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Research Article

Beilschmiedia obscura seeds powder: Potential functional food ingredient for glycemic control in Diabetes Mellitus

Florine Mbappé Essouman ¹, Ferdinand Lanvin Ebouel Edoun ^{1,2}, Nyemb Nyunaï ³, Nadine Ndoe Essola ¹, Sandra Leila Nnanga ^{1,5}, Pauline Vervaine Hagbe ^{1,5}, Fils Armand Ella ^{1,5}, Nguemto Guy Roussel Takuissu ², Innocent Gouado ⁴, Judith Laure Ngondi ^{1,5*}

1 Department of Biochemistry, Faculty of Science, University of Yaoundé I, P.O. Box 812 Yaoundé, Cameroon.

2 Centre for Food, Food Security and Nutrition Research (CRASAN), Institute for Medical Research and Medicinal plant studies (IMPM), P.O. Box 13033, Yaoundé, Cameroon.

3 Centre for Research on Health and Priority Pathologies, Institute of Medical Research and Medicinal Plants Studies (IMPM), P.O. Box 13033, Yaoundé, Cameroon

4 Department of Biochemistry, Faculty of Science, University of Douala, P.O. Box Cameroon Douala, Cameroon.

5 Center of Nutrition and Functional Foods, P.O. Box 8024 Yaoundé, Cameroon

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For Correspondence:

Judith Laure Ngondi, Department of Biochemistry, Faculty of Science, University of Yaoundé I, P.O. Box 812 Yaoundé, Cameroon.

Abstract

Beilschmiedia obscura seeds are used as dietary enhancers in some Cameroonian traditional dishes. They have preventive effects against metabolic disorders, but their potential effects in diabetes management have not yet been studied. This study therefore aims to evaluate the antidiabetic effect of *Beilschmiedia obscura* seed powder as a novel local therapeutic resource. Diabetes was induced in rats using streptozotocin, and the diabetic rats were treated with a diet supplemented with 10% *B. obscura* seed powder for 14 days. Fasting blood glucose were assessed weekly. Additionally, oral glucose, sucrose, or starch tolerance tests were conducted in normoglycemic rats. Finally, *in vitro* study to investigate glucose adsorption capacity, and glucose uptake in non-insulin-dependent cells (yeast) and insulin-dependent cells (skeletal muscle cells) was carried out. *B. obscura* seed powder significantly decrease glycemia of diabetic rats (81.71% of the initial value at 14th day). It significantly restored hepatic glycogen levels in diabetic rats. Additionally, *B. obscura* seeds powder significantly reduced glycemic peak (about 2-fold) compared to normal control following oral glucose, sucrose, and starch administration. *In vitro*, *B. obscura* seeds powder showed the ability to scavenge glucose (up to 48.27% at 10mg/mL) and to stimulate glucose uptake both into non-insulin-dependent cells (up to 25.45% at 10mg/mL) and insulin-dependent cells (up to 35.40% at 7.5mg/mL). These findings suggest that *B. obscura* seeds powder has multifaceted actions in modulating blood glucose, which position it as a promising plant-based intervention for glycemic control, especially in resource-limited settings where affordable natural therapies are critically needed.

Keywords: *B. obscura* powder seeds, Diabetes, Post-prandial hyperglycemia, fasting hyperglycemia, glucose-lowering mechanisms

1. INTRODUCTION

Diabetes mellitus (DM) affects more than one out of ten people globally, with an estimated prevalence of over 12.2% in 2021. It has become a paradigmatic chronic disease, exposing the world's most vulnerable populations to a syndemic of metabolic dysfunction, cardiovascular risk, and profound socio-economic hardship¹. In low- and middle-income countries, like Cameroon, the issue is grave, with rising rates of diabetes and metabolic syndrome. Despite the development of anti-diabetic medicines, ranging from insulin to oral medications, the majority of people still struggle to achieve long-term glycemic control. Barriers include the high cost of pharmacotherapy, the growing burden of

complications such as neuropathy and nephropathy, and a pharmacological paradigm in which few single agents target the disease's three primary physiological defects: excessive hepatic glucose production, decreased peripheral glucose uptake, and insufficient insulin secretion^{2,3}.

The management of diabetes due to its physiologic and progressive nature requires a combination of lifestyle modifications and pharmacologic therapy to achieve and maintain long-term glycemic control. Optimal glycemic control is thus fundamental to the management of diabetes. Additionally, evidence indicates that both fasting and post-prandial plasma glucose levels correlate with the risk of developing microvascular and

macrovascular complications. The primary physiologic defects in glycemic control include excessive hepatic glucose production, diminished peripheral glucose uptake by insulin-sensitive tissues, and inadequate insulin^{3,4}. There is an urgent need to find bioactive sources, particularly those that are indigenous to African food systems, as therapeutic agents within a "food as medicine" framework.

In the past decade, increasing focus has been given to dietary fibers, polyphenols, and plant-based metabolites as alternative or supplementary treatments for managing diabetes. Numerous studies have demonstrated that polyphenols may stimulate insulin secretion and sensitivity, modulate cellular glucose uptake, and suppress hepatic glucose production, while fibers can inhibit carbohydrate absorption⁵⁻⁷. Among the plant families studied for these properties, the Lauraceae family is noted for its abundance of bioactive compounds that exhibit antidiabetic and antioxidant effects. *Lauraceae* family plants are endowed with a high content of dietary fiber and polyphenols. Numerous studies have already demonstrated the anti-diabetic potential of this plant family⁸⁻¹⁰.

