**Viscosity of Raw and Boiled Honey from Tabora Tanzania at Constant and Variable Temperatures.**

ABSTRACT

The aim of this study to investigation and determination of the viscosity of the raw honey and boiled honey from Tabora Tanzania at constant temperature and different temperatures by the mechanics' method of stoke law. this study help to known the different and similarities between the physical properties especially viscosity raw honey and boiled honey, finally this study reveal which types of honey either raw honey or boiled honey can use for medical, industry, business, and food processing.

# 1. INTRODUCTION

## 1.1 Introduction and Background of the research problem

Quality of Tanzanian honey based on physicochemical parameters namely water content, sugar content, pH, ash content, hydroxymethyl furfural (HMF) and honey colour was studied using 26 honey samples collected from ten popular honey producing regions. Analyses were carried out in triplicates using standard methods (Muruke 2014). Data was analysed using averages, correlation and ANOVA tests. Majority of the honeybees' honey samples were light coloured while all stingless bees honey samples were dark coloured. Dark coloured honeys contained more minerals; mainly iron, copper and manganese which make them especially fit for medicinal purposes. pH values ranged from 2.61±0.12 to 4.37±0.08, stingless bees honey samples were more acidic than honeybees' honey samples. Total sugar content values (64.16-84.84 g/100g) were all above the minimum requirement of the national and international standards of not less than 60g/100g. HMF values ranged from 5.0 – 26.4 mg/kg honey, an indication of good quality, being far below the maximum limit allowed by national and international standards of 40mg/kg or 80mg/kg for honeys from the tropics.

In the study we are going to determine viscosity of boiled honey and raw honey to provide the differences between viscosities of boiled honey against viscosity of raw honey and will be stored at the same temperature and at various temperatures, the sample are taken from Tabora Tanzania.

Viscosity is property of fluid by virtue of which a frictional force acts tangentially on the layers of the fluids in motion .Viscosity is kind of internal friction that offers resistance to the motion of one layer of fluid passed another. However, the viscosity of particular fluids can be differing due to the coefficient of viscosity of fluids. (Mehta 1999).

There are many types of honey but in our study, we dealt with bees' honey. Bees store honey in wax structure called honeycombs. There are two types of honey according to the preparation. There are boiled honey and raw honey. Raw honey is only strained before bottled which means it retains most of the beneficial nutrients and antioxidant that naturally contains , Boiled honey or regular honey this may undergo a variety of

processing which remove nutrient like pollen and reduce its level of antioxidant. It is practically to determine the viscosity of boiled honey and raw honey by finding their coefficients of viscosity by stokes' method (Nelkon$Parker, 1970).

In journal physics, conference series 1386, this kind of research conducted .The research explained the work an experimental methodology was proposed combined the development of software to determine the viscosity of honey aggregate (sugar and water) and without those, considering that the experimental methodology used here there does not alter the properties of honey. With ball viscometer and using honey as viscometer medium times that took metal spheres to pass through the sample tube with different densities where measured.(Gonzalez 2019)

In journal of food engineering, this kind of research of research was conducted. This research explained that viscosity of honey was measured in two honeydew honeys (thymus, orange, helianthus, and cotton) at their initial moisture content as well as at 17%, 19%, and 21% water content at 25,30,35,40 and 45℃. It was found that viscosity varied between 0.421 and 23.405Pas.shear stress varied linearly with shear rate for all the sample indicating Newtonian behavior. Shear stress was also measured at constant shear rate as function of time. Viscosity was time independent. Arrhenius equation was used to express the variation of viscosity with temperature. (S.Yanniottis 2006).

In International journal of food science, Honey brand commonly available in Indian market were characterized for their rheological and thermal properties. Viscosity of all the honey samples belonging to the differential commercial brands was found to decrease with increase in temperature (5-40℃) and their sensitivity towards temperature varied significantly. This was explained by calculating activation energy based on Arrhenius model and ranged from 54.0 to 89.0kg/mol. However shear rate was not found to alter the viscosity of honey indicating their Newtonian character. The result provides information about some key physical properties of commercial Indian honey. (Saxena 2014).

In Journal of Agriculture and Social Research (JASR), this study analyzed the physical and chemical composition of seven samples which were obtained from selected market in

Ibadan metropolis .The variables analyzed were PH value, % purity, and ash content, refractive index, Viscosity, color, and specific gravity. The result further revealed that the variable considered were within the standard by codex acceptability improvements in processing and packaging technique will not only enhance acceptability of those products but also brings about higher income to producers and markets.(Adams et el. 2010)

In world, many scientists conducts this research of assessment of honey but deal on effect temperature, moisture, rheological properties and quality of honey by using various scientific method.

This study will go to reveal the difference between the boiled honey and raw honey at same temperature by stake's law methods.

## 1.2 Statement of the problem

This is due to various researches conducted in various places in world but not for the boiled and raw honey from Tabora Tanzania. This lead to get a research gap to conduct a project by taking samples from Tabora region in Tanzania. There different studies related with determination of viscosity of boiled honey and raw honey but of the different temperature.Its being states that the general tendency for individuals boiled honey and raw honeyhave different viscosities when placed in different temperature. Various researches conducted in various places in world such as. Data will be collected by stokes' method. This study will reveal viscosity difference between boiled honey and raw honey at a constant temperature that will be taken from Tabora, Tanzania.

