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Blood Glucose Lowering Activity of the Terpenoid – Phenol Extract from The Pulp of Crescentia Cujete

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Abstract — Diabetes mellitus is a major endocrine disorder affecting the population worldwide. The Philippines, which has a population of about 88.6 million and is categorized as a lower- middle income country by the World Bank has been reported to have about 7.8% of its population in the year 2030 to be suffering from diabetes mellitus. Diabetes mellitus is a complex and a multifarious group of disorders that disturbs the metabolism of carbohydrates, fat and protein. It results from shortage or lack of insulin secretion or reduced sensitivity of the tissue to insulin. Of the diabetes mellitus cases, it has been reported that there are a greater number of patients suffering from type 2 diabetes mellitus. Medicinal plants play an important role in the management of diabetes mellitus especially in developing countries where affordability and accessibility of drugs is a problem. Several plant constituents have shown to possess hypoglycemic and anti- diabetic activities. Among these are terpenes like iridoids, flavonoids, glycosides like iridoid glucosides, alkaloids, etc. Experimental method using standard laboratory procedures was utilized to determine the ALD and the median lethal dose, and blood glucose lowering activity of the Terpenoid – Phenol extract of Crescentia cujete in Swiss mice.After conducting the different tests, the following findings were obtained: (1.)The toxicological test of the terpenoid – phenol extract of the pulp of Crescentia cujete revealed a non-toxic dose of up to 1000 mg/kg. The approximate lethal dose confirmed a physiological changed commencing at 2500mg/kg until 10, 000mg/kg. The LD50 was established to be 14,454.40 mg/kg. (2.) Crescentia cujete extract at a dose of 100 mg/kg, 160 mg/kg, 250 mg/kg, 400 mg/kg, and 630 mg/kg lowered the blood glucose level on glucose induced hyperglycemic Swiss mice. (3.) The difference in the blood glucose lowering activity of the Crescentia cujete terpenoid – phenol extract and that of a standard hypoglycemic agent, Glibenclamide is not statistically significant. This research demonstrated that the Terpenoid – Phenol extract of Crescentia cujete has no statistically significant blood glucose lowering activity.

I. Introduction

Diabetes mellitus is a major endocrine disorder affecting the population worldwide. Recent statistics show that about 25.8 million people of all ages or an equivalent of 8.3% of the United States' population is suffering from the disease. Of these, 18.8 million are diagnosed and 7 million are undiagnosed (World Health Organization, 2011). Developing countries like the Philippines is not exempted in this health burden. The Philippines, which has a population of about 88.6 million and is categorized as a lower-middle income country by the World Bank has been reported to have about 7.8% of its population in the year 2030 to be suffering from diabetes mellitus. This represents an increase from 2.8 million in 2000 (Higuchi, 2009).

Diabetes mellitus is a complex and a multifarious group of disorders that disturbs the metabolism of carbohydrates, fat and protein. It results from shortage or lack of insulin secretion or reduced sensitivity of the tissue to insulin. There are three types of diabetes mellitus. Type 1 diabetes is a condition where the body produces too little or no insulin. This condition is usually diagnosed in childhood or adolescence. The exact cause is unknown. Type 2 diabetes is characterized by the inability of the body to respond well to insulin. It is usually secondary to obesity and sedentary lifestyle. The last type is known as gestational diabetes. This refers to high blood glucose that develops in a pregnant woman, who originally did not have diabetes. Women who have gestational diabetes are at high risk of type 2 diabetes later in life (Standards of Medical Care in Diabetes Care, 2009).

Of the diabetes mellitus cases, it has been reported that there are a greater number of patients suffering from type 2 diabetes mellitus. Apart from the rising case rates are the falling ages at which the disease develops and the rising prevalence of type 2 diabetes in children, adolescents and young adults. It seems clear that the rising case rates mirror changes in lifestyle, notably over-nutrition, physical inactivity and urbanization. Though the new, urbanized, affluent young from the more prosperous parts of the region are under particular threat, this does not exempt population from developing countries due to the widespread use of readily available foods, sedentary lifestyles brought about by modernization like home computers, televisions, and the motor car. These have rapidly altered the behavioural patterns of the very young, and the health consequences threaten to become the epidemic of the new millennium and thus, diabetes mellitus is becoming a public health concern that needs to be prioritized and given utmost attention.

