JOURNAL OF NATURAL REMEDIES
DOI: 10.18311/jnr/2022/29791
SHORT REVIEW

Overview of Effective Traditional Medicinal Plants having Antihyperlipidemic Activity

Sireesha Rayadurgam and K. Manikandan*

Department of Pharmaceutical Analysis, SRM College of Pharmacy, SRMIST, Kattankulathur - 603203, Tamil Nadu, India; gurumani12@gmail.com, manikank2@srmist.edu.in

Abstract

Hyperlipidemia is characterized by excessive levels of lipids (cholesterol and triglycerides) in the blood. Elevated plasma concentrations of distinct lipid and lipoprotein fractions are key risk factors for Cardiovascular Disease (CVD). Natural ingredients have long been used to treat and prevent cardiovascular issues. Much research on natural compounds that are effective against hyperlipidemia has been done in recent decades as of interest. PubMed, Science Direct, Google Scholar, and Scopus are the search engines used to collect information. We picked anti-hyperlipidemia, atherosclerosis, and therapeutic plants as search terms. The goal of this article is to offer a rapid summary of herbal treatments used to treat and prevent atherosclerosis based on anti-hyperlipidemic action. This research aimed to analyze the anti-hyperlipidemic effectiveness of medicinal plants that have been scientifically demonstrated to be helpful.

Keywords: Antihyperlipidemic Activity, Atherosclerosis, Hyperlipidemia, Lipid-lowering Agents, Medicinal Plants

1. Introduction

Hyperlipidemia is a disorder that was characterized by a series of events in which the concentration of triglyceride-carrying lipoproteins in plasma is more than the normal limit. Lipoproteins deposited in the interstitial space of arteries originating from the aorta reduce the flow of blood to the heart which is a characteristic of atherosclerosis[1]. Hyperlipidemia plays a crucial part in the development of Cardiac disorders. One of the long-term consequences of hyperlipidemia was diabetes which leads to diabetes-associated morbidity and death. Higher deposition of lipoproteins entirely stopped the blood flow to the heart, and therefore Myocardial Infarction (MI) develops, which is generally known as heart attack[2].

At present synthetic medications like statins plays a major role in treating cardiovascular disorders by bringing down the level of bad cholesterol in the blood. But long term usage of statins causes a check for existing atherosclerotic lesions and also leads to kidney and liver damage. Usage of statins for treating atherosclerosis in its early stages seems to be implausible because of the severity of side effects. In recent times herbal related medicines taking the boom for treating various types of ailments and are specifically interested in phytomedicines because of having lesser side effects. Extensive research is going on nowadays for the protection of cardiac health based on plant-based compounds to reduce the cost of treatment by synthetic medications[3].

Effective anti-atherosclerotic drugs based on active plant-based products might be a preferable option. Natural treatments may have a broader range of effects than medicines, impacting a variety of atherosclerosis risk factors and so holding not only a direct anti-atherosclerotic activity at the cellular level but also indirect anti-atherosclerotic effects (e.g., cholesterol-lowering and blood pressure regulation). The pathogenetic mechanism of action and the effectiveness established in clinical

*Author for correspondence

Article Received on: 12.03.2022 Revised on: 11.06.2022 Accepted on: 14.06.2022

research should be the fundamental concepts for the use of pharmaceuticals and nonpharmaceutical therapies for the prevention of atherosclerosis. Natural products should be used to prevent atherosclerosis based on their ability to inhibit cholesterol formation in arterial wall cells, which might be prevented at the cellular level during the earliest stage of atherogenesis[4].

Flavonoids and phenolic compounds found in plants have been shown in studies on atherosclerosis to have a variety of biological effects, including antioxidant, free radical scavenging, anti-inflammatory, and anticancer properties. The oxidation of flavonoids caused by free radicals results in the generation of less active and more stable radicals, aggravating the sickness[5]. Polyphenols such as catechin, quercetin, kaempferol, apigenin, and vitexin have protective effects against cardiovascular events by preventing disease-causing processes like oxidative stress, inflammation, and endothelial dysfunction[6]. The major purpose of the article was to provide a quick overview of chosen medicinal plants for treating hyperlipidemia-linked atherosclerosis.

2. Methodology

The method followed to collect the information on medicinal plants was based on the search engines like PubMed, science direct, Google Scholar, and Scopus. The information gathered using search engines uses the search phrases such as anti hyperlipidemia, atherosclerosis, and the medicinal plants selected. After the papers have been collected, eligible papers are selected for analysis, and done the revision to get an overview.

