original Article

Anti-diabetic Effect of Sprouted *Trigonella foenum-graecum* L. Seed Solid Dosage Form in Low-dose Streptozotocin Induced Diabetic Rats

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ABSTRACT

Background: *Trigonella foenum-graecum* L (Fenugreek) is an annual herb, mainly cultivated for its seed as well as for its sprouts. Pharmacological investigations reported anti-bacterial, anti-diabetic, anti-cancer, anti-diarrheal, anti-hypercholesteremic, and anti-inflammatory activities of *Trigonella foenum-graecum* L. **Aim:** The purpose of this study was to accentuate on formulation of granules and investigate the effect of germinated *Trigonella foenum-graecum* L. (TFG) granules in Diabetes mellitus (DM) rats induced by streptozotocin as fenugreek retains hypoglycemic property. **Materials and Methods:** Granules of germinated TFG powder were arranged by means of several excipients comprising diverse amounts of super disintegrants by (wet) granulation method and proceed for the solid dosage form evaluation. Further, *in-vivo* study was performed in STZ induced DM Wister rats for four weeks. TFG granules 1600mg/kg and Glibenclamide 0.45 mg/kg (as a positive control for comparison) were orally administrated and evaluate the diabetics in rats. **Results:** All evaluation parameter are correct: as in standard tablet. The STZ (Streptozotocin) induced rats the treatment with the Drug (Glibenclamide) and TFG granules significantly lowered the blood plasma glucose levels by 36% (mean ± SD glucose 120 ± 0.6 mg/dL ($p < 0.001$)) and 38% (mean ± SD glucose 114 ± 0.4 mg/dL; $p < 0.001$) respectively after 4 weeks of treatment when compared to T2DM (Type 2 Diabetes mellitus) rats. **Conclusion:** Experimental studies had shown that bioactive compounds found in *Trigonella Foenum graceum* herb have potential to cure diabetes especially due to the presence of unique chemical constituent including trigonelline, galactomannan and amino acid 4-hydroxy isoleucine. These findings suggested that TFG granules may be an alternative medicine for the management of DM.

Keywords: *Trigonella foenum-graecum,* Fenugreek, Anti-diabetic, Tablet, Diabetes mellitus.

INTRODUCTION

Medicinal plants are a higher source of the beneficial agents for hindrance and treatment of various disorder ever since long ago. The affluence of plant centered medicines, health products, pharmaceuticals, nutraceuticals and other formulations are aggregate day by day in all over the world. As it has been acknowledged by researchers and health professionals that the natural products are non-toxic, having insignificant side effects and effortlessly accessible with inexpensive costs. Several researches have begun to clinch from customary plants as scientists and investigators search for new replacements for treatment of diabetes. The Chinese and traditional Indian medicinal system since long ago consuming plants, herbal extracts, crude drug powders etc. As anti-diabetic agents. Therefore, investigation on such agents from traditional plants has become astonishing lead and investigators are competing to find novel and effective

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therapeutic agent which is also safe for the management of blood sugar level in diabetic patient.[1] Diabetes Mellitus (DM) is a long-lasting metabolic-disorder categorized by common feature of chronic hyper glycaemia with concerned carbohydrate, fat and protein metabolism, with a mounting dominance all over the world, owing to insufficiency of insulin, substandard insulin exploit, or both. The terms "Diabetes", and "Mellitus" is derived from Greek. "Diabetes" signifies "a passer through; a siphon" however "Mellitus" signifies "sweet". It was understood that Greeks named it so owing to extreme quantities of urine produced via diabetics engrossed flies, and bees. A customary way of analyzing DM in prehistoric Chinese was by witnessing whether ants are engrossed to a person's urine or not.[2]

