Preparation Of Antihyperglycemic Capsule by Using Inflorescence of *Musa Paradisiaca*

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***Abstract*—India is the world's largest producer of banana with 13.90 million tons followed by Uganda (10.14 million tons). Banana blossom also known as banana heart, is a fleshy, purple-skinned flower shaped like tear, which grows at the end of banana fruit cluster. Banana blossom (*inflorescence*) is a rich source of nutrients and antioxidants which have several health benefits. The banana (*Musa paradisiaca*) grows best in humid tropical environment with an optimum temperature 27°C during the day and minimum temperature is not below 13°C. Flower of banana plant (*Musa paradisiaca*) is often consumed as a vegetable in many Asia countries such as Shri Lanka, Malayasia, Indonesia and Philippines.**

Banana flowers contain flavonoids, tannins, phenolic compounds which improve insulin secretion, reduce intestinal glucose absorption, and provide antioxidant protection to pancreatic cells.

***Index Terms*—*Musa paradisiaca*, Inflorescence, Insulin secretion, Diabetes, Antihyperglycemic activity, Banana plant, Pancreatic secretion, Banana flower.**

I. INTRODUCTION

The banana plant is belonging to the genus, Musa is technically the world's largest herbaceous plant, not a tree. Native to tropical Southeast Asia and Australia. Today Tamil Nadu ranks first in banana cultivation with a production area of 118.04 hectors in the crop year 2013-14. The byproduct of banana cultivation is estimated at about 220 tons of plant mass per hector. Flower of *Musa paradisiaca* is often consumed as a vegetable in many countries.

It is generally rich in fiber, proteins, multivitamins, A, C, and E. Banana flowers have tremendous nutritional value. Banana flower (*Musa paradisiaca*) is traditionally used for managing diabetes due to this its bioactive compounds such as flavonoids, tannins, and phenolics. This study focuses on the extraction, formulation, and evaluation of antidiabetic capsules containing extract of inflorescence of *Musa paradisiaca*. The prepared capsule evaluated for the physiochemical properties, drug release and antihyperglycemic activity.

Diabetes mellitus is a chronic metabolic disorder characterized by hyperglycemia. Herbal medicines are gaining importance due to less side effect. *Musa paradisiaca* has potential in reducing blood sugar level. The sedentary lifestyle and improper diet have accounted for the disease reaching an epidemic proportion over the past decades and on these lines, the International Diabetes Federation (IDF) predict an average of 592 million diabetic patients by 2035. Diabetes is characterized by persistent hyperglycemia due to the defects in insulin secretion, insulin action, or both. Standard antihyperglycemic drug such as acarbose, miglitol, and voglibose mainly target the activity of α-glucosidase and α-amylase enzymes, which are primary enzymes of the carbohydrate metabolism.

Chemistry:

The chemistry of the banana inflorescence has yet to be extensively explored but it is acknowledged that its proximate composition and profiles of other nutritional contents, such as fatty acids, amino acids, vitamins and minerals are routinely being analysed. Existing data seem to suggest that the banana inflorescence is a good source of nutrients, similar to the pulp. From the phytochemical perspective, progress is being made to elucidate the bioactive compounds in the banana inflorescence

Functional properties of the banana inflorescence:

While ethnobotanical knowledge serves as the reference for the possible use of many plants, including edible crops like bananas, scientific validation of these claimed medicinal properties, which are mainly based on traditional practices, is still needed. Overall, the banana inflorescence has been

shown to exhibit various biological activities which might be indicative of its potential health-promoting properties. In particular, the antioxidant and anti-diabetic activities of the banana

- Antidiabetic Potential:

Inhibits the activity of certain enzymes involved in carbohydrate digestion. Its high soluble and insoluble fiber content improves glucose tolerance and stimulates insulin uptake, thereby lowering blood sugar spikes.

- High Dietary Fiber:

Rich in both soluble and insoluble dietary fibers. The fibrous network boasts high water-holding and swelling capacities, which promote gastrointestinal health, aid digestion, and prevent constipation.

