Acta Scientific Pharmaceutical Sciences (ISSN: 2581-5423)

Volume 9 Issue 1 January 2025

Review Article

Traditional and Modern Approaches to Diabetes: A Review on *Terminalia arjuna* Gutika

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Received: November 29, 2024

Published: December 23, 2024

Abstract

The rising prevalence of diabetes mellitus has spurred significant interest in alternative therapies, particularly those derived from herbal sources. *Terminalia arjuna* (commonly known as Arjuna) is a well-known medicinal plant traditionally used in Ayurveda for its cardio protective, antioxidant, and hypoglycemic properties. This review explores the potential of formulating Gutika (an Ayurvedic herbal tablet) using Arjuna extract as a novel approach for managing antidiabetic activity.

The bioactive compounds in Arjuna, such as flavonoids, glycosides, and tannins, have demonstrated significant hypoglycemic and insulin-sensitizing effects in various studies. This review highlights the formulation techniques, pharmacological properties, and pre-clinical and clinical evidence supporting its role in glycemic control. Additionally, the safety profile, dose optimization, and potential mechanisms of action of Arjuna extract in improving glucose metabolism are discussed.

The findings suggest that Gutika prepared from Arjuna extract offers a promising herbal alternative for managing diabetes, potentially reducing dependency on synthetic drugs and their associated side effects. Future research should focus on clinical trials and formulation standardization to establish its efficacy and safety for widespread use.

Keywords: *Terminalia arjuna*; Cardio Protective; Compounds

Introduction

Diabetes mellitus, a metabolic disease with several etiologies, is one of the biggest global public health issues. It is characterized by a breakdown in glucose homeostasis and abnormalities in the metabolism of proteins, fats, and carbohydrates due to deficiencies in insulin secretion and/or action [1,3]. Diet, exercise, and contemporary medications (insulin and/or oral hypoglycemic medications, including sulfonylureas and biguanides) can all help treat diabetes mellitus. Around the world, 1-3 different extracts from medicinal plants have also been used traditionally to treat diabetes; these are said to be reasonably priced, less poisonous, and to have few to no side effects [2,5].

Terminalia, the genus Arjuna, is a medicinal plant. Ayurvedic doctors frequently employ terminalia for its therapeutic benefits in treating organic and functional cardiac issues, such as angina, hypertension, and artery deposits [6,7]. Its astringent bark is applied to fractures, contusions, and fevers. Pulverized bark that is styptic, tonic, febrifuge, and anti-dysenteric. reduces the symptoms of hypertension and works as a diuretic in liver cirrhosis. Deobstruent and tonic fruits. Leaf juice is applied to earaches [4,8]. While the saponin glycosides may have beneficial inotropic effects, the antioxidant properties of some of Terminalia's component flavonoids and oligomeric proanthocyanidins are likely to be responsible for the cardioprotective effects [9]. Terminalia may have preventive properties against stomach ulcers, including those brought on by

NSAIDs, in addition to its cardiac effects. This study evaluated the extraction, phytochemical screening, and anti-diabetic properties of *Terminalia arjuna* root extract [11,12].

Several indigenous traditional medical systems in India are based on medicinal herbs. In ancient times, *Terminalia arjuna* was considered a miracle herb to treat cardiac issues. Arjuna Terminalia Arn and Wight. is commonly referred to as Arjuna [10,14]. Arjuna Terminalia Numerous hereditary disorders can demonstrate the Roxb effect. The bark of the Arjuna plant, which is mostly found in the Himalayan region, is used in traditional Indian medicine to treat heart conditions in a variety of herbal formulations [13]. Arjuna Terminalia, the Roxb tree, which belongs to the Combretaceae family, has thick, smooth bark and simple leaves. Flowering from April to July, the small, regular, sessile, cup-shaped, polygamous flowers are white, creamy, or greenish-white and have a strong honey aroma. Tiny terminal panicles or axillary spikes make up the inflorescences [18,19].