Fenugreek seeds comprise steroidal saponins as were chief ingredients. These saponins include trigofoenoside. Other saponins comprise yamogenin tetroside B and C, Tenugrin B, neotigogenin, gitogenin, tigogenin, and diosgenin. Seeds comprise glycosides of diosgenin. These also comprise lots of flavonoid complexes such as isovitexin, luteolin, homoerietin, vitexin, saponaretin, vicenin-1 and vicenin-2. Fenugreek seed is a higher source of anti-diabetic compounds which embrace 4-hydroxyisoleucine, fenugrekine, quercetin, trigonelline and 3-hydroxy4, 5-dimethyl-2(5H) furanone (stolone). The Fenugreek seed sprouts have tremendous benefits in our day-to-day life and also have greater anti-diabetic activity. It is not as acceptable by large group of population as the reason are its bitter taste, appearance and non-uniformity of dose. The stake prandial hypoglycemic commotion of fenugreek seeds in type 2 DM on patients and bring into being the considerable dropping of blood sugar level in patients.[3]

The powder of *Trigonella foenum graecum* (fenugreek) seed has the latent Antidiabetic stuffs. The consequence of oral administration of Trigonella complete seed powder on diabetic rats have been studied. Trigonella seed powder treatment to diabetic rats worse down higher fasting glucose levels in blood into the control levels. Improved enzyme actions were noticeably returned to control values in both the liver as well as kidney, after the treatment of Trigonella seed powder.[4] Sprouting procedure of fenugreek upsurges the hypoglycemic activity have several folds, and can turn in a well way for controlling diabetes. The effect of oral running of germinated fenugreek seed extracts on innumerable biological indicators like blood, hepatic glycogen, glucose, insulin content besides significant molecular indicators of insulin signaling path in STZ-induced diabetic rats was measured. The germinated seed extract regularized suggestively, several deregulated molecular and biochemical indicators of insulin signaling pathway, then their seeds.[5]

MATERIALS AND METHODS

Seed sprouting/powder materialization

Dehydrated fenugreek seeds will be soaked into distilled water in round bottom flasks for 24 hr in B.O.D indicator at a controlled temperature of 30°C. After 24 hr, the seeds would be transmitted into formerly moisturized muslin cloth and placed inside the jars such that appropriate ventilation would deliver to the seeds which aids them to sprout. These sprouts then dehydrated for 36 hr and placed into hot air oven at temperature not more than 40°C to reduce total dampness. These dehydrated fenugreek seeds then milled to acquire fine powder.[6-7]

Calibration curve of trigonelline by UV spectrophotometer

10mg of standards of trigonelline hydrochloride was dissolved in phosphate buffer pH 6.8 in 100ml volumetric flask and volume was make up to 100 mL so that 100 µg/mL of stock solution is prepared. From this solution, 1 mL was taken and then volume was made up to 100 mL. Then different dilutions of strengths viz. 10, 20, 30, 40 and 50 µg/ml from this solution and then absorbance was taken in UV (UV-1700SHIMADZU) at 264.40nm, and standard curve was plotted.[5]

Optimization of formulation of sprouted fenugreek seeds powder

A typical process optimization methodology includes a systematic identification of critical quality attributes, critical processing parameters and a risk assessment to identify the critical selection of key parameters. In this experimental design different concentrations of disintegrating agents were taken in formulation of tablets to determine the effect of the disintegrants. Configuration of different designs as per Table 1 prepared using varying amounts of the disintegrating agents. The trial-and-error method was used in design of these formulation. In S-1 to S-6 formulation concentration of microcrocrystalline cellulose, crosspovidone, sodium starch glycolate and cross carmellose sodium were taken in the different concentrations which are stated in Table 1 and disintegration time and dissolution tests were carried out in which the formulations were failed to comply the limits.

Table 1: Formulation of Tablet containing germinated fenugreek powder.

Ingredients (mg)	Formulation Batches					
	S-1	S-2	S-3	S-4	S-5	S-6
Fenugreek Powder	400	400	400	400	400	400
Lactose	185	185	185	185	185	185
Cross povidone	25	20	10	10	20	30
Microcrocrystalline Cellulose	10	15	15	-	-	-
Crosscarmellose Sodium	-	-	-	30	20	25
Sodium Starch Glycolate	25	35	45	20	10	5
Magnesium Stearate	2	2	2	2	2	2
Talc	3	3	3	3	3	3