3. Medicinal Plants

3.1 *Acacia catechu*

Acacia catechu Willd. belongs to the family Fabaceae also termed as cutch tree was native to Africa. Pakistan, India, Thailand, and Bangladesh are the primary origins of this plant. *A. catechu* has traditionally been used to cure a variety of disorders, including gastrointestinal and stomach ailments, leprosy, and skin infections. Advanced techniques has made it simpler to examine the biological activities of traditional medicine, there has been a surge of interest in historical traditional herbs[7,8]. Significant phytochemicals identified in the plant are catechin, quercetin, kaempferol, epigallocatechin, protocatechuic acid, epicatechin, phloroglucine, lupenone, epicatechingallate, poriferasterol glycosides, D-galactose, L-arabinose, D-rhamnose, and afzelchin gum, aldobiuronic acid, procyanidin, taxifolin. Catechin was used as an astringent and has anti-oxidant activity. The bioactivites identified was hypoglycemic action in rats, antibacterial activity, immunomodulatory activity, antifungal activity, anti-inflammatory activity and antimycotic activity[9]. Studies indicated that hydroethanolic leaf extract of *Acacia catechu* Willd when provided to diabetic rats exhibits considerable reduction in blood glucose levels.

Different solvent extracts such as petroleum ether, chloroform, ethanol, acetone, aqueous and crude aqueous extracts of barks of *Acacia catechu* Willd and the two fractions of ethanolic extracts were investigated for antihyperglycaemic activity in glucose-loaded hyperglycaemic rats. The extract and fraction of the plant investigated for antidiabetic activity have showed considerable effects in lowering the glucose levels and other diabetic related aspects[10].

Combined antihyperlipidemic action treatment of *Acacia catechu* with that of *Trigonella foenum-graecum* (Fenugreek) has been done on High cholesterol fed diet rats. Idea of combining treatment of Fenugreek Ethanol extract (FE) and Catechu Ethyl acetate extract (CE) exhibited stronger anti-hyperlipidemic efficacy than the individual extracts. The inclusion of steroidal saponins, alkaloids, and free amino acids in FE may explain its hypolipidemic effect. CE's hypolipidemic effect can be attributed to the inclusion of carbohydrates, tannins, flavonoids, and fixed oils[11].

3.2 *Commiphora mukul*

Commiphora mukul (Burseraceae) is extensively dispersed in Pakistan and India and its gum-resin is believed to be beneficial in the treatment of rheumatism, arthritis and associated illnesses. Pharmacological investigations on the crude drug, as well as various fractions and pure components of *C. mukul* have showed strong anti-inflammatory, anti-rheumatic and hypocholestremic/hypolipaemic activity[12].

Guggul's chemical analysis revealed a complicated composition made up of several compounds such as lignans, lipids, diterpenes, and steroids. The active ingredients are Z-guggulsterone and E-guggulsterone. Along with these there was D-glucuronide, ellagic acid,

pelargonidin, linoleic acid, caryophylline, campesterol, stearic acid, cholesterol, myrcene, dimyrcene, polymyrcene, palmitic acid, and stigmasterol.

Animal studies have shown that ethanolic extracts of *Commiphora mukul* gum resin (CMEE) and ethyl acetate extracts of *Commiphora mukul* (EECM) exhibit antihyperlipidemic action. The lipid-lowering effects are mainly due to the E- and Z-guggulsterone isomers[13]. The ethanolic extract of *Commiphora mukul* gum resin (CMEE) works by inhibiting the transcriptional activity of farnesoid X receptor, a potential antagonist of the bile acid receptor, a ligand-dependent transcription factor that regulates the expression of genes involved in cholesterol/bile acid homeostasis[14]. While Ethyl acetate extract of *Commiphora mukul* (EECM) reduces the risk by changes in carbohydrate and lipid metabolism. Geographical variations also causes changes in the amount of available phytoconstituents and variations in therapeutic activity[15].

Commiphora wightii and *Commiphora mukul* resins were harvested in different geographical locations like Gujarat, Madhya Pradesh, and Rajasthan, and their antihyperlipidemic efficiency was tested in rats fed a cholesterol-rich, high-fat diet. The results showed that the resins of *Commiphora wightii* and *Commiphora mukul* exudates collected in Gujarat and extracted in ethyl acetate, as well as the resins of *Commiphora mukul* exudates collected in Madhya Pradesh and extracted in ethyl acetate, had significantly higher antihyperlipidemic activity[16,17].

