International Digital Organization for Scientific Research ISSN: 2579-0730
IDOSR JOURNAL OF BIOLOGY, CHEMISTRY AND PHARMACY 8(3)106-118, 2023.
https://doi.org/10.59298/IDOSR/JBCP/23/11.1119

Postprandial Hypolidaemic Effect of Aloe Vera Methanolic Extract via the Mechanism of Intestinal Pancreatic Lipase Enzyme Inhibition in Male Wistar Rats

[1]Faseun Yusuf Olusola, [2*]Ezeonwumelu Joseph Obiezu Chukwujekwu, [3]Odda John, [3]Odoma Saidi, [4]Idania Hidalgo, [5]Moazzam Mohiuddin Lodhi, [6]Patrick Maduabuchi Aja, [7]Hambali Kaltume Umar, [6]Mpumbya Jackie Rachael, [2]Ebere Emilia Ayogu, [2]Narayana Goruntla, [3]Hope Onohuean and [8]Ugwu Okechukwu Paul-Chima

[1]Department of Biochemistry and Department of Pharmacology and Toxicology, School of Pharmacy, Kampala International University, Western Campus, Ishaka, Bushenyi, Uganda.

[2]Department of Clinical Pharmacy and Pharmacy Practice, School of Pharmacy, Kampala International University, Western Campus, Ishaka, Bushenyi, Uganda.

[3]Department of Pharmacology and Toxicology, School of Pharmacy, Kampala International University, Western Campus, Ishaka, Bushenyi, Uganda.

[4]Department of Pathology, Kampala International University and Kampala International Teaching Hospital, Western Campus, Ishaka, Bushenyi, Uganda.

[5]Department of Public Health, School of Allied Health Kampala International University, Western Campus, Ishaka, Bushenyi, Uganda

[6]Department of Biochemistry, Faculty of Biomedical Sciences, Kampala International University, Western Campus, Ishaka, Bushenyi, Uganda.

[7]Department of Microbiology, Faculty of Biomedical Sciences,Kampala International University, Western Campus, Ishaka, Bushenyi, Uganda.

[8]Department of Publication and Extension, Kampala International University, Western Campus, Ishaka, Bushenyi, Uganda.

***Corresponding Author: Ezeonwumelu Joseph Obiezu Chukwujekwu**
Email: ezeonwumelu.joseph@kiu.ac.ug; nduezeh@gmail.com

ABSTRACT

This study explores the ability of *Aloe vera*, a traditional medicinal plant, to inhibit the digestive enzyme pancreatic lipase and its potential impact on post-prandial lipidaemia in adult male Wistar rats. *Aloe vera* extract was administered in varying doses alongside olive oil as a source of triglycerides. The study investigates the kinetics of post-prandial blood triglyceride concentration, Area Under the Curve (AUC) values, and the percentage inhibition of pancreatic lipase. The results reveal significant inhibition of pancreatic lipase, indicating a potential role in moderating post-prandial blood lipid levels. The inhibition type is

suggested to be a mixed type, combining uncompetitive and competitive characteristics. This finding suggests that *Aloe vera* may have therapeutic potential in managing conditions related to post-prandial dyslipidaemia, such as diabetes.
Keywords: *Aloe vera*, starch, triglycerides, post-prandial blood glucose and post-prandial triglyceride,

INTRODUCTION

The term "lipidemia" describes the blood's lipid content. Anomalies in blood lipid and lipoprotein levels are referred to as hyperlipidemia or dyslipidaemia [1-3]. One of the main contributors to atherogenesis and diabetogenesis is dyslipidemia. Obesity, cardiovascular disease, and type 2 diabetes mellitus are all influenced by postprandial glycaemia and lipidaemia [4-5]. Glycated hemoglobin levels are determined by both post-prandial and fasting glycaemia; however, post-prandial glucose plays a crucial role in the pathophysiology of type 2 diabetes [6-8]. In diabetic individuals, post-prandial triglycerides and high density lipoprotein levels provide a more accurate indicator of cardiovascular health [9-11]. A study with Spanish reported that postprandial lipemia was associated with incidence of T2D for 5 years [11-14]. A recent study with Japanese subjects reported that postprandial hypertriglyceridemia was associated with all-cause mortality in patients with T2D [15-17]. The development of chronic metabolic illnesses such as obesity, type 2 diabetes mellitus (T2DM), and cardiovascular disease (CVD) has been linked to post-prandial glycaemia and lipidaemia [18-20]. In both prediabetes and diabetes, dyslipidaemia is a major factor in the development of atherosclerosis. Postprandial triglycerides and the TG/HDLc indicate lipid abnormalities more so than the comparable fasting measures in these conitions. In people with prediabetes and diabetes, post-prandial TG and TG/HDLc represent cardiovascular state more accurately [21-23]. Pancreatic lipases digest triglycerides to fatty acids and monoglycerides. Bile salts surround the fatty acids and monoglycerides, forming micelles, thus they are facilitated for absorption into the enterocytes [24-25]. Thereafter, triacylglycerol is resynthesized, repackaged with other lipid and protein molecules as chylomicrons are transported in lymphs to muscles, adipose tissues and to the liver where they are repackaged into Very Low Density Lipoproteins (VLDL) which is released into the blood for uptake by tissues [26-28]. Hypolipidemic drug**,** also called lipid-lowering drug**,** any agent the reduces the level of lipids and lipoproteins (lipid-protein complexes) in the blood [29-32]. Lipoproteins bind cholesterol and can accumulate in blood vessels. High levels of specific lipoproteins, namely, low-density lipoprotein (LDL) and very low-density lipoprotein (VLDL), have been associated with an elevated risk of certain forms of cardiovascular disease, including coronary artery disease, heart attack, and stroke [33-36]. There have been reports about traditional herbs with hypolipidaemic effects [37-40]. *Aloe vera* has been claimed to elicit hypolipidaemic effect vima certain mechanisms. *Aloe vera* has hypolipidemic effect and thus, protect tissues from insulin resistance [35-38]. Glucomannan in *Aloe vera* has the ability to block the activity of HMG Co-A reductase in lipid profile biosynthesis in cells and of Acyl Co-A Cholesterol-Acyl Transferase (ACAT), so it can act as anti-lipidaemic agent [39-40]. Dietary *Aloe* reduces adipogenesis via the activation of AMPK and suppresses obesity-related inflammation in obese mic [34-35]. ***Aloe vera*** is a traditional herb used as a medicinal plant for various diseases including diabetes and cardiovascular diseases. Due to its diverse medicinal properties, historically, it has been used by many ethnic groups in Egypt, India, China, Europe for more than 5000 years [8]. It is native to the East African/Mediterranean region [34]]. It is the most popular among the herbs being used for diabetes in some regions in Uganda [36]. It is a plant with succulent, fleshy, thick leaves with spines. It is one of

