EVALUATION OF ANTIOXIDANT ACTIVITY: HYPOGLYCEMIC EFFECTS FROM JACKFRUIT (*Artocarpusheterophyllus Lam*)"

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Abstract
This research aimed to evaluate the hypoglycemic effect of hydroalcoholic and aqueous extracts of jackfruit leaves (Artocarpus heterophyllus Lam) based on their analysis in rats (Rattus norvegicus). Hydroalcoholic and aqueous extracts were prepared with 125, 250 and 400 ppm concentrations. The hypoglycemic analysis was carried out for 30 days, using 45 male rats, which were divided into 9 groups of 5 rats each, target, negative control, positive control, 3 groups for the hydroalcoholic extract at 125, 250 and 400 ppm, and 3 groups for the aqueous extract at the same concentrations. All 8 groups except the blank were fed a starch-rich diet at a concentration of 2000 ppm (mg/kg) of body weight for 15 days, thus affecting hyperglycemia. After the starch diet, blood glucose was measured on the first, seventh and fifteenth days at 30, 60 and 120-minute intervals. The pharmacological effect was evidenced in hydroalcoholic and aqueous extracts at a concentration of 400 ppm with a p-value < 0.05 through statistical tests comparing their results with the commercially used ones. In conclusion, the antioxidant activity was evaluated: hypoglycemic effects from the hydroalcoholic and aqueous extracts of the leaves of Jackfruit (*Artocarpus heterophyllus Lam*). Thus, it was recommended to carry out studies onthe identification and chemical purification of the active principle.

Keywords:<YACA LEAVES (*Artocarpus heterophyllus Lam)*>,<BIOTHERIUM><AQUEOUS EXTRACT>, <HYDROALCOHOLIC EXTRACT>.<PHYTOCHEMICAL SCREENING>, <TOTAL PHENOLS>, <RATS (*Rattus norvegicus*)>, <ALMIDON>, <GLUCEMIA>.

1. Introduction

The following study proposes an alternative to using drugs to counteract hyperglycemia, more commonly known as transient diabetes, through natural medicine, such as using plants with hypoglycemic effects.

The main objective is to evaluate the hypoglycemic effect of jackfruit (Artocarpus heterophyllus Lam) by preparing a hydroalcoholic extract and an aqueous extract, based on an analysis in experimental biomodels, such as *Rattusnovergicus*(rats), and thus determine which of the two extracts has a better hypoglycemic effect.

An experimental methodology is used, due to the obtaining of data by using reagents that exhibit properties to the extracts, a descriptive due to the particularities of the research, since it is estimated the inquiry of the events, and an exploratory, since it allows to obtain a general knowledge of the subject to launch in the future some product with hypoglycemic effect through the Jackfruit (*Artocarpus heterophyllus Lam*).

This research begins with the identification of the problem in order to provide a solution to hyperglycemia, which in the future will cause permanent diabetes.

1.1 Justification

One of the diseases that is booming is undoubtedly diabetes, which is influencing the population significantly regardless of social status or age. Through a survey conducted by ENSANUT, it was established that in Ecuador, diabetes presents 1.7% of people between the ages of 10 and 59 years, and this number rises at the age of 30 years, and at 50 years 2 out of 20 Ecuadorians have diabetes (PAHO/WHO, 2020).

Causes such as poor diet, lack of exercise, excessive alcoholic beverages and cigarette abuse represent four dangerous factors that are related to those diseases known as non-communicable diseases, one of which is diabetes.

With this work,the authors intend to collaborate in developing new natural products that contribute to the population with problems related to hyperglycemia, which in the future may lead to possible diabetes. For this reason,it will seek to compare two extracts demonstrating the hypoglycemic effects, i.e., the effect these extracts have on blood sugar.

Due to the promotion of a healthy and healthful life, the use of natural products is bet by their nature, their great production and the low cost ofusing these products. Therefore, an extensive literature review will determine the best extraction method to obtain the highest concentration of the active principle responsible for antioxidant activity.

1.2 Problem statement

Health is the most important thing that the human being can have, that is why every time alternatives are sought in medicine, with the use of medicinal plants, which help to combat diseases, which with regular treatments would be very expensive and could not be accessible to all people.

Most people face health problems daily, which in many cases, claim the lives of the elderly, young people and even children. In recent years, health problems due to diabetes have been increasing. It is a disease that does not look at the social status, age or gender of people. This disease results in high blood glucose levels.

Currently, diabetes mellitus is considered a severe disease worldwide since it represents one of the most significant cardiovascular hazards, mainly because its treatment is costly. Diabetes mellitus accounts for 4.6 million deaths per year worldwide. This disease is one of the ten leading causes of disability in the world, reducing productivity and human development. The National Institute of Statistics and Census in 2014 was the second leading cause of general mortality to diabetes mellitus, placing it as the leading cause of mortality in the female population and the third in the male population (MSP, 2017).

This is why it is important to combat diabetes with alternative treatments to conventional medicine, with the use of medicinal plants, such as the leaves of the Yaca (*Artocarpusheterophyllus Lam*), a species that has been investigated in recent times, giving efficient results, with characteristics of being hypoglycemic.

The antioxidant activity of jackfruit leaves (*Artocarpus heterophyllus Lam*) will be evaluated, and this will depend on the aqueous or hydroalcoholic extract through a qualitative and quantitative characterization of

the species in question, extraction method, experimental design and statistical analysis to evaluate the results obtained in order to determine the hypoglycemic activity and which extract influences with greater relevance in the antioxidant activity of the leaves of jackfruit (*Artocarpus heterophyllus Lam*).

1.2.1 Problem formulation

Are there hypoglycemic effects from hydroalcoholic and aqueous extracts of jackfruit (*Artocarpus heterophyllus Lam*) leaves?

2. Objectives

2.1 General objective

To evaluate the antioxidant activity: hypoglycemic effects of hydroalcoholic and aqueous extracts of jackfruit leaves (*Artocarpus heterophyllus Lam*).

2.2 Specificobjectives

- To characterize jackfruit leaves (*Artocarpus heterophyllus Lam*) by phytochemical screening.
- To evaluate the flavonoids and phenols of the hydroalcoholic and aqueous extracts by Uv-visible spectroscopy.
- To compare the effect of the antioxidant activity of the two leaf extracts by checking the glycemic levels obtained from the experimental biomodels.

Methodology

3.1 Research site

The present research work was carried out in the following laboratories:

- **Identification and certification of plant material:** Herbarium of the Escuela Superior Politécnica de Chimborazo.
- **Quality control of plant material:** Organic Chemistry Laboratory of the Science Faculty of the School of Chemical Sciences of the Escuela Superior Politécnica de Chimborazo.
- **Phytochemical screening (qualitative analysis):** Laboratory of Natural Products of the Faculty of Sciences of the School of Biochemistry and Pharmacy belonging to the Escuela Superior Politécnica de Chimborazo.
- **Preparation of extracts and their subsequent quality control, as well as the quantification of phenols and flavonoids (quantitative analysis):** Research Laboratory of the Faculty of Sciences belonging to the Escuela Superior Politécnica de Chimborazo.
- **Analysis of the extracts in the UV spectrophotometer:** Laboratory of instrumental analysis of the Faculty of Sciences of the Escuela Superior Politécnica de Chimborazo.
- **Lyophilization of the extracts:** Toxicology laboratory of the Faculty of Sciences, School of Biochemistry and Pharmacy belonging to the Escuela Superior Politécnica de Chimborazo.
- **Hypoglycemic analysis:** Biotherium of the Faculty of Sciences, School of Biochemistry and Pharmacy of the Escuela Superior Politécnica de Chimborazo.

