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Research Article

EFFECT OF COSTUS IGNEUS TEA ON FASTING BLOOD GLUCOSE IN OLDER ADULTS WITH TYPE 2 DIABETES

Rosmin Ilham[1,*], Rona Febriyona[1], Fifi Ishak[1]

[1] Nursing Study Program, Universitas Muhammadiyah Gorontalo, Gorontalo, Indonesia
Corresponding author email: rosminilham4@gmail.com

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Abstract
Type 2 diabetes mellitus (T2DM) constitutes a major global health burden among older adults, necessitating exploration of adjunctive therapeutic strategies. Costus igneus, commonly known as the insulin plant, contains bioactive compounds, including corosolic acid and diosgenin, which have demonstrated hypoglycemic effects by enhancing insulin sensitivity and glucose uptake in preclinical studies. This study evaluated the effects of Costus igneus tea consumption on fasting blood glucose (FBG) levels in older adults with T2DM. A community-based quasi-experimental pretest-posttest control group study was conducted in Gorontalo, Indonesia. A total of 156 older adults (≥60 years) with T2DM were assigned to an intervention group (n=78), receiving Costus igneus tea twice daily for 30 days alongside standard antidiabetic medication, and a control group (n=78) receiving standard medication alone. FBG was measured at baseline, day 15, and day 30. Data were analyzed using paired t-tests, independent t-tests, and repeated-measures ANOVA. The intervention group demonstrated a significant reduction in FBG from 198.37±32.45 to 156.21±28.73 mg/dL ($p<0.001$; 21.3% decrease), with a significant time×group interaction ($F=24.67$, $p<0.001$). Costus igneus tea may serve as a complementary intervention for glycemic management; however, the quasi-experimental design limits causal inference and warrants confirmation through randomized controlled trials.

Keywords: Costus Igneus, Fasting Blood Glucose, Herbal Tea, Older Adults, Type 2 Diabetes Mellitus.

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INTRODUCTION

Type 2 diabetes mellitus (T2DM) is a chronic metabolic disorder characterized by persistent hyperglycemia resulting from progressive loss of β-cell insulin secretion frequently on the background of insulin resistance (Młynarska et al., 2025). The global prevalence of T2DM has reached epidemic proportions, with approximately 536.6 million adults affected in 2021 and projections estimating 783.2 million by 2045 (Sun et al., 2022). T2DM accounts for approximately 90% of all diabetes cases worldwide and is associated with significant morbidity and mortality (Tang et al., 2025). In Indonesia, the prevalence of diabetes has been steadily increasing, posing substantial challenges to the healthcare system,

particularly in community settings where access to optimal medical care may be limited (Muharram et al., 2025).

The pathophysiology of T2DM involves a complex interplay of genetic predisposition, environmental factors, and lifestyle behaviors, including physical inactivity, unhealthy dietary patterns, and obesity (Galicia-Garcia et al., 2020). Chronic hyperglycemia in T2DM leads to long-term complications affecting the cardiovascular system, kidneys, eyes, and nervous system (Hussain, 2025). While pharmacological interventions such as metformin, sulfonylureas, and insulin remain the cornerstone of T2DM management (Gieroba et al., 2025).

Medicinal plants have been used for centuries in traditional medicine systems to manage diabetes mellitus. Approximately 800 plants have been traditionally used to manage diabetes, although only about 410 have been experimentally studied for their antidiabetic properties. This perennial plant belongs to the Costaceae family and is characterized by its spirally oriented leaves and rhizomes (Ismayil M et al., 2024). The leaves of *Costus igneus* have been widely utilized for glycemic control in traditional medicine, particularly in South and Central America, where diabetic patients consume one leaf daily to maintain low blood glucose levels (Tran et al., 2020).

The antidiabetic potential of *Costus igneus* is attributed to its rich phytochemical composition, including proteins, fibers, minerals (potassium, calcium, chromium, iron, manganese, copper, zinc), and bioactive compounds such as flavonoids and phenolic compounds (Kambale et al., 2022). These phytochemicals exert their antidiabetic effects through multiple mechanisms, including suppression of metabolic enzymes essential for carbohydrate metabolism, inhibition of α-glucosidase activity, enhancement of insulin secretion, and reduction of excessive reactive oxygen species (ROS) levels (Situmorang et al., 2025).

