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Bioactive Components Profiling With Hplc Technique And Antidiabetic Assessment Of Ethanol Leaf-Extract Of Scoparia Dulcis

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Abstract
This study analyzed the bioactive components and antidiabetics potentials of ethanol leaf-extract of *Scoparia dulcis*. The bioactive compounds and vitamins were quantified using HPLC technique procedures and the antidiabetic properties were evaluated based on the α-amylase and α-glucoamylase inhibitory activities of the extract using spectrophotometric methods. Results showed significant amounts of water-soluble vitamins, with vitamin B1 as the most abundant (0.041 ppm), followed by B9 (0.0246 ppm) and B12 (0.0167 ppm) others are B6 (0.01 ppm), .B3 (0.001 ppm) and B2 (0.0001 ppm). The most abundant among the fat soluble vitamins was calciferol (2.898 ppm) followed by tocopherol (0.72 ppm) and retinol (0.478 ppm) while the carotenoids has the least concentration (0.19 ppm). In addition to vitamins, *Scoparia dulcis* is rich in bioactive compounds. Cardiac glycosides were the most prominent (17.24 µg/mL), followed by naringin (17.09 µ/mL), ribalindine (16.79 µ/mL), phytate (15.58 µg/g), and epicatechin (14.38 µ/mL). Meanwhile, those with moderate concentrations include flavone (6.22 ppm), proanthocyanin (9.49 ppm), resvereratol (15.22 ppm), flavanones (18.99 ppm), and steroid (21.49 ppm). Antidiabetic activities of the extract differed significantly ($p<0.05$) and the effects showed concentration dependent. The α-amylase inhibitory activities ranged from 47.876% to 69.043% and α-glucosidase inhibitory activities ranged from 39.887 to 59.644 % in 5 and 100 mg/mL of the extract respectively. The findings underscored the medicinal potentials of *Scoparia dulcis* leaf extract in managing diabetes and other health conditions. The plant's combination of essential nutrients and diverse bioactives may offer synergistic benefits for metabolic health and chronic disease treatment.
Keywords: *Scoparia dulcis*, antidiabetics, bioactivity, vitamins, phytochemicals, HPLC.

I. Introduction

Diabetes mellitus is a chronic metabolic disorder characterized by persistent hyperglycemia due to insulin deficiency, insulin resistance, or a combination of both (IDF, 2021). The global prevalence of diabetes has been rising rapidly, affecting millions of individuals worldwide and imposing significant health and economic challenges. Managing diabetes effectively is crucial in preventing complications such as cardiovascular diseases, kidney failure, and neuropathy. While synthetic antidiabetic drugs are widely available, their long-term use is often associated with adverse effects. As a result, there has been growing interest in exploring alternative therapies, particularly from medicinal plants known for their bioactive components and minimal side effects (Patel, 2022).

One of such plants is *Scoparia dulcis*, commonly known as sweet broomweed or licorice weed, belonging to the family Plantaginaceae. *Scoparia dulcis* is a perennial herb widely distributed in tropical and subtropical regions, including parts of Africa, Asia, and South America. Traditionally, the plant has been used in various cultures for its therapeutic potential, including its use in treating ailments such as fever, wounds, bronchitis, hypertension, and gastrointestinal disorders. In few years ago, the potential of *Scoparia dulcis* to manage diabetes has gained attention, primarily due to its rich phytochemical profile (Rahmatullah *et al.*, 2015).

The medicinal properties of *Scoparia dulcis* are attributed to the presence of a variety of bioactive components, including flavonoids, alkaloids, saponins, glycosides, and terpenoids. These compounds have demonstrated a range of pharmacological activities, such as anti-inflammatory, antioxidant, antimicrobial, and antidiabetic effects. Among the key bioactive constituents identified in the plant are scoparin, amellin, and betulinic acid, which have been linked to its therapeutic benefits (Jaiswal *et al.*, 2016). Flavonoids, in particular, are known for their antioxidant properties, which help to mitigate oxidative stress, a condition that plays a critical role in the pathogenesis of diabetes. Furthermore, alkaloids and terpenoids found in *Scoparia dulcis* have been shown to exert hypoglycemic effects by enhancing insulin sensitivity and regulating blood glucose levels. For instance, scoparic acid and scoparin, two significant flavonoid glycosides present in the plant, have been reported to possess potent antidiabetic activity in preclinical studies (Gupta *et al.*, 2022).

Several studies have evaluated the medicinal properties of *Scoparia dulcis*, particularly its antidiabetic potential. The use of ethanol leaf extracts of the plant has been demonstrated to lower blood glucose levels in diabetic animal models. The antidiabetic effect is thought to be mediated through various mechanisms, including the inhibition of key enzymes involved in carbohydrate metabolism, such as α-amylase and α-glucosidase. Inhibiting these enzymes helps delay the digestion of carbohydrates, reducing postprandial hyperglycemia, a hallmark of type 2 diabetes (Umamaheswari, 2017).

