

Evaluation of Antihyperlipidemic Activity of *Althaea Officinalis* Extract Against Dexamethasone-Induced Hyperlipidemia in Rats.

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Abstract

Background: Hyperlipidemia is a major metabolic disorder and a significant risk factor for cardiovascular diseases. Although conventional lipid-lowering drugs are effective, their long-term use may be associated with adverse effects, prompting the search for safer plant-based alternatives. The present study evaluated the antihyperlipidemic activity of the hydroalcoholic extract of *Althaea officinalis* in dexamethasone-induced hyperlipidemic Wistar rats.

Methods: The hydroalcoholic extract of *Althaea officinalis* was subjected to physicochemical evaluation, phytochemical screening, thin-layer chromatography, quantitative phytochemical analysis, and in vitro antioxidant assays. Acute oral toxicity was assessed according to OECD guideline 423. Hyperlipidemia was induced by dexamethasone (10 mg/kg, s.c.), and the extract was administered orally at doses of 200 and 400 mg/kg. Serum lipid profile, liver function markers, oxidative stress marker (MDA), and histopathological changes in liver tissue were evaluated.

Results: The extract contained appreciable amounts of phenolics, flavonoids, alkaloids, and saponins and exhibited significant antioxidant activity in DPPH, hydrogen peroxide, superoxide radical scavenging, and reducing power assays. Acute toxicity studies confirmed its safety up to 2000 mg/kg. Treatment with the extract significantly reduced serum total cholesterol, triglycerides, LDL, VLDL, SGPT, SGOT, and MDA levels while increasing HDL levels in a dose-dependent manner. Histopathological examination demonstrated marked restoration of normal hepatic architecture, with the 400 mg/kg dose producing effects comparable to atorvastatin.

Conclusion: The hydroalcoholic extract of *Althaea officinalis* possesses significant antihyperlipidemic, antioxidant, and hepatoprotective activities, supporting its potential as a natural therapeutic agent for the management of hyperlipidemia.

Keywords: *Althaea officinalis*; Hyperlipidemia; Dexamethasone; Antihyperlipidemic activity; Antioxidant.

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1. Introduction

Hyperlipidemia is a common metabolic disorder characterized by elevated levels of total cholesterol, triglycerides, low-density lipoprotein (LDL), and very low-density lipoprotein (VLDL) in the bloodstream. It is one of the major modifiable risk factors for cardiovascular diseases, including atherosclerosis, coronary artery disease, myocardial infarction, and stroke. Rapid urbanization, unhealthy dietary habits, physical inactivity, obesity, and diabetes have contributed to the increasing global prevalence of hyperlipidemia, making it a significant public health challenge. Early diagnosis and effective management are essential to reduce cardiovascular morbidity and mortality.[1-3]

Dexamethasone, a potent synthetic glucocorticoid, is widely used for its anti-inflammatory and immunosuppressive effects but is known to produce metabolic disturbances following prolonged administration. It enhances hepatic lipid synthesis, increases circulating free fatty acids, impairs lipid clearance, and promotes insulin resistance, leading to elevated serum cholesterol and triglyceride levels. Because these metabolic alterations closely resemble human dyslipidemia, dexamethasone-induced hyperlipidemia is a well-established experimental model for screening potential antihyperlipidemic agents.[4-6]

Statins remain the first-line drugs for the management of hyperlipidemia; however, their long-term use may be associated with adverse effects such as hepatotoxicity, myopathy, gastrointestinal disturbances, and drug interactions. These limitations have encouraged the exploration of medicinal plants as safer alternatives. Numerous plant-derived phytochemicals, including flavonoids, phenolics, tannins, and saponins, have demonstrated lipid-lowering, antioxidant, and anti-inflammatory properties that may help improve lipid metabolism and reduce cardiovascular risk.[7-10]

Althaea officinalis L. (Marshmallow), a medicinal plant belonging to the family Malvaceae, has been traditionally used for the treatment of inflammatory, respiratory, and gastrointestinal disorders. The plant contains mucilage polysaccharides, flavonoids, phenolic compounds, and tannins, which possess antioxidant, anti-inflammatory, hepatoprotective, and other pharmacological activities. These biological properties indicate that *Althaea officinalis* may offer therapeutic benefits in oxidative stress-related metabolic disorders, including hyperlipidemia.[11-14] Despite its well-documented pharmacological activities, limited scientific evidence is available regarding the antihyperlipidemic potential of *Althaea officinalis* in dexamethasone-induced hyperlipidemia. Therefore, the present study was undertaken to evaluate the antihyperlipidemic activity of *Althaea officinalis* extract in dexamethasone-induced hyperlipidemic Wistar rats and to explore its potential as a natural therapeutic agent for the management of hyperlipidemia.[11,15]

2. Materials and Methods

2.1 Materials

The study utilized dexamethasone for the induction of hyperlipidemia, atorvastatin as the standard antihyperlipidemic drug, hydroalcoholic extract of *Althaea officinalis* as the test drug, normal saline as the vehicle for the control group, and ether as the anesthetic agent during blood collection.

