JOURNAL OF SCIENTIFIC RESEARCH IN ALLIED SCIENCES
ISSN NO. 2455-5800
Contents available at www.jusres.com

Bioactive Plant Compounds as Natural Alternatives for the Treatment of Hyperlipidemia

Pooja Gourav, Tirthankar Choudhury
School of Pharmacy, ITM University, Gwalior-474001, Madhya Pradesh

ARTICLE INFO

Article History
Received: December 2025
Accepted: January 2026

Keywords: Hyperlipidemia, Cardiovascular disease, Cerebrovascular diseases, Bioactive substances.

Corresponding Author
***Tirthankar Choudhury**

ABSTRACT

Hyperlipidemia is a metabolic disorder marked by increased plasma lipid levels, including total cholesterol, triglycerides, and low-density lipoprotein (LDL), and decreased high-density lipoprotein (HDL). This condition is a major factor in serious health issues such as atherosclerosis, coronary heart disease, fatty liver, and cerebrovascular disorders. Conventional treatments like statins and fibrates are effective but often have side effects like liver damage. When there is a problem with the metabolism or transport of lipids, the result is an abnormal rise in plasma lipid levels, a condition known as hyperlipidaemia. As a result of this disorder, low-density lipoprotein cholesterol, total cholesterol, and triglyceride levels rise, whereas high-density lipoprotein cholesterol falls. Among the many potential outcomes include arteriosclerosis, coronary heart disease, cerebral infarction, and impaired vision. In addition to fatty liver disease, atherosclerosis, cardiovascular disease, cognitive and cerebrovascular disorders, and other conditions, an excess of lipids can clog blood vessels. A considerable risk factor for coronary heart disease, hyperlipidaemia is also linked to diabetes, insulin resistance, and obesity. Liver damage is a typical adverse effect of the anti-hyperlipidemic medications routinely used, such as fibrates, nicotinic acid, and statins. Bioactive compounds produced from plants provide an alternative to conventional medicine that is both natural and associated with fewer side effects. These considerations led to the discovery of phytoconstituents as a potential medicinal agent. It is reasonable to assume that phytochemicals' efficacy in treating hyperlipidaemia is due to their targeting of specific components of lipid metabolism, given that these compounds have several modes of action. There have been several experiments that have revealed components that may reduce blood glucose levels. Polysaccharides, alkaloids, flavonoids, polyphenols, and steroidal saponins are all examples of bioactive chemicals. Investigating natural compounds and how they lower lipid levels is the main goal of this research. This study serves as a resource for future phytoconstituent research and development by offering an outline of these bioactive components and how they work.

1. INTRODUCTION

Abnormally high blood lipida (fat) levels are the hallmark of hyperlipidaemia and related diseases. One of the many components of the metabolic syndrome is hyperlipidaemia, a common and noticeable manifestation of the disease (1). Increased morbidity and mortality may result from this disease's association with

other common illnesses, such as diabetes mellitus, hypertension, and cardiovascular problems. Because of the side effects linked with modern lipid-lowering medications, there has been a shift towards seeking out more conventional and alternative methods of therapy (2). In a variety of different countries, epidemiological data have demonstrated that alternative treatments, medicinal plant intake, nutrition, and fruit consumption all have sufficient effects in treating the repercussions of hyperlipidaemia (3). It is worth noting that the demand for medical herbs with a cholesterol-lowering effect has increased dramatically in most countries, even industrialised ones. It is critical to use these herbs, especially when traditional therapies fail to control the condition (4). Drug interactions and side effects can make disease control a challenge for hyperlipidemic patients who use medicinal herbs, even if they may feel better overall (5). Death from cardiovascular disease ranks first globally, according to several government agencies and organisations, including the American Heart Association, the CDC, the NIH, and others. This causes about 17.3 million deaths yearly, and experts predict that it will rise to over 23.6 million by 2030 (6). A dramatic shift in the prevalence of cardiovascular disease has occurred in India throughout the last several decades. Of India's 30 million heart disease sufferers, 14% call metropolitan areas home and 16% call rural areas their second home (7). By 2020, atherothrombotic cardiovascular diseases are expected to be more prevalent in India than in any other country globally. This is predicated on the present trend holding. Between 2001 and 2003, 17% of all deaths and 26% of adult deaths in India were attributed to coronary heart disease, according to the Registrar General of India (8). Between 2010 and 2013, this proportion increased to 23% of all fatalities and 32% of adult deaths. The global increase in hyperlipidaemia cases is linked to poor dietary choices, excess body fat, and insufficient physical activity (9). The leading causes of mortality and disability in modern society are widely acknowledged to be cardiovascular issues. Globally, the number of deaths caused by cardiovascular illnesses increased from 14.4 million in 1990 to 17.5 million in 2005. In 2015, the number of fatalities is expected to reach over 20 million (10). Also thought to have a significant role in the disease's progression are certain circulating chemicals, such as nicotine, low-density lipoprotein free radicals, and homocysteine. Mortality and morbidity rates are increased when other common conditions, such as diabetes and hypertension, are present (11). The involvement of inflammatory cytokines in atherosclerosis is evident throughout the disease progression, earning it the label of chronic inflammatory disease. Some of the factors that lead to atherosclerotic plaque's development include LDL buildup in the intima, LDL oxidation, absorption of oxidised LDL by macrophage scavenger receptors, macrophage effects on foam cells, and plaque stabilisation (12).

