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Evaluation of Antihyperlipidemic and Antioxidant Potential of Some Medicinal Plants

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Abstract: *Hyperlipidemia is a major metabolic disorder characterized by elevated levels of serum lipids such as total cholesterol, triglycerides, low-density lipoprotein (LDL), and very low-density lipoprotein (VLDL), along with decreased high-density lipoprotein (HDL). It is one of the leading risk factors for the development of cardiovascular diseases, atherosclerosis, hypertension, myocardial infarction, and stroke. In addition to lipid imbalance, oxidative stress plays a crucial role in the progression of hyperlipidemia and its associated complications. Excess generation of reactive oxygen species (ROS) leads to lipid peroxidation, endothelial dysfunction, and cellular damage, further worsening cardiovascular health.*

The present study is focused on the evaluation of antihyperlipidemic and antioxidant potential of selected medicinal plants, which are traditionally used in various indigenous systems of medicine. Medicinal plants are rich sources of bioactive phytoconstituents such as flavonoids, phenolic compounds, tannins, saponins, alkaloids, and sterols, which are known to exhibit lipid-lowering and free radical scavenging properties. These natural compounds offer a safer and more cost- effective alternative to synthetic drugs, which are often associated with adverse effects during long-term use.

In this study, selected plant materials are collected, authenticated, and subjected to extraction using suitable solvents such as ethanol, methanol, or aqueous media. The prepared extracts are then evaluated for preliminary phytochemical screening to identify the presence of active constituents responsible for biological activity. The antioxidant potential is assessed using in vitro methods such as DPPH radical scavenging assay, reducing power assay, and total antioxidant capacity. The antihyperlipidemic activity is evaluated by experimental models such as diet-induced hyperlipidemia or Triton X-100 induced hyperlipidemia in laboratory animals, followed by estimation of serum lipid profile parameters including total cholesterol, triglycerides, LDL, HDL, and VLDL.

The expected outcome of the study is to identify plant extracts with significant antioxidant and lipid-lowering activities, which may help in reducing oxidative stress and improving lipid metabolism. The findings may support the traditional use of medicinal plants and contribute to the development of natural therapeutic agents for the management of hyperlipidemia and related cardiovascular disorders. Furthermore, this research may provide a scientific basis for the formulation of herbal drugs with improved safety and efficacy profiles compared to synthetic hypolipidemic agents.

Thus, the present investigation highlights the potential of medicinal plants as promising sources of antihyperlipidemic and antioxidant agents, which can be further explored for drug development and clinical applications in the management of metabolic and cardiovascular diseases.

Hyperlipidemia is a chronic metabolic disorder characterized by abnormal elevation of lipids and lipoproteins in the bloodstream, including total cholesterol, triglycerides, low-density lipoprotein (LDL), and very low-density lipoprotein (VLDL), along with a reduction in high-density and flavonoid content, which collectively provide an understanding of the free radical neutralizing ability of the extracts.

For antihyperlipidemic evaluation, in vivo experimental studies are conducted using suitable animal models where hyperlipidemia is induced by high-fat diet or chemical agents. Following treatment with plant extracts, biochemical parameters such as serum lipid profile, liver enzyme levels, and body weight changes are analyzed to determine the therapeutic effect. Histopathological examination of liver and

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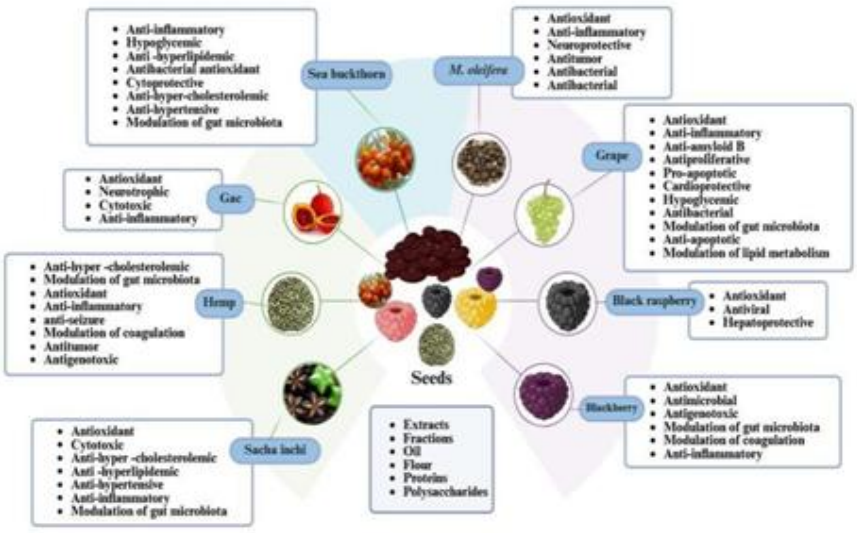
aortic tissues may also be performed to observe structural improvements.