about four hundred existing species. It is characterized by short or no stems [38]. It is classified as a member of Lilacea family. It has the ability to retain water, thus can withstand a long period of drought [32]. This study aims to investigate the ability of *Aloe vera* to inhibit the digestive enzyme pancreatic lipase in adult male wistar rats thereby moderating post-prandial lipidaemia. If *Aloe vera* is found to regulate the post-prandial levels of blood lipids, then its preparations, dosage and administration could be targeted at achieving this purpose.

METHODS

Preliminary studies

The doses of the triglycerides used for experimentations in animals were based on the preliminary studies and observation of the fact that the doses can cause saturation of the intestinal enzymes which were to be inhibited by *Aloe vera*. Also, preliminary studies revealed that the dose of 7.5g/kg body weight of the *Aloe vera* extract could yield lower post-prandial blood triglycerides than other lower doses. Thus, a fixed dose of 7.5g/kg was used against varying doses of the triglycerides, for experimentations. Also, the 7.5g/kg dose did not cause purging in the animals, but a higher dose caused it. Thus, the dose of 7.5g/kg is an optimized dose.

Research Design

An *Aloe vera* methanolic extract was prepared using the method of [38] with slight modifications. Their method was used because they reported positive results on inhibition of digestive enzymes by *Aloe vera in vitro*. Thirty five animals were used in this study. The animals were grouped into seven and each group was having five animals per cage. Kinetics studies were done on the animals on two occasions. In the first occasion, only olive oil was administered to the animals intragastrically, at varying doses. In the second occasion, an optimized dose of 7.5g/kg of the *Aloe vera* extract was administered to the animals after olive oil was administered some few minutes after. Before blood collection, the animals were fasted for eighteen hours, after which fasting blood glucose was collected and recorded as 0 minutes (in Table 1). This was followed by administration of olive oil in the first occasion, but olive oil plus *Aloe vera* in the second occasion, at varying doses of the substrate but an optimized dose of the inhibitor (Table 1). Counting from the time of food and/or extract administration, blood samples were taken at sixty minutes interval for a period of six hours. The blood samples were collected from the tail of the animals into a red top vacutainer. Plasma triglycerides levels were measured before and after inhibition.

Study area

The study was conducted at Kampala International University, Western campus, Uganda Animal breeding and blood collection was done at the Animal Laboratory, KIU, Western Campus. The extract was prepared at the Institute of Biomedical Research Laboratory, KIU, Western Campus and Mbarara University of Science and Technology. Samples analyses were done at the Department of Biochemistry, KIU, Western Campus.

Target population

The target population is the diabetic patients who may sometimes wish to take carbohydrate and lipid foods which they are medically restricted. For ease of experimentations in the study, rats were used in place of human subjects.

Sample size and sampling techniques

Five animals were used per group in order to get an average data from each group dedicated for experimentations. There were seven groups designed for each of the three objectives

Data collection sources/methods/instruments.

The data sources were blood samples collected from experimental animals at the animal laboratory of Kampala International University, Western Campus. The blood samples were subjected to assays for biochemical parameters determination using spectrophotometer. These were done at the Institute of Biochemical Research, Kampala International University, Western Campus; and the Biochemistry Department Laboratory, Kampala International University, Western Campus.

Research procedures

a. Materials

Aloe vera leaves, Olive oil, Orlistat drug.

b. Collection of materials

Aloe vera leaves weighing about 25kg were harvested from Kamushana village, Bushenyi District, Uganda. Olive oil was used as the source of triglycerides and was purchased from a supermarket in Ishaka, Bushenyi District, Uganda. Orlistat was purchased from a pharmacy store in Kampala, Uganda. About 25kg of *Aloe vera* leaf was collected from Buramba, Ishaka, Bushenyi District, Uganda. Some of the samples were taken to the botanist at Mbarara University of Science and Technology for identification.

c. Animal Feeding

The animals feed were purchased at Ishaka market, Bushenyi District. The animals were placed on normal rats feed, with free access to the feed and water. However, when it was a day before blood samples collection, they were fasted for eighteen hours.

d. Preparation of the *Aloe vera* extract

The whole leaves of *Aloe vera* plant were mechanically air-dried at room temperature and it yielded about 2.5kg dry weight. The dried leaves were powdered with a milling machine. The powder was extracted with 50% methanol-water in water bath for three hours. The extract was freeze-dried and the final sample yielded 136g of dry granules of the processed *Aloe vera*.

e. Administration of *Aloe vera* extract.

