

A Review on the Pharmacological Potential of Herbal Drugs Responsible for the Anti-Hyperlipidemic Activity

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Abstract

Review Article

Herbal drugs are the oldest remedies known to mankind. Man's dependence on plants for health care is as old as the civilization. Herbs had been used by all cultures throughout history, but India has one of the oldest, richest and most diverse cultural living traditions associated with the use of medicinal plants. The uses of herbal plants as traditional medicine are well known. This is mainly due to the presence of bioactive metabolite in plants which formed the basis of herbal medication. Hyperlipidemia plays an important role in the development of atherosclerosis, the main cause of death in the world. Hyperlipidemia is the greatest hazard factor of coronary heart disease. At present scenario the use of allopathic drugs for antihyperlipidemic effect have been associated with large number of side effects. Herbal treatment for hyperlipidemia has no side effects and is relatively despicable and locally and cheaply available. The review article is undertaken to investigate the herbal plants for antihyperlipidemic activity and various models use in this investigation. This review is specified on the anti-hyperlipidemic activity of the most recognizable therapeutic plants of medicine and to explore some of the medicinal plant and their phytoconstituents for their anti-hyperlipidemic activity.

Keywords: Hyperlipidemia, Herbal medicine, coronary heart disease.

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INTRODUCTION

Ischemic heart disease is one of the major causes of mortality and disabilities in the whole world, especially in the developing countries. Because of its rapid progression in order to inappropriate lifestyle and nutritional modification, it has been produced as the greatest vulnerable event [1]. Hyperlipidemia is the elevated levels of lipids and cholesterol in the blood, and is also identified as dyslipidemia to describe the expression of different disorders of lipoprotein metabolism [2]. Hyperlipidemia is a condition of excess fatty substances called lipids, largely cholesterol and triglycerides in the blood. It is also called hyperlipoproteinemia because these excess lipids travel in the blood and attached to the protein's receptors. These fatty substances can remain undissolved while in circulation [3]. It is a disorder of lipid metabolism manifested by elevation of plasma concentrations of the various lipid and lipoprotein fraction, which are the key risks factors for cardiovascular disease (CVD). It is also elucidated as an elevation of one or more of the following cholesterols, Phospholipids or triglycerides. Abnormalities of plasma lipids can result in predisposition to Coronary, cerebrovascular and

peripheral vascular arterial diseases and has been reported & has most common cause of death in developed & has most common cause of death in developing nations [4]. Nowadays statins which is an antihyperlipidemic drug have been associated with large number of side effects. Herbal treatment for hyperlipidemia has no side effects and is relatively contemptible and easily available. Medicinal plants are the "backbone" of traditional medicine so considered as good source of life for all people due to its wealthy therapeutic properties and being 100% natural. Medicinal plants are widely used by majority of populations to treat various diseases and have high effect on the world's economy. Traditional therapeutic drugs which mainly rely on plants, herbs and shrubs always played a fundamental role in the global health system. Herbal drugs are generally less toxic and have very less side effects and easily available when requirement for herbal drugs is rising [5].

Hyperlipidemia is a medical as well as social problem, especially associated with diabetes mellitus leading to increasing morbidity and mortality. The chief risk factors of hyperlipidemia are associated with atherosclerosis which predisposes ischemic heart

disease and cerebrovascular disease [6]. The plant extracts and their constituents play the major role in traditional medicines and therapies [4]. There are number of research studies which report the hypolipidemic activity of various traditional medicines from different regions of India. The present review constitutes the plants with hypolipidemic activity.

CLASSIFICATION OF HYPERLIPIDEMIA

Hyperlipidemia may be classified as either familial (also called primary) caused by definite genetic abnormalities or acquired (also called secondary) that leads to change in diagnosis [7].