The fruits are oblong-oblong, dark brown to reddish brown, fibrous, woody, indehiscent drupes that ripen from February to May. The inflorescences are tiny axillary spikes or short terminal panicles. Every component of Arjuna has been utilized for its medicinal benefits [15,17]. *Terminalia arjuna* helps keep the heart healthy and lessens the effects of anxiety and stress. It has anti-inflammatory, antibacterial, anti-mutagenic, hypolipidemic, antioxidant, and hypocholesterolemic properties. By boosting antioxidative defense activities, *Terminalia arjuna* can shield the liver and renal tissues from oxidative stress caused by CCl4 [16,20]. Arjunolic acid, one of the several bioactive compounds that have been extracted from this medicinal plant, is highly valued in medicine. In the traditional medical system, *T. arjuna* plant components are utilized to treat a variety of illnesses [24,25]. With its anti-ischemic, antioxidant, and cardioprotective qualities, as well as its fungicidal and antibacterial, antimicrobial, anti-inflammatory, immunomodulatory, and antinociceptive effects, the bark powder was created. Arjuna is also effective in treating obesity, hypertension, and hyperglycemia [21]. Because *Terminalia arjuna* stem bark contains more phenolic and flavonoid compounds, it has a stronger antioxidant capacity. As one of the greatest heart tonics, it can be used on a regular basis to support a healthy circulatory system [22].

History

Gutika

Overview Ayurvedic gutika, also referred to as pills or spheroids in modern times, is a very beneficial and significant dosage type. There are a lot of historical allusions in the gutika setting [27,28]. These contain at least one drug from the origin of a plant, animal, mineral, or metal. Vatikalpana was described by Gutika. Gutika refers to vati because the techniques are identical for both, but there is a size difference [32]. Plants or minerals are pulverized using particular liquid media that are recommended in ancient texts and then shaped into pills or tablets to create vatikalpana. Different vati plans are mentioned in various contexts in ancient texts known as Brhatrayi. In any case, Acharya [36,37].

The primary source of the point was Sarngadhara's accurate depiction of vatikalpana in a separate chapter (Srikantamurty, 2001). Spheroids' smooth, mathematically described surfaces make them more amenable to film covering [30]. It is possible to combine and arrange spheroids with different drug formulations in a single measuring framework, even those that exhibit varying rates of delivery for the same drug. Spheroids can disperse as distinct subunits in the gastrointestinal tract, ensuring a steady rate of drug absorption and hence reducing variations in peak plasma. It is possible to avoid the bother caused by a high-close convergence of a drug from a single unit measuring structure [31,33].

Arjuna

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renal tissues from oxidative stress caused by CCl4 (6). Arjunolic acid, one of the several bioactive compounds that have been extracted from this medicinal plant, is highly valued in medicine. The indigenous medical practice uses the plant parts 7 [45]. Arjuna to treat a variety of illnesses. With its anti-ischemic, antioxidant, and cardioprotective qualities, as well as its fungicidal and antibacterial, antimicrobial, anti-inflammatory, immunomodulatory, and antinociceptive effects, the bark powder was created. Arjuna is also effective in treating obesity, hypertension, and hyperglycemia [47]. Because *Terminalia arjuna* stem bark contains more phenolic and flavonoid compounds, it has a stronger antioxidant capacity. As one of the greatest heart tonics, it can be used on a regular basis to support a healthy circulatory system [50].

Diabetic

An endocrine illness known as diabetes mellitus, or diabetes, is defined by a loss of glucose homeostasis brought on by deficiencies in insulin action, secretion, or both. This impairs the metabolism of glucose and other fuels that provide energy, such as protein and fat (WHO, 1985) [48]. While normal pancreatic cells can increase insulin secretion to compensate for insulin resistance, prolonged exposure to high glucose levels results in cell dysfunction, which is linked to decreased insulin biosynthesis and secretion. By 2025, the number of people with diabetes is expected to reach 300 million or more, according to World Health Organization estimates. It has underlined the necessity of assessing plants' potential as potent medicinal agents, particularly in regions where there aren't any safe, contemporary medications available (WHO, 1994) [50].