2. SYMPTOMS OF HYPERLIPIDEMIA

Although hyperlipidaemia usually goes undiagnosed, signs can be found during checkups or when the illness has worsened to the point where it increases the risk of cardiovascular events like strokes or heart attacks. Xanthomas, or cholesterol deposits that can form beneath the skin, especially around the eyes, are a danger for people with high blood cholesterol levels or who have familial variants of the disorder. Concurrently, elevated triglyceride levels are associated with an increased risk of developing acne-like lesions in a variety of skin types and locales (13–15). When complex macromolecules involving lipids and proteins are not synthesised and turnoverd properly, the result is an imbalance in the metabolism of these substances, which manifests as elevated plasma cholesterol and triglyceride levels. Low density lipoprotein (LDL), very low density lipoprotein (VLDL), and high density lipoprotein (HDL) are the three subtypes of plasma lipoproteins (16). After being separated from total cholesterol and spun on an ultra centrifuge, the density ranges of the lipoproteins establish these groups. The levels of triglycerides in plasma are significantly correlated with age group (17). A cholesterol level of 175 mg/dl is considered normal for a 19-year-old. This amount keeps going up as people get older; by the time they're around 60 years old, it's 245 mg/dl (18-20).

3. COMPLICATIONS ASSOCIATED WITH HYPERLIPIDEMIA

3.1 Atherosclerosis

The main reason why people get heart disease is because of atherosclerosis. Atherosclerosis is the main cause of cardiovascular disease, and hyperlipidaemia is the most important risk factor for this condition. The development of fibrous plaques inside the walls of large and medium arteries, together with the accumulation of lipids, cholesterol, and calcium, constitute the pathologic process referred to as atherosclerosis (21).

3.2 Myocardial Infarction (MI)

Heart cells can be irreversibly injured or destroyed in a condition called myocardial infarction (MI), which occurs when blood and oxygen supplies are partially or completely prevented from flowing in one or more coronary arteries. A ruptured atherosclerotic plaque might be the cause of the obstruction. Research showed that hyperlipidaemia was present in around 25% of myocardial infarction survivors (22).

3.3 Coronary Artery Disease (CAD)

The constriction of the arteries that provide blood to the heart is a hallmark of Coronary Artery Disease (CAD), which is caused by the buildup of lipids and fibrous plaques inside the arterial wall. Reduced blood flow and oxygen levels fall short of the heart's needs as a consequence of atherosclerosis. Coronary atherosclerosis has been associated with an increased lipid profile (23).

3.4 Ischemic Stroke

Stroke is the fourth largest cause of mortality worldwide. A blood clot or a fragment of atherosclerotic plaque that breaks away in a tiny conduit within the brain is often the cause of strokes. Strokes mostly occur when an artery is blocked by one of these two factors. According to the findings of a number of clinical trials, a reduction of 15% in both total cholesterol and low-density lipoprotein cholesterol greatly lowered the chance of experiencing a stroke for the first time (24).

4. PHARMACOLOGICAL MANAGEMENT OF HYPERLIPIDEMIA

Combining pharmacologic treatment of hyperlipidaemia with therapeutic lifestyle modifications can provide both primary and secondary prevention of cardiovascular disease. For those at higher risk, statins provide the strongest evidence for primary prevention. That is why it is crucial to classify risks. For everyone already known to have cardiovascular disease or a risk equivalent risk, taking statins is a recommended secondary preventative measure. Administering high-dose statins is suggested for the treatment of persons with acute coronary syndrome (25). If statins are not an option for patients recovering from a myocardial infarction, omega-3 fatty acids may provide an adequate substitute (26). Fiberates and niacin may be useful supplements when statins aren't enough to control cholesterol levels, even if they haven't been shown to reduce mortality from any cause in secondary prevention (27). Other cholesterol-lowering medications used for primary or secondary prevention of cardiovascular disease have not been shown to consistently improve patient-oriented outcomes. For secondary prevention of peripheral arterial disease and stroke, there is a large amount of evidence that supports the use of statins (28).

4.1 Statins

When it comes to primary prevention of cardiovascular disease (CVD), statins have been assessed in two big meta-analyses. Statins outperformed placebo in the first study when it came to all-cause mortality, major coronary events, and cerebrovascular events. When comparing statins to a placebo in terms of all-cause mortality, the second meta-analysis came up empty. Research has also looked at statin treatment depending on C-reactive protein level (29). Primary composite end goals, including myocardial infarction, stroke, unstable angina hospitalisation, arterial revascularisation, and cardiovascular mortality, were less common among those who used statins, according to the JUPITER trial (30). The positive effects of statin medication on specific outcomes, however, were very variable. Some people think that the JUPITER study's findings shouldn't be used to support a huge increase in the use of statins for primary prevention. Rosuvastatin was not compared to other therapies, and cost-effectiveness was not evaluated either (31). At the same dosages, all statins significantly lower LDL

cholesterol, and no statin has been shown to be more effective at preventing CVD (32).

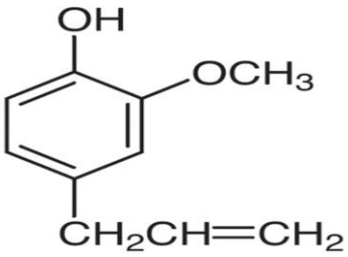
4.2 Non Statins

Even when patients achieve their goal levels of low-density lipoprotein (LDL) cholesterol, they may still have elevated levels of triglycerides or low levels of high-density lipoprotein (HDL) cholesterol. Other than statins for primary prevention, there is no compelling evidence for treating these secondary lipid abnormalities with drugs (33). In primary prevention, fibrates do not reduce mortality and may even be hazardous. It seems that there is no benefit to combining fibrates with statin medication. There is no proof that niacin lowers primary prevention all-cause or cardiovascular mortality, despite the fact that it is the only medication regularly shown to increase HDL cholesterol levels (34). Taking rosuvastatin reduced the risk of cardiovascular events in patients independent of their HDL cholesterol level, which suggests that reducing LDL cholesterol levels much may be as beneficial as artificially increasing HDL cholesterol levels in preventing cardiovascular disease. Lowering levels of bad cholesterol (LDL) is the only effect of bile acid-binding resins; mortality is unaffected (35).

