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Experimental Design on the Potency of *Moringa oleifera* with Acarbose on the Blood Glucose Level and Weight of Diabetic Type II Rats in Relative to the Case of Human Patient

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Authors' contributions

This work was carried out in collaboration between all authors. Author OMB designed the study, performed the statistical analysis. Authors ASK and AEO wrote the first draft of the manuscript and managed the analyses of the study. Authors ASK and AEO managed the literature searches. All authors read and approved the final manuscript.

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Abstract

In this study, an experimental design was carried out on the potency of *Moringa oleifera* to Acarbose of STZ-induced type II diabetic rats. It also examined the blood glucose level of those rats and the weight gain and losses of the rats during the experimental period. The data used were primary data which were collected through field experimental method, taking sources from the Federal University of Technology Akure, Ondo state and Rufus Giwa Polytechnic Owo, Ondo state of Nigeria. The result from the analysis showed that *Moringa oleifera* had a significant potency on the blood glucose level of STZ-induced type II diabetic rats. The treatment when combined that is moringa with acarbose showed a greater decrease in glucose level. The [1] was adopted for the analysis of the results. The study, however, concluded that since rats and humans often suffer from the basic physiology, similar organs and similar body plans, moringa should be added to the diet of diabetic patients by their nutritionist and more awareness should be created by health workers on the use of *Moringa oleifera* to the populace.

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Keywords: Experimental design; completely randomised design (CRD); albino rat; Moringa oleifera; analysis of variance (ANOVA).

DEFINITION OF TERMS

$CRD \Rightarrow$ Completely Randomised Design
$DM \Rightarrow$ Diabetic Mellitus
$ANOVA \Rightarrow$ Analysis of Variance
$STZ \Rightarrow$ Streptozotocin
$Glycemia \Rightarrow$ The presence or the level of glucose in one's blood
$Nephonopat\,hy \Rightarrow$ Means Kidney disease or damage
$Nateglinid\,e \Rightarrow$ is a drug for the treatment of type II diabetes which is used to control blood sugar levels.

1 Introduction

Experimental design is a way to carefully plan experiments so that your results are both objective and valid. Ideally, your experimental design should describe how participants are allocated to experimental groups. A common method is a completely randomised design, where participants are assigned to groups at random. A second method is randomised block design, where the participants are divided into the homogeneous block. In an experiment, we deliberately change one or more process variables (or factors) to observe the effect, the changes have on one or more response variables. The design of experiment (DOE) is an efficient procedure for planning experiments so that the data obtained can be analysed to yield a valid and objective conclusion. Most times, experimenters get involved with experimentation using people or animals. This has been done, especially in the area of clinical trials involving health care delivery or other medical problems or in testing out educational teaching and institutional strategies or even in psychological experiments and animal nutrition problems.

Analysis of variance (ANOVA) is a process of decomposition or partition or breaking down the total observed variance in a sample, into independent sources of variation such that the contribution due to each source can be tested for significance. Hence it is an inferential method that is used to test the equality of three or more population means. The interest is to know or study the effect of one factor on the performance of each experiment.

2 Empirical Literature Review

According to [2], this study revealed that treated STZ-induced diabetes male rats with low doses of *Moringa oleifera* has a safe and an excellent anti-diabetic activity due to its content of antioxidant compounds such as phenols and flavonoids and almost restored the diabetic rats to the normal healthy state. In addition, lower doses of moringa under study may have greater medical benefits when used as food supplement for diabetic people's diet. According to [3], with the use of Latin Square Design revealed that STZ induced diabetes affects the biochemical function of the liver significantly and causes disturbance in the activity of liver enzymes. Medicinal plants are used for the treatment of type II diabetes mellitus as a great sign in correcting the abnormalities in the pancreatic beta cell in the body system. According to [4], the nutritional analysis indicates that the leaves contain wealth of essential disease-preventing nutrients which makes it suitable as supplements in food. According to [5], in his study using Dunnett's T-test revealed that the administration of *Moringa oleifera* is a significant restoration of the glucose, liver and muscle glycogen and insulin. [6], the study revealed that the aqueous extract of *Moringa oleifera* leaves possesses potent hypoglycemic effects through the normalization of elevated hepatic pyruvate carboxylase enzymes and regeneration of damaged hepatocytes and pancreatic beta cells via its antioxidant properties.