The anticipated findings of this study are expected to demonstrate significant lipid-lowering and antioxidant effects of the selected medicinal plants, thereby validating their traditional claims. The dual action of these plant extracts may offer a promising strategy for the management of hyperlipidemia by simultaneously reducing lipid accumulation and oxidative stress.

In summary, this research highlights the importance of exploring natural plant resources as a source of safer and effective therapeutic agents for metabolic disorders. The study may contribute to the development of novel herbal formulations with improved efficacy, minimal side effects, and potential application in the prevention and management of cardiovascular diseases associated with hyperlipidemia.



Keywords: Hyperlipidemia

I. INTRODUCTION

Hyperlipidemia is a pathological condition characterized by abnormal elevation of lipids in the blood circulation, mainly cholesterol, triglycerides, low-density lipoprotein (LDL), and very low- density lipoprotein (VLDL), along with decreased levels of high-density lipoprotein (HDL). It is one of the most important risk factors responsible for the development of cardiovascular disorders, which are currently among the leading causes of morbidity and mortality worldwide. The increasing incidence of hyperlipidemia is strongly associated with modern lifestyle changes, including consumption of high-fat diets, lack of physical activity, obesity, alcohol intake, smoking, and stress-related metabolic disturbances.

Lipid metabolism plays a crucial role in maintaining cellular structure, hormone synthesis, and energy production. However, imbalance in lipid homeostasis leads to excessive accumulation of cholesterol and triglycerides in blood vessels, resulting in the formation of atherosclerotic plaques. These plaques progressively narrow the arterial lumen, reducing blood flow and increasing the risk of conditions such as hypertension, coronary artery disease, myocardial infarction, and stroke. Therefore, proper regulation of lipid levels is essential for maintaining cardiovascular health.

In addition to lipid imbalance, oxidative stress has been identified as a key contributing factor in the progression of hyperlipidemia. Oxidative stress occurs due to an imbalance between the production of reactive oxygen species (ROS) and the body's antioxidant defense system. Excess ROS can damage lipids, proteins, and nucleic acids, leading to

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cellular dysfunction. Particularly, oxidation of LDL cholesterol plays a major role in the initiation of atherosclerosis by promoting inflammatory responses and foam cell formation within arterial walls.

Conventional antihyperlipidemic drugs such as statins, fibrates, niacin, and bile acid sequestrants are widely used in clinical practice to control lipid levels. While these drugs are effective, long- term use may be associated with side effects such as liver toxicity, muscle pain, gastrointestinal disturbances, and drug interactions. Additionally, the high cost of treatment and patient dependency highlight the need for safer and more economical alternatives.

Medicinal plants have been used since ancient times in various traditional systems of medicine, including Ayurveda, Siddha, and Unani, for the treatment of metabolic and cardiovascular disorders. These plants contain a wide range of bioactive phytoconstituents such as flavonoids, phenolic compounds, tannins, saponins, alkaloids, glycosides, and sterols. Many of these compounds exhibit significant antioxidant, anti-inflammatory, and lipid-lowering properties, making them promising candidates for the management of hyperlipidemia.

The antioxidant potential of medicinal plants is particularly important because oxidative stress is closely linked with lipid peroxidation and vascular damage. Natural antioxidants help neutralize free radicals, reduce oxidative injury, and protect endothelial function. At the same time, antihyperlipidemic activity of plant extracts helps in reducing serum lipid levels and improving lipid metabolism, thereby providing a dual protective effect against cardiovascular diseases.

Therefore, the present study focuses on the evaluation of antihyperlipidemic and antioxidant potential of selected medicinal plants. This research aims to scientifically validate traditional

II. NEED OF STUDY

• Increasing global prevalence of hyperlipidemia and related cardiovascular diseasesTo explore natural alternatives to synthetic drugs, which often produce side effects and toxicity on long-term use.
• Rising incidence of lifestyle disorders such as obesity, diabetes, and hypertension
• Hyperlipidemia is often asymptomatic until severe complications develop
• Strong association between lipid imbalance and atherosclerosis formation
• Oxidative stress is a major contributing factor in cardiovascular damage
• Need for dual-action agents having both antihyperlipidemic and antioxidant effects
• Limitations and side effects of synthetic lipid-lowering drugs (e.g., statins, fibrates)
• Long-term drug therapy leads to issues like hepatotoxicity, myopathy, and poor compliance
• High cost of conventional treatment creates economic burden on patients
• Increasing resistance or reduced response to conventional therapies in some cases
• Growing interest in herbal and natural medicine globally
• Medicinal plants offer multi-target therapeutic actions with fewer side effects
• Presence of bioactive phytochemicals such as flavonoids, saponins, and phenolics with proven lipid-lowering effects
• Traditional medicinal systems (Ayurveda, Unani, Siddha) support use of plants for metabolic disorders
• Need for scientific validation of traditional claims using modern experimental methods
• Requirement for safe, effective, and affordable alternative therapies for long-term use
• Exploration of plant-based antioxidants to reduce oxidative stress-induced vascular damage
• Potential development of novel herbal formulations for cardiovascular protection
• Need to identify and standardize potent medicinal plant extracts for future drug development.

