ionized. For a gas at STP [$P = 760$ Torr, $T = 273$ K, and, $N = 2.69 \times 10^{25}$ /m³],

$$A_1 = 1.2 \times 10^{10} \sum f_i \lambda_j^2 \quad (2.52)$$

Cauchy's formula correctly accounts for the fact that most transparent materials we encounter daily (e.g. water, air, glass) have refractive indices greater than unity at visible wavelengths. According to our analysis, this is a consequence of these materials having resonance wavelengths λ_j that are small compared to optical wavelengths (which lie roughly between 400 and 700 nm). It also follows from (2.44) that $\frac{dn}{d\lambda} < 0$, which is also a familiar feature of refractive indices in the visible: A glass prism, for instance, causes violet to be dispersed more than red when it separates white light into its spectral components. In fact, the increase of $n(\lambda)$ with decreasing λ ($\frac{dn}{d\lambda} < 0$) is sufficiently ubiquitous that it is called "normal dispersion." an example of normal dispersion appears in Fig. 2.4 (Milonni, 2010).

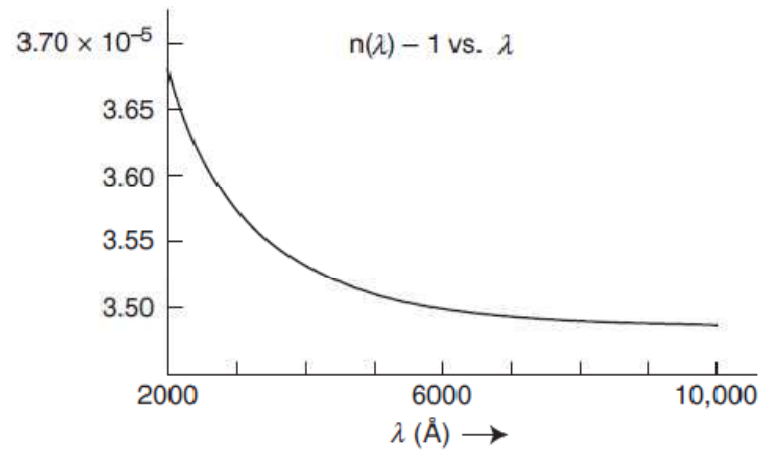


Figure 2.1 Refractive Index (n) of Helium at Standard Temperature and Pressure.
[Milonni2010]

3. MATERIALS AND METHODS

3.1. Materials

Green, Red diode laser and He-Ne laser as a light source used in addition to those different instruments such as prism Spectrometer, cuvette, dropper, measuring cylinder of 100ml, 50ml, 25ml and 10ml to measure the concentration of edible oils. Samples of edible oils are Palm oil, Sunflower oil, Coconut Oil, mustard oil and paraffin oil from local market.



Figure 3.1 The samples Edible Oils and set up of prism spectrometer.

3.2.Methods Of The Experiment

3.2.1.Methods Of Measuring Refractive Index(n) Of Edible Oils with Adulterated Palm Oils by Snell's Law

Solutions of Palm Oil with the Appropriate Concentration (C %) 0%, 5%, 10%, 15%, 20% and 25%) in Edible Oils and 100% (v/v) with EVOO and CGO, respectively. Finally the collected samples will be kept at room temperature for analysis. A convenient formula for Refractive Index(n) can be obtained in the minimum deviation case when a ray of light suffers deviation while passing through a prism. The deviation produced by the prism depends on the angle of incidence. For a certain value of the angle of incidence, the angle of deviation is minimum. If θ_{md} denotes the angle of minimum deviation for a given prism of refractive angle 60° , then the refractive index of the material of the prism n is given by Eq.(2.23).

The Measurements will be made three times on each sample to eliminate random errors and ensure high degree of precision and accuracy. The Average of three measurements was computed to find Refractive Index. The standard deviation for the measurements of Refractive Index(n) will be also calculated. In optics Cauchy's equation is an empirical relationship between the refractive index and wavelength of the light for particular transparent materials. The most general form of Cauchy's equation: (Jenkins et al. 1981).

$$n(\lambda) = A + \frac{B}{\lambda^2} + \frac{C}{\lambda^4} + \dots \quad 3.1$$

where n is Refractive Index(n), λ is the wavelength A, B, C , etc., are coefficients that can be determined for a material by fitting the equation to measured refractive indices at known wavelengths.