- Hypoglycemic Action:

Studies show it reduces postprandial blood glucose and holds a high Glucose Dialysis Retardation Index (GDRI), meaning it can slow down sugar absorption in the gut.

- Mineral Rich:

Provides a well-balanced macro and -Banana flowers are rich in soluble and non-soluble fibers, which help you feel full for a longer time and prevent constipation and other digestive problems. These fibers improve healthy gut microbes and reduce the risk of gut cancer. They also lower blood sugar levels and decrease the risk of type-2 diabetes.

Scope and approach

The present review systematically summarises the nutritional attributes, bioactive components and potential health-promoting properties of the inflorescence of the banana plant for the first time.

- Health Benefits:

Ethnopharmacological and clinical studies indicate the inflorescence has anti-allergic, antimicrobial, anti-inflammatory, and anti-carcinogenic properties.

- Therapeutic Use:

Its extracts are being studied to help regulate blood sugar levels, heal wounds, and alleviate menstrual issues

II. PHARMACOGNOSTIC ACCOUNT OF *MUSA PARADISIACA*

Musa paradisiaca is an evergreen, flowering, erect, herbaceous, fleshy, succulent, pseudo stem consisting of overlapping leaf sheath.

The pharmacogenetic account of *Musa paradisiaca* is as follows:

1. Synonym: Keliche phool
kadali

2. Biological name: Musa paradisiaca
Musa cavendish
Musa sapientum

3. Geographical source/ Origin:
It is mainly originated from Southeast Asia and Australia.
It is grown in several parts of Maharashtra.

4. Scientific classification:
- Kingdom: Plantae
- Division: Magnoliophyta
- Class: Liliopsida
- Order: Zingiberales
- Family: Musaceae
- Genus: Musa
- Species: paradisiaca

5. Macroscopic characters:
- Shape: Large, conical or spindle-shaped
- Color: Outer bracts deep purple, inner part red in color
- Size: 10-30 cm long
- Surface: Smooth, waxy bracts
- Odor: Slight, characteristic
- Taste: Slightly bitter and astringent

6. Microscopic character:
Transverse section (T.S) shows-
- Epidermis: single layered with cuticle
- Parenchyma cells: Thin-walled containing starch grains
- Vascular bundles: Scattered (typical monocot feature)
- Fibers: Lignified supporting tissue
- Calcium oxalate crystal

7. Chemical constituents:
Flower of banana (*inflorescence*) contains various chemicals like- Flavonoid, tannins, phenolic compounds, saponins, reducing sugars, non-reducing sugars, sterols, triterpenes, and oxalates.

8. Identification tests:
Chemical tests
a. Ferric chloride test - Phenolics (blue/green color)
b. Shinoda test: Flavonoids (pink/red color)
c. Foam test- Saponins
d. Lead acetate test- tannins

9. Standardization parameters:
1. Physicochemical parameters:
- Moisture content
- Total ash value
- Acid-insoluble ash
- Water-soluble extractive value
- Alcohol-soluble extractive value

2. Chromatographic analysis:
- TLC/HPTLC for marker compounds (e.g., quercetin)

10. Uses:
- Balancing hormones
- Promoting digestive health
- Supporting blood sugar management
- Anti-diabetic activity


Banana Flower

III. PREPATION OF BANANA FLOWER EXTRACT

Preparation of banana flower extract consist of different processes-
1. Collection and pre-treatment: Mature banana flowers are collected, the bracts are removed, and the white florets are washed.
2. Drying: The florets are dried in a hot air oven at a controlled temperature (preferably 40°C to 50°C) for 5-6 hours to prevent nutrient loss and browning.
3. Grinding: The dried flowers are ground into a fine, homogenous powder.
4. Lubrication: Add magnesium stearate and talc, mix gently to avoid over-lubrication.
5. Encapsulation: The formulated granules or powder blend are filled into hard gelatin capsule using a capsule filling machine.
6. Standardization: The capsule contain should be standardized to a specific concentration of active compound, such as phenolic content (using the foline-
ciocalteau method).

