IN THIS ISSUE

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IMAGE: OBSERVATORY WITH STAR TRAILS ON MOUNTAINS FOR CLEAR SKY

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Supreme Theory of Everything: A New Quantum Concept of the Photoelectric Effect

Ulaanbaatar Tardad

Mongolian University

ABSTRACT

In the early XX century, physicists accepted that Einstein's photoelectric equation was a profound move toward the quantum mechanical description of energy and matter and it is one of the critical equations leading us to quantum physics and mechanics. But looking today the photoelectric effect couldn't be formulated perfectly because the proportionality constant h/e in the equation is linear regression in the very short interval of frequency. Of course, at that time it was. Even now, not only the photoelectric effect but many phenomena haven't been explained in the aspect of classical physics because of that they are not linear, but cyclical. The photoelectric effect hasn't been possible to describe precisely without the open hysteresis of the magnetism. In this paper, the open hysteresis of the photoelectric effect, the Fermi-Dirac distribution, the intensity of the quantum photoelectric effect, the saturation, the influences of the various materials on it, and the area of the hysteresis loop are presented. I examine models that can be solved exactly with the tools of mathematics so that neither approximations nor computer simulations are required.

Keywords: fermi-dirac distribution, the intensity of the photoelectric effect, its saturation, periodicity, influences of the materials, and area of the hysteresis loop.

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I. INTRODUCTION

The photoelectric effect was discovered in 1887 by the German physicist Heinrich Rudolf Hertz. Further research showed that the photoelectric effect represents an interaction between wave and particle that cannot be explained by classical physics, which describes light as an electromagnetic wave. One inexplicable obser vation was that the maximum kinetic energy of the released electrons did not vary with the intensity of the light, as expected according to the wave theory, but was proportional instead to the frequency of the light. What the light intensity did determine was the number of electrons released from the metal (measured as an electric current). Another puzzling observation was that there was virtually no time lag between the arrival of radiation and the emission of electrons. [1] [2] The photon produces the photoelectric effect. The energy resource of the photon is described by the Planck relation. The Planck relation [3][4] (referred to as Planck's energy–frequency relation, [5] the Planck relation, [6] Planck equation, [7] and Planck formula, [8] though the latter might also refer to Planck's law [9]) is a fundamental equation in quantum mechanics which states that E, known as photon energy, is proportional to its frequency, ν:

$$E = h\nu \qquad [3] \qquad (1)$$

Where *h* is Planck's constant

Do the photon's energy and photoelectric effect have this simple relationship? I doubt it. It is imperfect because the Planck relation and photoelectric effect must not be linear but cyclical. This is where problems begin. Planck himself had suspected Formula (1) is linear. So, he developed the nonlinear law of the spectral density of electromagnetic radiation emitted by a black body. But Planck's theory is flawed. [10] Whereas Einstein wasn't hesitated by Formula (1). Consequently, Einstein's law of the photoelectric effect is also incorrect.

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The research aims to present a new description of the photoelectric effect, Fermi-Dirac distribution, the intensity, saturation, area (total energy) of the photoelectric effect, and the influences of various materials on it. Since 2018, in the frame of the project Supreme Theory of Everything (hereafter STE) we have been able to publish some articles concerning open hysteresis, Newton's and Planck's laws, climate change, the fate of the Universe, moreover, Early Mongolian calculus, problems in complex number, and so on.

We scour cooperation and financial support for this perspective project.

II. DISTRIBUTION OF ELECTRONS DURING THE PHOTOELECTRIC EFFECT

2.1 Fermi-Dirac Distribution for The Photoelectrons

There are two methods to determine the distribution of the photoelectrons: Fermi-Dirac statistics and open hysteresis. The open hysteresis is written in Section 3.

The Fermi-Dirac distribution applies to fermions, particles with half-integer spin which must obey the Pauli exclusion principle. [11] Energy distribution in the atom is described by Fermi–Dirac statistics [12], which was first published in 1926 by Enrico Fermi [13] and Paul Dirac. [14] According to Max Born, Pascual Jordan developed 1925 the same statistics, which he called Pauli statistics, but it was not published on time. [15] [16] [17] According to Dirac, it was first studied by Fermi, and Dirac called it "Fermi statistics" and the corresponding particles "fermions". [18] F–D statistics was applied in 1926 by Ralph Fowler to describe the collapse of a star to a white dwarf. [19]. In 1927 Arnold Sommerfeld applied it to electrons in metals and developed the free electron model, [20], and in 1928 Fowler and Lothar Nordheim applied it to field electron emission from metals. [21] Fermi–Dirac statistics continues to be an important part of physics.

Electrons are fermions. Therefore, the Fermi function provides the probability that an energy level at the atom, *E*, in thermal equilibrium with an extensive system, is occupied by an electron.

Let's look closely at how physics describes this probability because of that we can never count electrons. So, Fermi-Dirac statistics gives us the probability of electrons or fermions in some energy levels. The system is characterized by its temperature, *T*, and its Fermi energy, E_f. [22]

The Fermi function is given by

$$f(E) = \frac{1}{1+e^{(E-E_f)/kT}} \quad (2)$$

Where E_f is Fermi level, and T is Kelvin temperature.

Equation (2) is the Fermi-Dirac distribution function at various temperatures in semiconductor physics.
When $T = 0\,K$,

1) $E_2 < E_f;\ f(E_2) = 1$ Its probability of finding the electron is 1 or 100%.
2) $E_1 > E_f;\ f(E_1) = 0$ It shows the probability of 0 above the Fermi level. It means there are no electrons above the Fermi level.
3) $E = E_f;\ f(E_f) = 1/2$ The probability is 50%.

$$f(E) = \frac{}{1+e^{0/0}} = \frac{1}{1+e^0} = \frac{1}{2}$$

$\frac{0}{0}$ *is undefined mathematically*. But according to Early Mongolian calculus, it is equal to 0 (Table 1) [23]:

Table 1: Division by zero in Early Mongolian calculus

Number of cutting	Slice	Comment
10/0	10	There is no action of division. So, the numbers are unchanged.
1/0	1	
0/0	0	
-1/0	-1	
-10/0	-10	

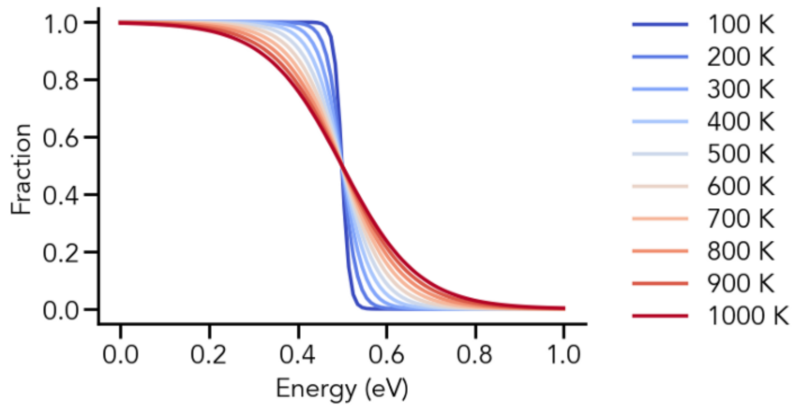


Figure 1: Plot Fermi-Dirac distribution function [24]

Figure 1 shows that electron distribution has saturations and energy distribution increases by the temperature or intensity. It is a good method. The results of our method are the same Fermi-Dirac distribution as shown in Subsection 3.2.

2.2 Einstein's Photoelectric Effect

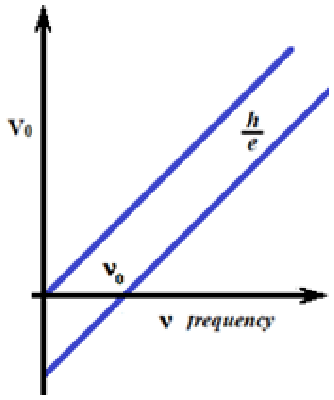
Albert Einstein formulated in 1905 a new corpuscular theory of light in which each particle of light, or photon, contains a fixed amount of energy, or quantum, that depends on the light's frequency. [1][2] He also used Equation (1) to describe the law of the photoelectric effect, but it remained linear. Second, both Planck's and Einstein's theories have no derivations. I have heard somewhere that a law of physics without some form of formula extraction, is not a law of physics, just some magic.

And the logic is also weak: How difficult is it to derive a simple linear law of the form $P + W = E$ expressing an energy balance of energy in and energy out? Is it impossible to derive the law using a wave model of light? [25] The photoelectric effect is a phenomenon in which electrically charged particles are released from a material when it absorbs electromagnetic radiation. The effect is often defined as the ejection of electrons from a metal plate when light falls on it. In a broader definition, the radiant energy may be infrared, visible, or ultraviolet light, X-rays, or gamma rays; the material may be a solid, liquid, or gas; and the released particles may be ions (electrically charged atoms or molecules) as well as electrons. [1] The photoelectric effect refers to the change of electrical conduction properties in matter induced by light and other forms of electromagnetic radiation. To induce this effect, the absorption of incident light by matter should cause a generation of charged carriers, such as conduction electrons and positive holes in the case of a semiconductor, or free electrons (photoelectrons) emitted from a metal surface with immobile positive ions left behind. These two phenomena are called the internal photoelectric effect and the external photoelectric effect, respectively, the mathematical concept was referred to as Einstein's Photoelectric Equation. [26] [27].

$$h\nu = h\nu_0 + K_{max} \tag{3}$$

$$K_{max} = h\nu - h\nu_0 \tag{4}$$

Equation (3) was referred to as Einstein s law of the photoelectric effect. According to this equation, maximum kinetic energy depends linearly on ν and is independent of the intensity of radiation.