Cauchy's two-term equation for air, expanded by Lorentz to account for humidity, is as follows :(Rohman et al.2020).

$$n_{air}(\lambda, T, v, P) \simeq 1 + \frac{77 \times 10^{-6}}{T} \left(1 + \frac{7.52 \times 10^{-3}}{\lambda^2} \right) \left(\rho + 4810 \frac{v}{T} \right) \quad 3.2$$

3.2.2. Methods Of Measuring Concentration Dependent Refractive Index of Edible Oils

To Measure the Refractive Index(n) of Different Edible Oils standard samples of varying concentration of volume (v/v: 0%, 5%, 10%, 15%, 20% and 25%) will prepare. A theory and method for derivation of Refractive Index(n) have been discussed elsewhere. The angle of minimum deviation is responsible for deviation produced in the path of light beam. The angle

of deviation θ_{md} is minimum when incident and refracted angle of the prism are equal. Therefore, The Refractive Index, n_{sol} of the edible oil can be calculated (Jenkins et al.1981).

$$n_{sol} = 2\sin\left(\frac{1}{2}\theta_{md} + 30^\circ\right)$$

3.3

3.3.3. Wavelength Dependent Refractive Index Of Edible Oils

An Empirical Relationship between the Refractive Index(n) and wavelength of light for particular transparent materials can be expressed using Cauchy Where n is the wavelength dependent Refractive Index(n), λ is the wavelength and A,B,C are the coefficients that can be determined for a materials (Jenkins et al. 1981).

$$n(\lambda) = A + \frac{B}{\lambda^2} + \frac{C}{\lambda^4}$$

3.4

3.4. Effects Of Wavelength and Concentration On The Refractive Index of Edible Oils

Dispersion of light measures the change of the Refractive Index(n) with wavelength. It can be explained by applying electromagnetic theory to the molecular structure of the materials. If an electromagnetic wave impinges on an atom or molecule the bound charge vibrate at the frequency of the incident wave. As Refractive Index(n) of Edible Oils Increase the concentration, wavelength of the Edible Oils Increases and the Temperature is linearly Decreases.

4.RESULTS AND DISCUSSION

In This chapter, The Results and Discussion of the Thesis are presented. In the first sections of this chapter the results of Refractive Indices of Edible Oils determined by the three lasers were presented; The graph of the Refractive Index(n) versus Sunflower, Mustard, Palm and Coconut, graph of Refractive Index(n) versus Percentage of adulteration found in sunflower, coconut oil and palm oil and graph of Refractive Index(n) versus wavelength were presented.

4.1 Results of Refractive Index (n) of Edible Oils (Sunflower, Mustard, Palm and Coconut) using He-Ne laser, Green and Red diode Laser

Table 4.1-4.3 shows the Refractive Indices of various types Edible Oils at Different Concentrations using Red diode laser ($\lambda = 650 \text{ nm}$), Green diode laser ($\lambda = 532 \text{ nm}$) and He-Ne laser ($\lambda = 632.8 \text{ nm}$). The results in the tables indicate the Refractive Index(n) of the Sunflower 1.4702, 1.4706, 1.4708, Mustard 1.4702, 1.4704, 1.4706, Palm 1.4566, 1.4573, 1.4587 and Coconut 1.4469, 1.4471, 1.4472 using Red diode laser, He-Ne laser and Green diode laser respectively. The Refractive Index(n) Decreases linearly sunflower to Coconut. In the mentioned types of Edible Oils range, the minimum value of Refractive Index(n) was 1.4469 ± 0.0002 obtained using Red diode laser for Cocunut and the maximum value was 1.4708 ± 0.0001 obtained using Green diode laser for Sunflower and the angle of minimum deviation was 32.680° measured by using Red diode laser and maximum angle deviation was 34.691° measured by using Green diode laser. The obtained results are in a good agreement with the reported results by [6, 24].