3.2 Study population

Leaves of the Yaca plant (*Artocarpusheterophyllus Lam*).

3.3 Sample size

To determine the size, random sampling was conducted, acquiring approximately 2 kg of fresh plant leaves of the Yaca plant species (*Artocarpus heterophyllus Lam*).

3.4 Sample selection

Inclusion criteria: Those leaves that are in good condition, vigorous and, above all, fresh. Considering that they are young plants, present an adequate size, and are accessible (Zurita, 2019, p. 20).

Exclusion criteria: Leaves that show damage due to the action of animals or external conditions. Also those leaves show deterioration due to water or wind and in the process of decomposition (Zurita, 2019a, p. 20).

3.5 Type of research

This study is quantitative because it will measure the glycemic values in experimental biomodels and quantify the hypoglycemic fraction in the extracts. According to the objective, this research is applied because, through theoretical knowledge, experimental methods will be put into practice to achieve this research's objective. The manipulation of variables is experimental because the independent variables (hydroalcoholic and aqueous extracts) will be manipulated to observe their effects on the dependent variable hypoglycemic activity in rats (*Rattus norvegicus*). According to the level of depth in the object of study, it is explained because all the processes have an investigative purpose. According to the type of inference, it is hypothetical deductive because it will be possible to demonstrate if the extracts exert hypoglycemic effects and compare which have better antioxidant activity. Finally, according to the time, it is of transversal type because the experimentation can be carried out at any time, which will depend on the researchers.

Finally, the study is laboratory-type because the preparation of extracts, quantification and measurement of glycemic values will be done in the Escuela Superior Politécnica del Chimborazo laboratories.

3.6 Hypotheses

Null Hypothesis:

There are hypoglycemic effects from the hydroalcoholic and aqueous extracts of the leaves of Jackfruit (*Artocarpus heterophyllus Lam*).

Alternative Hypothesis:

There are no hypoglycemic effects from the hydroalcoholic and aqueous extracts of the leaves of Jackfruit (*Artocarpus heterophyllus Lam*).

4. Results

4.1 Quality control of plant material

The results of each quantitative determination performed on the plant drug are presented in the following table.

Parameter (%)	*Artocarpusheterophyllus* Lam	Reference values according to the Royal SpanishPharmacopoeia 2002
Humidity	7.72	14
Total ash	9.88	5
Soluble ash in H_2O	1.11	1
HCl-insoluble ash	0.77	2

Table 1. Results of the determination of the quality parameters of leaves of Artocarpus heterophyllus Lam.
Source: Lopez and Masabanda(2021).

The moisture content (free water) of the leaves of Artocarpus heterophyllus Lam was 7.72%, which denotes stability (absence of microorganisms, enzymatic reactions and chemical reactions), ensuring that the chemical composition is not affected and that there is no degradation of the secondary metabolites present and necessary in the research. In their study, Mera and Murillo (2018a) determined a humidity that varies between 6.34% to 6.45% in dry leaves, which shows agreement with the result obtained.
The evaluation of total ash in the sample was 9.88%, which was found to be within the established limits, indicating the presence of inorganic matter (salts and mineral elements) after the combustion or incineration of organic matter. Similarly,Mera and Murillo (2018b), in this parameter, determined a percentage ranging from 9.26% to 9.76%, which deduced a homogeneity with the above.
The percentage obtained for water-soluble ash was 1.11%, which was within the permitted limit, indicating the presence of soluble salts in the sample. Finally, the value of ash insoluble in hydrochloric acid was 0.97%, reflecting the presence of oxalates or carbonates within the permitted limit. Therefore, it was deduced from these determinations that there was no contamination by foreign matter in the vegetable drug (López, 2016c, p. 52). Likewise,Mera and Murillo (2018c) determined a value of 1.97 % of minerals that are not ingestable.

4.2 Phytochemical Screening

For the phytochemical screening, a maceration was performed using isopropyl alcohol and water as solvents, thus allowing the extraction and qualitative identification of both lipophilic and hydrophilic compounds, obtaining the following results.

Metabolite	Essay	Extract Hydroalcoholic	AqueousExtract
Alkaloids	Mayer	+++	+
	Dragendorff	+++	+
	Wagner	+++	+++
Flavonoids	Shinoda	+++	+++
	1/2 Alkaline	++	+++
Phenols and Tannins	FerricChloride (Cl_3 Fe)	+	+
Resins	Resins	NA	NA
ReducingSugars	Fehling	+	+++
Lactones	Baljet	NA	NA
Triterpenes-Esteroids	Libermann-Bucharl	NA	NA
Catechins	Catechins	NA	NA
Saponins	Foam	+	+
Amino acids	Ninhydrin	+	NA
Quinones	Bontrager	+++	NA
Anthocyanins	Anthocyanidin	+	NA
BitterPrinciples	BitterPrinciples	NA	NA

Mucilagos	Mucilagos	NA	NA

Table 2. Results of phytochemical screening of leaves of Artocarpus heterophyllus Lam.
Source: Lopez and Masabanda(2021).

The results of the phytochemical screening of the leaves of Artocarpus heterophyllus Lam showed the presence of phenolic compounds through the ferric chloride assay; flavonoids through the Shinoda and alkaline medium assays, in both extracts; these metabolites are relevant to the research. In addition, reducing sugars and saponins were obtained in the aqueous extract, while amino acids, anthraquinones, anthocyanins, and reducing sugars and saponins were found in the hydroalcoholic extract. However, there are no sterols, or cardiotonic glycosides, among other secondary metabolites.
Publications such as Carvajal (2018c) and Meriño (2019a), which analyzed the leaves and pulp of *Artocarpus heterophyllus Lam* phytochemically, respectively, showed the presence of phenols and flavonoids, these results showed concomitant to those determined in the present study ratifying that the analyzed species undoubtedly has the presence of these compounds.
Mera and Murillo (2018d), in their study "Evaluation of the normoglycemic effect of the hydroalcoholic extract of *Artocarpus heterophyllus Lam* leaves in diabetic mice," identifies the presence of flavonoids and phenols supporting the use of the species with an antioxidant effect. Similarly, Alvarado (2019a), in his research on aqueous and ethanolic extracts with and without leaf treatment, obtained similar results in the presence of secondary metabolites. However, all the studies cited are not comparable because the experimental conditions are different in the extraction method, solvents used and uncontrolled conditions.

4.3 Quality control of the hydroalcoholic and aqueous extract of Artocarpus Heterophyllus Lam.

After obtaining the two extracts using solvents such as 70% isopropyl alcohol and water, with a total of 10 g of dry plant matter (pulverized leaves), subjected to concentration, the quality parameters of the extracts were controlled: the results obtained are presented below.