Beilschmiedia obscura (*Lauraceae*) is a plant from the Cameroonian-Gabonese forest, whose seed is used as a food improver (condiment) in some Cameroonian dishes¹¹. Our previous work demonstrated the presence of water-soluble polysaccharides in the seeds of *B. obscura*. It also showed the preventive effects of *B. obscura* seeds powder on metabolic syndrome disorders, notably oxidative stress and dyslipidemia in rats fed with a High Fat/High Sucrose diet¹². However, the capacity of *B. obscura* to control glycemia in an overt diabetic state, particularly through direct effects on carbohydrate digestion or cellular glucose uptake, has yet to be investigated and exploited. This is a gap, given the critical need for low-cost, culturally-anchored therapies in places where conventional pharmaceutical options are structurally limited.

This study aims to fill this gap by using an experimental strategy that includes: (i) oral carbohydrate tolerance testing in normoglycemic rats to investigate the acute, post-prandial glycaemic effects of *B. obscura* seed powder; (ii) evaluation in the gold-standard streptozotocin-induced diabetic model to characterize chronic glycemic modulation and potential β -cell preservation; and (iii) mechanistic assays in yeast and mammalian skeletal muscle cells to reveal direct and insulin-facilitated glucose uptake.

2. MATERIAL AND METHODS

2.1. Reagents

All chemicals and reagents used in this study were of analytical grade and were procured from Sigma-Aldrich (St. Louis, MO, USA).

2.2. Plant material and powder preparation

Mature seeds of *B. obscura* were collected from Abong-Mbang (East region, Cameroon) and taxonomically identified at the National Herbarium (Yaoundé, Cameroon), where a voucher specimen was deposited

under the reference number 2102/SRFR. Seeds were thoroughly washed with distilled water, oven-dried at 40°C for 48 hours, and ground into a fine powder PHILIPS® blender. The resulting powder was sieved a homogeneous flour, which was stored in airtight containers at room temperature until use in experimental protocols. The mucilage was extracted according to the protocol of Benaoun et al.¹³. The procedure consisted of dispersing *B. obscura* seed flour (50 g) in 7500 mL of distilled water. The resulting mixture was agitated in a water bath at 60°C for 4 hours and then centrifuged at 12,000 rpm for 15 minutes. The clear supernatant was collected and precipitated with 95% ethanol (one volume of supernatant to four volumes of ethanol). The resulting precipitate was collected after another centrifugation, washed twice with ethanol, and then twice more with acetone. The obtained mucilage was dried in an oven at 45°C and weighed. The mucilage was characterized post-extraction using the protocols of Assi et al.¹⁴.

2.3. Animals

Rats of Wistar strain, aged 8 weeks old and weighing 250-280 g were obtained from the Laboratory of Nutrition and Nutritional Biochemistry (Department of Biochemistry, University of Yaoundé I). Animals were housed under controlled environmental conditions (22 ± 1 °C, 12-h light/dark cycle) with ad libitum access to standard laboratory chow and water. All experimental procedures complied with the institutional ethical guidelines for animal research and were approved by the relevant ethics committee

2.4. Quantitative determination of bioactive compounds

2.4.1. Determination of total polyphenol content

The total polyphenol content was determined using the method described by Singleton and Rossi¹⁵. Briefly, 30 μ L of the sample (1 mg of powder in 1 mL of water) was mixed with 1 mL of alkalized Folin Ciocalteu reagent (10%). After 30 minutes of incubation at 25°C, absorbance was measured at 750 nm. Gallic acid was used as reference standard, and the results were expressed in μ g gallic acid equivalents (GAE) per mg of powder.

2.4.2. Determination of flavonoid content

Total flavonoid content was measured using the method described by Aiyegoro and Okoh (2010). Each 1 mL of sample (1 mg/mL, powder in ethanol) was mixed with 1 mL AlCl_3 (10%), 1 mL potassium acetate (1 M), and 5.6 mL distilled water. After 30 minutes at room temperature, absorbance of the reaction mixture was measured at 420 nm. Quercetin was used as reference standard, and the results were expressed in mg quercetin equivalents (QE) per g of powder.

2.4.3. Determination of alkaloid content

Alkaloid content was quantified using the method described by Singh et al. (2004). One hundred of the powder was mixed with 10 mL of ethanol (80%). Then, 1 mL of supernatant was added to 1 mL of FeCl_3 (0.025 M

in 0.5 M HCl) and 1 mL of 1,10-phenanthroline (0.05 M in ethanol). After incubation at $70 \pm 2^\circ\text{C}$ for 30 minutes, absorbance was measured at 510 nm. Quinine was used as reference standard, and the results were expressed as μg quinine equivalents per mg of powder.

2.5. Study of effects of a diet enriched with *B. obscura* seeds powder on diabetic rats

Diabetes was induced in overnight-fasted rats by intraperitoneal injection of streptozotocin (50 mg/kg body weight) freshly dissolved in citrate buffer (0.01 M; pH 4.5), following the method of Al-Shamaony et al.,¹⁶. After 24 hours, blood glucose was measured using a tail prick and glucometer (Gluco-Plus™). Animals with fasting blood glucose levels ≥ 200 mg/dL were considered diabetic and included in the study.

Diabetic rats were randomly assigned to one of the following groups (n = 5 per group):

- Diabetic control group: standard diet
- Test group: standard diet supplemented with *B. obscura* powder seeds (10 %)
- Reference group: standard diet + Glibenclamide (4 mg/kg bw/day).
- Non-diabetic control group: normoglycemic rats, standard diet.

Blood glucose was measured on days 0, 7, and 14 using glucose oxidase method. On day 14, rats were euthanized by cervical dislocation under light anesthesia, following a 12-h fast. Livers were harvested, rinsed in saline solution, and stored at -20°C for glycogen content analysis¹⁷.