In addition to its enzyme inhibitory activity, *Scoparia dulcis* has been found to enhance insulin secretion from pancreatic β-cells, improve glucose uptake in peripheral tissues, and reduce insulin resistance, thereby providing a multifaceted approach to diabetes management. Its antioxidant properties further contribute to its therapeutic effect by protecting β-cells from oxidative damage, which is often associated with the progression of diabetes (Ashok *et al.,* 2021). The use of *Scoparia dulcis* as a natural remedy for diabetes offers a promising alternative to conventional therapies, especially for individuals seeking plant-based treatments with fewer side effects. Given its rich composition of bioactive compounds and its demonstrated antidiabetic effects in preclinical studies, further research is warranted to explore its clinical efficacy and potential applications in diabetes management (Gurav *et al.,* 2021).

The increasing prevalence of diabetes and its associated complications call for the exploration of new therapeutic strategies. *Scoparia dulcis*, with its diverse array of bioactive components, presents a promising candidate for the development of natural antidiabetic agents. High Performance Liquid Chromatography (HPLC)-based analysis of the ethanol leaf extract of *Scoparia dulcis* can provide valuable insights into the specific compounds responsible for its medicinal properties and further validate its use in diabetes management. By identifying and quantifying these bioactive constituents, researchers can better understand the mechanisms underlying the plant's antidiabetic effects and potentially develop more effective plant-based treatments for diabetes.

Figure 1: *Scoparia dulcis*

II. Materials And Methods

Sample Collection and Extract Preparation

Scoparia dulcis leaves were collected from healthy, mature plants found in Ishieke, Abakaliki Ebonyi State. The plant was identified and authenticated by a taxonomist in the Department of Applied Biology, Ebonyi State University, Nigeria. The leaves were cleaned and kept for 20 days to dry at room temperature. Using a mechanical blander, the dried sample was grounded and sieved to obtain fine powder, after which it was weighed. Extraction was carried out by soaking 400g of the sample powder in 1000ml of 98% absolute ethanol for 72 hours with intermittent shaking. Then the extract was filtered and concentrated to dryness using a rotary evaporator.

Determination of Water Soluble Vitamins

Water soluble vitamins were analyzed using HPLC procedures according to the method described by Rokayya *et al*. (2014). Exactly 2 g of the extract was placed in 25 mL of H_2SO_4 (0.1 N) solution and incubated for 30 min at 121°C. Then, the contents were cooled and adjusted to pH 4.5 with 2.5 M sodium acetate, and 50 mg takadiastase enzyme was added. The preparation was stored at 35°C overnight. The mixture was then filtered through a Whatman No. 4 filter, and the filtrate was diluted with 50 mL of ditilled water and filtered again through a micropore filter (0.45 μm). Twenty microliters of the filtrate were injected into the HPLC system. Quantification of vitamin B content was accomplished by comparison to vitamin B standards. Standard stock solutions for thiamine, riboflavin, niacin, pyridoxine, and cobalamin were prepared. Chromatographic separation was achieved

on a reversed phase- (RP-) HPLC column (Agilent ZORBAX Eclipse Plus C18; 250 × 4.6 mm i.d., 5 µm) through the isocratic delivery mobile phase (A/B 33/67; A: MeOH, B: 0.023 M H3PO4, pH = 3.54) at a flow rate of 0.5 mL/min. Ultraviolet (UV) absorbance was recorded at 270 nm at room temperature.

Determination of Fat-Soluble Vitamins

Fat soluble vitamins were analyzed using HPLC procedures according to the method described by Rokayya *et al*. (2014). Exactly 10 g of the sample, 1 g of pyrogallic acid, 70 mL ethanol, and 30 mL (50%) KOH were added together, stirred, and refluxed for 40 min using a water bath at 50°C. Extracts were obtained three times using various ether concentrations (50 mL, 30 mL, and 20 mL). Double-distilled water was used to neutralize the extract, which was dehydrated using anhydrous sodium sulfate. Further, the extract was concentrated to approximately 5 mL by using a water bath (50°C), diluted to 10 mL by using methanol, filtered using a 0.45 µm membrane, and finally subjected to HPLC analysis. RP-HPLC analysis was performed with the Agilent 1100 series HPLC system (Agilent; USA), including a diode array detector. The column was made of stainless steel. For -carotene quantification, the Agilent TC-C18 column was used (5 µm, 4.6 × 250 mm) with an acetonitrile-methyl alcohol-ethyl acetate (88: 10: 2) solvent, and UV absorbance was recorded at 453 nm. For fat-soluble vitamins, the Agilent Eclipse XDB-C18 column was used (5 µm, 4. 6 × 150 mm), the solvent was methanol, and UV detection was recorded at 325 nm for vitamin A, 265 nm for vitamin D3, 290 nm for vitamin E, and 244 nm for vitamin K3. Separation of all vitamins was based on isocratic elution and the solvent flow rate was maintained at 1 mL/min. Twenty microliters of the extract oil was directly injected into the HPLC column. Fat-soluble vitamins were identified by comparing their retention times with those of authentic standards. All procedures were carried out under subdued light conditions. Standard solutions of vitamins were prepared by serial dilution to concentrations of 0.1, 1, 2, 5, and 10 mg per liter of vitamins D3, E, K3, A, and -carotene, respectively. Standard solutions were prepared daily from a stock solution, which was stored in the dark at –20°C. Twenty microliters of standard solution was injected, and peak areas were determined to generate standard curves.