KEY BIOACTIVE COMPOUNDS:
1. Active ingredient:
Ethanol extract of banana flower is rich in umbelliferone (C1) and lupeol (C2), which demonstrate significant antihyperglycemic effects.

2. Antidiabetic mechanism:
The extract inhibits intestinal α-glucosidase and Pancreatic amylase, preventing rapid starch digestion and lowering post prandial blood glucose levels.

3. Antioxidant activity:
The extract also prevents protein glycation and inhibit the aldose reductase, which helps reduce diabetic related complications.

IV. REVIEW LITERATURE

1. Herbal Antidiabetic Plants and Their Importance:
A review by researchers in A Review: Antihyperglycemic Plant Medicines in Management of Diabetes reported that more than 35 medicinal plants possess significant antihyperglycemic activity. These plants act by enhancing insulin secretion,

improving glucose uptake, reducing oxidative stress, and inhibiting carbohydrate-digesting enzymes.

2. Polyherbal Formulations for Diabetes Management:
Recent studies have emphasized the effectiveness of polyherbal formulations. A comprehensive review published in Protoplasma (2025) reported that combinations of medicinal plants exhibit synergistic antihyperglycemic effects by improving insulin sensitivity, regulating glucose metabolism, and reducing inflammation and oxidative stress.

3. Role of Medicinal Plants in Diabetes:
Researchers reviewing 81 medicinal plants with antidiabetic properties found that phytoconstituents such as flavonoids, phenolics, alkaloids, and glycosides contribute significantly to blood glucose regulation. These compounds also provide antioxidant protection against diabetic complications.

4. Phytotherapy and Antihyperglycemic Mechanisms:
A review on phytotherapy for diabetes management reported that herbal extracts exert antihyperglycemic effects through:
- ✓ Inhibition of α-glucosidase and α-amylase enzymes.
- ✓ Enhancement of GLUT-4 expression.
- ✓ Activation of PPAR receptors.
- ✓ Antioxidant and anti-inflammatory activities.

V. AIM AND OBJECTIVE

AIM:
To formulate and evaluate antihyperglycemic capsules containing medicinal plant inflorescence extract and assess their potential for blood glucose reduction

OBJECTIVE:
- ✓ To collect and authenticate selected medicinal plant inflorescences.
- ✓ To prepare and standardize the inflorescence extract.
- ✓ To formulate herbal antihyperglycemic capsules using the dried extract.
- ✓ To evaluate physical parameters such as capsule weight variation, disintegration time, and drug content.
- ✓ To investigate antihyperglycemic activity through suitable in-vitro or in-vivo studies.
- ✓ To assess the stability and safety of the formulated capsules.

VI. MATERIALS AND METHODS

- Plant material:

Flowers were separated from the inflorescence and the spathe was discarded. The isolated flowers were cleaned, cut into small pieces and dried at 40°C in an oven. This was powdered using a homogenizer and further stored at 4°C until use.

- Preparation of extract and isolation of active compounds:

The coarse powder was subjected to hot solvent extraction using ethanol in a Soxhlet apparatus. The extraction was performed twice with ethanol (500 ml) followed by filtration. The filtrate thus obtained was concentrated *in vacuo* using rotary evaporator (Rotavapor R-200, Buchi, Switzerland). The active compounds present in the ethanol extract of banana flower (EF) were identified as Umbelliferone (C1) and Lupeol (C2) using various spectroscopic methods *via* successive solvent extraction followed by repeated silica gel column chromatography.