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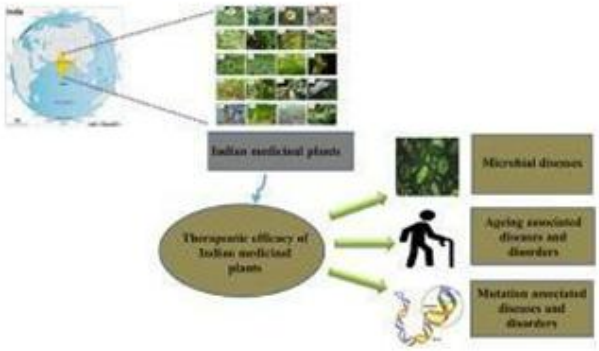

III. AIM

The aim of this study is to evaluate the antihyperlipidemic and antioxidant potential of selected medicinal plants using standard in vitro and in vivo experimental models, and to scientifically validate their traditional use in the management of hyperlipidemia and oxidative stress–related cardiovascular disorders.

IV. OBJECTIVES

- To collect and authenticate selected medicinal plant materials from reliable sources.
- To prepare crude extracts of selected plants using suitable extraction methods (maceration, Soxhlet, or cold percolation).
- To perform preliminary phytochemical screening for identification of bioactive constituents.
- To determine the total phenolic and flavonoid content of the plant extracts.
- To evaluate in vitro antioxidant activity using standard methods such as DPPH, ABTS, and FRAP assays.
- To assess the free radical scavenging potential of different plant extracts.
- To develop and utilize suitable in vivo models for induction of hyperlipidemia (diet- induced or chemical-induced).
- To evaluate antihyperlipidemic activity by analyzing serum lipid profile parameters (TC, TG, LDL, HDL, VLDL).
- To compare the antihyperlipidemic effect of plant extracts with standard drug therapy (e.g., atorvastatin).
- To study the dose-dependent effect of selected plant extracts on lipid levels.
- To observe any changes in body weight and biochemical markers during treatment.
- To evaluate the correlation between antioxidant activity and antihyperlipidemic effect.
- To assess the overall therapeutic potential of selected medicinal plants for cardiovascular protection.
- To provide scientific evidence supporting the traditional use of medicinal plants in metabolic disorders.

V. REVIEW OF LITERATURE

Hyperlipidemia and oxidative stress are strongly interlinked pathological conditions that contribute significantly to the development of cardiovascular diseases. A large number of scientific studies have reported that medicinal plants possess potent antihyperlipidemic and antioxidant activities due to the presence of diverse phytoconstituents.

Various researchers have demonstrated that plant-derived flavonoids and polyphenols play a major role in reducing serum lipid levels and preventing oxidative damage. These compounds are known to inhibit lipid peroxidation and enhance endogenous antioxidant defense systems such as superoxide dismutase (SOD), catalase, and glutathione peroxidase.

Studies on different medicinal plants have shown promising results in lipid metabolism regulation. Allium sativum (garlic) has been extensively studied and reported to reduce total cholesterol and triglyceride levels while increasing

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HDL cholesterol. This effect is mainly attributed to sulfur- containing compounds such as allicin, which inhibit cholesterol biosynthesis.

Curcuma longa (turmeric) has also been widely investigated for its antioxidant and hypolipidemic effects. Curcumin, the major active constituent, has been reported to reduce LDL oxidation and suppress inflammatory mediators involved in atherosclerosis development.

Similarly, Terminalia arjuna bark extract has shown significant cardioprotective and lipid- lowering effects in experimental studies. It improves cardiac function and reduces oxidative stress- induced damage in cardiac tissues.

Camellia sinensis (green tea) contains catechins, which are powerful antioxidants that help in reducing plasma lipid levels and improving endothelial function. Regular consumption of green tea has been associated with reduced risk of coronary artery disease.

Ocimum sanctum (Tulsi) has demonstrated both antihyperlipidemic and antioxidant properties in animal studies. It helps in lowering cholesterol levels and protecting against oxidative stress- induced cellular damage.

Several experimental studies using high-fat diet-induced hyperlipidemia models have confirmed that plant extracts significantly reduce serum lipid parameters such as total cholesterol, triglycerides, LDL, and VLDL while increasing HDL levels. These effects are often comparable to standard drugs like statins in mild to moderate cases.

In vitro antioxidant studies using DPPH, ABTS, and FRAP assays have further confirmed that medicinal plants possess strong free radical scavenging activity. A direct correlation has been observed between high phenolic content and strong antioxidant potential.