There have been a lot of efforts done to control the incidence of the disease. Among these are awareness campaign through education, support by the government and non-governmental organization for the early diagnosis followed by appropriate care and support, provision for affordability of medications as dictated by the maximum retail drug price mandated by the Cheaper Medicines Act and the discovery of new drugs that are available for use by the whole population. These efforts are geared towards curbing medical complications to arise that may have more serious implications in the country's economy.

Medicinal plants play an important role in the management of diabetes mellitus especially in developing countries where affordability and accessibility of drugs is a problem. Among the medicinal plants that have been found most commonly studied in relation to diabetes and its complications are Oliver's gentian (Gentiana olivieri griseb), Pata de Vaca (Bauhinia forficatakoeingii), Jambul (Eugenia jambolana L.), Indian Lettuce (Lactuca indica L.), Velvet bean (Mucuna pruriens), Guduchi Satva (Tinospora cordifolia), Ampalaya (Momordica charantia L.), Vettikan (Aporosa lindleyana Baill),True Myrtle (Myrtus communis L), and Sheng Yu Zu (Rhizoma Polygonati Odorati). Most of these plants have shown varying degrees of hypoglycemic and anti-hyperglycemic activity. Among the active medicinal herbs are Momordica charantia L. (Cucurbitaceae), Pterocarpus marsupium Roxb. (Leguminoceae), and Trigonella foenum greacum

L. (Leguminosae) have been reported to beneficial for treatment of type 2 diabetes (Jung, Park, Lee, & al., 2010).

Several plant constituents have shown to possess hypoglycemic and anti- diabetic activities. Among these are terpenes like iridoids, flavonoids, glycosides like iridoid glucosides, alkaloids, etc. Ampalaya, Momordica charantia, a plant well recognized for its hypoglycemic property contains sterols (charantin) and triterpenes (momorcharaside A and B) (Zhu & al, 1990). A study on the hypoglycemic activity of Ajugaremota and Sgygium guineense showed that the alcoholic extract of the plant materials which exhibited these properties contains saponins, flavonoids, phytosteroids and alkaloids (Worku, February 2009). Terpenoid like Iridoids and polyphenolic substances like flavonoids are also well known hypoglycemic agents. These substances have manifested effectiveness in decreasing hyperglycemic states at the same time reduce diabetic renal damage by reducing renal lipid peroxidation (Geetanjali & al., March 25, 2008).

Statement of the Problem

This study aimed to determine the antioxidant and blood glucose lowering activities of the terpenoid-phenol extract from the pulp of Crescentia cujete.

It specifically sought to answers the following questions:

1. What is the approximate lethal dose (ALD) and Median Lethal dose (LD50) of the terpenoid – phenol extract of Crescentia cujete?
2. Does the terpenoid – phenol Crescentia cujete extract possess blood glucose lowering activity on glucose induced hyperglycemic Swiss mice?
3. Is there a significant difference between the blood glucose lowering activity of the terpenoid – phenol extract and that of a standard hypoglycemic agent, glibenclamide?

Hypothesis

H1: There is significant difference in the blood glucose lowering activity of the terpenoid

– phenol extract from the pulp Crescentia cujete from that of ascorbic acid.

H0: There is no significant difference in the blood glucose lowering activity of the terpenoid – phenol extract from the pulp Crescentia cujete from that of the standard hypoglycemic drug Glibenclamide.

Significance of the Study

This study focused on the investigation of the blood glucose lowering activities of the terpenoid – phenol extract from the pulp of Crescentia cujete, a new plant in the Philippines which

has not been extensively studied for its phytochemical and pharmacological properties. The results of this study offer benefit to the following:

The **people with diabetes mellitus** or predisposed to the disease. This provides a cheap alternative to existing anti-oxidants and blood glucose lowering agents.