Since K_{max} cannot be negative $h\nu$ greater than $h\nu_0$ or $h\nu > h\nu_0$ writing the equation in terms of stopping potential (V_0).

$$eV_0 = h\nu - h\nu_0 \quad (5)$$

$$V_0 = \frac{h}{e} - \frac{\varphi_0}{e} \quad 6)$$

The graph of V_o versus ν is a straight line with a slope equal to h/e and intercept on $X - axis$ ν_0.

Figure 2: The proportionality constant [28-31]

Einstein's law of the photoelectric effect didn't reflect the Fermi-Dirac distribution.

III. A NEW DESCRIPTION OF THE PHOTOELECTRIC EFFECT IN THE SUPREME THEORY OF EVERYTHING

3.1 A New Formula of the Open Hysteresis

Fermi-Dirac distribution is a statistical method for the calculation of unaccountable electrons. We have processed newly formula based on the hysteresis of the electromagnetic phenomenon (Formula (7)). It is the Formula of open hysteresis including the Fermi-Dirac distribution. [32] [33] [34]

According to the STE the amplitude or intensity of the photoelectrons is determined by different intensities (temperatures):

$$F(x) = \frac{t \cdot sin(x-\theta)}{|cos(x)|} \quad (7)$$

Where t is the intensity of the photon energy or amplitude of the function ($F(x)$) or the thickness of a flat slab through which passes the light, θ is the incident angle of the photon and x denotes the degrees of a circle. θ denotes the external influence or applied energy, or force.

Equation (7) may be written by the degree of a circle, but it is expressed by frequency (Equation (8)) as next:

$$\theta = \frac{2\pi}{T}\nu; \qquad E_{photo} = \frac{t \cdot sin\left(\frac{2\pi}{T}(\nu_1 - \nu_2)\right)}{\left|cos\left(\frac{2\pi}{T}(\nu_2)\right)\right|} \quad (8)$$

Where ν_1 is the frequency of the incident photon, ν_2 is the frequency of the refraction ray to the electron, and T is the period of a circle.

The calculation results display in Figure 3.

3.2 Intensity of The Photoelectric Effect and Fermi-Dirac Distribution

To simplify the understanding of photoelectric effect we use Equation (7) without the external forcing θ shown in Subsection 3.2 and Subsection 3.3. In the photoemission process, when an electron within some material absorbs the energy of a photon and acquires more energy than its binding energy, it is likely to be ejected. If the photon energy is too low, the electron is unable to escape the material. Since an increase in the intensity of low-frequency light will only increase the number of low-energy photons, this change in intensity will not create any single photon with enough energy to dislodge an electron. Moreover, the energy of the emitted electrons will not depend on the intensity of the incoming light of a given frequency, but only on the energy of the individual photons. Part of the acquired energy is used to liberate the electron from its atomic binding, and the rest contributes to the electron's kinetic energy as a free particle. [35][36] Because electrons in a material occupy many different states with different binding energies, and because they can sustain energy losses on their way out of the material, the emitted electrons will have a range of kinetic energies. The electrons from the highest occupied states will have the highest kinetic energy. In metals, those electrons will be emitted from the Fermi level. [1] The intensity is the same as the temperature (H). Equation (8) exhibits the different intensity of the electron ejected and their Fermi-Dirac distributions (Figure 3)

$$e(x) = \frac{0.6\sin(x)}{|\cos(x)|}; \quad e1(x) = \frac{0.4\sin(x)}{|\cos(x)|}; \quad e2(x) = \frac{0.2\sin(x)}{|\cos(x)|}; \quad e3(x) = \frac{0.1\sin(x)}{|\cos(x)|} \tag{9}$$

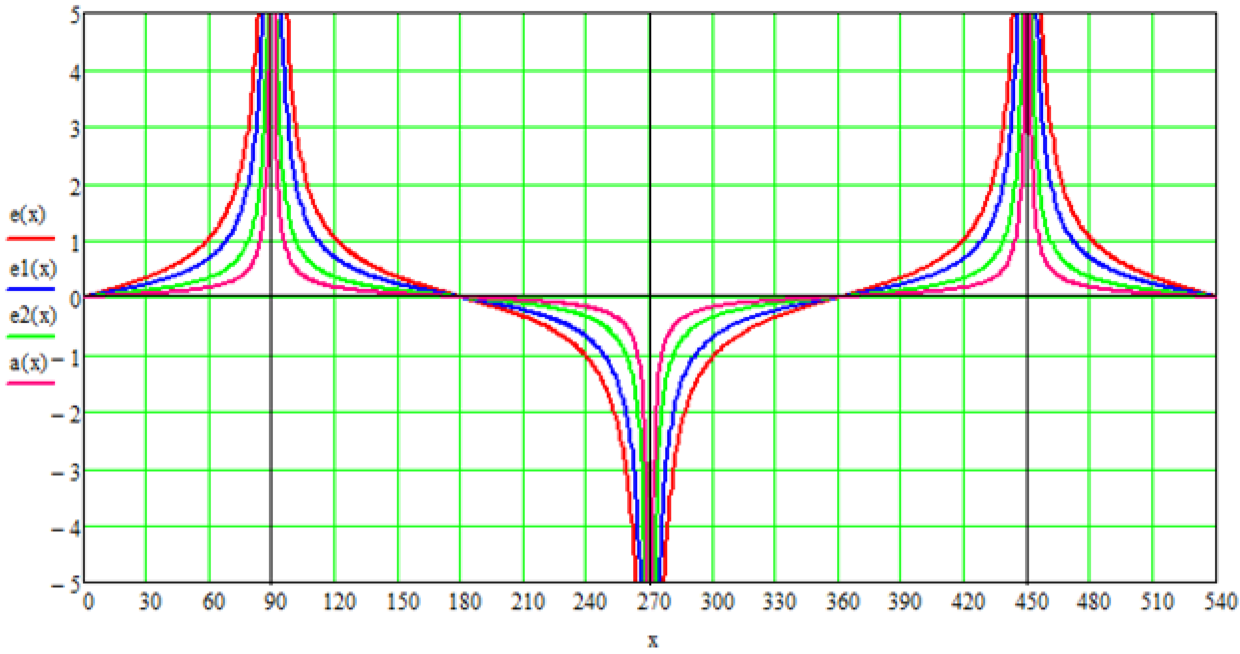


Figure 3: Intensities of the incident quantum energy of a photon or Fermi-Dirac distribution of electron energy

The electrical current saturation doesn't change by the intensity of photon energy. The intensity of the light increases between the angle of 270°-90° (450°) and decreases from 90° to 270°. However, the high intensity is higher between 0° to 180° and lower between 180°-360°(0°), contrary, the low intensity is lower between 0° and 180°, and higher between 180° and 0° (360°).

More specifically, Figure (3) exhibits the Fermi-Dirac distribution described by Equations (7-9) and it locates between 90°-270° and 270°-450° (90°).

Fermi function is a sigmoid function which is a mathematical function having a characteristic "S"-shaped curve or sigmoid curve. [37]

Another calculation result is plotted in Figure 4. The curve illustrates beautiful real data which proves the nature of the photoelectric effect. There isn't a discrepancy or any regression.

The curve (denoted by red dots) reveals not only the real principle of the Fermi-Dirac function but open hysteresis of the photoelectric effect.

We see that the regression on any graph eliminates the live behavior of nature. It is a poor method of statistics.

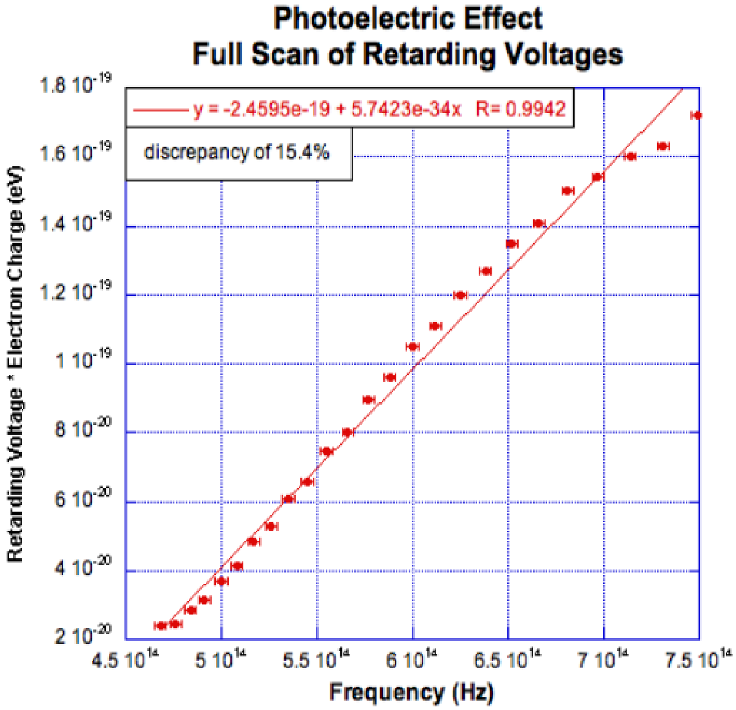


Figure 4: The Fermi function at three different frequencies [38].

This is a nice diagram from [38] that demonstrates how STE works.