The experimental procedures were carried out using standard laboratory instruments, including an analytical balance for weighing chemicals, a centrifuge for serum separation, a spectrophotometer for biochemical estimations, a water bath for maintaining the required temperature, and a light microscope for histopathological examination. Animal cages were used for housing the experimental animals, while syringes, oral feeding needles, a dissection kit, and routine laboratory glassware (beakers, test tubes, and pipettes) were employed for drug administration, tissue collection, and other laboratory procedures.

2.2 IAEC Approval

The animals were provided with standard pellet diet and water ad libitum throughout the study period. Prior

to the experiment, the animals were acclimatized to laboratory conditions for one week. All experimental procedures were conducted in accordance with the guidelines approved by the Institutional Animal Ethics Committee (IAEC).

2.3 Experimental Animals

Healthy male Albino Wistar rats weighing between 150–200 g were used for the experimental study. The animals were obtained from a registered animal house facility and maintained under standard laboratory conditions. The rats were housed in polypropylene cages with paddy husk bedding under controlled environmental conditions of temperature ($24 \pm 2^\circ\text{C}$) and 12 h light–dark cycle.

2.4 Methods

2.4.1 Collection and Authentication of Plant Material

Fresh leaves of *Althaea officinalis* were collected from Pune, Maharashtra, India, and authenticated by Dr. A. B. Sharma, Department of Pharmacognosy, Poona College of Pharmacy, Bharati Vidyapeeth (Deemed to be University), Pune. The authenticated plant material was used for further studies.

2.4.2 Preparation of Hydroalcoholic Extract

The collected leaves were washed, shade-dried at room temperature ($25\text{--}30^\circ\text{C}$), pulverized into coarse powder, and stored in airtight containers. Approximately 500 g of the powdered material was extracted using a Soxhlet apparatus with a hydroalcoholic solvent (ethanol). The extraction was continued until complete exhaustion of the plant material. The extract was filtered, concentrated on a water bath, dried to obtain a semi-solid mass, and stored in an airtight container until further pharmacological evaluation.[16,17]

2.4.3 Physicochemical Evaluation

The powdered plant material was subjected to standard physicochemical evaluation, including determination of total ash, acid-insoluble ash, water-soluble ash, loss on drying, and water- and alcohol-soluble extractive values according to standard pharmacognostic procedures. These parameters were determined to assess the identity, purity, and quality of the crude drug.[18,19]

2.4.4 Qualitative Phytochemical Screening

Preliminary phytochemical screening of the hydroalcoholic extract of *Althaea officinalis* was carried out using standard qualitative chemical tests to identify the presence of major phytoconstituents, including alkaloids, glycosides, flavonoids, phenolic compounds, tannins, saponins, steroids, terpenoids, carbohydrates, and proteins. Alkaloids were detected using Wagner's, Dragendorff's, Hager's, and Mayer's tests; glycosides by Keller–Killiani and Borntrager's tests; proteins by the Ninhydrin test; carbohydrates by Fehling's and Benedict's tests; phenolic compounds

and tannins by ferric chloride and potassium ferricyanide tests; flavonoids by the Shinoda test; steroids and terpenoids by Liebermann–Burchard and Salkowski tests; and saponins by the froth and foam tests. The presence or absence of each phytochemical constituent was recorded based on the characteristic color change or precipitate formation according to standard pharmacognostic procedures. [18-20]

2.4.5 Thin Layer Chromatography (TLC) Analysis

Thin-layer chromatography (TLC) of the hydroalcoholic extract of *Althaea officinalis* was performed using pre-coated silica gel 60 F₂₅₄ aluminum plates as the stationary phase. The extract was dissolved in methanol, filtered, and applied as spots on the activated TLC plates using a capillary tube. The plates were developed in a pre-saturated TLC chamber containing the appropriate mobile phase until the solvent front migrated approximately 8 cm. After drying, the chromatograms were examined under UV light at 254 nm and 366 nm. For enhanced visualization, the plates were sprayed with suitable detecting reagents, such as vanillin–sulphuric acid or anisaldehyde reagent, followed by heating at 105°C for color development. The retention factor (R_f) values of the resolved spots were calculated and recorded according to standard pharmacognostic procedures. [18,19]

2.4.6 In vitro Antioxidant Assay

I. DPPH Radical Scavenging Assay

The antioxidant activity of the hydroalcoholic extract of *Althaea officinalis* was evaluated using the 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging assay. Various concentrations of the extract and ascorbic acid (standard) were reacted with DPPH solution and incubated in the dark for 30 min. The absorbance was measured at 517 nm, and the percentage inhibition was calculated. The IC₅₀ value was determined from the concentration–response curve. [21,22]

II. Hydrogen Peroxide (H₂O₂) Scavenging Assay

The hydrogen peroxide scavenging activity of the extract was determined by mixing different concentrations of the extract with phosphate buffer (pH 7.4) containing hydrogen peroxide. After incubation, the absorbance was recorded at 230 nm against the corresponding blank. The percentage scavenging activity and IC₅₀ value were calculated using standard procedures. [23]