## 1.3 Research objective

### 1.3.1General objectives

Determination of viscosity of boiled and raw honey at a constant temperature.

### 1.3.2Specific objectives

- Determination of the viscosity of the boiled honey..
- Determination of the viscosity of the raw honey.
- To compare the difference viscosity between boiled honey and raw honey at same temperature

- To compare the similarities of viscosity between boiled honey and raw honey at same temperature.
- To compare the viscosity of boiled honey and raw honey at different temperatures.

## 1.4 Research questions

- What the value of viscosity of boiled honey.
- What the value of viscosity of raw honey.
- There are similarities or equal value of viscosity between boiled honey and raw honey.
- There are difference in value of viscosity between boiled honey and raw honey.

## 1.5 Scope of the study

### 1.5.1 Focus

This study will focuses on viscosity difference of raw honey and boiled honey that will be taken fromTabora Tanzania

### 1.5.2 Limitation

- This study will involve only honey who manufactured by insect known as sweet bees, because there is many types of bees that produce honey other kind of insects or bees orchid bees, digger bees, leaf cutter bees, carpenter bees.
- This study will base only on honey that will be taken from Tabora Tanzania, because there are many parts or regions in Tanzania that manufacturing honey.
- This study will base at same temperature and various temperature, because temperature the affects the viscosity when increase or decrease.

### 1.5.3 Research gap

- This study was conducted in many parts in world for example in Australia(Mossel et el 2000),lndia(Nayik,G.A2018),china(Junzherg,P 1998),America(White,J.W et el 1962)and some region in Tanzania but our research gap in this study deal with honey from Tabora that available at Mtawaz's honey shop .

- This study was conducted by many scientific researcher's that uses various methods for examples, (Oppen 1939) uses ball viscometer method to determine the viscosity of honey that published in Industrial engineering and chemistry and (Mossel et el 2000) uses Arrhenius method to determine the viscosity of honey that published in International journal of food science and others uses palm methods, but research gap of this study is due to methodology because this study use stake'slaw methods.
- This study was conducted by many scientific researchers that uses various temperature for example (Nayik2018) uses various temperature to obtain the values of viscositybut the research gap of this study is temperature because this study deal on constant temperaturebut also at various temperature.

All above research gap obtained from various research journals, It helps to get the research problem of this study that state that "*Viscosity of Boiled Honey and Raw Honey of Tabora Tanzania at Constant Temperature and Various temperetures " . and this study will use the stoke's law method.*

## 1.7 Significance of the research

- This study will reveal the physical properties of viscosity of honey of Tabora Tanzania
- This study will reveal the acceptability improvements in processing and packaging technique.
- This study will show or distinguish two kinds honey with different viscosity.
- This study will show how viscosity affected by change of value raw honey and boiled honey due to increase or decrease of Temperature

# 2 LITERATURE REVIEW

## 2.1 Introduction

Viscosity is a measure of the resistance of fluid which is being deformed by shear stress or tensile stress. For liquid, it corresponds to the informal concepts of "thickness "for example, and syrup has a higher viscosity than water (Assil et el 1991)

Viscosity can be conceptualized as quantifying the internal frictional force that arises between adjacent layers of fluid that are in relative motion. For instance, when a viscous fluid is forced through a tube it flows more quickly near the tube's axis than near its walls. In such cases, experiment show that some stress (such as a pressure difference between the two ends of the tube) is needed to sustain the flow through tube. This is because a force required to overcome the friction between the layers of the fluid.so for a tube with a constant rate flow, the strength of the compensating force is proportional to the fluid's viscosity. (Trouton 1906)

Continuous viscosity of honey –water mixture was measured in rotating viscometer at nominal water content weight from 0% to 60% 0ver a range of temperature (30-70℃).The thermal properties of honey water mixtures that have been investigated by differential scanning calorimetry (DSC).The melt fragility during the heating process (MH) and cooling process (MC) has been calculated .The result show that viscosity and flow activation energy decrease as water content increase. This study distinguish two kinds of honey with different water content.(Ren et el 2010).

The rheological properties of high altitudes India honey were analyzed in honeydew and nectar honey (multifocal and acacia) varieties at wide range temperature (0, 5, 10, 20, and 30).All the honey samples were significantly dominated by loss modulus (G) which displayed their viscous nature .Irrespective of geographical origin and temperature, all the honey varieties showed a Newtonian behavior .The viscosity of all honey varieties showed a strong dependence on temperature and Arrhenius model was examined this.(Nayik 2018) .

Rheological properties of four unprocessed unifloral Australian honey (health, tea tree, yapunya, and yellow box) and an artificial honey were analyzed at 20℃ .A model previously used to describe viscosity data of various sugar and sugar mixtures was used to describe the concentration dependence of the viscosity of honey samples with varying moisture contents. The model successfully described the sugar concentration dependence of the un adulterated and medium moisture (70-85% solids) range honey samples.(Goldshank et el 1977).