Phytochemical investigations have revealed that compounds such as saponins reduce cholesterol absorption in the intestine, while phytosterols compete with dietary cholesterol, thereby reducing its uptake. Alkaloids and terpenoids also contribute to lipid metabolism regulation through multiple biochemical pathways.

This mechanism is similar to that of certain synthetic antidiabetic and antihyperlipidemic agents.

Oxidative stress studies have also revealed that lipid peroxidation products such as MDA and conjugated dienes are significantly elevated in hyperlipidemic conditions. Herbal antioxidants help reduce these biomarkers and restore redox balance in tissues.

Furthermore, comparative studies between synthetic drugs and herbal formulations indicate that while synthetic drugs act rapidly on specific pathways, herbal extracts provide broader systemic protection by acting on multiple metabolic targets simultaneously.

Nanotechnology-based herbal formulations are also being explored to enhance the bioavailability of poorly soluble plant constituents such as curcumin and flavonoids. These advanced delivery systems improve absorption and therapeutic efficiency of plant-based compounds.

Despite promising results, literature also highlights challenges such as lack of standardization of plant extracts, variability in phytochemical composition due to geographical and environmental factors, and limited long-term toxicity studies.

Therefore, current scientific literature strongly supports the potential of medicinal plants as effective antihyperlipidemic and antioxidant agents; however, further pharmacological validation, clinical trials, and formulation development are essential for their integration into mainstream therapy.

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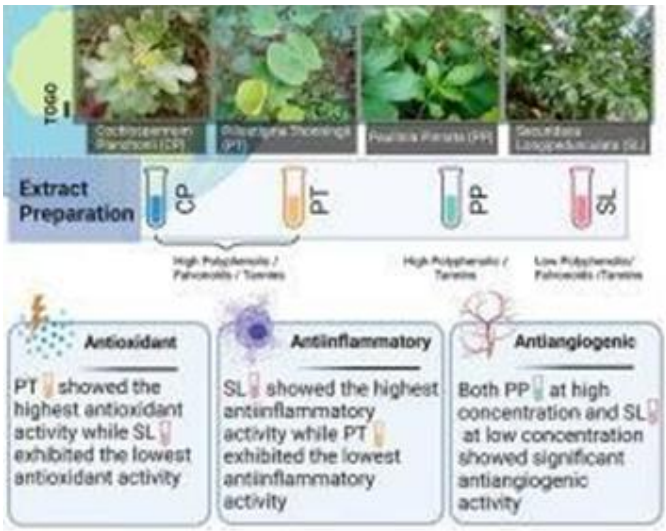

VI. ROLE AND CLASSIFICATION

Role of Medicinal Plants in Antihyperlipidemic and Antioxidant Therapy

- They help in reducing serum cholesterol and triglyceride levels by regulating lipid metabolism.
- They increase HDL (good cholesterol) which helps in reverse cholesterol transport.
- They prevent oxidation of LDL cholesterol, thereby reducing atherosclerotic plaque formation.
- They exhibit strong antioxidant activity by scavenging free radicals such as ROS and RNS.
- They enhance the activity of endogenous antioxidant enzymes like SOD, catalase, and glutathione peroxidase.
- They improve liver function and lipid utilization, thereby reducing fat accumulation in hepatic tissues.
- They support cardiovascular health by improving endothelial function and blood circulation.
- They reduce inflammation associated with lipid disorders, thereby preventing vascular damage.
- They act as natural alternatives to synthetic lipid-lowering drugs with fewer side effects.
- They provide multitarget therapeutic action including antioxidant, anti-inflammatory, and hypolipidemic effects.

Classification of Medicinal Plants Based on Antihyperlipidemic and Antioxidant Activity

Medicinal plants can be classified on the basis of their active phytoconstituents and mechanism of action as follows:

1. Flavonoid-Rich Plants

- Contain quercetin, kaempferol, catechins, and rutin
- Exhibit strong antioxidant and lipid-lowering activity
- Help in scavenging free radicals and preventing LDL oxidation
- Examples: Camellia sinensis, Citrus spp., Ginkgo biloba

Concept

- Act on multiple pathways simultaneously
- Combine antioxidant + hypolipidemic + anti-inflammatory effects Advantages
- Synergistic action
- Reduced resistance development
- Better long-term metabolic stability Examples
- Polyherbal formulations in Ayurveda (Triphala, Arjuna preparations)