The *Aloe vera* extract was weighed using a beam balance. The weighed sample was dissolved in distilled water to make 1g/ml solution. A calculated dose of 7.5g/kg was administered to each animal. The dose was measured in milliliters and administered intragastrically. This was done on the second occasion of blood samples collection, after eighteen hours fasting and collection of fasting blood triglycerides for each animal.

i. Administration of olive oil

After the 18 hours fasting and measurement of fasting blood glucose, olive oil liquid was administered to each animal in all the seven groups in the first occasion. In the second occasion, Group 1, 2, 3, 4, 5 and 7 received olive oil and the *Aloe vera* extract. The Group 6 animals which served as the Negative Control Group received olive oil water instead of *Aloe vera* extract. The sucrose solution was administered in graded doses as presented in Table 4.7. (in the first occasion) and 4.8 (in the second occasion). After the administration, blood samples were collected from the tail every hour for six hours and these were measured with a glucometer and a test strip. In the second occasion, the procedure was repeated, except that *Aloe vera* extract was added with the olive oil.

ii. Administration of Standard Drug (Orlistat)

Orlistat was administered to the Standard Drug Control Group 7 instead of *Aloe vera* extract. The drug was administered some minutes after the administration of olive oil. Orlistat dose of 50mg/kg body weight was administered.

f. Biochemical tests

Test for triglycerides was done using an automatic icroma analyzer machine.

Data Analyses

Data analyses were done by:

1. Calculating the average and standard error of the mean (SEM) of the kinetics data obtained during data collection in the animal laboratory. The average and SEM values were presented in a table. ANOVA tests were conducted with Microsoft Excel 3. The data obtained were compared for statistical significance of their mean variances as follows:
   a) ANOVA was conducted between groups "before inhibition and after inhibition".
   b) ANOVA was conducted between the negative control group and other groups. p – value less than 0.05 was considered to indicate statistical significance.
   c) ANOVA was conducted between the five test groups before inhibition to test for the effect of substrate dose variation before inhibition.
   d) ANOVA was conducted between the five test groups after inhibition to test for the effect of substrate dose variation after inhibition.
2. Estimating the Area Under Curve (AUC) for the data obtained from the groups using trapezoidal rule. The AUC "Before Inhibition and After Inhibition" was computed for each of the seven experimental groups. To calculate AUC for each group, a graph of concentration versus time was plotted and the bound area under the curve was calculated using trapezoidal rule. The area was divided into the intervals and the area bound by each interval was calculated using the formula for the area of a trapezium stated as follows:

   $$A = \frac{a+b}{2} * h$$

   Where A = area a and b are the two sides of the trapezium shape formed; h is the height.
   In this context, the consecutively measured blood glucose concentrations represent the two sides of the trapezium. Each fifteen minutes interval represents the height of each trapezium in the plotted "Concentration and time graph". The area calculated for each interval was summed up to get the total area under the curve. Microsoft Excel was the software used to achieve this. The computed Area under the Curve values were presented in a bar char
3. Calculation of percentage inhibition of the enzyme by the *Aloe vera* extract was done using the formula:

   $$\frac{\text{AUC } bi - \text{AUC } ai}{\text{AUC } bi} * 100$$

   Where AUC *bi* represents AUC before inhibition
   AUC *ai* represents AUC after inhibition
   The computed percentage inhibition values were presented in a bar chart.

Study limitations and delimitations

The major study limitations were the influence of the intervening variables as they are presumed to be the factors that made some data to be insignificant at 0.05 p-value despite that the AUC values clearly showed that there were inhibitions in the observed groups.

Ethical considerations

The ethical principle of 3Rs (Replace, Reduce, Refine) was observed in the research design and it was observed in experimental work and the laboratory practice. In the research design, lower mammals was chosen to **replace** higher animals such as pigs, dogs, monkeys etc. Also, the number of animals to sacrifice

per group was **reduced** to ethical recommendations. The burden on the animals was **refined** in the sense that blood collection was done at two weeks intervals. Also, the principles of Good Laboratory Practice and guidelines for the use and care of laboratory animals was adhered to. Approval for the research sought from the Research Ethics Committee at Kampala International University, Western campus, Uganda.

RESULTS

Table 1: Kinetics data on post-prandial blood triglycerides concentration (in mmol/L) after oral olive oil administration.

Animal groups	Doses	0 mins	60 mins	120 mins	180 mins	240 mins	300mins	360 mins	p-value
Group 1 before Inhibition	5ml/kg bw Olive oil	1.25±0.21	1.7±0.24	1.65±0.08	1.35±0.05	1.65±0.02	1.9±0.08	1.3±0.17	0.06
Group 1 after inhibition	7.5g/kg Aloe vera +5mL/kg bw 0live oil	1.15±0.25	1.15±0.34	1±0.05	1.35±0.02	1.25±0.04	1.6±0.17	1.55±0.25	
Group 2 before inhibition	10mL/kg bw olive oil	1.2±0.25	1.3±0.19	1.3±0.25	1.25±0.24	1.1±0.08	1.1±0.08	2±0.01	0.48
Group 2 after inhibition	7.5g/kg Aloe vera +10 mL /kg bw Olive oil	1.65±0.03	1.3±0.01	0.95±0.08	1.3±0.15	1.3±0.19	1.4±0.25	1.5±0.34	
Group 3 before inhibition	15mL/kg bw olive oil	0.90±0.01	1.00±0.08	1.90±0.03	1.40±0.01	1.10±0.25	1.90±0.34	1.85±0.05	0.31
Group 3 after inhibition	7.5g/kg Aloe vera +15mL/kg bw olive oil	1.35±0.25	0.95±0.34	1.3±0.05	0.95±0.05	1.65±0.02	1.6±0.04	1.35±0.17	
Group 4 before inhibition	20mL/kg bw olive oil	1.40±0.15	2.00±0.19	1.20±0.25	1.75±0.34	1.95±0.02	2.05±0.04	2.25±0.17	**0.004**
Group 4 after inhibition	7.5g/kg Aloe vera +20mL/kg bw Olive oil	1.20±0.01	1.05±0.08	1.10±0.15	1.25±0.05	1.85±0.05	1.50±0.02	1.70±0.04	
Group 5 before inhibition	30mL/kg bw olive oil	0.85±0.25	1.25±0.34	1.25±0.05	2.20±0.02	1.85±0.08	2.15±0.15		0.32
Group 5 after inhibition	7.5g/kg Aloe vera +30mL/kg bw Olive oil	1.80±0.08	1.10±0.03	0.80±0.01	1.05±0.08	1.85±0.05	1.75±0.02	1.70±0.04	
Group 6 before inhibition	20mL/kg bw olive oil	1.00±0.08	1.35±0.03	1.15±0.01	1.20±0.08	1.30±0.15	1.00±0.34	1.30±0.05	0.5
Group 6 after inhibition	7.5g/kg *Aloe vera* +20mL/kg bw	1.00±0.25	1.25±0.34	1.15±0.03	1.15±0.01	1.25±0.08	1.75±0.02	1.25±0.04	
Group 7 before inhibition	20mL/kg bw Olive oil	1.30±0.34	1.70±0.05	1.20±0.02	1.65±0.03	1.90±0.04	2.10±0.17	2.20±0.25	**0.04**