Table 4.1: Results of Refractive Index(n) of Edible Oils using Green Diode Laser (532 nm)

Edible oils	$\theta_{md}(\circ)$	RI (exp't)	RI (lit)[6,24]
Sunflower	34.691	1.4708	1.4709
Mustard	34.662	1.4706	1.4701
Palm	33.630	1.4587	1.4583
Coconut	32.896	1.4472	1.4495

Table 4.2: Results of Refractive Index(n) of Edible Oils using He- Ne Laser (632.8 nm)

Edible oils	$\theta_{md}(\circ)$	RI (exp't)	RI (lit)[56,57]
Sunflower	34.665	1.4706	1.4709
Mustard	34.648	1.4704	1.4701

Palm	33.546	1.4573	1.4583
Coconut	32.696	1.4471	1.4495

Table 4.3: Results of Refractive Index(n) of Edible Oils using Red Diode Laser (650 nm)

Edible oils	$\theta_{md}(\circ)$	RI (exp't)	RI (lit)[56,57]
Sunflower	34.630	1.4702	1.4709
Mustard	34.622	1.4701	1.4701
Palm	33.488	1.4566	1.4583
Coconut	32.680	1.4469	1.4495

Figure 4.1 shows the plot of Refractive Index(n) versus concentration of Edible Oils solution measured using red diode laser, green diode laser and He-Ne laser. As shown in the figure the experimental values are best linearly fitted ($R^2 = 0.876, 0.899, 0.799$) for He-Ne laser, green diode and red diode respectively.

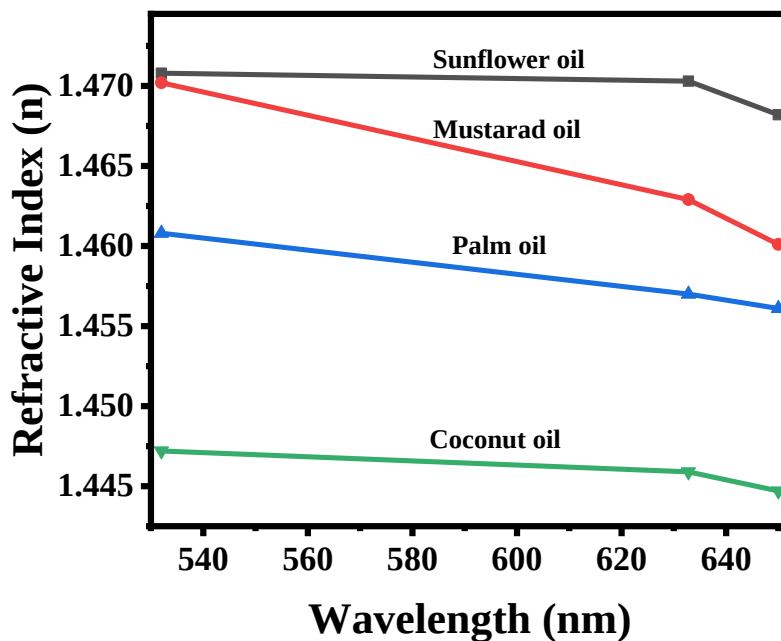


Figure 4.1 Refractive Index (n) of selected Edible Oils

4.2.Wavelength Dependence Of The Refractive Index (n) Of Adulterated Oils

The Refractive Index(n) of four selected standard Oils sunflower,coconut, palm, and mustarad oils have been determined by prism spectrometer.All are found to be in good agreement with each other and shown in table 4.4, 4.5.Adulteration is a common problem everywhere. It has been confirmed from different people that the palm oil is mostly used for adulteration of edible oils because of its lower cost and odorless property. Therefore, the coconut oil and sunflower oil have been chosen for the present adulteration study and they have been mixed with palm oil in different percentages.The refractive index(n) of these mixed oils have been found out by using prism spectrometer and presented in table 4.4 and 4.5.

The calibrated graphs of refractive index(n) as a function of percentage of palm oil mixed with coconut oil and sunflower oil respectively are shown in figure 4.2 and figure 4.3.Now,various samples of coconut and sunflower oils have been collected from various stores and the refractive index(n) of these oils have been determined by prism spectrometer. From the calibrated graphs (figure 4.2 and figure 4.3) the percentage of adulteration have been deduced and presented in table 4.4 and 4.5.

4.2.1 Refractive Index (n) Of Adulterated Sunflower With Palm Oil

Figure 4.2 Shows Comparatively,the Refractive Index(n) of Adulterated Sunflower Oil with palm oil by volume ratio (v/v%).As can be noticed from this figure 4.2.there are significant differences between the Refractive Index(n) of Sunflower oil with palm oil percentage 0%, 5%, 10%, 15%, 20% and 25%).The single major difference is the wavelength dependence of refractive index of Sunflower oil,which is edible oil as influence of adulterated palm oils. i.e linearly decresing of adulterated Sunflower oils with Palm oils.

