Comparative Evaluation of Alpha-Amylase and Alpha-Glucosidase Inhibitory Potential of Aqueous Seed Extract of *Trigonella Foenum-Graecum* and *Moringa Oleifera* - An In vitro Study

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**Authors’ contributions**

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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**ABSTRACT**

**Background:** *Trigonella foenum-graecum* is one of the commonly used herbs in food. *Moringa oleifera* is a source of food, accommodation and conventional medicine for many peoples in the developing countries. The seeds of both the plants were explored for antidiabetic potential.

**Methods:** The current work was designed to probe the in vitro anti diabetic potential of the aqueous seed elicited from *Trigonella foenum-graecum* and *Moringa oleifera* using the enzymes alpha amylase and alpha glucosidase. Both the extracts were screened for their phytochemicals and antioxidant potential was also analysed. The data were examine statistically by a one-way analysis of variance (ANOVA) followed by Duncan’s multiple range test was used to see the statistical significance in conjunction with groups. The results with the p<0.05 level were considered to be statistically significant.

**Result:** Due to its chemical ingredient and active compounds like amino acids, alkaloids, flavonoids, it proceeds as a good antioxidant. *Trigonella foenum-graecum* seed extract exhibited comparatively higher antidiabetic potential with an IC<sub>50</sub> of 300µg/ml than the Moringa oleifera extract. Results of the work designate that both extracts of the plant possessed by forbidding alpha amylase, alpha glucosidase show maximum inhibition. Hence concluded that, *Trigonella foenum-graecum*
graecum leaves might be considered as herbal remedies for diabetes.

**Conclusion:** *In vitro* antioxidant and antidiabetic potential of seed elicit of *Trigonella foenum-graecum* and *Moringa oleifera* were analyzed and compared. This study shows that *Trigonella foenum-graecum* has higher antidiabetic potential than the *Moringa oleifera* extract.

**Keywords:** Alpha amylase; alpha glucosidase; fenugreek; Moringa oleifera; innovative technology; novel method.

1. **INTRODUCTION**

*Trigonella foenum-graecum* is an herb extensively cultivated in India and some parts of China. In India, seeds are used as condiments [1]. It is an annual plant, which belongs to the family *leguminosae* [2]. Seeds play a predominant role in the herbal therapeutics and are acknowledged for tonic, carminative and aphrodisiac potential [3]. *Trigonella foenum-graecum* is a self pollinating crop and it is a vernacular plant used to make maple syrup and the steroidal saponin are used widely in industries. *Trigonella foenum-graecum* is rich in calcium, iron, beta carotene, vitamins, lipids [4] and the seeds are rich in carbohydrates and proteins. It is also used as a folk treatment for non insulin dependent diabetes [5]. *Trigonella foenum-graecum* is also used to control Hyperglycemia and hyperlipidemia [6]. It is also called fenugreek. It is used to control the glucose, cholesterol, triglyceride and acts as a lowering compounds. It exhibits a long time antidiabetic action [4].

In the current framework, phytochemicals have obtained much attention in the treatment of diabetes. For various reasons, many researchers have concentrated on isolation of hypoglycemic agents from the medicinal plant [7]. Plant polyphenols and the flavonoids are some of the commonly occurring antidiabetic agents [8]. *Trigonella foenum-graecum* contributes to lower postprandial hyperglycemia in diabetes the mechanisms of action involves provocation of glucose dependent insulin secretion from beta cells of pancreas along with embarrasment of activity of enzymes like amylase and glucosidase [9,10].