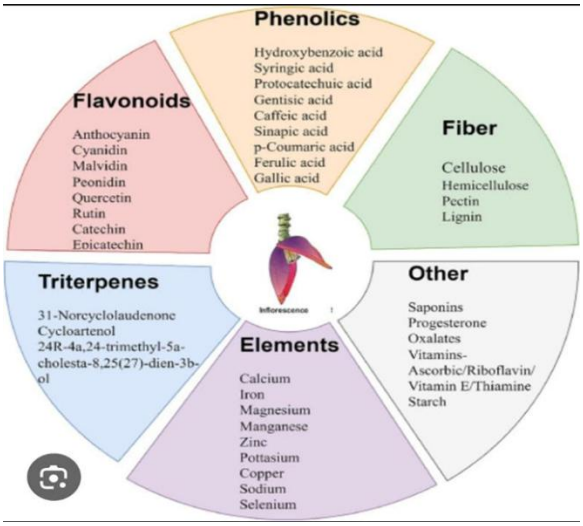


Fig: Chemical constituents of Musa paradisiaca

VII. MECHANISM OF ACTION

Banana flower (inflorescence) extract exhibits anti-diabetic effects by inhibiting carbohydrate digesting enzymes, reducing oxidative stress, and mimicking insulin actions to improve glucose uptake and utilization in the body.

Steps involved in mechanism of action-
1. Inhibition of digestive enzymes (lowers postprandial glucose):

The extract contains bioactive flavonoids and phenolic compounds (like Umbelliferone and lupeol) that inhibit enzymes such as α-glucosidase and pancreatic α-amylase. By slowing the breakdown of complex carbohydrate into simple sugar moiety.

2. Increased insulin secretion and receptor activity:
In-vivo and in-vitro studies shows that the extract can stimulate remnant pancreatic β-cells to secrete insulin. They stimulate the remaining β-cells in the pancreas to secrete more insulin.

3. Increased glucose uptake and utilization:
The extract promotes glucose absorption into skeletal muscle tissue (such as C2C12) by stimulating glucose transport mechanism. This improved peripheral glucose utilization helps lower overall blood glucose concentration.

4. Antioxidant effects and protection against complications:
Diabetes is often accompanied by high levels of free radicles, which causes cellular damage and complications like kidney disfunction. Banana flower extract exhibits strong antioxidant properties and inhibit the formation of Advanced Glycation End-product (AGEs).

5. Insulin-Mimetic activity and Signaling:
- Insulin secretion:

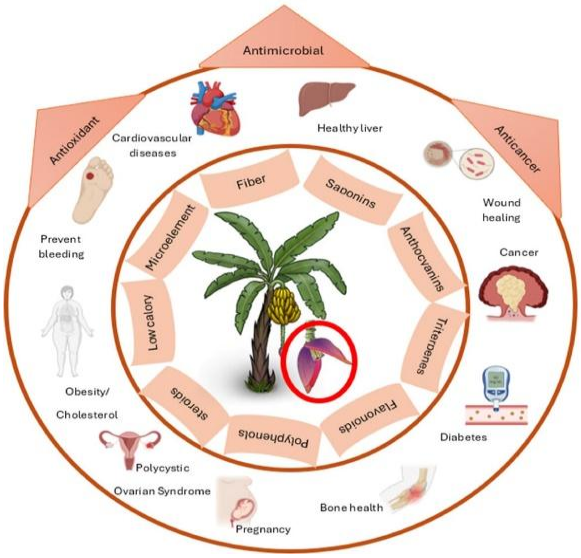
Studies show the extract can stimulate remnant pancreatic beta-cells to secrete insulin.

- Receptor Activation:

Molecular docking studies reveal that flavonoids within the extract act as potential activators of the insulin receptor tyrosine kinase, thereby facilitating the crucial autophosphorylation steps needed for insulin signaling.

- Glucose Translocation:

The extract has been shown to include the translocation and activation of glucose transporters (like GLUT4), encouraging glucose uptake into skeletal muscle and adipose tissues.
Antidiabetic drug manage blood glucose levels in diabetic mellitus. They work by distinct mechanism like stimulating insulin secretion, reducing hepatic glucose production, enhancing peripheral tissue sensitivity to insulin, blocking carbohydrate absorption.



INFLORESCENCE OF *MUSA PARADISIACA*

VIII. PROCEDURE FOR PREPARATING CAPSULES FROM INFLORESCENCE EXTRACT OF MUSA PARADISIACA

Banana flower (banana blossom) contains flavonoids, tannins, phenolics, dietary fiber, and antioxidant that may show anti-diabetic, anti-inflammatory, and antioxidant activity. The following is a sample pharmaceutical procedure for preparing banana flower extract capsules.

