ARTICLE

In vitro inhibition of α-glucosidase by *Rubus rosifolius* leaf and fruit extracts

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ABSTRACT

Prickly-stemmed *Rubus rosifolius* is an endemic Philippine plant growing in the mountainous areas and bearing edible red berries reportedly rich in phenolic compounds with known antioxidant, anti-inflammatory, antimicrobial, and antidiabetic properties. However, planting elevation and climate change affect the fruit-bearing season and the quantity that can be harvested, leading to the exploration of the pharmacological properties of the leaves. This study aimed to compare the α-glucosidase inhibitory activities of the *R. rosifolius* leaf and fruit extracts to maximize the potential plant parts that can be further studied in managing insulin resistance in diabetic patients. Physicochemical characteristics, phytochemical screening, and α-glucosidase inhibitory assay of the methanolic leaf and fruit extracts were performed using acarbose and phosphate buffer solution as positive and negative controls. The *R. rosifolius* leaf and fruit extracts were abundant in reducing sugars, flavonoids, saponins, tannins, alkaloids, steroids, triterpenoids, and anthraquinone glycosides for the fruit extract only. Spectrophotometric analysis at 405 nm showed that the leaf extract can inhibit 93.86% of the enzyme at 62.5 µg/mL, 77.84% at 250 µg/mL for the fruit extract, and 59.13% at 500 µg/mL for acarbose. Statistical analysis using one-way ANOVA showed a significant difference (p-values < 0.05) in inhibiting α-glucosidase at various concentrations among the treatment groups, indicating better inhibitory activities of the leaf extract (IC_{50} of 22.24 µg/mL) than the fruit extract (IC_{50} = 195.32 µg/mL) and acarbose (367.96 µg/mL). In conclusion, the methanolic *R. rosifolius* leaf and fruit extracts are promising candidates in lowering postprandial plasma glucose levels.

INTRODUCTION

Impairment in the biological response to insulin stimulation by the liver, muscle, and adipose tissue hinders glucose disposal, causing postprandial hyperglycemia that may result in non-communicable diseases in later age, such as Type 2 diabetes mellitus (T2DM), hypertension, dyslipidemia, and hyperuricemia. Insulin resistance is associated with weight gain, which is managed by weight reduction through calorie reduction, healthy food choices, regular exercise, or prescribing oral antidiabetic agents (OADs) if targets are not reached within three months (Freeman et al. 2023; Farmaki et al. 2021). Metformin and gliclazide are the first-line OADs frequently prescribed by physicians due to their cost-effectiveness, but in some individuals with high risk of hypoglycemia or lactic acidosis, second-line α-glucosidase inhibitors (AGIs) such as acarbose, miglitol, and voglibose are given as monotherapy or in combination with other hypoglycemic agents. AGIs manage the fasting and postprandial plasma glucose levels by delaying

KEYWORDS

Rubus rosifolius, diabetes mellitus, α-glucosidase inhibition, phenolics, flavonoids

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carbohydrate absorption in the gastrointestinal tract through competitive α-glucosidase inhibition (Cando et al. 2024; Gao 2017; Akmal et al. 2024). However, medication non-adherence and challenges in T2DM management due to inadequacies in psychological support, training, and caregiving aggravate patients' chances of developing vascular complications and nonalcoholic fatty liver disease. Increasing morbidity and mortality rates relating to DM and its complications are a global public health concern as it is ranked 8th in the 2021 leading mortality cause both in high and low-income countries (Nikpour et al. 2022; World Health Organization 2024).