Table 4.4:The Percentage of adulteration found Sunflower oil and palm oil from the measurement of refractive index.

Percentage of adulteration	Refractive Index(n) of adulterated Sunflower		
	Using He-Ne	Using Green diode	Using Red diode
0	1.4706	1.4708	1.4702
5	1.4700	1.4702	1.4696
10	1.4695	1.4697	1.4691

15	1.4690	1.4692	1.4686
20	1.4685	1.4687	1.4681
25	1.4680	1.4682	1.4675

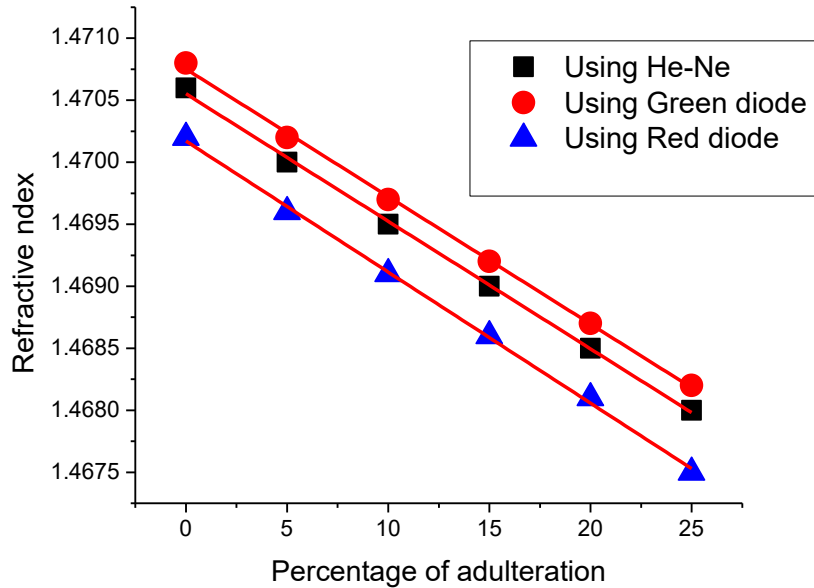


Figure 4.2: The Percentage of Adulteration found Sunflower Oil and palm oil from the Measurement of Refractive Index(n).

The Regression Equations of the graph obtained using different laser light are shown in table 4.4. Using these regression equations we have calculated the refractive index of adulterated edible oils.

Table: 4.5 Results of refractive index versus types of Edibles Oils graph for the three lasers (red diode, green diode and He-Ne) laser.

Source of light	Slopes	Intercept	R ²	Regression equation
Red diode laser	0.005 ± 0.001	1.4702 ± 0.0002	1	$n = -0.005c + 1.4702$
Green diode laser	0.002 ± 0.001	1.4708 ± 0.003	1	$n = -0.002c + 1.4708$
He-Ne laser	0.003 ± 0.001	1.4706 ± 0.005	1	$n = -0.003c + 1.4706$

4.2.2 Refractive Index (n) Of Adulterated Palm oils with Coconut Oils

Figure 4.3 shows comparatively, the refractive index of adulterated Coconut oil with palm oil by volume ratio (v/v %). As can be noticed from this figure 4.3, there are significant differences between the refractive index of Coconut oil with palm oil percentage 0%, 5%, 10%, 15%, 20% and 25%. The single major difference is the wavelength dependence of Refractive Index(n) of Coconut oil, which is Edible Oil as influence of adulterated Palm Oils. i.e linearly Decreasing of Adulterated Coconut oils with Palm oils.

Table 4.6 The Percentage of adulteration found in Coconut oil and palm oil from the measurement of refractive index.