*Moringa oleifera* is a famous consumable plant having therapeutic and the nutritive values. *Moringa oleifera* is also known as *Horseradish tree* and also called as drumstick tree. It is rich in phytochemicals and minerals [9-11]. It is a constituent of folk medicine and helps to cure the diabetes. It is commonly called as Miracle tree. It also helps to control cancer [12-14]. This medicinal plant is used as a food additive to get relieved from malnutrition. It acts as an antioxidant, anti inflammatory, antidiabetic, antimicrobial agent and also takes measures as a natural coagulant. *Moringa oleifera* is also used in the treatment of anemia [15-17]. It has been widely accepted by major population as nutrition and therapeutic agents [18]. It can be suggested as a potential herbal source to treat diabetes mellitus and as being commonly accepted by major population. Our team has extensive knowledge and research experience that has interpret into high quality publications [19-34]. The aim of the study is to compare and assess the alpha amylase and alpha glucosidase inhibitory potential of aqueous seed extracts of *Trigonella foenum-gracus* and *Moringa oleifera* through an *in vitro* study.

2. **MATERIALS AND METHODS**

2.1 Plant Extract

*Trigonella foenum-graecum* and *Moringa oleifera* seed were collected from a farm in Chennai. Washed, crushed and made into powder. Powder was utilized to prepare an 80% aqueous extract. The extract was prepared by a hot percolation method.

2.2 Phytochemical Screening Test

2.2.1 Test for phlobatannin

1 ml of the extract was treated with 1 ml of 1% HCl and boiled for 10 mins. The formation of red color precipitate indicates the presence of phlobatannin.

2.2.2 Test for Carbohydrates

Three to five drops of Molisch reagent was added with 1 mL of the extract and then 1 mL of concentrated sulphuric acid was added carefully through the side of the test tube. The mixture was then allowed to stand for two minutes and diluted with 5 mL of distilled water. The development of red or dull violet rings at the
junction of the liquids showed the presence of carbohydrates.

2.2.3 Test for Flavonoids

Few drops of 1% liquid ammonia were taken in a test tube and along with it 1ml of the extract was added resulting in the formation of yellow color thereby indicating the presence of flavonoids.

2.2.4 Test for Alkaloids

2ml of sample was mixed with 2ml of HCl. Then 6 drops of HCN was added and further 2 drops of picric acid was added that resulted in a creamish pale yellow ppt indicating the presence of alkaloids.

2.2.5 Test for Terpenoids

2 ml of sample along with 2ml of chloroform and 3ml of con. H₂SO₄ was added. Red color ppt obtained indicates the presence of terpenoids.

2.2.6 Test for proteins

One milliliter of ninhydrin was dissolved in 1 mL of acetone and then a small amount of extract was added with ninhydrin. The formation of purple colour revealed the presence of protein.

2.2.7 Detection of saponins

Foam test: A fraction of the extract was vigorously shaken with water and observed for persistent foam.

2.2.8 Test for steroids

One milliliter of chloroform was mixed with 1 mL of extract and then ten drops of acetic anhydride and five drops of concentrated sulphuric acid were added and mixed. The formation of dark red colour or dark pink color indicates the presence of steroids.

2.3 Antioxidant Activity

2.3.1 DPPH free radical scavenging activity

Scavenging of 2, 2-Diphenyl-1-picrylhydrazyl (DPPH) radicals was assessed by the method of [35]. DPPH solution (1.0 ml) was added to 1.0 ml of extract at different concentrations (0.1 to 0.5mg/ml). The mixture was kept at room temperature for 50 minutes and the activity was measured at 517 nm. Ascorbic acid at the same concentrations was used as standard. The capability to scavenge the DPPH radical was calculated and expressed in percentage (%) using following formula:

\[
\text{DPPH radical scavenged} \% = \frac{\text{Control OD} - \text{Sample OD}}{\text{Control OD}} \times 100
\]

2.3.2 Alpha amylase inhibitory activity of aqueous seed extract of Trigonella foenum-graecum and Moringa oleifera

Alpha amylase inhibitory activity of extract was carried out according to the standard method of Ademiluyi et al 2013. In a test tube a reaction mixture containing 500 mu/l phosphate buffer (100mM ; pH=6.8), 100 mu alpha amylase (2 mu/l) and varying concentration of extract (0.1 - 0.5 mg/ml) was incubated at 37degree Celsius for 20 minutes. Then the 200 mu/l of 1% soluble starch(100 MM phosphate buffer 6.8) was added as a substrate and incubated further at 37 degree Celsius for 30 minutes, 1000 mu/l of the 3,5 Dinitrosalicylic acid [DNS], DNS colour reagent was then added and boiled for 10 minutes. The absorbance of the resulting mixture was measured at 540 nm using a multi plate reader. Acarbose at various concentrations (0.1- 0.5 mg/ml) was used as a standard.

\[
\text{Inhibitory activity} \% = \left(1 - \frac{\text{AS}}{\text{AC}}\right) \times 100
\]

AS= absorbance in the presence of test substance ; AC=absorbance of control.