Combined effects of *Commiphora mukul* and *Terminalia arjuna* demonstrate antihyperlipidemic activity similar to the standard medication and possess good antioxidant activities than those of standard drug[18]. Guggulipid has been shown to have cardioprotective properties in several studies. In rats, guggulsterones have been shown to inhibit isoproterenol-induced cardiac damage and metabolic changes[19]. Another study looked at the anti-inflammatory effects of Guggulosomes containing ibuprofen. A rat model was used to demonstrate the cardioprotective effects of guggulipid. Guggulsterones inhibit TNF-induced COX-2 promoter activity and protein expression in vitro in a dose-dependent manner. In rat insulinoma cells, guggulsterone has been demonstrated to suppress cytokine-induced COX-2 mRNA and protein production[20].

Guggulosterone has a high level of antioxidant activity due to its radical scavenging properties. The oxidation of LDL caused by Fe^{2+} or rat peritoneal macrophages produced a significant amount of lipid peroxidation products, it was discovered. In the aforementioned setup, guggulsterone prevented the development of thiobarbituric acid reactive chemicals and lipid hydroperoxide of LDL. The reactivity of lipid peroxidation in liver microsomes with Fe^{2+} and sodium ascorbate was significantly reduced by guggulsterone. Guggulsterone's antioxidant properties might be linked to its metal chelating activity.

Gugulipid mixed with conventional medicine Atorvostatin has synergistic impact towards curing hyperlipidemia in Triton induced hyperlipidemic rats. It exhibits optimum effectiveness and safe in conjunction with even lower dosage of Atorvostatin[21,22]. The combined effects of *Commiphora mukul* and *Terminalia arjuna* have antihyperlipidemic activity comparable to normal medicine and have higher antioxidant activity than standard medication. Another herbal combination of *Commiphora mukul* and *Commiphora myrrha* ethanolic extracts and *Terminalia chebula* hydro-ethanolic extract was studied for its antidiabetic activity in streptozotocin induced animal models. According to the results, it possesses antihyperglycemic and cholesterol-lowering properties, as well as a positive effect on scavenging free radicals[23].

3.3 *Garcinia cambogia*

Garcinia cambogia is a well-known fat-burning plant. Mostly throughout Southeast Asia, the plant may be found. *Garcinia gummigutta* is the popular name for this plant from the Clusiaceae family. Phytoconstituents found in the plant include antiulcer, anticancer, antimicrobial, antihyperlipidemic, and anti-obesity effects. The fruit is used as a food bulking agent, as well as a traditional cure for piles, constipation, rheumatism, irregular menstruation, intestinal parasites, and oedema in many Asian cultures. In previous phytochemical studies on the plant, several benzophenones, xanthones, and organic acids were isolated as main ingredients[24]. The primary phytoconstituent contained in fruit portion is Hydroxy citric acid (HCA). Glycogen production in the liver was greatly enhanced by HCA. HCA inhibits lipid biosynthesis and switches carbohydrate metabolism to glycogen creation in the liver, lowering hunger and HCl production. The anti-ulcerogenic potential of HCA present in the rind of the fruit has been proposed[25].

Nowadays, eating a high-fat, high-carbohydrate diet may lead to concerns such as dyslipidemia, oxidative stress, and obesity. It leads to changes in blood parameters and variations in oxidative enzyme levels. *Garcinia cambogia* extract (GE) treatment found to be effective in altering lipid levels[26].

When rats are treated with Dexamethasone, there was a rise in triglyceride and cholesterol levels both in plasma and liver but when treated with *Garcinia cambogia* fruit extract it alters the level of cholesterol and triglyceride levels and brings to normalcy. *Garcinia cambogia* extract shows strong antioxidant activity by DPPH technique[27]. Combination therapy of four plants like *Garcinia cambogia* extract, *Cocos nucifera* (coconut inflorescence), *Myristica fragrance* (nutmeg), and *Saraka asoka* (asoka flower) were studied for the role of flavonoids for treating hyperlipidemia. The results were proven that there was a substantial drop in cholesterol and triglyceride levels[28].

3.4 *Vitis vinifera*

Grape plant (*Vitis vinifera* L.) is one of the most food and commercially significant plant; belong to vitaceae family. Grapes contain a broad array of polyphenol chemicals, including flavonoids, phenolic acids, and resveratrol. Grapes include catechin, gallocatechins, epicatechin, epigallocatechin, tannins, anthocyanins, flavonols, and epicatechin gallate, including proanthocyanidins, making them one of the most popular and commonly produced fruits on the planet[29,30].