3.3 The Saturations of Photocurrent in the Photoelectric Effect

From Figure 3 we can see the saturation of the current lies at 90, 270, and 450 degrees, which are the frequencies or wavelengths. The trigonometric phase displacements in Formula (10) exhibit the saturation of current as shown in Figure 5.

$$a(x) = \frac{10\sin(x)}{|\cos(x)|}; \quad a1(x) = \frac{10\sin(2x)}{|\cos(2x)|}; \quad a2(x) = \frac{10\sin(4x)}{|\cos(4x)|}; \quad a3(x) = \frac{10\sin(8x)}{|\cos(8x)|} \tag{10}$$

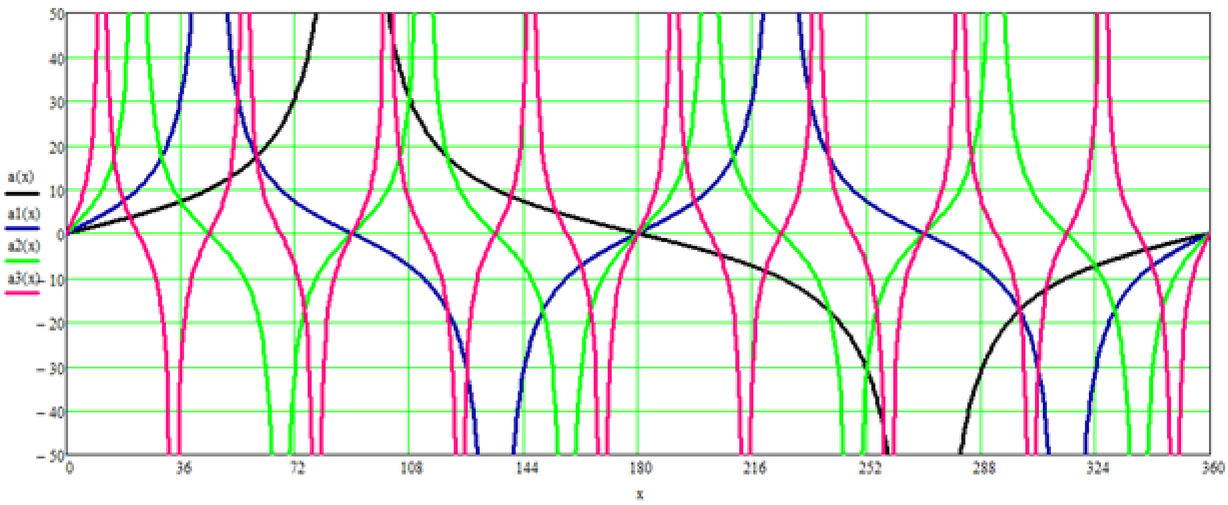


Figure 5: Influences of the phase displacement on the saturation of the electric currents

From Figure 5 the phase changes are 2 times (a1(x)), 4 times (a2(x)), and 8 times (a3(x)) shorter than a(x). The values of the phase decide the material quality of the magnetic materials. A

(x) and a1(x) illustrate the hard magnetic material, and a2(x) and a3(x) indicate the soft magnetic, respectively.

3.4 The Influences of the Various Materials on the Photoelectric Effect

Let the external forcing is active. Equation (7) and Equation (8) are expressing not only a cyclic, periodic nature with memory, saturations, and singularities (Figure 3). But it exhibits the impacts of the material quality on the photoelectric effect (Figure (6)).

The photon has gone already on the surface of the metal and gives constant kinetic energy to electrons (yellow zone). But the frequency further increases, and the working function of the electron increases (Figure 6). In other words, photon energy expends only for the working function of the electron eject.

We see the emitted electron's working function and kinetic energy exist simultaneously at a given ν_2 frequency.

Because of that, the photoelectric effect consists of working energy and kinetic energy simultaneously at every frequency. We experience no time lag between the arrival of radiation and the emission of electrons. Second, light, particle, or wave, still needs no pre-existing medium. [35] What it means is that the photoelectric effect needs no pre-existing medium.

One inexplicable observation of the photoelectric effect is the high influences of the different materials which are described by Equation (11) and Equation (12). It is also Fermi level exhibits shown in Figure 7 and Figure 8.

$$E_F = \frac{t \cdot sin(\theta_1 - \theta_2)}{|cos(\theta_2)|} + b \qquad [32] \qquad (11)$$

Where b is the energy state which differs in various materials.

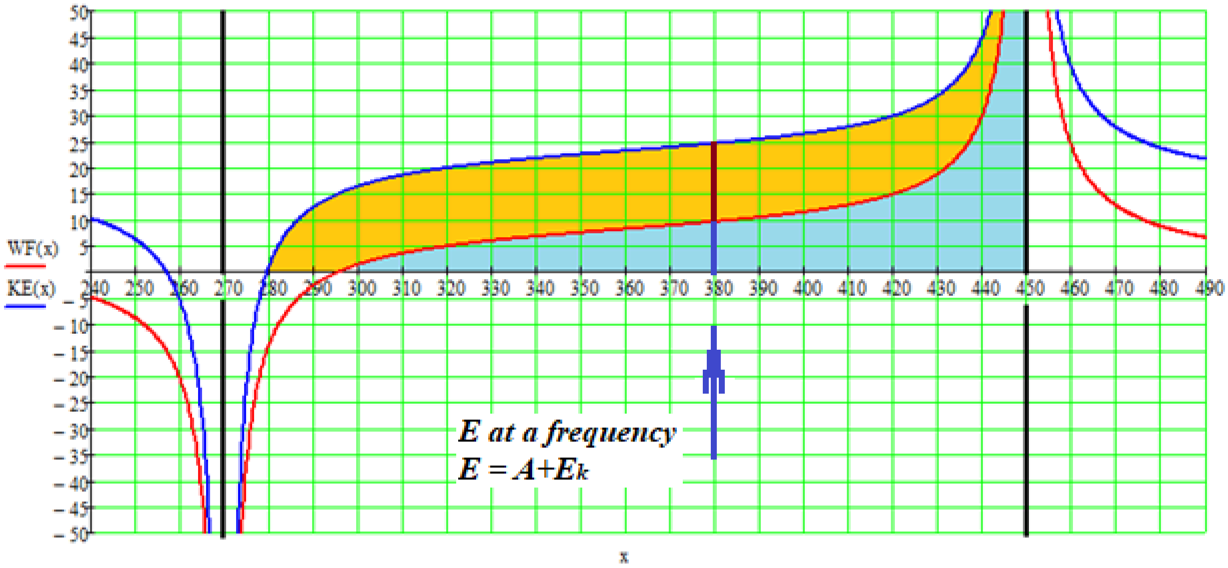


Figure 6: Working function (light blue color) and kinetic energy (yellow) of an electron at a frequency in the open hysteresis

Term b is nothing more than the influences of different materials over the Fermi level.

When the photoelectrons are produced, however, their number is proportional to the intensity of light. [39] [40]

$$e(x) = \frac{5\,\mathrm{si}}{|\cos x|} + 0 \quad e1(x) = \frac{5\sin x}{|\cos x|} + 5 \quad e2(x) = \frac{5\sin x}{|\cos x|} + 10 \quad a(x) = \frac{5\sin x}{|\cos x|} + 15 \tag{12}$$

There is a cut off frequency, but neither proportionality constant h/e, nor a Planck constant anywhere.

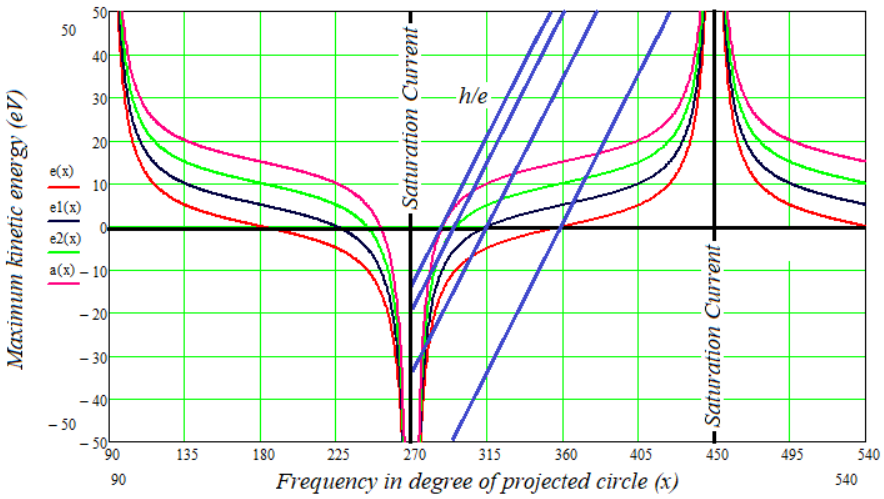


Figure 7: Fermi-Dirac distributions of the photoelectric effects in the different materials (blue lines are the proportionality constant (h/e) as in Einstein's equation)

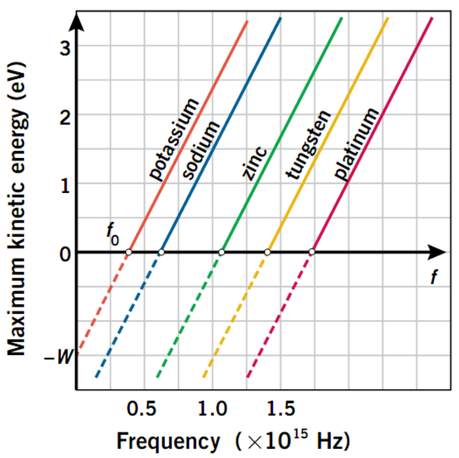


Figure 8: Threshold frequencies of the various materials in the photoelectric effect

Figure 7 and Figure 8 illustrate that there is a definite cut-off frequency below which electrons cannot be ejected by any substance. The kinetic energy of emitted electrons depends on the frequency of incident light on the substance. There is no stopping potential because it determines by the eigenvalue of a circle.

Einstein's approach is a linear regression (blue) for the photoelectric effect. A and E_k showed in Equation (11) change for different materials (Figure 9).