III. Superoxide Radical Scavenging Assay

The superoxide radical scavenging activity was evaluated using the PMS–NADH–NBT system. Different concentrations of the extract were reacted with NADH, nitroblue tetrazolium (NBT), and phenazine methosulfate (PMS), followed by incubation at room temperature. The absorbance was measured at 560 nm, and the percentage inhibition of

superoxide radicals was calculated. The IC₅₀ value was determined from the inhibition curve. [24]

IV. Reducing Power Assay

The reducing power of the hydroalcoholic extract was assessed by measuring its ability to reduce ferric ions. Different concentrations of the extract were incubated with phosphate buffer and potassium ferricyanide, followed by treatment with trichloroacetic acid and ferric chloride. The absorbance was recorded at 700 nm, where an increase in absorbance indicated greater reducing power of the extract. [25]

2.4.7 Quantitative Phytochemical Analysis

The hydroalcoholic extract of *Althaea officinalis* was quantitatively analyzed for total phenolic, flavonoid, alkaloid, and saponin contents using standard spectrophotometric methods. [25-29]

I. Total Phenolic Content

The total phenolic content was determined using the Folin–Ciocalteu method. The extract was reacted with Folin–Ciocalteu reagent followed by sodium carbonate solution and incubated at room temperature. The absorbance was measured at 765 nm, and the total phenolic content was calculated from the gallic acid calibration curve and expressed as mg gallic acid equivalents (GAE)/g of dry extract. [26]

II. Total Flavonoid Content

The total flavonoid content was estimated by the aluminium chloride colorimetric method. The extract was mixed with methanol, aluminium chloride, potassium acetate, and distilled water, followed by incubation at room temperature. The absorbance was recorded at 415 nm, and the flavonoid content was expressed as mg quercetin equivalents (QE)/g of dry extract using a quercetin standard curve. [27]

III. Total Alkaloid Content

The total alkaloid content was estimated by the bromocresol green (BCG) method. The extract was acidified, treated with bromocresol green reagent and phosphate buffer, followed by chloroform extraction. The absorbance of the chloroform layer was measured at 470 nm, and the alkaloid content was quantified using atropine as the reference standard. [28]

IV. Total Saponin Content

The total saponin content was determined by the vanillin–sulphuric acid colorimetric method using diosgenin as the standard. The extract was reacted with vanillin reagent and sulphuric acid, incubated in a water bath, and the absorbance was measured at 544 nm. The saponin content was calculated from the diosgenin calibration curve and expressed as diosgenin equivalents. [29]

2.4.8 In vivo Activity

I. Acute Oral Toxicity Study

The acute oral toxicity study of the hydroalcoholic extract of *Althaea officinalis* was performed according to OECD guideline 423. Healthy Wistar rats were

fasted overnight before oral administration of the extract at graded doses of 100, 200, 500, 1000, and 2000 mg/kg body weight. The animals were observed continuously during the initial 4 h, periodically for 24 h, and daily for 14 days for signs of toxicity, behavioral changes, and mortality. Body weight, food intake, and general health status were also monitored throughout the study. The extract did not produce any mortality or significant toxic effects up to a dose of 2000 mg/kg, indicating its safety for pharmacological evaluation.[30-32]

II. Selection of Experimental Doses

Based on the acute toxicity study, experimental doses of 200 mg/kg and 400 mg/kg body weight, corresponding to one-tenth and one-fifth of the maximum safe dose, respectively, were selected for evaluating the antihyperlipidemic activity of the hydroalcoholic extract of *Althaea officinalis*. [32]

III. Experimental Design

Wistar rats were randomly divided into five groups (n = 6). Group I served as the normal control and received normal saline (0.5 mL, p.o.). Group II served as the hyperlipidemic control and received dexamethasone (10 mg/kg, s.c.). Group III received dexamethasone (10 mg/kg, s.c.) along with atorvastatin (10 mg/kg, p.o.) as the standard treatment. Groups IV and V received dexamethasone (10 mg/kg, s.c.) along with the hydroalcoholic extract of *Althaea officinalis* at doses of 200 mg/kg and 400 mg/kg (p.o.), respectively. Dexamethasone was administered once daily for 8 consecutive days to induce hyperlipidemia, and the respective treatments were administered orally once daily throughout the experimental period under identical conditions.[32]

IV. Sample Collection

At the end of the treatment period, the animals were fasted overnight, and blood samples were collected on the 9th day under light ether anesthesia by cardiac puncture or the retro-orbital plexus method. The blood samples were allowed to clot and centrifuged at 2000 rpm for 30 min to obtain serum, which was stored for subsequent biochemical analysis.[6]

V. Biochemical Evaluation

The antihyperlipidemic activity of the hydroalcoholic extract of *Althaea officinalis* was evaluated by estimating serum lipid profile parameters, including total cholesterol (TC), triglycerides (TG), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), and very low-density lipoprotein cholesterol (VLDL-C). Liver function markers such as serum glutamate pyruvate transaminase (SGPT/ALT), serum glutamate oxaloacetate transaminase (SGOT/AST), and malondialdehyde (MDA) were also determined. Body weight, liver weight, and histopathological changes in

liver tissue were additionally evaluated to assess the protective effect of the extract.[6]

VI. Histopathological Analysis

Liver tissues were excised immediately after blood collection, washed with normal saline, and fixed in 10% neutral buffered formalin. The tissues were processed by routine paraffin embedding, sectioned at 4–5 μ m thickness, and stained with hematoxylin and eosin (H&E). The stained sections were examined microscopically for hepatic steatosis, hepatocellular degeneration, inflammatory cell infiltration, and other histopathological alterations.