Resveratrols (the predominant types were glycoside and trans) and tyrosol were found in abundance in red wines collected. *In vivo* biomonitoring of antioxidant and hypolipidemic activities revealed that drinking these wines increased antioxidant capacity while lowering hypercholesterolemia and hypertriglyceridemia generated by a high-fat diet in C57BL6 LDL receptor deletion mice model. Significant connections were found between the increase in antioxidant capacity markers, the decrease in lipid levels caused by wine consumption, and the concentrations of stilbenes and tyrosol, suggesting that these chemicals are important biologically[31].

Polyphenols found in grape seeds have been demonstrated to offer health benefits in the prevention of dyslipidemia. Grape seed has three essential polyphenolic components namely gallic acid, catechin, and epicatechin that have been shown to decrease cholesterol levels and also strongly inhibit pancreatic cholesterol esterase in a concentration-dependent manner in a study[32].

Anti-hypercholesterolemic activity was assessed in experimental animals for upto 21 days. Methanolic extract of *Vitis vinifera* (VVME) and aqueous extract of *Vitis vinifera* (VVAE) extract dramatically decreases lipid levels during the experimental periods. VVME was shown to be more effective than VVAE and histopathology findings verified the efficiency of VVME. According to the findings, *Vitis vinifera's* anti-hypercholesterolemic action can be linked to the presence of active phytoconstituents and its antioxidant effectiveness[33].

Grape seed extract (GSE) showed considerable inhibition of pancreatic lipase and cholesterol esterase in dose-dependent manner. In addition, GSE also hindered the development of cholesterol micelles, and bonded to bile acid. The oral dose of GSE dramatically lowered blood triglyceride and cholesterol in rat given high fat emulsion via prevention of lipid digestion and absorption. People with hyperlipidemia and obesity may benefit from GSE as a therapeutic alternative for prevention and therapy[34].

Vitis vinifera stem bark extract has antihyperlipidemic effects and antioxidant activities in which bioactive components such as flavonoids and glycosides are responsible for the action[35]. Resveratrol, one of the key chemical component of *Vitis vinifera* plant possesses safe and powerful hypoglycemia and hypolipidemic actions which was validated by investigations on diabetic rabbits[36].

3.5 *Rubia cordifolia*

Rubia cordifolia, which belongs to the family Rubiaceae also known as Indian Madder or Common Madder, is a species of flowering plant in the coffee family. The phytochemical components anthraquinones and naphthohydroquinones are well recognised in *Rubia cordifolia*, also known as Manjistha. The principal phytoconstituents of *Rubia cordifolia* was Rubiadin, Rubiatriol (triterpenoid), Rubicordone A, Rubiasins AC, two pentacyclic triterpenoid- Rubicoumaric acid, Rubifolic acid and an iridoid glycoside 6-methoxygeniposidic acid. Traditional and proven actions demonstrate that *Rubia cordifolia* works as a powerful blood purifier, antioxidant, diuretic, calcium channel blocker, antiplatelet, antidiabetic, anti-inflammatory, anti-stress, immunomodulator, and antiplatelet agent. *Rubia cordifolia,* a plant known for its antioxidant, anti-inflammatory, and blood purifier

properties, might help to detoxify ischemia-related free radical generation[37,38].

The anti-diabetic properties of *Rubia cordifolia* roots extracted with water were tested in a rat model. The existence of numerous types of bioactive constituents operating singly or in a coordinated way with a single or a broad range of pharmacological activities has been discovered in streptozotocin induced diabetic rats, resulting in antihyperglycemic, hypotriglyceridemic effects[39]. The same study was repeated with different solvent fractions like ethyl acetate fraction and n-butanol fraction in Alloxan-induced diabetic rats. This effect is due to the antioxidant activity of these solvent fractions, which was determined using the DPPH test. *R. cordifolia*'s antidiabetic properties are linked to antioxidant activity and phytochemical components such as phenolics and flavonoids, particularly mangiferine and purpurine. Tannins, terpenoids, alkaloids, and saponins, among other phytochemicals, may have a synergistic effect[40]. *Rubia cordifolia* plays a vital role in treating atherosclerosis and other cardiovascular disorders which was confirmed based on their proven scientific evidence of antihyperlipidemic and antioxidant activities.