2.6. Investigation of potential antihyperglycemic mechanisms of *B. obscura* seeds powder

2.6.1. Study of the effect of *B. obscura* seeds milling on postprandial blood glucose after carbohydrate loading

Three sets of oral carbohydrate tolerance tests were performed using normoglycemic rats (n = 5 per group), fasted overnight (12 h). Each rat received one of the following treatments via oral gavage:

- Group 1 (Control): glucose (2 g/kg body weight)
- Group 2 (Test): glucose (2 g/kg body weight) + *B. obscura* (400 mg/kg body weight)
- Group 3 (Reference): glucose (2 g/kg body weight) + Acarbose (3 mg/kg body weight).

After the administration of glucose, seeds powder and anti-diabetic drug, the animals were not allowed access to food. The volume of administration of powder and drug was 5 mL/kg body weight. Blood glucose was measured at 0, 30, 60, and 120 minutes after glucose loading using a glucometer (One touch™). Percentage changes in blood glucose were calculated.

The same experimental procedure was done to evaluate the effects of *B. obscura* seeds powder on sucrose and starch loading except that glucose was replaced by

sucrose (2 g/kg body weight) and starch (1g/kg body weight) respectively.

2.6.2. Glucose Adsorption Capacity

The glucose adsorption capacity of *B. obscura* seed powder was evaluated following the method described by Ou et al.,¹⁸. Briefly, 1 mL of *B. obscura* seeds powder at varying concentrations (2.5, 5, 7.5, and 10 mg/mL; prepared in distilled water) was mixed with 1 mL of glucose solution (12.5 mM). The mixtures were vortexed and incubated in a shaking water bath at 37°C for 60 minutes. After incubation, samples were centrifuged at 4,000 g for 20 minutes, and the glucose concentration in the supernatant was quantified using the glucose oxidase method. Bound glucose was calculated using the following formula.

The percentage of glucose bound by the powder was calculated using the following formula:

$$\text{Percentage bound glucose (\%)} = [(\text{initial Glucose} - \text{final Glucose}) / \text{initial Glucose}] \times 100$$

2.6.3. Glucose Uptake by Yeast Cells

The capacity of *B. obscura* seed powder to enhance glucose uptake was assessed in yeast cells, using the method of Trinder¹⁹. Commercial baker's yeast was repeatedly washed by centrifugation (4,000g for 5 minutes) in distilled water until the supernatant was clear. A 10% (v/v) yeast suspension was then prepared in distilled water. Various concentrations of *B. obscura* seed powder (2.5, 5, 7.5, and 10 mg/mL) were added to 1 mL of glucose solution (25 mM) and pré-incubated at 37°C for 10 minutes. Glucose uptake was initiated by adding 100 μL of the yeast suspension. The mixture was vortexed, and further incubated at 37°C for 60 minutes. After incubation, tubes were centrifuged (3,000 g for 5 minutes), and the residual glucose in the supernatant was measured using the method of Cirillio²⁰. A reaction without extract was used as the control. The percentage increase in glucose uptake was calculated using the following formula.

$$\text{Percentage increase in glucose uptake (\%)} = [(\text{Abs control} - \text{Abs sample}) / \text{Abs control}] \times 100$$

2.6.4. Glucose Uptake in Rat Psoas Muscle Tissue

Glucose uptake in rat psoas muscle tissue was determined according to the method of Al-Awadi et al.,²¹. Psoas muscle was isolated from an anesthetized adult rat and immediately immerse in ice-cold Krebs-Ringer bicarbonate buffer containing 11.1 mM glucose. Muscle tissues were cut into pieces of equal mass, about 0.25 g, and preincubated for 5 minutes at 37°C in a CO_2 incubator. The following experimental conditions were established:

- Control: Muscle tissue alone
- Insulin group: Muscle tissue + insulin (50 mU/L)
- Test groups: Muscle tissue + insulin (50 mU/L) + *B. obscura* seed powder (5, 7.5, 10 mg/mL).

All groups were incubated for 2.5 hours in a CO_2 incubator (5% CO_2 , 95% O_2 atmosphere). Aliquots (2

mL) were collected at 0, 30, and 60 minutes, and the glucose concentration in the incubation medium was measured using the method of Trinder¹⁹. Percent glucose uptake was calculated using the following formula:

$$\text{Glucose uptake (\%)} = \frac{[(\text{Abs control} - \text{Abs sample}) / \text{Abs control}] \times 100}{1}$$

2.7. Statistical analysis

GraphPad Prism software version 10.2.2 was used for statistical analysis. Intergroup differences were assessed using one-way Analysis of variance (ANOVA) followed by the LSD (Least Significant Difference) post hoc test for pairwise comparisons. Significant differences were detected at a 95% confidence interval. Data are

expressed as mean $\pm$ standard deviation (SD) from triplicate independent observations.

3. RESULTS

3.1. Bioactive compounds of *B. obscura* seed powder

3.1.1. Bioactive compounds content of *B. obscura* seed powder

The polyphenol, flavonoid, alkaloid, and mucilage contents of *B. obscura* seeds powder are presented in Table 1. *B. obscura* powder seeds contain polyphenols (208.667 μg GAE/mg of powder), flavonoids (5.958 μg EQu/mg of powder), alkaloids (1484 μg EQu/mg of powder), and mucilage (40%).

Table 1: Bioactive compounds content of *B. obscura* powder seeds

	Polyphenols (μg EGA/mg of powder)	Flavonoids (μg EQuer/mg of powder)	Alkaloids (μg EQui/mg of powder)	Mucilage (%)
<i>B. obscura</i> powder seeds	208.667 $\pm$ 0.236	5.958 $\pm$ 0.600	1,484 $\pm$ 0.010	40 $\pm$ 5,29

EGA: Equivalence of Gallic Acid; EQuer: Equivalence of Quercetin; EQui: Equivalence of Quinine

3.1.2. Monosaccharide composition of mucilage

Figure 1 presents the monosaccharide composition of the mucilage in *B. obscura* seed meal. The results, shows that

arabinose (46.8%), xylose (40%) are the major sugars in the *B. obscura* monosaccharide matrix, followed by galacturonic acid (6.8%), rhamnose (2.45%) and glucose (2.2%).