The **health practitioners** who are on their way to address the health conditions of the country. The results of this study offer solutions to the ever growing incidence of the disease.

Future researchers in herbal medicines, who continuously search for new plants with medicinal values and who are on their way developing methods of isolation, characterization and identification of specific constituents with pharmacologic activities. The results may serve as a basis for their future investigations.

The **Manufacturing Industry** is in constant search for better essential or active ingredients that can be incorporated in the manufacture of drugs.

Scope and Limitations of the Study

The study focused on the toxicological and blood glucose lowering activity and was carried out using Swiss mice as subjects. Blood glucose levels were determined using a gluco-meter.

The study did not deal with the determination of the specific phenolic or terpenoid substance that possess blood glucose lowering activity.

Definition of Terms

Approximate Lethal Dose (ALD) is a standard measure of the toxicity of a material that will kill half of the sample population of a specific test animal in a specified period through exposure via ingestion, skin contact, or injection (Akhila, Shyamjith, & Alwar, October 10, 2007).

Bignoniaceae family of flowering plants in the order Cucurbitales. The Bignoniaceae consists of two genera: Begonia, with some 1,000 species, and Hillebrandia, with one species. The family is distributed throughout most tropical and warm temperate regions, with a large percentage of species being native to the Americas (2011)

Diabetes mellitus is a chronic disease, which occurs when the pancreas does not produce enough insulin, or when the body cannot effectively use the insulin it produces. This leads to an increased concentration of glucose in the blood (hyperglycemia) (World Health Organization, n.d.)

Fasting Blood Glucose is a test that measures the amount of sugar in the blood. Fasting means not had food or drink for at least 8 hours (Medline Plus, n.d.).

Glucose is a major source of energy for most cells of the body, including those in the brain. The carbohydrates we eat eventually end up as glucose in the blood (Association, 2010).

Half Maximal Inhibitory Concentration (IC50) is a concentration of an inhibitor at which 50% inhibition of the response is seen; should only be used of in vitro test systems (Le Berre, Gerlach, Dziembala, & Kilcoyne, 2022).

Hypoglycemia refers to low plasma glucose (PG) level which is lower than 4 millimole / liter (Saunders, 2011).

Insulin is a protein hormone formed from proinsulin in the beta cells of the pancreatic islets of Langerhans. The major fuel-regulating hormone, it is secreted into the blood in response to a rise in concentration of blood glucose or amino acids. Insulin promotes the storage of glucose and the uptake of amino acids, increases protein and lipid synthesis, and inhibits lipolysis and gluconeogenesis (Marak & al., 2002).

Median Lethal Dose is the quantity of an agent that will kill 50 per cent of the test subjects (https://revive.gardp.org/resource/median-lethal-dose-ld50/?cf=encyclopaedia, n.d.)

Normoglycemia refers to the normal concentration of glucose in the blood (G, 1990)

II. Methodology

This chapter presents the methods that were used to answer the problems of the study.

Crescentia cujete was collected during the fruiting season from Davao. Experimental method using standard laboratory procedures was utilized to determine the ALD and the median lethal dose, and blood glucose lowering activity of the Terpenoid – Phenol extract of *Crescentia cujete* in Swiss mice.

Research Procedures

1. Biological Assay

The safety of the Terpenoid – Phenol Extract of *Crescentia cujete* was evaluated using swiss mice. The toxicological and pharmacological testing were conducted under the provision of official assistant from an accredited laboratory facility in accordance with the guidelines of the Philippine Association for Laboratory Animals Science (PALAS).

1.1. Toxicity test (Williamson et al, 1996)

Healthy 6-7 weeks old of swiss mice, weighing 18-25 grams, bred at the University of the Philippines, Department of Pharmacology were obtained and used as subjects of this study. The mice were fed pigeon pellets and water. They were acclimatized for a period of three days prior to toxicological testing. Different doses of the terpenoid-phenol extract were determined using the logarithmic method with 0.6 increments. The administration of all treatments was done via intraperitoneal injection.