Percentage of adulteration	Refractive Index(n) of adulterated Coconut		
	Using He-Ne	Using Green diode	Using Red diode
0	1.4471	1.4472	1.4469
5	1.4466	1.4467	1.4464
10	1.4461	1.4464	1.4459
15	1.4456	1.4458	1.4454
20	1.4451	1.4453	1.4449
25	1.4446	1.4448	1.4444

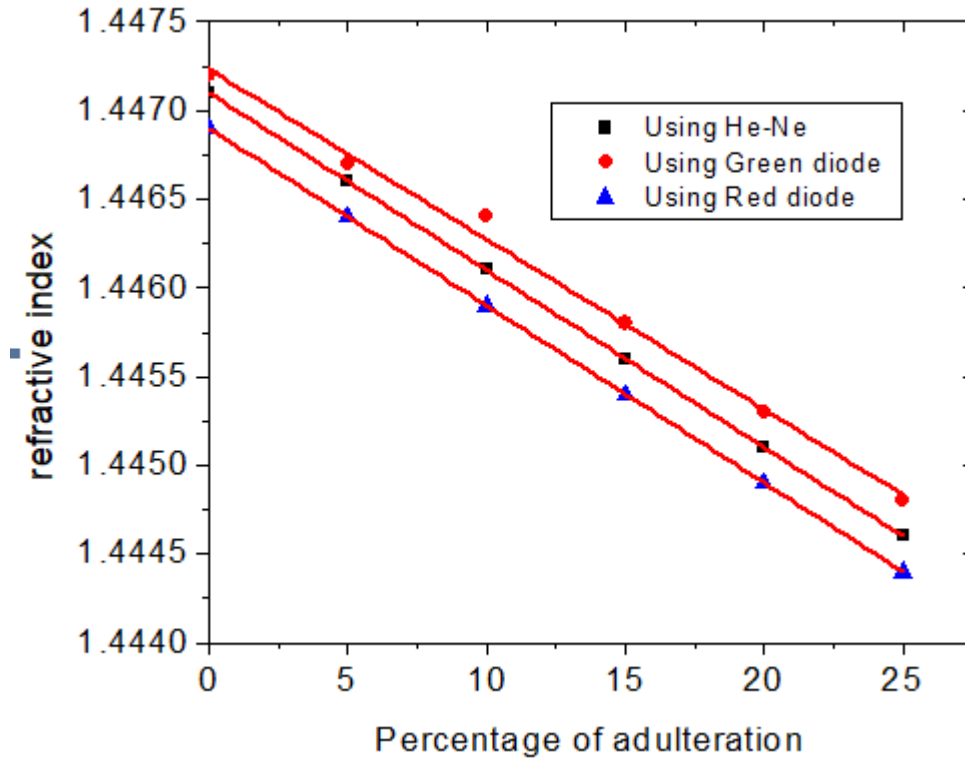


Figure 4.3: The Percentage of adulteration found Coconut oil and palm oil from the measurement of Refractive Index(n).

4.3 Wavelength Dependence Of Refractive Index (n) of Edible Oils and Adulterated Edible Oils

Figure 4.4 shows the Refractive Index(n) versus wavelength graph for different lasers. The graph indicates the Refractive Index(n) of adulterated edible oils decreases as the wavelength of the laser light increases. Hence the obtained results are in a good agreement with the theoretical description expressed in equation (2.44). In equation(2.44), the refractive index decreases exponentially as the wavelength of laser light increases as shown in figure 2.4. From this graph the values of Cauchy's coefficients A and B were determined using non-linear curve fitting. The value of A and B are 0.030305 ± 0.00106 , 32236 ± 1341.4 respectively with $R^2 = 0.887$. A and B are the parameters that depend on the nature of the medium in which the light is propagating.