Despite the growing body of preclinical evidence supporting the antidiabetic properties of Costus igneus, clinical studies evaluating its effects on glycemic control in humans, particularly among older adults, remain scarce. Most existing studies have been conducted on animal models or have involved small sample sizes with limited methodological rigor. Furthermore, the specific effects of Costus igneus tea, a culturally acceptable and easily accessible beverage, on fasting blood levels in older adults with T2DM have not been investigated in community-based settings. Therefore, this study aimed to evaluate the effects of Costus igneus tea consumption on fasting blood glucose levels in older adults with T2DM in Gorontalo City, Indonesia. The findings of this study are expected to provide evidence-based support for the integration of Costus igneus tea as a complementary intervention in community-based diabetes management programs.

RESEARCH METHOD

This study employed a quasi-experimental design with a pretest-posttest control group approach. A quasi-experimental design was selected because random assignment of participants to groups was not feasible in the community setting. The study was conducted over a 30-day intervention period, with measurements taken at three time points: baseline (day 0), midpoint (day 15), and endpoint (day 30). The study was conducted in community health centers across Gorontalo City, Gorontalo Province, Indonesia, from August 2025 to March 2026. Gorontalo City was selected because of the high prevalence of T2DM among older adults and the availability of community health infrastructure for participant recruitment and monitoring. The target population comprised older adults aged ≥ 60 years who were registered at community health centers and had been diagnosed with T2DM.

Gorontalo City has a population of approximately 215,000, with an estimated T2DM prevalence of 8.2% among adults aged ≥60 years. The selected community health centers serve predominantly low-to-middle-income populations in urban and semi-urban areas, providing primary healthcare services including chronic disease management programs (*Prolanis*). Each center manages approximately 150–200 registered T2DM patients.

The sample size was calculated using the formula for comparing two group means with a significance level (α) of 0.05, power (1-β) of 0.80, and an anticipated effect size based on previous studies of herbal interventions on blood glucose levels. The calculation yielded a minimum of 64 participants per group for the study. Accounting for a potential 20% dropout rate, the final sample size was set at 78 participants per group, totaling 156. Participants were recruited using purposive sampling based on the following inclusion criteria: (1) age ≥60 years; (2) diagnosed with T2DM for at least one year based on medical records; (3) currently receiving standard oral antidiabetic medication (metformin and/or sulfonylureas); (4) fasting blood glucose ≥126 mg/dL at screening; and (5) willing to participate and

provide written informed consent. The exclusion criteria were as follows: (1) insulin-dependent diabetes; (2) severe hepatic or renal impairment; (3) known allergy to *Costus igneus* or related plants; (4) current use of other herbal supplements for diabetes management; (5) presence of acute illness or hospitalization during the study period; and (6) cognitive impairment that would preclude informed consent.

Participants were assigned to two groups based on their community health center of registration to minimize contamination between the groups. Four community health centers were selected: two were designated as intervention sites and the other two as control sites. The intervention group (n = 78) received *Costus igneus* tea supplementation in addition to their standard antidiabetic medication, whereas the control group (n = 78) continued with standard antidiabetic medication only. To minimize selection bias inherent in the quasi-experimental design, propensity score matching was employed to balance baseline characteristics between groups, including age, sex, BMI, duration of diabetes, and type of antidiabetic medication. Additionally, multivariable regression adjustment was applied in the final analysis to control for potential confounding variables. To reduce information bias, outcome assessors and laboratory personnel were blinded to group allocation. Standardized data collection protocols and instruments were used across all sites to minimize measurement bias.

Costus igneus leaves were sourced from a certified local herbal garden in Gorontalo and authenticated by a botanist at the State University of Gorontalo, Indonesia. Fresh leaves were washed, air-dried at room temperature for 48 h, and ground into a fine powder. The tea was prepared by steeping 5 g of dried *Costus igneus* leaf powder in 200 mL of hot water (80–90°C) for 10 min and then strained before consumption. Participants in the intervention group were instructed to consume one cup (200 mL) of *Costus igneus* tea twice daily—once in the morning before breakfast and once in the evening before dinner—for 30 d. The tea preparation was standardized, and pre-measured sachets of 5 g each were provided to the participants weekly to ensure consistency. The participants were trained on the proper preparation method during an initial orientation session. Compliance was monitored through daily consumption logs maintained by the participants and verified during weekly home visits by trained research assistants.