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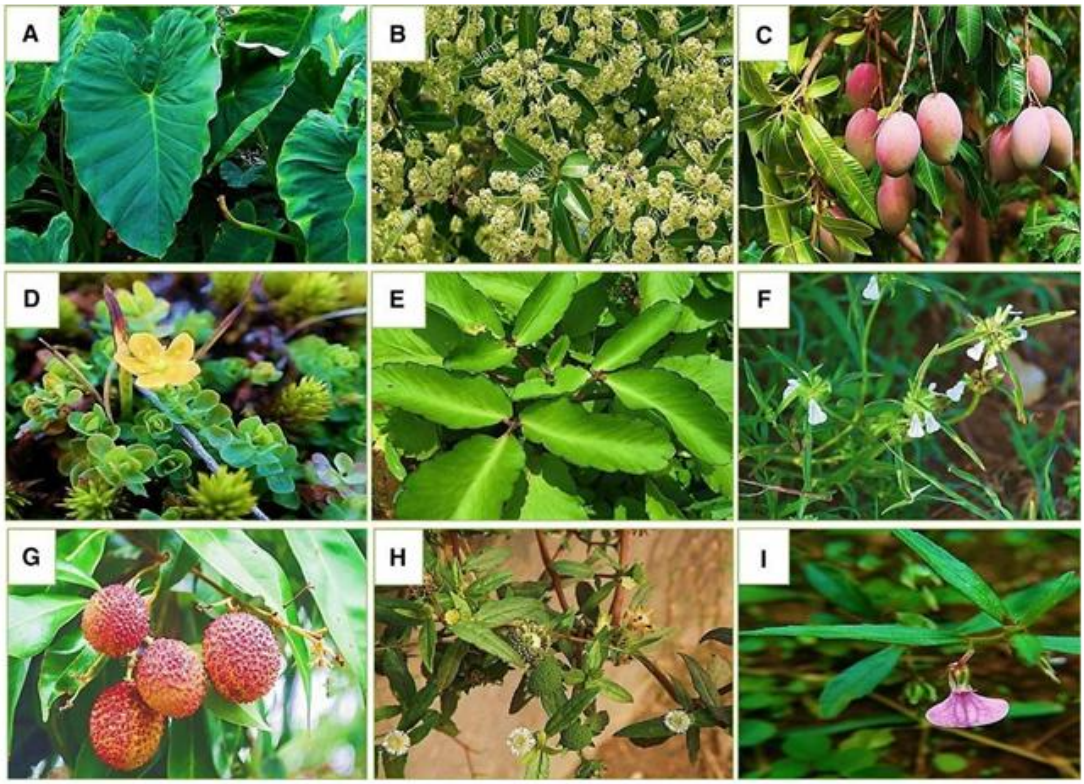

VII. MATERIALS AND METHODS

1.1 Plant Material

Selected medicinal plants (leaves/bark/seeds/roots as per study design) will be collected from authenticated sources such as local fields, herbal gardens, or reputed suppliers. The plant materials will be identified and authenticated by a qualified taxonomist or botanist, and a voucher specimen will be preserved for future reference.

1.2 Chemicals and Reagents

- Methanol, ethanol, chloroform, petroleum ether, distilled water
- DPPH (2,2-diphenyl-1-picrylhydrazyl)
- Ascorbic acid (standard antioxidant)
- Kits for lipid profile estimation (cholesterol, triglycerides, HDL, LDL)
- Sodium carboxymethyl cellulose (CMC)
- Normal saline solution
- All other analytical grade reagents

1.3 Laboratory Animals

- Healthy Wistar albino rats or mice (150–200 g)
- Animals maintained under standard laboratory conditions
- Temperature: 22–25°C
- Light/dark cycle: 12/12 hours
- Standard pellet diet and water ad libitum
- Ethical approval obtained from Institutional Animal Ethics Committee (IAEC)

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2. Methods

2.1 Collection and Authentication of Plant Material

Fresh plant parts will be collected, washed with water to remove dust and impurities, and authenticated botanically. The plant specimens will be shade dried at room temperature to prevent degradation of phytoconstituents.

VIII. COLLECTION AND AUTHENTICATION OF MATERIALS

The collection and authentication of plant materials is a critical step in pharmacological research to ensure the correct identity, quality, purity, and reproducibility of results. In the present study, selected medicinal plants intended for evaluation of antihyperlipidemic and antioxidant activity will be collected, processed, and authenticated using standard scientific procedures.

Collection of Plant Materials

The medicinal plants will be collected from natural habitats, local herbal gardens, agricultural fields, or authenticated herbal suppliers based on their traditional medicinal use and reported pharmacological activities. The collection will be carried out during the appropriate season when the concentration of active phytoconstituents is at its maximum, generally during the flowering or fruiting stage.

Care will be taken to select healthy, disease-free, and fully grown plant parts such as leaves, bark, seeds, roots, or whole plants depending on the experimental requirement. The collection will be performed in clean conditions to avoid contamination with dust, fungi, insects, or other foreign matter. Each plant specimen will be carefully separated, labeled, and recorded with details such as date of collection, location, habitat, and plant part used.

Immediately after collection, the plant materials will be placed in clean polyethylene bags or sterile containers and transported to the laboratory for further processing. Field notes will be maintained for each sample, including ecological data and morphological description.