Around the world, a wide variety of herbs, spices, and other plant materials have been described for the treatment of diabetes. Few of the plants used to cure diabetes suggest that more research should be done in this area. A significant variety of plants have demonstrated efficient hypoglycemic activity following laboratory testing, and 1200 plant species are utilized globally to treat diabetes mellitus. Both dietary supplements to current treatments and oral hypoglycemic substances for the creation of new pharmaceutical products are beneficial services offered by medicinal plants (Bailey and Day, 1989). There are around 45,000 plant species in India, and many of them have therapeutic uses [49].

Disease

Diabetes

According to the WHO, diabetes mellitus is a metabolic disease with several etiologies that is typified by persistently high blood sugar levels and abnormalities in the metabolism of carbohydrates, fats, and proteins brought on by deficiencies in either insulin secretion, insulin action, or both [42]. Long-term harm, malfunction, and failure of several organs, including the kidney, nerves, heart, and gastrointestinal tract, are consequences of diabetes mellitus. With an incidence ranging from 1 to 8%, it is the most prevalent endocrine condition globally. According to estimates, the prevalence of diabetes will rise from 4% in 1995 to 5.4% in 2025 [45].

Notwithstanding recent advances in synthetic anti-diabetic medications, diabetes is still astonishingly incurable. The lack of safe and effective medications makes treating diabetes more difficult, and it lacks the capacity for long-term histological, biochemical, and clinical healing [44]. Instead, herbal medications have become more popular around the world, mostly because they are safer, have fewer side effects, and consistently lower blood sugar levels. The use of herbal remedies for patients in developed nations with diabetes is prompted by worries about the negative consequences and expense of long-term synthetic medication use [45]. Numerous phytoconstituents are helpful in the management of diabetes. These consist of steroids, guanidine, glycopeptides, terpenoids, alkaloids, glycosides, peptidoglycan, hypoglycan, amino acids, and inorganic ions. An ethnobotanical survey indicates that over 800 plants have the ability to prevent diabetes [44].

Diabetes mellitus

Diabetes mellitus is an endocrine system metabolic disease. Diabetes is a long-term condition that affects how fat, protein, and carbohydrates are metabolized. It is caused by a total or relative lack of insulin secretion, with or without variable levels of insulin resistance. Additionally, it can be described as a condition in which the body either stops producing insulin, produces very little of it, or develops growing resistance to its action [48].

It is projected that 171 million individuals worldwide had diabetes in 2000, and by 2030, that number is expected to double due to the increased incidence of both type 1 and type 2 diabetes [50].

Types of Diabetes: Diabetes comes in three primary forms:

- **Type 1 Diabetes:** Type I diabetes, also known as insulin-dependent diabetes (IDDM), is one of the most dangerous metabolic diseases. It is autoimmune in nature and is typified by the breakdown of the beta cells in the pancreas [41]. It is not surprising that HLA-DR3 and HLA-DR4 confer vulnerability to type 1 diabetes mellitus, as both genetic and environmental variables play a role [47].
- **Type 2 Diabetes:** Type 2 diabetes It used to stand for adult-onset diabetes and non-insulin-dependent diabetes mellitus,

or NIDDM for short. Hyperglycemia is a hallmark of type 2 diabetes mellitus, a collection of dysfunctions brought on by a combination of insufficient insulin production, excessive or incorrect glucagon secretion, and resistance to the effect of insulin [43].

- **Gestational diabetes:** Gestational diabetes, known as gestational glucose intolerance or gestational diabetes mellitus (GDM), affects around 7% of pregnancies. Because gestational diabetes mellitus (GDM) can be linked to a number of maternal and fetal problems, including macrosomia, birth trauma, cesarean sections, hypocalcemia, hypoglycemia, and hyperbilirubinemia in newborns [49].