2.1 Albino Rat

By late 18 or early 19 centuries, albino rat became the most commonly used experimental animals in the numerous biomedical researchers as they have been recognised as the pre-eminent model mammalian system. More importantly, rats and humans often suffer from the same basic physiology, similar organs and similar body plans. We both have a nervous system that works in the same way. But, the precise correlation between age of laboratory rats and human is still a subject of debate. A recent population dealing with biomedical research application list the following areas of biomedical investigation as one in which the rats are widely used and are particularly useful in toxicology, teratology, experimental oncology, experimental genontology, cardiovascular research immunogenetics and experimental parasitology.

2.2 *Moringa oleifera*

This is popularly known in many countries as ‘’miracle plant’’ because of its nutritional and medical properties. *Moringa oleifera* is the most cultivated plant in moringaceae family. Primarily it grows in tropical, sub-tropical and semi-arid climate. This plant was well known to the ancient world until recently rediscovered as a multipurpose tree with a tremendous variety of potential uses. It is commonly used in folk medicine as an antidiabetic agent. It is used in traditional Indian medicine for centuries, this plant is overflowing with vitamins A,B,C,D,E and minerals including potassium, calcium, iron, selenium and magnesium. Moringa leaves are rich in essential amino acids which are not commonly found in plants and it is extremely rich in proteins. It is well known as stimulant for milk production for breastfeeding mothers. Moringa leaves can be dried at low temperature and made into powder using a mortar and pestle. Moringa leaves are completely safe for human consumption. There are no any toxic elements or side effects. Traditional medicine techniques used moringa leaves to treat gastrointestinal problems, headache, inflammation, anaemia, fever, eye infection, bronchitis, poor nutrition, inner ear infection, skin infection (tropical use).

2.3 Diabetes mellitus (DM)

Diabetes mellitus (DM) is a metabolic disorder characterized by chronic hyperglycemia or high blood glucose levels with deranged carbohydrates, fats and proteins metabolism resulting from absolute or relative lack of insulin secretion or insulin resistance by peripheral tissues mainly the liver, skeletal muscle and adipose tissues or both. Left untreated diabetes can cause many complications. Acute complication can include diabetic ketoacidosis, nonketotic hyperasmolar coma, or death. Serious long-term complication includes heart diseases, stroke, chronic kidney failure, foot ulcer and damage to the eyes. There are several drugs for the treatment of diabetes. They, however, have prominent side effects [7] and most often out of reach for most diabetics. The next option is dietary treatment using foods that are locally available with hypoglycaemic effect. There has been increasing demand for the use of natural plant products with antidiabetic activity [8]. This is because of their Diabetes is due to either the pancreas is not producing enough insulin or the cells of the body not responding properly to the insulin produced.

2.4 Acarbose

Acarbose is a glucosidose inhibitor. It works by slowing down the enzyme that turns carbohydrates into glucose. This results in a smaller rise in blood sugar levels following a meal. It is used for treating type 2 diabetes.It is used along with diet and exercise. It may be used alone or with other antidiabetic medicines. Acarbose (INN) is an anti-diabetic drug used to treat diabetes mellitus type 2 and in some countries prediabetes. It is generic. It is a starch blocker and inhibits alpha-glucosidase, an intestinal enzyme that releases glucose from larger carbohydrates. It composes on acarviosin moiety with a maltose at the reducing terminus.

3 Research Methodology

3.1 The experimental animals

A total of (35) healthy and pathogen-free albino rats of male sex with the body weight of 200-255g were obtained at Federal University of Science and Technology, Akure, Ondo state. The animals were housed in a cage and kept in the animal house of the Science Laboratory Department, Rufus Giwa Polytechnic Owo Ondo state. Maintained under the standard husbandry conditions (between 22^0c, 12hours light, 12hours dark and 30-35% humidity). The animals were fed with standard feed(animal feed) and clean drinking water to acclimatize for 10 days. Proper sanitation was maintained in the animal house to ensure healthy and clean environment. Handling management and the use of animals for experiments were maintained and supervised by MrsAkintemi A.O. (Department of Science Laboratory Technology).