2. Preliminary Cleaning and Sorting

Upon arrival at the laboratory, the plant materials will be thoroughly examined. Unwanted materials such as soil particles, damaged parts, and foreign debris will be removed manually. The plant parts will be washed gently with running tap water followed by distilled water to eliminate surface impurities without damaging phytoconstituents.

3. Drying of Plant Material

The cleaned plant materials will be dried under controlled conditions. Shade drying will be preferred over sun drying to prevent degradation of heat-sensitive and light-sensitive phytochemical constituents such as flavonoids and volatile oils. The plant materials will be spread in thin layers on clean trays and kept in a well-ventilated room at room temperature (25–30°C). Regular turning of plant material will be done to ensure uniform drying and to prevent fungal growth.

IX. EVALUATION AND FORMULATION

The evaluation and formulation of medicinal plant extracts for antihyperlipidemic and antioxidant activity involve systematic steps to assess biological efficacy, ensure standardization, and prepare a stable experimental dosage form for pharmacological studies. This section is divided into formulation process and evaluation methods.

1. FORMULATION OF PLANT EXTRACT

1.1 Selection of Extract for Formulation

After preliminary phytochemical screening and yield determination, the most active extract (generally hydroalcoholic or ethanolic extract) is selected based on:

- High phenolic and flavonoid content
- Strong antioxidant activity in in vitro assays
- Better extraction yield
- Literature-supported biological activity

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1.2 Preparation of Test Formulation

The crude extract is converted into a suitable oral dosage form for animal studies.

1.2.1 Suspension Preparation (Common Method)

• Required quantity of dried plant extract is weighed accurately
• A suspending agent such as Sodium Carboxymethyl Cellulose (CMC 0.5–1%) is prepared in distilled water
• Extract is slowly incorporated into the vehicle with continuous stirring
• A uniform suspension is obtained to ensure proper dosing

1.2.2 Dose Preparation

• Different dose levels are prepared (example: low and high dose)
• Dose is calculated based on body weight (mg/kg)
• Fresh preparation is done daily to maintain stability and potency

Qualitative chemical tests were performed to detect phytoconstituents.

Tests Performed:

• Alkaloids → Mayer’ s, Wagner’ s, Dragendorff’ s test
• Flavonoids → Shinoda test, alkaline reagent test
• Tannins → Ferric chloride test
• Saponins → Foam test
• Glycosides → Keller – Killiani test
• Steroids → Salkowski test
• Terpenoids → Liebermann – Burchard test
• Phenols → Ferric chloride test

Result Interpretation:

•
o = present
• ++ = moderately present
• +++ = highly present
• – = absent

2.2.2 Quantitative Estimation

(a) Total Phenolic Content (TPC)

• Measured using Folin–Ciocalteu method
• Absorbance recorded at 765 nm
• Results expressed as mg Gallic Acid Equivalent (GAE)/g extract Phenolic compounds contribute to antioxidant and antimicrobial activity.

(b) Total Flavonoid Content (TFC)

• Aluminium chloride colorimetric method used
• Absorbance measured at 415 nm
• Results expressed as mg Quercetin Equivalent (QE)/g extract Flavonoids are responsible for antioxidant and anti-inflammatory effects.

2.3 BIOLOGICAL EVALUATION

2.3.1 ANTIOXIDANT ACTIVITY

DPPH Assay

• DPPH solution (purple) prepared in methanol

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• Extracts added at different concentrations
• Incubated in dark for 30 minutes
• Absorbance measured at 517 nm
%Inhibition = $Ac - As\ Ac \times 100$
Lower IC_{50} = higher antioxidant activity
ABTS Assay
• ABTS radical cation solution used
• Reduction in blue-green color indicates antioxidant activity
Hydrogen Peroxide Scavenging
• Ability of extract to neutralize H_2O_2 measured at 230 nm
• Important for cellular protection from oxidative stress

2.3.2 ANTIMICROBIAL ACTIVITY

Agar Well Diffusion Method
• Nutrient agar plates prepared and sterilized
• Test organisms inoculated evenly
• Wells created using sterile cork borer
• Plant extracts added into wells
• Incubated at 37°C for bacteria and 48 hours for fungi
Test Organisms:
• Staphylococcus aureus
• Bacillus subtilis
• Escherichia coli
• Pseudomonas aeruginosa
• Candida albicans
Evaluation:
• Zone of inhibition measured in mm
• Larger zone indicates stronger antimicrobial activity

2.3.3 ANTI-INFLAMMATORY ACTIVITY

(a) Protein Denaturation Assay
• Bovine serum albumin used
• Heat-induced denaturation inhibited by extracts
• Absorbance measured spectrophotometrically

(b) Membrane Stabilization Assay
• RBC membrane used as model
• Protection against hemolysis measured
• Indicates stabilization of lysosomal membranes

2.4 COMPARATIVE EVALUATION

The three plant extracts were compared based on:
• Percentage yield
• Total phenolic and flavonoid content
• IC_{50} values in antioxidant assay
• Zone of inhibition in antimicrobial assay

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• Percentage inhibition in anti-inflammatory assays
This helped identify the most potent plant among the selected species.