Both groups continued their prescribed oral antidiabetic medications (metformin 500–1000 mg/day and/or glibenclamide 5 mg/day), as directed by their physicians. The participants were advised to maintain their usual dietary habits and physical activity levels throughout the study period. To ensure standardization across sites, a detailed standard operating procedure (SOP) manual was developed covering participant recruitment, intervention delivery, data collection, and laboratory procedures. All research assistants (n = 8) underwent a two-day training workshop prior to data collection. Inter-rater reliability was assessed and achieved a Cohen's kappa ≥0.85. The same accredited laboratory processed all blood samples, and identical tea preparation sachets were distributed from a single production batch to ensure phytochemical consistency.

Demographic data, including age, sex, education level, duration of diabetes, body mass index (BMI), and current medications, were collected at baseline using a structured questionnaire. BMI was calculated from the measured height and weight (kg/m²). Venous blood samples were collected from the participants after an overnight fast of at least 8 h at three time points: baseline (day 0), day 15, and day 30. Blood samples were drawn from the antecubital vein by trained phlebotomists and processed at the accredited clinical laboratory of Gorontalo Provincial General Hospital. FBG levels were measured using the enzymatic hexokinase method with an automated chemistry analyzer. All laboratory procedures followed standard operating protocols, and quality control measures were implemented to ensure the accuracy and reliability of the results.

Data were analyzed using SPSS version 26.0. Descriptive statistics are presented as means ± standard deviations for continuous variables and frequencies with percentages for categorical variables. The normality of the data distribution was assessed using the Kolmogorov-Smirnov test. The homogeneity of baseline characteristics between groups was evaluated using independent t-tests for continuous variables and chi-square tests for categorical variables. Within-group changes in FBG across the three time points were analyzed using repeated-measures ANOVA with Bonferroni post-hoc correction. Between-group differences in FBG levels at each time point were assessed using independent t-tests. The interaction effect of time and group was evaluated using repeated-measures ANOVA. The magnitude of the intervention effect was quantified using Cohen's d effect size. Statistical significance was set at $p < 0.05$ for all analyses.

Ethical approval was obtained from the Health Research Ethics Committee of Muhammadiyah University of Gorontalo (approval number 075/KEPK-FIKES/VIII/2025). Written informed consent was

obtained from all participants before enrollment. Participants were informed of their right to withdraw from the study at any time without consequences to their medical care. All data were kept confidential and anonymized for the analysis. This study was conducted in accordance with the Declaration of Helsinki.

RESULTS AND DISCUSSION

Participant Characteristics

Of the 156 participants enrolled, 149 completed the study (intervention group: n = 75; control group: n = 74). Seven participants were excluded due to dropout (n = 3 in the intervention group; n = 4 in the control group) due to relocation (n = 2), hospitalization for unrelated illness (n = 3), and voluntary withdrawal (n = 2). The baseline demographic and clinical characteristics of the participants are presented in Table 1.

Table 1. Baseline Demographic and Clinical Characteristics of Participants (Independent t-test and Chi-square test)

Characteristic	Intervention Group (n = 75)	Control Group (n = 74)	p-value
Age (years), mean ± SD	65.42 ± 4.38	64.89 ± 4.72	0.478[a]
Sex, n (%)			0.712[b]
Male	32 (42.7)	34 (45.9)	
Female	43 (57.3)	40 (54.1)	
Education, n (%)			0.635[b]
Primary school	22 (29.3)	19 (25.7)	
Junior high school	18 (24.0)	21 (28.4)	
Senior high school	24 (32.0)	25 (33.8)	
Higher education	11 (14.7)	9 (12.2)	
Duration of diabetes (years), mean ± SD	6.84 ± 3.21	7.12 ± 3.45	0.601[a]
BMI (kg/m²), mean ± SD	25.63 ± 3.14	25.89 ± 3.27	0.621[a]
Antidiabetic medication, n (%)			0.548[b]
Metformin only	41 (54.7)	38 (51.4)	
Metformin + Glibenclamide	34 (45.3)	36 (48.6)	
Baseline FBG (mg/dL), mean ± SD	198.37 ± 32.45	196.82 ± 31.89	0.773[a]

[a] Independent t-test; [b] Chi-square test; SD = Standard Deviation; BMI = Body Mass Index; FBG = Fasting Blood Glucose

Table 1 demonstrates that there were no statistically significant differences between the intervention and control groups in any baseline demographic or clinical characteristics (all $p > 0.05$), confirming the homogeneity of the two groups at the start of the study.