Nutraceutical supplementation is integrated in the therapeutic strategies of medical practitioners due to its tolerability, safety, and efficacy on glucose homeostasis. Isolated bioactive compounds from plants, such as polyphenols and flavonoids, exhibited potential in modulating glucose metabolism and reducing inflammation. Bioactive compounds reportedly present in *Rubus rosifolius (R. rosifolius)*, such as anthocyanin, ellagic acid, and quercetin, compete with sugar, maltose, maltotriose, maltooligosaccharides, or α-dextrin for binding to α-glucosidase, thus preventing its conversion to glucose and delaying its absorption in the small intestine (Olalekan et al. 2024; Derosa et al. 2022; Jansen-Alves et al. 2021; Gudej and Tomczyk 2024). Various studies on its edible fruit demonstrated *in vitro* and *in vivo* potential in inhibiting DM progression, wherein some studies suggested that consumption of at least one cup of fresh or frozen raspberries (locally known as sampinit) improves insulin sensitivity and pancreatic β-cell function (Derrick et al. 2021). Supply shortages of seasonal fruits are experienced due to climate change; however, the leaves are abundant throughout the year and can be further explored for their health benefits. With this, the researchers aimed to compare the α-glucosidase inhibitory activities of the *R. rosifolius* leaf and fruit extracts to maximize the potential plant parts that can be further studied in managing postprandial plasma glucose levels.

MATERIALS AND METHODS

Materials

Phytochemical screening reagents, methanol, dimethyl sulfoxide, and chemicals needed for preparing phosphate buffer solution, such as sodium dihydrogen phosphate dihydrate, disodium hydrogen phosphate dihydrate, sodium chloride, and deionized water, were provided by the Pharmacy Laboratory, Adamson University - College of Pharmacy. Acarbose and α-glucosidase activity assay kit were purchased from Sigma-Aldrich.

Collection, Identification, and Processing of Plant Material

Fresh leaves and fruits of *R. rosifolius* were collected at the Bangkong Kahoy Valley Nature Retreat and Field Study, Dolores, Quezon, in January 2022. Photos of the plant samples were sent for identification to the Jose Vera Santos Memorial Herbarium (PUH), Institute of Biology, University of the Philippines Diliman. The extraction process proceeded after receiving the identification certificate. The *R. rosifolius* leaf and fruit samples were air-dried for 3 days until their texture became brittle enough to be mechanically comminuted using a portable mechanical grinder. Powdered *R. rosifolius* leaves and fruit samples were macerated separately with 80% methanol for three days, filtered using Whatman No. 1, and concentrated using a BÜCHI rotary evaporator set at 45°C and 70 rpm. The leaf concentrates were further subjected to a water bath to evaporate any moisture present, and the fruit concentrates underwent lyophilization using the Ilshin Biobase Freeze Dryer (FDS 8508) set at 5 mm Torr and -70°C to prevent excessive heat exposure that may degrade the heat-sensitive phytochemical constituents present. Concentrated *R. rosifolius* leaf and fruit extracts were weighed separately in an analytical balance to determine the percentage yield using the formula provided below before storing at 10 - 12°C:

Equation 1. % Yield = (actual weight of crude extract / weight of dried plant used) x 100

Physicochemical Characterization

- **A. Organoleptic Evaluation -** Adobe Color version 2021 was used to precisely determine the color gradients of the *R. rosifolius* leaf and fruit extracts, whereas the odor was described through a visual-tactile method.
- **B. pH evaluation -** Aqueous solutions (10% w/v) of the *R. rosifolius* leaf and fruit extracts were prepared, and their respective pH were determined in triplicate using an MRC PL-600 pH meter at 25°C to describe their acidic characteristics.
- **C. Solubility Determination -** One gram each of the *R. rosifolius* leaf and fruit extracts was weighed and separately dissolved in volumes of distilled water to describe their solubility characteristics in accordance to the United States Pharmacopeia criteria.