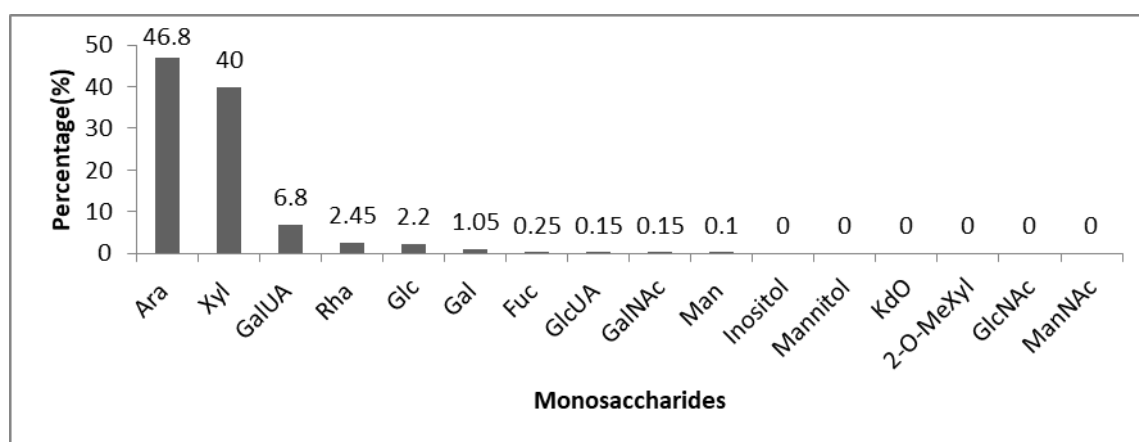


Figure 1: Monosaccharide composition of *B. obscura* seed mucilage

Ara: Arabinose; Xyl: Xylose; GalUA: Galacturonic acid; Rha: Rhamnose; Glc: Glucose; Gal: Galactose; Fuc: Fucose; GlcUA: Glucuronic acid; GalNAC: N-acetylgalactosamine; Man: Mannose; GlcNAC: N-acetylglucosamine; ManNAC: N-acetylmannosamine.

3.2. Effects of diet enriched in *B. obscura* seeds powder on fasting blood glucose variation and on hepatic glycogen in diabetic rats

3.2.1. Acute effect on fasting blood glucose variation

Figure 2 presents the acute effects of *B. obscura* seed on fasting glucose, the results are presented in glycemia mean (left) and percentages of variation (right). In the group receiving *B. obscura* seed flour supplemented with 10% of the experimental feed (BS 10%), a significant decrease in blood glucose levels after 30 min of 14.35%

was noted, while no reduction was noted in the Diabetic Control group even after 5 hours. The BS 10% group showed a greater decrease in blood glucose levels after 30 min compared to the diabetic rats + 4 mg/kg of Glibenclamide group (7.37%). On the other hand, after 2 hours up to 5 hours, the decrease was significantly less in the diabetic rats + 4 mg/kg of Glibenclamide group: 19.71% and 21.92% respectively, compared to 37.47% and 65.87% in the group receiving *B. obscura* seed flour supplemented with 10% of the experimental feed.

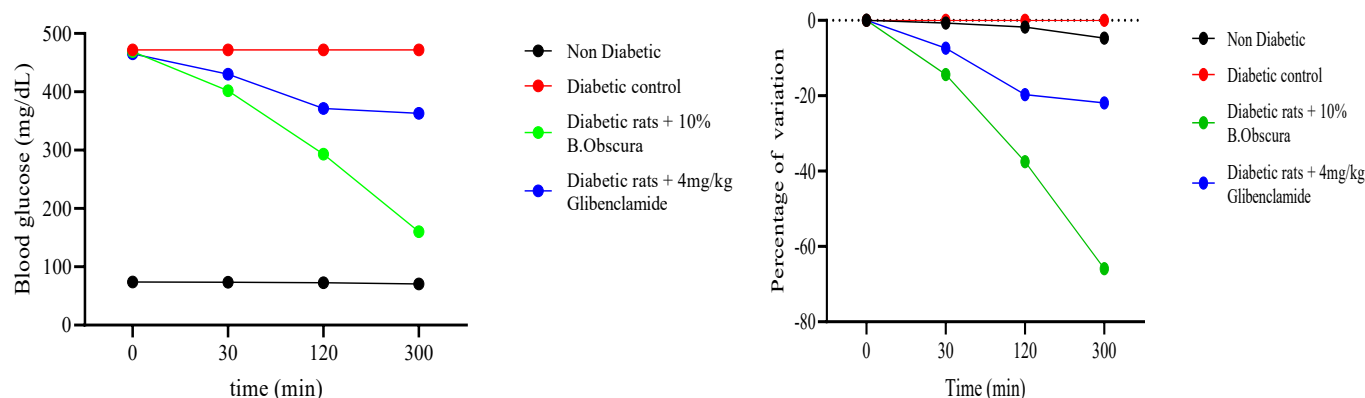


Figure 2: Blood glucose values and percentage variation after 5 hours of supplementation of *B. obscura* seeds powder in diet of diabetic rats. **Non-Diabetic:** Normoglycemic rat + H_2O_2 ; **Diabetic control:** hyperglycemic rats (50 mg/kg bw of STZ) + H_2O_2 ; **Diabetic rats + 10% B. Obscura:** hyperglycemic rats (50 mg/kg bw of STZ) + supplemented to 10% in the feed; **Diabetic rats + 4mg/kg Glibenclamide:** hyperglycemic rats (50 mg/kg bw of STZ) + 4mg/kg bw Glibenclamide. STZ: Streptozotocin, body weight.