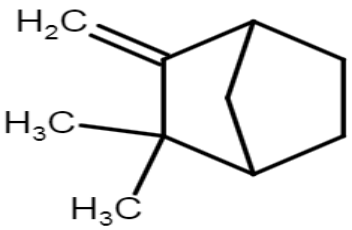
5. HERBAL MANAGEMENT OF HYPERLIPIDEMIA

5.1 Phytochemical Constituents in Management of Hyperlipidemia

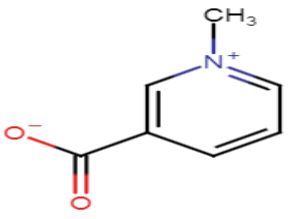
There are a number of methods for treating hyperlipidaemia in traditional medicine, which relies heavily on medicinal plants. Hyperlipidaemia therapy is one of these therapies. Evidence from modern research on traditional medicinal herbs and dietary supplements suggests that their antioxidant compounds—which include vitamins, flavonoids, sterols, and dietary fibers—can lower lipid levels, prevent low-density lipoprotein oxidation, neutralise oxygen free radicals, and potentially ameliorate this condition by influencing the immune system and enhancing metabolic disorders (36, 37). These plants include a wide variety of bioactive chemicals. Diosgenin, Yamogenin, Trigonelline, Sarsapogenin, Fenugreekine, Smilagenin, Cinnarine and Luteolin, sylimarin, Pourin, Comstrole and Genistein, Allicin, Oxalic Acid, Cinic Acid, Beta Glucogaline, and Renin are among the most significant chemicals (38-42). Some phytoconstituents with anti-hypolipidemic action are shown in Figure 1 by their chemical structures. These substances may be used as hypolipidemic medications after pharmacological studies on medicinal plant active components and their active constituents that have been effective in treating hyperlipidaemia are finished and verified.



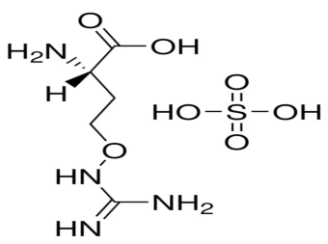
Eugenol



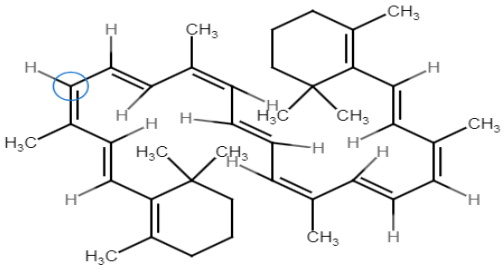
Camphene



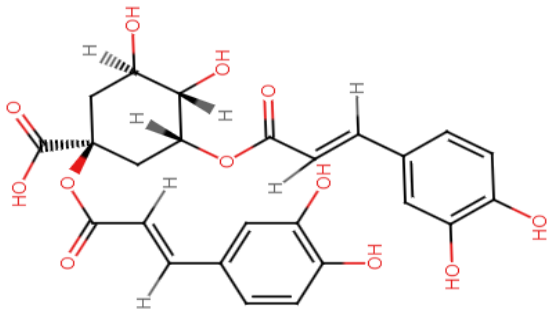
Trigonelline



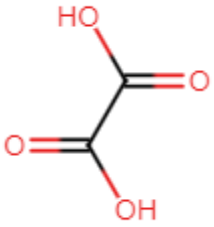
L-cavanine



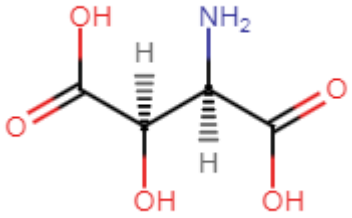
beta-carotene



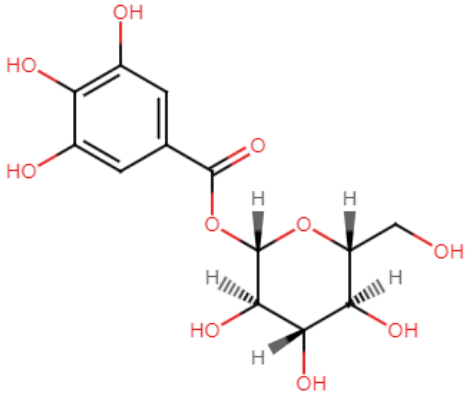
Cinnarine



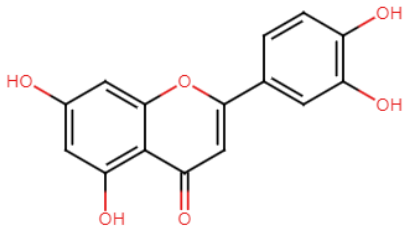
Oxalic Acid



(3R)-3-hydroxy-D-aspartic acid



Beta Glucogaline



Luteolin

Figure 1: Phytoconstituents with Anti Hyperlipidiamic activity

5.1.1 Eugenol (Ocimum sanctum)

Through the stimulation of β-adrenergic actions, the aqueous extract of basil has the ability to exert its own benefits on the heart and high blood pressure (i.e. ≥ 33 mm Hg). In hypertensive rats, the extract lowers both the systolic and diastolic blood pressure to around 20-15 mm Hg. Additionally, it decreases cardiac hypertrophy, angiotensin, and endothelin, which are indicators of high blood pressure, and it improves cardiac function. In addition to this, it inhibits endothelial dysfunction that is brought on by lipidemia and has a considerable impact in the thoracic aorta of hypoclustrolytic mice when administered at a dose of 5-10 mg (43).