1. Collection and authentication:
- Collect fresh banana flowers from healthy banana plants,
- Wash thoroughly with clean water to remove dirt.

- Authenticate the plant material by a pharmacognosy expert to Herbarium.

2. Drying of banana flower method:
- Remove the outer bracts and separate edible florets.
- Cut into small pieces.
- Dry under shade for 5-7 days or use a hot air oven at 40-45℃.
- Continue drying until moisture is minimized.

3. Pulverization:
- Griend the dried banana flower using a grinder.
- Pass through sieve no.40 to obtain uniform powder.
- Store in an airtight container.

4. Extraction process: Soxhlet extraction is involved in the extraction of
Banana flower.

Soxhlet Extraction:
Soxhlet extraction of banana flowers is a hot, continuous solid-liquid extraction method used to isolate bioactive compounds (like phenolics and flavonoids). It involves drying and grinding the flower, continuously refluxing it with a solvent (usually methanol or ethanol), and evaporating the solvent to yield a concentrated tube extract.

Sample preparation:
a) Cleaning: Collect fresh banana blossoms remove the tough outer bract, and clean the edible inner florets thoroughly.
b) Drying: Cut the florets into small pieces and dry them in an oven at a controlled temperature (typically 40℃-50℃) for 2-3 days until they are completely moisture free.
c) Grinding: Grind the dried pieces into a fine, homogenous powder using a mechanical grinder or mortar and pestle. Sieve the powder to a uniform particle size (e.g., 50µm) and store it in an air tight container at 4℃.

- Extraction Setup:
a) Packing the thimble: weigh a precise amount of the dried banana flower powder (often about 5g-10g) and pack it securely into a cellulose or porous thimble. Place the thimble inside the main extraction chamber of the Soxhlet apparatus.
b) Adding solvent: Pour the chosen extraction solvent (commonly 95% ethanol or methanol) into a clean, pre-weighed round-bottom flask. Typically, about 250ml -300ml of solvent is used for 5g of powder.
c) Apparatus assembly: Attach the extraction chamber to the round bottom flask, and connect a condenser to the top of the chamber to cool the solvent vapors.

- Extraction Process:
a) Heating: Place the round-bottom flask on a heating mantle or an oil bath. Adjust the temperature according to the boiling point of your solvent (e.g., 65-70℃ for methanol/ethanol).
b) Refluxing: As the solvent boils, the vapors rise up through the side arm of the Soxhlet extractor, enter the condenser, and drip as a condensed liquid onto the sample in the thimble.
c) Siphoning: The solvent slowly feels the extraction chamber until it reaches the top of the siphon arm. At this point, the liquid is automatically siphoned back into the round-bottom flask, carrying the extracted bioactive compounds with it.
d) Cycles: Allow the continuous cycle to repeat for approximately 4-8 hours (or 6-7 cycles), depending on the specific target compounds you are analyzing.