VII. Statistical Analysis

The experimental data were expressed as Mean $\pm$ Standard Error of Mean (SEM). Statistical analysis was performed using one-way analysis of variance (ANOVA) followed by an appropriate post hoc multiple comparison test. A value of $p < 0.05$ was considered statistically significant. All statistical analyses were carried out using GraphPad Prism version 10.6.

3. Results

3.1 Standardization of Plant Material

The physicochemical evaluation of *Althaea officinalis* powder demonstrated that the crude drug possessed acceptable quality and purity. The ash values indicated minimal contamination with inorganic and siliceous materials, while the moisture content was within acceptable limits, suggesting good stability during storage. The extractive values revealed that the plant material contained a higher proportion of water-soluble constituents than alcohol-soluble constituents, indicating the abundance of polar phytochemicals such as phenolics, flavonoids, glycosides, and tannins. Fluorescence analysis showed characteristic color changes under visible and ultraviolet light after treatment with different chemical reagents, confirming the identity and authenticity of the plant material. Overall, the physicochemical and fluorescence characteristics established the quality, purity, and suitability of *Althaea officinalis* for further phytochemical and pharmacological investigations.

3.2 Extraction of Plant Material

The hydroalcoholic extraction of *Althaea officinalis* yielded a dark brown semisolid extract with a percentage yield of 14.8% (w/w). The satisfactory extractive yield indicates the efficient extraction of bioactive constituents using the hydroalcoholic solvent system. The extract is likely to contain a wide range of polar phytochemicals, including flavonoids, phenolic compounds, glycosides, and tannins, which are considered responsible for the pharmacological activities of the plant. The obtained extract was therefore considered suitable for subsequent phytochemical analysis and evaluation of its antihyperlipidemic activity.

3.3 Qualitative Phytochemical Screening

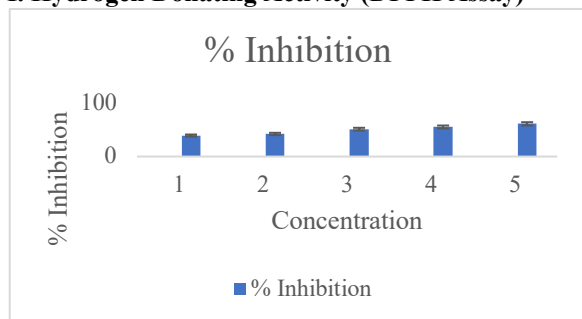
Preliminary phytochemical screening of the hydroalcoholic extract of *Althaea officinalis* confirmed the presence of several important secondary metabolites, including alkaloids, flavonoids, glycosides, saponins, carbohydrates, proteins, polyphenols, and tannins, while steroids and fats/oils were absent. The presence of these bioactive phytoconstituents suggests that the extract possesses significant therapeutic potential. In particular, flavonoids and phenolic compounds are well known for their antioxidant and lipid-lowering properties, whereas saponins and glycosides have been reported to improve lipid metabolism. These findings support the potential use of *Althaea officinalis* as a natural source of antihyperlipidemic agents and justify its further pharmacological evaluation.

3.4 Thin Layer Chromatography (TLC) Analysis

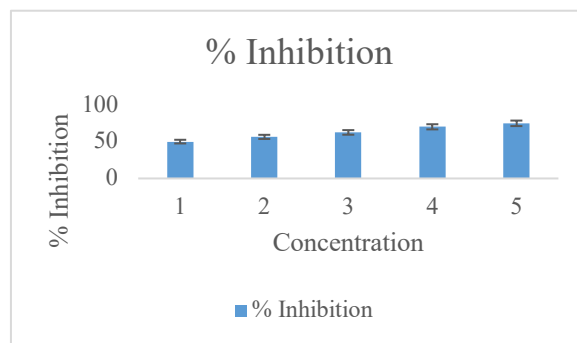
Thin layer chromatographic analysis of the hydroalcoholic extract of *Althaea officinalis* revealed the presence of a well-resolved chromatographic spot with an R_f value of 0.82. The developed chromatogram exhibited a distinct spot under UV light, and enhanced visualization following derivatization with vanillin-sulphuric acid reagent confirmed the presence of phytoconstituents in the extract. The characteristic TLC profile serves as a fingerprint for the identification and quality assessment of *Althaea officinalis* extract. The observed chromatographic pattern further indicates the presence of bioactive secondary metabolites that may contribute to the antioxidant and antihyperlipidemic activities of the plant.