2.3.3 Alpha glucosidase inhibitory activity of aqueous seed extract of Trigonella foenum-graecum and Moringa oleifera

Alpha glucosidase inhibitory activity of extract was carried out according to the method of Ademiluyi et al (2013) Reaction mixture containing 500 mu/l phosphate buffer(100mM pH 6.8), 100mu/l glucosidase (10 ml) and varying concentration of extract (0.1 to 0.5 mg /ml) was pre incubated at 37 degree Celsius for 15 minutes. Then 200 mu/l p-NPG(5mM) was added as a substrate and incubated further at 37degree Celsius for 30 minutes. The reaction was stopped by adding 50 mu/l sodium carbonate (0.1M). The absorbance of the released p-nitrophenol was measured at 405 nm using multiple readers. Acarbose at various concentrations (0.1-0.5mg/ml)was used as a standard.

\[
\text{Inhibitory activity} \% = \left(1 - \frac{\text{AS}}{\text{AC}}\right) \times 100
\]
AS=absorbance of test substance; AC=absorbance of control.

2.4 Statistical Analysis

The data were subjected to statistical analysis using two-way analysis of variance (ANOVA) and Tukey’s multiple range test to assess the significance of individual variations between the groups. In Tukey’s test, significance was considered at the level of \( p<0.05 \).

3. RESULTS

*Trigonella foenum-graecum* shows the presence of Amino Acids, Flavonoids, Alkaloids which have higher antidiabetic potential than Terpenoids and carbohydrates. In *Moringa oleifera*, the presence of flavonoids, steroids indicates the higher antidiabetic potential than Alkaloids and carbohydrates.

4. DISCUSSION

Phytochemicals are secondary metabolites only present in plants. Plants possess various biologically active compounds that protects and helps human body [36]. Phytochemical analysis has revealed (Table 1) a energetic presence of alkaloids, flavonoids and terpenoids in *trigonella foenum-graecum* and *Moringa oleifera* seed elicit [3]. The presence of phytochemicals like alkaloids, glycoside, tannins, carbohydrates, phenols indicates that the extract is potential for further in vitro analysis like antioxidant activity and antidiabetic activity.

| Phytochemicals   | Fenugreek | *Moringa oleifera* |
|------------------|-----------|--------------------|
| Amino Acids      | ++        | -                  |
| Flavonoids       | ++        | ++                 |
| Alkaloids        | ++        | +                  |
| Terpenoids       | +         | +                  |
| Steroids         | ++        | ++                 |
| Carbohydrates    | -         | -                  |

Table 1. Phytochemical analysis of aqueous seed extract of *Fenugreek* and *Moringa oleifera*

Antioxidant potential of aqueous seed extract of *Trigonella foenum-graecum* and *Moringa oleifera*

Graph 1. represents Antioxidant potential of aqueous seed extracts of *Trigonella foenum-graecum* and *Moringa oleifera* compared with standard Ascorbic acid. X axis represents the concentration in µg/ml and Y axis represents the inhibitory potential of the extracts. Blue bar represents standard Acarbose, orange bar represents *Trigonella foenum-graecum* and green bar represents *Moringa oleifera* Each bar represents Mean ± SEM of 3 independent observations. Significance at \( p < 0.05 \)
Graph 2. Represents Alpha Amylase Inhibitory potential of aqueous seed extracts of Trigonella foenum-graecum and Moringa oleifera. X axis represents the concentration in µg/ml and Y axis represents the Alpha amylase inhibitory potential of the extracts. Green bar represents standard Acarbose, orange bar represents Trigonella foenum-graecum and purple bar represents Moringa oleifera. Each bar represents Mean ± SEM of 3 independent observations. Significance at p < 0.05.