Group 7 after inhibition	50mg/kg Std drug (Orlistat) + 20mL/kg Olive oil	1.25±0.08	1.8±0.15	1.0±0.19	1.05±0.25	1.25±0.34	1.25±0.05	1.6±0.02	

Key:
* = Significant p value "before and after inhibition" of *Aloe vera* against pancreatic lipase; Significance at p-value = 0.05

Only Group 4 and 7 show that the differences in their post-prandial blood glucose kinetics "before inhibition' and 'after inhibition" were significant. Group 1, 2, 3, 5 and 6 show that the differences in their post-prandial blood glucose kinetics 'before inhibition' and 'after inhibition' are not significant. For Group 6, which is the negative control group, the difference is not expected to be significant because the results are expected to be almost the same. Distilled water was administered to the group in the second occasion, instead of *Aloe vera* in the Test Groups, and Orlistat in the Drug Control Group 7. ANOVA among the test groups 1, 2, 3, 4 and 5 before inhibition gave the p value of 0.29. ANOVA among the test groups 1, 2, 3, 4 and 5 after inhibition gave the p value of 0.93. These ANOVA values are insignificant, and it may be interpreted that the post-prandial triglycerides are not substrate dose-dependent. The non-dose-dependence might have been caused by the intervening variable factors such as pancreatic insulin release, tissue receptors sensitivity to insulin etc.

AUC values computed from post-prandial blood triglycerides before and after inhibition

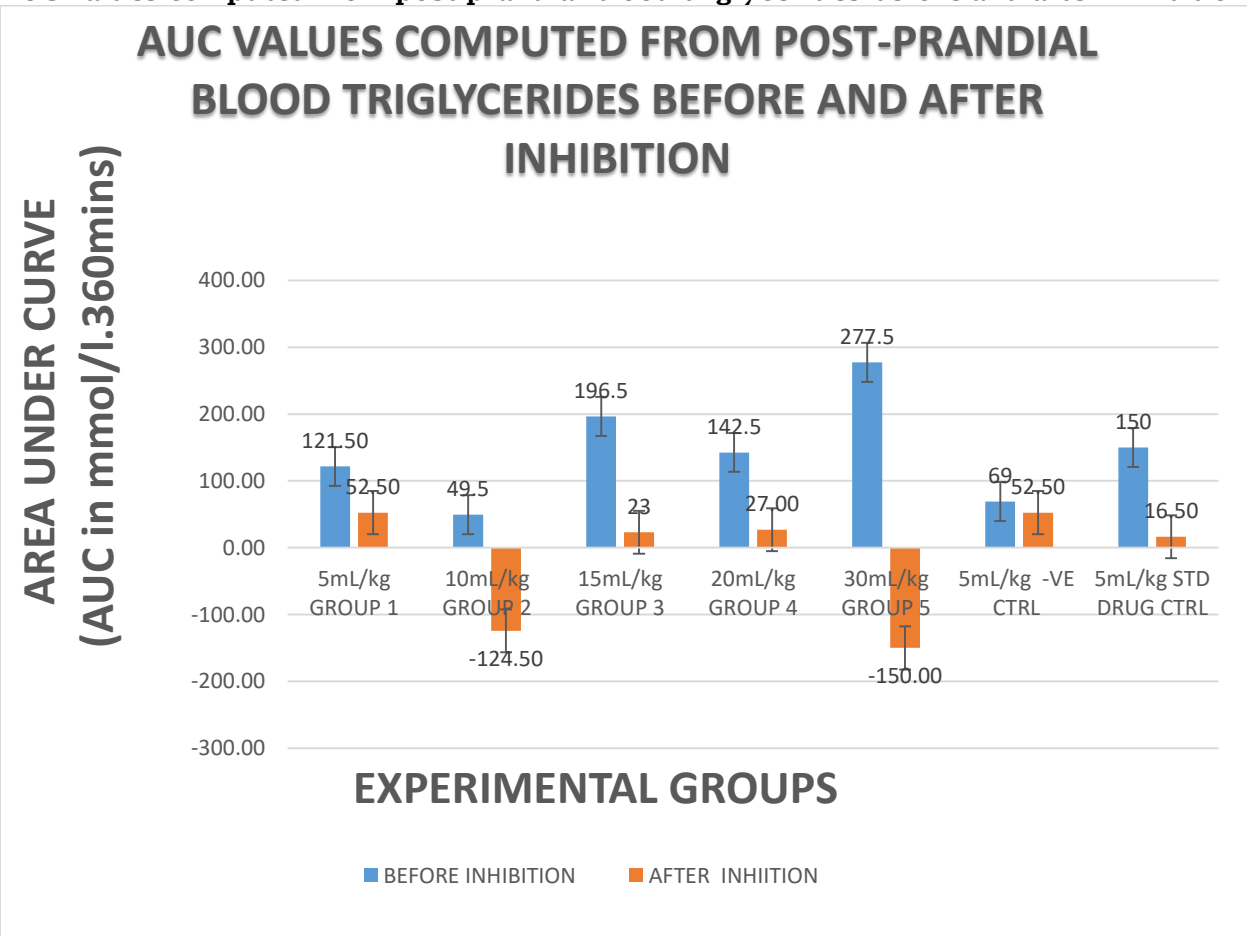

Figure 1 shows the AUC values of the seven experimental groups before and after inhibition of pancreatic lipase Groups 1 to 5 are test groups. Group 6 is the negative control. Group 7 is the standard drug control (+ ve control). The blue bars are for "Before Inhibition" data and the orange bars are for "After Inhibition" data. The olive oil doses were administered as graded in the bar chart. The bar chart shows the significance of inhibition between the compared groups (Before Inhibition and After Inhibition) as observed in the non-over-lapping of the error bars, except for group 6 (negative control group).