Parameter	Hydroalcoholic Extract (70% Isopropyl alcohol)	AqueousExtract
OrganolepticCharacteristics		
Odor	Sweet	Sweet
Color	Intense orange	Orange
Appearance	Liquid	Liquid
PhysicochemicalCharacteristics		
pH	7,65 ± 0,03	6,95 ± 0,03
Refractiveindex	1,342 ± 0,000	1,344 ± 0,000
Relativedensity	0,907 ± 0,004	0,949 ± 0,02
Total Solids (%)	2.48 %	2.54 %

Table 3. Determination of quality parameters of hydroalcoholic and aqueous extracts of leaves of Artocarpus heterophyllus Lam.
Source: Lopez and Masabanda(2021).

Based on the process carried out and after the results obtained, the pH of the hydroalcoholic and aqueous extracts was slightly acidic due to the study plant, the solvents and the extraction method. These results indicated that the two extracts have an appreciable amount of phenolic compounds in their composition and thus reaffirmed the research regarding the utilization of Artocarpus heterophyllus Lam (Lopez, 2016c, p. 53).

It was also evident that the value of the refractive index and total solids indicated that the different phytochemical compounds presented good solubility in the solvents used; in other words, the chemical transfer of compounds in the drug-solvent interrelationship was effective and allowed the development of the research.

Finally, this quality control had a relative density value (0.907 ± 0.02) and (0.949 ± 0.02) for the hydroalcoholic and aqueous extracts, respectively, denoted the presence of substances with the ability to interrelate by hydrogen bonds (Lopez, 2016d, p. 53).

4.4 Infrared analysis

4.4.1 Hydroalcoholic extract

The hydroalcoholic extract was analyzed in infrared spectroscopy, obtaining the following results for the functional groups.

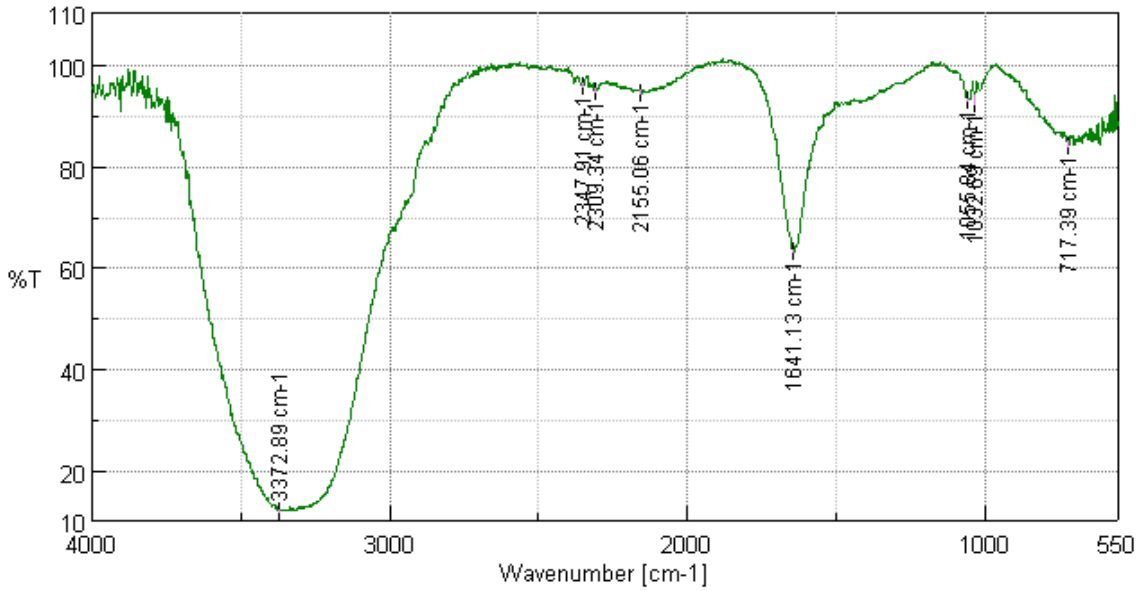

Figure 1. IR spectrum of the hydroalcoholic extract.
Source: Lopez and Masabanda(2021).

The data obtained in the infrared spectrum are presented below, showing the wavenumber (cm-1), % transmittance and the functional group belonging to each peak.

Wave number [cm^{-1}]	% Transmittance	Structure
3372.89	11.7658	O-H
2309.34	94.3706	C≡N or Diazonium salts
2155.06	94.1646	C=C=O

1641.13	62.9628	C=C
1055.84	92.8533	C-O
1032.69	91.8593	Alkanecycle
717.39	83.8299	(CH2)n

Table 4. Wave number and % transmittance of the hydroalcoholic extract.
Source: Lopez and Masabanda(2021).

4.4.2 Aqueous extract

In the same way, the aqueous extract was analyzed in infrared spectroscopy, obtaining the following results of the peaks belonging to each functional group.

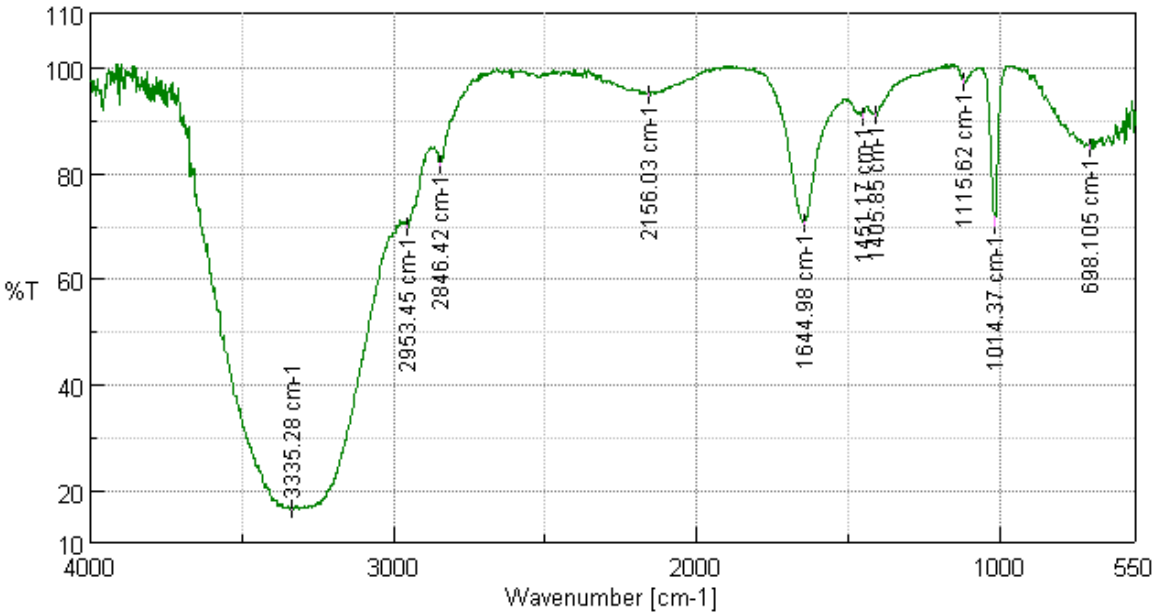

Figure 2.IR spectrum of the aqueous extract.
Source: Lopez and Masabanda(2021).