And the horizontal axis is the Fermi level.

The value of f_0 (our symbol is ν_0) depends on the type of metal used. Figure 8 illustrates the present scientific concept. [30] [31][40-42]

As shown in Figure 7 the high-intensity purple light will eject many high-energy electrons. The low-energy red light hits the metal as low-energy photons. These photons "bump" low-energy electrons off of the metal. If the intensity of the light increases, then more low-energy photons hit the plate and more low-energy photons are ejected. By shining the high-energy blue light on the plate, high-energy photons hit the plate and energetic electrons are knocked off. [38]

See the following Subsections for why open hysteresis is the basis of the photoelectric effect.

3.5 Area of the Hysteresis Loop

The area of the hysteresis loop indicates the total energy of the photoelectric effect. The calculation of the hysteresis loop area was impossible. How can we calculate the area enclosed by the hysteresis loop? It has not been resolved until now without opening the hysteresis. Multitude theories and models were born for clarifying the hysteresis problem for a long time. Finally, the hysteresis loop opened in 2018. [32]-[34] [43-47] Its Formula has displayed in Equation (7) and Equation 8).

If we are interested in the spin-up, and spin-down electrons their open hysteresis is written by the STE by Equation (13) (Figure 9) as follows:

$$E_{\downarrow} = \frac{t \cdot sin((\theta_1+\theta_2))}{|cos(\theta_2)|} = \frac{t \cdot sin\left(\frac{2\pi}{T}(v_1+v_2)\right)}{\left|cos\left(\frac{2\pi}{T}(v_2)\right)\right|}$$
$$E_{\uparrow} = \frac{t \cdot sin((\theta_1-\theta_2))}{|cos(\theta_2)|} = \frac{t \cdot sin\left(\frac{2\pi}{T}(v_1-v_2)\right)}{\left|cos\left(\frac{2\pi}{T}(v_2)\right)\right|} \quad (13)$$

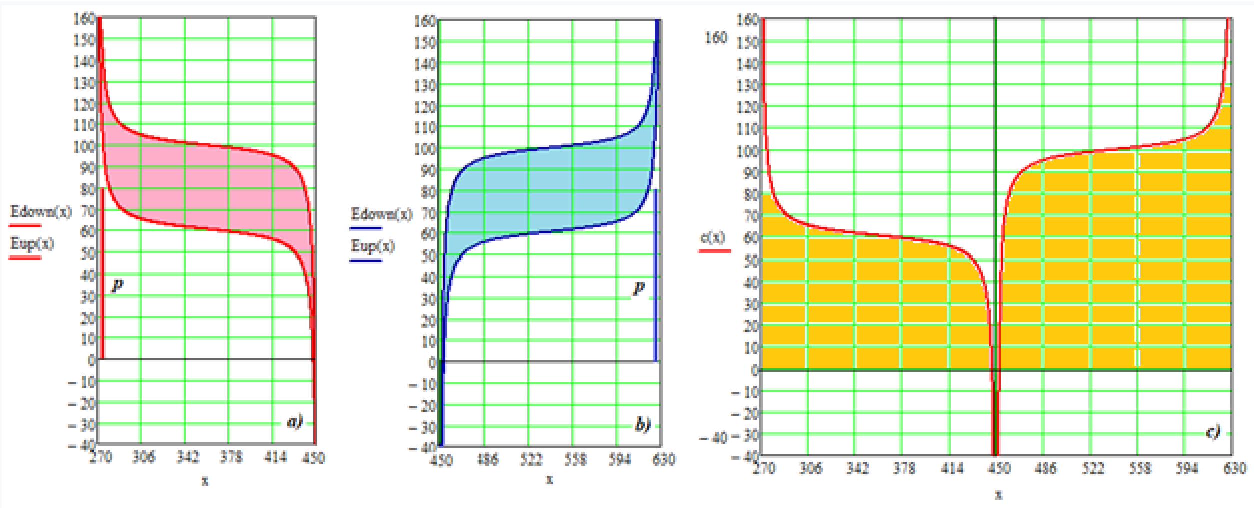
Where θ_1 is Fermi energy, θ_2 is the phase displacement

Formula (13) itself includes the spin-up and spin-down energies selectively by frequency (Figures 9a and 9b). If the influences of the materials on the photoelectric effect are important that *b* parameter is inserted into the total energy formula.

Hence, the total energy of the electron ejected is described by the area of the hysteresis loop (Figure 9c) as follows:

$$E = t \cdot \left(\int_{450}^{630} \left(\frac{sinsin\left(\frac{2\pi}{T}(v_1 - v_2)\right)}{\left|coscos\left(\frac{2\pi}{T}(v_2)\right)\right|} + b \right) dv_2 - \int_{270}^{450} \left(\frac{sinsin\left(\frac{2\pi}{T}(v_1 - v_2)\right)}{\left|coscos\left(\frac{2\pi}{T}(v_2)\right)\right|} + b \right) dv_2 \right) \quad (14)$$

Where *b* is the material constants



a) Left reverse hysteresis and b) right reverse hysteresis and
c) open hysteresis of the right reverse transition [10] [32]-[34] [43]-[47]

Figure 9: The total energy of the photoelectrons

The area of hysteresis gives the amount of energy lost in applying the external magnetic field. Large the area, the more energy is lost. The lesser the area, the least energy is lost. Depending upon the amount of area of the curve, the magnetic materials are classified into two types: Soft magnetic materials, and hard magnetic materials.

The area under the hysteresis curve gives us the energy loss or work done in magnetizing and demagnetizing a ferromagnetic substance up to several teslas to determine its coercivity and retentivity. [48].

IV. CONCLUSION

Based on the above materials we conclude as next:

i. The ultimate formula of the photoelectric effect is:

$$E = \frac{t \cdot sin(\theta_1 - \theta_2)}{|cos(\theta_2)|} + b$$

ii. The energy of the photon is constant during the photoelectric effect which is not linear but it changes cyclically.

iii. The intensity of the electron differs in every quarter of a circle. For example, the intensity of the electron increases between the angles of 270°-90° and decreases from 90° to 270°. But we see that the high intensity of the electron is higher than the lower intensity from 0° to 180°, and is lower than the low intensity of the electron from 180° to 360° (0°).

iv. There is a definite cut-off value of frequency below which electrons cannot be ejected. Every material has its cutting frequency.

v. There is no stopping potential in the photoelectric offset.

vi. The working energy of emitted electrons depends on the frequency of incident light (photon).

vii. The energy of the photon or kinetic energy of the ejected electrons is described by the area of the hysteresis loop.

viii. The open hysteresis of the photoelectric effect has a memory and saturation limit of frequency.

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ABSTRACT

Essential oil was extracted from the leaves of Hyptis suaveolens by hydro-distillation. The Mosquitocidal activity, mosquito larvae (larvicidal) and mosquito repellency effect was carried-out using standard methods. Percentage yield of the essential oils was gotten as 0.05, for the larvicidal activity dose dependent mortality of the larvae was observed; there was low mortality rate at lower dosage and not significantly different from each other e.g. 6.25 and 12.50ppm had same LC_{50} and LC_{90} of 25.21 and 302.67 respectively, 25ppm had LC_{50} and LC_{90} of 9.58 and 352.46 respectively, while 50-1000ppm had LC_{50} and LC_{90} of 0.55 and 0.85 respectively. It was observed that the amount of air that enters and leaves the cage affect the rate at which mosquitoes were repelled. In a group of mosquitoes kept in a cage with all sides open (ASO) 65% of the mosquitoes were repelled within 30 minutes while for one side open (OSO) and all sides closed (ASC), 73% and 85% of the mosquitoes were repelled within the same time frame. In a second experiment, 100% of mosquitoes were repelled from the surface of rats with shaven skin where essential oil was applied. The essential oil also demonstrated dose dependent mosquitocidal activity with LC_{50} and LC_{90} values of 6 and 21ppm respectively.

Keywords: hyptis suaveolens, essential oils, mosquitocidal, larvicidal.

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ABSTRACT

Essential oil was extracted from the leaves of Hyptis suaveolens by hydro-distillation. The Mosquitocidal activity, mosquito larvae (larvicidal) and mosquito repellency effect was carried-out using standard methods. Percentage yield of the essential oils was gotten as 0.05, for the larvicidal activity dose dependent mortality of the larvae was observed; there was low mortality rate at lower dosage and not significantly different from each other e.g. 6.25 and 12.50ppm had same LC_{50} and LC_{90} of 25.21 and 302.67 respectively, 25ppm had LC_{50} and LC_{90} of 9.58 and 352.46 respectively, while 50-1000ppm had LC_{50} and LC_{90} of 0.55 and 0.85 respectively. It was observed that the amount of air that enters and leaves the cage affect the rate at which mosquitoes were repelled. In a group of mosquitoes kept in a cage with all sides open (ASO) 65% of the mosquitoes were repelled within 30 minutes while for one side open (OSO) and all sides closed (ASC), 73% and 85% of the mosquitoes were repelled within the same time frame. In a second experiment, 100% of mosquitoes were repelled from the surface of rats with shaven skin where essential oil was applied. The essential oil also demonstrated dose dependent mosquitocidal activity with LC_{50} and LC_{90} values of 6 and 21ppm respectively.

Keywords: *hyptis suaveolens,* essential oils, mosquitocidal, larvicidal.

I. INTRODUCTION

A synthetic insecticide is a poisonous chemical or mixture of chemicals that is intended to prevent, repel, or kill any insect or pest. However, synthetic insecticides present hazardous impacts far beyond their intended targets. Insecticides have inherent toxicity because they are designed to kill living organisms that are considered "pests", that is any unwanted insect. Many insecticides are known to pose significant, acknowledged health risks to people—including birth defects, damage to the nervous system, disruption of hormones and endocrine systems, respiratory disorders, skin and eye irritations and various types of cancers (Agency for Toxic Substances and Diseases Registry, 1994).