5.1.2 Camphene and Limonene (Citrus medica)

For generations, people have turned to citron fruits and blooms as a folk remedy for irregular heartbeats and broken hearts. Researchers have shown that injecting a flying fruit ethanolic extract with isoproterenol (ISO) reduces cardiac damage. When given to diabetic mice at doses of 600 mg/kg over several days, citron seed extract prepared from petroleum ether significantly reduced fasting blood glucose levels and lipid profiles. The essential oil is derived

from the balloon and contains limonene, which is directly linked to adenosine receptors and one of the main components. Lowering blood pressure in the coronary arteries and the aorta is a result of adenosine receptor activation. In addition, during the healing period after an ischaemia injury, protein kinase A (PKA) reduces inflammation, which in turn prevents platelet aggregation and subsequent tissue damage (44).

5.1.3 Trigonelline (Trigonella foenum graecum L)

Traditional medicine practitioners often prescribe trigonelline to patients with diabetes, high cholesterol, bronchitis, dyspepsia, constipation, and kidney problems. Animal studies and human clinical trials have demonstrated that this plant can lower blood sugar and cholesterol levels in diabetics. This plant, together with other foods that are rich in fibre, may be useful in the treatment of constipation (45). For two months, twenty-five individuals with a diagnosis of type 2 diabetes mellitus were split into two groups: one that received the medication (1 g of the extract daily), and the other that received a placebo. The treatment group's blood sugar levels were much lower than those of the placebo group. In addition, this group's high-density lipoprotein level increased while their triglyceride level decreased. Fenugreek has been shown in various animal and human studies to lower levels of blood triglycerides, total cholesterol, and low-density lipoprotein. Not only that, but it also prevents atherosclerosis-causing oxidation of low-density lipoprotein, which is a major contributor to the disease. It has been established that these effects are caused by the plant's sapogenins and phytoestrogens. Sapogenins have been shown to enhance biliary cholesterol excretion, whereas phytoestrogens have been found to indirectly enhance thyroid hormone synthesis (47).

5.1.4 Saffron Glycated Carotenoids

Through a dose-dependent method, saffron aqueous extract (AES), saffron essential oil (EO), and crocin (saffron glycated carotenoids) (1.0 and 5.0 mg%) per day are able to lower the mean arterial blood pressure (MABP) in rats with normal blood pressure and hypertension. Additionally, AES is able to reduce ventricular fatal arrhythmias during reperfusion of the rat by reducing electrical conductivity and increasing the potential for action. Saffron contains powerful antioxidants known as crosteen and carotenoids. These antioxidants reduce the oxidation of LDL, which is a process that causes atherosclerosis and hyperlipidaemia in rabbits (48).

5.1.5 Luteolin-7-glucoside (Melissa officinalis)

Its ability to reduce CaCl2-induced ventricular immobilisation, ventricular fibrillation, and tachycardia is due to its function as a beta-adrenergic antagonist in rats. When administered to electrocardiogram-equipped rats, the aqueous extract can reduce the intervals between the QRS, JT, and TpTe QTc. A likely mechanism by which it achieves this over time is by modulating the expression or orientation of cardiac sodium and potassium channels. In addition to providing modest protection against reperfusion-induced fatal ventricular arrhythmia in rats, the aqueous extract of this plant (500 mg daily) stimulates muscarinic receptors. It also stimulates endothelial NO production, which contributes to reductive regurgitation; nevertheless, it is possible that prostacyclin interacts with it. Hyperplasarizing factors, which are endothelial proteins that promote hyperpolarisation, are also activated, as shown. There is an increase in glutathione reduction (GSH) levels and a decrease in total lipids, cholesterol, liver enzymes, and lipid peroxidation (LPO) in the liver tissue of hyperlipidaemia patients when the plant is extracted in water. In addition, the plant may reduce the formation of arterial foam cells and the oxidation of LDL due to its strong antioxidant activity (49, 50).

5.2 Natural Products in the Management of Hyperlipidemia

5.2.1 Red Yeast Rice

Red yeast rice is a mainstay in Chinese cuisine and a recommended supplement in TCM due to its effects on blood flow and digestion. It is thought to reduce blood cholesterol levels since it contains statins, which are medications that do just that. Among the many nutrients found in red yeast rice are the active substances monacolin K, dehydromonacolin, monacolin I–VI, starch, protein, fibre, sterols, and fatty acids. The HMGCoA reductase enzyme is responsible for more than 70% of the body's total cholesterol, and monetalin K blocks its synthesis. Some additional

substances, such as sterols, may be present in red yeast rice, which might help lower cholesterol levels, according to the researchers. Regular dosing with the concentrated yeast extract—which contains around 13.5 mg monacolin—has been demonstrated in clinical trials to considerably reduce total serum cholesterol levels, raise HDL levels, and lower LDL and triglyceride levels (51, 52).

5.2.2 Oat

Oats, a food item with several beneficial properties and a high fibre content, may help reduce blood cholesterol levels if consumed regularly. After six weeks on an oat diet, 152 participants demonstrated a decrease in total cholesterol and low-density lipoprotein levels. Patients had triglyceride levels below 400 and low-density lipoprotein values between 120 and 190.53 rd Obese women whose diets include oats have a metabolic benefit, researchers found. Researchers found that those with hyperlipidaemia whose diets included oats had lower concentrations of cholesterol and low-density lipoprotein. Many studies have demonstrated that oat's antioxidant capacities can prevent low-density lipoprotein oxidation, and this effect is dose-dependent (53).

5.2.3 Commiphora mukul

Commiphora mukul, an adhesive gum from the Mukul myrrh tree, is used in traditional Indian medicine to treat skin, nervous system, obesity, diabetes, digestive, rheumatoid, mouth infection, and menstrual issues. A study on 61 individuals found that Guggul, a 100 mg daily dose, significantly reduced total cholesterol levels by 11.7%, low-density lipoprotein levels by 12.7%, triglyceride by 12%, and cholesterol-high-density lipoprotein ratio by 11.1%. A double-blind study on 228 individuals found similar effects to clofibrate, with none of the patients showing significant side effects except one patient with gastrointestinal symptoms (54).