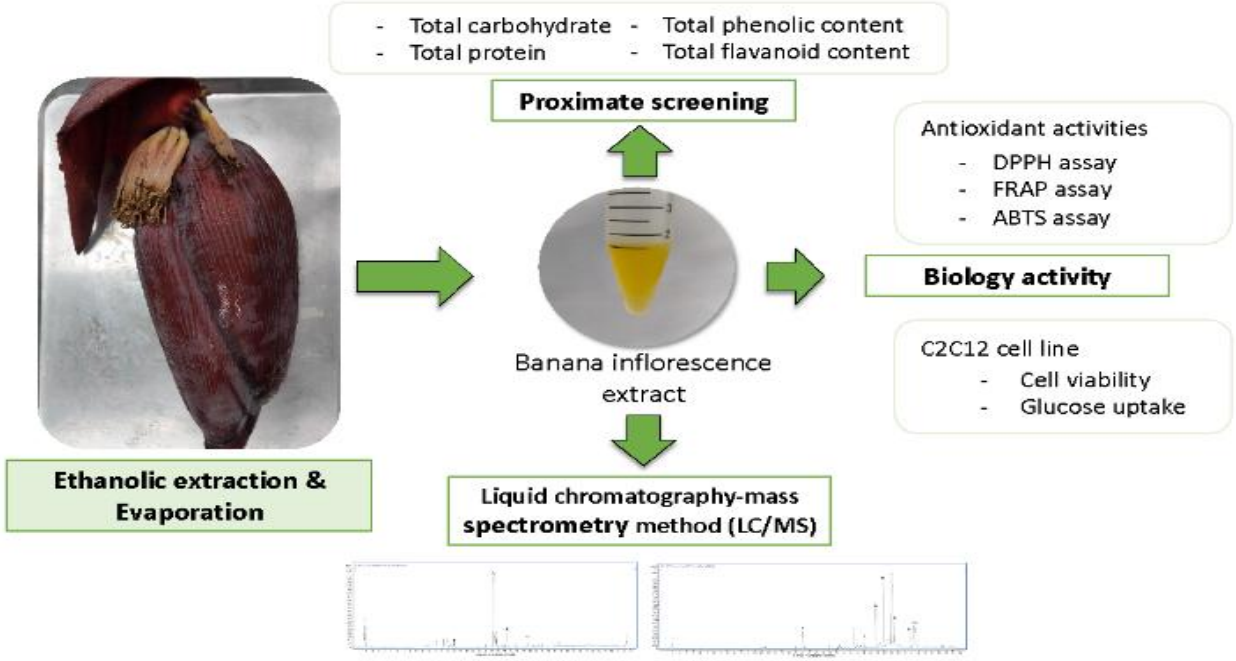
- Recovery and Concentration:
a) Solvent removal: Once the extraction cycles are complete, allow the system to cool. Remove the sample thimble.
b) Evaporation: Transfer the solvent mixture from the round-bottom flask to a rotary evaporator (rotovap) operating under reduced pressure. This safely evaporates the solvent without degrading heat sensitive compounds.
c) Final yield: Once all the solvent is removed, a thick, crude viscous extract will remain in the flask. Then calculate the extraction yield and store the extract in an airtight, amber-colored container in a refrigerator.

Formula:
Annual yield (%): Total mass of dried extract product
Total mass of raw material

- Calculation:
a) Mass of raw material: Weigh the total amount of raw material (e.g., plant matter, ore, or beans) introduced into the extraction process over the year.

b) Mass of dried extract: After extracting and completely removing the solvent (e.g., via lyophilization or a rotary evaporator), weigh the final dried extract.

c) Calculate: Divide the final extract weight by the raw material weight and multiply by 100 to get annual extraction percentage yield.



5.Preparation of Capsule Blend:

Example formula: (FOR SINGLE CAPSULE)

INGREDIENTS	QUANTITY
Banana flower extract	250 mg
Starch	20 mg
Talc	5 mg
Magnesium stearate	5 mg
Microcrystalline cellulose	120 mg
TOTAL	400 mg

6.Capsule filling:

- Select appropriate capsule size (usually size 0 or 00)
- Fill powder blend into empty hard gelatin capsule manually or using capsule filling machine.
- Lock capsule properly.

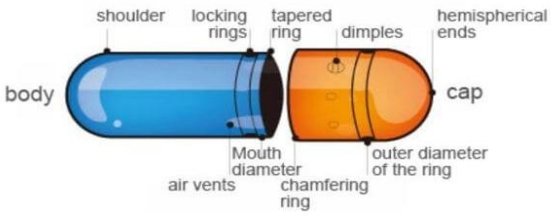
7.Evaluation Parameters:

A. Evaluation parameters for powder blend:

- Bulk Density
- Tap density
- Angle of repose
- Carr's Index
- Hausner's Ratio
- Particle size and distribution
- Cohesivity and surface morphology
- Loss on drying/ moisture content
- Content uniformity

B. Evaluation parameters for capsule:

- Weight variation
- Disintegration time
- Drug content
- In-vitro drug release
- Stability studies
- Dissolution rate
- Moisture permeation test
- Shell strength and Thickness
- Microbial limit test