Chemical repellents are important in protecting people from blood-feeding insects such as mosquito, ticks, mites, and other arthropods and may therefore also reduce transmission of arthropod borne diseases. N, N-diethyl- 3-methyl benzamide (DEET) is one of the most well-known arthropod repellents and has been in the market for almost half a century. DEET is effective against many different blood-sucking arthropods. The protection efficacy depends on the type of formulation, application pattern, species, and feeding behavior of the arthropod. DEET is generally safe for topical use if applied as recommended, although adverse effects such as serious neurologic effects have been reported. Many people consider that DEET and related compounds as a health and environmental hazard. It does not readily degrade by hydrolysis at environmental pHs and has been identified as a ubiquitous pollutant in aquatic ecosystems. Concern about the deleterious effects associated with synthetic chemicals has revived interest to explore plants as a source of natural insecticides, acaricides, and repellents for medical, veterinary and crop protection use (Abagli and Alavo, 2011).

Plants are endowed with a potential to produce a wide range of allele-chemicals that protect the plants from insect-pests. (Ramya, *et. al.*, 2008). Mechanisms were developed to repel phytophagous pests, i.e. protective hairy or waxy surfaces, hardened cuticles or tissues or the

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cellular production of repellent and toxic chemicals. In most cases these protective devices are sufficient to repel generalists among the phytophagous insects (Kiprop, *et. al.*, 2005; Din, *et.al.*, 2011).

In developing countries, Lamiaceae have traditionally been used for their insecticidal and repellent properties against several insects' species. Most of them belong to the *Hyptis* genus that includes more than 400 species that grow in the tropical regions of the world, mainly in Africa and America and are highly aromatic plants (Shenoy, *et. al.*, 2009; Benelli, *et. al.*, 2012).

Hyptis suaveolens (L.Poit) is one of the aromatic and odoriferous important traditional plants belonging to the family lamiaceae, an ethno-botanically important medicinal plant. The plant has been considered as an obnoxious weed. It is a brushy erect plant with fragrant hairy cordate. (Gavani and Paarakh, 2008; Shenoy, *et. al.*, 2009; Moreira, *et. al.*, 2010; Singh, *et. al.*, 2011; Malar *et. al.*, 2012; Agarwal, *et. al.*, 2013; Noudogbessi, *et. al.*, 2013; Islam, *et. al.*, 2013; Umedum, *et. al.*, 2014; Islam, *et. al.*, 2014). *Hyptis suaveolens* is a medium aromatic shrub found in the tropics and subtropics, and distributed as the aggressive annual weedy species in the northern part of Thailand. The plant is native to tropical America but now distributed throughout the whole world from tropical to subtropical regions and, therefore, the plant is sometimes regarded as pan-tropical, it is a soft ruderal weed that normally grows along the roadsides and the wet margins of ponds. (Gavani and Paarakh, 2008; Shenoy, *et. al.*, 2009; Moreira, *et. al.*, 2010; Singh, *et. al.*, 2011; Malar, *et. al.*, 2012; Agarwal, *et. al.*, 2013; Noudogbessi, *et. al.*, 2013; Islam, *et. al.*, 2013; Umedum, *et. al.*, 2014; Islam, *et. al.*, 2014).

II. MATERIALS AND METHODS

2.1 Plant Material

Fresh *Hyptis suaveolens* leaves were used in the experiment for the extraction of essential oil via hydro-distillation.

2.2 Other Materials

Anopheles' mosquito larvae were identified and gotten from the drainage in Samaru, Zaria along Sokoto Road, Nigeria. Some of the larvae were allowed to pupate and transform to the adult mosquito.

2.3 Chemicals and Reagents

All chemicals and reagents were of analytical grade.

2.4 Equipments

Round bottom flask, water condenser, Erlenmeyer flasks, separating funnel, glass bottles with tight cover, paper tape, Cardboard papers, Aluminium cage with wire gauge, Cage made of Mosquito net with wooden support, plastic containers and petri dishes.

2.5 Methods

Plant Material Collection and Identification

The plants were collected from Samaru area of Zaria, Kaduna-Nigeria. They were then taken to the herbarium, department of Biological Science for identification. Voucher specimen number 2020 was deposited. More of the plant leaves were then plucked and taken to the laboratory for further use.

2.6 Extraction of Essential Oil from Hyptis suaveolens leaves

Hyptis suaveolens (1kg) leaves were washed and placed in round bottom flasks of the hydro-distillation set up with 1liter distilled water. The round bottom flask was then heated on heating mantle for 2 hrs. The essential oil evaporated due to the heat, it was cooled and collected as distillate (mixture of essential oil and water). This was transferred to a glass separating funnel and the essential oil separated from the water based on density. Percentage yield of the essential oil extracted was then calculated using this formula;

$$\%\ \text{yield} = \frac{mass\ of\ product}{Mass\ of\ sarting\ material} \times 100$$

2.7 Mosquito Breeding

Some of the collected mosquito larvae were taken to the laboratory washed three to four times and introduced into a clean transparent glass container; the container was placed in a mosquito cage that was prepared for the experiment. Cracker biscuit powder was sprinkled into the glass container which serves as food for the larvae. The 3^{rd} and 4^{th} instar larvae were collected and used according to WHO 2005 guidelines for the larvicidal bioassay. For mosquito repellency determination, the larvae were left to pupate, transform into adult stage and remain in that same cage for at least 24 hours before introducing them into another cage for repellency experiment to be carried out. They were left for 24 hours prior to the commencement of the experiment so as to be strong to be sure that whatever behavior that will be observed will not be due to their fragility.

2.8 Determination of Mosquitocidal Capability of the Essential oil

In this experiment 25 adult mosquitoes each were introduced into a separate mosquito cages and tagged 1-6. Group 1 had no essential oil and therefore served as control, group 2 had 1 ml essential oil, group 3 had 2 mls essential oil, group 4 had 3 mls essential oil, group 5 had 4 mls essential oil while group 6 had 5 mls essential oil dropped into a container in the cages according to the method described by Bulugahapitiya, *et. al.,* 2007. The mosquitocidal effects of the essential oil were observed and records taken at the end of 90 minutes in all the groups.

2.9 Determination of Mosquito Repellency Effect of Essential oil

This was carried out by modified method of Bulugahapitiya, *et. al.,* 2007. Large cages were prepared by introducing 1 ml of the essential oil into each cage containing 25 adult mosquitoes. The behavior of the mosquitoes was then observed and recorded at 30 minutes, 40 minutes, 60 minute and 90 minutes respectively. The control group was set up with pure acetone and no essential oil. The test groups were three; group one was carried out under 100% aeration, group two was done under 20% aeration and group three under 0% aeration.

All the above methods were repeated three times.

2.10 Determination of Mosquito Repellency Activity of Essential oil of Hyptis suaveolens leaves on Rats

Mosquitoes (25 adults) were introduced into each three separate cages grouped I, II and III. Restrained rats (3) each were also introduced into the cages. The rats had their back hairs scrapped off and essential oil (0.5 ml) applied on the bare skin of group one (test rats). The other two groups served as control. Group two (II) had no essential oil applied to the scrapped skins but glycerine. Group three (III) had no essential oil or glycerine applied to their bare skins. The number of mosquito bites were counted at the end of 90 minutes by observing red spot on the scrapped area due to the effect of bite on the rats' bare skin.

2.11 Test for Larvicidal Effect of the Essential oil (WHO, 2005)

Essential oil concentrations of 6.25 ppm, 12.50 ppm, 25 ppm, 50 ppm, 100ppm, and 1000ppm were prepared from 1% stock solution. For each of the above concentrations using 25 larvae in their 3^{rd} and 4^{th} instar, numbers of dead larvae were counted after 6 hours, 12 hours and 24 hours. A control group was set up for the same timing without the essential oil.

III. RESULTS

3.1 Extracted Essential Oil from Hyptis Suaveolens Leaves

The quantity of essential oil obtained from three (3) independent extractions using 1 kg in each case of leaves of *Hyptis suaveolens* is presented in Table 1. An average quantity of 0.4-0.5 mls was extracted and the average yield was 0.1%. The oil is a clear liquid with physical appearance of pale yellow.

Table 1: Extracted Essential oil from *Hyptis suaveolens* leaves

Weight of leaves used	Quantity of oil obtained
One (1) kilogram	0.5 mls
One (1) kilogram	0.6 mls
One (1) kilogram	0.4 mls
Average quantity extracted	0.5 mls
Percentage yield of essential oil extracted	0.05

3.2 Mosquitocidal capability of Essential oil from Hyptis suaveolens leaves

Essential oil from *Hyptis suaveolens* leaves showed mosquitocidal activity against adult mosquitoes. At the end of 90-minute observation of mosquitocidal effect, all the mosquitoes in different groups except those in control group were not active. In the first cage, that is, the group with 1 ml essential oil 16 % were knockdown (dead) while the remaining 84% were seen resting on the wall, all far from the petri dish where the essential oil was placed. In the group with 2mls essential oil, 72% were inactive far away from the essential oil while 28% were knockdown (dead). As the concentration increases the percentage of dead mosquitoes increases and the inactive ones in all cases were seen far away from the essential oil. At 3mls 36% were knockdown (dead) and 64% weakened while at 4mls, 40% were knockdown (dead) and 60% weakened. At 5mls, 44% were knockdown (dead) while 56% were weakened (not active).