Preparation of granules and tablets of germinated fenugreek seeds powder

Granules of germinated fenugreek powder were arranged by means of several excipients comprising various amounts of super disintegrants using the wet granulation process External binding agents are not used because the mucilaginous elements in fenugreek act as binding agents. The granules were punched in a single tablet punching machine (Hicon Single Tablet punching machine) having die and punch no-12. For wet granulation sieve no-20 was used. The granules were dried out in warm air oven at temperature 50°C. Other components like flour, talc, and magnesium stearate were added in the needed amounts. Formulae for different batches are shown in table given below:

Evaluation of Granules

Angle of repose

It is calculation of granule movement or flow characteristic. The coefficient of friction between a particle is equal to the tangent of angle repose. An angle of repose was calculated by pouring grains onto surface from an immovable height of 2 cm using a funnel. The radius of a pile's base was calculated five times and the average was used to calculate the angle of repose applying the formula below.[8]

Angle of repose = tan (h/r)

Where,

h = height of a pile (2 cm),

r = radius of pile base.

Bulk/tapped density, compressibility index and hausner's ratio

Bulk density was determined in accordance with the method specified in USP. 20g of granules were placed in a 50 ml graduated cylinder and marks 0.5 ml. The bulk volume was estimated after manually tapping the cylinder two times on a flat table top surface.[8-9]

Tapped density determined in accordance through method specified in USP. Samples 20g of granules were taken in 50 ml graduated cylinder with 0.5 ml mark. Manually tapping the cylinder on a level table top surface in increments of 500, 750, and 1250 taps was used to determine the tapped volume.[8-9]

Bulk density (Db) = M/Vo

The tapped density (Dt) = M/Vb

Compressibility index = {(Dt-Db)/Dt} x100

Hausner's ratio = Dt/Do

Wherever, M= powder taken in mass

Vo = a volume that appears to be unsettled (Bulk Volume)

Vb = settled apparent volume (tapped Volume)

Drug Content of Granules

200mg of granules were weight up independently and powdered. Powder corresponding to 10mg of trigonelline was weighted, further dissolved in 6.8 pH phosphate buffer. The capacity was completed to 100 with the 6.8 pH phosphate buffer solution, used to this above stock solution, 10 µg/ml solution was arranged. UV absorbance was used to calculate the drug content of the resultant solution at 264.40 nm. The drug content of granules was found to be 280.86 µg/ml.[10-11]

Percentage Drug release study

Using a single station USP type 1 apparatus, *in-vitro* drug release investigations of the produced granules were done for 120 min (basket type). The agitation speed was set to 50 revolutions per minute. Germinated fenugreek powder granules were filled in capsule shell and added to phosphate buffer pH 6.8 (900 ml) at 37±0.5°C. The 5 ml aliquots were reserved at time intermissions of 5, 10, 15, 30, 60, 90, 105 and 120 min and filtered done by Whatman's filter paper. To maintain the capacity of the dissolution medium, an identical capacity of new dissolution medium was substituted. At 264.40 nm, the filtered samples were spectrophotometrically analyzed.

The cumulative proportion of the drug's labelled quantity discharged was computed.[10-11]

Evaluation of Tablets

Weight variation

Weight variation was determined using 20 tablets from each batch. The total weight of the 20 tablets was calculated and average weight was determined. The tablets were also weighed individually and the difference from the average weight were determined. Finally, % weight difference was determined.[10-12]

$$\% \text{ Deviation} = \frac{\text{Individual weight} - \text{Average weight}}{\text{Average weight}} \times 100$$

Hardness

Hardness of the tablet was determined, by using the monsanto tester.

Friability

10 tablets were weighed collectively and accurately and the 100 revolutions were made in ROCHE FRIABILATOR friability testing instrument. After completion of 100 revolutions tablets were weighed again collectively.[10-12] After this % friability was determined by using formula given below:

$$\% \text{ Friability} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100$$

Drug content

Individual tablets were weighed and powdered. Weighed powder containing 10 mg trigonelline was dissolved in phosphate buffer pH 6.8. With phosphate buffer pH 6.8, the volume was increased to 100. A 10 g/ml solution was made from this stock solution. UV absorbance at 264.40 nm was used to calculate the drug content of the resultant solution.