1.1.1 Approximate Lethal Dose (ALD) Test

The approximate lethal dose of the *Crescentia cujete* Terpenoid-phenol extract was evaluated using 16 Swiss mice (equally numbered to male and female) and was grouped into 8. They were kept in individual observation cages and were acclimatized 7 days prior to the conduct of the study. Physiological changes and deaths were observed in all groups and were rated based on the standard central nervous system monitoring parameters.

1.1.2 Median Lethal Dose (LD50) Test

Post Approximate lethal dose test further acute toxicity study – median lethal dose or LD50 was carried out using sixty Swiss mice (30 males and 30 females). Ten Swiss mice, (5 males and 5 females), were assigned to each group: Negative control (NSS) and 5 *Crescentia cujete* Terpenoid – Phenol extract dose groups. The mice were fasted overnight before the administration of the treatments.

Starting dose for the *Crescentia cujete* Terpenoid – Phenol extract for LD50 was observed based on ALD results for any physiological changes.

The mortality rates were observed for a period of seven days and the median lethal dose was computed using the regression method.

2. Pharmacological Assay

2.1 Test Animals

Two month old males Swiss mice weighed 18-25 grams bred at the University of the Philippines Department of Pharmacology were used for the study. The mice were fasted overnight and their blood glucose levels were determined prior to the experiment. The mice with baseline fasting blood glucose levels of 6-8 mmol/L or corresponding to 109-144 mg/dL were used in the bioassay. Total of forty-two mice were divided into seven groups (6 mice per group) following this scheme: Five groups were assigned with the *Crescentia cujete* Terpenoid – Phenol extracts with varying doses, one group for the normal control (NSS) and another group for the positive control using a commercially available drug - Glibenclamide.

2.2 Crescentia cujete – terpenoid phenol extract

Different doses of the Terpenoid-phenol extract were prepared. The initial dose of the extract was 100 mg/kg body weight and succeeding doses corresponded to an increment of 0.2 log dose. These doses corresponded to 160, 250, 400, 630 mg/kg body weight of the test animals.

2.2.1 Negative Control

The negative control group were consists of mice treated with normal saline solution (NSS).

2.2.2 Positive Control - Glibenclamide (commercially available)

The positive control that was used was Glibenclamide at a dose level of 2.5 mg/kg body weight.

2.2.3 Glucose-induced Hyperglycemia

A 10% glucose solution was administered orally to induced hyperglycemia. A dose of 1 g/kg of glucose was given to all the test animals. The blood glucose level of the test animals was taken 15 minutes after glucose induction.

2.2.4 Determination of the blood glucose lowering activity

The decline in blood glucose level of Swiss mice after administration of Glibenclamide was used as basis for determining blood glucose lowering activity.

The determination of the blood glucose lowering activity was done by administering different doses of the Crescentia cujete terpenoid-phenol extract to the test animals. Terpenoid – Phenol extract of Crescentia cujete were prepared by dissolving it in sterile water for injection (SWFI). Not more than 1.0 mL of the test drug solutions were administered separately to the test animals by intraperitoneal injection 15 minutes after administration of glucose. Blood glucose levels of the test animals were determined through the use of Gluco-strips® method. Blood glucose levels were noted at the following time intervals post induction of treatment: 15, 30 and 45 minutes. Blood were collected from the tail vein of the mic.

The same procedure was followed for determining the blood glucose lowering activity of the positive (Glibenclamide) and the negative (NSS) controls. The decline in blood glucose levels at different time period and % decline in blood glucose levels will be computed as follows:

Table 1: Different Groups and Treatments for Pharmacological Assay

GROUP	DRUG
Negative Control	Normal Saline Solution (NSS)
Positive Control	Glibenclamide 2.5 mg
Extract 1	100mg/kg Terpenoid – Phenol of *Crescentia cujete*
Extract 2	160mg/kg Terpenoid – Phenol of *Crescentia cujete*
Extract 3	250mg/kg Terpenoid – Phenol of *Crescentia cujete*
Extract 4	400mg/kg Terpenoid – Phenol of *Crescentia cujete*
Extract 5	630mg/kg Terpenoid – Phenol of *Crescentia cujete*