Classification of diabetes mellitus

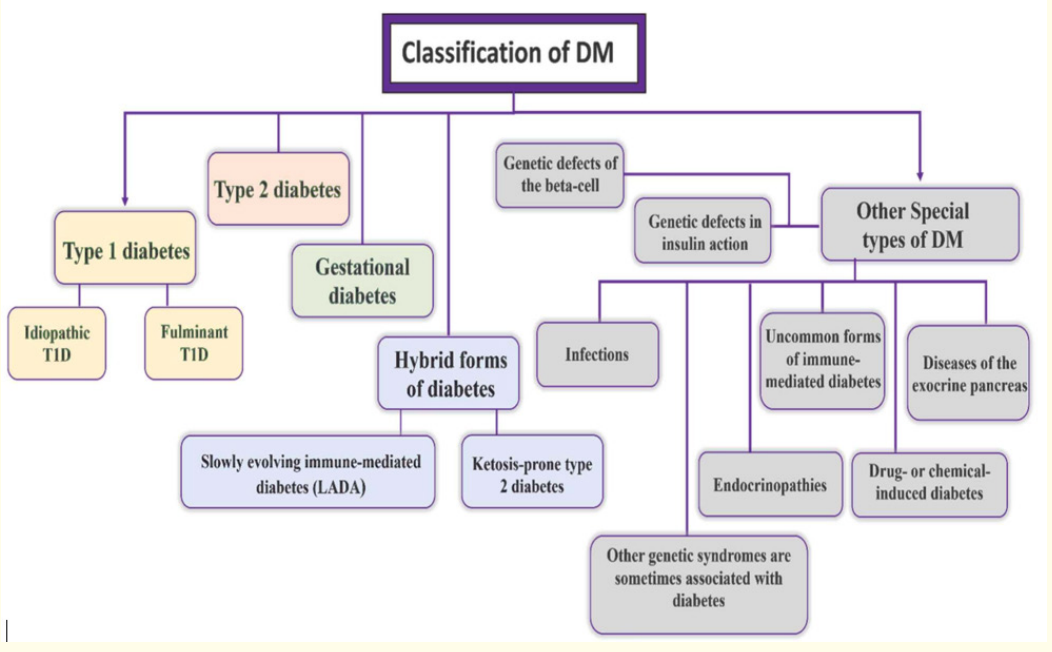

Figure 1

Signs and symptoms

Figure 2

Causes of diabetes

Multifactorial, encompassing a number of risk factors and predisposing conditions. Diabetes is frequently influenced by a person's environment, lifestyle, and genetics.

Diabetes type 1

It is thought that type 1 diabetes is an autoimmune condition. The immune system of the body targets the insulin-producing cells in the pancreas specifically.

- Type 1 diabetes may run in families, but Type 2 diabetes is far more likely to be caused by genetics (a positive family history).
- Type 1 diabetes may also be caused by environmental causes, such as frequent, unavoidable virus infections.
- Those of Northern European and non-Hispanic ancestry are most likely to have type 1 diabetes, followed by African Americans and Hispanic Americans.
- Men are slightly more likely than women to have type 1 diabetes.

Type 2 diabetes

- High blood pressure
- High blood triglyceride (fat) levels
- Gestational diabetes or giving birth to a baby weighing more than 9 pounds
- High-fat diet
- High alcohol intake
- Sedentary lifestyle
- Obesity or being overweight
- Aging

Complications of diabetes

Those with well-controlled blood sugar levels had a much lower incidence and severity of diabetes mellitus sequelae.

Microvascular complication

- Diabetic Retinopathy
- Diabetic Nephropathy
- Diabetic Neuropathy

Macrovascular complication

- Atherosclerosis
- Cardiovascular Disease (CVD)
- Stroke

Dosage form

Table 1: Dosage Form.