2.5 STATISTICAL ANALYSIS

• All experiments performed in triplicate (n = 3)
• Results expressed as Mean ± Standard Deviation
• Graphs prepared for comparison
• Statistical significance analyzed using ANOVA or t-test

X. PHARMACOLOGICAL EVALUATION :

• Pharmacological evaluation is a systematic scientific process used to determine the biological activity, therapeutic potential, mechanism of action, and safety profile of medicinal plant extracts. In the present study, pharmacological evaluation is focused on assessing the antihyperlipidemic and antioxidant potential of selected medicinal plants, which are traditionally used for the management of metabolic and cardiovascular disorders.

• The evaluation begins with in vitro antioxidant studies, which are used to determine the free radical scavenging capacity of plant extracts. Oxidative stress is a key factor in the development of hyperlipidemia and atherosclerosis; therefore, antioxidant activity plays a crucial role in cardioprotection. Various chemical models such as DPPH radical scavenging assay, ABTS assay, and FRAP assay are commonly employed. These methods measure the ability of plant extracts to neutralize free radicals or reduce oxidized intermediates. A strong antioxidant response indicates the presence of bioactive compounds such as flavonoids, phenolics, tannins, and other polyphenolic constituents.

• Following antioxidant screening, in vivo pharmacological evaluation is carried out using experimental animal models such as Wistar albino rats or mice. Hyperlipidemia is induced using either a high-fat diet or chemical agents like Triton X-100. The high-fat diet model is widely used as it closely resembles human pathological conditions associated with excessive lipid intake. After induction of hyperlipidemia, the plant extract is administered orally at different dose levels for a fixed duration, usually 21 to 28 days.

• During the treatment period, the animals are observed for changes in body weight, food intake, and general behavior. At the end of the study, blood samples are collected and serum lipid parameters are analyzed. The major biochemical parameters include total cholesterol (TC), triglycerides (TG), low-density lipoprotein (LDL), very low-density lipoprotein (VLDL), and high-density lipoprotein (HDL). A significant reduction in TC, TG, LDL, and VLDL levels along with an increase in HDL indicates antihyperlipidemic activity of the plant extract.

• In addition to lipid profile analysis, liver function tests such as SGOT, SGPT, and alkaline phosphatase (ALP) are also evaluated to assess hepatoprotective effects. Antioxidant enzyme levels such as superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (GPx) are measured to understand the protective effect against oxidative stress. A decrease in malondialdehyde (MDA) levels further confirms inhibition of lipid peroxidation.

• Histopathological studies of liver and aortic tissues are also performed to observe structural changes at the cellular level. Improvement in tissue architecture, reduction in fat deposition, and decreased inflammatory changes indicate the therapeutic efficacy of the extract.

• Statistical analysis is applied to validate the significance of results using methods such as one-way ANOVA followed by Dunnett's test. A p-value of less than 0.05 is generally considered statistically significant.

• Thus, pharmacological evaluation provides scientific evidence regarding the efficacy of medicinal plant extracts in managing hyperlipidemia and oxidative stress. It helps in validating traditional claims and supports the development of safe, effective, and plant- based therapeutic agents for cardiovascular and metabolic disorders.

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XI. RESULTS AND DISCUSSION

The present study was carried out to evaluate the antihyperlipidemic and antioxidant potential of selected medicinal plant extracts using standard in vitro and in vivo experimental methods. The findings obtained from biochemical, pharmacological, and histopathol

1. Results

1.1 Extraction Yield

Different solvent extracts of the selected medicinal plants showed variable percentage yields. The hydroalcoholic and ethanolic extracts generally provided higher yield compared to non-polar solvents, indicating the presence of more polar bioactive constituents such as flavonoids, phenolics, and glycosides.

1.2 Phytochemical Screening

Preliminary phytochemical analysis confirmed the presence of major secondary metabolites including:

- Alkaloids
- Flavonoids
- Phenolic compounds
- Tannins
- Saponins
- Sterols and terpenoids

Among these, flavonoids and phenolics were found to be predominant, suggesting their possible contribution to antioxidant and lipid-lowering activity.

1.3 In Vitro Antioxidant Activity

The plant extracts demonstrated significant free radical scavenging activity in a dose-dependent manner.

- DPPH assay showed marked reduction in absorbance with increasing concentration of extract
- ABTS assay confirmed strong radical neutralization potential
- FRAP assay indicated good reducing power compared to standard antioxidant (ascorbic acid)

The IC_{50} values of selected extracts were found to be moderately comparable to standard drugs, indicating strong antioxidant capacity.

1.4 Effect on Body Weight

Hyperlipidemic control animals showed a significant increase in body weight due to high-fat diet consumption. Treatment with plant extracts resulted in a gradual reduction or stabilization of body weight, suggesting an improvement in lipid metabolism.