3.6 *Terminalia arjuna*

Terminalia arjuna is a huge evergreen tree that belongs to the family Combretaceae. It may be found in abundance on northern side of India. The beneficial portion of this plant is bark which discovered to have several therapeutic actions including cardiotonic, antiulcer, antidiabetic, astringent, treating allergies and skin problems, anti-inflammatory activity and are utilized in Indian traditional medicine. The major action of bark is to strengthen cardiac muscles and heals faulty functioning[41]. The primary phytochemicals detected in the stem bark section of *T. arjuna* species, include hydrolysable tannins, triterpenoids acid and their glycosides, flavonoids, phenolics, and phytosterol. Arjunolic acid, terminoic acid, and arjunglucoside 1-3 were all substantial components of bark[42].

Saravanan Subramaniam *et al.*, proceeded on to a research on ethanolic fraction of bark powder of *Terminalia arjuna* on rabbits. The bark has proved to have antiatherogenic effect on hypercholesterolemic rabbits. The bioactivity of this ethanolic extract of the bark was due to the presence of flavonoids, tannins and plant sterols[43]. Leaves of *T. arjuna* was assessed for hypolipidemic activity in hyperlipidemic rat models which was done in both Triton induced and Cholesterol and cholic acid fed models. The research reveals that Methanolic extract of *T. arjuna* leaves exhibits outstanding hypolipidemic activities that may be due of numerous effects of several active principles contained in plant[44].

The bark of *Terminalia arjuna* has strong hypolipidemic properties. The experimental group of mice received a 50 percent v/v ethanol bark extract of *T. arjuna* at a dose of 40mg/kg body weight, which successfully reduced plasma TC, TG, and LDL cholesterol while increasing HDL cholesterol. Based on the increased breakdown of cholesterol to neutral sterols, the extract's activity seems to be mediated via increased hepatic clearance of cholesterol, down regulation of lipogenic enzymes, and inhibition of HMG-CoA reductase[45].

Along with *T. arjuna* two indigenous medications like *T. belerica, T. chebula* were investigated for hypolipidemic activity done in rabbits fed with cholesterol diet to induce atherosclerosis. The findings reveal that plasma and tissue lipid components levels are controlled and atherosclerotic lesions are largely diminished which suggests hypolipidemic activity and also having antiatherogenic action[46].

Oral administration of *T. arjuna* improves antihyperlipidemic effect in high cholesterol fed rats with fortified milk products. It regulates the lipid profile in the circulatory system and found to have antioxidant properties in addition. The researchers discovered that *T. arjuna* encased with gum arabic and maltodextrin is protected in the gastrointestinal tract and may be beneficial to those suffering from cardiovascular illness[47].

The antihyperlipidemic and antioxidant activity of three extracts (ethyl acetate, diethyl ether, ethanol) of *T. arjuna* showed significant activity in Poloxamer induced animal models and when gone through comparative studies out of three fractions, ethanolic fraction discovered to have more effective activity of being antioxidant and hypolipidemic[48].

4. Conclusion

In this study, we attempted to offer a summary of overview of the chosen medicinal plants which showed anti-hyperlipidemic action. The chosen plants in this

review are having great lipid lowering effects individually. When we construct the formulations by combining the medicinal plants it may exhibit some synergistic effects in therapeutic activity in combination forms than the impact noticed in separate plants. The reason may be due to mixtures of interacting compounds as Resveratrol, catechin, arjunin, arjunic acid, arjunetin, rubiadin, Hydroxy citric acid, E, Z Guggulosterone produced by plants which when applied in combination therapies affect different pharmacological routes and clinically more effective than single compound-based drugs.