IX. IN VITRO GLUCOSE UPTAKE ASSAY

Glucose uptake by rat hemi-diaphragm was determined according to the method described by Prashantha *et al*. with slight modifications. After sacrificing male Wistar albino rats (220 g) under ether anaesthesia, the diaphragms were detached expeditiously with minimal trauma and divided into two equal halves. The resulting hemi-diaphragms were rinsed with cold glucose free Tyrode solution to wash the blood clots and swiftly transferred to the six well microlitre plates (5 ml capacity, n=3). Furthermore, these were grouped as follows, Group 1 (control): 2 ml of Tyrode solution with 2% glucose; Group 2 (insulin treated): 2 ml of Tyrode solution with 2% glucose + 100 µl of regular insulin (0.4 U/ml, Biocon Ltd.,); Group 3 to 8: 2 ml of Tyrode solution with 2% glucose + 50 and 100 µg/ml of EF, C1 and C2; Group 9 to 14: 2 ml of Tyrode solution with 2% glucose + 50 and 100 µg/ml of EF, C1 and C2 + 100 µl of regular insulin. The initial glucose concentration was estimated by glucose oxidase method by addition of distilled water with the final volume of 4 ml. The plates were further incubated at 37°C for 30 minutes with continuous shaking at 60 cycles per minute. Following the incubation, glucose uptake per gram of tissue was estimated as the difference between the initial and final glucose content in the incubated wells.

Table no 1: α- Amylase and α- Glucosidase activity of selected samples:

Extract standard	*In vitro* model	
	α-amylase	α-amylase
Seed Methanolic extract	121 ± 0.40	101 ± 0.53
Peel Methanolic extract	171 ± 0.53	142±0.62
Flower Methanolic extract	214 ± 0.51	187± 0.71
Acarbose	53 ± 1.1	49 ±0.59

Assays:
1.Phenolic content assay
2.Flavonoid content assay
3.α-amylase assay
4.FRAP assay

Graphical abstract:

X. RESULT

Studies oninflorescence extracts demonstrated does dependent reductions in blood glucose levels and improved glucose utilization compared with diabetic controls

PHYSICAL EVALAUATION

SR. NO	PARAMETER	OBSEVATION
1	Capsule appearance	Uniform and intact
2	Weight variation	Within pharmacopoeial limit
3	Disintegration time	10-15 min
4	Drug content 9	95-99%
5	Flow properties	Good

ANTIHYPERGLYCEMIC ACTIVITY:

SR.NO	PARAMETER	BEFORE TREATMENT	AFTER TREATMENT
1	BLOOD GLUCOSE LEVEL	ELEVATED	SIGNIFICANTLY
2	GLUCOSE TOLERANCE	POOR	IMPROVED
3	OXIDATIVE STRESS	HIGH	REDUCED

XI. FUTURE PERSPECTIVES:

Based on previous scientific reports on the biological activities of the banana inflorescence, there is indeed great potential for it to be utilised as an alternative ingredient in the pharmaceutical and nutraceutical industries. Its application as a preventive agent against oxidative stress, diabetes, cancer and microbial infections should be further studied. Even though promising findings have been obtained from the *in vitro* and *in vivo* studies, they are still at a rather preliminary stage

- Advanced Glycation End-product (AGE) Inhibition: It prevents protein glycation and reduces oxidative stress, which helps lower the risk of secondary diabetic complications like neuropathy and retinopathy.

- Insulin Secretion and Glucose Uptake: *In vitro* and *in vivo* studies suggest that the extract stimulates peripheral tissue glucose uptake and enhances insulin sensitivity.