## 2.2 Theory of the research done on the problem

According George Gabriel Stokes (In 1851) which derived an expression, now known as stokes law, state that the force acting between the liquid and falling body Interface is proportional to velocity and radius of the spherical object and viscosity of fluid. (Mehta1999)

The force of viscosity on a small sphere moving through a viscous fluid is given by

$$f_d = 6\pi\mu r v$$

Where by,$f_d$=frictional force,μ=dynamic viscosity=radius of the spherical body,v=flow velocity. The strokes' law the following assumptions for the behavior of a particle in a fluid which are laminar flow, spherical particles, homogenous material, smooth surface, Particles do not interfere with each other (Chirife et el 1997))

Stokes 'law used to calculate the viscosity of fluid. A series of steel ball bearing of different diameter are normally used in classic experiment to improve the accuracy of the calculation.

Terminal velocity is the maximum velocity(speed) attainable by an object as it falls through a fluid. It occurs when the some of drag force ($F_d$) and buoyance is equal to the downward force of gravity ($F_g$) acting on the object. Since the net force on object is zero, the has zero acceleration. In fluid dynamic object is moving at its terminal velocity if its speed is constant due to the restraining force exerted by the fluid throuh which it is moving.

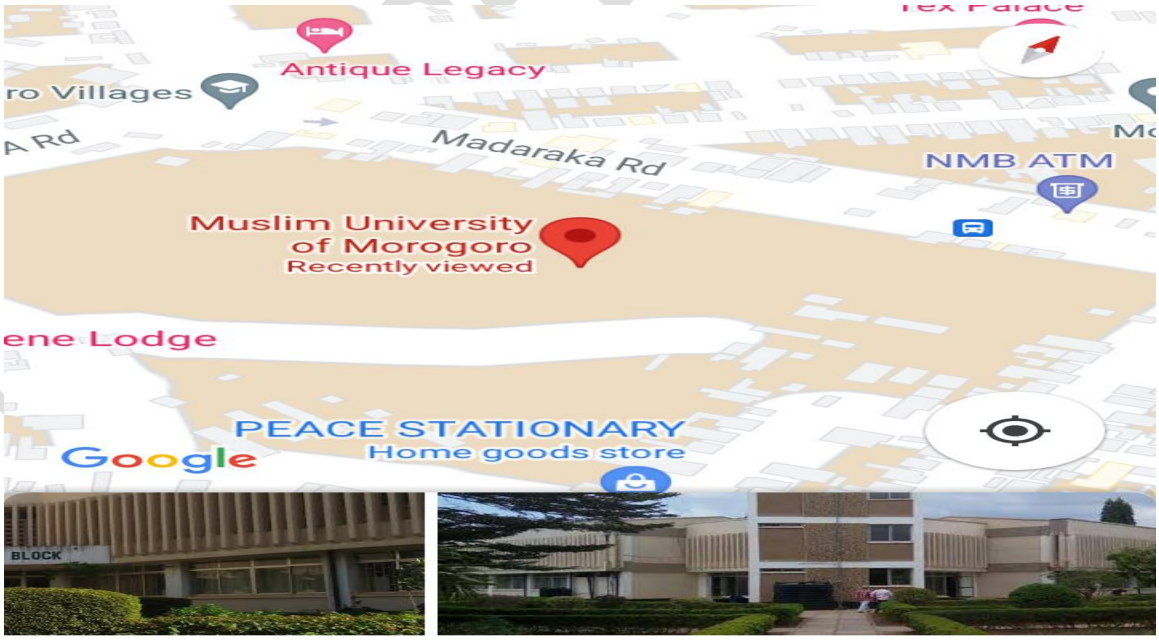
# 3 RESEACH METHODOLOGY

## 3.1 Description and map of the study area

The study will have conducted in Tanzania at Muslim University of Morogoro.

Geographically the area lies north of the Magnificent Ulugulu Mountains, some 4km from the center of Morogoro.

Founded in 2004, Muslim University of Morogoro is a private higher-education institution located in the urban setting of the small city of Morogoro (population range of 50,000-249,999 inhabitants). Officially recognized by the Tanzania Commission for Universities, Muslim University of Morogoro (MUM) is a very small (unranked enrollment range: 1,000-1,999 students) coeducational Tanzanian higher education institution formally affiliated with the Islamic religion. Muslim University of Morogoro (MUM) offers courses and programs leading to officially recognized higher education degrees in several areas of study. See the unranked degree levels and areas of study matrix below for further details. MUM also provides several academic and non-academic facilities and services to students including a library, as well as administrative services.




Map 1 : HONEY SHOP -- MUSLIM UNIVERSITY OF MOROGORO

**Figure 1: shows the study site location around Muslim University Of Morogoro where the practical project was conducted**



**Sample collection and preparation**

The samples of this study were collected at MTAWAZI'S HONEY SHOP at Muslim University of Morogoro. This study used two types of sample, which are boiled honey sample, and raw honey sample. These samples both differ according to the ways local farmers harvesting and processing. The samples collected, the samples were prepared in the Laboratory to wait for further practical experiments. Both boiled honey and raw honey sample were put in small bottles of 500ml. They were then stored in cool place to make sure both sample have same or constant temperature.