Table-1: Normal values of lipid [5]

S.NO	TEST NAME	NORMAL VALUES	INDICATORS
1	Total Cholesterol	Total Cholesterol: < 200 mg/dL (desirable) (< 180 optimal)	200-239mg/dL = Borderline High (borderline risk for coronary heart disease > 240 mg/Dl Hypercholesterolemia)
2	Total Cholesterol for children	< 180 mg/Dl	> 180 mg/dL may lead to Atherosclerosis
3	Triglyceride Levels	Less than 150 mg/dl	150-199 mg/dL is Border line High 200-499 mg/dL is High 500 mg/dL or above is Very High
4	VLDL cholesterol	The VLDL normal range is between 0–40 mg/dL and the suggested optimum range is between 0–30 mg/dL	>40 suggest increase the risk of developing heart disease
5	C-reactive Protein (CRP)	CRP< 1 mg/dl	CRP> 1mg/dl (> 10mg/dl suggests inflammation)
6	LDL Cholesterol	< 100 mg/dL (optimal) 100-129 mg/dL (near /above optimal)	130-159Mg/dL Borderline High 160-189 Mg/dL High ≥190 Mg/dL Very High
7	HDL Cholesterol	> 60 mg/dl is enviable	HDL levels < 40 Mg/dL increases risk for CHD. women with levels < 47 mg/dL and men < 37 mg/dL have increased risk

Some Anti-hyperlipidemic activity, pharmacological and clinical studies reported on ayurvedic and other herbs are described below.

- 1. *Aegle marmelos*** – Biological Source- leaf of *Aegle marmelos* family-Rutaceae. Common name-Bael. The present work was done to study qualitative investigation of extractability of the useful compounds from *Aegle marmelos* leaves via supercritical fluid extraction technique (SFE) and to evaluate antihyperlipidemic activity of *Aegle marmelos*(Am). The obtained extract and fractions were treated on Triton induced rat models and the results showed lowering the lipid profile level in the experimental models by in-vivo methods. The fractions of *Aegle marmelos* (AmF1) also exhibited excellent anti-hyperlipidemic property at 3rd week and lowering the serum cholesterol, triglycerides in Triton induced rats. The most important ingredients present in plant communities turn out to be alkaloids, terpenoids, steroids, phenols glycosides and tannins are responsible for monitoring the normal lipid profile in Triton induced rats due to LA of lecithin acetyl transferase (LCAT), which regulates lipids concentration. The LCAT plays a key role in the incorporation of free cholesterol into HDL (this may increase HDL) and transferring it back to VLDL and LDL which are taken back later in liver cells. The changes in the level of serum lipids in experimental rats are illustrated in (Table 1). The total Cholesterol, TG1, LDL and VLDC

significantly decreased ($P < 0.001$) and simultaneously there is increase in level of HDLs. Supercritical Fluid extraction of leaves of *Aegle marmelos* (Am) possess significant antihyperlipidemic activity as compared to control group [8].

- 2. *Allium sativum***- Biological Source-Fresh fruit of *Allium sativum* family-Alliaceae. Common name-Lasun. The present study is designed to evaluate the effect of garlic extract on lipid profiles in Triton X-100 induced hyperlipidemia in male wistar rats. Three fractional extracts (AS1, AS2 and AS3) were obtained by column chromatography from methanolic extract of garlic. All three *Allium sativum* extract significantly increased ($p < 0.0001$) plasma HDL-Cholesterol and decreased plasma TC, LDL-Cholesterol and TG levels as compared with hyperlipidemic control rats. Among three fractions, AS3 has more significantly reduced the plasma lipid levels than others AS1 and AS2 [9].
- 3. *Lagenaria siceraria***- Biological Source- Fresh fruit of *Lagenaria siceraria* family- Cucurbitaceae. Common name- Bottle gourd. Antihyperlipidemic activity of the fruit extracts in triton induced hyperlipidemic rats and hypolipidemic effect in normocholesteremic rats were investigated. In the study, four different extracts viz. petroleum ether, chloroform, alcoholic, and aqueous extracts were prepared. Oral administration of the extracts doses dependently inhibited the total cholesterol, triglycerides, low-density lipoproteins level, and

significantly increased the high-density lipoproteins level. Both the chloroform and alcoholic extracts exhibited significant effects compared others. However, the petroleum ether extract did not show significant effects. Antihyperlipidemic activity Nain wal *et al.* evaluated the juice of fresh fruits of *Lagenaria siceraria* for anti-hyperlipidemic activity by evaluating the blood cholesterol level of atherogenic diet rat and proved that juice of the fresh fruits of *Lagenaria siceraria* have the potent effect to cause a blood cholesterol lowering effect and the serum biochemistry changes may suggest that the juice extract has a tonic effect on the kidneys and the liver and their organs play central role in drug metabolism [10].