The data obtained in the infrared spectrum are presented below, showing the wavenumber (cm-1), % transmittance and the functional group belonging to each peak.

Wave number [cm-1].	%Transmittance	Structure
3335.28	16.1734	H-O-H
2953.45	69.4168	-CH3
2846.42	81.1547	-CH2
2156.03	94.4537	> C=C=O (ketene)

1644.98	70.3047	C=C
1451.17	90.3635	(CH2)n cyclic
1115.62	96.7969	Aromaticreplaced
1014.37	69.9338	Aromaticreplaced
698.105	84.3918	Aromatics

Table 5. Wavenumber and % transmittance of the aqueous extract.
Source: Lopez and Masabanda(2021).

Infrared spectrophotometry is based on the interaction between infrared radiation and matter producing absorption bands with certain energy levels within the infrared zone to determine the presence of functional groups in the sample qualitatively through the intensity of the molecular vibrations originated by the tension or bending of the atoms. The infrared spectra presented for the hydroalcoholic and aqueous extracts showed greater or lesser intensity vibrations due to the different vibrational movements.
In the hydroalcoholic spectrum, a band can be observed at 3372.89 cm-1, characteristic of the alcohol group. In addition, the intensity of absorption is marked; there is the presence of CH2 chains that appear between 730-710 cm-1, a zone marked by the denominated fingerprint characteristic of each structure. At 1600 cm-1, the presence of double bonds was shown; on the other hand, there was also the presence of the C-O or C=C=O bond; it was deduced the presence of functional groups which is consequent to the solvent used in the preparation of the extract.
Meanwhile, the characteristic signal of water bordering between 3000 cm-1 was present;methyl and methylene groups oscillated between 2000 cm-1, substituted aromatics and alkenes in the extract corresponding to the aqueous medium.
The spectra showed the presence of different functional groups; from this analysis, various spectroscopic techniques can be used to determine exactly which substance is in the sample.

4.5 Quantifying hydroalcoholic (70% isopropyl alcohol) and aqueous extracts by UV-vis spectrophotometry.

After the quantification process based on the Folin-Ciocalteau reaction, the results obtained were presented in the following table.

Extracts	Total phenols (mg of gallic acid/ kg of the plant)	Percentage
Hydroalcoholic FD10	3256,30 ± 183.35	0,326 ± 0,018
Aqueous FD10	1439,12 ± 133,41	0,144 ± 0,013

Table 6. Quantifyingtotal phenols by UV-visible spectroscopy in hydroalcoholic and aqueous extracts of leaves of Artocarpus heterophyllus Lam.
Source: Lopez and Masabanda(2021).

The percentage of total phenols in the hydroalcoholic extract (isopropyl alcohol 70%) deduced a moderate amount of phenolic compounds, which may be due to the extraction and purification method to which the extract was subjected, the amount of plant matter and solvent used and external factors or uncontrolled

environmental conditions. This fact confirmed that *Artocarpus heterophyllus Lam* contains these active principles that exert an antioxidant activity about the hypoglycemic effect.
In the same context, the value of total phenols in the aqueous extract is lower because the solvent drags a smaller amount of the active principles or because of the process above conditions; nevertheless, the presence of these secondary metabolites in the species existed; under the results of both extracts, the study in experimental biomodels was endorsed.
The calibration curve showed a straight line equation of y: -0.051 + (0.010) C and a positive correlation coefficient r2:0.998 which signified the correct preparation of the standard solutions of gallic acid, Folin-Ciocalteau reagent and 20% sodium carbonate, as well as the safety of these substances.

4.6 Quantifying total flavonoids in hydroalcoholic and aqueous extracts of Artocarpus Heterophyllus Lam leaves.

After the quantification process was completed, the results obtained were presented in the following table.

Extracts	Total flavonoids (mg of gallic acid/ kg of the plant)	Percentage
Hydroalcoholic	1739,14 ± 805.05	0,211 ± 0,002
Aqueous	645,16 ± 105.34	0,101 ± 0,003

Table 7. Quantification of total flavonoids in hydroalcoholic and aqueous extracts of leaves of Artocarpus heterophyllus Lam.
Source: Lopez and Masabanda(2021).

The amount of total flavonoids in the hydroalcoholic extract is higher than that of the aqueous extract because the content presented in the quantification of phenols is higher, which depends on the extraction method, the solvent used, and the purification of the extract. However, based on the above, the two extracts have these phytochemical compounds that are responsible for the antioxidant activity of the Artocarpus Heterophyllus Lam, thus allowing its application in the units put to experimentation.
The calibration curve showed a straight line equation of y: 0.0218 + 0.0012x and a correlation coefficient equal to 0.99, which indicates that the prepared samples have been correctly analyzed in the Uv-visible spectrophotometer.

4.7 Hypoglycemic activity in experimental biomodels (*Rattusnovergicus*)

4.7.1 Blood glucose analysis on day 1 of experimentation

Once the experimental animals were subjected to a diet with starch for 15 days in each corresponding group, the analysis was carried out on the first day of experimentation, yielding the following results established in terms of the amount of glycemia expressed in mg/dl versus time in the graph shown below.