### 3.2 Methods and material

This study uses the method of stokes' law method to determine the coefficient of viscosity of boiled honey and raw honey sample. This method helps to get data, which includes terminal velocity and radius of grass beads. It helped to draw the graph and finally we get slope that show the viscosity coefficient of the particular samples. In the world today, there are many methods of determination viscosity including viscometer and other digital method. However this study uses the stokes' law method because it has best accuracy calculation. Number of experiment replicate, **was** conducted to the experiment order to obtain reproducible Data.

**Theory.**

When a spherical ball of ( radius r) is dropped in viscosity field it moves in it with certain velocity v is experience's an opposing force (viscous force $f_d$).according to stokes law this viscous force is given by

$f_d = 6\pi\boldsymbol{\eta r v}$

Simultaneously it experiences an upthrust (or buoyant force)$f_b$ and gravitational force $f_g$.$f_g$tries to increase the velocity of ball where as $f_d$ decrease the velocity. After some times the ball will moves with a steady velocity. Called the terminal velocity.

$f_g = f_b + f_d$

$$f_d = f_g - f_b$$

$$6\pi\boldsymbol{\eta r v} = \frac{\mathbf{4}}{\mathbf{3}}\boldsymbol{\pi(\rho - \sigma)g}$$

$$\boldsymbol{\eta} = \frac{2}{9}\frac{(\rho-\sigma)gr^2}{v}$$

$\rho$=density of ball bearing, $\sigma = density\ of\ liquid, \boldsymbol{\eta} = \boldsymbol{coefficient\ of\ viscosity}, \boldsymbol{r = radius\ 0f\ ball\ bearing}, \boldsymbol{g} = \boldsymbol{acceleration\ due\ to\ gravity}$.

APPARATUS AND MATERIALS

The apparatus used in this methods are A long cylindrical gas jar, Retort stand, Vernier caliper, Micrometer screw gauge, bearing ball , Stop watch, Thread, Meter scale, Raw and Boiled honey, Thermometer, beaker, Note book, pencil, Plastic measuring cylinder

**PROCEDURE**

Procedure a

1. A long cylindrical glass jar with marketing is taken
2. Fill the glass jar with the experimental liquid (raw honey and boiled honey)
3. Two points A and B are marked on the jar. The mark A is made well below the surface of liquid so that when the ball reaches B it would have acquired terminal velocity V.
4. The radius of the metal spherical ball is determined using screw gauge
5. The spherical ball is dropped gently into the liquid
6. Start the stop clock when the ball crosses the point A. Stop the clock when the ball reaches B
7. Note the distance between Aand B and use it to calculate terminal velocity.
8. Now repeat the experiment for different distances between A and Make sure that the point A is below the terminal stage.

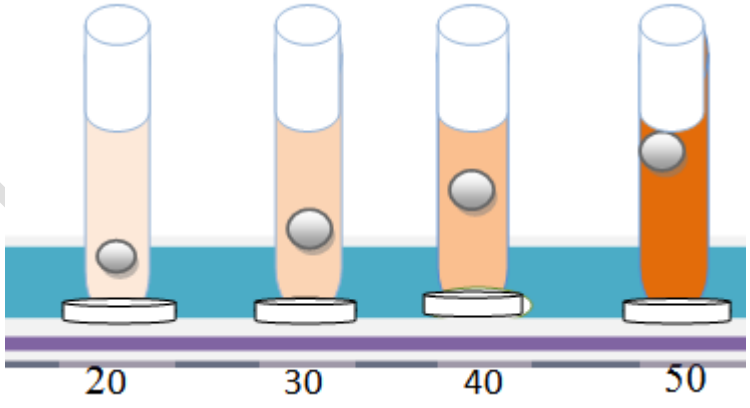



**Figure 2: shows the how the practical part was conducted**

Procedure b

1.A long cylindrical glass jar with marking is taken

2.Fill the glass jar with the experimental liquid (which raw honey and boiled honey)

3.Two points A and B are marked on the jar. The distances mark A and B should be constant.

4.Use the only one ball bearing to find the time taken to completely mark A to B with different values of temperature starting with 30,40,50,60 and 70℃

5.Record the table that contains the temperature $\theta$ *and time* $t$



## 4.0 RESULTS AND DISCUSSION

### 4.1 RESULTS

After practices the laboratory experiment we obtains the various result in both at constant temperatures and different temperatures

Table 1 : The result from procedure (a) of raw honey at constant temperatures(20℃)

| Ball bearing | Mass(gram) | Radius(m) | Distance covered from mark A to B | Time taken from mark A to B | Terminal velocity (v) |
|---|---|---|---|---|---|
| A | 45 | $5.05\ 10^{-3}$ | 0.2 | 7.31 | 0.027 |
| B | 56 | $5.55\times 10^{-3}$ | 0.2 | 6.28 | 0.032 |
| C | 69 | $6.4\times 10^{-3}$ | 0.2 | 5.60 | 0.036 |
| D | 81 | $7.1\times 10^{-3}$ | 0.2 | 4.90 | 0.042 |