3.2 Collection and identification of plants material

Fresh leaf samples of *Moringa oleifera* leaves and seeds were harvested from the Department of Agricultural farm of the Rufus Giwa Polytechnic, Owo, Ondo state. The fresh leaves and seed of *Moringa oleifera* were air-dried for one month and grinded into powder. A little portion was taken to Food Science and Technology laboratory for proximate analysis, 50 g of the sample was weighed and soaked 100ml distilled water (aqueous solution) and 98% ethanol respectively and allowed to stand for 48 hours for extraction of active ingredients. After 48 hours, the samples were double filtered using whatman No 1 filter paper and porocelain cloth. The filtrate was evaporated to dryness at a reduced temperature of 40°C.

3.3 Induction of diabetes

The experimental animals were first weighed before the commencement of the experiment. After 10 days, the animal was grouped into 7 (A,B, C, D, E, F and G). 0.35 g of streptozotocin was dissolved in 10ml of distilled water and were administered to each of the rats in group B, C, D, E, F and G base on the body weight of each rat and on a dosage of 35 mg/kg. The administration of streptozotocin was done intraperitoneally using diabetic syringes. After 72 hours, the rats with sugar level more than 200mg/di were considered experimentally diabetic. Animal in group A is the normal rats i.e. has no diabetes, B serves as control i.e has diabetes but no treatment, C were treated with 0.2ml acarbose which serves as reference drug, group D were treated with 20mg *Moringa oleifera* leaves for the first week and 40mg for second and third weeks,group E were treated with 20mg moringa leaves and 0.2mi drug for the first week and 40 mg for the second and third weeks, F were treated with 20mg *Moringa oleifera* seeds for the first week and 40mg for the second and third weeks, while group G were treated with 20mg moringa leaves and 0.2ml drug for the first week and 40mg for the second and third weeks for 7,14 and 21 days respectively. Hence the blood glucose levels were measured using reagent strip with a glucometer (Accucheck Active, Roche, Germany) in samples obtained from the tail vein. Animal with blood glucose levels of 200 mg/dl and more were accepted as diabetic rats.

4 Model Specification

4.1 Design analysis of a one-factor randomised experiment (CRD)

In a one-factor experiment measurements (or observations) are obtained for an independent group of samples, where the number of measurements in each group is b. We speak of treatments, each of which has b repetitions or b replications some basic background and basic procedure that should be followed in the design and analysis of this kind of experiment are as follows:

(i) Firstly, identify the only factor of the experiment and let this factor be represented by X with levels $X_1, X_2, ..., X_p$;

(ii) Determine and/or define the number of replications of each level (treatment) X_i

(iii) Determine the number of homogenous plot available for the experiment; let $N = \sum_{i=1}^{n} n_i$

if there exits no prior information about the experiment, it is advisable for the experimenter to apply uniformly trials on the plots (or experimental units) that is apply the same treatment to all the units to detect those ones that are inherently different.

(iv) A procedure for the allocation of treatments to the plots would need to be defined. This allocation is usually by randomization.

(v) The data from the experimental units are collected for analysis. The data would appear as in form of the table below:

Tables of Data

		Repetitions (j)				
		1	2	3	⋯	n_i
Treatment (i)	$Y_1 = t_1$	y_{11}	y_{12}	y_{13}	⋯	$y_1 n_1$
	$Y_2 = t_2$	y_{21}	y_{22}	y_{23}	⋯	$y_2 n_2$
	⋮	⋮	⋮	⋮	⋯	⋮ $y_3 n_3$
	$Y_p = t_p$	y_{p1}	y_{p2}	y_{p3}	⋯	$y_p n_p$

(vi) It will be useful to analyse the data above by firstly describing the observations using the linear statistical model:

$$y_{ij} = \mu + t_i + e_{ij};$$
$$i = 1,2,...,p$$
$$j = 1,2,...,n_i \qquad \therefore (n_1 = n_2 = ... = n_p = n)$$

Interpretation of the model:

y_{ij} is the observed value of the ith treatment in the jth replication.

μ is the universal constant independent of the treatments.

t_i is the average effect of the ith treatment.

e_{ij} is the observational error associated with y_{ij}

Assumptions:

(i) Normality: All the random variables are normally distributed, i.e. $e_{ij} \sim N(0, \sigma_e^2)$, $t_i \sim N(0, \sigma_t^2)$, $y_{ij} \sim N(\mu_y, \sigma_y^2)$; $\sum_{i=1}^{n} t_i = 0$ under fixed.