Graph 3. Represents Alpha Glucosidase Inhibitory potential of aqueous seed extract of Trigonella foenum-graecum and Moringa oleifera. X axis represents the concentration in µg/ml and Y axis represents the alpha glucosidase inhibitory potential of the extracts. Green bar represents standard Acarbose, red bar represents Trigonella foenum-graecum and purple bar represents Moringa oleifera. Each bar represents Mean ± SEM of 3 independent observations. Significance at p < 0.05.
Antioxidant activity of aqueous seed extracts of *Trigonella foenum-graecum* and *Moringa oleifera* was determined by performing DPPH free radical scavenging assay. Free radicals are molecules influencing an unpaired electron [37]. Herbal elicit which are rich in phenolic compounds have great importance in free radical scavenging. The effect of antioxidants on DPPH free radical scavenging was considered to be due to their hydrogen donating ability. The extracts were analyzed for their antioxidant potential. Both the extract exhibited a significant antioxidant potential, when compared *Trigonella foenum-graecum* exhibited a strong antioxidant potential with IC50 of 320 µg/ml then *Moringa oleifera* (IC50 of 360 µg/ml) (Graph 1) as compared with the standard vitamin C.

In vitro Antidiabetic activity was analyzed for the extract and compared with the standard drug metformin. Both Alpha amylase and Alpha glucosidase inhibitory potential was estimated to analyze antidiabetic potential [38]. The ethanolic seed extract of *Trigonella foenum-graecum* exhibited significantly more inhibition for Alpha amylase and Alpha glucosidase (Graph 2and 3) with IC50 of 280 and 390 µg/ml respectively. Previous studies on antidiabetic potential of *Trigonella foenum-graecum* has also exhibited a significant inhibitory potential, where aqueous seed extract of *Trigonella foenum-graecum* a dose of 25mg/kg body weight given to experimental animals for 60days, significantly decreased blood glucose and liver enzymes level. However, no histological liver protective role was reported [3].

The extracts were tested for its role as a starch blocker [39]. Since, it prevents or slows the absorption of starch mainly by blocking the hydrolysis of glycosidic linkage in starch [40]. There is a positive relationship between phytoconstituents contents and its ability to inhibit alpha glucosidase and alpha amylase. From the obtained results, it was evident that both the aqueous seed extract of *trigonella foenum* and *Moringa oleifera* possess antioxidant and antidiabetic potential and escalated in a dose dependent manner as compared to standard [41]. The extracts are capable of inhibiting the absorption of glucose [42]. Further research is needed to assess the *in vivo* antidiabetic potential of the extracts. Further validation of the drug’s ability to decrease glucose concentration in serum can help in the drug formulation.

### 5. CONCLUSION

Even though there are many drugs available for diabetes, a complete cure remains a dream. Current *in vitro* findings on the antioxidant and antidiabetic potential of seed elicit of *Trigonella foenum-graecum* and *Moringa oleifera* showed that both the plant extracts have potential antidiabetic activity due the existence of the bioactive compounds.

### CONSENT

It is not applicable.

### ETHICAL APPROVAL

It is not applicable.

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### COMPETING INTERESTS

Authors have declared that no competing interests exist.

### REFERENCES

1. Geberemekel GA, Debebe YG, Nguse NA. Antidiabetic Effect of Fenugreek Seed Powder Solution (*Trigonella foenum-graecum* L.) on Hyperlipidemia in Diabetic Patients [Internet]. Vol. Journal of Diabetes Research. 2019;1–8. Available: http://dx.doi.org/10.1155/2019/8507453

2. Fenugreek: A review on its nutraceutical properties and utilization in various food
products. Journal of the Saudi Society of Agricultural Sciences. 2018;17(2):97–106.