Table 2 : The result from procedure (a) of boiled honey at constant temperature(20℃)

| Ball b earing | Mass(gram) | Radius(m) | Distance covered from mark A to B | Time taken from mark A to B | Terminal velocity (v) |
|---|---|---|---|---|---|
| A | 45 | $5.05 \times 10^{-3}$ | 0.2 | 6.18 | 0.032 |
| B | 56 | $5.55\times 10^{-3}$ | 0.2 | 5.44 | 0.037 |
| C | 69 | $6.4\times 10^{-3}$ | 0.2 | 5.00 | 0.040 |
| D | 81 | $7.1\times 10^{-3}$ | 0.2 | 4.69 | 0.043 |

Table 3 : The result from procedures (b) of raw honey at various or different temperatures

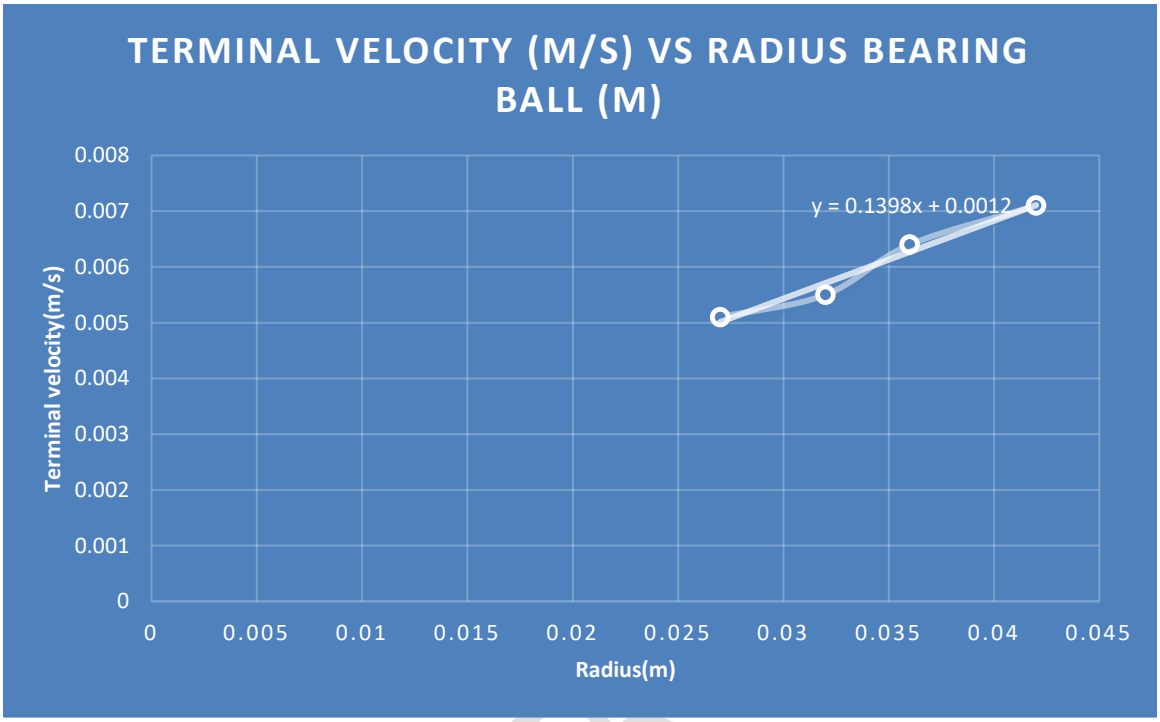
We use only ball bearing A has mass of 45 g covered distances is 30 cm.

| Temperature(℃) | Time taken (s) | Distance (m) |
|---|---|---|
| 30 | 5.6 | 0.3 |
| 40 | 4.6 | 0.3 |
| 50 | 3.6 | 0.3 |
| 60 | 2.44 | 0.3 |
| 70 | 1.56 | 0.3 |

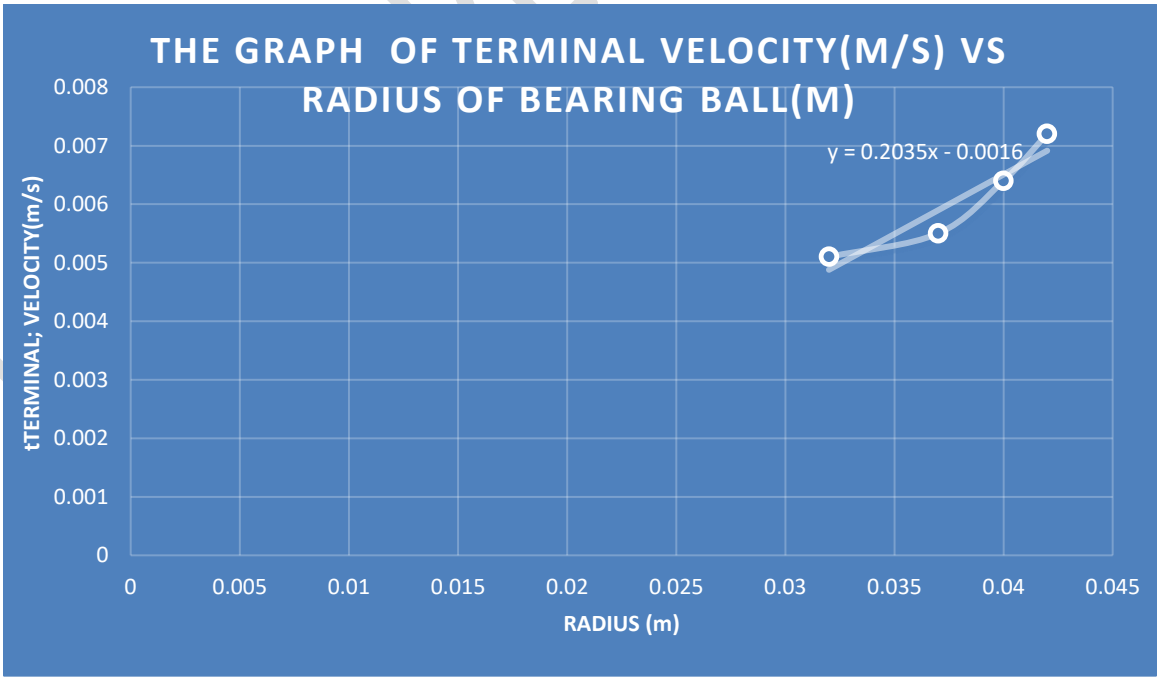
Table 4 : The result from procedures (b) of boiled honey at various temperatures or different temperatures.