(ii) Independence" All the random variables are independently distributed i.e $\text{cov}(e_{ij}, t_i) = 0,\ \text{cov}(e_{ij}, \mu) = 0,\ \text{cov}(t_i, \mu) = 0,\ \text{cov}(t_i, t_j) = 0 \quad \forall i = j$.

(iii) Constant Variance: All the random variables follow constant variance i.e

$$\text{var}(t_i) = \sigma_t^2 \ \forall i$$

$$\text{var}(e_{ij}) = \sigma_e^e \ \forall i, j$$

$$\text{var}(y_{ij}) = \sigma_y^2 \ \forall i, j$$

Our interest is to test for the equality of the p treatment effects. We therefore, propose the following suitable hypothesis: $H_0 : t_1 = t_2 = t_3 = ... = t_p = 0$

$H_1 : t_i \neq 0$ for at least one i

Decision Rule: Reject H_0 if $\dfrac{Mst}{Mse} \geq F_{(p-1),(1-\alpha)}$

at α the level of significance.

4.2 Applying the method of least square

Making e_{ij} the subject of the model stated earlier and taking the sum of squares of both sides of the equation we obtain $\phi(\mu, t_i) = \sum_{ij} e_{ij}^2 = \sum_{ij} (y_{ij} - \mu - t_i)^2$

Taking the partial derivative of $\phi(\mu, t_i)$ with respect to t_i and μ equating them to zero.

$$\frac{\partial \varphi(\mu, t_i)}{\partial t_i} = \frac{\partial \varphi(\mu, t_i)}{\partial \mu} = -2\sum_{ij} (y_{ij} - \hat{\mu} - \hat{t}_i) = 0$$

which is the normal equation.

Then solving this normal equation for $\hat{\mu}$, $\hat{t}_i$ and $\hat{e}_{ij}$, we get

$$\hat{\mu} = \bar{y}_{..}$$

$$\hat{t} = \bar{y}_{i.} - \bar{y}_{..}$$

$$\hat{e}_{ij} = y_{ij} - \bar{y}_{i.}$$

To calculate the sum of squares:

Firstly, we notice that for

$y_{ij} = \hat{\mu} + \hat{t}_i + \hat{e}_{ij}$ we can write

$y_{ij} = \bar{y}_{..} + \bar{y}_{i.} - \bar{y}_{..} + y_{ij} - \bar{y}_{i.}$

Squaring both sides of the identity gives

$$y_{ij}^{\ 2} = (\bar{y}_{..} + \bar{y}_{i.} - \bar{y}_{..} + y_{ij} - \bar{y}_{i.})^2$$

Summing over all the subscript gives

$$\sum_{ij} y_{ij}^{\ 2} = \sum_{ij} (\bar{y}_{..} + \bar{y}_{i.} - \bar{y}_{..} + y_{ij} - \bar{y}_{i.})^2$$

Simplifying further we have

$$\sum_{ij} y_{ij}^{\ 2} = \sum_{ij} (\bar{y}_{..}^{\ 2} + (\bar{y}_{i.} - \bar{y}_{..})^2 + 2\bar{y}_{..}(\bar{y}_{i.} - \bar{y}_{i.}) + (y_{ij} - \bar{y}_{i.})^2 + 2\bar{y}_{..}(y_{ij} - \bar{y}_{i.}) + 2(\bar{y}_{i.} - \bar{y}_{..})(y_{ij} - \bar{y}_{i.}))$$

$$\Rightarrow \sum y_{ij}^{\ 2} = N\bar{y}_{ij}^{\ 2} + \sum_{i} n_i((\bar{y}_{i.} - \bar{y}_{..})^2 + 0 + \sum_{ij} (y_{ij} - \bar{y}_{i.})^2 + (0+0)$$

Hence,

$$SST = \sum y_{ij}^{\ 2}$$

$$SS\mu = \mu\bar{y}^2$$

$$SSt = \sum_{i} n_i (\bar{y}_{i.} - \bar{y}_{..})^2$$

$$SSe = \sum_{ij} (y_{ij} - \bar{y}_{i.})^2$$

ANOVA TABLE

SV	D.F	SS	MS	EMS OR F-Ratio
μ	1	$SS\mu$	–	
t_i	$p-1$	SSt	MSt	$\frac{MSt}{MSe} \sim F_{(p-i),p(n-1).(1-\alpha)}$
e_{ij}	$p(n-1)$	SSe	MSe	
Total	np	SST	–	

Where; $MSt = \frac{SSt}{p-1}$ and $MSe = \frac{SSe}{p(n-1)}$

Sum of Square:

$$SS\mu = \frac{T_{..}^{\ 2}}{np} = c$$

$$SSt = c_i - c \text{ where } c_i = \sum_{i} \frac{T_{i.}^{\ 2}}{n}$$

$$SSe = c_{ij} - c_i \text{ where } c_{ij} = \sum_{ij} y_{ij}^{\ 2}$$

4.3 Purpose of the study

Our interest is to test if there exists a significant difference among the treatments on the glucose level of the diabetic rats.