3. Statistical Analysis

Descriptive and inferential statistics were employed in the study. Approximate Lethal dose test was done succeeded by the Median lethal dose (LD50) determination through the use of Regression Method. Furthermore, means of the absorbance and half maximal inhibition concentration (IC50) were computed in the anti-oxidant assay. Test Significant differences among treatment groups in the Pharmacological assay– Blood lowering activity were determined using Analysis of Variance (ANOVA) through t-test and f-test.

III. Results and Discussion

1. Results on Biological Assay

Table 2: Approximate Lethal Dose of the Terpenoid – Phenol Extract of *Crescentia cujete, L*

Log Dose	Dose mg/kg	Deaths	Physiological Activities Monitored								
			1	2	3	4	5	6	7	8	9
1.0	10	0 / 2	0	0	0	0	0	0	0	0	0
1.6	40	0 / 2	0	0	0	0	0	0	0	0	0
2.2	160	0 / 2	0	0	0	0	0	0	0	0	0
2.8	630	0 / 2	0	0	0	0	0	0	0	0	0
3	1 000	0 / 2	0	0	0	0	0	0	0	0	0
3.4	2 500	0 / 2	1	1	1	1	0	0	0	0	2
4.0	10 000	1 / 2	3	3	4	2	1	2	2	1	4
4.4	25 000	2/2	3	3	4	2	1	3	2	2	4

Approximate lethal dose test showed a relative safety dose of up to 1000mg/kg and did not demonstrate visible symptoms of toxicity in the test animals as reflected in Table 2. However, there were physiological changes observed starting at a dose of 2,500 mg/kg and significant changes were seen at 10,000 mg/kg.

Table 3: Median Lethal Dose (LD50) of the Terpenoid – Phenol Extract of *Crescentia cujete, L*

Log Dose	Dose mg/kg	Deaths	Percentage death (%)
3.4	2 500	0 / 8	0
3.6	4 000	0 / 8	0
3.8	6 300	2 / 8	25
4.0	10 000	3 / 8	37.5
4.2	16 000	4 / 8	50
4.4	25 000	5 / 8	62.5
4.6	40 000	7 / 8	87.5
4.8	63 000	8 / 8	100

Legend of Monitored Physiological Activity

1 – Decrease in motor activity
2 – Ataxia ratinghe
3 – Loss of righting reflex
4 – Analgesia
5 – Anesthesia
6 – Respiratory rate and depth
7 – Corneal and pinnal reflex
8 – Paralysis of forelegs, hind legs and head
9 – Loss of screen grip

The Median Lethal Dose of the terpenoid – phenol extract of *Crescentia cujete* was calculated using percent mortality and established to be 16,000 mg/kg. The regression equations between log of doses and percentage death is Y = 75.14881 x + -262.798 and resulted in 14,454.40 mg/kg. The two values are equal confirming the validity of LD50. All swiss mice were died at a dose of 63,000 mg/kg.

2. Results on Pharmacological Assay

2.1 Blood Glucose Lowering Activity of *Crescentia cujete*

The hyperglycemic effect, induced by intraperitoneal administration of glucose in normoglycemic Swiss mice, was antagonized after administration of different doses of *Crescentia cujete* terpenoid – phenol extract and standard drug glibenclamide thus, produced a blood glucose lowering activity.