S. No	Brand Name	Types	Dose	Quantity
1	Diabecon	Tablet	300 mg	60
2	Diazero	Capsule	550 mg	60
3	Glucotrol	Tablet	500 mg	60
4	Glycomet	Tablet	500 mg	60
5	Herbo Diabeat	Capsule	250 mg	60
6	Madhunashini	Tablet	300 mg	60
7	Arjuna	Capsule	500 mg	60
8	Arjunarishta	Syrup	10-15ml	200 ml
9	Arjunin	Tablet	250 mg	60
10	Arjunolic acid	Capsule	250 mg	60
11	Arjuna Extract	Powder	1-2 teaspoons	100g
12	Arjuna juice	Juice	10-15 ml	500 ml
13	Metformin	Tablet	500-1000 mg	10
14	Glyburide	Tablet	1.5-5 mg	60
15	Actos	Tablet	15-30 mg	30
16	Januvia	Tablet	25-50 mg	30
17	Trulicity	Injection	1.5 mg	1.5 ml
18	Levemir	Insulin	10-40 unit	10 ml
19	Galvus	Tablet	100 mg	30
20	Onglyza	Tablet	2.5-5 mg	30
21	Invokana	Tablet	100-300 mg	30
22	Arjuna tea	Tea Bag	1-2 cups	20
23	Arjunin Forte	Tablet	500 mg	60
24	Arjuna plus	Capsule	500 mg	60
25	Victoza	Tablet	0.6-1.2 mg	30

New drug

- Arjuna Infusion
- Arjuna Topical Cream
- Arjuna Extract Injection
- Arjuna Softgels
- Arjuna Liquid Extract

Patent

Table 2: Patent.

S. No	Authors	Title	Patent No.	Submission	Publication	Reference
1	G. Geetha Krishnan	An herbal formulation for prevention and treatment of diabetes and associated complications	Ep2326338b1	2009-09-17	2009-09-17	[26-50]
2	Merina Benny Anthony	Preparation, process, and a regenerative method and technique for prevention, treatment, and glycemic control of diabetes mellitus	Us7378113b2	2007-06-08	2008-05-27	
3	Palpu Pushpangadam, Dhan Prakash	Herbal nutraceutical formulation for diabetics and process for preparing the same.	Us20060147561a1	2005-11-16	2006-07-06	
4	Muhammed Majeed, Kalyanam Nagabhushanam, Beena Bhat	Process for the preparation of standardized composition of Arjun glucoside from the bark of Terminalia arjuna	Ca3066772c	018-06-21	2018-12-27	
5	Vinita Vijay Kale, Amarnath Bhaskar Rao Pattamar	Rapid dissolvable oral film for delivering herbal extracts with or without other pharmaceutically active agents	WO2010146601A4	2010-06-15	2011-03-10	
6	Kelly Heaton	Method and glucose monitoring system for monitoring individual metabolic responses and for generating nutritional feedback	EP2006786B1	2007-06-18	2008-12-24	
7	Stefan Weinert, Nicole Bernini, Derek Brandt	System for collecting patient information for diabetes management	US20200168328A1	2020-01-30	2020-05-28	
8	Iddo Gescheit, Hans-Juergen Kuhr	Control unit for infusion pump units, including a controlled intervention unit	US20180361063A1	2018-08-24	2018-12-20	
9	Timothy L. Ruchti, William Patrick BURGESS, and John Dumas	Systems and methods for determining insulin therapy for a patient	US10842935B2	2018-07-30	2018-11-22	
10	Ashok Balasubramanian, Karthikeyan Krishnaswamy RAJA	Methods and systems for automated software natural language documentation	US11893385B2	2022-01-31	2022-08-18	

Future prospects

- **Clinical studies:** To determine Gutika's effectiveness and safety in people, conduct comprehensive clinical trials.
- **Standardization:** To guarantee uniformity and quality, standardize the extraction and formulation procedures.
- **Combination therapy:** Examine the possibility of mixing Gutika with other herbal extracts or traditional antidiabetic medications as part of combination therapy.
- **Mechanism of action:** Examine the molecular processes that underlie the antidiabetic effects of gutika.
- **Pharmacokinetics and pharmacodynamics:** Examine how gutika is absorbed, distributed, metabolized, and eliminated.
- **Toxicity and safety:** To guarantee the safety of prolonged usage, carry out toxicity tests.
- Pharmaceutical applications: Create different pharmaceutical forms of Gutika, like injectables, pills, and capsules.
- **Patent protection:** Take into account obtaining a patent for the extraction and formulation procedures.
- **Commercialization:** Increase output and promote Gutika as a natural treatment for diabetes.