Disintegration time

The Tablet Disintegration Test Apparatus was used to conduct the *in-vitro* disintegration studies. In each of the basket assembly's six tubes, one tablet has put, and added disc in each tube. The assembly was then suspended at 372°C in a one-liter beaker containing 0.1N HCl. Over a distance of 5 to 6 cm, the basket was pushed up and down at a frequency of 28 to 32 cycles per minute. The time it took for the tablet to completely disintegrate was recorded. The test was carried out on pills of various formulations (F1-F6).[10-11]

Percentage Drug release

Using a 6-station USP type 2 apparatus, *in-vitro* drug release investigations of the manufactured 6 formulations tablets were undertaken for 90 min (paddle type). The agitation speed was set to 50 revolutions per minute. Germinated fenugreek powder tablet was added to 900 ml of phosphate buffer pH 6.8 at 37 ± 0.5°C. 5 ml aliquots were withdrawn at time intervals of 5, 10, 15, 30, 60, 90,105 and 120 min and filtered through Whatman's filter paper. To maintain, an equivalent volume of fresh medium was replaced. The filtered samples were examined at 264.40 nm spectrophotometrically and cumulative proportion of drug's amount released was calculated.[10,13]

In-vivo study

Male Wistar albino (180-200g) rats were found from the Institute of Pharmaceutical Research, GLA University, Mathura's central animal house. In the exploratory study, the animals were divided into five groups, each with six animals. Rats were housed in poly-acrylic birdcages at a constant temperature of 25°C and a relative humidity of 45–55%, with a 12:12 hr light/dark cycle. Throughout the experiment, animals were allowed to eat their usual capsule food (Lipton India, Ltd., Mumbai) and drink as much water as they wanted. The investigational techniques were accomplished according to the moralities of the Institutional Animal Ethics Committee. Experimental research is conducted in strict accordance with the Committee for the Determination of Control and Supervision of Experiments on Animals (CPCSEA) methods.

The F-6 batch formulation exhibited improved drug release profile then other batches hence, it was selected for *in-vivo* study. The effect of oral administration of fenugreek entire germinated powder seed and tablet for 28 days on streptozotocin-induced diabetic Wistar albino rats were studied.

The data was all mean with a standard error of the mean (SEM). To monitor significance among groups, statistical data analyses were done using two-way analysis of variance (ANOVA) with Bonferroni post-hoc test analysis. $P < 0.001$ was regarded as statistically significant.[13]

RESULTS AND DISCUSSION

The obtained germinated fenugreek powder yielded 85.42 percent. Alkaloids, steroids, phenols, proteins, flavonoids, amino acids and carbohydrates were

found in the preliminary phytochemical investigation of fenugreek extracts. Germinated fenugreek seed powder was characterized and reported for the first time. Germination resulted 20.12% loss in dry weight when compared to ungerminated fenugreek seeds. The identification test was confirmed by UV spectroscopy method and resulted in straight line was obtained with regression value 0.995 (Figure 1).

Characterization of powder flow properties

The granules of germinated Fenugreek powder were arranged by using several excipients covering various concentration of superdisintegrants through wet granulation process and preformulation investigations was carried out on the produced granules, the results of which are reported in Table 2. The best result was obtained in batch F-6. The compressibility index of the F-6 formulation granules was 19.72 percent, and angle of repose was 28.66°C. A compressibility index of more than 25% indicates poor granule flowability, while a value of less than 15% indicates great granule flowability. Since F-6 formulation had angle of repose below 30° granules own good flow property. After that granule was proceeded by *in-vitro* release and resulted in 72.03% drug released in 2 hr (Figure 2).

Preparation and evaluation of tablets of germinated fenugreek powder

The germinated Fenugreek tablet formulations pass the weight variations evaluation giving to IP. 2010, since deviation (%) of individual capsule weight from mean has found to be less than 5%. The *trigonelline* content of germinated fenugreek seed tablets for all the corresponding formulations were quantified and the resultant value ranged about 436.36 µg/mL.

The drug content of granules was found to be 280.86 µg/ml. The F6 formulation showed better hardness of 10.33kgf and % friability of 0.736 within the permissible limits among all six formulations prepared. Disintegration time of formulations F1, F2, F3, F4, F5 and F6 was found to be 67, 57, 23, 50, 25 and 14 min respectively, this indicates that as Cross-povidone concentration rises, and other disintegrant were increased results in the increased rate of disintegration. Among all the six formulations F6 formulation shows excellent rate of disintegration.