Table 2: Mosquitocidal potential of the *Hyptis suaveolens essential* oil

Amount of essential oil (mls).	Time (mins)	Percentage dead (%)	Percentage inactive (%)
0	90	0	0
1	90	16	84
2	90	28	72
3	90	36	64
4	90	40	60
5	90	44	56

N = 25. $LC_{50} = 6.20$ *and* $LC_{90} = 21.28ppm$

3.3 Repellency property of Hyptis suaveolens Essential oil

The mosquito repellency property of *Hyptis suaveolens* essential oil under 100% Aeration is presented in table 3. Essential oil from *Hyptis suaveolens* leaves had strong repellency effect against mosquitoes. In this study 1 ml of the essential oil repelled 65.32% of 25 adult mosquitoes within a period of 30 minutes. At 40 minutes 73.32% of the mosquitoes were repelled, at 1-hour post application, 77.32% of the mosquitoes were completely repelled from the source of the essential oil not only were they repelled but were weakened as they were observed to be resting on the wall of the net far away from the source of the essential oil.

Table 3: Repellency property of *Hyptis suaveolens* essential oil at 100% aeration

Amount of essential oil (mls)	Time (Mins)	Active Mean/SD	Percentage Active (%)	Inactive Mean/SD	Percentage Inactive(%)	Mortality (%)
1	30	8.67 ± 1.25^{b}	34.68	16.33 ± 1.25^{a}	65.32	0
1	40	6.67 ± 1.25^{ab}	26.68	18.33 ± 1.25^{ab}	73.32	0
1	60	5.67 ± 1.25^{a}	22.68	19.33 ± 1.25^{b}	77.32	0
1	90	7.33 ± 0.94^{ab}	29.32	17.66 ± 0.94^{ab}	70.64	0

Group one (1), N=25.LC_{50} = 0.061 and LC_{90} = 183.078ppm. Means with different letters are statistically different ($p \leq 0.05$)

Table 4 shows the result of group two (2) conducted under 20% aeration. At 30 minutes after application, 73.32% of 25 adult mosquitoes were repelled from the source of the oil. The increase in percentage repellency within the same time frame may be due to level of aeration that is less in this second group which builds up the concentration of the essential oil considering its volatility.

Table 4: Repellency property of *Hyptis suaveolens* Essential oil 20% aeration

Amount of essential oil (mls)	Time (Mins)	Active Mean/SD	Percentage Active (%)	Inactive Mean/SD	Percentage Inactive (%)	Mortality Mean/SD	Percentage Mortality (%)
1	30	6.67 ± 1.57^{b}	26.68	18.33 ± 2.05^{a}	73.32	0	0
1	40	3.00 ± 2.16^{a}	12.00	22.00 ± 2.16^{b}	88.00	0	0
1	60	0.33 ± 0.47^{a}	1.32	23.33 ± 0.47^{b}	93.32	1.33 ± 0.47	5.32
1	90	0.00 ± 0.00^{a}	0.00	22.67 ± 0.94^{b}	90.68	2.33 ± 1.33	9.32

Group two (2), N =25. LC_{50} = 0.572 and LC_{90} = 2. 005ppm. Means with different letters are statistically different ($p \leq 0.05$).

A third group recorded in Table 5 was done under 0% aeration; the repellency effect was higher in this group. At 30-minute post application 85.32% were repelled from the essential oil, at 40 minutes 97.32% were repelled at 60 minutes there was 100% (88% repelled and 12% dead) repellency and at the end of 90 minutes 100% repellency (84% repelled and 16% dead) was recorded also. In all groups the repelled mosquitoes were weak, unable to fly and resting on the wall of the cage far away from the essential oil.

Table 5: Repellency effect of *Hyptis suaveolens* Essential oil 0% aeration

Amount of essential oil(mls)	Time (Mins)	Active M/SD	Percentage Active (%)	Inactive M/SD	Percentage Inactive (%)	Mortality Mean/SD	Percentage Mortality (%)
1	30	3.67 ± 0.47^{b}	14.68	21.33 ± 0.47^{ab}	85.32	0.00	0.00
1	40	0.67 ± 0.47^{a}	2.68	24.33 ± 0.47^{c}	97.32	0.00	0.00
1	60	0.00 ± 0.00^{a}	0.00	22.00 ± 0.00^{b}	88.00	3.00 ± 0.00	12.00
1	90	0.00 ± 0.00^{a}	0.00	21.00 ± 0.00^{a}	84.00	4.00 ± 0.00	16.00

Group three (3), N =25.LC_{50} = 0.511 and LC_{90} = 1.178ppm. Means with different letters are statistically different ($p \leq 0.05$)

3.4 Control groups

Control was set up for each of the three group without essential oil but conditions remain unchanged (aeration of 100%, 20% and 0%) and in all cases the mosquitoes were actively flying through out, the results are shown in tables 6, 7 and 8.

Table 6: Repellency property of *Hyptis suaveolens* Essential oil at 100% aeration (control)

Amount of essential oil (mls).	Time (Mins.)	Percentage Repellency (%)	Percentage Mortality (%)
0	30	0	0
0	40	0	0
0	60	0	0
0	90	0	0

N= 25

At the end of 90 minutes there was 100% repellency in the first group, this has been proven by zero number of bites on shaven dorsal part of rats. In the second group with 0.5mls glycerine on the bare skin there was 46.67% of bites at the end of 90 minutes. In the third group with nothing applied on the bare skin of the rats, 45.33% bites were recorded at the end of 90 minutes. Table 9 shows the summary of this experiment.

Table 9: Summary of repellency effect of *Hyptis suaveolens* Essential oil

Amount of essential oil (mls).	Time (Mins)	Percentage Repellency (%)	Percentage Mortality (%)
0	30	0	0
0	40	0	0
0	60	0	0
0	90	0	0

3.5 Larvicidal Property of Essential oil from Hyptis suaveolens

Hyptis suaveolens essential oil has shown very strong larvicidal properties against mosquito larvae. There is low mortality rate at lower dosage and not significantly different from each other. At a concentration of 6.25ppm the mortality rate is 4% over a period of 6 hours, same concentration at 12 and 24 hours gave mortality rate of 11%. The Lc50 and Lc90 at this concentration were 25.206 and 302.669 respectively and a regression equation of Y= 818.6x-161.36. At a concentration of 12.50ppm a mortality rate 4% was recorded at 6 hours, at 12 and 24 hours 13% mortality were recorded, same Lc50, Lc90 and regression equation with 6.25ppm. At concentration of 25.00ppm 20% mortality rate was recorded for 6 hours and 30% for both 12 and 24 hours, the Lc50, Lc90 and regression equation are 9.575, 352.458 and Y=0.7264x+0.2465 respectively. There are no significant differences at 50ppm, 100ppm and 1000ppm, the mortality rate was 100% for the period of 6 hours, 12 hours and 24 hours with Lc50, Lc90 and a regression equation of 0.549, 0.853 and Y=0.7264x+0.2465 respectively. There was no record of death in the control even after 24 hours. The summary of the larvicidal properties are recorded in Table 10.

Table 10: Larvicidal property of essential oil from *Hyptis suaveolens* leaves

Concentrations (ppm).	Time (hours)	Percentage Mortality (%)	Lc50	Lc90	Regression Equation
6.25	6	4	25.206	302.669	Y=818.6x-161.36
	12	11			
	24	11			
12.50	6	4	25.206	302.669	Y=818.6x-161.36
	12	13			
	24	13			
25	6	20	9.575	352.458	Y=1695.8x-360.07
	12	30			
	24	30			
50	6	100	0.549	0.853	Y=0.7264x+0.2465
	12	100			
	24	100			
100	6	100	0.549	0.853	Y=0.7264x+0.2465
	12	100			
	24	100			
1000	6	100	0.549	0.853	Y=0.7264x+0.2465
	12	100			
	24	100			
Control	6	0			
	12	0			
	24	0			

Larvicidal overall $Lc_{50} = 3.579$

$Lc_{90} = 13.828$

Overall Regression equation=$y = 0.2868e^{0.1402x}$

Overall $R^2 = 0.9959$

IV. DISCUSSION

The clear liquid oil with physical appearance of pale yellow is same with all previous work. Essential oil yield of about 0.4-0.6ml/kg (equivalent to 0.1%) got in this studies is same with the work of Raizada (2006) who got a percentage yield of 0.1 from the same plant, never the less it is low compared with the work of the following researchers; Iwalokun *et. al.*, (2012) a percentage yield of 0.31 and Okonogi, *et. al.*, (2005) percentage yield of 0.21; The difference in percentage yield could be due to the moisture level of the leaves and the chemotypic profile of the *Hyptis suaveolens* strains analysed (Iwalokun, *et. al.*, 2012). Latitude, altitude, soil composition, climate and genetic composition are factors that have been implicated for chemotype variations in *Hyptis suaveolens* and other species of *Hyptis* as well as other aromatic herbs belonging to the Lamiaceae family (Iwalokun, *et. al.*, 2012). Various bioactive compounds were recovered from the essential oil samples of this chemotypes with variations in yield, composition and pharmacological effects (Iwalokun, *et. al.,* 2012). Mandal, *et. al.*, (2007) got the following percentage yield from the same plant using several solvents which are Steam distillation (yield: 0.24%), petroleum ether extract (yield: 1.6%) and ethanol extract (yield: 2.64%); Bachheti, *et. al.*, (2013) got a percentage yield of 17.44 from seed oil and not leave oil; Shenoy, *et. al.*, (2009) reported percentage yield of 4.78% for Petroleum ether, 8.52% for Solvent ether, 3.30% for Chloroform, 5.48% for Alcohol and 15.22% for Chloroform water; Gavani and Paarakh, (2008) got a percentage yield of 4.86% methanol extract. The difference in these studies and the present work could be due to the different solvents used and in one case different part of the plant, apart from the above mentioned factors.