Changes in Fasting Blood Glucose Within Groups

The mean FBG levels at baseline, day 15, and day 30 for both groups are shown in Table 2. Within-group changes were analyzed using repeated-measures ANOVA with Bonferroni post-hoc tests.

Table 2. Fasting Blood Glucose Levels (mg/dL) at Baseline, Day 15, and Day 30 (Repeated Measures ANOVA with Bonferroni Post-hoc Test)

Time Point	Intervention Group (n = 75) Mean ± SD	Control Group (n = 74) Mean ± SD
Baseline (Day 0)	198.37 ± 32.45	196.82 ± 31.89
Day 15	175.64 ± 30.18	193.47 ± 31.24
Day 30	156.21 ± 28.73	188.54 ± 30.12
Mean difference (Day 0 – Day 30)	−42.16 ± 15.82	−8.28 ± 10.45
Percentage reduction (%)	21.3%	4.2%
Repeated measures ANOVA (F)	68.34	3.87
p-value (within-group)	< 0.001*	0.042*

*Statistically significant at $p < 0.05$; SD = Standard Deviation

In the intervention group, FBG decreased significantly from baseline to day 15 (mean difference: −22.73 mg/dL, $p < 0.001$) and from day 15 to day 30 (mean difference: −19.43 mg/dL, $p < 0.001$). The overall reduction from baseline to day 30 was 42.16 mg/dL, representing a 21.3% reduction. From a clinical perspective, the mean FBG in the intervention group decreased from 198.37 mg/dL to 156.21 mg/dL, approaching the glycemic target of <130 mg/dL recommended by the American Diabetes Association (ADA) for most adults with diabetes (American Diabetes Association ADA, 2024). Although the day-30 mean FBG remained above this threshold, the magnitude of reduction (42.16 mg/dL) is clinically meaningful, as prior evidence suggests that sustained FBG reductions of ≥30 mg/dL are associated with decreased risk of microvascular complications (Stratton et al., 2000).

In the control group, FBG levels showed a modest but statistically significant decrease from baseline to day 30 (mean difference: −8.28 mg/dL, $p = 0.042$), representing a 4.2% reduction. However, this reduction is unlikely to be clinically significant, as the mean FBG at day 30 (188.54 mg/dL) remained substantially above the ADA-recommended target (ADA, 2024). The reduction from baseline to day 15 in the control group was not statistically significant (mean difference: −3.35 mg/dL, $p = 0.318$).

Between-Group Comparison of Fasting Blood Glucose

Between-group differences in FBG levels at each time point were assessed using independent t-tests (Table 3).

Table 3. Between-Group Comparison of Fasting Blood Glucose at Each Time Point (Independent t-test)

Time Point	Intervention Group (n = 75) Mean ± SD	Control Group (n = 74) Mean ± SD	Mean Difference	t-value	p-value	Cohen's d
Baseline (Day 0)	198.37 ± 32.45	196.82 ± 31.89	1.55	0.29	0.773	0.05
Day 15	175.64 ± 30.18	193.47 ± 31.24	−17.83	−3.56	< 0.001*	0.58
Day 30	156.21 ± 28.73	188.54 ± 30.12	−32.33	−6.72	< 0.001*	1.10

*Statistically significant at $p < 0.05$; SD = Standard Deviation

At baseline, there was no significant difference in FBG levels between the two groups ($p = 0.773$). By day 15, the intervention group demonstrated significantly lower FBG compared to the control group ($p < 0.001$, Cohen's $d = 0.58$), representing a medium effect size according to Cohen's (1988) classification. At day 30, the between-group difference was highly significant ($p < 0.001$) with a large effect size (Cohen's $d = 1.10$). The 32.33 mg/dL between-group difference at day 30 exceeds the minimal clinically important difference (MCID) threshold of 20 mg/dL commonly applied in diabetes intervention trials (Riddle et al., 2003), supporting the clinical relevance of the observed effect beyond mere statistical significance.

Adjusted Analysis for Potential Confounding Variables

To account for potential confounding variables, an analysis of covariance (ANCOVA) was conducted with day-30 FBG as the dependent variable, group assignment as the fixed factor, and baseline FBG, age, BMI, duration of diabetes, sex, education level, and type of antidiabetic medication as covariates. The results are presented in Table 5.