4. ***Asparagus racemosa***- Biological Source- Dried root of *Asparagus racemose* family- Asparagaceae. Common name-Shatavari. Hypercholesteremia was induced in normal rats by including 0.75 % cholesterol and 1.5 % bile salt in normal diet and were used for the experiments. The root powder of *Asparagus racemosus* was administered as feed supplement at 5 % and 10% dose levels in the hypercholesteremic rats. Plasma and liver lipid profiles, hepatic HMG-CoA reductase, bile acid, malondialdehyde, ascorbic acid, catalase and SOD, fecal bile acid, cholesterol and neutral sterols were estimated using standard methods. Feed supplementation with 5 % and 10 % *Asparagus racemosus* showed the result in a significant decline in plasma and hepatic lipid profiles. The feed supplementation increased the HMG-CoA reductase activity and bile acid production in both groups (5 and 10 % supplemented groups) with increase in fecal bile acid and fecal cholesterol excretion. The activities of catalase, SOD and ascorbic acid content increased in both the experimental groups (5 and 10 % supplemented groups). On the other hand, the concentration of malondialdehyde in these groups (5 and 10 g% supplemented groups) decreased significantly, indicating decreased lipid peroxidation. The present study discovered that the addition of *Asparagus racemosus* root powder at 5 % and 10 % level as feed supplement reduces the plasma and hepatic cholesterol levels and decreases lipid peroxidation [11].
5. ***Plantago psyllium***- Biological Source- Dried seeds of *Plantago psyllium* family - plantaginaceae. Common name-ispaghula. In a study of 28 patients who took 3 doses (3.4 g/dose) per day compared with placebo for 8 weeks, the psyllium-treated patients showed decreases in total serum cholesterol levels compared with the placebo group after 4 weeks. Decreases were also seen in LDL- C and LDL/HDL ratio. At the end of 8 weeks, values for TC, LDL- C and the LDL/HDL ratio were 14, 20, and 15%, respectively, below baseline. This study suggested that a high cholesterol level could be managed safely and easily by including psyllium preparations in the diet [12].
6. ***Trigonella foenumgraecum* Linn.** – Biological Source- Dried seeds of *Trigonella foenumgraecum* family-Fabaceae. Common name-Methi. The study performed in vitro adopting the everted-sac technique showed that the ethanol extract had the ability to inhibit taurocholate and deoxycholate absorption in a dose-dependent manner. In two separate feeding experiments, hypercholesterolemia rats were fed on 30 or 50 g ethanol extract/kg for a 4-week period. Reductions in plasma cholesterol levels ranged from 18 to 26% and a tendency for lower concentrations of liver cholesterol was observed. These results indicate that the ethanol extract from fenugreek seeds contained hypocholesterolaemic components which appear to be saponins that interact with bile salts in the digestive tract [13].
7. ***Bauhinia variegata* Linn-** Biological Source- *Bauhinia variegata* family-Fabaceae. Common name-Kachnar. Aqueous and ethanolic extracts of the stem, bark and root of *B. variegata* Linn. were prepared and assessed for in vitro antioxidant activity by various methods namely total reducing power, scavenging of various free radicals such as 1,2-diphenyl-2-picrylhydrazyl (DPPH), super oxide, nitric oxide, and hydrogen peroxide. The percentage scavenging of various free radicals was compared with standard antioxidants such as ascorbic acid and butylated hydroxyl anisole (BHA). The extracts were also evaluated for antihyperlipidemic activity in Triton WR-1339 (iso-octyl poly oxyethylene phenol)-induced hyperlipidemic albino rats by estimating serum triglyceride, very low-density lipids (VLDL), cholesterol, low-density lipids (LDL), and high-density lipids (HDL) levels. Significant antioxidant activity was observed in all the methods, ($P < 0.01$) for reducing power and ($P < 0.001$) for scavenging DPPH, super oxide, nitric oxide, and hydrogen peroxide radicals. The extracts showed significant reduction ($P < 0.01$) in cholesterol at 6 and 24 h and ($P < 0.05$) at 48 h. There was significant reduction ($P < 0.01$) in triglyceride level at 6, 24, and 48 h. The VLDL level was also ($P < 0.05$) reduced from 24 h and maximum reduction ($P < 0.01$) was seen in 48 h. There was significant increase ($P < 0.01$) in HDL at 6, 24, and 48 h it is evident that alcoholic and aqueous extracts of *B. variegata* Linn. Can effectively decrease plasma cholesterol, triglyceride, LDL, and VLDL and increase plasma HDL levels. In addition, the alcoholic and aqueous extracts have shown significant antioxidant activity. By the virtue of its antioxidant activity, *B. variegata* Linn. May show antihyperlipidemic activity [14].
8. ***Carica papaya* Linn-** Biological Source- Fresh leaves of *Carica papaya* family-Caricaceae. Common name- papaya Hydro alcoholic extract of