3.5 In Vitro Antioxidant Activity

I. Hydrogen Donating Activity (DPPH Assay)

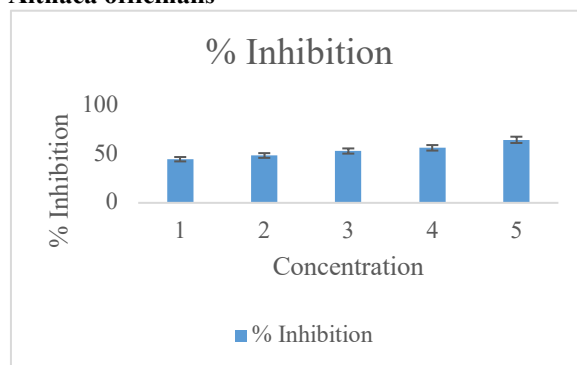


Graph 1: DPPH Free Radical Scavenging Activity of Hydroalcoholic Extract of *Althaea officinalis*:

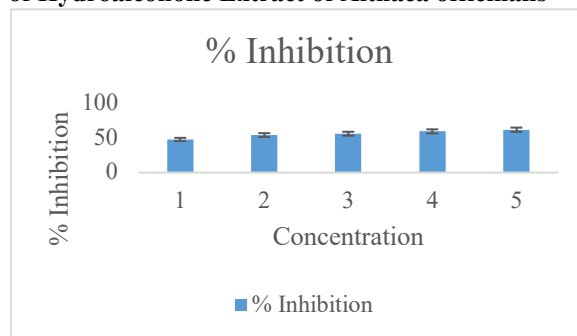


Graph 2: DPPH Free Radical Scavenging Activity of Ascorbic Acid

II. Hydrogen Peroxide Scavenging Activity of *Althaea officinalis*

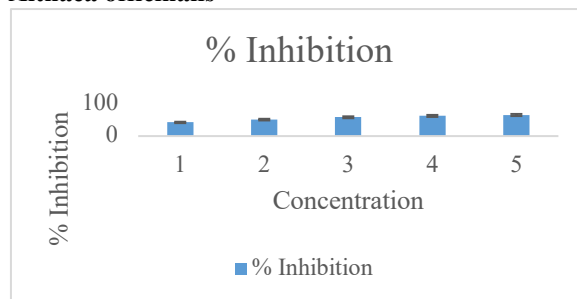


Graph 3: Hydrogen Peroxide Scavenging Activity of Hydroalcoholic Extract of *Althaea officinalis*

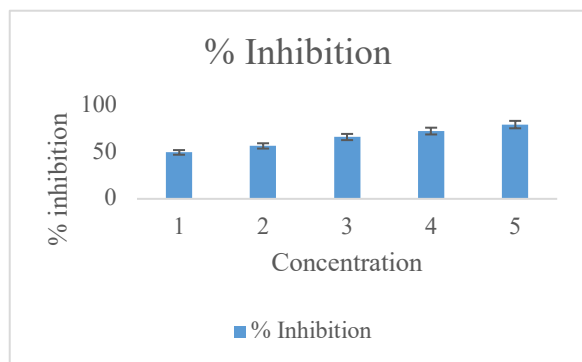


Graph 4: Hydrogen Peroxide Scavenging Activity of Ascorbic Acid

III. Superoxide Radical Scavenging Activity of *Althaea officinalis*

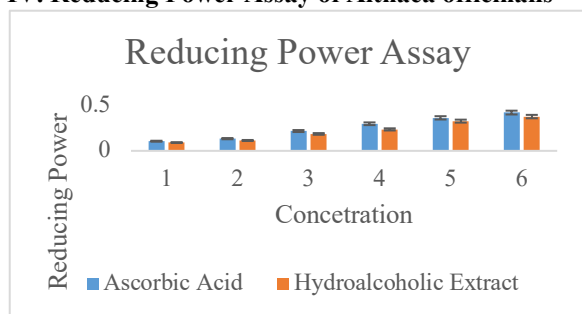


Graph 5: Superoxide Radical Scavenging Activity of Hydroalcoholic Extract of *Althaea officinalis*



Graph 6: Superoxide Radical Scavenging Activity of Ascorbic Acid

IV. Reducing Power Assay of *Althaea officinalis*



Graph 7.7: Reducing Power Assay of Hydroalcoholic Extract of *Althaea officinalis*

3.6 Quantitative Phytochemical Analysis of *Althaea officinalis*

3.6.1 Total Phenolic Content (TPC)

The total phenolic content of the hydroalcoholic extract of *Althaea officinalis* was determined using the Folin–Ciocalteu method with gallic acid as the reference standard. The extract exhibited a total phenolic content of 217.00 ± 0.916 mg GAE/g extract, indicating the presence of a high concentration of phenolic compounds. These compounds are well known for their antioxidant activity and play an important role in scavenging free radicals, thereby contributing to the pharmacological potential of the extract.