Percentage inhibition of pancreatic lipase by *Aloe vera* extract

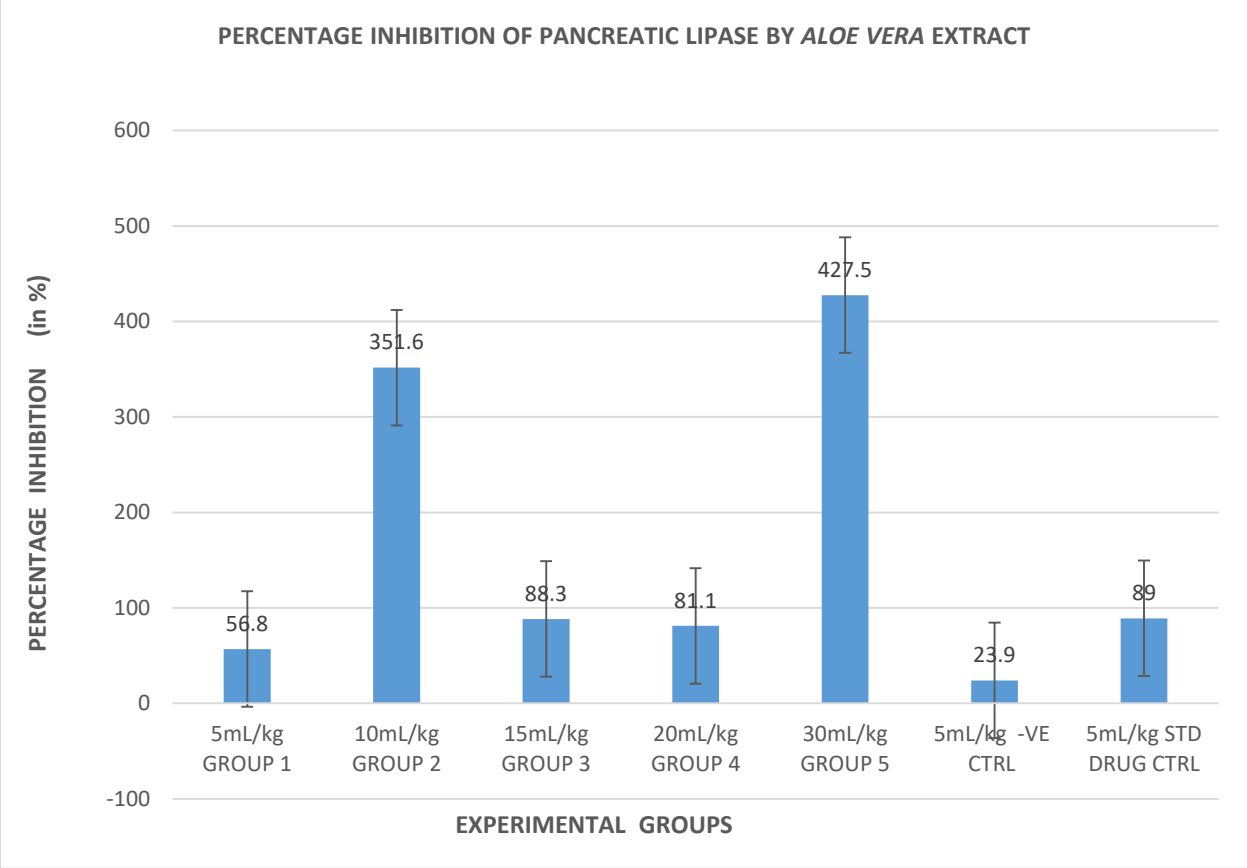

Figure 2: shows the graphical view (in form of bar chart) of the percentage inhibition in each of the seven groups

The greatest percentage inhibition of pancreatic lipase by *Aloe vera* extract was expressed by Group 5 (427.5%), followed by Group 2 (351.6%). Ideally, the percentage inhibition should be either 100% or less. A percentage inhibition greater than AUC shows that effects which are other than pancreatic lipase enzyme inhibition have been elicited by *Aloe vera* in the systemic blood and tissues. In the Test Groups, the trend of inhibition increases as the substrate dose increases. Increase in substrate dose does not avert inhibition. This trend is not indicative of competitive inhibition. It indicates that addition of substrate increases the affinity of inhibitor for the enzyme, hence increased inhibition. This trend is characteristic of uncompetitive inhibition. The negative control (Group 6) has the least inhibition and that is expected, because it contains distilled water instead of inhibitor. The positive standard drug control (Group 7) has a percentage

inhibition of 89%. When it is compared to the Test Group 1 that has the same substrate dose, the inhibition is far greater.

DISCUSSION

A 7.5g/kg dose of *Aloe vera* whole leaf methanolic extract significantly inhibits the digestive enzyme pancreatic lipase in the presence of olive oil, by 56.8% (at 5mL/kg olive oil dose) and 427.5% (at 30mL/kg olive oil dose) in male Wistar rats by 427.5%. This result is corroborates the result of [8] who reported an inhibition of 15% by pancreatic lipase in their *in vitro* study, when 5 mg/ml of the extract was used for the test while the control drug (orlistat) used showed 99% inhibition. In this study, the control drug showed 89% inhibition. [15], also reported an 85.56% percentage inhibition of pancreatic lipase by *Aloe vera in vitro*, while the standard drug control, Orlistat, caused an inhibition percentage of 70.58%. In this present study, it is discovered that *Aloe vera* caused the highest percentage inhibition of pancreatic lipase by 427.5%, in the presence of highest olive oil dose of 30mL/kg in Group 5 (Figure 2).