Table 5. ANCOVA for Day-30 FBG Adjusted for Potential Confounders

Source	Sum of Squares	df	Mean Square	F-value	p-value	Partial η^2
Group (adjusted)	35,412.67	1	35,412.67	42.18	< 0.001*	0.231
Baseline FBG	28,764.32	1	28,764.32	34.26	< 0.001*	0.196
Age	312.45	1	312.45	0.37	0.543	0.003
BMI	587.21	1	587.21	0.70	0.405	0.005
Duration of diabetes	1,245.38	1	1,245.38	1.48	0.225	0.010
Sex	423.67	1	423.67	0.50	0.479	0.004
Education level	678.94	3	226.31	0.27	0.847	0.006

Source	Sum of Squares	df	Mean Square	F-value	p-value	Partial η^2
Antidiabetic medication type	1,892.56	1	1,892.56	2.25	0.136	0.016
Error	117,342.18	139	844.19			

*Statistically significant at $p < 0.05$; df = degrees of freedom; η^2 = eta squared

After adjusting for all potential confounders, the effect of group assignment on day-30 FBG remained statistically significant ($F = 42.18$, $p < 0.001$, partial $\eta^2 = 0.231$). Baseline FBG was the only significant covariate ($p < 0.001$), while age, BMI, duration of diabetes, sex, education level, and antidiabetic medication type did not significantly influence the outcome (all $p > 0.05$). The adjusted mean FBG at day 30 was 155.89 mg/dL (95% CI: 149.32–162.46) for the intervention group and 188.87 mg/dL (95% CI: 182.24–195.50) for the control group, yielding an adjusted mean difference of −32.98 mg/dL (95% CI: −42.71 to −23.25). These findings confirm that the observed effect of Costus igneus tea on FBG reduction was independent of the measured confounding variables.

Interaction Effect of Time and Group

The interaction effect between time and group assignment on FBG was evaluated using a two-way repeated-measures ANOVA, as presented in Table 4.

Table 4. Repeated Measures ANOVA for Time × Group Interaction Effect on Fasting Blood Glucose

Source of Variation	Sum of Squares	df	Mean Square	F-value	p-value	Partial η^2
Time (within-subjects)	52,847.32	2	26,423.66	45.82	< 0.001*	0.238
Group (between-subjects)	38,214.56	1	38,214.56	18.93	< 0.001*	0.114
Time × Group interaction	28,436.78	2	14,218.39	24.67	< 0.001*	0.144
Error (within-subjects)	169,542.14	294	576.67			
Error (between-subjects)	296,784.23	147	2,018.94			

*Statistically significant at $p < 0.05$; df = degrees of freedom; η^2 = eta squared

Repeated-measures ANOVA revealed a significant main effect of time ($F = 45.82$, $p < 0.001$, partial $\eta^2 = 0.238$), indicating that FBG levels changed significantly over the 30-day period across both groups. A significant main effect of group was also observed ($F = 18.93$, $p < 0.001$, partial $\eta^2 = 0.114$), confirming that the overall FBG levels differed between the intervention and control groups. Most importantly, the time × group interaction was statistically significant ($F = 24.67$, $p < 0.001$, partial $\eta^2 = 0.144$), demonstrating that the pattern of FBG changes over time differed significantly between the two groups. According to Cohen's (1988) benchmarks, the partial eta squared value of 0.144 indicates a large effect size, suggesting that the Costus igneus tea intervention substantially impacted the trajectory of FBG reduction over the study period.

Figure 1 illustrates the progression of FBG levels from the baseline through Day 30. The Control Group shows a marginal decline, while the Intervention Group demonstrates a significant reduction over the 30-day period.