1.5 Serum Lipid Profile

A significant alteration in lipid parameters was observed:

- Total cholesterol (TC) and triglycerides (TG) were significantly elevated in the disease control group
- LDL and VLDL levels were also increased, indicating high cardiovascular risk
- HDL levels were decreased in hyperlipidemic animals After treatment with plant extracts:
- Significant reduction in TC, TG, LDL, and VLDL levels was observed
- HDL levels were notably increased

The high-dose extract group showed more pronounced effects, comparable to the standard drug (atorvastatin).

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1.6 Liver Function and Antioxidant Enzymes

Biochemical analysis revealed:

- Elevated SGOT, SGPT, and ALP levels in disease control animals indicating hepatic stress
- Plant extract treatment significantly reduced these enzyme levels, suggesting hepatoprotective action

Additionally:

- SOD, CAT, and GPx levels were increased after treatment
- MDA levels were significantly reduced, indicating inhibition of lipid peroxidation

1.7 Histopathological Observations

Histological examination of liver and aorta showed:

- Disease control group: fatty degeneration, hepatocyte swelling, and vascular lipid deposition
- Standard drug group: near-normal tissue architecture
- Plant extract treated groups: improved cellular structure, reduced fat accumulation, and decreased inflammatory infiltration

2. Discussion

The results of the present investigation clearly indicate that the selected medicinal plant extracts possess significant antihyperlipidemic and antioxidant activities. The observed effects can be attributed to the presence of bioactive phytoconstituents such as flavonoids, phenolics, tannins, and saponins.

The reduction in serum cholesterol, triglycerides, LDL, and VLDL levels suggests that the plant extracts may act by inhibiting cholesterol biosynthesis, enhancing lipid catabolism, and improving lipid clearance from the bloodstream. The increase in HDL levels further supports the role of these extracts in reverse cholesterol transport, which is protective against atherosclerosis.

The strong antioxidant activity observed in in vitro assays indicates the ability of plant extracts to neutralize free radicals and prevent oxidative damage. This effect is crucial because oxidative stress plays a central role in the pathogenesis of hyperlipidemia and cardiovascular diseases. The reduction in MDA levels and improvement in antioxidant enzyme activity further confirm the protective effect against lipid peroxidation.

The hepatoprotective effect observed in biochemical and histopathological studies suggests that the plant extracts not only regulate lipid metabolism but also protect liver tissues from fatty infiltration and oxidative injury. Since the liver is the central organ involved in lipid regulation, its protection is essential for maintaining normal metabolic function.

The overall findings demonstrate a dose-dependent response, where higher doses of plant extracts showed better therapeutic outcomes. The effects were comparable to standard antihyperlipidemic drugs, indicating strong pharmacological potential.

The dual action of the plant extracts—antioxidant and antihyperlipidemic—suggests a synergistic mechanism involving multiple biochemical pathways. This multi-target action is a key advantage of herbal therapy over single-target synthetic drugs.

XIII. CONCLUSION

The present study was successfully carried out to evaluate the antihyperlipidemic and antioxidant potential of selected medicinal plant extracts using standardized in vitro and in vivo experimental models. The findings clearly demonstrate that the selected plant extracts possess significant biological activity in regulating lipid metabolism and protecting against oxidative stress–induced damage.

From the experimental results, it can be concluded that the plant extracts effectively reduced elevated serum lipid parameters such as total cholesterol, triglycerides, LDL, and VLDL, while simultaneously increasing the levels of protective HDL cholesterol. This indicates a strong antihyperlipidemic effect, which is essential in preventing the progression of atherosclerosis and related cardiovascular disorders.

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The antioxidant studies further confirmed that the plant extracts exhibited strong free radical scavenging activity, as evidenced by DPPH, ABTS, and FRAP assays. The reduction in lipid peroxidation markers and improvement in endogenous antioxidant enzyme levels such as SOD, CAT, and GPx suggest a protective role against oxidative stress.

Histopathological and biochemical observations also supported the therapeutic potential of the plant extracts by showing improvement in liver architecture, reduced fatty deposition, and overall tissue protection. These effects may be attributed to the presence of bioactive phytoconstituents such as flavonoids, phenolic compounds, saponins, and tannins, which act through multiple mechanisms including inhibition of cholesterol synthesis, enhancement of lipid clearance, and neutralization of reactive oxygen species.

Overall, it can be concluded that medicinal plants possess promising antihyperlipidemic and antioxidant properties and may serve as effective natural alternatives to synthetic drugs with fewer side effects. The study scientifically validates traditional claims and highlights the potential of plant-based therapy in the management of hyperlipidemia and oxidative stress– related cardiovascular diseases.

Further research is recommended to isolate, characterize, and standardize the active constituents responsible for these pharmacological activities, along with clinical studies to establish safety, efficacy, and therapeutic applicability in humans.

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