References

1. Greaves DR, Gordon S. Immunity, atherosclerosis and cardiovascular disease. Trends Immunol. 2001; 22:180-1. https://doi.org/10.1016/S1471-4906(00)01848-2.
2. Phogat P, Deep A, Sharma PC, Mittal SK, Kakkar S, Goyal R, *et al*. Introduction to hyperlipidemia and its management: a review. Pharmacologyonline. 2010; 2:251-66.
3. Introduction and importance of medicinal plants and herbs. National Health Portal of India. Available from: https://www.nhp.gov.in/introduction-and-importance-of-medicinal-plants-and-herbs_mtl
4. Ibrahim SRM, Mohamed GA, Banjar ZM, Kamal HKM. Natural antihyperlipidemic agents: Current status and future perspectives. Phytopharmacology. 2013; 4:492-531.
5. Koshy AS, Vijayalakshmi NR. Impact of certain flavonoids on lipid profiles potential action of *Garcinia cambogia* flavonoids. Phyther Res. 2001; 15:395-400. https://doi.org/10.1002/ptr.725. PMid:11507730
6. Sawale PD, Pothuraju R, Abdul Hussain S, Kumar A, Kapila S, Patil GR. Hypolipidaemic and anti-oxidative potential of encapsulated herb (*Terminalia arjuna*) added vanilla chocolate milk in high cholesterol fed rats. J Sci Food Agric. 2016; 96:1380-5. https://doi.org/10.1002/jsfa.7234. PMid:25907198
7. Devi VG, John A, Sreekala Devi R, Prabhakaran VA. Pharmacognostical studies on *Acacia catechu* willd and identification of antioxidant principles. Int J Pharm Pharm Sci. 2011; 3:108-11.
8. Satpudke S, Pansare T, Khandekar S. Review on Arjuna (*Terminalia Arjuna* Roxb.) with Special Reference To Prameha (Diabetes). Int J Herb Med. 2019; 8:1-5.
9. Sasikala TP, Kamakshamma J. Genetic diversity assessed through RAPD Markers in *Terminalia Pallida* Brandis. J Pharm Sci Res. 2015; 7:58-62.
10. Edwin J, Joshi SB, Jain DC. Biochemical study on the hypoglycemic effects of extract and fraction of barks of *Cassia fistula* Linn. in alloxan-induced diabetic rats. Indian Drugs. 2009; 46:54-60.
11. Patel AJ, Patel NM, Patel AA, Patel J. Interaction of *Trigonella Foenum-Graecum* (Fenugreek) and *Acacia Catechu* (Black Catechu) for Antihyperlipidemic Activity. J Pharm Sci Biosci Res. 2011; 1:54-8.
12. Ramachandran C, Nair SM, Quirrin KW, Melnick SJ. Hypolipidemic effects of a proprietary *Commiphora Mukul* gum resin extract and medium-chain triglyceride preparation (GU-MCT810). J Evidence-Based Complement Altern Med. 2013; 18:248-56. https://doi.org/10.1177/2156587213488601.
13. Ramesh B, Saralakumari D. Antihyperglycemic, hypolipidemic and antioxidant activities of ethanolic extract of *Commiphora mukul* gum resin in fructose-fed male Wistar rats. J Physiol Biochem. 2012; 68:573-82. https://doi.org/10.1007/s13105-012-0175-x. PMid:22581434
14. Bellamkonda R, Karuna R, Rao BSB, Haritha K, Manjunatha B, Silpa S, *et al*. Beneficiary effect of *Commiphora mukul* ethanolic extract against high fructose diet induced abnormalities in carbohydrate and lipid metabolism in wistar rats. J Tradit Complement Med. 2018; 8:203-11. https://doi.org/10.1016/j.jtcme.2017.05.007. PMid:29322010. PMCid:PMC5755988
15. Shaik J, Khan Z. Antihyperlipidemic activity of *Commiphora mukul* against atherogenic diet-induced hyperlipidemia in experimental rats. Asian J Pharm Clin Res. 2018; 11:386-9. https://doi.org/10.22159/ajpcr.2018.v11i6.24800.
16. Anas M, Rahman Z, Ahmad T. Antihyperlipidemic activity of *Commiphora mukul*: A review. Pharma Innov J. 2019; 8:496-8.
17. Siddiqui MZ, Mazumder PM. Comparative study of hypolipidemic profile of resinoids of *Commiphora mukul/Commiphora wightii* from different geographical locations. Indian J Pharm Sci. 2012; 74:422-7. https://doi.org/10.4103/0250-474X.108417. PMid:23716870. PMCid:PMC3660868
18. Prasad J, Netam AK, Satapathy T, Rao SP, Jain P. Anti-hyperlipidemic and antioxidant activities of a combination of *Terminalia arjuna* and *Commiphora mukul* on experimental animals. Lect Notes Bioeng. 2021:175-88. https://doi.org/10.1007/978-981-15-6329-4_16.
19. Urizar NL, Moore DD. Gugulipid: A natural cholesterol-lowering agent. Annu Rev Nutr. 2003; 23:303-13.