- **Expansion of research:** Examine how arjuna extract might be used to treat additional medical issues, including metabolic syndrome or cardiovascular disease.

Conclusion

Arjuna extract has been widely utilized in Ayurvedic medicine for its multiple health advantages, including its antidiabetic effects. The following is a summary of the formulation and evolution process's conclusion: An herbal tablet called Gutika, which has been successfully made with arjuna extract, exhibits encouraging antidiabetic properties. The arjuna extract was purified and standardized, and extraction techniques were optimized as part of the formulation process. Given its strong antidiabetic effects, the developed Gutika formulation has promise as a natural blood sugar-regulation aid. It is advised that more research be done in order to completely determine Gutika's safety and effectiveness in people.

This advancement emphasizes the value of combining ancient knowledge with contemporary science and the promise of herbal medicine in treating contemporary health issues. All things considered, the creation and advancement of Gutika utilizing Arjuna extract for antidiabetic action marks a critical turning point in the creation of herbal medications for the treatment of diabetes.

Bibliography

1. Ghare Sanchita Sanjay and Mahesh Dolas. "A CONCEPTUAL REVIEW ON MADHUKADI ANJANA". (2024).

2. Bhattacharya Ruchi and Prof. GIDWANI. "Investigation of Antidiabetic Activity and Pharmacokinetics in Herbo-Mineral Ayurvedic Formulation 'Arogyavardhini Gutika in Streptozotocin-induced Wistar Rat". *Palestinian Medical and Pharmaceutical Journal* 9.1 (2024): 10.

3. Amalraj Augustine., *et al*. "Chemistry, Biological Activities, and Therapeutic Applications of Medicinal Plants in Ayurveda". *Royal Society of Chemistry* (2022).

4. Chattopadhyay Kaushik., *et al*. "Effectiveness and safety of Ayurvedic medicines in type 2 diabetes mellitus management: a systematic review and meta-analysis". *Frontiers in Pharmacology* 13 (2022): 821810.

5. Mukherjee Pulok K., *et al*. "3.14 Ayurveda in Modern Medicine: Development and Modification of Bioactivity".

6. Kaur Jaswinder., *et al*. "An Overview on Renowned Traditional Ancient Plant: Terminalia arjuna". (2021).

7. Khurana BS., *et al*. "Fingerprinting profiling of ayurvedic preparation: an overview". *Plant Archives* 21.1 (2021): 643-649.

8. Mukherjee Pulok Kumar., *et al*. "Evidence-based validation of herbal medicine: translational approach". *Evidence-Based Validation of Herbal Medicine*. Elsevier, (2022): 1-41.

9. Mamun-or-Rashid A N M., *et al*. "A review on medicinal plants with antidiabetic activity". *Journal of Pharmacognosy and Phytochemistry* 3.4 (2014): 149-159.

10. Patel DK., *et al*. "Diabetes mellitus: an overview on its pharmacological aspects and reported medicinal plants having antidiabetic activity". *Asian Pacific Journal of Tropical Biomedicine* 2.5 (2012): 411-420.

11. Kumar A., *et al*. "A review on medicinal plants with potential antidiabetic activity". *International Journal of Phytopharmacology* 2.2 (2011): 53-60.

12. Arumugam G., *et al*. "A review: anti-diabetic medicinal plants used for diabetes mellitus". *Journal of Acute Disease* 2.3 (2013): 196-200.

13. Mustaffa F., *et al*. "A review of Malaysian medicinal plants with potential antidiabetic activity". *Journal of Pharmacy Research* 4.11 (2011): 4217-4224.