The standard drug Orlistat caused 89% inhibition. In the negative control group 6, there was 23.9% percentage inhibition. However, in the negative control group, inhibition is not expected, because distilled water was administered to the animals instead of *Aloe vera*. The "Before Inhibition" and "After inhibition" data are expected to be similar but it still shows 23.9% inhibition. This observation may be accounted for, in the publication by [14]. They reported that *Aloe vera* was an efficient agent in retarding glucose movement or diffusion across a dialysis tubing *in vitro* study. As a result of this observation, they deduced that by the mechanism of retarding intestinal absorption, the anti-diabetic activity of *Aloe vera* may be accounted for. Thee AUC values estimated for post-prandial blood triglycerides "before inhibition" and "after inhibition" show significant levels, as seen in the error bars. It is observable that Group 2 and Group 5 yield negative "after inhibition" AUC values. This is because the post-prandial blood triglycerides levels are lower than the fasting blood triglycerides in the two groups. Ideally, the post-prandial blood triglycerides should be higher than fasting blood triglycerides. If the reverse happens, it could be viewed that *Aloe vera* elicits some effects which are other than pancreatic lipase enzyme inhibition in the systemic blood and/or tissues. In fact, in all the Test Groups 1,2,3,4, 5, this development can be observed, i.e. fasting blood triglyceride levels are equal or higher than post-prandial blood triglycerides "after inhibition" (Table 1). The possible explanation could be that the *Aloe vera* extract does more than inhibition of the enzyme pancreatic lipase. It might be stimulating the pancreas to release insulin or sensitize tissues to triglycerides uptake. This assumption corroborates is corroborated by the report published by [6]. They reported that dietary Aloe formula activates the intracellular enzyme AMP protein kinase (AMPK) which is known to be involved in acceleration of ATP-generating catabolic pathways, including glucose and fatty acid oxidation [20-23].In another vein, besides enzyme inhibition mechanism, it has been reported that *Aloe vera* retards intestinal absorption of glucose [5-8]. This could be the case for oils also. The statistical ANOVA between the kinetics data of "Before Inhibition" and "After Inhibition" (Table 1) reveals significance level of $p < 0.05$ in Group 1, 4, 5 and 7. The statistical ANOVA among the test groups 1, 2, 3, 4 and 5 before inhibition gave the p value of **0.29**. The statistical ANOVA among the test groups 1, 2, 3, 4 and 5 after inhibition gave the p value of **0.93**. These ANOVA values are insignificant, and it may be interpreted that the post-prandial triglycerides are not substrate dose-dependent. The non-dose-dependence might have been caused by the intervening variable factors such as pancreatic insulin release, tissue receptors sensitivity to insulin etc. Also, the fact that addition of more substrate dose increases percentage inhibition which prevents absorption of olive oil into the blood and

consequently, not being measured. Thus, increase in olive oil dose may not cause significant difference in the blood triglycerides of the different animal groups.

The trend of the calculated percentage inhibition data values mimics both uncompetitive and competitive inhibition types. As substrate dose increases from 5mL/kg in Group 1 to 10mL/kg in Group 2, the percentage inhibition increases from 56.8% to 351.6% respectively. Increase in substrate dose from 10mL/kg to 15mL/kg in Group 3 and 20mL/kg in Group 4 decreases the percentage inhibition to 88.3% and 81.1% respectively. Increase in substrate dose from 20mL/kg to 30 mL/kg increases the percentage inhibition from 81.1% to 427.5%. This trend of inhibition mimics both Uncompetitive and Competitive Inhibition type [13]. Thus, the inhibition type can be regarded as Mixed Inhibition type.

The implication of this finding is that a diabetic patient may eat some reasonably measured oily foods in combination with processed *Aloe vera* in order to protect him/her from the surge of post-prandial blood triglycerides that can aggravate the diabetic condition. Thus, their quality of life would be enhanced. Also, the plant stands a chance to be a substitute for the standard drug Orlistat among the drugs being used to manage diabetes.

CONCLUSION

Aloe vera methanolic extract of 7.5g/kg dose, administered with triglycerides (olive oil), inhibits intestinal pancreatic lipase in male wistar rats thereby significantly lowering post-prandial blood triglycerides as evident in the post-prandial blood triglycerides kinetics data, estimated Area Under Curve values and percentage inhibition calculated. The inhibition type is supposedly "Uncompetitive" and "Competitive". Thus, it is a mixed type of inhibition. In addition, the extract might be doing more than the inhibition of pancreatic lipase in order to lower post-prandial triglycerides.

REFERENCES

1. Maan A. A., A. Nazir and M. K. I. Khan et al., "The therapeutic properties and applications of *Aloe vera*: a review," *Journal ofHerbal Medicine*, vol. 12, pp. 1–10, 2018.
2. Agarwal, O.P., 1985. Prevention of atheisease. Angiology 36 (8), 485–492.
3. Akmal M, Wadhwa R. Alpha Glucosidase Inhibitors. [Updated 2022 Aug 12]. In: StatPearlsTreasure Island (FL): StatPearls Publishing; 2022 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK557848/
4. Alethia Muñiz-Ramirez , Rosa M. Perez, Efren Garcia, and Fabiola E. Garcia Antidiabetic Activity of *Aloe vera* Leaves, Hindawi, Evidence-Based Complementary and Alternative Medicine, Volume 2020, Article ID 6371201, 9 pages,https://doi.org/10.1155/2020/6371201.
5. Al-Qodah, Zakaria & Daghstani, H. & Goepll, Ph & Lafi, Walid. (2007). Determination of kinetic parameters of α-amylase producing thermophile Bacillus sphaericus, AFRICAN JOURNAL OF BIOTECHNOLOGY. 6.
6. Adolfo Andrade-Cetto, Elda Carola Cruz, Christian Alan Cabello-Hernández, René Cárdenas-Vázquez, "Hypoglycemic Activity of Medicinal Plants Used among the Cakchiquels in Guatemala for the Treatment of Type 2 Diabetes", *Evidence-Based Complementary and Alternative Medicine*, vol. 2019, Article ID 2168603, 7 pages, 2019. https://doi.org/10.1155/2019/2168603
7. Ballinger, Anne & Peikin, Steven. (2002). Orlistat: Its current status as an anti-obesity drug. European journal of pharmacology. 440. 109-17. 10.1016/S0014-2999(02)01422-X.
8. Beppu, H., Shimpo, K., Chihara, T., Kanako, T., Tamai, I., Yamaji, S., Ozaki, S., Kuzuya, H., Sonoda, S., 2006. Antidiabetic effects of

dietary administration of Aloe arborescens Miller components on multiple low-dose streptozotocin-induced diabetes in mice: investigation on hypoglycaemic action and systemic absorption dynamics of aloe components. J. Ethnopharmacol. 103 (3), 468–477.