3.6.2 Total Flavonoid Content (TFC)

The total flavonoid content was estimated using the aluminium chloride colorimetric method with rutin as the standard. The hydroalcoholic extract showed a total flavonoid content of 79.33 ± 3.511 mg RE/g extract, demonstrating the presence of a considerable amount of flavonoids. Flavonoids possess potent antioxidant properties and are known to protect against oxidative stress by neutralizing reactive oxygen species.

3.6.3 Total Alkaloid Content (TAC)

The total alkaloid content of the hydroalcoholic extract was determined spectrophotometrically using atropine as the reference standard. The extract contained 26.66 ± 2.516 mg AE/g extract, indicating the presence of

moderate amounts of alkaloids. These phytoconstituents are reported to possess diverse biological activities and may contribute to the overall therapeutic efficacy of the plant.

3.6.4 Total Saponin Content (TSC)

The total saponin content was estimated using the vanillin–sulphuric acid method with diosgenin as the standard. The hydroalcoholic extract exhibited a total saponin content of 51.88 ± 1.347 mg DE/g extract, indicating the presence of appreciable quantities of saponins. Saponins are recognized for their antioxidant, anti-inflammatory, and lipid-lowering properties and may contribute significantly to the antihyperlipidemic activity of *Althaea officinalis*.

3.7 In vivo Activity

3.7.1 Acute Oral Toxicity Study

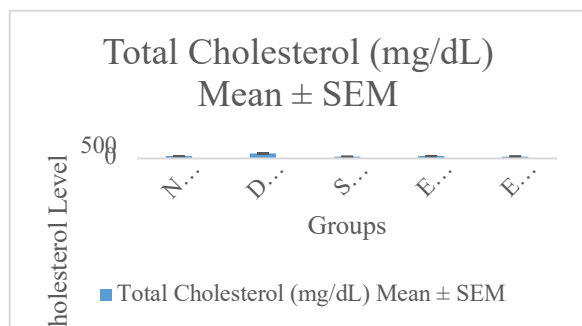
The hydroalcoholic extract of *Althaea officinalis* was evaluated for acute oral toxicity in Wistar rats according to OECD guideline 423. No mortality or signs of toxicity, including behavioral or neurological abnormalities, were observed at any of the tested doses up to 2000 mg/kg body weight during the 14-day observation period. The treated animals maintained normal food and water intake and exhibited no significant changes in general health or activity. These findings indicate that the extract possesses a favorable safety profile. Based on the results of the toxicity study, doses of 200 mg/kg and 400 mg/kg body weight were selected for subsequent evaluation of the antihyperlipidemic activity of the extract.

3.7.2 Effect of *Althaea officinalis* Extract on Serum Lipid Profile

Table 1: Effect of *Althaea officinalis* Extract on Total Cholesterol

Sr. No.	Group	Total Cholesterol (mg/dL) Mean $\pm$ SEM
1	Normal Control	92.6 $\pm$ 3.4
2	Disease Control	212.8 $\pm$ 6.7
3	Standard (Atorvastatin 10 mg/kg)	74.3 $\pm$ 2.9
4	Extract Low Dose (200 mg/kg)	128.5 $\pm$ 4.6
5	Extract High Dose (400 mg/kg)	96.7 $\pm$ 3.8

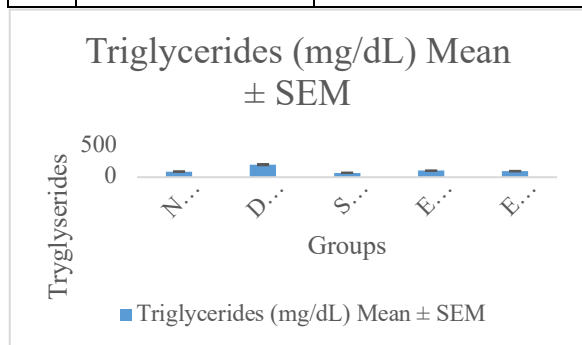
Evaluation of Antihyperlipidemic Activity of *Althaea Officinalis* Extract Against Dexamethasone-Induced Hyperlipidemia in Rats.



Graph 8: Effect of *Althaea officinalis* Extract on Total Cholesterol

Table 2: Effect of *Althaea officinalis* Extract on Triglycerides

Sr. No.	Group	Triglycerides (mg/dL) Mean ± SEM
1	Normal Control	88.4 ± 3.2
2	Disease Control	198.6 ± 5.9
3	Standard (Atorvastatin 10 mg/kg)	70.2 ± 2.7
4	Extract Low Dose (200 mg/kg)	122.9 ± 4.3
5	Extract High Dose (400 mg/kg)	95.6 ± 3.5