HPLC Procedure for Bioactive Composition of the Extract

The crude extract of *Scoparia dulcis* was subjected to further extraction using 80% methanol in a Soxhlet apparatus. The extract was concentrated under reduced pressure using a rotary evaporator and reconstituted in methanol. The sample was filtered through a 0.22 µm syringe filter prior to analysis. Standard solutions of known bioactive compounds, including scopadulcic acid and selected flavonoids, were prepared in methanol. A calibration curve was constructed using serial dilutions of these standards. A reverse-phase C18 column (250 mm × 4.6 mm, 5 µm) was utilized. The mobile phase consisted of water containing 0.1% formic acid (solvent A) and acetonitrile (solvent B). A gradient program was employed as follows: 80% solvent A and 20% solvent B at 0 minutes, transitioning to 20% solvent A and 80% solvent B over 30 minutes. The flow rate was set at 1.0 mL/min, and the column was maintained at 30°C. The injection volume for all samples was 20 µL. The HPLC system was equilibrated with the mobile phase for 30 minutes prior to injection. The plant extract and standard solutions were injected into the system, and the chromatographic data were recorded. A PDA detector set at 280 nm was used to monitor the compounds.

Alpha-Amylase Inhibitory Assay.

The α-amylase inhibitory test was performed using a modified procedure of McCue and Shetty (2005). .A volume of 250 µl of extract (1-300 mg/ml) was mixed with 250 µl of 0.02 M sodium phosphate buffer (pH 6.9) containing α-amylase at a concentration of 0.5 mg/ml. The mixture was pre- incubated for 10 minutes. Then, 250 µl of 1% starch solution in 0.02 M sodium phosphate buffer (pH 6.9) was added and incubated at 25° C for another 10 minutes. The reaction was stopped by adding 500 µl of dinitrosalicylic acid (DNS). The tubes were then incubated in a water bath at 95° C for 5 minutes and cooled at room temperature followed by dilution with 5 ml distilled water. The optical density was measured at 540 nm. The inhibitory activity on α-amylase was calculated as percent inhibition using the following formula:

$$\%\text{inhibition} = \frac{\text{OD control} - \text{OD extracts OD}}{\text{Control}} \times 100$$

Alpha-Glucosidase Inhibitory Assay.

The ability of extracts to inhibit the activity of α-glucosidase was assessed according to Kim *et al*. (2005). Shortly, α-glucosidase (1 U/ml) from *Saccharomyces cerevisiae* was pre-incubated with 250 µl of the extracts for 10 minutes. P-Nitrophenyl glucopyranoside substrate solution (pNPG, 3 mM) prepared in a 20 mM phosphate buffer (pH 6.9) containing 2 mg/ml BSA was added to start the reaction. The reaction mixture was incubated at 37° C for 20 minutes and stopped with 1 ml of Na_2CO_3 (1M). The α-glucosidase activity was determined by measuring p-nitrophenol released from pNPG at 405 nm. The percent inhibition was calculated as follows:

$$\%\text{inhibition} = \frac{\text{OD control} - \text{OD sample}}{} \times 100$$

OD control

III. Results

Water Soluble Vitamin Contents of the *Scoparia dulcis* Ethanol Leaf Extract

The result showed that Vitamin B1 recorded the highest concentration (0.041 ppm) followed by B9 and B12 (0.0246 ppm and 0.0167 ppm respectively) among water soluble vitamins present in the *Scoparia dulcis* ethanol leaf extract. Other water soluble vitamins detected include B6 (0.01 ppm), B3 (0.001 ppm) and B2 (0.0001 ppm) as shown in Figure 2 and chromatogram in Figure 3.