Percentage Drug Release

In vitro dissolving studies were used to assess rate and degree of release profile of the drug (trigonelline) from various tablet batches, and the findings are presented in

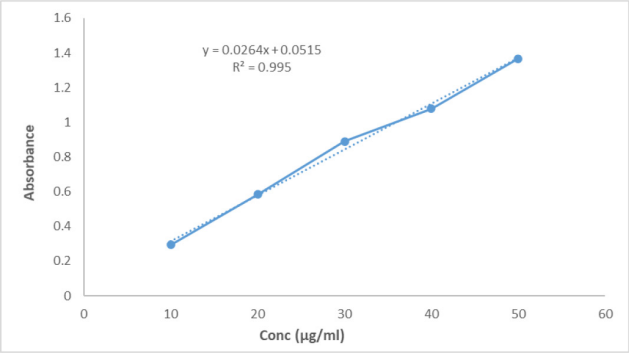

Figure 1: Calibration Curve of Trigonelline HCl at 264.4 nm (Reference Standard).

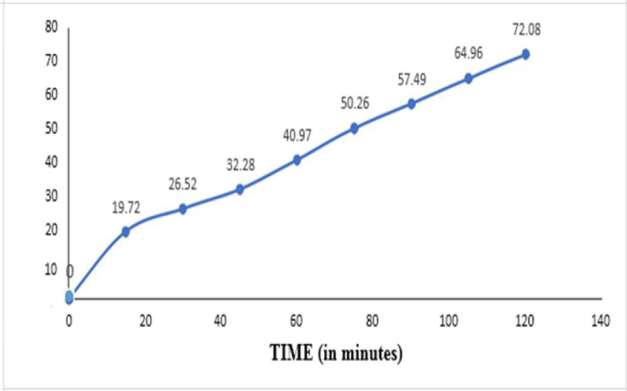

Figure 2: Graph between percentage drug release and time for granules.

Table 2: Evaluation Parameters of prepared granules of germinated fenugreek powder.

Evaluation Parameters	Formulation Batches					
	F-1	F-2	F-3	F-4	F-5	F-6
Bulk Density (gm/ml)	0.498	0.486	0.522	0.502	0.512	0.472
Tapped Density (gm/ml)	0.614	0.602	0.638	0.618	0.628	0.588
Compressibility Index %	18.89	27.57	18.18	18.77	18.47	19.72
Hausner's Ratio	1.261	1.243	1.245	1.251	1.246	1.189
Angle of Repose (°)	23.94	29.16	26.01	24.61	28.14	28.66

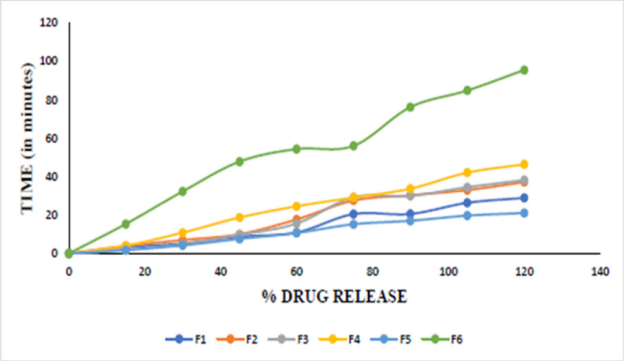

Figure 3: Release of Trigonelline from different tablet formulations.