Phytochemical Screening

Phytochemical constituents in *R. rosifolius* leaf and fruit extracts were qualitatively determined using 2 mL each of the diluted extract samples for the following confirmatory tests:

- **A. Fehling's Test for Reducing Sugar -** Test tubes with diluted extracts and 1 mL of hydrochloric acid (HCl) were heated in a water bath for 5 min, removed to cool down, and neutralized with anhydrous sodium carbonate until no effervescence was observed. Fehling's solution at 1 mL was added to each test tube, reheated in a water bath for 2 min, and observed for the brick-red precipitate formation, indicating a positive result for glycosides (Shaiful et al. 2015).
- **B. Modified Bornträger's Test for Reduced Form of Anthraquinone -** Test tubes with diluted extracts, 1 mL of 5% ferric chloride solution, and 1 mL of diluted HCl were heated in a water bath for 5 min and cooled. Diethyl ether of 1.5 mL volume was added to the tubes, then shaken to separate the organic layer. Equal volumes of 10% ammonia solution were added to the tubes, and the rose-pink or red coloration at the ammonia layer indicates a positive result for anthraquinones (BaoDuy et al. 2015).
- **C. Magnesium Turing Test for Flavonoids -** Diluted extracts were treated with magnesium ribbon and 1 mL of 10% HCl, wherein red coloration in the solutions indicates the presence of flavonoids (Shrestha et al. 2015).
- **D. Froth Test for Saponins -** Diluted extracts in separate test tubes were shaken vigorously until foam formed. Three drops of olive oil were added, then repeatedly shaken to produce a stable frothy solution for 10 min, indicating a positive result for saponins (Gul et al. 2017).
- **E. Ferric Chloride Test for Tannins** - Ferric chloride solution was added dropwise to diluted extracts. Dark coloration of the test solutions, either black, dark blue, or blue-black, indicates the presence of tannins (Hassan et al. 2020).
- **F. Wagner's Test for Alkaloids -** Wagner's reagent was added dropwise to individual test tubes containing the filtered solutions of diluted extracts in 2.5 mL of 1% HCl. Brown precipitate indicates a positive result for alkaloids (Iqbal et al. 2015).

G. Liebermann-Burchard Test for Sterols and Triterpenes - Test tubes with diluted extracts, 2 mL of chloroform, and 4 drops of acetic anhydride were boiled in a water bath, then cooled using ice water. Concentrated sulfuric acid (H_2SO_4) was added to the cooled solutions. Color change from pink to red indicates the presence of triterpenoids, whereas a brown ring color to green is a positive result for steroids (Iqbal et al. 2015).

H. Salkowski's Test for Sterols and Triterpenes - Two mg each of *R. rosifolius* leaf and fruit extracts were separately dissolved in 2 mL of chloroform, then 2 mL of concentrated H_2SO_4 was added to each tube. Red color formation indicates a positive result for triterpenoids and blue for steroids (Iqbal et al. 2015).

α-glucosidase Inhibitory Assay

A slightly modified method by (Naing et al. 2019) was adopted using a prepared substrate stock solution (1.86 mM p-nitrophenyl-α-D-glucopyranoside in phosphate buffer) and α-glucosidase enzyme (120 mU/mL in phosphate buffer) for plating. Phosphate buffer solution (PBS) at 50 mM concentration with pH adjusted to 6.80 served as the negative control. The *R. rosifolius* methanolic leaf and fruit extracts, including the standard drug acarbose, were separately dissolved in 100% analytical grade dimethyl sulfoxide (DMSO) to prepare solutions of 15000 µg/mL, 7500 µg/mL, 3750 µg/mL, 1875 µg/mL, 937.50 µg/mL, 485.75 µg/mL, and 234.375 µg/mL concentrations. These prepared samples for analysis were homogenized using a vortex mixer, sonicated, and centrifuged. Aliquots of mother stock and working stock solutions at 10-µL were transferred into designated wells to achieve concentrations of 1000 µg/mL, 500 µg/mL, 250 µg/mL, 125 µg/mL, 62.50 µg/mL, 31.25 µg/mL, 15.625 µg/mL, and 17.8125 µg/mL, followed by adding of 190 µL of PBS and 50 µL of the enzyme working stock solution to individual sample well. On the negative control wells, 200 µL of 5% DMSO in PBS and 50 µL of the enzyme working stock solution were transferred. Triplicates per trial were employed in the assay. Plated reagents into the 96-well quartz, except for the substrate, underwent incubation in a Multiskan Go$^{®}$ UV/Vis Spectrophotometer for 10 min at 37°C. After incubation, 50 µL of the substrate working stock solution was added to each well to initiate the enzymatic reaction. Absorbance of liberated p-nitrophenol in the samples was read at 405 nm every 30 seconds for 30 min, recorded, and used for computing the percent inhibitory activities of the triplicate samples using the equation provided below:

Equation 2. % Inhibition = ((Absorbance control – Absorbance sample) / Absorbance control) x 100

The half-maximal inhibitory concentration (IC_{50}) values of the extracts and acarbose were computed using a dose-response curve with linear regression interpolation expressed as percentage inhibition (Momina and Rani 2020; Kifle et al. 2021), wherein % inhibition greater than or equal to 50% is considered active. One-way analysis of variance (ANOVA) with Tamhane T2 post-hoc tests was employed to statistically analyze the data, in which a p-value < 0.05 indicates a significant mean difference.

RESULTS AND DISCUSSION

Percentage Yield

As shown in Table 1, the extraction yield using 80% methanol for *R. rosifolius* leaves was 25.10% after concentrating using a rotary evaporator and further on a water bath. Due to the high moisture content (Rambaran and Bowen-Forbes 2020) and to protect the heat-sensitive anthocyanin that may degrade if further exposed at higher temperatures, lyophilization was performed on rotavaped *R. rosifolius* fruit concentrates instead of a water bath to remove any water present through the sublimation process, which produced an extraction yield of 11.90%. Extraction method, solvent types/ratio, set temperature, and time were considered to maximize the extraction yields of the secondary metabolites from the plant samples (Sulaiman et al. 2017). Previous studies on *R. rosifolius* fruits mentioned methanol as a better extraction solvent than ethyl acetate and hexane in extracting higher yields of phenolic compounds due to its high polarity (Abu Bakar et al. 2016; Campbell et al. 2017). However, prolonged heat exposure under Soxhlet extraction of the *R. rosifolius* leaves produced a lower yield of 6.23%, wherein environmental and cultivation techniques could be the other impacting factors (Elya et al. 2020; Jansen-Alves et al. 2021).

Table 1: Percentage yields of R. rosifolius leaf and fruit extracts

R. rosifolius extract	Dried and ground sample (g)	Concentrated extract (g)	% Yield
Leaves	195.96	49.26	25.10%
avdddbb	425.71	50.86	11.90%

Physicochemical Characterization

Table 2 provides the physicochemical characteristics of *R. rosifolius* leaf and fruit extracts as to color, odor, solubility, and pH, wherein both extracts were acidic with respective pHs of 3.38 and 4.74. The leaf extract had a very dark, desaturated orange color with a leafy odor and was soluble in distilled water. In contrast, the fruit extract was dark red with a fruity, slightly acidic odor and was sparingly soluble. Dark red pigment of *R. rosifolius* fruits is associated with high anthocyanin content, wherein this water-soluble flavonoid is red in acidic conditions due to stabilized flavylium cations. In contrast, the dark brown characteristic of leaf extract can be due to the presence of procyanidins and tannins (Rambaran and Bowen-Forbes 2020; Chua et al. 2024), which can be quantitatively determined through Liquid Chromatography - Mass Spectrometry (LC-MS).

Table 2: Physicochemical characteristics of R. rosifolius leaf and fruit extracts

***R. rosifolius* Extract**	**PHYSICOCHEMICAL CHARACTERISTICS**			
	Color	**Odor**	**pH**	**Solubility**
Fruits	🟥 #A101A11 Dark red	Fruity & slightly acidic odor	4.74 ± 0.005	Sparingly soluble