Figure 2: Acute effects of *B. obscura* seed on fasting glucose; glycemia mean (left), percentages of variation (right).

3.2.1. Effect on fasting blood glucose during the experimentation

Figure 3 presents the effects of *B. obscura* seed on fasting glucose during the experimentation, the results are presented in glycemia mean (left) and percentages of variation (right). The hypoglycemic effect of *B. obscura* powder seeds is presented in Table 2. Administration of streptozotocin successfully induced diabetes in rats, resulting in a baseline fasting blood glucose level of approximately 470 mg/dL. In the untreated diabetic control group, blood glucose levels remain consistently elevated, showing only an approximate 17% reduction

from day 0 (472.00 mg/dL) to day 14 (391.76 mg/dL) which was not statistically significant.

In contrast, diabetic rats receiving a diet supplemented with 10 % *B. obscura* seeds powder exhibited a marked and sustained hypoglycemic response. Between day 0 and day 7, blood glucose levels decreased by approximately 74% (from 469.00 to 123.75 mg/dL), and a further 30.7% reduction was observed between day 7 and day 14 (down to 85.75 ± 7.53 mg/dL), amounting to an overall reduction of 81.7% over the study period. Comparatively, Glibenclamide-treated rats showed a more modest 58.4% decrease in glycemia from day 0 to day 7.

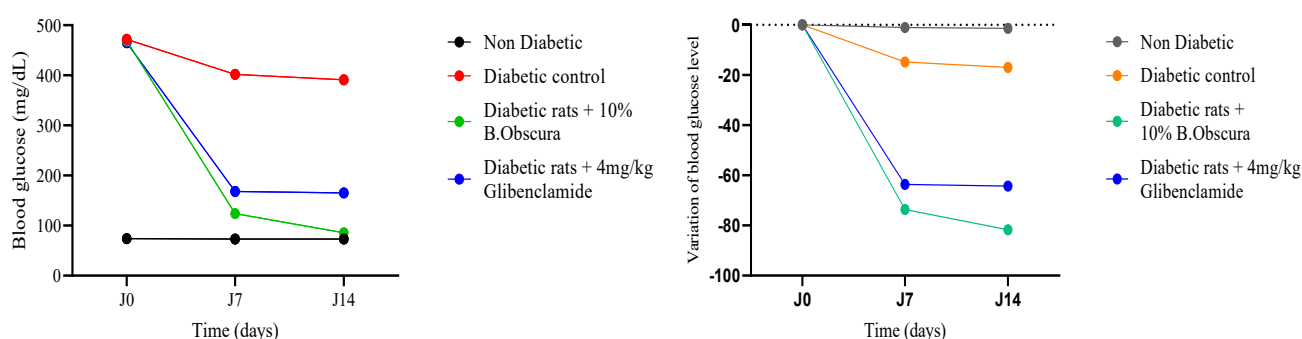


Figure 3: Effects of *B. obscura* seed on fasting glucose during the experimentation; glycemia mean (left), percentages of variation (right).

Non-Diabetic: Normoglycemic rat + H_2O_2 ; **Diabetic control:** hyperglycemic rats (50 mg/kg bw of STZ) + H_2O_2 ; **Diabetic rats + 10% B. Obscura:** hyperglycemic rats (50 mg/kg bw of STZ) + supplemented to 10% in the feed; **Diabetic rats + 4mg/kg Glibenclamide:** hyperglycemic rats (50 mg/kg bw of STZ) + 4mg/kg bw Glibenclamide. STZ: Streptozotocin, body weight.

3.2.2. Effect on hepatic glycogen content

The effects of *B. obscura* seeds on hepatic glycogen levels are summarized in Figure 4. Diabetic control rats exhibited a significantly lower hepatic glycogen content (6.07 g/L) compared to the normoglycemic group. In contrast, diabetic rats received a diet enriched with *B. obscura* seeds powder showed a significant increase ($p < 0.05$) in hepatic glycogen (10.49 g/L). Notably, the glycogen level in the *B. obscura*-treated group was also significantly higher than that observed in the Glibenclamide-treated reference group.

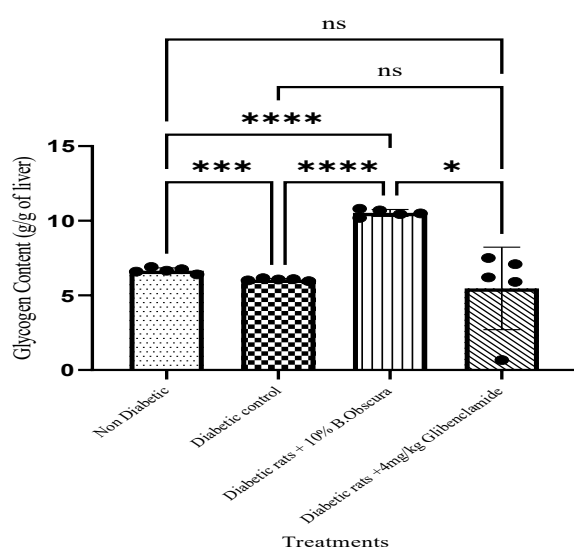


Figure 4: Hepatic glycogen content after supplementation of *B. obscura* seeds powder in diet of diabetic rats.