Mosquitocidal capability against adult mosquitoes could be due to the presence of terpenes in the essential oil as reported by Bala *et. al.*, (2020). Terpenes are generally known to have insecticidal capability. Earlier work done by Olotuah, (2013) showed that essential oil from *Hyptis suaveolens* leaves has insecticidal activities against several insects. Adda, *et. al.*, (2011) also showed that essential oil from *Hyptis suaveolens* leaves has larvicidal activity against some insects, all these could be as a result of terpenes in the plant as reported by Bala *et. al.*, (2020)

The strong repellent activity against mosquitoes as seen in this work is still connected to the presence of terpenes. This agrees with the work of Benelli, *et. al.,* (2012) where the essential oil repels some insects such as *Sitophilus granarius* which kept distance from source of the essential oil that was applied on white man filter paper. As expected the repellency effect is concentration dependant, this goes in line with the work of Abagli and Alavo (2011) which showed that essential oil from *Hyptis suaveolens* has strong repellency property towards mosquitoes. The higher the concentration the higher the repellency property. In their work 97% of mosquitoes were repelled within a period of 15 minutes which demonstrated same effectiveness as DEET. The overall lethal concentration at 50% (Lc_{50}) is 3.336ppm and Lc_{90} is 0.878ppm. A significant ($\leq$ 0.05) repellent activity with differences in repellency rates is a function of both concentration and observation time, this is in perfect agreement with the work of Conti *et. al.*, (2011), these authors showed that differences in repellency rates, were as a function of both concentration and observation time. Singh *et. al.,* (2011) also showed that *Hyptis suaveolens* has strong ability to repel mosquitoes, these authors proved that plant placement, smoldering (dry and fresh leaves, which gives 90% repellency), spraying (essential volatile oil) and sticks formation of *Hyptis suaveolens* leaves repels mosquitoes strongly due to the presence of intense pungency of the leaves. In their study they were able to prove that *Hyptis suaveolens* is an effective plant to repel mosquito as well as various insects.

Strong larvicidal properties against mosquito larvae due to the presence of terpenes are concentration dependant. Lower concentrations gave lower mortality rates and not significantly ($\leq$ 0.05) different from each other, at higher concentrations mortality rates was higher and there were no significant ($\leq$ 0.05) differences between higher concentrations. These are further confirmed by giving same Lc_{50} and Lc_{90} for lower concentration (25.206 and 302.669 respectively for both 6.25ppm and 12.50ppm) and same Lc_{50} and Lc_{90} for higher concentrations (0.549 and 0.853 respectively for 50-1000ppm). The work of Conti *et. al.,* (2011) also showed that there is no significant difference between lower concentrations, at dosages ranging from 250 to 350 ppm, mortality rates were lower and not significantly different from each other. Arivoli and Samuel, (2011) also showed that essential oil of *Hyptis suaveolens* has larvicidal activities against mosquito larvae, which is concentration dependant as was seen in this research work.

V. CONCLUSION

Percentage yield of 0.05. This is averagely sufficient using hydro-distillation. Essential oil from *Hyptis suaveolens* leaves has shown mosquitocidal activity. It has strong repellency effect against adult mosquitoes. It also has very strong larvicidal properties.

Since terpenes have been revealed from previous studies to be present in the essential oil from the leaves of this plant (*Hyptis suaveolens*) and the oil has successfully killed and repelled adult mosquitoes and at the same time eliminated mosquito larvae, it then suggests that the activities of the essential oil is as a result of the terpenes contained in the oil.

Considering the insecticidal properties of essential oil from *Hyptis suaveolens* leaves, we therefore recommend that the essential oil be used in subsequent work to make soap, perfume and or mosquito repellent popularly known as mosquito coil (right concentration of the essential oil mixed with saw dust or any other dust that can be used). Further studies could be done by extracting the components of the essential oil and test each one of them to know the particular compound(s) that are responsible for the mosquitocidal, larvicidal and repellency properties. This information could help in determining the possibility of using the oil to make insecticides or use it as a component of fumigant to eliminate all unwanted target insects.

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Antibacterial Activity of Extracts of the Baobab (Seeds and Bulbs) Against Pathogenic Bacteria

Fatimah M. Omar Dabnoun, Rihab H. Ezeldin Maaly & Somayya M. Abdulwahid Othman

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ABSTRACT

The study was carried out on the methanolic and aqueous extracts of the baobab (Adansonia digitata L.) seeds and pulps. The extracts were tested for their antibacterial activity against; Staphylococcus aureus, Escherichia coli, and Klebsiella pneumonia at different concentrations of 40, 80, 100, and 120 µl. The methanol extracts obtained by baobab were more effective than water extract. The methanol extract showed variation in the anti-bacterial activity toward S. aureus isolated from a clinical source. The zone of their inhibition ranged between 10 and 25mm.

Keywords: baobab, antibacterial activity, seed, pulp.

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I. INTRODUCTION

Adansonia digitata L. belongs to the Malvaceae family [1]. which consists of around 20 genera and 180 species. The tree species is widespread throughout tropical Africa's hot-dry regions [2; 3]. It extends from Northern Transvaal and Namibia to Ethiopia, Sudan, and the Southern Fingers of the Sahara. The baobab tree is found in Sudan in sandy soils, streams, grasslands, and in low savannahs. It is a deciduous tree massive, royal tree. It has thick, angular, wide spreading branches and a short, stout trunk, and often becomes deeply fluted [2].

Literature reviews on baobab published biochemical analyses revealed that the leaves, the seeds, and the pulp from baobab are rich in nutrients and it is used as food sources, especially for rural people [4; 5; 6]. *Adansonia digitata* is used in the medical and fishing fields. The fruit consists of large seeds embedded in a dry, acidic pulp and shell [7], the pulp is used in preparing cool drinks or sucked in rural areas. The fruit pulp has a very high vitamin C content; it contains sugars but no starch and is rich in pectin. However, the vitamin C content of the bulk fruit pulp varies from 1623 mg/kg-1 in one to 4991mg/kg-1 in another tree [8].

The baobab tree is a good source of vitamin C, iron calcium, and pectin. Its vitamin C content has been compared with oranges and found that it is about three times higher [8], reported that the fruit pulp may also serve as a calcium supplement because of its high calcium content; moreover, Leaves and seeds are identified as good sources of vitamins and minerals [9], reported that the knowledge of nutrition value of local dishes, soup ingredients, and local foodstuffs are necessary to encourage the increase in cultivation and consumption . According to [10] literature review revealed a great variation in reported values of nutrient contents of the baobab part which may be due to the quality of the sample, Papaya is used as food for African peoples and is used to improve the nutritional value of foods. This suggests that the ecological provenance of the baobab does not induce variability in the nutritional concentration of its parts [7].

II. MATERIALS AND METHOD

2.1. Collection of the samples

The plant material was collected from the Omdurman area, Khartoum state. This plant was identified in Herbarium (28.75cm . 41.25cm) by the Department of Biology, Faculty of Science, Benghazi University, Al Marj, Libya.

2.2. Preparation of the extracts

The seeds and pulp were air-dried at room temperature, and ground into a fine powder using an electric blender. The powder used was transferred into closed containers. Each powdered air-dried plant material was extracted with water and methanol. Five grams (5g) of each powdered sample was mixed in a conical flask with 100mL of deionized water or organic solvent, plugged, then shaken at 100 rpm for 24 hours, each of the extracts was filtered rapidly through the gauge and then by No. 1 Whatman filter paper. The filtrates were then concentrated in a rotary evaporator [11; 12].

2.3 Test organisms

Escherichia coli, *Staphylococcus aereus* and, *Klebsiella pneumoniae*. The bacterial strains obtained from Al Marj hospital.

2.4. Antibacterial Screening Method

To objectively evaluate the antimicrobial activity of the baobab (Adansonia digitata) extracts, the following microorganisms were tested: Gram-negative – *Escherichia coli* and *Klebsiella pneumonia*; Gram-positive - *Staphylococcus aureus*, were cultivated and stored in Nutrient Agar (NA) bacterial cultures incubated for 24 hours at 37° C. Muller-Hinton agar medium was used for bacterial growth. The agar diffusion method was used to accurately assess the antimicrobial activity of the extracts Equip the bacterial suspension by taking from 3-5 colonies of bacteria and putting in 3-4 ml Normal saline. Then, we took from the suspension 100 µl and put it in all agar plates with a sterile cotton swab containing bacterial cultures incubated for 24 hours at 37° C [13; 14]. Then, the extracts were applied directly on agar plates using the drop method (100 µL), [4; 5]. Next, the prepared extracts were poured into the well in the standard concentration (100 µL). The dishes were placed in incubation for 24 hours at a temperature of 37°C. The measurements of the inhibition zones of the dishes were taken. All tests performed in triplicate and clear zones greater than 7 mm were considered positive results because the Cork borer was 7 mm in diameter [15; 5].