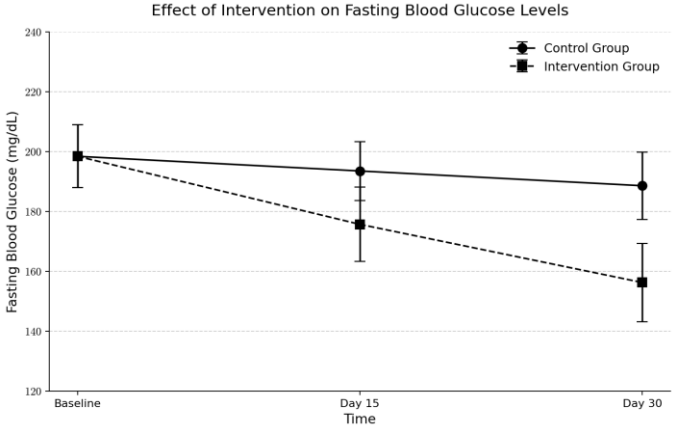


Figure 1. Longitudinal Trends in Fasting Blood Glucose

The present study demonstrated that Costus igneus tea supplementation significantly reduced fasting blood glucose levels in older adults with T2DM over a 30-day intervention period. The intervention group exhibited a 21.3% reduction in FBG compared to the 4.2% reduction in the control group, with a highly significant time × group interaction effect. These findings provide community-based clinical evidence supporting the traditional use of Costus igneus as an antidiabetic herbal remedy and are consistent with the growing body of literature on the therapeutic potential of plant-derived compounds in diabetes management.

The significant hypoglycemic effect observed in this study is consistent with the known phytochemical properties of Costus igneus. As a member of the Costaceae family, Costus igneus is rich in bioactive compounds including flavonoids, phenolic compounds, alkaloids, and minerals such as chromium and zinc, which play important roles in glucose metabolism (Hajam et al., 2022; Yadav et al., 2025). Chandrakar et al. reported that the antidiabetic mechanism of Costus igneus involves suppression of metabolic enzymes essential for carbohydrate metabolism, including α-glucosidase and α-amylase, as well as inhibition of dipeptidyl peptidase-4 (DPP-4), which prolongs the activity of incretins such as GLP-1 and GIP, resulting in increased insulin secretion and better glucose control (Chandrakar et al., 2024). Furthermore, the antioxidant activity of Costus igneus helps reduce excessive reactive oxygen species levels implicated in the pathogenesis of T2DM and its complications (Caturano et al., 2023; Yadav et al., 2025).

The magnitude of FBG reduction observed in our study (42.16 mg/dL over 30 days) is noteworthy when compared with findings from studies of other herbal interventions. Similarly, Magtulis and Itable Chen et al. (2023) demonstrated that ethanolic extracts of Costus woodsonii, a species within the same genus, exhibited potent hypoglycemic effects in alloxan-induced diabetic mice, supporting the antidiabetic properties shared across Costus species (Melesie Taye et al., 2020). The traditional practice of consuming Costus igneus leaves to maintain low blood glucose levels, as documented in South and Central American populations (Joshi et al., 2023).

Compared with other plant-based interventions, the effects of Costus igneus tea were more pronounced than those of green tea. Xu et al. Xu et al., 2020) conducted a meta-analysis of 27 randomized controlled trials involving 2,194 subjects and found that green tea supplementation significantly lowered FBG by only 1.44 mg/dL, with no significant effects on fasting insulin or HbA1c (Xu et al., 2020). Similarly, Alkhudaydi and Spencer Alkhudaydi & Spencer (2024) reported that short-term administration of green tea and cocoa did not significantly reduce FBG, fasting blood insulin, HbA1c, or HOMA-IR in T2DM patients. The substantially greater FBG reduction observed with Costus igneus tea in our study may be attributed to its unique phytochemical profile, particularly its high content of specific flavonoids and the presence of chromium, which enhances insulin sensitivity (Asbaghi et al., 2021).

However, it is important to acknowledge that not all studies on Costus species have yielded consistently positive results. Some preclinical studies have reported variable hypoglycemic efficacy depending on extraction methods, dosage, and duration of administration, suggesting that the therapeutic effects may be preparation-dependent (Phung et al., 2025; Rahimpour et al., 2023). Additionally, certain herbal intervention trials in T2DM have failed to demonstrate clinically meaningful glycemic improvements when confounding variables were rigorously controlled (Chahrour et al., 2025; Li et al., 2025; Vajdi et al., 2024). The heterogeneity in findings across herbal medicine studies underscores the need for cautious interpretation of our results and highlights that the magnitude of FBG reduction observed here requires confirmation through randomized controlled trials with larger samples and longer follow-up periods.

The role of dietary polyphenols and flavonoids in modulating glucose metabolism has been well established in the literature (Martiniakova et al., 2025). Martiniaková et al. Selim et al. (2023) highlighted that flavonoids such as quercetin, kaempferol, and epicatechin have the ability to lower hyperglycemia, enhance insulin sensitivity, and improve insulin secretion through multiple molecular pathways (Wen & Li, 2025). Plant-derived antioxidants exert beneficial effects by modulating oxidative stress, reducing systemic inflammation, and improving insulin signaling pathways (Clemente-Suárez et al., 2025). The phytochemicals present in Costus igneus, including flavonoids and phenolic acids, likely contribute to its antidiabetic effects through similar mechanisms (Chandrakar et al., 2024).