3. Baset M, Ali T, Elshamy H, El Sadek A, Sami D, Badawy M, et al. Anti-diabetic effects of fenugreek (Trigonella foenum-graecum): A comparison between oral and intraperitoneal administration - an animal study [Internet]. International Journal of Functional Nutrition; 2020. Available:http://dx.doi.org/10.3892/ijfn.202.0.2

4. Ranade M, Mudpalkar N. A simple dietary addition of fenugreek seed leads to the reduction in blood glucose levels: A parallel group, randomized single-blind trial [Internet]. AYU (An international quarterly journal of research in Ayurveda). 2017;38:24. Available:http://dx.doi.org/10.4103/ayu.ayu _209_15

5. Hadi A, Arab A, Hajianfar H, Talaei B, Miraghaianj M, Babajafari S, et al. The effect of fenugreek seed supplementation on serum irisin levels, blood pressure, and liver and kidney function in patients with type 2 diabetes mellitus: A parallel randomized clinical trial [Internet]. Complementary Therapies in Medicine. 2020;49:102315. Available:http://dx.doi.org/10.1016/j.ctim.20 20.102315

6. Hasler CM. Regulation of Functional Foods and Nutraceuticals: A Global Perspective. John Wiley & Sons; 2008:432.

7. Sharma MS, Choudhary PR. Effect of Fenugreek Seeds Powder (Trigonella foenum-graecum L.) on Experimental Induced Hyperlipidemia in Rabbits [Internet]. Journal of Dietary Supplements. 2017;14:1–8. Available:http://dx.doi.org/10.3109/193902 11.2016.1168905

8. Haile T, Cardoso SM, de Oliveira Raphaelli C, Pereira OR, Pereira EDS, Vizzotto M, et al. Chemical Composition, Antioxidant Potential, and Blood Glucose Lowering Effect of Aqueous Extract and Essential Oil of Hochst. Ex Benth. Front Pharmacol. 2021;12:621536.

9. Rahman MH. Anti-diabetic Activity Studies of Aqueous Extract of Psidium Guajava L Leaves on STZ-induced Type 2 Diabetic Model Rats; 2017.

10. Saadh MJ. Hypoglycemic and hypolipidemic activity of combined milk thistle and fenugreek seeds in alloxan-induced diabetic albino rats [Internet]. August-2020. 2020;13:1732–6. Available:http://dx.doi.org/10.14202/vetworl d.2020.1732-1736

11. Anti-diabetic Potential of Aqueous Extract of Moringa oleifera, Ocimum gratissimum and Vernonia amygdalina in Alloxan-Induced Diabetic Rats [Internet]. Journal of Diabetes and Clinical Research. 2020; 2. Available:http://dx.doi.org/10.33696/diabet es.1.023

12. Lakshmi SJ, Jyothi Lakshmi S, Gopalakrishnan K. Clinical evaluation and role of patch testing in identifying the exogenous causes in patients presenting with hand eczema [Internet]. International Journal of Research in Dermatology. 2019;5:1. Available:http://dx.doi.org/10.18203/issn.24 55-4529.intjresdermatol20185081

13. Wu F, Zhu J, Li G, Wang J, Veeraraghavan VP, Krishna Mohan S, et al. Biologically synthesized green gold nanoparticles from Siberian ginseng induce growth-inhibitory effect on melanoma cells (B16). Artif Cells Nanomed Biotechnol. 2019;47(1):3297–305.

14. Chen F, Tang Y, Sun Y, Veeraraghavan VP, Mohan SK, Cui C. 6-shogaol, a active constituents of ginger prevents UVB radiation mediated inflammation and oxidative stress through modulating Nrf2 signaling in human epidermal keratinocytes (HaCaT cells). J Photochem Photobiol B. 2019;197:111518.

15. Muhammadd AA, Arulsevkan P, Cheah PS, Abas F, Fakurazi S. Evaluation of wound healing properties of bioactive aqueous fraction from Moringa oleifera Lam on experimentally induced diabetic animal model. Drug Des Devel Ther. 2016;10: 1715–30.