4.4 Hypothesis formulation

H_0: There is no significant difference among the treatments on the glucose level of the diabetic rats.
Vs
H_1: There is a significant difference among the treatments on the glucose level of the diabetic rats.

5 Discussion of Results

The data were obtained during the course of the treatment of the albino rats, based on blood glucose level in (mg/dl) and weight in (mg/kg) for three consecutive weeks. The analysis of the data was carried out on blood glucose versus treatments and weight versus treatments in a similar approach, using one-way analysis of variance at first, second and third weeks respectively. The F -values and P -values and $\pm S.E$ -values were used to reach statistical conclusions. The [1] was adopted to obtain the necessary results for discussion.

Table 1. Output of one-way ANOVA: Blood glucose of animal at week 1 versus treatments

Source	DF	SS	MS	F	P
TREATMENTS	6	187440.755	31240.126	15.88	<0.001
Error	28	55087.995	1967.428		
Total	34	242528.948			

S = 37.63 R-Sq = 17.73% R-Sq (adj) = 0.00%

Source: Authors computation from [1].

Table 2. Output of one-way ANOVA: Blood glucose of animal at week 2 versus treatments

Source	DF	SS	MS	F	P
TREATMENTS	6	182482.571	30413.761	14.74	<0.001
Error	28	57784.4	2063.729		
Total	34	240266.971			

S = 35.02 R-Sq = 15.49% R-Sq (adj) = 0.00%

Source: Authors computation from [1].

Table 3. Output of one-way ANOVA: Blood glucose of animal at week 3 versus treatments

Source	DF	SS	MS	F	P
TREATMENTS	6	175836.286	29306.048	13.65	<0.001
Error	28	60093.6	2146.2		
Total	34	235929.886			

S = 29.80 R-Sq = 19.97% R-Sq (adj) = 0.00%

Source: Authors computation from [1].

Table 4. Output of the confidence interval of the treatments

Treatments	FBG	7th day	14th day	21st day
Group A	85.0 ± 3.4^{c}	86.0 ± 1.4^{c}	86.6 ± 3.2^{c}	87.4 ± 3.1^{c}
Group B	320.0 ± 2.3^{a}	330.0 ± 2.1^{a}	335.0 ± 1.9^{a}	337.6 ± 2.3^{a}
Group C	306.4 ± 2.1^{b}	280.8 ± 2.1^{b}	290.0 ± 1.7^{b}	289.4 ± 2.3^{b}
Group D	307.4 ± 1.5^{d}	274.4 ± 2.1^{d}	268.0 ± 1.9^{d}	256.2 ± 2.2^{d}
Group E	322.2 ± 2.1^{a}	294.4 ± 2.2^{a}	281.0 ± 1.9^{a}	249.8 ± 2.3^{a}
Group F	298.0 ± 1.9^{e}	277.8 ± 2.1^{e}	268.6 ± 1.7^{e}	255.6 ± 2.3^{e}
Group G	304.0 ± 2.1^{c}	274.0 ± 2.1^{c}	259.0 ± 1.9^{c}	230.6 ± 2.3^{c}

Source: Each value was obtained by calculating the average of one experiment $\pm S.E$ *, and the superscript letters indicated statistically significant differences with* $p < 0.05$.

Table 5. Output of one-way weight of animal at week 1 versus treatments

Source	DF	SS	MS	F	P
TREATMENTS	6	13568.971	2713.794	5.51	<0.001
Error	28	11823.2	492.633		
Total	34	25392.171			

S = 37.63 R-Sq = 17.73% R-Sq (adj) = 0.00%

Source: Authors computation from [1].