9. Birabwa C, Bwambale MF, Waiswa P, Mayega RW. Quality and barriers of outpatient diabetes care in rural health facilities in Uganda - a mixed methods study. BMC Health Serv Res. 2019 Oct 16;19(1):706. doi: 10.1186/s12913-019-4535-x. PMID: 31619234; PMCID: PMC6796349.
10. Ugwu OPC and Amasiorah, V. I. (2020). The effects of crude ethanol root extract and fractions of sphenocentrum jollyanum on the lipid profile of streptozotocin-induced diabetic wistar albino rats. *IDOSR Journal of Biology, Chemistry And Pharmacy*, *5*(1), 36-46.
11. Anaduaka, E. G., Egba, S. I., Ugwu, J. U., Apeh, V. O., & Ugwu, O. P. C. (2014). Effects of dietary tyrosine on serum cholesterol fractions in rats. *Afr J Biochem Res*, *8*(5), 95e100.
12. Eze-Steven, P. E., Udeozo, I. P., Chidiebere, E. U., Emmanuel, O., Okechukwu, P. U., & Egba, J. J. (2014). Anti-Lipidemic Effects of Desmodium velutinum Water Leaf Exract on Albino Wistar Rats Fed with High Fat Diet. *American-Eurasian Journal of Scientific Research*, *9*(2), 26-30.
13. Ezekwe, C. I., Okorie, A., PC, U. O., OFC, N., & SC, E. (2014). Blood Pressure Lowering Effect of Extract ofGongronema latifolium. *Research Journal of Pharmaceutical, Biological and Chemical Sciences*, *5*(2), 952-959.
14. Aja PM, IO Igwenyi, PU Okechukwu, OU Orji, EU Alum (2015). Evaluation of anti-diabetic effect and liver function indices of ethanol extracts of Moringa oleifera and Cajanus cajan leaves in alloxan induced diabetic albino rats. Global Veterinaria,14(3): 439-447.
15. Bolkent, S., Akev, N., Ozsoy, N., Sengezer-Inceli, M., Can, A., Alper, O., Yanadaq, R., 2004. Effect of *Aloe vera* (L.) Burm fil. leaf gel. and pulp extracts on kidney in type II diabetic rat model. Indian J. Exp. Biol. 42 (2), 48–52.
16. Botanical notes, University of California Davis Botanical Conservatory, volume 1, issue 1.0 July, 2009
17. Brand-Miller JC, Holt SH, Pawlak DB, McMillan J. Glycemic index and obesity. Am J Clin Nutr 2002; 76: 281S–285S.
18. Brown CM, Dulloo AG, Yepuri G, Montani JP. Fructose ingestion acutely elevates blood pressure in healthy young humans. Am J Physiol 2008;294(3):R730 –7.
19. Camila Gabriel Kato, Geferson de Almeida Gonçalves, Rosely Aparecida Peralta, Flavio Augusto Vicente Seixas, Anacharis Babeto de Sá-Nakanishi, Lívia Bracht, Jurandir Fernando Comar, Adelar Bracht, Rosane Marina Peralta, "Inhibition of α-Amylases by Condensed and Hydrolysable Tannins: Focus on Kinetics and Hypoglycemic Actions", *Enzyme Research*, vol. 2017, Article ID 5724902, 12 pages, 2017. https://doi.org/10.1155/2017/5724902.
20. Catherine Peyrot des Gachons, Paul A. S. Breslin "Salivary Amylase: Digestion and Metabolic Syndrome", Curr Diab Rep. 2016 October ; 16(10): 102. doi:10.1007/s11892-016-0794-7.
21. Catherine Birabwa, Mulekya F. Bwambale , Peter Waiswa and Roy W. Mayega, 2019,Quality and barriers of outpatient diabetes care in rural health facilities in Uganda – a mixed methods study, BMC Health Services Research (2019) 19:706 https://doi.org/10.1186/s12913-019-4535-x.
22. Choudhary, M., Kochhar, A., & Sangha, J. (2014). Hypoglycaemic

and hypolipidemic effect of *Aloe vera* L. in non-insulin dependent diabetics. *Journal of food science and technology*, *51*(1), 90–96. https://doi.org/10.1007/s13197-011-0459-0