5.2.4 Silybum marianum L

The active ingredient in Silybum marianum L extract is called silymaryne. Among the four components that comprise silimaryne, sylymarin is one. The natural medicine silimaryne has hepatoprotective effects. Flavonoids are one of the other substances it contains; they aid in antioxidant defence, stabilise cell membranes, and increase blood glutathione levels. According to research conducted in controlled environments, silimaryne can alleviate symptoms of hyperlipidaemia and other disorders (55). Clinical trials have shown that silimaryne may be useful in reducing blood cholesterol levels in patients with hypercholesterolaemia. Compared to the control group, 15 people with high blood cholesterol whose daily dosage of silimaryne was 420 milligrammes had lower cholesterol concentrations in their bile. The results of a clinical research involving fourteen individuals with type 2 hypercholesterolaemia show that silimaryne, when administered at a dosage of 420 milligrammes, decreases the liver's capacity to manufacture cholesterol. Blood high-density lipoprotein levels rose while total cholesterol levels fell, according to the data. Clinical investigation showed that people with diabetes and hyperlipidaemia who took silimaryne had lower levels of total cholesterol, low-density lipoprotein, and triglycerides (56).

5.2.5 Glycine max (Soybean)

A meta-analysis research indicated that soy protein lowers blood levels of low-density lipoprotein. The study discovered that consuming soybeans had a notable impact on blood lipid profiles. Cholesterol levels dropped by 23.2 mg/dL, low-density lipoprotein cholesterol by 21.7 mg/dL, and triglyceride levels by 13.3 mg/dL. Daily soy protein consumption averaged 47 g (57). To lower blood cholesterol, the US Food and Drug Administration suggests 25 g of soybean protein; however, larger dosages have better results. Researchers have shown that consuming 20 grammes of animal protein instead of soy protein might have a similar effect on blood cholesterol levels. Research suggests taking 40 g everyday. In general, soybean protein helps lower blood cholesterol levels more effectively than animal protein does (58).

5.2.6 Allium sativum L

One of the major causes of cardiovascular disease, atherosclerosis, can be inhibited by garlic. Garlic has showed promise in reducing atherosclerosis plaque development in animal studies. Atherosclerosis plaque development was shown to be greatly reduced after 4 years of taking 900 mg of garlic powder daily, according to a clinical trial (59). For at least two years, healthy

people (50–80 years old) were given 300 mg of garlic powder daily in a research. The aorta's elastic characteristics were assessed by measuring pulse wave velocity, elastic vascular resistance, and pressure. Both elastic vascular resistance and pulse wave velocity were lower in the garlic group than in the control group. There was a positive association between age and pulse wave velocity that was statistically significant. Pulse wave velocity was most strongly influenced by age and systolic blood pressure. There were no confounding variables in the garlic impact on pulse wave velocity (60). The elastic characteristics of the ageing human aorta were shown to be conserved by garlic consumption, according to the study. roughly 10 milligrammes of alliin, which yields roughly 4 to 5 milligrammes of allicin, is the optimal dosage for garlic powder. Garlic powder, which contains 1.3% alliin, should be taken daily in a quantity of 900 mg. All the benefits of fresh garlic may be yours with just 1–7 grammes of alliin-free garlic used everyday. Researchers found that garlic consumption mitigated the age-related decline in the aorta's elastic characteristics in humans (61).

5.2.7 Cynara cardunculus (Artichoke)

Artichoke leaves have been found to inhibit cholesterol synthesis in liver cells and protect the liver from chemical toxins. A study on 143 patients with high cholesterol found that the leaves significantly improved cholesterol levels. Patients received either 1.8 mg/day artichoke dry extract or a placebo for 6 weeks. The drug group showed an 18.5% decrease in total cholesterol, 23% reduction in low-density lipoprotein cholesterol, and 20% reduction in low-density lipoprotein to high-density lipoprotein ratios (62, 63).

5.2.8 Medicago sativa (Alfalfa)

An anti-allergen, anti-diabetic, anti-hyperlipidemic, and nutritional supplement are just a few of the many uses for the ancient medicinal herb Medicago sativa. Arteritis, burns, irregular periods, gastrointestinal problems, renal problems, and urinary tract infections are among its other uses (64). The plant is a dietary supplement due to its abundance of b-carotene and vitamins, which include vitamins B, C, E, and K. The Medicago sativa plant's seeds may have a cholesterol-lowering effect in animals, according to research (65). There were no side effects and a decrease in blood cholesterol levels when given to monkeys for a year. A teaspoon or two of powder, steeped in ten to twenty minutes of boiling water, is the recommended dosage for the plant. Due to oestrogenic effects, it is not advised for children, nursing mothers, pregnant women, or anybody else who may be taking it during pregnancy or while breastfeeding. The plant's high vitamin K content also makes it a potential drug interaction concern. Splenomegaly and disruption of blood cell activity can be caused by the poisonous chemical L-cavanin, which is present in both the powdered plant and the seeds (66).

6. CONCLUSIONS

When lipid metabolism or transport are off, the result is hyperlipidaemia, a condition in which plasma lipid levels rise abnormally. Symptoms include a decline in HDL cholesterol levels and a rise in total and triglyceride cholesterol levels as well as LDL cholesterol. This has the ability to cause a variety of health problems, including atherosclerosis, coronary heart disease, stroke, and eyesight loss. Fatty liver disease, atherosclerosis, cardiovascular disease, cognitive and cerebrovascular abnormalities, and other conditions can arise from the narrowing of blood vessels caused by excess lipids. In addition to being associated with diabetes, insulin resistance, and obesity, hyperlipidaemia is a major risk factor for coronary heart disease. Despite their widespread usage, anti-hyperlipidemic drugs such as fibrates, nicotinic acid, and statins pose a risk to the liver. A natural alternative to conventional pharmaceuticals, bioactive molecules derived from plants have fewer side effects. Phytochemicals' ability to target components of lipid metabolism is the reason for their effectiveness in treating hyperlipidaemia. These compounds contain bioactive molecules such as alkaloids, polysaccharides, polyphenols, flavonoids, and steroidal saponins. In order to provide a foundation for future studies on phytoconstituents, this one will look at natural chemicals and how they work to lower cholesterol levels. A synopsis of these bioactive substances and how they work is given. According to what is known, dietary fibres, vitamins, flavonoids, sterols, and other antioxidants found in dietary

supplements and medicinal plants can impact the metabolic processes of many tissues, making them helpful for lipid metabolism.