| Temperature(℃) | Time taken(s) | Distance (m) |
|---|---|---|
| 30 | 5.0 | 0.3 |
| 40 | 4.2 | 0.3 |
| 50 | 3.3 | 0.3 |
| 60 | 2.1 | 0.3 |
| 70 | 1.23 | 0.3 |

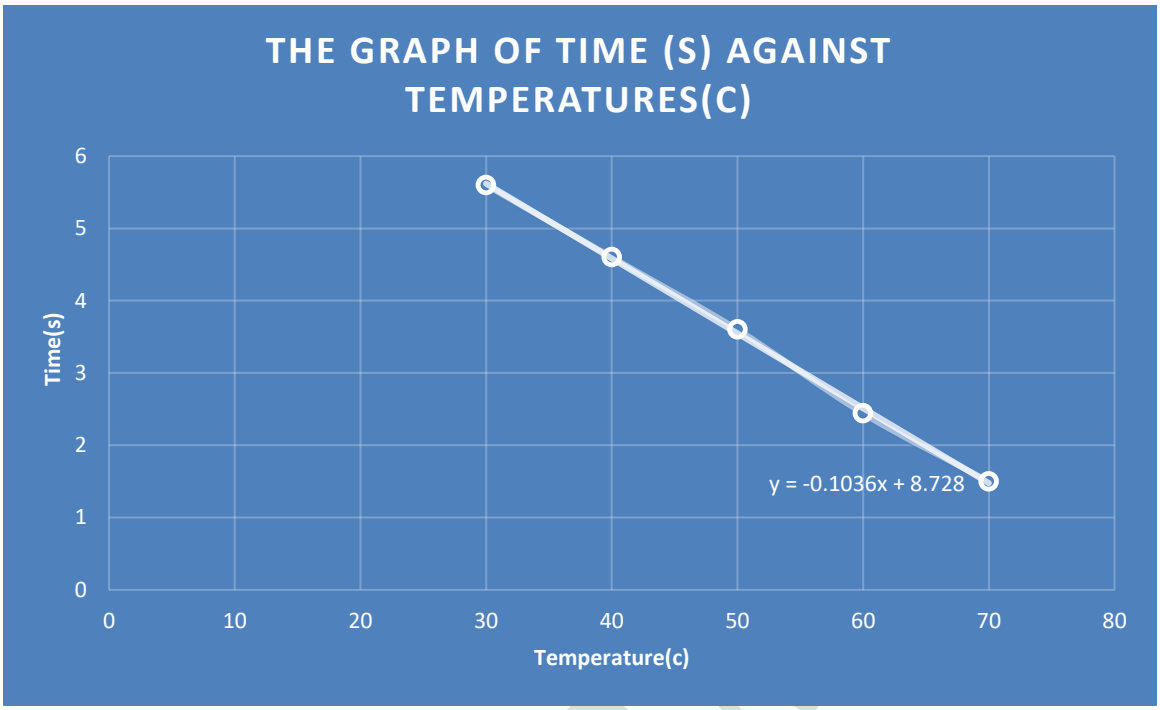
**Graph 1 : The Graph of Terminal Velocity against Radius of Bearing Ball of Raw Honey at Constant Temperature (20℃)**