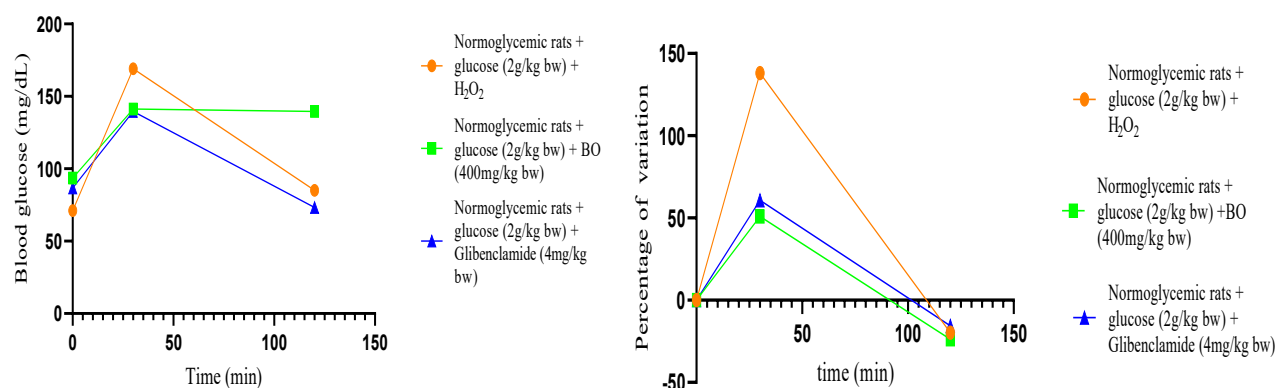


Figure 5: Blood glucose values (left) and percentage change (right) after simultaneous administration of glucose, *B. obscura* seeds powder or acarbose in normoglycemic rats.

3.3.1.2. After sucrose loading

Figure 6 presents the postprandial blood glucose levels and percentage changes after oral sucrose administration in normoglycemic rats. Blood glucose peak was observed at approximately 30 min after sucrose intake across all groups. In the control group, a significant reduction in blood glucose was observed between 30 and 60 minutes post-load, but not significant decrease was noted at the 120 minutes.

In the group receiving the *B. obscura* seed powder, the glycemic peak at 30 minutes was lower than that of the

Non-Diabetic: Normoglycemic rat + H₂O₂; Diabetic control: hyperglycemic rats (50 mg/kg bw of STZ) + H₂O₂; Diabetic rats + 10% *B.Obscura*: hyperglycemic rats (50 mg/kg bw of STZ) + supplemented to 10% in the feed; Diabetic rats + 4mg/kg Glibenclamide: hyperglycemic rats (50 mg/kg bw of STZ) + 4mg/kg bw Glibenclamide. STZ: Streptozotocin, body weight. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, **** $p < 0.0001$ for each group.

3.3. Potential Antihyperglycemic mechanisms of *B. obscura* seeds powder

3.3.1. Effect of *B. obscura* seeds powder on postprandial blood glucose variation in normal glycemic rats

3.3.1.1. After glucose loading

Figure 5 presents the postprandial blood glucose levels response following oral glucose loading in normoglycemic rats, the results are presented in glycemia mean (left) and percentages of variation (right). In the control group, a sharp increase in blood glucose level was observed, peaking at 30 minutes post-load with a 92.5% increase compared to baseline. In contrast, the group receiving the *B. obscura* seed powder exhibited a significantly attenuated glycemic response, with a peak increase of only 54.4% at 30 minutes post-load, indicating a 41.2% reduction in peak glycemia relative to the control group. From 30 to 120 minutes, blood glucose levels declined in both groups. However, the group receiving *B. obscura* seed powder showed a more pronounced reduction: blood glucose levels decreased by 47.2% between 30 and 120 minutes, compared to a 31.7% reduction in the control group.

control group. However, no significant change in blood glucose levels was observed between 30 and 60 minutes. A significant reduction was recorded only between 60 and 120 minutes, with a 26.65% decrease in glycemia. Comparatively, acarbose-treated animals exhibited a markedly stronger antihyperglycemic effect, with 5.13% reduction from 30 to 60 minutes, and a 47.49% reduction between 60 and 120 minutes.

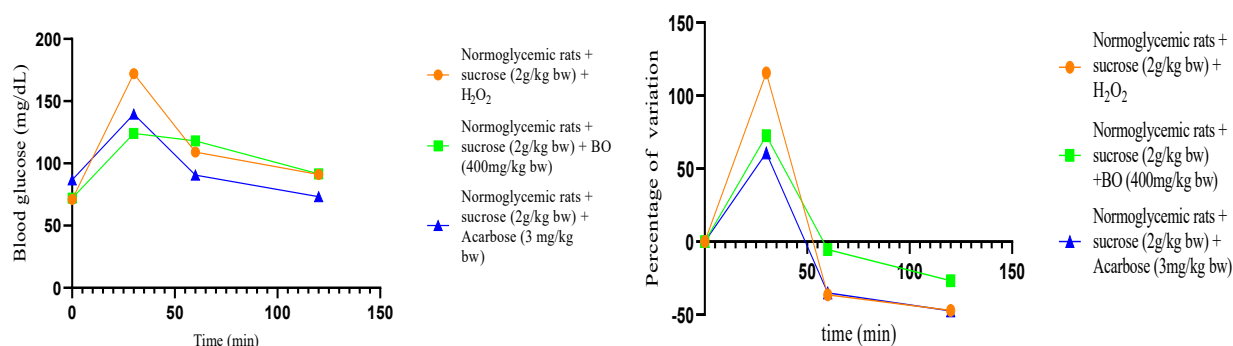


Figure 6: Blood glucose values (left) and percentage change (right) after simultaneous administration of sucrose, *B. obscura* seeds powder or acarbose in normal glycemic rats

3.3.1.3. After Starch loading

Figure 7: presents the postprandial blood glucose levels and percentage changes after oral starch administration in normoglycemic rats. Blood glucose peak was observed approximately 30 min after oral starch administration in all groups. In the control group, no significant reduction in blood glucose levels was observed between 30 and 60 minutes. However, a significant decrease occurred between 60 and 120 minutes.