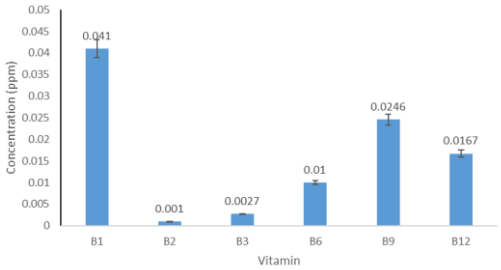

Figure 2: Water soluble vitamin content of the *Scoparia dulcis* ethanol leaf extract

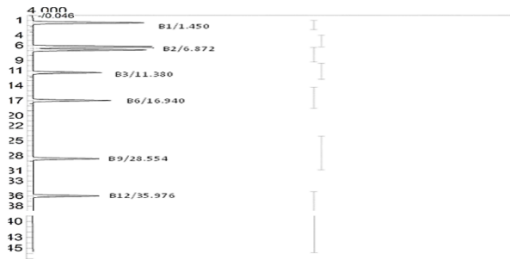

Figure 3: HPLC chromatogram of water soluble vitamin content of *Scoparia dulcis*

Fat Soluble Vitamins from Ethanol Leaf Extract of *Scoparia dulcis*

The result showed the presence of four fat soluble vitamins in the extract including retinol, calciferol, tocopherol and carotenoids. The most abundant among the fat soluble vitamins was calciferol (2.898 ppm) followed by tocopherol (0.72 ppm) and retinol (0.478 ppm) while the carotenoids has the least concentration (0.19 ppm) as shown in Figure 4 and chromatogram in Figure 5

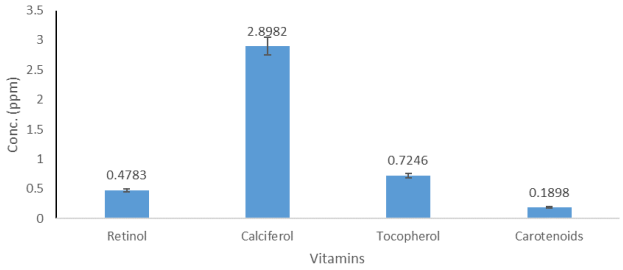

Figure 4: Fat Soluble vitamin content of ethanol extract of *Scoparia dulcis*

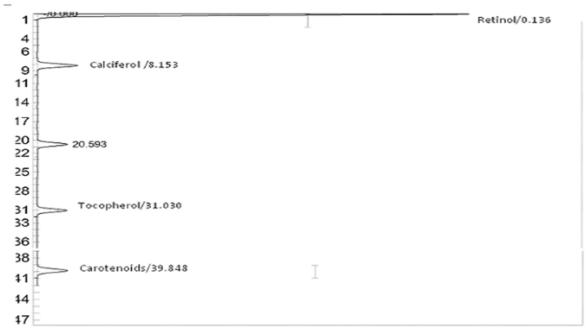

Figure 5: HPLC Chromatogram of fat soluble vitamin content of *Scoparia dulcis*

Bioactive Compounds of *Scoparia dulcis* Ethanol Leaf Extract

The most abundant bioactive component in the sample include cardiac glycoside (17.24 µg/mL), naringin (17.09 µ/mL), ribalindine (16.79 µ/mL), phytate (15.58 µg/g), and epicatechin (14.38 µ/mL). Meanwhile, those with lower concentration (part per million) include flavone (6.22 ppm), proanthocyanidin (9.49 ppm), resveratrol (15.22 ppm), flavanones (18.99 ppm), and steroid (21.49 ppm) as shown in Table 1 and chromatogram in Figure 6.

Table 1: HPLC Bioactive compounds present in *Scoparia dulcis* ethanol leaf extract

Component	Retention	Area	Height	External	Units
Proanthocyanidin	0.243	6748.1622	186.127	9.4911	Ppm
Naringin	2.416	13734.599	127.494	17.0928	ug/ml
Lunamarin	4.043	3830.0267	72.432	5.6077	ug/ml
Cardiac glycoside	6.076	27765.479	192.246	17.2296	ug/ml
Ribalinidine	10.366	19573.998	196.238	16.7873	ug/ml
Rutin	12.966	5831.6243	61.298	7.2375	ug/ml
Spartein	15.46	4546.6606	48.162	8.1481	ug/ml
Flavonoids	17.97	11071.61	112.422	18.9908	Ppm
Steroids	20.313	12530.699	126.489	21.4935	Ppm
Kaempferol	22.726	9138.5044	94.421	6.3286	ug/ml
Epicatechin	25.693	9586.0825	101.535	14.3812	ug/g
Phytate	27.506	11596.128	116.07	15.5862	ug/ml
Flavone	29.853	5011.7522	53.655	6.22	Ppm
Resveratrol	33.036	20032.37	146.508	15.2222	Ppm
Catechin	36.88	6797.7006	69.976	1.4924	ug/ml
Tannin	39.196	10247.371	102.707	5.9509	ug/ml
Sapogenin	42.47	2500.8001	37.299	4.1098	ug/ml
Epihedrine	44.156	11076.623	106.808	14.2495	ug/ml
Total		191620.19		205.619	