16. Li Z, Veeraraghavan VP, Mohan SK, Bolla SR, Lakshmanan H, Kumaran S, et al. Apoptotic induction and anti-metastatic activity of eugenol encapsulated chitosan nanopoylmer on rat glioma C6 cells via alleviating the MMP signaling pathway [Internet]. Vol. 203. Journal of Photochemistry and Photobiology B: Biology. 2020;203:11773. Available:http://dx.doi.org/10.1016/j.jphoto biol.2019.111773

17. Babu S, Jayaraman S. An update on β-sitosterol: A potential herbal nutraceutical
for diabetic management. Biomed Pharmacother. 2020;131:110702.

18. Al-Malki AL, El Rabey HA. The Antidiabetic Effect of Low Doses of Moringa oleifera Lam. Seeds on Streptozotocin Induced Diabetes and Diabetic Nephropathy in Male Rats [Internet]. Vol. 2015, BioMed Research International. 2015;1–13. Available: http://dx.doi.org/10.1155/2015/381040

19. Malaikolundhan H, Mookkan G, Krishnamaoorthy G, Matheswaran N, Alsawalha M, Veeraraghavan VP, et al. Anticarcinogenic effect of gold nanoparticles synthesized from Albizia lebbeck on HCT-116 colon cancer cell lines. Artif Cells Nanomed Biotechnol. 2020;48(1):1206–13.

20. Han X, Jiang X, Guo L, Wang Y, Veeraraghavan VP, Krishna Mohan S, et al. Anticarcinogenic potential of gold nanoparticles synthesized from Trichosanthes kirilowii in colon cancer cells through the induction of apoptotic pathway. Artif Cells Nanomed Biotechnol. 2019;47(1):3577–84.

21. Gothai S, Muniandy K, Gnanaraj C, Ibrahim IAA, Shahzad N, Al-Ghamdi SS, et al. Pharmacological insights into antioxidants against colorectal cancer: A detailed review of the possible mechanisms. Biomed Pharmacother. 2018;107:1514–22.

22. Veeraraghavan VP, Hussain S, Balakrishna JP, Dhawale L, Kullappan M, Ambrose JM, et al. A Comprehensive and Critical Review on Ethnopharmacological Importance of Desert Truffles: Terfezia claveryi, Terfezia boudieri, and Tirmania nivea [Internet]. Food Reviews International. 2021;1–20. Available: http://dx.doi.org/10.1080/87559129.2021.1889581

23. Sathya S, Ragul V, Veeraraghavan VP, Singh L, Niyas Ahamed MI. An in vitro study on hexavalent chromium [Cr(VI)] remediation using iron oxide nanoparticles based beads. Environmental Nanotechnology, Monitoring & Management. 2020;14:100333.

24. Yang Z, Pu M, Dong X, Ji F, Priya Veeraraghavan V, Yang H. Piperine loaded zinc oxide nanocomposite inhibits the PI3K/AKT/mTOR signaling pathway via attenuating the development of gastric carcinoma: In vitro and in vivo studies. Arabian Journal of Chemistry. 2020;13(5):5501–16.

25. Rajendran P, Alzahrani AM, Rengarajan T, Veeraraghavan VP, Krishna Mohan S. Consumption of reused vegetable oil intensifies BRCA1 mutations. Crit Rev Food Sci Nutr. 2020;1–8.

26. Barma MD, Muthupandiyan I, Samuel SR, Amaechi BT. Inhibition of Streptococcus mutans, antioxidant property and cytotoxicity of novel nano-zinc oxide varnish. Arch Oral Biol. 2021;126:105132.

27. Samuel SR. Can 5-year-olds sensibly self-report the impact of developmental enamel defects on their quality of life? Int J Paediatr Dent. 2021;31(2):285–6.

28. Samuel SR, Kuduruthullah S, Khair AMB, Shaye MA, Elkaseh A, Varma SR. Dental pain, parental SARS-CoV-2 fear and distress on quality of life of 2 to 6 year-old children during COVID-19. Int J Paediatr Dent. 2021;31(3):436–41.