III. RESULTS AND DISCUSSION

The best result was the extracts of the baobab pulp dissolved in methanol more than the extracts of baobab seeds dissolved in methanol. Perhaps the reason is that the active substances are found at higher rates in the pulp of the plant than in the seeds. Methanol extracts gave better results than distilled water extracts. *Staphylococcus aureus* bacteria were more affected than other bacteria (24.45 mm) at 100 µl compared with Klebsiella pneumonia and *Escherichia coli*. This may be due to the difference in the structure of the cell wall between positive and negative bacteria, where the effect of the extract is on the cell membrane. Raw organic analysis of bacterial cell wall. We observed that the greater the concentration the greater the diameter of the inhibition zone, where concentrations were used: 40µl & 80µl & 100 µl & 120 µl. Table (1,2,3,4)

Table 1: Effect of Different Concentrations of Methanol Extract of Baobab pulp on Growth of Bacteria

Bacteria	40µl	80µl	100µl	120µl
Escherichia coli	18.36	21.72	22.66	24.37
Staphylococcus aureus	19.51	21.45	24.45	25.25
*Klebsiella pneumonia*e	19.24	21.53	23.45	25.28

Diameter of the well 7 mm - average diameter of the inhibition zones in mm - at least 6 replicates

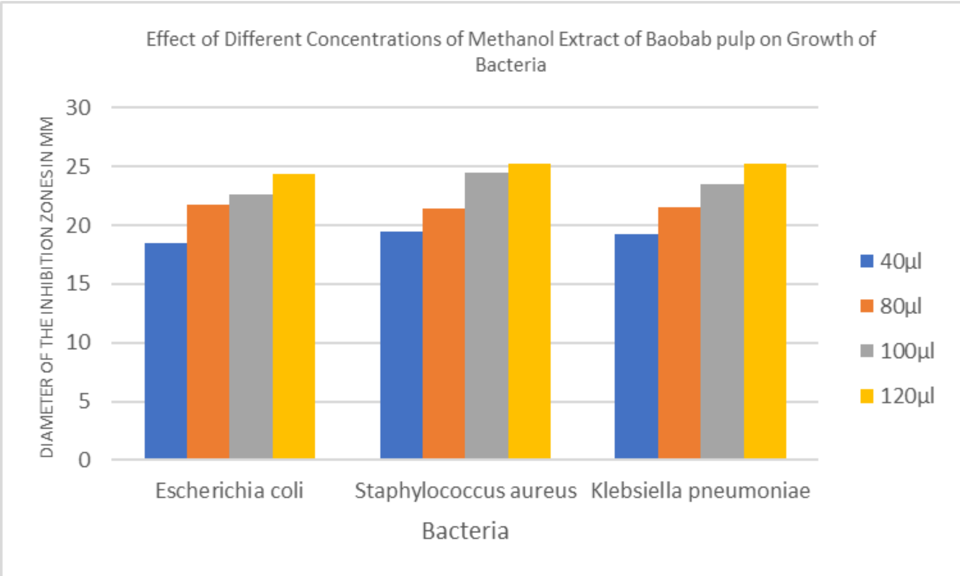


Table 2: Effect of Different Concentrations of Distilled Water Extract of Baobab pulp on Growth of Bacteria

Bacteria	40µl	80µl	100µl	120µl
Escherichia coli	16.4	17.38	18.27	25.39
Staphylococcus aureus	18.44	19.59	24.42	25.55
Klebsiella pneumoniae	14.51	16.2	21.20	22.65

Diameter of the well 7 mm - average diameter of the inhibition zones in mm - at least 6 replicates

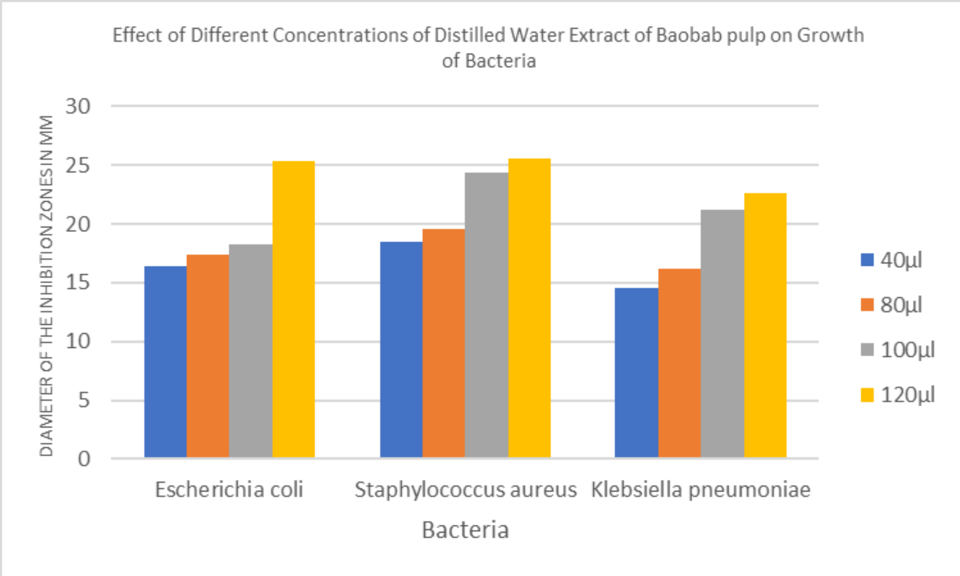


Table 3: Effect of Different Concentrations of Methanol Extract of Baobab Seed on Bacterial Growth

Bacteria	**40µl**	**80µl**	**100µl**	**120µl**
Escherichia coli	11.41	12.21	13.33	14.46
Staphylococcus aureus	11.61	17.55	18.35	22.35
Klebsiella pneumoniae	11.53	12.1	14.41	15.54

Diameter of the well 7 mm - average diameter of the inhibition zones in mm - at least 6 replicates

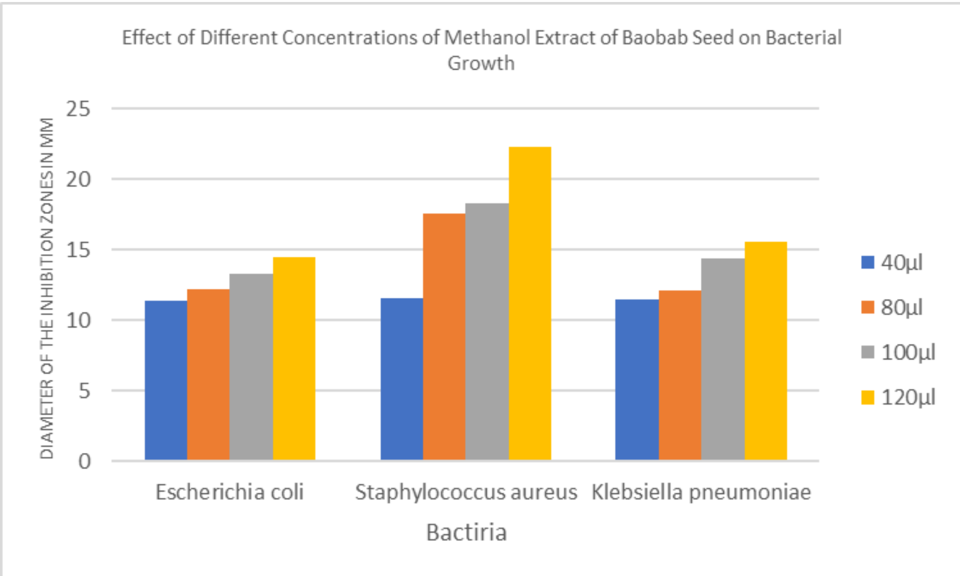
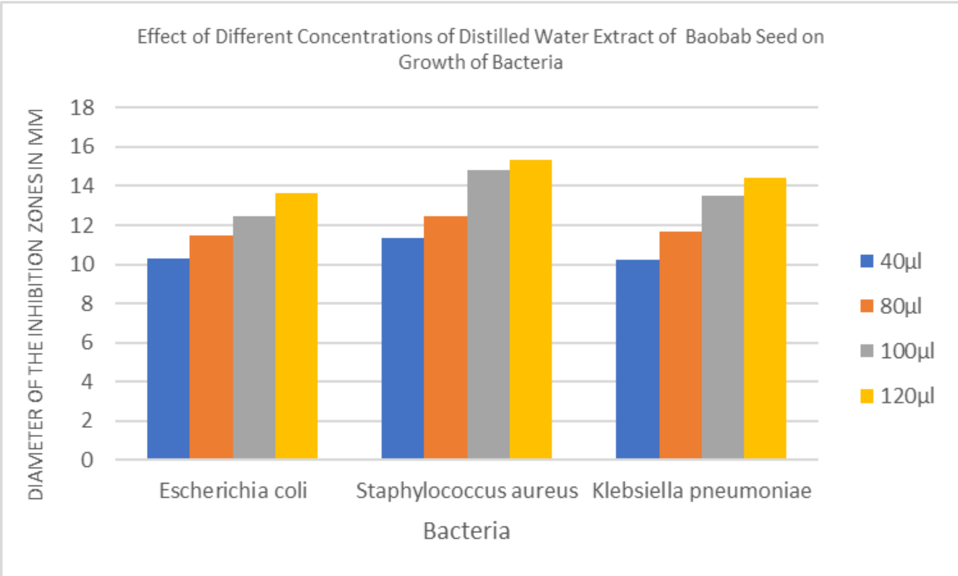


Table 4: Effect of Different Concentrations of Distilled Water Extract of Baobab Seed on Growth of Bacteria

Bacteria	**40µl**	**80µl**	**100µl**	**120µl**
Escherichia coli	10.32	11.50	12.44	13.65
Staphylococcus aureus	11.33	12.46	14.85	15.33
Klebsiella pneumoniae	10.22	11.66	13.50	14.45

Diameter of the well 7 mm - average diameter of the inhibition zones in mm - at least 6 replicates



IV. CONCLUSIONS

In conclusion, the antibacterial activity of baobab methanol extracts was found to be high for Gram-positive and Gram-negative strains. So, we can conclude that the activity varies according to the plant's species and the type of solvents used for extraction. Different solvents with different polarities may result in the extraction of different types of biologically active compounds from plants. These bioactive compounds may go and bind to the microbes' cell walls, leading to the inhibition of their growth.

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