14. Gurjar Himanshu PS., *et al*. "Review on some medicinal plants with antidiabetic activity". *Journal of Drug Delivery and Therapeutics* 6.2 (2016): 45-51.

15. Benalla Wafaa., *et al*. "Antidiabetic medicinal plants as a source of alpha glucosidase inhibitors". *Current Diabetes Reviews* 6.4 (2010): 247-254.

16. Ragavan B and S Krishnakumari. "Antidiabetic effect of T. arjuna bark extract in alloxan-induced diabetic rats". *Indian Journal of Clinical Biochemistry* 21 (2006): 123-128.

17. Biswas Moulisha., *et al*. "Antihyperglycemic activity and antioxidant role of Terminalia arjuna leaf in streptozotocin-induced diabetic rats". *Pharmaceutical Biology* 49.4 (2011): 335-340.

18. Morshed M Alam., *et al*. "Anti-hyperglycemic and lipid-lowering effect of Terminalia arjuna Bark extract on Streptozotocin-induced Type-2 Diabetic Model Rats". *International Journal of Pharmacy and Pharmaceutical Sciences* 3.4 (2011): 450-454.

19. Singh Shikha., *et al*. "Evaluation of anti-diabetic activity of Terminalia arjuna root extract in alloxan-induced diabetic rats". *Journal of Biomedical and Pharmaceutical Research* 8.1 (2019): 20-29.

20. Pingili Divya., *et al*. "Evaluation of the polyherbal extract for antioxidant, anticancer, and antidiabetic activity". *Annals of Phytomedicine* 1.1 (2012): 39-45.

21. Rao B Kameswara., *et al*. "Antidiabetic activity of Terminalia pallida fruit in alloxan-induced diabetic rats". *Journal of Ethnopharmacology* 85.1 (2003): 169-172.

22. Kumar Chandan., *et al*. "Phytochemical properties, total antioxidant status of acetone and methanol extract of Terminalia arjuna Roxb. Bark and its hypoglycemic effect on Type-II diabetic albino rats". *Journal of Pharmacognosy and Phytochemistry* 2.1 (2013): 199-208.

23. Khatkar Sarita., *et al*. "Extraction, HPTLC Estimation, In silico, and In Vitro Evaluation of α-Amylase Inhibition Potential of Stem Bark of Terminalia arjuna". *Current Biomarkers (Formerly: Recent Patents on Biomarkers)* 6.1 (2016): 47-53.

24. Rajni H S and R A Manish. "Review on pharmacological Ayurvedic compound of Terminalia arjuna". *International Journal of Phytotherapy Research* 4.4 (2014): 31-8.

25. Shengule Sushant A., *et al*. "Anti-hyperglycemic and anti-hyperlipidaemic effect of Arjunarishta in high-fat-fed animals". *Journal of Ayurveda and Integrative Medicine* 9.1 (2018): 45-52.

26. Kumar Vikas., *et al*. "Therapeutic potential and industrial applications of Terminalia arjuna bark". *Journal of Ethnopharmacology* 310 (2023): 116352.

27. Aamir Khurram., *et al*. "Arjunolic acid downregulates elevated blood sugar and pro-inflammatory cytokines in streptozotocin (STZ)-nicotinamide-induced type 2 diabetic rats". *Life Sciences* 289 (2022): 120232.

28. Tafesse Tadesse Bekele., *et al*. "Antidiabetic activity and phytochemical screening of extracts of the leaves of Ajuga remota Benth on alloxan-induced diabetic mice". *BMC Complementary and Alternative Medicine* 17 (2017): 1-9.

29. Khaliq Farah., *et al*. "Improvement in myocardial function by Terminalia arjuna in streptozotocin-induced diabetic rats: possible mechanisms". *Journal of Cardiovascular Pharmacology and Therapeutics* 18.5 (2013): 481-489.

30. Gupta Simmy., *et al*. "Terminalia arjuna (Roxb.) Wight & Arn.: Competent source of bioactive components in functional food and drugs". *The Pharma Innovation Journal 3* (2018): 223-231.