The application of Costus igneus in tea form represents a practical and culturally acceptable mode of delivery for community-based diabetes management. From a public health perspective, integrating such herbal interventions into primary healthcare requires addressing several critical considerations. First, standardization of herbal preparations is essential to ensure consistent dosing and reproducibility of

therapeutic effects. Second, regulatory frameworks governing herbal medicine use must be strengthened to ensure safety, quality control, and appropriate labeling, particularly given the potential for herb-drug interactions with oral hypoglycemic agents. Third, public education strategies should emphasize that herbal supplementation serves as a complementary not alternative approach to conventional pharmacotherapy, to prevent treatment abandonment. Community health workers could be trained to deliver evidence-based guidance on herbal tea supplementation alongside standard diabetes care, thereby facilitating integration into existing primary care infrastructure.

The finding that the control group also showed a modest but significant FBG reduction (4.2%) may be attributed to the Hawthorne effect, improved medication adherence due to regular monitoring, or seasonal dietary variations during the study period. Nevertheless, the between-group difference remained highly significant, with a large effect size (Cohen's d = 1.10), confirming the independent contribution of Costus igneus tea to glycemic improvement.

This study has several limitations. First, the quasi-experimental design without randomization may have introduced selection bias, although baseline homogeneity was confirmed. Second, the 30-day intervention period may not capture the long-term effects or sustainability of the observed glycemic improvements. Third, the study measured only FBG and did not include HbA1c, fasting insulin, or HOMA-IR, which would provide a more comprehensive assessment of glycemic control and insulin resistance (Huang et al., 2021; Mao et al., 2021). Fourth, the study did not perform detailed phytochemical analysis of the specific Costus igneus tea preparation used, which limits the ability to identify the specific bioactive compounds responsible for the observed effects (GHENABZİA et al., 2023). Fifth, dietary intake and physical activity were not rigorously controlled, although participants were advised to maintain their usual habits (Hadi et al., 2025).

CONCLUSION

This community-based quasi-experimental study provides evidence that *Costus igneus* (insulin plant) tea supplementation significantly reduces fasting blood glucose levels in older adults with type 2 diabetes mellitus. The intervention group demonstrated a clinically and statistically significant 21.3% reduction in FBG over a 30-day period, compared with a 4.2% reduction in the control group receiving standard antidiabetic medication alone. The significant time × group interaction effect with a large effect size confirmed that the observed glycemic improvement was attributable to the *Costus igneus* tea intervention rather than temporal or medication effects alone. The findings support the traditional use of *Costus igneus* as a complementary antidiabetic remedy, offering a practical, affordable, and culturally acceptable approach particularly relevant for older adults in resource-limited settings. However, several limitations warrant cautious interpretation, including the quasi-experimental design with inherent selection bias, the relatively short 30-day intervention period, the absence of HbA1c measurement for long-term glycemic assessment, and the lack of blinding. Additionally, potential confounding variables such as dietary intake and physical activity were not rigorously controlled. Future research should employ randomized controlled trial designs with longer follow-up periods, incorporate biomarkers including HbA1c and insulin levels, conduct dose-response analyses, evaluate hepatic and renal safety profiles, and identify the specific bioactive compounds responsible for the hypoglycemic effects of *Costus igneus* through phytochemical analysis.

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AUTHOR CONTRIBUTIONS

Conceptualization: R.I., R.F., and F.I.; Methodology and Software Development: R.I., R.F., and F.I.; Validation and Formal Analysis: R.I., R.F., and F.I.; Writing—Original Draft: R.I., R.F., and F.I.; Project Administration: R.I. and R.F.; Funding Acquisition: R.I., R.F., and F.I.

CONFLICTS OF INTEREST

The author(s) declare no conflict of interest.

USE OF ARTIFICIAL INTELLIGENCE (AI)-ASSISTED TECHNOLOGY

The authors declare that no artificial intelligence (AI) tools were used in the generation, analysis, or writing of this manuscript. All aspects of the research, including data collection, interpretation, and manuscript preparation, were carried out entirely by the authors without the assistance of AI-based technologies.

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