Table 6. Output of one-way weight of animal at week 2 versus treatments

Source	DF	SS	MS	F	P
TREATMENTS	6	11364.8	1194.133	2.07	0.689
Error	28	25528.6	911.736		
Total	34	36893.4			

S = 46.89 R-Sq = 14.34% R-Sq (adj) = 0.00%

Source: Authors computation from [1].

Table 7. Output of one-way weight of animal at week 3 versus treatments

Source	DF	SS	MS	F	P
TREATMENTS	6	265686.734	44281.124	37.72	0.00
Error	28	32871.4	1173.979		
Total	34	298558.143			

S = 29.80 R-Sq = 19.97% R-Sq (adj) = 0.00%

Source: Authors computation from [1].

At 5% level of significance,

Critical value $\Rightarrow F_{tab} = F_{v1,v2,}\alpha = F_{6,28}\,0.05 = 2.42$

Decision Rule: Reject H_0 if $F_{cal} > F_{tab}$ if otherwise accept H_0

Table 8. Output of the confidence interval of the treatments

Treatments	0 day	7th day	14th day	21st day
Group A	207.2 ± 2.2^{a}	206.8 ± 1.8^{a}	206.0 ± 2.5^{a}	208.4 ± 2.3^{a}
Group B	166.6 ± 2.2^{c}	158.8 ± 1.8^{c}	155.0 ± 2.5^{c}	149.2 ± 2.3^{c}
Group C	162.8 ± 2.2^{b}	167.4 ± 1.8^{b}	171.0 ± 2.5^{b}	172.6 ± 2.3^{b}
Group D	150.0 ± 2.2^{d}	153.8 ± 1.8^{d}	166.4 ± 2.5^{d}	164.6 ± 2.3^{d}
Group E	138.0 ± 2.2^{e}	143.8 ± 1.8^{e}	148.8 ± 2.5^{e}	151.0 ± 2.3^{e}
Group F	145.4 ± 2.2^{e}	149.8 ± 1.8^{e}	153.8 ± 2.5^{e}	157.2 ± 2.3^{e}
Group G	144.6 ± 2.2^{f}	151.0 ± 1.8^{f}	156.8 ± 2.5^{f}	163.6 ± 2.3^{f}

Source: Each value was obtained by calculating the average of one experiment $\pm S.E$*, and the superscript letters indicated statistically significant differences with* $p < 0.05$.

5 Interpretation

Acute STZ-induced diabetic albino rats were treated with moringa leaves, moringa seeds, acarbose drug, moringa leaves and acarbose drug and moringa seeds and acarbose drug for a period of 21 days. The diabetic studies revealed non-toxic nature of the *Moringa oleifera* at a concentration of 40mg/kg. There were some morphological changes like weight losses, more drinking water and more urine. There were no any toxic reactions found at either dose selected till the end of the treatment period.

The findings from the above statistical analysis showed that there is a significant difference among the treatments on the blood glucose level for the three weeks. The level of blood was significantly decreased in group D, F and G compared with the diabetic group B (268.0 mg/dl, 268.6 mg/dl, 259.0 mg/dl and 335.0 mg/dl) in the second week of treatment. There was also significant difference observed on the third week of the blood glucose levels among the groups D, E, F and G compared with the diabetic group B (256.2 mg/dl, 249.8 mg/dl, 255.6 mg/dl, 230.6 mg/dl and 337.6 mg/dl).

Based on the findings on weight, the 1st week and 3rd week shows that there is a significant difference among the treatments used on the weight of the STZ-induced diabetic rats. The 2nd week shows that there is no significant difference among the treatment, which means good affection of dose. Hence, the weight shows a significant increase in the moringa and acarbose group compared to the control diabetic group.

6 Conclusion

Based on the findings the addition of moringa compared with acarbose had superior anti-hyperglycemia potency and provided an efficacious and safe alternative for the treatment of type 2 diabetic rats. Acarbose/moringa reduced the fasting blood glucose level. Treating STZ-induced diabetic rats with low doses of moringa revealed a safe and excellent anti-diabetic activity, due to its contents of antioxidant compounds such as glucomoringa, phenols and flavonoids and almost restored the diabetic rats to the normal healthy state. However, since rats and humans often suffer from the same basic physiology, similar organs and similar body plans, the lower doses of moringa under study may have greater medical benefits when used as food supplement for diabetic patient's diet.

Ethical Approval

As per international standard or university standard, ethical approval has been collected and preserved by the authors.

Competing Interests

Authors have declared that no competing interests exist.

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