7. CONFLICT OF INTEREST

None

8. REFERENCES

1. Jorgensen, T., Capewell, S., Prescott, E., Allender, S., Sans, S.,Zdrojewski, T. Population-level changes to promote cardiovascular health. Eur. J. Prev. Cardiol., 20(3):409-21 (2013).
2. Mishra, P. R., Panda, P. K., Apanna, K.C., Panigrahi, S. Evaluation of acute hypolipidemic activity of different plant extracts in Triton WR-1339 induced hyperlipidemia in albino rats. Pharmacologyonline., 3: 925-934 (2011).
3. Jeyabalan, S., Palayan, M. Antihyperlipidemic activity of Sapindusemarginatus in Triton WR-1339 induced albino rats.Res. J. Pharm. Tech., 2(2):319-323 (2009).
4. Brouwers, M. C.,VanGreevenbroek, M. M.,Stehouwer, C. D.,de Graaf, J.,Stalenhoef, A. F. Thegenetics of familial combined hyperlipidaemia.Nat. Rev. Endocrinol., 8(6): 352-62 (2012).
5. Kumar, D., Parcha, V.,Maithani, A., Dhulia, I. Effect and evaluation of antihyperlipidemic activity guided isolated fraction from total methanol extract of Bauhinia variegata (linn.) in Triton WR–1339 induced hyperlipidemic rats. Asian Pac. J. Trop. Dis., 2(2): 909-913 (2012).
6. Wells, G. B.,Dipiro, J., Schwinghammer, T., Hamilton, C. Phamacotherapy Handbook, 7thedn, USA, TheMcgraw Hill Companies, 2007; pp98-108.
7. Scapa, E. F.,Kanno, K., Cohen, D.E. Lipoprotein metabolism In: Rodés,J.; Benhamou, J. P.; Blei, A. T.; JürgReichen, J. and Mario Rizzetto, M.,Hepatology: From Basic Science to Clinical Practice, 3rdedn, U.K: Blackwell Publishing Ltd, 2007; pp133- 134.
8. Jonas, A. Lipoprotein structure In: (Vance DE, Vance JE), Biochemistry of Lipids, Lipoproteins and Membranes, 4thedn, Amsterdam: Elsevier, 2002; pp483–504.
9. Harvey, R. A., Ferrier, D. R. Cholesterol and steroid metabolism In: (Rhyner, S.), Biochemistry, 5th edn, USA: Lippincott Williams & Wilkins, 2011; pp227-237.
10. Wang, H.,Eckel, R. H. Lipoprotein lipase: from gene to obesity.Am. J. Physiol.Endocrinol.Metab., 297 (2): 271-288 (2009).
11. Santamarina-Fojo, S.,González-Navarro, H., Freeman, L., Wagner, E.,Nong, Z. Hepatic lipase, lipoprotein metabolism, and atherogenesis.Arterioscler.Thromb.Vasc.Biol., 24(10): 1750-1754 (2004).
12. Nakhjavani, M., Morteza, A.,Karimi, R.,Banihashmi, Z.,Esteghamati, A. Diabetes induces gender gap on LCAT levels and activity.life Sci., 92(1): 51–54 (2013).
13. Durrington, P. N. Cholesteryl ester transfer protein (CETP) inhibitors. Br. J. Cardiolo., 19(3):126–133 (2012).
14. Hussain, M., Rava, P., Walsh, M., Rana, M., Jahangir Iqbal, J. Multiple functions of microsomal triglyceride transfer protein.Nutr.Metab., (9):14-30 (2012).
15. Chang, T. Y., Li, B. L., Chang, C. Y., Urano, Y. Acyl-coenzyme A: cholesterol acyltransferases.Am. J. Physiol- Endoc. M., 297(1): E1-E9 (2009).
16. McLaren J. E., Michael D. R., Ashlin T. G., Ramji D. P.Cytokines, macrophage lipid metabolism and foam cells: Implications for cardiovascular disease therapy.Prog. Lipid Res., 50(4):331–347 (2011).
17. Hegele, A. R. Plasma lipoproteins: genetic influences and clinical implications.Nat. Rev. Genet., (10): 109-121 (2009).
18. Tripathi, K. D. Essentials of Medical Pharmacology, 6thedn, India: JP brothers medical publishers, pp613-614 (2008).
19. Joseph, D. Pharmacotherapy, A pathophysiological approach, 8thedn, The McGraw Hill companies, Inc. 2011; pp370.
20. Wouters, K., Shiri-Sverdlov, R., van Gorp, P. J., van Bilsen, M., Hofker, M.H. Understanding hyperlipidemia and atherosclerosis: lessons from genetically