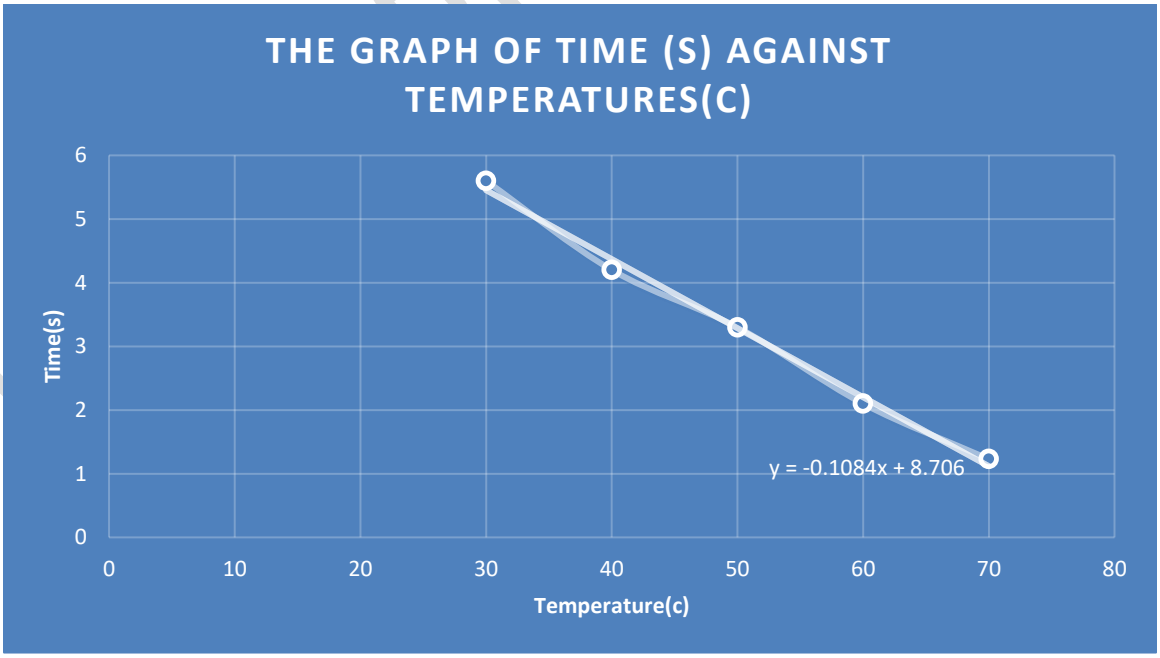

**Graph 2 : The graph of terminal velocity against radius of bearing ball of boiled honey at constant temperature (20℃)**



**Graph 3 : The graph of times (s) against the temperature (℃) of raw honey**




**Graph 4 : The graph of times (s) against the temperature (℃) of boiled honey**



## 4.2.Calculation of Result from the Graphs;

1. FROM GRAPH OF RAW HONEY AT CONSTANT TEMPERATURES

The coefficient of viscosity of raw honey = $\frac{2}{9}\frac{(\rho-\sigma)gr^2}{v}$

But radius( m) =0.0051s/m. $\rho = 2800\text{kg}/m^3$,$\sigma = 1490kg/m^3, g = 9.8m/s$.v=0.027

The coefficient of viscosity $\boldsymbol{\eta}$ =$\frac{2}{9}\frac{(2800-1490)9.8\times0.0051^2}{0.027}$

The coefficient of viscosity $\boldsymbol{\eta}$ = $2.75Nsm^{-2}$

2. from graph of boiled honey at constant temperatures

The coefficient of viscosity of raw honey = $\frac{2}{9}\frac{(\rho-\sigma)gr^2}{v}$

But radius ( m) =0.0051s/m. $\rho = 2800\text{kg}/m^3$,$\sigma = 1490kg/m^3, g = 9.8m/s$.v=0.032

The coefficient of viscosity $\boldsymbol{\eta}$ =$\frac{2}{9}\frac{(2800-1490)9.8\times0.0051^2}{0.032}$

The coefficient of viscosity $\boldsymbol{\eta}$ = $2.32Nsm^{-2}$

### 3. The comparisons of viscosity coefficient of raw honey and boiled honey at constant temperatures.

Therefore, the value of coefficient of raw honey is greater than boiled honey according to our result above;

The difference coefficient between the raw honey and boiled honey is 2.75-2.31=$0.43Nsm^3$

4.The comparisons of viscosity coefficient of raw honey and boiled honey at different temperatures by using their slopes.

From the graph of time against temperature of both raw honey and boiled honey we obtain the following data;

The slope of times against temperature of raw honey is- $0.1036s/℃$

The slope of times against temperature of boiled honey is- $0.1084s/℃$

Therefore, the slope of raw honey is greater than boiled honey by $0.0048s/℃$.

### 4.3 DISCUSSION AND CONCLUSION

According to the stoke law method, the value of coefficient of viscosity show that the viscosity of liquid or sample is large or low, because the viscosity of liquid depend on the nature of liquid.

According to results obtained from experiment of this study through tables, graphs and calculation, the value of coefficient of viscosity of raw honey at constant temperature is 2.75 Ns$m^{-2}$ and the value of coefficient of viscosity of boiled honey is 2.32Ns$m^{-2}$ at constant temperature of 20℃ ,this result reveals that the raw honey is more important than boiled honey because the viscosity of raw honey is greater than boiled honey .the boiled honey has low value due to various factor such as amount of moisture content, and rheological properties. **Rheology** is the study of these properties, which are important in many industries and fields, including food science, manufacturing, and physiology. Rheological properties are the material properties that describe how a material deforms or flows when a force or stress is applied. Some common rheological properties include: **Viscosity**: The opposition to flow in a material. For example, honey is more viscous than water and flows more slowly. **Thixotropy**: A property of some materials that change viscosity in response to stress. For example, a material may become less viscous when agitated, but more viscous when left at rest.