C. papaya at the dose of 400 mg/kg b.w. showed reduced levels of plasma cholesterol and triglycerides along with reduced levels of plasma glucose. This evidence showing that C. papaya has capability to reduce the level of glucose, plasma cholesterol and triglycerides. The similar results were shown in experimentally alloxan induced diabetic rats. These biological activities might be shown due to the presence of phytoconstituents i.e. flavonoids, alkaloids and tannins. There is a strong link between diabetes mellitus, dyslipidemia, obesity and hypertension. Further scientific evaluation is required to develop its molecular level of action. Wilson *et al.* 2002 A compound present in crushed papaya seed that is believed to have activity against helminthic intestinal parasites, benzyl isothiocyanate (BITC –derived from benzyl glucosinolate), has been shown to influence vascular contraction using a canine carotid artery in vitro model. Other studies have suggested possible purgative effects of root extracts and antihypertensive activity of fruit extracts. The present invention shows for the first time that cow urine with herbal combination or fresh juice of herbal combination is useful for treating of hyperlipidemia and obesity in mammals. An object of the present invention shows for the first time that cow urine with herbal combination or fresh juice of herbal combination or a pharmaceutically acceptable for the manufacture of medicament or nutritional supplement useful for treating Hyperlipidemia and obesity in a mammal [15].

9. **Zingiber Officinale-** Biological Source-Rhizome of *Zingiber officinale* family- Zingiberaceae. Common name- Ginger. Diabetes was induced in male Wistar rats by single intraperitoneal injection of 50 mg/kg body weight (bw) of streptozotocin. This was followed by oral administration of 500 mg/kg each of free and bound polyphenol extracts of *Z. officinale* to the rats daily for 42 days. Distilled water and glibenclamide (5 mg/kg) were used as normal and positive controls, respectively. Enormous increases ($p < 0.05$) in blood glucose level (369.26 mg/dL, lipid profile and atherogenic indices, with decrease in high density lipoprotein cholesterol (HDL-C) (15.55 mg/dL) were observed in diabetic rats compared to control. Polyphenolic extracts of *Z. officinale* reduced ($p < 0.05$) blood glucose (147.96 mg/dL), lipid profile and atherogenic indices while it significantly increased HDL-C (23.28 mg/dL). However, bound polyphenol extract did not cause any significant change in the lipid profile of the diabetic rats except for LDL-C. The study indicates that free and bound polyphenols from *Z. officinale* can ameliorate diabetes as well as its complications, and its effect is comparable to that of the standard drug, Glibenclamide [16].
10. **Emblica officinalis Gaertn-** Biological source- Fresh fruit of *Emblica officinale* Family-

Phyllanthaceae. Common name- Amla *E. officinalis* has been found to reduce serum Total cholesterol, aortic cholesterol and hepatic cholesterol significantly, without any effect on the serum triglyceride levels in both normal and cholesterol induced hypercholesterolemic rabbits. The effect of *E. officinalis* on total serum cholesterol and its lipoprotein fractions was also studied in normal and hypercholesterolemic individuals aged 35–55 years. When the supplement was given for a period of 28 days in the raw form, both normal and hypercholesterolemic subjects showed a decrease in cholesterol levels. Two weeks after withdrawing the supplement, the total serum cholesterol levels of the hypercholesterolemic subjects rose significantly almost to the initial levels [17].