modified apoe and ldlr mice.Clin. Chem. Lab. Med., 43(5):470-9 (2005).
21. Gao, W.,He, H. W, Wang, Z. M., Zhao, H., Xiao-Qing Lian, X. Q., Wang, Y. S., Zhu, J., Jian-Jun Yan, J. J., Zhang, D. G., Zhi-Jian Yang, Z. J., Wang, L. S. Plasma levels of lipometabolism-related miR-122 and miR370 are increased in patients with hyperlipidemia and associated with coronary artery disease.Lipids Health Dis., (11): 55 (2012).
22. Nickolas, T.L.,Radhakrishnan, J.,Appel, G.B. Hyperlipidemia and thrombotic complications in patients with membranous nephropathy.Semin.Nephrol.; 23(4):406-11 (2003).
23. Amarenco, P., Labreuche, J. Lipid management in the prevention of stroke: review and updated meta-analysis of statins for stroke prevention. Lancet Neurol., 8 (5): 453 – 463 (2009).
24. Belay, B.,Belamarich, P. F., Tom-Revzon, C. The use of statins in pediatrics: knowledge base, limitations, and future directions. Pediatrics., 119(2): 370–380 (2006).
25. Eiland, L. S.,Luttrell, P. L. Use of statins for dyslipidemia in the pediatric population.J. Pediatr. Pharmacol. Therap., 15(3): 160–172 (2010).
26. Sharma, M.,Tiwari, M., Chandra, R. Bis(3-(4'- substituted phenyl)prop-2-ene)disulfides as a new class of antihyperlipidemic compounds.Bioorg. Med. Chem. Lett., 14(21); 5347-5350 (2004).
27. Mahley, R. W., Bersot, T. P. Drug therapy for hypercholesterolemia and dyslipidemia, In: Hardman, J.G.; Limbird, L. E. and Gilman, A. G., Goodman & Gilman's, The Pharmacological Basis of Therapeutics. 10thedn, New York: McGraw Hill, 2001; pp971–1002.
28. Bellosta, S.,Paoletti, R.,Corsini, A. Atherosclerosis: Evolving vascular biology and clinical implications, safety of statins: focus on clinical pharmacokinetics and drug interactions.Circulation., (109): 50-57 (2004).
29. Mills, E. J.,Wu, P.,Chong, G.,Ghement, I.,Singh, S.,Akl. E. A.,Eyawo, O.,Guyatt, G.,Berwanger, O., Briel, M. Efficacy and safety of statin treatment for cardiovascular disease: a network meta-analysis of 170,255 patients from 76 randomized trials.QJM., 104(2):109-124 (2011).
30. Russell, D. W. The enzymes, regulation, and genetics of bile acid synthesis, Annu. Rev. Bioch., (72): 137–174 (2003).
31. Kishor, S., Kathiravan, M., Somani, R., Shishoo, C.H. The biology and chemistry of hyperlipidemia.Bioorg. Med. Chem., 15(14): 4674-4699 (2007).
32. Arnold, M.A.,Swanson, B.J.,Crowder, C.D.,Frankel, W.L.,Lam-Himlin, D.,Singhi, A.D.,Stanich, P.P.,Arnold, C.A. Colesevelam and colestipol: novel medication resins in the gastrointestinal tract. Am. J. Surg. Pathol.; 38(11):1530-7 (2014).
33. Safeer, R. S., Lacivita, C.L. Choosing drug therapy for patients with hyperlipidemia.Am. Fam. Physician., 61(11): 3371-82 (2000).
34. Ginghina, C., Bejan, I.,Ceck, C. D. Modern risk stratification in coronary heart disease.J. Med. Life. 4(4): 377-86 (2011).
35. Goldberg, A. S., Hegele, R. A. Cholesteryl ester transfer protein inhibitors for dyslipidemia: focus on dalcetrapib.Druges.Devel.Ther., 6: 251–259 (2012).
36. Berthou, L., Duverger, N., Emmanuel, F., Langoue¨t, S., Auwerx, J., Guillouzo, A., Fruchart, J-C., Rubin, E., Dene'fle, P., Staels, B., Branellec, D. Opposite regulation of human versus mouse apolipoprotein A-I by fibrates in human apo A-I transgenic mice.J. Clin. Invest., 97(11): 2408 –2416 (1996).
37. The Lipid Research Clinics Coronary Primary Prevention Trial results. I. Reduction in incidence of coronary heart disease. JAMA. 1984;251:351-364.
38. Carlson, L.A. Nicotinic acid: the broadspectrum lipid drug. A 50th anniversary review.J. Intern. Med., 258(2):94-114 (2005). 40. Nutescu, E. A.,