In the group receiving the *B. obscura* seed powder, the glycemic peak at 30 minutes was notably lower than in the control group. Between 30 and 60 minutes, no significant decline in blood glucose was observed. However, from 60 to 120 minutes, a significant reduction was observed. Quantitatively, the *B. obscura*-treated group showed a 19,84% reduction in glycemia from 30 to 60 minutes, which was lower than the 35.13% reduction achieved with acarbose during the same interval.

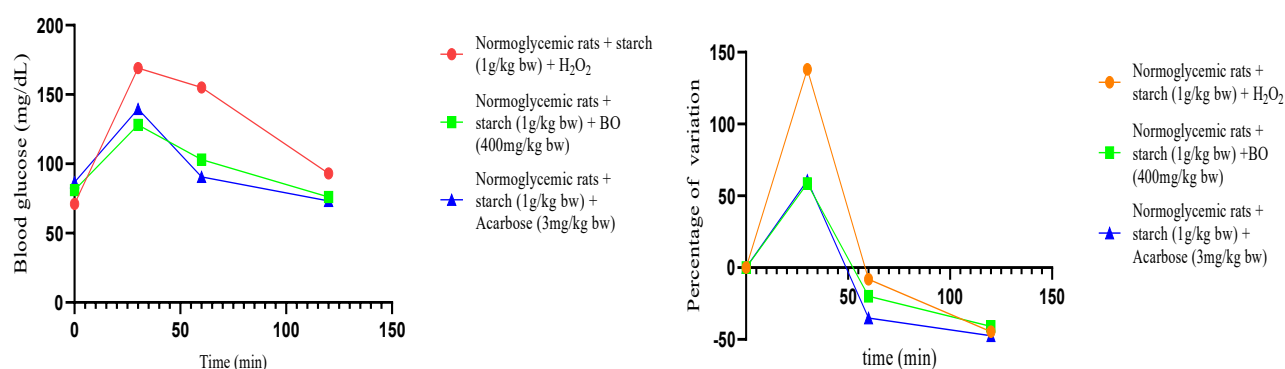


Figure 7: Blood glucose values (left) and percentage change (right) after simultaneous administration of starch, *B. obscura* seeds powder or acarbose in normal glycemic rats

3.3.2. Glucose binding capacity of *B. obscura* seeds powder

Figure 8 presents the glucose binding capacity of *B. obscura* powder seeds. The results demonstrate a clear

concentration-dependent effect, with glucose adsorption increasing progressively as the powder concentration rises. Specifically, *B. obscura* powder seeds exhibited a binding capacity of 25.74% at 2.5 mg/mL, which increased to 48.27% at 10 mg/mL.

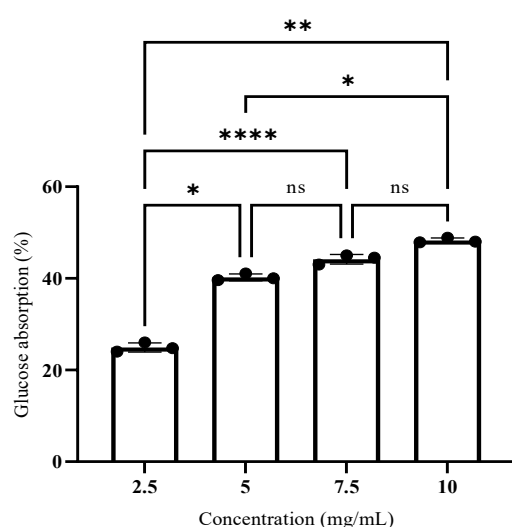


Figure 8: Glucose binding capacity of *B. obscura* powder seeds. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, **** $p < 0.0001$ for each group.

3.3.3. Effect of *B. obscura* seeds powder on glucose uptake by yeast cells

Figure 9 presents the effects of *B. obscura* seeds powder on glucose uptake by yeast cells. The results demonstrate a concentration-dependent enhancement of glucose uptake. Specifically, *B. obscura* powder seeds exhibited glucose uptake of 3.46% at 2.5 mg/mL, which increased to 25.45% at 10 mg/mL.

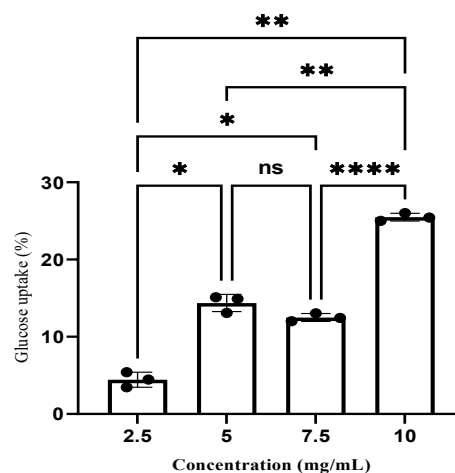


Figure 9: Glucose uptake by yeast cells of *B. obscura* powder seeds. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, **** $p < 0.0001$ for each group.

3.4.3. Effect of *B. obscura* seeds powder on glucose uptake by muscle cells

Table 2 presents the effects of *B. obscura* seed powder on glucose uptake by muscle cells are presented in. Insulin alone stimulated a time-dependent increase in glucose uptake, rising from 5.37% at 30 minutes to 22.22% at 90 minutes. Co-incubation with *B. obscura* seed powder at the concentrations of 5 mg/mL and 7.5 mg/mL significantly potentiated the effects of insulin, particularly at the 90-minute time point.