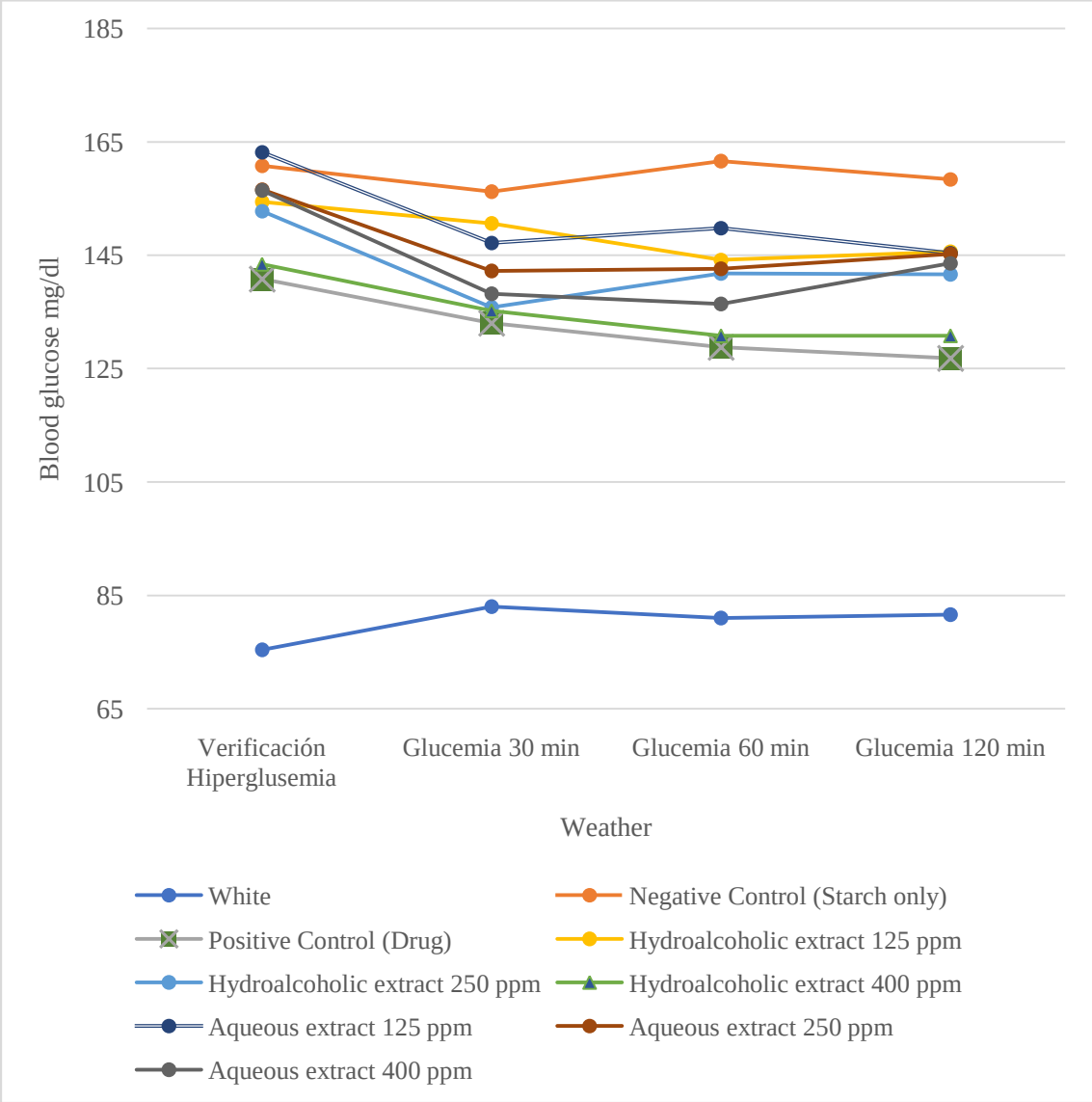

Figure 3. Glycemia Levels Day 1.
Source: Lopez and Masabanda(2021).

The 45 experimental units were divided into 9 groups; except for the white group, all were subjected to a diet with a starch solution at a concentration of 2000 ppm for 15 days, then blood samples were taken to verify the induction of hyperglycemia; then they were subjected to treatment with aqueous and hydroalcoholic extracts at different concentrations and the drug; at times of 30, 60 and 120 minutes the glycemia values in mg/dl were measured.

Figure 3shows that the 8 groups reached values in a range between 140 and 165 mg/dl, which confirmed the induction to the pathology; the white group presented values up to 85 mg/dl because it has not been submitted to the pathology while the negative control group did not show major changes, this is because only starch was administered, and its values fluctuated between 160 and 156 mg/dl; The positive control group presented a slight decrease in glycemia at different times; the aqueous extracts groups of 125 ppm, 250 ppm and 400 ppm follow the tendency of glucose decrease without a marked difference because it was the first day of experimentation; similarly the groups of hydroalcoholic extracts of 125 ppm, 250 ppm and

400 ppm decrease their glycemic values, being a greater effect at concentrations of 250 ppm and 400 ppm. On the first day of experimentation, the decrease in glycemia of the treatment groups was observed for the initial values of hyperglycemia and the negative control, however, with no noticeable differences; on the other hand, the dispersion of the glycemic values by each group in time intervals was also not significant due to the short period of experimentation.

3.7.2 Analysis of blood glucose on day 7 of experimentation.

The following graph shows the results obtained regarding the amount of glycemia expressed in mg/dl versus time on day 7 of experimentation.

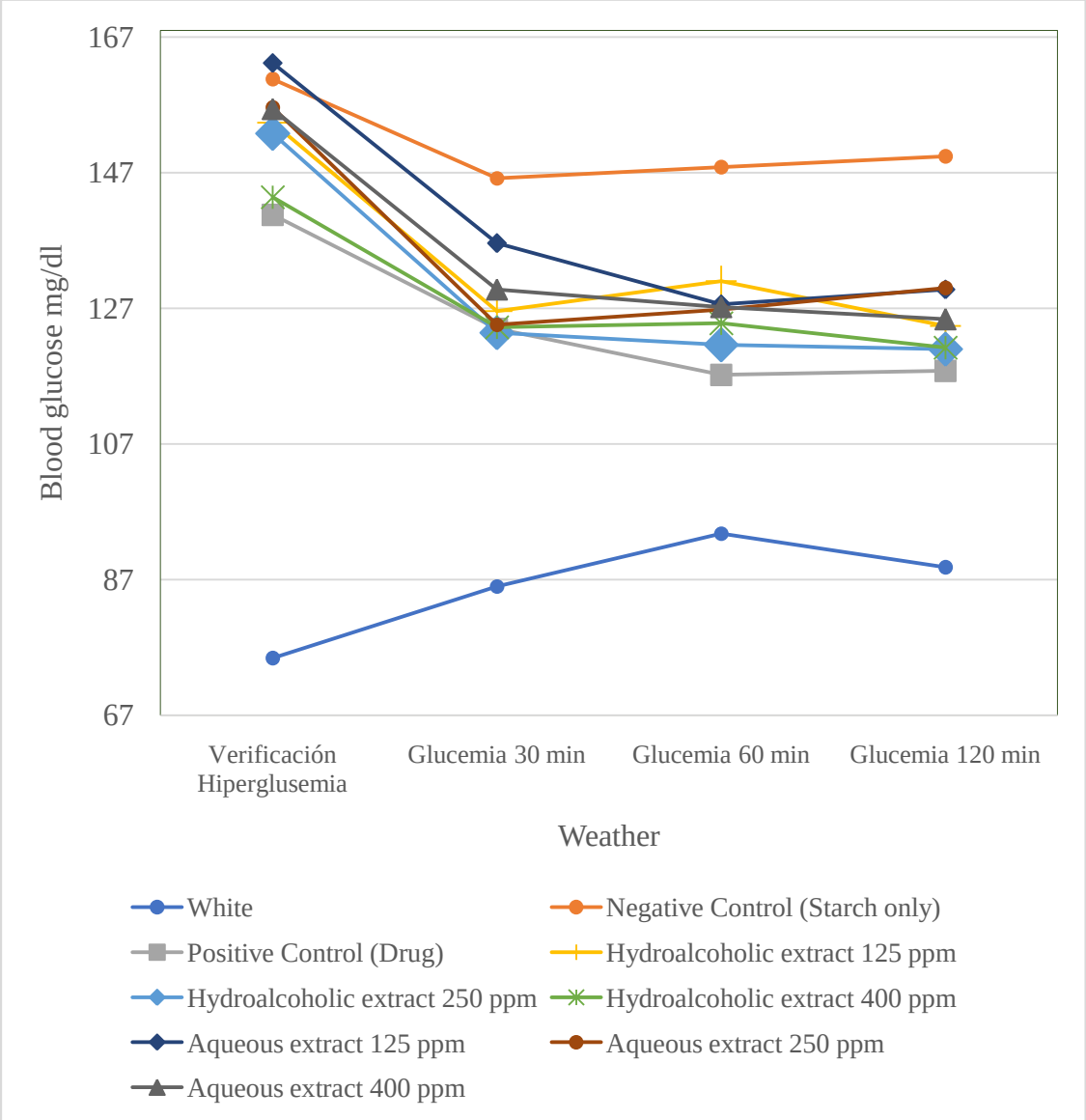

Figure 4: Blood Glucose Levels Day 7.
Source: Lopez and Masabanda(2021).