Shapiro, N. L. Ezetimibe: a selective cholesterol absorption inhibitor. Pharmacotherapy., 23(11): 1463-74 (2003).
39. Denke, M., Pearson, T., McBride, P. Ezetimibe added to ongoing statin therapy improves LDL-C goal attainment and lipid profile in patients with diabetes or metabolic syndrome. Diab. Vasc. Dis. Res., 3(2): 93– 102 (2006).
40. Altmann, S. W., Davis, H. R., Zhu, L. J. Niemann-Pick C1 Like 1 protein is critical for intestinal cholesterol absorption. Science., 303(5661): 1201–1204 (2004).
41. Shinkai, H. Cholesteryl ester transfer-protein modulator and inhibitors and their potential for the treatment of cardiovascular diseases.Vasc.Health risk Manag., (8): 323- 331 (2012).
42. Liu, C.-I., Jeng, W.-Y., Chang, W.-J., Ko, T.-P., Andrew Wang, A. H.-J. Binding modes of zaragozic acid A to human squalene synthase and staphylococcal dehydrosqualene synthase.J. Biol. Chem., 287(22): 18750–18757 (2012).
43. Shinkai, H. Cholesteryl ester transfer-protein modulator and inhibitors and their potential for the treatment of cardiovascular diseases.Vasc.Health risk Manag., (8): 323- 331 (2012).
44. Rafieian-Kopaei M, Setorki M, Doudi M, Baradaran A, Nasri H. Atherosclerosis: process, indicators, risk factors and new hopes. Int J Prev Med. 2014;5:927-946.
45. Sekhar MG, Shanmugam KR, Prasad KS, Chilakala R. Amelioration of lipid metabolic profiles by trigonelline a bioactive compound of Trigonella Foenum-graecum in alcohol induced albino rats. Indian Journal of Pharmaceutical Education and Research. 2024 Jan 1;58(1):172-7.
46. Mehrafarin A, Ghaderi A, Rezazadeh SH, NAGHDI BH, NOURMOHAMMADI G, Zand ES. Bioengineering of important secondary metabolites and metabolic pathways in fenugreek (Trigonella foenum-graecum L.).
47. Anwar S, Bhandari U, Panda BP, Dubey K, Khan W, Ahmad S. Trigonelline inhibits intestinal microbial metabolism of choline and its associated cardiovascular risk. Journal of Pharmaceutical and Biomedical Analysis. 2018 Sep 10;159:100-12.
48. Ronsisvalle S, Panico A, Santonocito D, Siciliano EA, Sipala F, Montenegro L, Puglia C. Evaluation of Crocin Content and In Vitro Antioxidant and Anti-Glycation Activity of Different Saffron Extracts. Plants. 2023 Oct 18;12(20):3606.
49. De Stefano A, Caporali S, Di Daniele N, Rovella V, Cardillo C, Schinzari F, Minieri M, Pieri M, Candi E, Bernardini S, Tesauro M. Anti-inflammatory and proliferative properties of luteolin-7-O-glucoside. International journal of molecular sciences. 2021 Jan 28;22(3):1321.
50. GARAD SV, PATIL SS. INVESTIGATION ON THE INTERACTION OF β-SITOSTEROL AND LUTEOLIN-7-GLUCOSIDE BINDING TO BOVINE SERUM ALBUMIN. atherosclerosis. 2023;3:4.
51. Wang J, Lu Z, Chi J. Multicenter clinical trial of the serum lipidlowering effects of a Monascus purpureus (red yeast) rice preparation from traditional Chinese medicine. Curr Ther Res. 1997;58:964-977.
52. Heber D, Yip I, Ashley JM, Elashoff DA, Elashoff RM, Go VL. Cholesterol-lowering effects of a proprietary Chinese red-yeast-rice dietary supplement. The American journal of clinical nutrition. 1999 Feb 1;69(2):231-6.
53. Urizar NL, Moore DD. GUGULIPID: a natural cholesterol-lowering agent. Annual review of nutrition. 2003 Jul;23(1):303-13.
54. Tajmohammadi A, Razavi BM, Hosseinzadeh H. Silybum marianum (milk thistle) and its main constituent, silymarin, as a potential therapeutic plant in metabolic syndrome: A review. Phytotherapy research. 2018 Oct;32(10):1933-49.
55. Grela ER, Świątkiewicz M, Florek M, Wojtaszewska I. Impact of milk thistle (Silybum marianum L.) seeds in fattener

diets on pig performance and carcass traits and fatty acid profile and cholesterol of meat, backfat and liver. Livestock Science. 2020 Sep 1;239:104180.
56. Di Pierro F, Bellone I, Rapacioli G, Putignano P. Clinical role of a fixed combination of standardized Berberis aristata and Silybum marianum extracts in diabetic and hypercholesterolemic patients intolerant to statins. Diabetes, metabolic syndrome and obesity: targets and therapy. 2015 Feb 4:89-96.
57. Uchendu IK, Onwukwe SO, Agu CE, Orji CO, Eluke BC, Nwosu TF. Hypolipidaemic and renoprotective effects of Glycine max (soy bean) against lipid profile and renal biochemical alterations in hypercholesterolemic rat. International Journal of Biomedical Research. 2016;7(12):822-8.
58. Lee JH, Lee BW, Kim JH, Jeong TS, Kim MJ, Lee WS, Park KH. LDL-antioxidant pterocarpans from roots of Glycine max (L.) Merr. Journal of agricultural and food chemistry. 2006 Mar 22;54(6):2057-63.
59. Amal AF, Sanaa T. Effect of Allium sativum extract on serum lipid and antioxidant status in hypercholesterolemic rabbits. Life Science Journal. 2012;9(3):187-96.
60. Hosseini A, Hosseinzadeh H. A review on the effects of Allium sativum (Garlic) in metabolic syndrome. Journal of endocrinological investigation. 2015 Nov;38:1147-57.
61. Ali M, Al-Qattan KK, Al-Enezi F, Khanafer RM, Mustafa T. Effect of allicin from garlic powder on serum lipids and blood pressure in rats fed with a high cholesterol diet. Prostaglandins, Leukotrienes and Essential Fatty Acids (PLEFA). 2000 Apr 1;62(4):253-9.
62. Santos HO, Bueno AA, Mota JF. The effect of artichoke on lipid profile: A review of possible mechanisms of action. Pharmacological research. 2018 Nov 1;137:170-8.
63. Alkushi AG. Biological effect of Cynara cardunculus on kidney status of hypercholesterolemic rats. Pharmacognosy magazine. 2017 Oct;13(Suppl 3):S430.
64. Rafińska K, Pomastowski P, Wrona O, Górecki R, Buszewski B. Medicago sativa as a source of secondary metabolites for agriculture and pharmaceutical industry. Phytochemistry Letters. 2017 Jun 1;20:520-39.
65. Badar A, Kaatabi H, Bamosa A, Al-Elq A, Abou-Hozaifa B, Lebda F, Alkhadra A, Al-Almaie S. Effect of Nigella sativa supplementation over a one-year period on lipid levels, blood pressure and heart rate in type-2 diabetic patients receiving oral hypoglycemic agents: nonrandomized clinical trial. Annals of Saudi medicine. 2017 Jan;37(1):56-63.
66. Sabzghabaee AM, Dianatkhah M, Sarrafzadegan N, Asgary S, Ghannadi A. Clinical evaluation of Nigella sativa seeds for the treatment of hyperlipidemia: a randomized, placebo controlled clinical trial. Medical archives. 2012 May 1;66(3):198.