11. **Moringa oliefera Lam-** Biological Source-Fresh leaves of *Moringa oliefera* Family- Moringaceae. Common name-Drumstick tree. The leaves of *Moringa oleifera* Lam (Moringaceae) are used by the Indians in their herbal medicine as a hypocholesterolemia agent in obese patients. The scientific basis for their use in hypercholesterolemia was therefore examined. The administration of the leaf extract of *Moringa oleifera* along with high-fat diet decreased the high-fat diet-induced increases in serum, liver, and kidney cholesterol levels 14.35%, 6.40% and 11.09% respectively. The effect on the serum cholesterol was statistically significant. No significant effect on serum total protein was observed. However, the extract increased serum albumin by 15.22% (46-53 g/l). This value was also found to be statistically significant. It was concluded that the leaves of *Moringa oleifera* have definite hypocholesterolaemic activity and that there is valid pharmacological basis for employing them for this purpose in India [18].
12. **Morinda Citrifolia-** Biological Source-fruit of *Morinda citrifolia* Family- Rubiaceae Common Name-Mulberry. *Morinda citrifolia* (Noni) fruit juice (NFJ), 2 ml per kg bw per day, was consumed by twenty patients with DT2 after they undergo a standard treatment regimen with carbohydrate reduced diet and then treatment with an antidiabetic drug or insulin. NFJ consumption started only after no further improvement was achieved. The intake of NFJ was terminated after eight weeks. The fasting blood sugar level was observed every morning during the entire treatment period. Blood samples were taken before and four and eight weeks after the start of NFJ intake. The analysis of the blood samples included the concentration of blood glucose, HbA1c, C-peptide, hs -CRP, triglycerides, total cholesterol, LDL, and HDL. The consumption of NFJ by 20 patients with DT2 resulted in a significant mean decrease of the morning blood sugar level monitored over a period of eight weeks. While NFJ reduced the blood glucose level in most of them but not all

hyperglycemic patients, it does not cause hypoglycemia in normoglycemic patients. NFJ consumption also reduced the mean HbA1c value ($p=0.033$). Significant decreases ($p=0.01$) were also achieved for highly sensitive CRP values in patients starting with high levels (>2 mg/L), whereas no change was observed in patients with normal values (<2 mg/L). The level of C-peptide showed a significant mean increase after four weeks of NFJ consumption in those patients who started with low levels (<3 μ g/l, $p=0.004$, $N=11$) but not in patients with higher levels (>3 μ g/L). The daily consumption of NFJ has the potential to regulate elevated blood sugar levels and some other pathological parameters in patients with DT2. NFJ therefore serves as a suitable additive to the diet of diabetic patients [19].

13. **Cassia auriculata**- Biological source- Flowers of *Cassia auriculata*. Family- Caesalpinaceae. Common name-Avaram senna. The extract of flower of *Cassia auriculata*, herb has been used traditionally in India for medicinal and therapeutic purposes. The plant has been reported in traditional books to treat hyperglycemia and associated hyperlipidemia. The reported work was undertaken to investigate the antihyperlipidemic and antioxidative effect of *C. auriculata* flower in hyperlipidemic rats. Hyperlipidemia was induced in rats by a single intravenous (iv) injection of Triton WR 1339 (300 mg/kg b.w.) and it showed significant elevated levels of serum cholesterol and triglyceride. Ethanolic extract of *C. auriculata* flowers (Et-CAF) at a dose of (150, 300, 450 mg/kg b.w./day) was administered to normal group and hyperlipidemic group for 14 days. Serum and liver tissue were analysed at three different time intervals for lipid profile, lipid peroxidation products, antioxidants enzymes and the activity were compared to the cholesterol-lowering drug, lovastatin (10 mg/kg/b.w.). Parameters were altered during hyperlipidemia and reverted to near normal values after Et-CAF treatment or standard drug lovastatin. Lipid peroxidation decreased whereas the activities of glutathione peroxidase, superoxide dismutase, and catalase increased in Et-CAF treated rats. Pronounced changes were observed at 450 mg/kg b.w. of Et-CAF for 2 weeks and it was comparable to the standard drug lovastatin. The current study provides strong evidence that Et-CAF has a beneficial effect in treating hyperlipidemia [20].
14. **Nelumbo Nucifera**- Biological Source- Fruit of *Nelumbo Nucifera* Family- Nelumbonaceae. Common name- Indian lotus. Hyperlipidemia is the main cause of the development of various diseases which made pharmaceutical companies to turn towards the herbal products with fewer side effects. In the present research, the Hyperlipidemia activity of *Nelumbo nucifera* Flower (NN) has been done. The Hyperlipidemia activity of hydroalcoholic extract of *Nelumbo nucifera* flower was evaluated in Poloxamer 407 induced hyperlipidemic in male Wistar rats. Hyperlipidemia was induced by giving Poloxamer 407 intraperitoneal route for 15 days. The groups of rats approved for the study were treated with Atorvastatin, ethanolic extract of *Nelumbo nucifera* (NN). The analysis of lipids profile such as cholesterol, HDL, LDL, VLDL, Triglycerides and liver markers such as SGOT, SGPT were carried out at the end of the study. Administration of *Nelumbo nucifera* significantly decreases the Lipid profile and Liver Markers. Likewise, remarkable increase in the level of HDL-C when compared to standard Atorvastatin drug. The levels of SGOT and SGPT were estimated and found to be significantly less than that of hyperlipidemic control group. The results reveal that *Nelumbo nucifera* is a rich source for phytoconstituents and can be used as a potent anti-Hyperlipidemic agent in pharmaceutical industry [21].
15. **Terminalia arjuna**- Biological Source- Bark of *Terminalia arjuna* Family- Combretaceae. Common name-Arjun tree. An open prospective randomized controlled study was conducted in on 60 patients for the duration of 12 weeks. Patients were distributed into two groups of 30 patients each. Group I was given Rosuvastatin 10 mg daily and group II was given capsules containing bark powder of *T.arjuna* 500 mg twice daily. Patients TC and LDL-C levels were performed at baseline and then repeated at 4 weeks, 8 weeks and 12 weeks. The results of both the therapies were then compared and statistically analyzed. Arjuna leads to greater reduction in mean TC level than Rosuvastatin ($-14.06\pm 8.07\%$ vs $-10.10\pm 5.39\%$), ($-24.73\pm 10.69\%$ vs $-19.42\pm 9.98\%$) and ($-27.89\pm 9.25\%$ vs $-24.74\pm 10.02\%$) at 4, 8 and 12 weeks respectively. The difference between both the groups was statistically non-significant ($p>0.05$) at 4, 8 and 12 weeks. The reduction in LDL-C level was also greater with *T.arjuna* as compared to Rosuvastatin. Both Rosuvastatin and *T.arjuna* were effective in causing significant decrease in serum TC and LDL-C levels, but *T.arjuna* had a slight edge over Rosuvastatin as it showed greater reduction in TC and LDL-C levels as compare to Rosuvastatin. And was found to be safe and well tolerated [22].
16. **Capparis Decidua**- Biological Source- Stem of *Capparis decidua* Family- Capparidaceae Common name-Karira. The study revealed the effect of various extracts (50% ethanolic) of Capparis decidua on lipid profile of streptozotocin diabetic rats was studied. Procedure: the extract was administered to the diabetic models for 30 days. Findings: The extract produced a significant ($p<0.05$) dose-dependent decrease in the levels of total cholesterol (TC), Triacylglycerol (TG), low-density lipoprotein-cholesterol (LDL cholesterol),