Leaves	■ #4B2F25 Very dark, desaturated orange	Leafy odor	3.38 ± 0.037	Soluble

Phytochemical Screening

Table 3 presents the qualitative phytochemical screening of *R. rosifolius* leaf and fruit extracts using various test reagents which confirms the presence of reducing sugars (Fehling's test), flavonoids (Magnesium Turning test), saponins (Froth test), tannins (Ferric Chloride test), alkaloids (Wagner's test), steroids, and triterpenoids (Liebermann-Burchard and Salkowski's tests) for both diluted extracts. A positive result on anthraquinone glycoside using Modified Borntrager's test was observed on the fruit extracts alone. These confirmatory results were similar to (Recuenco et al. 2020) findings for the methanolic *R. rosifolius* fruit extracts, except for the negative alkaloid detection in their study. Negative presence of alkaloids, saponins, cardiac glycosides, and coumarins was also reported by (Campbell et al. 2017), which can be due to the cultivation techniques and extraction protocol employed. Since there are limited studies about the *R. rosifolius* leaves, these findings provide initial information about the phytochemical constituents that can be quantitatively detected, such as quercetin, kaempferol, ellagic acid, and tannins (Gudej and Tomczyk 2024) using other methods. Flavonoids are significantly higher in *Rubus* leaves than in its fruits, wherein quercetin-3-O-rutinoside, quercetin-3-O-glucoside, luteolin, myricetin, and quercetin were isolated from *R. ideaus* leaves and cyanidin-3-glucoside in *R. rosifolius* fruits (Ponder and Hallman, 2019; Rambaran and Bowen-Forbes, 2020). Anthocyanin, ellagic acid, and quercetin are notable compounds identified in the leaves and fruits of *Rubus* species according to published studies.

Table 3: Phytochemical screening results of R. rosifolius leaf and fruit extracts

Phytochemicals	Leaf Extract Result	Fruit Extract Result	Test Used
Glycosides	(+++)	(+++)	Fehling's Test
	(-)	(+++)	Modified Borntrager's Test
Flavonoids	(+++)	(+++)	Magnesium Turning Test
Saponins	(+++)	(+++)	Froth Test
Tannins	(+++)	(+++)	Ferric chloride Test
Alkaloids	(+++)	(+++)	Wagner's Test
Steroids	(+++)	(+++)	Liebermann - Burchard Test Salkowski's Test
Triterpenoids	(+++)	(+++)	Liebermann - Burchard Test Salkowski's Test

Note: (+) Traces, (++) Moderate, (+++) Abundant and (-) Absence of constituents

α-Glucosidase Inhibitory Assay

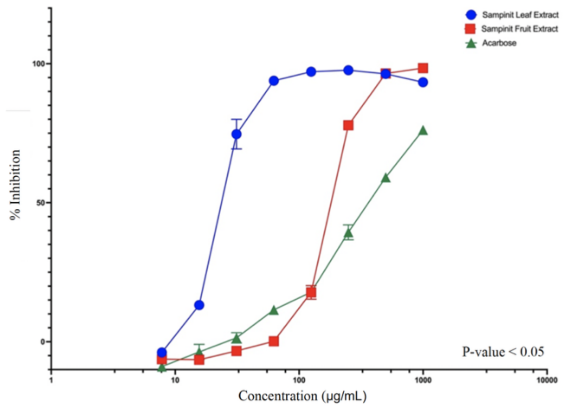

Figure 1: Alpha-glucosidase inhibition of R. rosifolius leaf and fruit extracts against the standard drug Acarbose