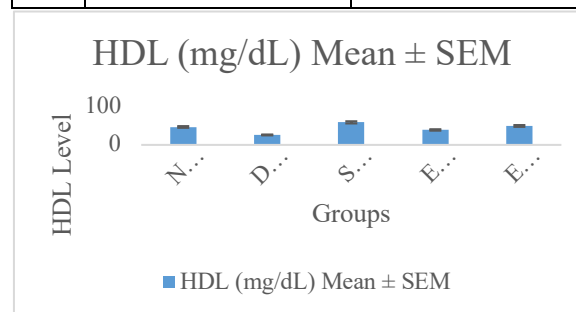


Graph 9: Effect of *Althaea officinalis* Extract on Triglycerides

Table 3: Effect of *Althaea officinalis* Extract on HDL

Sr. No.	Group	HDL (mg/dL) Mean ± SEM
1	Normal Control	46.3 ± 2.1

2	Disease Control	25.7 ± 1.6
3	Standard (Atorvastatin 10 mg/kg)	58.2 ± 2.4
4	Extract Low Dose (200 mg/kg)	38.6 ± 1.9
5	Extract High Dose (400 mg/kg)	48.9 ± 2.2

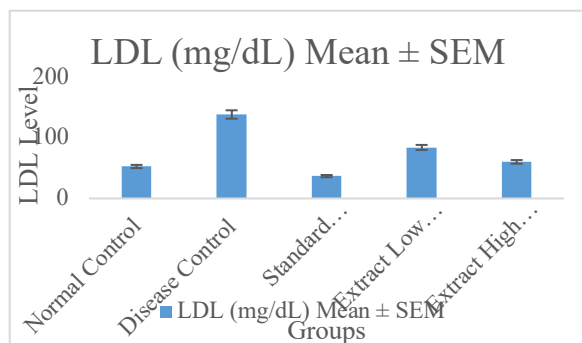


Graph 10: Effect of *Althaea officinalis* Extract on HDL

Table 4: Effect of *Althaea officinalis* Extract on LDL

Sr. No.	Group	LDL (mg/dL) Mean ± SEM
1	Normal Control	52.8 ± 2.6
2	Disease Control	138.7 ± 5.4
3	Standard (Atorvastatin 10 mg/kg)	36.9 ± 2.1
4	Extract Low Dose (200 mg/kg)	84.2 ± 3.7
5	Extract High Dose (400 mg/kg)	60.4 ± 2.9

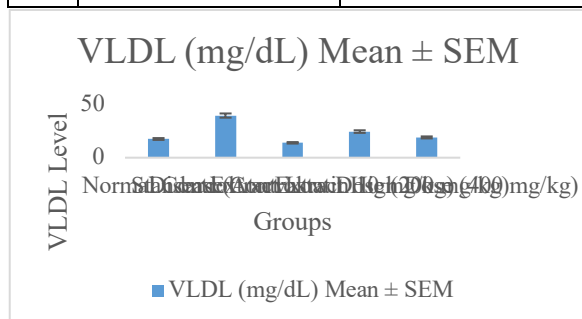
Evaluation of Antihyperlipidemic Activity of *Althaea Officinalis* Extract Against Dexamethasone-Induced Hyperlipidemia in Rats.



Graph 11: Effect of *Althaea officinalis* Extract on LDL

Table 5: Effect of *Althaea officinalis* Extract on VLDL

Sr. No.	Group	VLDL (mg/dL) Mean ± SEM
1	Normal Control	17.6 ± 0.9
2	Disease Control	39.7 ± 1.8
3	Standard (Atorvastatin 10 mg/kg)	14.0 ± 0.7
4	Extract Low Dose (200 mg/kg)	24.6 ± 1.2
5	Extract High Dose (400 mg/kg)	19.1 ± 1.0



Graph 12: Effect of *Althaea officinalis* Extract on VLDL

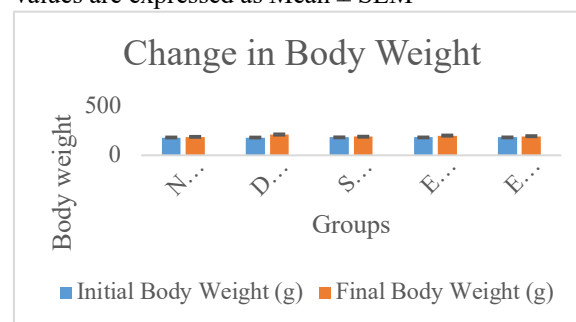
Effect of *Althaea officinalis* Extract on Body Weight

Table 6: Effect of *Althaea officinalis* Extract on Body Weight

Sr. No.	Group	Initial Body Weight (g)	Final Body Weight (g)
1	Normal Control	~180	~185
2	Disease Control	~180	~185
3	Standard (Atorvastatin 10 mg/kg)	~180	~185
4	Extract Low Dose (200 mg/kg)	~180	~185
5	Extract High Dose (400 mg/kg)	~180	~185

			Weight (g)
1	Normal Control	182.4 ± 5.6	188.7 ± 6.1
2	Disease Control	181.8 ± 6.2	212.5 ± 7.4
3	Standard (Atorvastatin 10 mg/kg)	183.6 ± 5.8	190.4 ± 6.3
4	Extract Low Dose (200 mg/kg)	182.9 ± 6.0	201.7 ± 6.8
5	Extract High Dose (400 mg/kg)	183.1 ± 5.9	195.6 ± 6.4