Figure 4 shows the experiment results after the third day, in which the white group does not present a substantial difference from the first day since the animals are in normal feeding conditions.

The negative control group showed values in the range of 145 to 150 mg/dl, which, compared to the first day of the experiment, tended to decrease as the animals' bodies began to eliminate the polysaccharide naturally.
The positive control showed a minor decrease but does not yet represent a significant value compared to the blank, in which the efficiency of the drug should be determined on the last day of the experiment. Concerning the extracts, glycemia is decreasing minimally, but its hypoglycemic degree is not yet evident, and its efficiency will be determined at the end of the experimentation.

4.7.3 Blood glucose analysis on day 15 of experimentation
The following graph shows the results obtained regarding the amount of glycemia expressed in mg/dl versus time at the end of day 15 of experimentation.

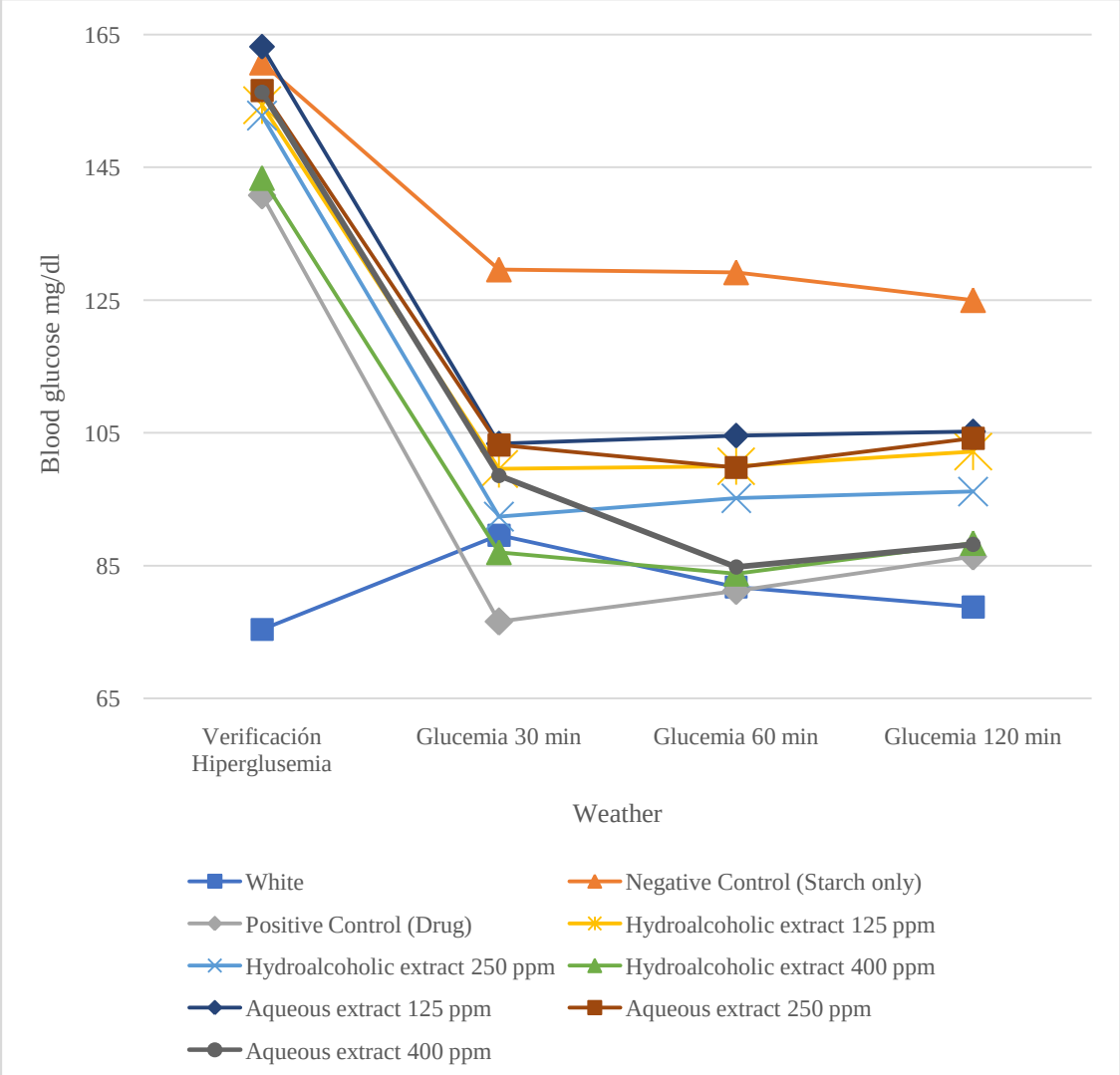

Figure 5. Glycemia Levels Day 15.
Source: Lopez and Masabanda(2021).

At the end of the experimentation, Figure 5 showed that the white group had no major differences for the other days since they had been fed in a usual way; the negative control group tends to an average reduction

since, as time goes by, the digestible polysaccharide begins to be eliminated naturally and spontaneously.However, hyperglycemia was maintained between 129 and 125 mg/dl. The positive control decreases almost to the normal glycemia values of the target, which determined its effect as an oral antidiabetic by inhibiting the absorption and uptake of glucose in the organism.

The aqueous and hydroalcoholic extracts of 125 ppm and 250 ppm denoted that the glycemia was lower than the rest of the treatment days. On the contrary, they did not reach values similar to those of the drug and the blank. This is because the active principles' content is insufficient in these concentrations. The aqueous and hydroalcoholic extract of 400 ppm showed the best hypoglycemic activity because the blood glucose values at the end of the experimentation were between 88 mg/dl, data similar to the drug and with a minimal difference for the target.

Studies such as Alvarado (2019b) showed the hypoglycemic effect of jackfruit (*Artocarpus heterophyllus Lam*) from the hydroalcoholic extract at a dose of 250 ppm but without significant statistical differences, while at a dose of 500 ppm, the blood glucose levels were lowered and remained stable at different times when blood samples were taken. These results agree with the present study since from a dose of 250 ppm, and there is a tendency for a reduction in glycemic levels.

Research such as Omar (2011a), Chackrewarthy et al. (2010a) and Shahin (2012a) with the extraction and application of hydroalcoholic, ethyl acetate fraction and aqueous extracts, respectively, support the hypoglycemic effect of the leaves of *Artocarpus heterophyllus Lam*, through the inhibition of pancreatic enzymes. The present study agrees with these publications in the antioxidant activity at similar concentrations of the extracts; in addition, in the times or days in which the blood sample was taken for the analysis, there is always a tendency to the reduction of glycemia as in the present study, which ratifies the antioxidant power of the extracts due to their content of phenolic compounds. However, no concordance was found in the values of confirmation of hyperglycemia; this is due to the use of streptozotocin as an induction substance, which produces a greater alteration in glucose levels.

4.7.4 Representation of the blood glucose levels of each group on the last experimental day.

The following graph (Figure 6) shows the results of the blood glucose levels of each group in the last experimental period.