with a significant increase in the level High-density lipoprotein-cholesterol (HDL-c). Conclusion: the extracts of *Capparis decidua* prove to have a hypolipidemic potential [23].

17. *Hibiscus rosa sinensis*- Biological Source-roots of *Hibiscus rosa sinensis* Family- Malvaceae. Common name-China rose. The hypolipidemic activity of *Hibiscus rosa sinensis* (family Malvaceae) root extract was studied in triton and cholesterol-rich high fat diet (HFD) induced models of hyperlipidemia in rats. In triton WR-1339 induced hyperlipidemia, treating with root extract (500 mg/kg body wt/day p.o.) shows lipid-lowering effect, by reversal of plasma levels of total cholesterol (TC), triglycerides (TG) phospholipids (PL) and reactivation of post-heparin lipolytic activity (PHLA) of plasma. The other group of rats was fed with cholesterol-rich HFD and root extract (500 mg/kg body wt/ day p.o.) parallelly for 30 days. The lowering of lipid levels in plasma and liver homogenate and reactivation of plasma PHLA and hepatic total lipoprotein lipase activity. The hypolipidemic effect of *Hibiscus rosa sinensis* root was compared with a standard drug Guggulipid (200 mg/kg body wt/day p.o.), a known lipid-lowering agent in both models. Histopathological study in rat liver supported the protective role of *H. rosa sinensis* root extract in preventing cholesterol-rich HFD-induced hepatic steatosis [24].