Figure 3. The release profile of germinated fenugreek tablets shown that release of *trigonelline* from, F1, F2, F3, F4 and F5 formulation has obtained 28.91%, 37.11%, 38.17%, 46.33% and 21.06% respectively after 2 hr. The presence of a high percentage of mucilage in fenugreek seeds contributed to the slow, and partial release of drug (trigonelline) from the F1 formulation. Germinated fenugreek dried powder when comes in contact with fluids it forms tacky mass which hinders the release of trigonelline. The mucilage present in fenugreek seeds serves as suspending, binding, gelling agent, and release material in different types of dosage forms. As this was observed that the trigonelline release obtained from F1, F2, F3, F4 and F5 formulations were not satisfactory. To improve the release of trigonelline super disintegrants in different ratio were taken and F6 formulation having maximum amount of cross povidone with other disintegrant was incorporated. The dissolution profile of F6 tablet formulation showed more than 95% trigonelline release after 2 hr. Thus, increase concentration of super disintegrants were significantly increasing the release of trigonelline. By rapidly immersing it in water and expanding it, Cross-povidone acts as a super disintegrant, causing granule capacity to skyrocket, resulting in quick, and even disintegration. The dissolution release of prepared tablet batch was associated among themselves, the drug release from batch F6 showed the better rate and release of trigonelline. The poor and incomplete dissolution of F1, F2, F3, F4 and F5 tablet formulation might be, a reason for poor drug compound then low release, compared to the batch F6. Since, F6 proved to be the best oral solid dosage dorm amongst all six formulations it was subjected to further *in-vivo* animal study.

In-vivo Study of Antidiabetic Activity

The purpose of study was to determine the effect of germinated fenugreek seed powder and F6 formulation on glucose level in streptozotocin induced diabetic rat model. The represented effect of drug ((1600 mg/kg) body weight germinated fenugreek seed powder) and Formulation (1600.0 mg/kg body weight F6) in levels of rats fasting plasma glucose. According to statistical analysis, levels of fasting plasma glucose differed significantly between groups, [$F(5, 25) = 839.62$; $p < 0.001$] and day [$F(5, 25) = 957.29$; $p < 0.001$]. Further, there was significant interaction between groups and day in fasting plasma glucose levels of animal [$F(5, 25) = 166.95$; $p < 0.001$]. The formulation (F6- 1600.0 mg/kg) therapy effectively reduced T2DM-induced increases in fasting plasma glucose levels in the mice, according to a Bonferroni post-hoc test. However, as compared to the conventional medicine Glibenclamide, the anti-diabetic effect of formulation (F6-1600 mg/kg) was lower in T2DM rats, significantly.

In present study, a significant and marked increase in plasma glucose level was found in STZ (Streptozotocin) induced rats (mean ± SD glucose 290 ± 0.4 mg/dL) after 5 days compared with the control (normal) group rats (mean ± SD glucose 75 ± 0.3 mg/dL; $p < 0.001$) (Table 3, Figure 4). As compared to the control group STZ induced rats showed 4 times increase in plasma glucose level. In STZ induced rats the treatment with the Drug (germinated fenugreek seed powder) and Formulation (F6) significantly lowered the blood plasma glucose levels by 36% (mean ± SD glucose 120 ± 0.6 mg/dL; $p < 0.001$) and 38% (mean ± SD glucose 114 ± 0.4 mg/dL; $p < 0.001$) correspondingly after 28 days of treatment, compared to T2DM (Type 2 Diabetes mellitus) rats.

The treatment of T2DM induced rats with drug and formulation shows reduction in plasma glucose level after 14 days and brought in normal range completely after 28 days. Among the drug (germinated fenugreek seed powder) and formulation (F6) there is no significant difference in reduction of plasma glucose level after 28 days of treatment similar to standard drug, Glibenclamide (0.45 mg/kg body weight). This shows that the germinated fenugreek seed powder and its formulation (F6) provides better absorption of phytoconstituents and producing antidiabetic effect. Hence it was concluded the germinated fenugreek seed powder and in STZ-induced diabetic rats, F6 formulations showed effective anti-hyperglycemic activity and recovered normal glucose levels.

CONCLUSION

The formulation F6 comprising germinated fenugreek seed powder exhibited better anti-hyperglycemic action.

Table 3: Fasting plasma glucose levels in rats receiving oral formulations.