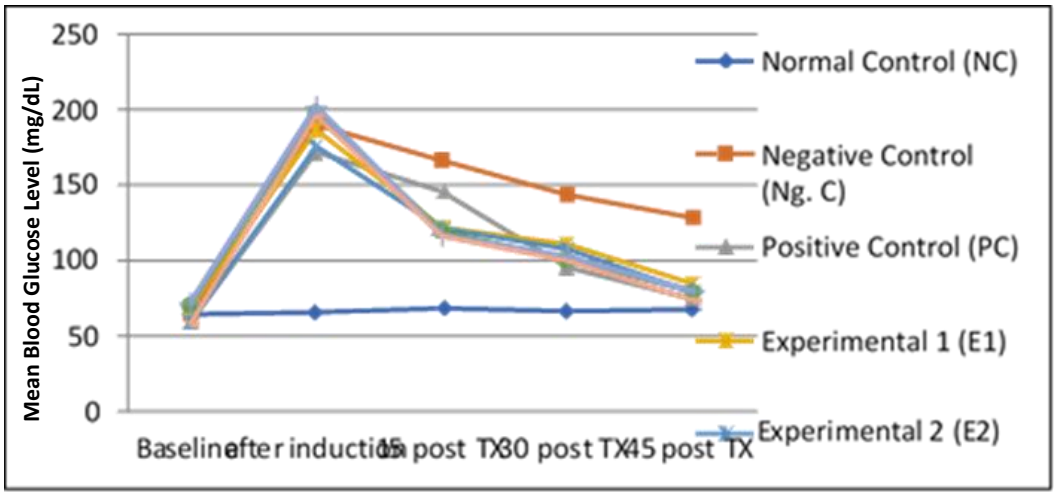
The *Crescentia cujete* terpenoid – phenol extract proved a dose dependent blood glucose lowering activity based on raw data as reflected in Table 5. This hypoglycemic effect was also explicitly reflected in figure 1. A continuous decline in blood glucose level were observed at different time intervals post induction of the Crescentia cujete extract to test animals – from a dose 100mg/kg to 630mg/kg. Likewise, this trend was observed with the induction of the Glibenclamide – Positive control. After 30 minutes post treatment, the dose at 250 mg/kg, 400 mg/kg and 630 mg/kg of *Crescentia cujete* gave the highest decline than that of Glibenclamide. But if the total decline is to be considered, the Glibenclamide gave the highest decline followed by 630 mg/kg of *Crescentia cujete*. However, statistical

treatment probe a non-significant relationship with Glibenclamide and all *Crescentia cujete* extract doses.

Table 4: Mean Baseline, Glucose – induced and Treated Blood Levels of Swiss Mice

				Minutes after administration of extract / dose		
Group	**Treatment**	**Mean Baseline Blood Glucose Level**	**Blood Glucose Level 15 min after induction**	**15 post TX**	**30 post TX**	**45 post TX**
NC	**NSS**	64.20	65.60	68.20	66.40	67.40
Ng. C	**Glucose**	64.40	189.60	166.00	143.20	128.00
PC	**Glibenclamide**	58.80	171.40	145.20	95.20	74.20
E1	**100 mg/kg extract**	68.00	186.20	121.40	110.40	84.20
E2	**160 mg/kg extract**	59.20	175.20	121.20	107. 40	78.40
E3	**250 mg/kg extract**	70.20	197.40	119.60	99.60	79.40
E4	**400 mg/kg extract**	71.20	201.20	116.40	101. 80	79.00
E5	**630 mg/kg extract**	57.80	195.80	115.80	99.40	73.40

Figure 1 : Comparison of Mean Blood Glucose Level of Swiss Mice Treated with Positive Control and different *Crescentia Cujete* Terpenoid-Phenol Extracts



3. Results on Statistical Analysis

The computed value 15, 30, and 45 minutes after induction of glucose were 1.64163, 0.363083 and 0.742574 respectively. Thus, the tabular value was 3.8951. Since, the tabular value is greater than the computed value, statistical treatment probe a non- significant different with Glibenclamide and all *Crescentia cujete* extract doses at 0.01 level. Therefore, null hypothesis is accepted. Hence, there is no significant difference in the blood glucose lowering activity of the terpenoid – phenol extract of Crescentia *cujete* from that of the standard drug, Glibenclamide. Since, all extracts of the terpenoid – phenol of *Crescentia cujete* is comparable with the standard Glibenclamide, the terpenoid – phenol of *Crescentia cujete* is a potential herbal medicine alternative in diabetes mellitus type II management.