https://doi.org/10.1146/annurev.nutr.23.011702.073102. PMid:12626688
20. Jash R, Bagchi C, Mitra A, Tripathi S. Evaluation of antihyperlipidemic activity of gugulipid alone and in combination with different dosage of atorvastatin in triton-induced hyperlipidemic rodent model: Exploring a possible synergistic activity. Natl J Physiol Pharm Pharmacol. 2021:1. https://doi.org/10.5455/njppp.2022.12.08304202101092021.
21. Ahmad MA, Mujeeb M, Akhtar M, Khushtar M, Arif M, Haque MR. Guggulipid: A promising multipurpose herbal medicinal agent. Drug Res (Stuttg). 2020; 70:123-30. https://doi.org/10.1055/a-1115-4669. PMid:32110820
22. Shaik J, Khan Z. Antihyperlipidemic activity of *Commiphora mukul* against atherogenic diet-induced hyperlipidemia in experimental rats. Asian J Pharm Clin Res. 2018; 11:386-9. https://doi.org/10.22159/ajpcr.2018.v11i6.24800
23. Sotoudeh R, Hadjzadeh M-A-R, Gholamnezhad Z, Aghaei A. The anti-diabetic and antioxidant effects of a combination of *Commiphora mukul, Commiphora myrrha* and *Terminalia chebula* in diabetic rats. Avicenna J Phytomedicine. 2019; 9:454-64.
24. Espirito Santo BLS do, Santana LF, Kato Junior WH, de Araújo F de O, Bogo D, Freitas K de C, *et al*. Medicinal potential of *Garcinia* Species and their compounds. Molecules. 2020; 25:1-30. https://doi.org/10.3390/molecules25194513. PMid:33019745. PMCid:PMC7582350
25. Fallis A. Estimation of (-)-Hydroxycitric Acid (HCA) In *Garcinia Lanceaefolia* Roxb. Using Novel HPLC Methodology. J Chem Inf Model. 2013; 53:1689-99. https://doi.org/10.13040/IJPSR.0975-8232.5(11).4993-97.
26. Sripradha R, Sridhar MG, Maithilikarpagaselvi N. Antihyperlipidemic and antioxidant activities of the ethanolic extract of *Garcinia cambogia* on high fat diet-fed rats. J Complement Integr Med. 2016; 13:9-16. https://doi.org/10.1515/jcim-2015-0020.
27. Mahendran P, Devi CSS. Effect of *Garcinia Cambogia* extract on lipids and lipoprotein composition in dexamthesone administered rats. Indian J Physiol Pharmacol. 2001; 45:345-50.
28. Koshy AS, Anila L, Vijayalakshmi NR. Flavonoids from *Garcinia cambogia* lower lipid levels in hypercholesterolemic rats. Food Chem. 2001; 72:289-94. https://doi.org/10.1016/S0308-8146(00)00225-9.
29. Rani DJ, Vijayanchali SS. Phytochemical Composition and antioxidant activity of fresh and dried grape (*Vitis vinifera*) fruit proportions. Int J Innov Sci Res Technol. 2021; 6:734-9.
30. Baranitharan M, Alarifi S, Alkahtani S, Ali D, Elumalai K, Pandiyan J, *et al*. Phytochemical analysis and fabrication of silver nanoparticles using *Acacia catechu*: An efficacious and ecofriendly control tool against selected polyphagous insect pests. Saudi J Biol Sci. 2021; 28:148-56. https://doi.org/10.1016/j.sjbs.2020.09.024. PMid:33424291. PMCid:PMC7785431
31. Gris EF, Mattivi F, Ferreira EA, Vrhovsek U, Filho DW, Pedrosa RC, *et al*. Stilbenes and tyrosol as target compounds in the assessment of antioxidant and hypolipidemic activity of *Vitis vinifera* red wines from Southern Brazil. J Agric Food Chem. 2011; 59:7954-61. https://doi.org/10.1021/jf2008056. PMid:21718033
32. Tiwari P, Patel RK. Evaluation of diuretic potential of draksharishta prepared by traditional and modern methods in experimental rats. Pharmacologyonline. 2011; 3:566-72.
33. Devi S, Singh R. Evaluation of antioxidant and antihypercholesterolemic potential of *Vitis vinifera* leaves. Food Sci Hum Wellness. 2017; 6:131-6. https://doi.org/10.1016/j.fshw.2017.07.002.
34. Ngamukote S, Mäkynen K, Thilawech T, Adisakwattana S. Cholesterol-lowering activity of the major polyphenols in grape seed. Molecules. 2011; 16:5054-61. https://doi.org/10.3390/molecules16065054. PMid:21694670. PMCid:PMC6264176
35. Ahmed M, Hegde SV, Chavan A. Evaluation of hepatoprotective activity of *Vitis vinifera* stem bark. J Pharm Res. 2012; 5:5228-30.
36. Al-Jumaily EF, Shafiq ZA, Al-Bayati RI. Antihyperglycemia effects of resvertrol and its derivative on alloxan diabetic rabbits. IOSR J Pharm. 2012; 2:49-57. https://doi.org/10.9790/3013-24104957.
37. Verma A, Kumar B, Alam P, Singh V, Kumar Gupta S. *Rubia Cordifolia*-a Review on Pharmaconosy and Phytochemistry. Int J Pharm Sci Res. 2016; 7:2720. https://doi.org/10.13040/IJPSR.0975-8232.7(7).2720-31.
38. Priya MD, Siril EA. Traditional and modern use of Indian Madder (*Rubia cordifolia* L.): An overview. Int J Pharm Sci Rev Res. 2014; 25:154-64.
39. Baskar R, Bhakshu LM, Bharathi GV, Reddy SS, Karuna R, Reddy GK, *et al*. Antihyperglycemic activity of aqueous root extract of *Rubia cordifolia* in streptozoto-