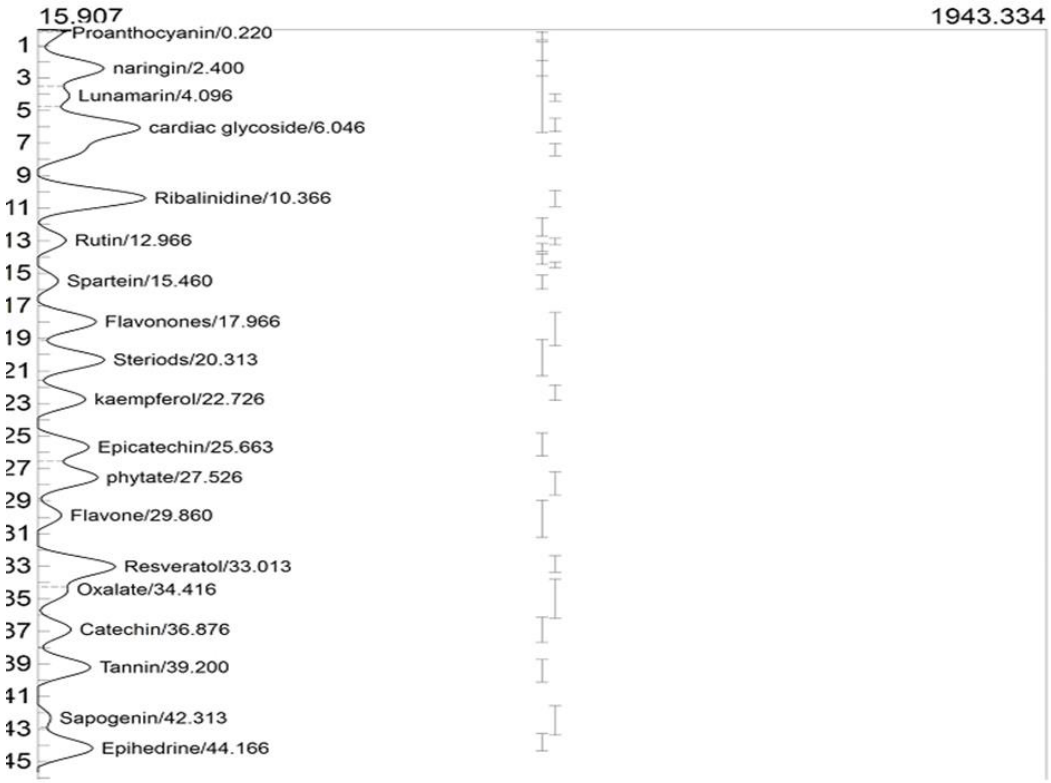

Figure 6: HPLC Chromatogram of bioactive compounds present in *Scoparia dulcis* ethanol leaf extract

Antidiabetic Activities of Ethanol Leaf Extract of *Scoparia dulcis*

Alpha Amylase Inhibitory Activity of Ethanol Leaf Extract of *Scoparia dulcis*

The result showed that the α-amylase inhibitory activities of the extract differed significantly ($p<0.05$) ranging from 47.876% to 69.043% (5 mg/mL and 100 mg/mL extract concentration). The effect of the extract was concentration dependent as shown in Figure 7.

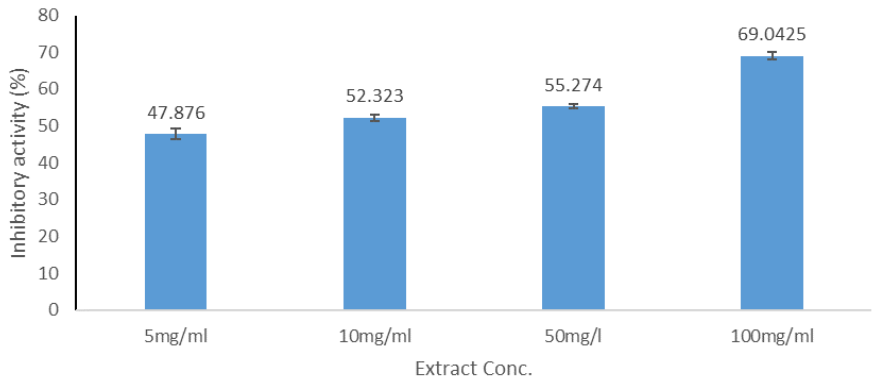

Figure 7: Alpha α-amylase inhibitory activity of ethanol leaf extract of *Scoparia dulcis*

Alpha-glucosidase Inhibitory Activity of Ethanol Leaf Extract of *Scoparia dulcis*

The result of the α-glucosidase inhibitory activity of ethanol leaf extract of *Scoparia dulcis* showed that the activities ranged from 39.887 to 59.644 % in 5 and 100 mg/mL extract conc. The effect of the extract was concentration dependent. (Figure 8). There was significant difference in the alpha glucosidase αactivities of the extract concentrations.