23. Iqbal, J., & Hussain, M. M. (2009). Intestinal lipid absorption. American journal of physiology. Endocrinology and metabolism, 296(6), E1183–E1194. https://doi.org/10.1152/ajpendo.90899.2008.
24. Kooti, W., Farokhipour, M., Asadzadeh, Z., Ashtary-Larky, D., & Asadi-Samani, M. (2016). The role of medicinal plants in the treatment of diabetes: a systematic review. *Electronic physician*, *8*(1), 1832–1842. https://doi.org/10.19082/1832.
25. Kruger MJ, Davies N, Myburgh KH, Pandey KB, Rizvi SI, et al. Antioxidant effects of plant phenolic compounds. In Basu TK, Temple NJ, Garg ML (eds):"Antioxidants in Human Health and Diseases,." Am J Clin Nutr. 2016
26. Lorenzati, B., Zucco, C., Miglietta, S., Lamberti, F., & Bruno, G. (2010). Oral Hypoglycemic Drugs: Pathophysiological Basis of Their Mechanism of ActionOral Hypoglycemic Drugs: Pathophysiological Basis of Their Mechanism of Action. *Pharmaceuticals (Basel, Switzerland)*, *3*(9), 3005–3020. https://doi.org/10.3390/ph3093005
27. Makinde, A. O., Gamble, J., & Lopaschuk, G. D. (1997). Upregulation of 5'-AMP-activated protein kinase is responsible for the increase in myocardial fatty acid oxidation rates following birth in the newborn rabbit. *Circulation research*, *80*(4), 482–489. https://doi.org/10.1161/01.res.80.4.482
28. Mero, N., Malmström, R., Steiner, G., Taskinen, M. R., & Syvänne, M. (2000). Postprandial metabolism of apolipoprotein B-48- and B-100-containing particles in type 2 diabetes mellitus: relations to angiographically verified severity of coronary artery disease. *Atherosclerosis*, *150*(1), 167–177. https://doi.org/10.1016/s0021-9150(99)00364-0
29. Pirillo, A., Casula, M., Olmastroni, E., Norata, G. D., & Catapano, A. L. (2021). Global epidemiology of dyslipidaemias. *Nature reviews. Cardiology*, *18*(10), 689–700. https://doi.org/10.1038/s41569-021-00541-4.
30. Raben, A., Møller, B. K., Flint, A., Vasilaris, T. H., Christina Møller, A., Juul Holst, J., & Astrup, A. (2011). Increased postprandial glycaemia, insulinemia, and lipidemia after 10 weeks' sucrose-rich diet compared to an artificially sweetened diet: a randomised controlled trial. *Food & nutrition research*, *55*, 10.3402/fnr.v55i0.5961. https://doi.org/10.3402/fnr.v55i0.5961
31. Sacks F. M. (2008). After the Fenofibrate Intervention and Event Lowering in Diabetes (FIELD) study: implications for fenofibrate. *The American journal of cardiology*, *102*(12A), 34L–40L. https://doi.org/10.1016/j.amjcard.2008.09.073
32. Shin, E., Shin, S., Kong, H., Lee, S., Do, S. G., Jo, T. H., Park, Y. I., Lee, C. K., Hwang, I. K., & Kim, K. (2011). Dietary Aloe Reduces Adipogenesis via the Activation of AMPK and Suppresses Obesity-related Inflammation in Obese Mice. *Immune network*, *11*(2), 107–113. https://doi.org/10.4110/in.2011.11.2.107 .
33. Trumbo, P., Schlicker, S., Yates, A. A., Poos, M., & Food and Nutrition Board of the Institute of Medicine, The National Academies (2002). Dietary reference intakes for energy, carbohydrate, fiber, fat, fatty acids, cholesterol, protein and amino acids. *Journal of the*

American Dietetic Association, *102*(11), 1621–1630. https://doi.org/10.1016/s0002-8223(02)90346-9.

34. Zhang, Y., Liu, W., Liu, D., Zhao, T., & Tian, H. (2016). Efficacy of *Aloe vera* Supplementation on Prediabetes and Early Non-Treated Diabetic Patients: A Systematic Review and Meta
35. Zong, H., Ren, J. M., Young, L. H., Pypaert, M., Mu, J., Birnbaum, M. J., & Shulman, G. I. (2002). AMP kinase is required for mitochondrial biogenesis in skeletal muscle in response to chronic energy deprivation. *Proceedings of the National Academy of Sciences of the United States of America*, *99*(25), 15983–15987. https://doi.org/10.1073/pnas.252625599.
36. Ugwu Okechukwu, P. C., Nwodo Okwesili, F. C., Joshua Parker, E., Odo Christian, E., & Ossai Emmanuel, C. (2013). Effect of ethanol leaf extract of Moringa oleifera on lipid profile of mice. *Research Journal of Pharmaceutical, Biological and Chemical Sciences*, *4*(1), 1324-1332.
37. Enechi, O. C., Manyawo, L., & Ugwu, P. O. (2013). Effect of ethanol seed extract of Buccholzia coriacea (wonderful kola) on the lipid profile of albino rats. *African Journal of Biotechnology*, *12*(32).
38. Ugwu Okechukwu, P. C., Onwe, S. C., & Okon, M. B. (2022). The effect of Methanol Extract of Rauwolfia vomitoria on Lipid Profile of Chloroform intoxicated Wistar Albino Rats. *IAA Journal of ScientificResearch*,*8*(1),73-82.
39. Aja, P. M., Ibekwe, V. I., Ekpono, E. U., Ugwu, P. C., & Okechukwu, P. C. (2015). Effect of ethanol extract of Cajanus cajan leaf on plasma lipid level in albino rats. *Inter J Cur Res Acad Rev*, *3*(1), 161-167.
40. Enechi OC, H Ikenna Oluka, PC Okechukwu Ugwu (2014). Acute toxicity, lipid peroxidation and ameliorative properties of *Alstonia boonei* ethanol leaf extract on the kidney markers of alloxan induced diabetic rats. African journal of biotechnology13: 5

CITE AS*:* Faseun Yusuf Olusola, Ezeonwumelu Joseph Obiezu Chukwujekwu, Odda John, Odoma Saidi, Idania Hidalgo, Moazzam Mohiuddin Lodhi, Patrick Maduabuchi Aja, Hambali Kaltume Umar, Mpumbya Jackie Rachael, Ebere Emilia Ayogu, Narayana Goruntla, Hope Onohuean and Ugwu Okechukwu Paul-Chima (2023). Postprandial Hypolidaemic Effect of Aloe Vera Methanolic Extract via the Mechanism of Intestinal Pancreatic Lipase Enzyme Inhibition in Male Wistar Rats. IDOSR JOURNAL OF BIOLOGY, CHEMISTRY AND PHARMACY 8(3)106-118. https://doi.org/10.59298/IDOSR/JBCP/23/11.1119