Figure 1 compares the α-glucosidase inhibitory activities at various concentrations of *R. rosifolius* leaf and fruit extracts against the standard drug acarbose in triplicate trials. The leaf extract competitively inhibited the enzyme as low as 31.25 µg/mL with 74.67% inhibition and reached enzyme saturation at 250 µg/mL with 97.64%. The Michaelis-Menten equation states that the enzymatic activity increases as the substrate concentration increases, following a hyperbolic curve until it reaches its maximum velocity. Enzyme saturation happens when all active sites are completely bound and occupied, leading to a plateau reaction rate regardless of increasing the substrate concentration (Mbria 2024). On the other hand, the fruit extract can inhibit 77.84% of the enzyme starting at a 250 µg/mL concentration. Its broad inhibitory activity increases as the concentration increases, wherein at 1000 µg/mL the fruit extract inhibited α-glucosidase at 98.42%, 93.33% for the leaf extract, and 76.18% for acarbose. This indicates better α-glucosidase inhibitory activities of the leaf and fruit extract than acarbose, especially the leaf extract at 62.50 μg/mL with 93.86% inhibition. Based on computed IC_{50} values, the leaf extract was potent at 22.24 μg/mL compared to the fruit extract (195.32 μg/mL) and acarbose (367.96 μg/mL). Further statistical analysis was performed using One-way ANOVA with a significant difference (p-values < 0.05) in inhibiting α-glucosidase among the treatment groups starting at 62.50 μg/mL, 250 μg/mL, and 500 μg/mL, indicating better inhibitory activities of the *Rubus* leaf extract than the fruit and acarbose. These findings support other published reports on the potency of *Rubus* species in inhibiting α-glucosidase and α-amylase enzymes to manage T2DM, such as the *R. erlangeri* leaf extract (IC_{50} = 10.38 μg/mL), *R. fraxinifolius* leaf (IC_{50} value = 8.86 μg/mL), and *R. corchorifolius* fruit (IC_{50} = 4.96 μg/mL) with comparable *in vitro* pharmacological activities to acarbose (Ayele et al. 2021; Dewi et al. 2019; Tian et al. 2020). In addition, the *R. rosifolius* n-hexane fruit extract exhibited potent *in vivo* hypoglycemic activity on male Sprague-Dawley rats against metformin (Rambaran and Bowen-Forbes, 2020).

Promising Effects of *R. rosifolius'* Secondary Metabolites in Managing Insulin Resistance

Impaired biological response of the liver, muscles, and adipose tissue leads to insulin resistance, which requires medical intervention to stimulate insulin secretion, improve insulin sensitivity, prevent carbohydrate absorption, or decrease gluconeogenesis for T2DM, wherein vascular complications and nonalcoholic fatty liver disease occur if insulin resistance is uncontrolled. One therapeutic approach is inhibiting the enzymes α-glucosidase and α-amylase that are responsible for converting oligosaccharides and disaccharides to monosaccharides, thereby decreasing glucose influx into the bloodstream. However, AGIs are reported to have several gastric discomforts, such as flatulence, abdominal distention, and diarrhea, resulting in a low compliance rate of 55.53% among T2DM patients worldwide (Freeman et al. 2023; Lam et al. 2024; Ayele et al. 2021; Boonpattharatthiti et al. 2024).

Several studies highlighted the potential of secondary plant metabolites, particularly phenolics and flavonoids, in managing insulin resistance due to their strong inhibition of α-glucosidase and α-amylase, making them promising candidates in developing OADs with minimal gastrointestinal side effects. Anthocyanins (ACNs) and ellagic acid are the phenolics abundantly detected in *R. rosifolius* fruits compared to its leaves, which alleviate insulin resistance by inhibiting the digestive enzymes, neutralizing the reactive oxygen species, and activating the IRS-1/AKT pathways (Campbell et al. 2017; Lam et al. 2024). Lowering free radical concentration associated with increased glucose and lipid levels in the body will inhibit the activation of programmed beta cell death, resulting in increased cell function and improvement in insulin production (Harakeh et al 2020; Momina and Rani 2020). Moreover, diabetic wounds are healed with cyanidin-3-O-glucoside as it helps accelerate the growth of blood vessels and collagen (Kozłowska and Nitsch-Osuch 2024). On the other hand, *Rubus* leaves are significantly abundant in flavonols, such as kaempferol and quercetin, than their fruits. The systematic review of 45 *in vitro* studies on flavonoids showed that quercetin exhibited superior efficacy than acarbose in inhibiting α-glucosidase by forming hydrogen bonds with specific amino acid residues, but was weak in α-amylase inhibition, which is beneficial in preventing abdominal pain and flatulence associated with excessive breakdown of resistant starch in the colon. Moreover, T2DM complications are managed by reducing the free radical oxidation in myocardial mitochondria, suppressing the inflammatory response, and restricting the endoplasmic reticulum stress pathway (Ponder and Hallman 2019; Lam et al. 2024; Günal-Köroğlu et al. 2024; Gevrenova et al. 2024; Yi et al. 2023).