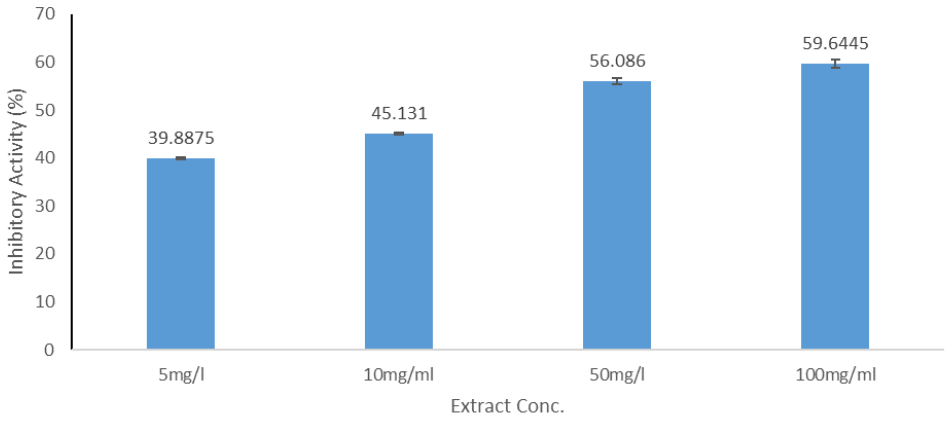

Figure 8: Alpha glucosidase inhibitory activity of ethanol leaf extract of *Scoparia dulcis*

IV. Discussion

The HPLC analysis of the ethanol leaf extract of *Scoparia dulcis* revealed a rich composition of bioactive compounds, both in micrograms per milliliter (µg/mL) and parts per million (ppm). This study contributes to understanding the pharmacological potential of the plant extract, known for its traditional medicinal uses, including antioxidant, anti-inflammatory, antidiabetic and antimicrobial activities. Here is an extensive discussion comparing the results with related studies:

The analysis of water-soluble vitamin content in *Scoparia dulcis* ethanol leaf extract revealed a diverse profile. The study indicates that the extract contains notable amounts of B-complex vitamins, which are essential for metabolic and physiological functions. The water-soluble vitamin analysis recorded vitamins B1 (0.041 ppm), B9 (0.0246 ppm), B12 (0.0167 ppm), B6 (0.01 ppm), B3 (0.001 ppm) and B2 (0.0001 ppm). The dominance of vitamin B1 highlights its importance in energy metabolism and neurological function. Moderate levels of B9 and B12 suggest potential benefits for DNA synthesis and blood cell formation, while the presence of B6 supports amino acids metabolism and neurotransmitter synthesis. A study on *Moringa oleifera* reported higher concentrations of water-soluble vitamins, particularly B2 and B6, than *Scoparia dulcis*. For instance, Moringa leaves showed B6 concentrations of up to 2.02 ppm, significantly surpassing the 0.01 ppm detected in *Scoparia dulcis* (Lakshmipriya *et al*., 2016). This suggests that while *Scoparia dulcis* may not be a primary source of water-soluble vitamins, it contributes modestly to dietary vitamin intake.

The detection of vitamin B12 (0.0167 ppm) in *Scoparia dulcis* is particularly notable, as B12 is rarely found in plant-based sources. Similar studies on algae like *Spirulina platensis* have shown significantly higher

levels of B12, often reaching 0.5 ppm. The presence of B12 in *Scoparia dulcis* is unusual and may suggest symbiotic interactions with microorganisms in the plant's environment (Wantanabe and Bito, 2018). The presence of B12, albeit in low amounts, positions *Scoparia dulcis* as an intriguing candidate for further study, particularly for vegetarians and vegans who often face challenges in obtaining adequate B12 from plant-based diets.