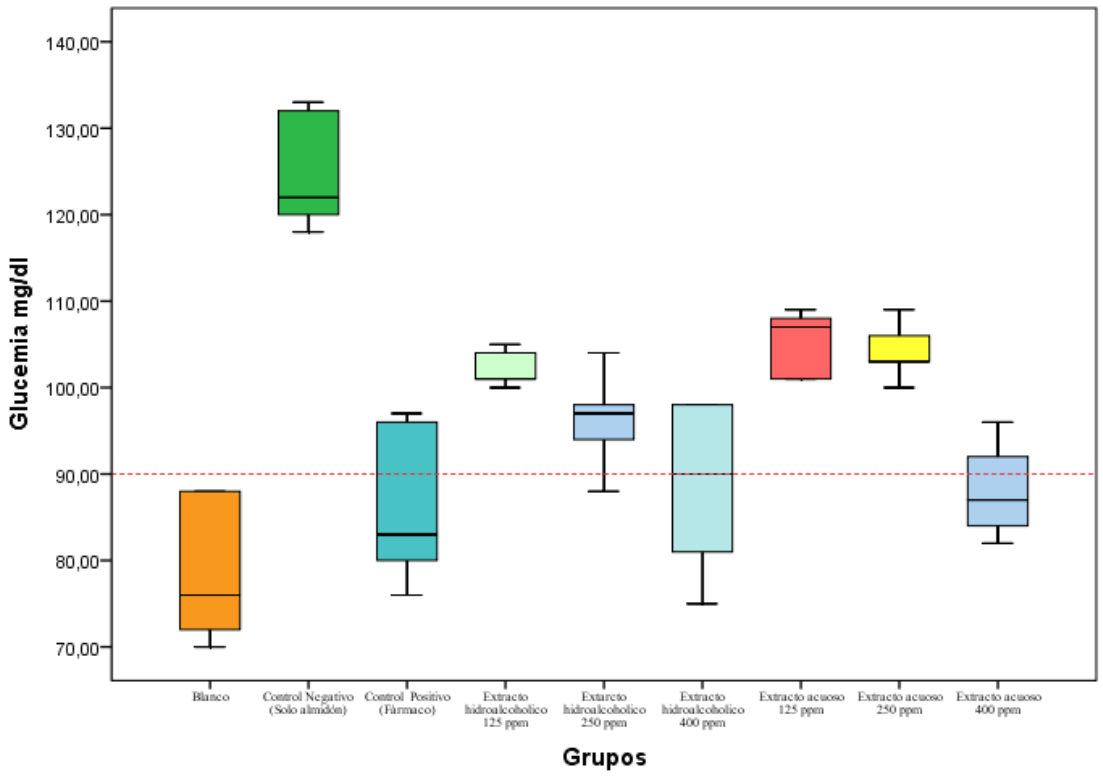

Figure 6. Blood glucose levels by groups.
Source: Lopez and Masabanda(2021).

At the end of the experimentation, the white group maintained blood glucose values below 90 mg/dL, which is evidence that the animals used did not present hyperglycemia at the beginning and end of the experimentation and can be confirmed with the established values of less than 90 mg/dL for normal blood glucose.

In the negative control, it was evident that the experimental animals had marked hyperglycemia, values that oscillated between 160 mg/dl at the beginning of the experiment. Moreover,in the end, due to the time elapsed and normal feeding causes, their hyperglycemia value dropped around 130 mg/dl, which is a constancy of hyperglycemia, but no longer so marked.

The positive control group showed a decrease in glycemia with values between 90 mg/dl due to the drug used (Metformin/Glibenclamide).

Concerning the extracts, the hydroalcoholic extract of 400 ppm was similar to the positive control, and the aqueous extract of 400 ppm had a lower proportion. Thus, it was found that the 400 ppm hydroalcoholic extract is as good as the drug.

4.7.5 Statistical Significance

Normality tests will be performed for quantitative variables to determine the significance values between the different hypotheses.

	Shapiro-Wilk		
	Statistician	**gl**	**Sig.**
Basal glucose (Day 1)	0,988	40	0,938**
Verification of hyperglycemia	0,982	40	0,765**

Bloodglucosevalue Day 1	0,829	45	0,000
Bloodglucosevalue Day 7	0,937	45	0,017
Bloodglucosevalue Day 15	0,969	45	0,278**

* This is a lower limit of true significance.

a Lillieforssignificancecorrection.

** Indicates normal distribution.

Table 8. Normality tests.

- **Hypothesis 1**

H_0: There are no statistically significant differences between baseline glucose values and their hyperglycemic verification.

CI= 95% CI= 95% CI= 95% CI= 95% CI= 95% CI= 95% CI= 95% CI= 95%
Error= 0.05
Decision= If p is less than 0.05, H_0 is rejected.
Test

		Matcheddifferences					t	gl	Sig.
		Media	Standard deviation	Mean standard error	95% confidence interval of the difference				
					Inferior	Superior			
Par 1	Basal glucose (Day 1) - Verification of hyperglycemia	-72,7	14,1425	2,23613	-77,22299	-68,17701	-32,51	39	0,00

Table 9.T-student-related samples H1.

Conclusion: The significance value was less than 0.05 (p=0.00); therefore, H_0 is rejected, and it is affirmed that there are statistically significant differences between the initial basal glucose values and their hyperglycemic verification.

- **Hypothesis 2**

H_0: There are no statistically significant differences in the glycemic values in the different groups of the experimental units.

CI= 95% CI= 95% CI= 95% CI= 95% CI= 95% CI= 95% CI= 95% CI= 95%
Error= 0.05
Decision= If p is less than 0.05, H_0 is rejected.
Test

	Bloodglucose Day 15				
	Sum of squares	gl	Root mean square	F	Sig.
Betweengroups	7627,378		953,422	20,44	0,00

Withingroups	1679,2	46,644
Total	9306,578	

Table 10.ANOVA H2.

Conclusion: The significance value was less than 0.05 (p=0.00); therefore, H_0 is rejected, and it is affirmed that there are statistically significant differences in the glycemic values in the different groups of the experimental units.

- **Hypothesis 3**

H_0: No statistically significant differences exist between hydroalcoholic and aqueous extracts of *Artocarpus heterophyllus Lam* leaves by checking glycemic levels obtained from the experimental biomodels.

CI=95%.

Error= 0.05

Decision: If p is less than 0.05, H_0 is rejected.

Test

	Bloodglucose Day 15				
	Sum of squares	**gl**	**Root mean square**	**F**	**Sig.**
Betweengroups	1486	5	297,2	8,728	0,00
Withingroups	817,2	24	34,05		
Total	2303,2	29			

Table 11. ANOVA H3.

Conclusion: The significance value was less than 0.05 (p=0.00); therefore, H0 is rejected, and statistically significant differences between hydroalcoholic and aqueous extracts of leaves are affirmed by verifying the glycemic levels obtained from the experimental biomodels.

- **Hypothesis 4**

H_0: There are no statistically significant differences between the glycemic values of the 400 ppm hydroalcoholic extract of *Artocarpus heterophyllus* Lam leaves and the positive control.