Table 2: Glucose uptake by muscle cells of *B. obscura* powder seeds

Time	Glucose uptake (%)		
	30 min	60 min	90 min
MT	-	-	-
MT + Insulin	5.37 ± 0.12 ^a	9.95 ± 0.87 ^a	22.22 ± 1.04 ^a
MT + Insulin + 2.5 mg/mL of <i>B. obscura</i>	7.21 ± 1.2 ^b	10.61 ± 1.25 ^{ab}	23.31 ± 4.12 ^{ab}
MT + Insulin + 5 mg/mL of <i>B. obscura</i>	7.32 ± 1.03 ^b	10.32 ± 0.97 ^{ab}	28.44 ± 3.60 ^c
MT + Insulin + 7.5 mg/mL of <i>B. obscura</i>	7.81 ± 0.87 ^b	10.89 ± 1.13 ^{ab}	35.40 ± 0.90 ^d

MT: Muscle Tissue. Values with different indices in the same lines had significant differences at 5%.

4. DISCUSSION

The present study was designed to investigate the potential of *Beilschmedia obscura* seed powder to modulate blood glucose levels and improve glycemic control under diabetic conditions. To establish the diabetic model, we utilized streptozotocin, which is toxic to pancreatic β -cells. As demonstrated in previous studies, such as those by Ye et al.,²² streptozotocin led to a notable increase in fasting blood glucose levels and a significant reduction in hepatic glycogen stores. These changes confirmed that hyperglycemia was successfully induced and that hepatic glucose metabolism was indeed impaired.

In untreated diabetic rats, hyperglycemia persisted throughout the experimental period, while hepatic glycogen content remained markedly reduced, reflecting insulin deficiency and hepatic insulin resistance. However, *B. obscura* seeds led to a significant decrease in blood glucose levels by 81.71% after 2 weeks. This effect, similar to that of Glibenclamide, suggests that *B. obscura* seeds may exert both insulin-sensitizing and insulin-mimetic activities. Medicinal plants of the same family (Lauraceae) like *Laurus nobilis* L. leaf have demonstrated similar glucose-lowering abilities, further supporting this hypothesis⁹.

This hypoglycemic effect of *B. obscura* seeds powder could be due to its ability to regenerate or protect insulin-producing pancreatic beta cells, given the destruction by

streptozotocin²³. Polyphenols, notably flavonoids present in *B. obscura* powder seeds have been documented to regenerate or attenuate the destruction of pancreatic beta cells after streptozotocin-induced damage^{24,25}. These beneficial effects on β -cell function could lead to the increased glycogen levels, as insulin not only stimulates glycogenesis via activation of glycogen synthase but also inhibit hepatic glucose output²⁶.

To better understand the potential mechanisms of action of *B. obscura* powder seed on glycemic control, we evaluated the carbohydrate digestion and absorption, glucose adsorption capacity and glucose uptake by yeast (non-insulin-dependent) and rat psoas muscle tissue (insulin-dependent). In fact, several available studies report multiple mechanisms by which antidiabetic plants exert blood glucose-lowering effects. This includes inhibition of carbohydrate enzymes, enhancement of insulin sensitivity, regeneration of damaged pancreatic β -cells as well as enhancement of secretion and release of insulin²⁷.

In the current study, *B. obscura* powder seed significantly attenuated postprandial blood glucose spikes induced by starch, sucrose, and glucose. The powder reduced glycemic peaks and enhanced glucose clearance over time, suggesting inhibition of carbohydrate digestion and delayed glucose absorption. The mucilage of *B. obscura* seeds contains a significant amount of soluble dietary fibers, which are known to play a crucial role in modulating glucose absorption and improving glycemic control. Soluble fibers, such as those derived from arabinose and xylose found in *B. obscura* seeds, can form viscous solutions in the gastrointestinal tract, which slow down the digestion and absorption of carbohydrates, thereby reducing postprandial blood glucose spikes^{28,29}. The American Diabetes Association encourage people to increase their intake of dietary fiber to reduce the risk and manage the progression of diabetes^{28,30}.

Furthermore, *B. obscura* seeds powder stimulates glucose uptake both into yeast (non-insulin-dependent cells) and skeletal muscle cells (insulin-dependent cells), indicating a possible enhancement of insulin signaling pathways. These findings suggest that *B. obscura* seeds powder may directly regulate blood glucose by stimulating glucose uptake into cells via non-insulin-dependent and insulin-dependent glucose transport or possibly increase insulin sensitivity. The ability of flavonoids to stimulate Glut 4 and 1 translocation has been already demonstrated³¹.

In addition, *B. obscura* powder exhibited a high glucose adsorption capacity, suggesting a presence of fiber-like compounds capable of binding free glucose within the gastrointestinal lumen. Such glucose sequestration could reduce intestinal glucose absorption and postprandial glycemia. These effects could be also due to the flavonoids present in *B. obscura* seeds powder. Flavonoids have been shown to bind through their hydroxyl group to glucose to form glycosyl-flavonoid complexes by glycosylation reactions³², reducing the availability of glucose. Moreover, consumption of dietary fiber, particularly soluble fiber could delay gastric emptying and decrease absorption of macronutrients,

resulting in lower postprandial blood glucose and insulin levels^{28,29}.

5. CONCLUSION

This study demonstrated that *Beilschmiedia obscura* seed powder exerts significant antihyperglycemic effects in both normoglycemic and streptozotocin-induced diabetic rats through multiple complementary mechanisms. The powder markedly reduced fasting and postprandial blood glucose levels, enhanced hepatic glycogen storage, and stimulated glucose uptake in both insulin-dependent and non-insulin-dependent cellular models. Together, these findings suggest that *B. obscura* seed powder is a promising functional food candidate for the prevention and management of type 2 diabetes, particularly in low-resource settings where plant-based interventions offer accessible alternatives.

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Authors' contributions

Essouman and Edoun carried out the study. Essouman, Ella and Takuissu wrote the manuscript. Gouado, Essola and Nnanga reviewed the manuscript. Essouman and Ella analyzed the data. Ngondi contributed to the conception and design of the study. All authors have read and approved the final manuscript.

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