31. Krishna RN., *et al*. "Aqueous extract of Tamarindus indica fruit pulp exhibits antihyperglycaemic activity". *Avicenna Journal of Phytomedicine* 10.5 (2020): 440.

32. Khan ZM Halleys., *et al*. "Phytochemistry and pharmacological potential of Terminalia arjuna L". *Medicinal Plant Research 3* (2013).

33. Patra Arjun., *et al*. "Antidiabetic activity of an aqueous extract of Eucalyptus citriodorahook. in alloxan-induced diabetic rats". *Pharmacognosy Magazine* 19s (2009).

34. Bhatia Astha., *et al*. "In vitro evaluation of the α-glucosidase inhibitory potential of methanolic extracts of traditionally used antidiabetic plants". *BMC Complementary and Alternative Medicine 19* (2019): 1-9.

35. Timilsina Arjun Prasad., *et al*. "Metabolomics and molecular networking approach for exploring the anti-diabetic activity of medicinal plants". *RSC Advances 44* (2023): 30665-30679.

36. Jaiswal K U L E S H W A R., *et al*. "Pharmacological approach of Terminalia arjuna: A review". *Plant Cell Biotechnology and Molecular Biology 57&58* (2021): 1-15.

37. Soni Neelam and Vinay Kumar Singh. "Efficacy and advancement of Terminalia arjuna in Indian herbal drug research: A review". *Trends in Applied Sciences Research* 4 (2019): 4.

38. Yadav Sheetal., *et al*. "Terminalia arjuna (Arjun Tree): A sacred plant with high medicinal and therapeutic potential". *Research Journal of Pharmacy and Technology 12* (2022): 5859-5867.

39. Yallappa S., *et al*. "Microwave-assisted rapid synthesis and biological evaluation of stable copper nanoparticles using T. arjuna bark extract". *Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy* 110 (2013): 108-115.

40. Jaiswal Priyanka and Padma Kumar. "Alpha amylase inhibitory activity of different extracts of Terminalia arjuna bark". *Current Trends in Biotechnology and Pharmacy 3* (2017): 253-258.

41. Bushra., *et al*. "Isolation and Bioassay of a New Terminalone A from Terminalia arjuna". *Molecules* 3 (2023): 1015.

42. Patel Urvi R., *et al*. "Pharmacological activities of terminalia arjuna: an overview".

43. Devi Anjana and Preeti Devi. "Emerging Therapeutic Properties of Terminalia Arjuna: A Review". (2024).

44. Malvi Reetesh., *et al*. "A review on antidiabetic medicinal plants and marketed herbal formulations". *International Journal of Pharmaceutical and Biological Archive* 2 (2011): 1344-1355.

45. Singh Arun K and Dharmendra Kumar. "Biochemical estimation of total sugar in the bark of anti-diabetic plant terminalia arjuna". *Pharma Science Monitor* 1 (2014).

46. Yallappa S and J Manjanna. "Biological evaluation of silver nanoparticles obtained from T. arjuna bark extract as both reducing and capping agents". *Journal of Cluster Science 25* (2014): 1449-1462.

47. Al-Harrasi Ahmed., *et al*. "Plant profile, phytochemistry, and ethnopharmacological uses of Terminalia bellirica, Terminalia chebula, and Terminalia arjuna". *Recent Advances in Natural Products Science*. CRC Press (2022): 143-172.

48. Swain Rupak K., *et al*. "A Study on Phytochemical and Pharmacological Activity of Terminalia arjuna: A Review". *Research Journal of Pharmacognosy and Phytochemistry 2* (2023): 111-117.

49. Sathyamurthy Balasubramanian., *et al*. "Invitro studies on the effect of Terminalia arjuna in adipocyte 3T3-L1 cell lines". *Pharma Tutor* 8 (2018): 17-26.

50. Chakrabarti R I T U P A R N A., *et al*. "Screening of nine herbal plants for in vitro a-amylase inhibition". *Screening* 4 (2014): 84-89.