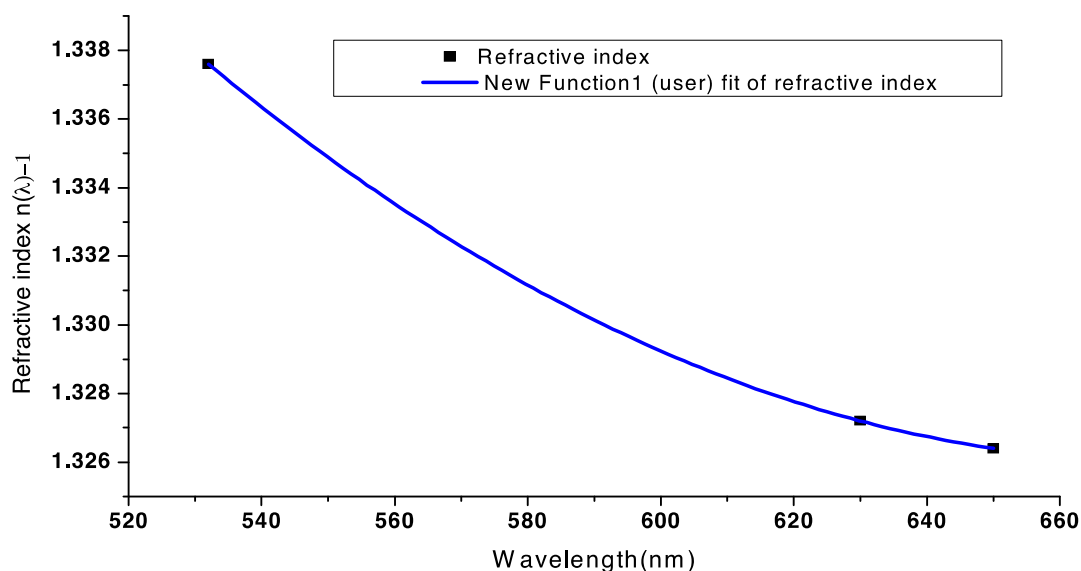


Figure 4.4: Graph of refractive index versus wavelength (532 nm, 632.8 nm, and 650 nm)

5. CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusions

We have been able to Investigate Edible Oils Adulteration Using Prism Spectrometer. The Refractive Index (n) of four standard oils from super market, Ethiopia was determined with accuracy of $\pm 1 \times 10^{-4}$ by using Prism spectrometer. The measurements were performed at room temperature 20°C in the minimum angle deviation $32.680^\circ - 34.691^\circ$. The experimental data were fitted to the simple Cauchy dispersion formula and the results were found to be consistent within the limits of experimental error. In all cases, the refractive index decreased monotonically with increasing wavelength. The refractive indices (n) of these oils have been measured as a function of the concentration (0% up to 25%) palm oils at Red and green diode and He-Ne laser were found to have linear concentration dependency of adulteration percentage. The refractive indices of the studied oils and the uncertainty in their values are calculated. The Lorentz–Lorenz (L–L) formula has been tested and it was found to be valid with a maximum deviation of 0.4% and was used to calculate the percentage of adulteration.

Experimental results showed that this technique could be safely employed to study the dependence of refractive index of adulterated edible oils on their concentration, the types of oils as well as on the wavelength. Then the pure refractive index of selected samples, concentration of adulteration percentage, and wavelength dependent of refractive indices for adulterated oils were determined and these were found that the values are in a good

agreement with the results obtained by other literatures. Therefore, the developed methods can be applied for other types of fluids which can be transmitted light. Refractive index is an important optical parameter to analyze the light rays traversing through materials medium. In laboratory, the refractive index of liquids can be found out by spectrometer using hollow prism. The Abbe's refractometer can also use for finding the refractive index with very good accuracy. Using the two techniques, present study deals with the refractive index and adulteration of oils.

Adulteration represents unhealthy and unethical act of adding prohibited substances to food with a profit motive. In these conditions it is necessary to ensure the authenticity of the food that we consume has intensified more and more in the last period of time all over the world. Usually, low priced oils are mixed with premium oils. Many analytical techniques such as chromatographic methods, differential scanning calorimetry, Fourier transform infrared spectroscopy, etc. can be used to discriminate different oils as well as to detect adulteration.

Any physical parameter should find applications in our day-today life. In this research we proposed a new method for quantitative adulteration of extra virgin olive oil (EVOO) or corn germ oil (CGO) with a mineral oil, such as paraffin oil (PO). The Effect of concentration and wavelength (λ) on refractive index of edible oil adulterated with paraffin, will be Investigate for the rapid, direct measurement of edible oils adulteration using prism spectrometry. In an overview presenting the principal sources of oils, it was concluded that most edible oils are obtained after extraction from seeds, while olive, coconut and palm, are extracted from fruits.

5.2.Recommendations

The Developed Methods can also be Applied for other types of liquid solutions. On top of this, in a future work, the hollow prism industrially made would need to be used to provide better predictive results. The Edible Oils samples need also to be subjected to Refracvtive Index oils, Adulterated Edible Oils and then their concentrations be monitored. Therefore further studies are required to be done in order to see the effects of Adulteration of Edible Oils on the Refractive Index(n) of the pure Edible Oils. It is Advisable to use Abbe refractometer and the concerning bodies like researcher, factory ownership of oils and wholesaler can perform further study collaborator to maintain quality.

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