29. Tang Y, Rajendran P, Veeraraghavan VP, Hussain S, Balakrishna JP, Chinnathambi A, et al. Osteogenic differentiation and mineralization potential of zinc oxide nanoparticles from Scutellaria baicalensis on human osteoblast-like MG-63 cells [Internet]. Materials Science and Engineering: C. 2021;119:111656. Available: http://dx.doi.org/10.1016/j.msec.2020.111656

30. Yin Z, Yang Y, Guo T, Veeraraghavan VP, Wang X. Potential chemotherapeutic effect of betalain against human non-small cell lung cancer through PI3K/Akt/mTOR signaling pathway. Environ Toxicol. 2021;36(6):1011–20.

31. Veeraraghavan VP, Periouradi ND, Karunakaran T, Hussain S, Surapaneni KM, Jiao X. Green synthesis of silver nanoparticles from aqueous extract of Scutellaria baicalensis on human osteoblast-like MG-63 cells [Internet]. Materials Science and Engineering: C. 2021;119:111656

32. Mickymaray S, Alfaiz FA, Paramasivam A, Veeraraghavan VP, Periouradi ND, Surapaneni KM, et al. Rhampectin suppresses osteosarcoma through the inhibition of PI3K-Akt-mTOR pathway. Saudi J Biol Sci. 2021 Jul;28(7):3641–9.

33. Teja KV, Ramesh S. Is a filled lateral canal – A sign of superiority? [Internet], Vol. 15, Journal of Dental Sciences. 2020;562–3.
34. Kadanakuppe S, Hiremath S. Social and Behavioural Factors Associated with Dental Caries Experience among Adolescent School Children in Bengaluru City, India [Internet]. Vol. 14, British Journal of Medicine and Medical Research. 2016;1–10. Available: http://dx.doi.org/10.9734/bjmrr/2016/24021

35. Kashiwagi S, Hatano M, Yokoyama T. Metastatic small cell carcinoma to the pineal body [Internet]. Neurosurgery. 1989;810. Available: http://dx.doi.org/10.1097/00006123-198911000-00020

36. Owolabi OO, James DB, Sani I, Andongma BT, Fasanya OO, Kure B. Phytochemical analysis, antioxidant and anti-inflammatory potential of FERETIA APODANTHERA root bark extracts. BMC Complement Altern Med. 2018;18(1):12.

37. Kifle ZD, Debeb SG, Belayneh YM. -Amylase and -Glucosidase Inhibitory and Antioxidant Activities of the Crude Extract and Solvent Fractions of Leaves. Biomed Res Int. 2021;2021:6652777.

38. Agatonovic-Kustrin S, Ramenskaya G, Kustrin E, Morton DW. Characterisation of α-amylase inhibitors in marigold plants via bioassay-guided high-performance thin-layer chromatography and attenuated total reflectance-Fourier transform infrared spectroscopy. J Chromatogr B Analyt Technol Biomed Life Sci. 2021;1173:122676.

39. Technical A. Measurement of alpha-Amylase Activity in Flour Supplemented with Fungal alpha-Amylase—Modified Amylograph Method [Internet]. AACC International Approved Methods; 2009. Available: http://dx.doi.org/10.1094/aaccint-method-22.12.01

40. Bingol Z, Kızıltaş H, Gören AC, Kose LP, Topal M, Durmaz L, et al. Antidiabetic, anticholinergic and antioxidant activities of aerial parts of shaggy bindweed (Miller subsp.) - profiling of phenolic compounds by LC-HRMS. Heliyon. 2021;7(5):e06986.

41. Rub M. In vitro α-amylase and α-glucosidase inhibitory assay v1 (protocols.io.tdgei3w) [Internet]. protocols.io. Available: http://dx.doi.org/10.17504/protocols.io.tdgei3w

42. Li C, Chen S, Sha J, Cui J, He J, Fu J, et al. Extraction and purification of total flavonoids from DC. and evaluation of their antioxidant and enzyme inhibitory activities. Food Sci Nutr. 2021; 9(5):2349–63.

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