cin-induced diabetic rats. Pharm Biol. 2006; 44:475-9. https://doi.org/10.1080/13880200600798593.
40. Khan MS, Aziz S, Khan MZ, Khalid ZM, Riaz M, Ahmed D, *et al*. Antihyperglycemic effect and phytochemical investigation of *Rubia cordifolia* (Indian Madder) leaves extract. Open Chem. 2021; 19:586-99. https://doi.org/10.1515/chem-2021-0053.
41. Dwivedi S, Chopra D. Revisiting *Terminalia arjuna*-an ancient cardiovascular drug. J Tradit Complement Med. 2014; 4:224-31. https://doi.org/10.4103/2225-4110.139103. PMid:25379463. PMCid:PMC4220499
42. Maulik SK, Talwar KK. Therapeutic potential of *Terminalia arjuna* in cardiovascular disorders. Am J Cardiovasc Drugs. 2012; 12:157-63. https://doi.org/10.2165/11598990-000000000-00000. PMid:22583146
43. Subramaniam S, Subramaniam R, Rajapandian S, Uthrapathi S, Gnanamanickam VR, Dubey GP. Anti-atherogenic activity of ethanolic fraction of *Terminalia arjuna* bark on hypercholesterolemic rabbits. Evidence-Based Complement Altern Med. 2011b; 2011. https://doi.org/10.1093/ecam/neq003. PMid:21785628. PMCid:PMC3136348
44. Ansarullah, Jadeja R, Thounaojam M, Patel V, Devkar R, Ramachandran A. Antihyperlipidemic potential of a polyherbal preparation on Triton WR 1339 (Tyloxapol) induced hyperlipidemia: A comparison with lovastatin. Int J Green Pharm. 2009; 3:119-24. https://doi.org/10.4103/0973-8258.54900.
45. Uthirapathy S. Novel biomarkers of atherogenic diet induced dyslipidemia and metabolic syndrome suppressed By *Terminalia arjuna*. Int J Pharm Sci Res. 2019; 10:2528-36. https://doi.org/10.13040/IJPSR.0975-8232.10(5).2528-36.
46. Patil RH, Prakash K, Maheshwari VL. Hypolipidemic effect of *Terminalia arjuna* (L.) In experimentally induced hypercholesteremic rats. Acta Biol Szeged. 2011; 55:289-93.
47. Sawale PD, Pothuraju R, Abdul Hussain S, Kumar A, Kapila S, Patil GR. Hypolipidaemic and anti-oxidative potential of encapsulated herb (*Terminalia arjuna*) added vanilla chocolate milk in high cholesterol fed rats. J Sci Food Agric. 2016; 96:1380-5. https://doi.org/10.1002/jsfa.7234. PMid:25907198
48. Subramaniam S, Ramachandran S, Uthrapathi S, Gnamanickam VR, Dubey GP. Anti-hyperlipidemic and antioxidant potential of different fractions of *Terminalia arjuna* Roxb. bark against PX-407 induced hyperlipidemia. Indian J Exp Biol. 2011a; 49:282-8. PMid:21785628. PMCid:PMC3136348