18. *Sesbania grandiflora*- Biological Source- Leaves of *Sesbania grandiflora* Family- Fabaceae. Common name-Agati. *Sesbania grandiflora* (SG) was selected and the present study focus on the anti-hyperlipidemic activity of aqueous extract of leaves of SG against triton induced hyperlipidemia in rats. *Sesbania grandiflora* administered in a dose of 200µg/kg (p.o) in the triton induced hyperlipidemic rats. *Sesbania grandiflora* shows a significant decrease in the levels of serum cholesterol, phospholipid, triglyceride, LDL, VLDL and significant increase in the level of serum HDL at the dose of 200µg/kg (p.o) against Triton induced hyperlipidemic in rats. Aqueous extract of SG leaves was investigated hypolipidemic activity in Triton induced hyperlipidemic profile. Aqueous extract fraction decreased serum level of total cholesterol by 69.72. The aqueous extract of SG increases the serum HDL cholesterol level by 24.11.and the reduction of LDL cholesterol level by aqueous extract was 30.31[25].

19. *Piper longum* -Biological Source- Root of *Piper longum* Family- Piperaceae. Common name Kali mirch. The extract of fruit of *Piper longum* was studied in two different experimental models of hyperlipidemia in which one acute model in which hyperlipidemia was induced by injecting a single dose of triton WR-1339 (400 mg/kg, b.w.) intraperitoneally in rats, Treatment with *Piper longum* extract at the dose of 500 mg/ kg, b.w.

resulted in effectively lipid lowering effect of total cholesterol (TC), phospholipids (PL), triglyceride (TG) and reactivation of post heparin lipolytic activity (PHLA). There is significant decrease in TC, PL and TG levels by 32%, 19%, 39%, respectively, and increase in PHLA activity by 29% as compared to hyperlipidemic animals. In chronic model, hyperlipidemia induced by cholesterol rich-high fat diet, there is significant decrease in TC, PL and TG levels by 27%, 15%, 34%, respectively, and increase in PHLA activity by 20 % as compared to induced hyperlipidemic animals. The treatment with the fruit extract of *Piper longum* (500 mg/ kg b.w) for 15 days causes the lowering of lipid levels in liver homogenate, following reactivation of plasma post heparin lipolytic activity in animals. This hypolipidemic activity of *Piper longum* was comparable to standard drug Guggulipid in both models [26].

20. *Cymbopogon citrates*- Biological Source -Leaves of *Cymbopogon citrates* Family- Graminaceae Common name -Lemon grass the present study was designed to investigate the hypoglycemic and hypolipidemic effects of the single, daily oral dosing of 125-500 mg/kg of fresh leaf aqueous extract of *Cymbopogon citratus* Stapf. (CCi) in normal, male Wistar rats for 42 days. The average weights of rats per group were taken at 2 weeks interval for 42 days. On day 43, blood samples from the rats were collected for fasting plasma glucose (FPG), total cholesterol, triglycerides, low-density lipoproteins (LDL-c), very low-density lipoprotein (VLDL-c) and high-density lipoprotein (HDL-c) assays through cardiac puncture under halothane anesthesia. Acute oral toxicity study of CCi was also conducted using limit dose test of the Up and Down Procedure statistical program (AOT425StatPgm, Version 1.0) at a dose of 5000 mg/kg body weight/oral route. Our results showed CCi to lower FPG and lipid parameters dose dependently ($p < 0.05$) while raising the plasma HDL-c level ($p < 0.05$) in same dose-related fashion but with no effect on plasma triglycerides level ($p > 0.05$). Results of acute oral toxicity showed CCi to be of low toxicity and as such could be considered relatively safe on acute exposure. Thus, confirming its folkloric use and safety in suspected Type 2 diabetic patients [27].

CONCLUSION

Hyperlipidemia is a critical condition of elevated lipid levels in the body that ultimately lead to the development and progression of various CVDs. The link between hyperlipidemia and occurrence of CVDs has already been established; the problem of enhanced cholesterol levels in blood is still prevailing and is being a cause for many coronary disorders. Among many diseases or disorders, hyperlipidaemia is one of the serious disorders effecting large population of the world. Hyperlipidaemia is associated with serious

health risks and increased mortality. Hypertension, insulin resistance and glucose intolerance are known as cardiac risk factors that cluster in obese individuals. Hyperlipidaemia, which needs further exploration for necessary development of drugs and nutraceuticals from natural resources. Many herbal remedies used nowadays have not undergone careful scientific assessment, and some have the potential to cause serious toxic effects and major drug-to-drug interactions. Continuing research is necessary to elucidate the pharmacological activities of the many herbal remedies now being used to treat Hyperlipidaemia, atherosclerosis and other cardiovascular diseases. Currently used hypolipidemic drugs are associated with so many adverse effects and withdrawal is associated with rebound phenomenon which is not seen with herbal preparations.

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