Also, according to the stokes law equation, time is directly proportional to the coefficient of viscosity. Therefore the slope from both graphs of time against temperature show negative sign, that implies when temperature increase the value of the coefficient of viscosity decrease. However, according this study, the slope of times against temperatures of raw honey is greater than the slope of graph of time against the temperatures of boiled honey. This study show that the value of coefficient of viscosity of raw honey decrease slowly compared to the value of coefficient of viscosity of boiled honey due to the effect of the temperature. Therefore, the raw honey is affected by temperature at low rate compare to the boiled honey.

Therefore, According to the data above the tables, graphs and calculation, the viscosity of raw honey from Tabora Tanzania is 2.75 Ns$m^{-2}$ , the boiled honey is 2.32 Ns$m^{-2}$at constant temperatures and when temperatures increase the viscosity of both raw honey and boiled honey decrease but boiled honey affected more than raw honey due to bond formation.

Based on the physicochemical parameters studied, Tanzanian honeys from honeybees were found to be of high quality meeting recommend national and international standards (Muruke 2014). However, all stingless bees' honey samples deviated from these standards on moisture content and two samples on ash content. With few exceptions, colour and moisture content are two most important physicochemical parameters that may give a fair clue on the quality of the honey. The two parameters are also easy to measure. The results of this study indicate that Tanzanian honey samples compare well with samples in many parts of the world but also fall within the limit of international standards. Nevertheless, more studies are needed to evaluate the quality of Tanzanian honeys based on medicinal, nutritional, antioxidant and viscosity properties.

**RECOMMENDATION;**

This study of determination of viscosity of raw honey and boiled honey from Tabora Tanzania is very important because mostly of peoples uses for food and medical purpose, so to know the rheological properties such as viscosity it helps to how uses and how reach our requirement. This study deal with only method of stokes law so, another method such viscometer methods in order to add things on this study and to obtained research gap of this exercise. Therefore, more data for all types of honey found in Tanzania or east Africa can internationalizes the results.



**COMPETING INTERESTS DISCLAIMER:**

Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

**REFERENCE**

- Adam, B.M. Osikabor, B. Olomola, A.A. and Adesope, A.A.A. (2010) .Physical and chemical composition of honey. Journal of Agriculture and Social Research (JASR).Vol 10.No.2..
- Assil, H. I., Sterling, R. and Sporns, P. 1991. Crystal control in processed liquid honey. *Journal of Food of Sciences*.56: 1034–1041.
- Chirife, J. and Buera, M. P. 1997. A simple model for predicting the viscosity of sugar and oligosaccharide solutions. *Journal of Food Engineering*.33: 221–226.
- Goldshank, D. E. and Franchetto, R. 1977. The viscosity of concentrated electrolyte solutions I. Concentration dependence at fixed temperature. *Canada Journal of Chemistry.*, 55: 1062–1072.
- Junzheng, P. and Changying, J. 1998. General rheological model for natural honeys in China. *Journal Food Engineering.*, 36: 165–168.
- Mehta , V.K and Mehta , R (1999). Principle of Physics.S.Chand& Company ltd. Third edition.258-864
- Muruke M H. (2014) Assessment of Quality of Tanzanian Honey based on Physicochemical Properties, Food Science and Quality Management www.iiste.org ISSN 2224-6088 (Paper) ISSN 2225-0557 (Online) Vol.33, 61
- Mossel, B.L, Bhandari, B., D'arcy. And Caffin,N,(2000).Use of an Arrhenius model to predict rheological behavior in some Australian Honeys.lebensm-wissTechnology. 33:545-552.
- Nayik, G.A. (2018). "The Rheological Properties of High Altitude India Honey". Journal of Saudi of Agriculture Sciences. Vol 17. Pag (323-329)
- Nelkon& Parker (1970).Advanced Physics. Heinmann Education Book ltd,(174181). Third edition.181-182.
- Oppen, F. C. and Schuette, H. A. 1939. Viscometric determination of moisture in honey. *Industrial Engineering and Chemistry.11:130-135.*
- Ren, Z. Bian, X. Bai, L.L.Y. and Wang W.(2010)."Continuous Viscosity of Honey – Water mixtures". Journal of food Engineering. Vol 100.pag(705-710)

- Saxena, S, Panicker, L. and Gautam, S. (2014).”Rheology of Indian honey, effect temperature and Gamma radiation”. International journal of food science .vol 2014, Article ID 935129, 6 pages.
- Trouton, Fred. T. (1906).”On the Coefficient of Viscous Traction and Its Relation to that of Viscosity. Processing of the Royal Society A: Mathematics, Physics and Engineering sciences.77 (519):426-440.
- White, J. W., Reithof, M. L., Subers, M. H. and Kushir, I. 1962. Composition of American honeys. *Technical Bulletin U.S. Department of Agriculture*, 1261: 1–124.
- Yanniotis, S. Skaltsi, S. and Karaburnioti, S. (2006).”Effect of moisture content on the viscosity of honey at different Temperatures”. Journal of food Engineering .72(4):372-377.