Differences in α-glucosidase inhibition of *R. rosifolius* leaf and fruit extracts can be due to the secondary metabolites present, pH, temperature, substrate specificity, and enzyme concentration. Since the leaf extract is more acidic than the fruit, the acidic environment neutralizes negatively charged groups, increasing the substrate-enzyme affinity. Increased hydroxyl groups in either ring A and B increase the α-glucosidase inhibitory activity of flavonoids, however, flavonoid glycosylation with alkyl or glycosyl groups and sugar substitution in anthocyanins decrease their activity due to the increased bulkiness and polarity, causing a steric effect on the binding interaction between flavonoids and the enzyme (Pan et al. 2024; Promyos et al. 2020).

Seventeen *Rubus species* were reported available in the Philippines, wherein *R. fraxinifolius* Poir., *R. moluccans* L., and *R. rosifolius* JE Smith are the three species commonly collected for herbarium deposition and observation, as these can be found 1000 feet (ft) above sea level (Real 2016). Several online literatures on Google Scholar ranked *R. rosifolius* as sixth in the most explored species, with 1350 published studies (Bhatt et al. 2023) frequently focusing on the pharmacological activities of its fruit. However, *R. rosifolius* is considered an agricultural pest by local farmers because of its thorny characteristics, and bears only its seasonal fruits if propagated at 5000 ft above sea level. The fruits during their bearing season provide livelihood income to the local community, as they can be used in making salads, milkshakes, jams, and wines. However, planting elevation and climate change affect its bearing season schedule, and the quantity harvested.

Despite the experimental limitations during the COVID-19 pandemic and procurement delays, the researcher contributed scientific knowledge about the α-glucosidase inhibitory activities of the methanolic *R. rosifolius* leaf and fruit extracts. Further research should be done focusing on improving the yield using modern extraction techniques on the leaves, as it is abundant and available throughout the year. Further research should perform qualitative-quantitative determination of the secondary metabolites through Thin Layer Chromatography and Liquid Chromatography-Mass Spectrometry, official pharmacopeial tests for identity and purity determination, and other *in vitro* or *in vivo* pharmacological assays that will provide evidence on *R. rosifolius* efficacy and safety.

CONCLUSION

The methanolic *R. rosifolius* leaf and fruit extracts were abundant in reducing sugars, flavonoids, saponins, tannins, alkaloids, steroids, triterpenoids, and anthraquinone glycosides for the fruit extract only. Qualitative confirmation of phenolics and flavonoids can be associated with α-glucosidase inhibitory activities, wherein the leaf extract can inhibit more than 50% of the enzyme at a low concentration of 62.5 μg/mL and 250 μg/mL for the fruit extract. Broad inhibitory activity of the fruit extract increases as the concentration increases; however, enzyme saturation at 250 μg/mL was observed in the leaf extract. The leaf extract (IC_{50} = 22.24 μg/mL) was more potent than the fruit extract (IC_{50} = 195.32 μg/mL), and both *R. rosifolius* extracts are promising candidates in lowering the postprandial plasma glucose levels.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

CONTRIBUTIONS OF INDIVIDUAL AUTHORS

LR Delgado, FHR Nimer, JM Jimenez, MAC Zurita, and AAS Rescober contributed to the conceptualization, experimentation, data gathering, analysis, and manuscript drafting. AAS Rescober and LR Delgado revised the manuscript according to the reviewers' comments and provided the final approval of the version to be published. All authors agree to be accountable for all aspects of the work and declare that the manuscript's data, figures, graphs, calculations, and such are authentic.

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