XII. DISCUSSION:

Diabetes is intricately associated with several microvascular and cardiovascular complications, which are caused due to persistent hyperglycaemic state. Impaired insulin and glucagon secretion along with the abnormalities in the glucose uptake in liver and peripheral tissues, as well as the hepatic glucose production contributes greatly to the elevation in the plasma glucose levels in diabetic patients. One of the prime means of inducing antihyperglycemia is by inhibiting the key enzyme, α-glucosidases, which catalyses the final step of carbohydrate metabolism. This enzyme located in the brush-border surface of the intestinal cells greatly contributes to the postprandial plasma glucose concentration, thereby inducing a hyperglycaemic state. A potent antihyperglycemic agent inhibits the activity of α-glucosidases thereby prolonging the duration of carbohydrate absorption and lowering plasma glucose levels. In the present study, we have evaluated the inhibitory potential of EF against the activities of maltase, sucrase and PNPG hydrolysis of rat intestinal epithelium. The results suggest a dose dependent inhibition exerted by EF at microgram concentrations, with the efficiency better than the standard drug acarbose. The nature of inhibition as inferred by the kinetics demonstrated a reversible, non-competitive mode of inhibition for sucrase, maltase and PNPG hydrolysis with lower Ki values. From the studies, it can be substantiated that EF binds to a site other than the active site of the enzyme, thereby retarding the enzyme substrate reaction, without competing with the substrate for the active site of the enzyme. Likewise, the mode of inhibition being reversible, the stability of the enzyme is also not affected by its inhibition. This is advantageous over the irreversible type since; it would then lead to hypoglycaemic state due to a permanent carbohydrate malabsorption.

The *in vitro* studies provided a basis for further *in vivo* studies to evaluate the effects of EF on postprandial hyperglycaemia associated with carbohydrate challenge in normal and diabetic rat models. In normal rats, the effect of EF was evaluated after monosaccharide and disaccharide load, by administering glucose and maltose, respectively. The postprandial plasma glucose levels (of rats fed with 3 g/kg of maltose and glucose)

Total carbohydrate, total protein, total phenolic, and flavonoid contents of the banana inflorescence extract. The value is shown as an average + S.D. (n = 3) 0.

Component	Amount
Total carbohydrate (g/100g extract)	38.53 ± 3.00
Total phenolic (mg GAE/g extract)	8.06 ± 0.70
Total flavonoid (mg QE/g extract)	4.79 ± 0.07

The major circulating glucose is utilized by the peripheral tissues by means of glucose uptake. The prime site for glucose uptake and insulin action is the

skeletal muscle, which represents about 30-40% of the total body weight. In our study, we have evaluated the glucose uptake using rat hemi-diaphragm, which is a reliable representative of the peripheral glucose uptake by the skeletal muscle cells. The findings confirm that its constituents C1 and C2 possess insulin-like properties as implied by the enhancement in the glucose uptake after its treatment and thus suggest that EF, C1 and C2 have some peripheral role either alone or together with insulin, which promotes glucose uptake in the muscle cells.

Therefore, it is highly likely that those phenolic acids might stimulate glucose uptake in those cells and could be the active compounds. Despite the findings, both studies have not performed the experiment to confirm that those phenolic acids were the bona fide anti-diabetic compounds in their extracts.

XIII. CONCLUSION

In conclusion, the ethanolic extract of banana inflorescence from *Musa paradisiaca* contains several phytochemicals including carbohydrate, protein, phenolic, flavonoid contents, and antioxidant activities. The phytochemical profiling of the LC/MS technique also showed that the extract found several compounds. Moreover, the extracts dose- and time dependently stimulated glucose uptake in the C2C12 myotubes cell line. These results suggest that the crude ethanolic extract possesses the antioxidant and antidiabetic activities. Identification of anti-diabetic component of the extract is of interest and will be investigated in future experimentations.

The study has illustrated the methanolic extract of *Musa paradisiaca* colla seed and flowers possess antidiabetic activity. The *Musa paradisiaca* colla seed and flower has antidiabetic potential resulting in lower blood glucose level after 8th day which could be due to its inhibitory potential on α-amylase and α-glucosidase enzymes. Thus, further investigations are required to establish its other therapeutic potential of different parts of the plant. Thus, the findings of the present study are noteworthy in designing potential drug attributes as well as novel dietary resources from banana flower for diabetes management.

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