Table 5: F-Test Results Comparing the Positive Control Glibenclamide and the Group Treated with the Extract

Source of Variation	df	Computed F	Tabular F	Interpretation
15 minutes after induction of Glucose				
Between Group	5	1.64163	3.8951	**NS**
Within Group	24			
30 minutes after induction of Glucose				
Between Group	5	0.363083	3.8951	**NS**
Within Group	24			
45 minutes after induction of Glucose				
Between Group	5	0.742574	3.8951	**NS**
Within Group	24			

p = 0.01

IV. Summary and Conclusion

The study dealt with study of the Blood Glucose lowering activity of the terpenoid– phenol extract from the pulp of *Crescentia cujete* Family Bignoniaceae (Calabash).

After conducting the different tests, the following findings were obtained:

1. The toxicological test of the terpenoid – phenol extract of the pulp of *Crescentia cujete* revealed a non-toxic dose of up to 1000 mg/kg. The approximate lethal dose confirmed a physiological changed commencing at 2500mg/kg until 10, 000mg/kg. The LD50 was established to be 14,454.40 mg/kg.

2. *Crescentia cujete* extract at a dose of 100 mg/kg, 160 mg/kg, 250 mg/kg, 400 mg/kg, and 630 mg/kg lowered the blood glucose level on glucose induced hyperglycemic Swiss mice.

3. The difference in the blood glucose lowering activity of the *Crescentia cujete* terpenoid– phenol extract and that of a standard hypoglycemic agent, Glibenclamide is not statistically significant.

Conclusion

This research demonstrated that the Terpenoid – Phenol extract of *Crescentia cujete* has no statistically significant blood glucose lowering activity.om

REFERENCES

[1] (n.d.). Retrieved from World Health Organization.
[2] (2011). Encyclopaedia Britannica.
[3] Akhila, S., Shyamjith, D., & Alwar, M. (October 10, 2007). Acute toxicity studies and determination of median lethal dose. Current Science Association, 917-920.
[4] Association, A. D. (2010). The American Diabetes Association Complete Guide to Diabetes.
[5] G, S. E. (1990). Normoglycemia as a therapy goal in diabetes treatment--concept and realization. National Library of Medicine, 306.
[6] Geetanjali, K., & al., e. (March 25, 2008). Commonly consumed Indian Plant food materials in the Management of Diabetes Mellitus. Delhi Hospital Indian Institute of Technology.
[7] Higuchi, M. (2009). Costs, Availability and Affordability of Diabetes Care in the Philippines. Japan: Foundation for Advanced Studies on International Philippines, 26-27.
[8] https://revive.gardp.org/resource/median-lethal-dose-ld50/?cf=encyclopaedia. (n.d.). Retrieved from Revive Advancing Antimicrobial R&D.
[9] Jung, M., Park, M., Lee, H. C., & al., e. (2010). Current Medicinal Chemistry.
[10] Le Berre, M., Gerlach, J., Dziembala, I., & Kilcoyne, M. (2022). Calculating Half Minimal Inhibitory Concentration Value from Glycomics Microarray Data Using GraphPad Prism. Methods in Molecular Biology.
[11] Marak, H., & al., e. (2002). Systemic, genotype-specific induciton of two herbivore-deterrent iridoid glycosides in Plantagolanceolata L. in response to fungal infection by Diaportheadunca. Niessel Department of Plant Population Biology, Netherlands Institute of Ecology.
[12] Medline Plus. (n.d.). Retrieved from https://medlineplus.gov/lab-tests/blood-glucose-test/
[13] Saunders. (2011). Dorland's Medical Dictionary for Health Consumers.
[14] Standards of Medical Care in Diabetes Care. (2009). American Diabetes Association.
[15] Worku, T. (February 2009). Investigation of Antihyperglycemic and Hypoglycemic Activity of Ajugaremota and Syzygium Guineese on Mice. Addis Ababa Ethiopia.
[16] World Health Organization. (2011). Retrieved from www.who.com.
[17] Zhu, Z., & al, e. (1990). Studies on the Active Constituents of Momordica charantia.