In comparison to *Scoparia dulcis*, medicinal plants like *Ocimum sanctum* (holy basil) show higher concentrations of thiamine (B1) and riboflavin (B2), often exceeding 0.1 ppm and 0.05 ppm, respectively. This indicates that *Scoparia dulcis* might serve as a supplementary rather than primary source of water-soluble vitamins. The high level of vitamin B1 suggests a role in energy production and nervous system health (Mrowicka *et al*., 2023). It supports the use of *Scoparia dulcis* in managing fatigue and neurological disorders. Moderate levels of B9 and B12 indicate potential benefits for hematological health, supporting traditional uses of the plant in treating anemia and related conditions (Green, 2011). While concentrations of vitamins like B6, B3, and B2 are low, their presence adds value to the plant as a complementary dietary supplement in vitamin-deficient regions. Although concentrations of these vitamins are lower compared to other medicinal plants like *Moringa oleifera* and *Ocimum sanctum*, their synergistic effects with other bioactive compounds in *Scoparia* dulcis may enhance its antidiabetic potential. This positions the plant as a complementary agent in diabetes management through its metabolic, neurological, and cardiovascular support.

The analysis of the fat-soluble vitamin profile of *Scoparia dulcis* ethanol leaf extract revealed the presence of four key vitamins: retinol Vitamins A, D, E, and carotenoids. These vitamins are essential for various physiological functions, including antioxidant defense, immune support, and bone health (Widasari *et al*., 2020). The experimental findings provide insights into the plant's potential health benefits and offer a basis for comparison with other studies on fat-soluble vitamins in medicinal plants. Calciferol is the most abundant fat-soluble vitamin in the extract. It plays a crucial role in calcium metabolism and bone health. Its relatively high concentration suggests that *Scoparia dulcis* could be a remedy to osteoporosis and vitamin D deficiency-related disorders. Tocopherol acts as a potent antioxidant, protecting cells from oxidative damage. Its presence indicates potential anti-inflammatory and cardioprotective properties, which align with the traditional use of *Scoparia dulcis* in managing chronic conditions (Tucker and Townsend, 2005). Retinol is essential for vision, immune function, and skin health. Although present in moderate amounts, it enhances the plant's potential role in promoting general well-being. Carotenoids, precursors to vitamin A, exhibit antioxidant activity and contribute to reducing oxidative stress (Prashant *et al*., 2021). Despite their low concentration, their presence adds value to the plant's overall nutritional and medicinal profile. The fat-soluble vitamin profile of *Scoparia dulcis* ethanol leaf extract highlights its potential as a medicinal plant with applications in promoting bone health, antioxidant defense, and immune function. While calciferol dominates the profile, tocopherol, retinol, and carotenoids contribute additional benefits. Comparisons with other plant sources reveal that *Scoparia dulcis* offers a unique composition, particularly as a potential source of Vitamin D.

Cardiac glycoside was found in higher concentration of 17.24 µg/mL. Cardiac glycosides are known for their therapeutic effects on heart-related diseases. The high concentration in this extract suggests potential cardiotonic properties. Studies by Lahlou (2017) highlight similar findings in plants with high glycoside content, linking them to antiarrhythmic activity and heart muscle fortification. Naringin was detected in higher concentration of 17.09 µg/mL. Naringin, a flavonoid glycoside, is recognized for its antioxidant and anti-inflammatory properties. Compared with citrus-derived naringin studied by Al-Dhabi *et al.* (2017), the *Scoparia dulcis* extract shows comparable concentrations, emphasizing its potential in reducing oxidative stress. Ribalinidine was also detected in higher concentration of 16.79 µg/mL. The presence of ribalinidine, though less explored, points to possible anti-inflammatory and analgesic properties, as observed in other alkaloid-rich extracts. It aligns with findings in *Strychnos potatorum* extracts studied by Kishore *et al*. (2015), which reported alkaloids with similar retention times in HPLC analysis. Phytate was detected in higher concentration of 15.58 µg/ml. Phytates have been noted for their role as antioxidant agents and in mineral chelation. Compared to cereals and legumes (e.g., soybean studies by Reddy *et al.* (2018), the phytate content in *Scoparia dulcis* is significant, suggesting its potential in bone health and reducing mineral deficiencies.

Epicatechin was detected in higher concentration of 14.38 µg/mL. A potent antioxidant, epicatechin has been linked to improved vascular health and neuroprotection. Its concentration is comparable to cocoa and green tea, where epicatechin is a major bioactive compound (Fraga *et al.*, 2019). Flavone was detected in lower concentration of 6.22 ppm. Flavones are less concentrated but critical for anti-inflammatory and anticancer activities. Studies on parsley and celery (Kooti *et al*., 2017) report higher flavone content, suggesting *Scoparia dulcis* could be supplemented by flavone-rich sources in herbal formulations. Proanthocyanidin was also detected in lower concentration of 9.49 ppm. Found in grape seed extracts and noted for antioxidant capacity, the lower concentration in *Scoparia dulcis* contrasts with the higher levels in berries and teas (Bagchi *et al*., 2017). This might limit its standalone efficacy but contributes synergistically to the antioxidant profile of the extract. Resveratrol was detected in lower concentration of 15.22 ppm. Resveratrol, popular for cardioprotective and anti-aging effects, is present in moderate amounts. Comparatively, red wine and grape skin extracts (Li *et al.*, 2020)

exhibit significantly higher concentrations, suggesting *Scoparia dulcis* as a supplemental rather than primary source.