Groups	Treatment	Fasting plasma glucose level in mg/dl				
		Day- 0	Day- 3	Day- 7	Day- 14	Day- 28
1	Control	77±0.2	76±0.4	75±0.3	75±0.4	75±0.2
2	T2DM	76±0.6[a]	245±0.2[a]	290±0.4[a]	315±0.1[a]	318±0.3[a]
3	T2DM+ Glibenclamide	78±0.2[a]	255±0.4[a]	298±0.4[a]	85±0.2[a,b]	80±0.7[a,b]
4	T2DM+Drug	77±0.3[a]	261±0.3[a]	300±0.4[a]	209±0.2[a,b,c]	120±0.6[a,b,c]
5	T2DM+Formulation	75±0.6[a]	253±0.3[a]	288±0.4[a]	205±0.2[a,b,c]	114±0.4[a,b,c]

*Value is expressed as mean±SEM; n=6 animal in each group; [a]p<0.001 compared to control, [b]p<0.001 compared to T2DM, [c]p<0.001 compared to T2DM+Glibenclamide.

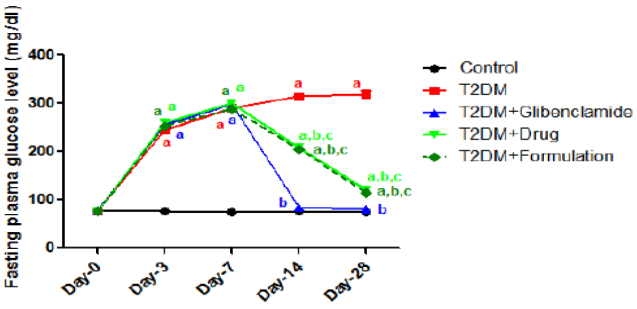

Figure 4: The effect of Germinated Fenugreek Powder (Drug), Glibenclamide (Standard), and Formulation (F-6) in T2DM exposed rats.

All values are mean ± SEM (n = 6) [a]p< 0.001 compared to control, [b]p< 0.001 compared to T2DM, [c]p< 0.001 compared to T2DM+ Glibenclamide. (Two-way ANOVA followed by Bonferroni post-hoc test).

The current study sturdily supports that the formulation containing germinated fenugreek seed powder proved to be a suitable herbal dosage form which is more promising, beneficial, effective, and therapeutically highly active than the plant materials or *phytoconstituents*. Thus, results obtained from present study provide a promising therapy for diabetes mellitus. This herbal antidiabetic formulation has a more potent hypoglycemic activity than the non-germinated fenugreek seeds possessing much lower side effects, much higher safety and cheaper as compared to the synthetic agents available in market. The pediatric and geriatric patients are more prone to have side effects possessed by the synthetic antidiabetic agents hence the herbal formulations show better patient compliance and acceptance in such population.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

ABBREVIATIONS

DM: Diabetes mellitus; **STZ:** Streptozotocin; **T2DM:** Type 2 Diabetes mellitus; **TFG:** *Trigonella foenum-graecum* L.

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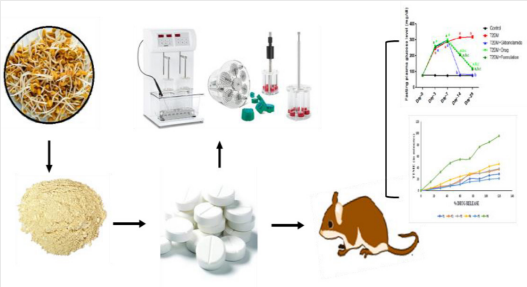
PICTORIAL ABSTRACT



SUMMARY

Trigonella foenum-graecum L (Fenugreek) is an annual herb and has been shown to have antibacterial, anti-diabetic, anti-cancer, anti-diarrheal, anti-hypercholesteremic, and anti-inflammatory properties in pharmacological studies. The goal of this study was to focus on granule formulation and explore the effects of germinated *Trigonella foenum-graecum* L. (TFG) granules in diabetic rats produced by streptozotocin since fenugreek has a hypoglycemic effect. Wet granulation method was used to prepare germinated TFG granules, which were then evaluated as solid dosage forms. In addition, a four-week *in-vivo* research was conducted in STZ-induced DM Wister rats. As a result, the findings of this study point to a possible treatment for diabetes mellitus. This herbal antidiabetic mixture is more potent than non-germinated fenugreek seeds in terms of hypoglycemic activity, has fewer side effects, is safer, and is less expensive than synthetic medicines on the market. Because synthetic antidiabetic medications are more likely to cause side effects in paediatric and geriatric patients, herbal formulations show improved patient compliance and acceptance in this demographic.

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