CI=95%.

Error= 0.05

Decision: If p is less than 0.05, H_0 is rejected.

Test

Levene's test of equality of variances	**t-test for equality of**

		Levene's test for equality of variances		t-test for equality of means						
		F	Sig.	t	gl	Sig. (bilateral)	Difference in averages	Standard error difference	95% confidence interval of the difference	
									Inferior	Superior
Bloodglucose Day 15	Equalvariances are assumed	0,01	0,922	-0,319		0,758	-2	6,27057	-16,45995	12,45995
	Equal variances are not assumed			-0,319	7,96	0,758	-2	6,27057	-16,47272	12,47272

Table 12. Student's t-test for independent samples H4.

Conclusion: The significance value was greater than 0.05 (p=0.758); therefore, H0 is acceptedand concluded that there are no statistically significant differences between the glycemic values of the 400 ppm hydroalcoholic extract of Artocarpus heterophyllus Lam leaves and the positive control.

- **Hypothesis 5**

H_0: No statistically significant differences exist between the glycemic values of the 400 ppm aqueous extract of *Artocarpus heterophyllus Lam* leaves and the positive control.

CI=95%.
Error= 0.05
Decision: If p is less than 0.05, H_0 is rejected.
Test

		Levene's test for equality of variances		t-test for equality of means						
		F	Sig.	t	gl	Sig. (bilateral)	Difference in averages	Standard error difference	95% confidence interval of the difference	
									Inferior	Superior
Bloodglucose Day 15	Equalvariances are assumed	0,01	0,922	-0,319		0,758	-2	6,27057	-16,45995	12,45995
	Equal variances are not assumed					-0,319	7,96	0,758	-2	6,27057

Table 13. Student's t-test for independent samples H5.

Conclusion: The significance value was greater than 0.05 (p=0.758); therefore, H_0 was accepted and it is concluded that there are no statistically significant differences between the glycemic values of the 400 ppm aqueous extract of Artocarpus heterophyllus Lam leaves and the positive control.

- **Hypothesis 6**

H_0: No statistically significant differences exist between the glycemic values of aqueous and hydroalcoholic 400 ppm extract of leaves of Artocarpus heterophyllus Lam.

CI=95%.
Error= 0.05
Decision: If p is less than 0.05, H_0 is rejected.
Test

		Levene's test of equality of variances		t-test for equality of means						
		F	Sig.	t	gl	Sig. (bilateral)	Difference in averages	Standard error difference	95% confidence interval of the difference	
									Inferior	Superior
Bloodglucose Day 15	Equalvariances are assumed	2,70	0,139	0,038		0,971	0,2	5,26308	-11,93668	12,33668
	Equal variances are not assumed			0,038	6,29	0,971	0,2	5,26308	-12,53375	12,93375

Table 14. Student's t-test for independent samples H6.

Conclusion: The significance value was greater than 0.05 (p=0.971); therefore, H_0 was accepted and it is concluded that there are no statistically significant differences between the glycemic values of the aqueous and hydroalcoholic 400 ppm extract of the leaves of Artocarpus heterophyllus Lam.

4.7.4.1 Statistical analysis

The glycemic values obtained presented a normal distribution through the Shapiro-Wilk normality test. Therefore, one-way analysis of variance (ANOVA) and T-student for independent samples were performed for the acceptance or rejection of hypotheses.

The results showed hypoglycemic effects of the aqueous and hydroalcoholic extracts because there were significant differences for the negative control with a value of ($p < 0.05$) using the ANOVA test for pooled data with a confidence interval of 95%. In addition, there were significant differences between the aqueous and hydroalcoholic extracts with a value of $p = 0.00$; on the contrary, there are no differences between the aqueous and hydroalcoholic extracts of 400 ppm, which indicated that they have an equal hypoglycemic effect.

Alvarado (2019c), in his study, showed statistically significant values with a value of ($p<0.05$) from a dose of 500 mg/kg; this is due to the inhibition of α-amylase enzyme while a dose of 250 mg/kg there was a decrease in glycemia during the experimental times however it was not significant. Finally, at a dose of 1000 ppm, there is no hypoglycemic effect of Artocarpus heterophyllus Lam. The research conducted by Shahin et al. (2012b) with extracts of Artocarpus heterophyllus Lam with doses of 250 and 500 mg/kg, using one-way analysis of variance, with a significance value ($p< 0.01$) demonstrated antidiabetic activity in experimental biomodels. Omar et al. (2011a) and Chackrewarthy et al. (2010b) supported the hypoglycemic activity in rats induced by streptozotocin from alcoholic extracts of 200 mg/kg and an ethyl acetate fraction, respectively, from the leaves of Artocarpus heterophyllus Lam with a significance value ($p< 0.05$), this activity is denoted due to the presence of phenolic compounds.

Thus, the present study showed similarity with the studies above, showing the reduction of glucose levels at concentrations similar to those exposed.

5. Conclusions

In this study, the leaves of jackfruit (*Artocarpus heterophyllus* Lam) were characterized through a phytochemical screening, identifying phenols and flavonoids that exert a hypoglycemic activity, corroborating also the presence of other secondary metabolites such as reducing sugars, saponins, and amino acids, anthraquinones and anthocyanins, based on coloration, precipitation and opalescence reactions.

Total phenols and flavonoids were evaluated by Uv-vis spectroscopy; the number of total phenols in the hydroalcoholic and aqueous extract was 3256.30 ± 183.35 mg of gallic acid/kg of plant and 1439.12 ± 133.41 mg of gallic acid/kg of plant respectively while the number of total flavonoids was 1739.14 ±

805.05 mg of Quercetin /kg of plant and 645.16 ± 105.34 mg of Quercetin/kg of plant respectively,which allowed ratifying the presence of the active fraction with hypoglycemic effect in the leaves of Yaca (*Artocarpusheterophyllus*Lam).

The chemical groups in the hydroalcoholic and aqueous extracts were identified through the infrared spectrophotometry technique, where the presence of peaks corresponding to carbonated chains, alcohols and aromatic rings was observed, which deduced the presence of aromatic compounds.

The hypoglycemic effects of hydroalcoholic and aqueous extracts were compared, demonstrating that the 400 ppm hydroalcoholic and aqueous extract exerted the reduction of blood glucose levels in starch-induced rats.

This research evaluated the antioxidant activity and hypoglycemic effects of hydroalcoholic and aqueous extracts of jackfruit leaves (*Artocarpus Heterophyllus* Lam). The hypoglycemic activity in experimental biomodels was transcendent, opening the possibility of future research in developing a natural product based on the extracts of this plant.

6. Recommendations

When presenting alkaloids through phytochemical screening of jackfruit (*Artocarpus heterophyllus Lam*), it is recommended that the anti-inflammatory effects be analyzed for future work.

It is recommended that future studies consider performing more extensive tests with the 400 ppm hydroalcoholic and aqueous extracts to determine which one retains the best properties once processed.

Applying the hypoglycemic test of Jackfruit (*Artocarpus heterophyllus Lam*) is recommended to carry out studies to identify and purify the active ingredient.

To carry out a toxicity analysis of Jackfruit (*Artocarpus heterophyllus Lam*) in order to be sure of its use.

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