Flavanones were also detected in lower concentrations of 18.99 ppm. These compounds are prominent in citrus fruits (e.g., orange and grapefruit). The concentration in *Scoparia dulcis* aligns with studies showing flavanones' anti-inflammatory and immune-modulating potential (González-Molina *et al.,* 2010). Steroid was detected in lower concentration of 21.49 ppm. Plant-derived steroids have applications in managing inflammation and promoting anabolic activities. The steroid content in *Scoparia dulcis* parallels findings in *Withania somnifera,* another plant known for adaptogenic properties (Dar *et al.,* 2015).

The compound diversity in *Scoparia dulci*s is comparable to *Moringa oleifera* and *Azadirachta indica,* both noted for similar phytochemical richness (Singh *et al*., 2020). However, the abundance of cardiac glycosides and naringin in this extract sets it apart. The retention times for key compounds in *Scoparia dulcis* align with other HPLC profiles of polyphenolic-rich plants like *Camellia sinensis* (green tea), emphasizing the accuracy and reliability of the analysis methodology. The combination of flavonoids, tannins, and glycosides positions this extract as a multi-functional candidate for pharmacological applications. Its moderate concentrations of proanthocyanidins and resveratrol suggest potential for synergy with other plant extracts.

Alpha-amylase is a key enzyme involved in the breakdown of starch into glucose, and its inhibition can moderate postprandial blood glucose levels, making it a vital target in diabetes management. The α-amylase inhibitory activity of *Scoparia dulcis* ethanol leaf extract demonstrates its potential role in managing diabetes through enzyme regulation. The experiment assessed the inhibitory activity of *Scoparia dulcis* ethanol leaf extract against α-amylase at varying concentrations (5 mg/mL, 10 mg/mL, 50 mg/mL, and 100 mg/mL). The results are summarized as follows: at 5 mg/mL: 47.876% inhibition , 10 mg/mL: 52.323% inhibition, 50 mg/mL: 55.274% inhibition, 100 mg/mL: 69.425% inhibition. These findings indicate a dose-dependent increase in alpha-amylase inhibitory activity, with higher concentrations exhibiting greater inhibitory effects. The highest inhibition (69.425%) was recorded at 100 mg/mL, suggesting that the extract contains active compounds capable of interacting with and inhibiting α-amylase activity. The α-amylase inhibitory activity of *Scoparia dulcis* ethanol leaf extract demonstrates its potential as an antidiabetic agent. While its inhibitory activity is moderate compared to certain other medicinal plants, its dose-dependent response and presence of bioactive compounds make it a promising candidate for managing postprandial hyperglycemia. Further research into its mechanisms, bioavailability, and synergistic effects could enhance its application in diabetes care.

The α-glucosidase inhibitory activity of *Scoparia dulcis* extract is dose-dependent, with higher concentrations showing greater inhibition. The results are as follows: 5 mg/mL: 39.88% inhibition, 10 mg/mL: 45.13% inhibition, 50 mg/mL: 56.09% inhibition, 100 mg/mL: 59.64% inhibition. The maximum inhibition (59.64%) was observed at 100 mg/mL, indicating that the extract possesses moderate α-glucosidase inhibitory activity. The α-glucosidase inhibitory activity of *Scoparia dulcis* ethanol leaf extract demonstrates its moderate antidiabetic potential, with a maximum inhibition of 59.64% at 100 mg/mL. While it is less potent compared to some other medicinal plants, its activity is significant and supports its traditional use in managing diabetes. The presence of bioactive compounds such as flavonoids and phenolics likely underpins its inhibitory effects. Further research into its mechanisms, bioavailability, and potential synergy with other therapies could pave the way for its use as a natural, complementary treatment for diabetes. Overall, this study's findings are consistent with other research on *Scoparia dulcis* that supports its medicinal uses.

V. Conclusion

In conclusion, the ethanol leaf extract of *Scoparia dulcis* demonstrates a diverse array of bioactive compounds and moderate levels of essential vitamins, supporting its traditional medicinal uses. The high concentrations of cardiac glycosides, naringin, and ribalinidine highlight its potential for cardiotonic, antioxidant, and anti-inflammatory applications. Moderate levels of fat-soluble vitamins and inhibitory activity against α-amylase and α-glucosidase further indicate its potential in managing bone health and diabetes. Although not a primary source of certain vitamins or bioactives, its synergistic profile positions it as a valuable complementary agent in pharmacological and dietary applications. Further studies could enhance its therapeutic utility and integration into natural medicine.

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