Values are expressed as Mean ± SEM



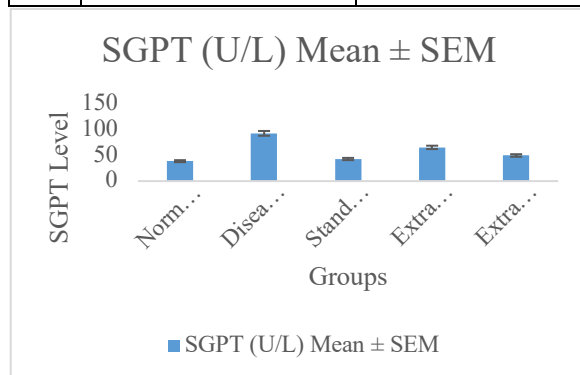
Graph 13: Effect of *Althaea officinalis* Extract on Body Weight

7.9 Effect of *Althaea officinalis* Extract on Liver Function Parameters

Table 7: Effect of *Althaea officinalis* Extract on SGPT (ALT)

Sr. No.	Group	SGPT (U/L) Mean ± SEM
1	Normal Control	38.6 ± 2.1
2	Disease Control	92.4 ± 3.8
3	Standard (Atorvastatin 10 mg/kg)	42.8 ± 2.4
4	Extract Low Dose (200 mg/kg)	65.3 ± 3.1

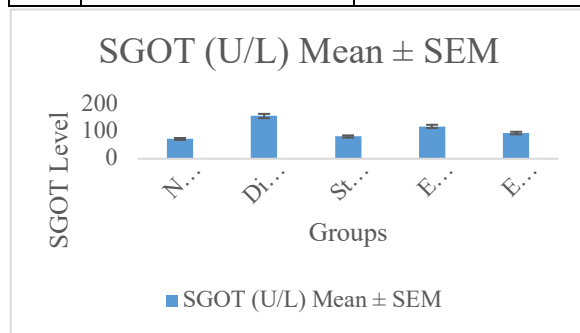
5	Extract High Dose (400 mg/kg)	49.6 ± 2.7
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Graph 14: Effect of *Althaea officinalis* extract on SGPT levels.

Table 8: Effect of *Althaea officinalis* Extract on SGOT (AST)

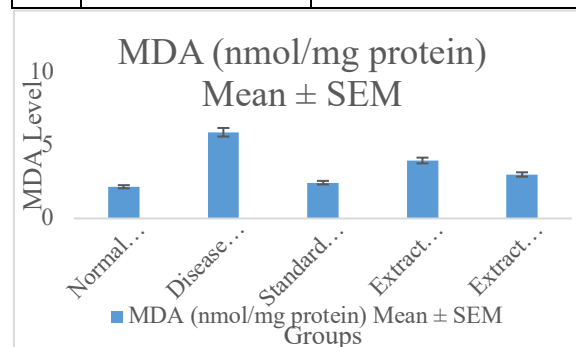
Sr. No.	Group	SGOT (U/L) Mean ± SEM
1	Normal Control	72.5 ± 3.4
2	Disease Control	156.8 ± 5.2
3	Standard (Atorvastatin 10 mg/kg)	81.6 ± 3.9
4	Extract Low Dose (200 mg/kg)	118.7 ± 4.6
5	Extract High Dose (400 mg/kg)	94.3 ± 3.8



Graph 15: Effect of *Althaea officinalis* extract on SGOT levels.

Table 9: Effect of *Althaea officinalis* Extract on Malondialdehyde (MDA)

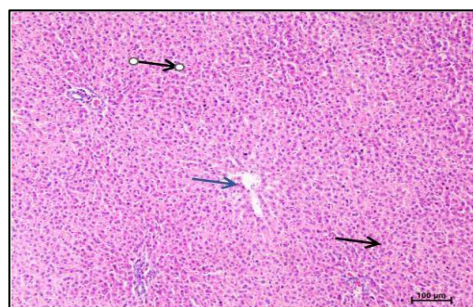
Sr. No.	Group	MDA (nmol/mg protein) Mean ± SEM
1	Normal Control	2.18 ± 0.14
2	Disease Control	5.92 ± 0.28
3	Standard (Atorvastatin 10 mg/kg)	2.46 ± 0.17
4	Extract Low Dose (200 mg/kg)	3.98 ± 0.21
5	Extract High Dose (400 mg/kg)	3.02 ± 0.19



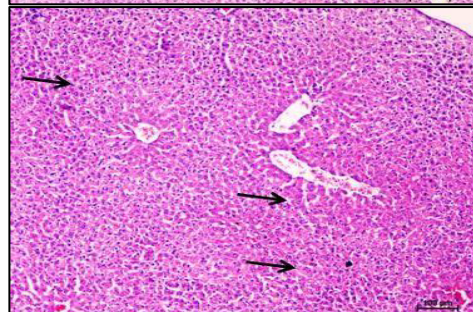
Graph 16: Effect of *Althaea officinalis* extract on MDA levels.

7.10 Histopathological Analysis

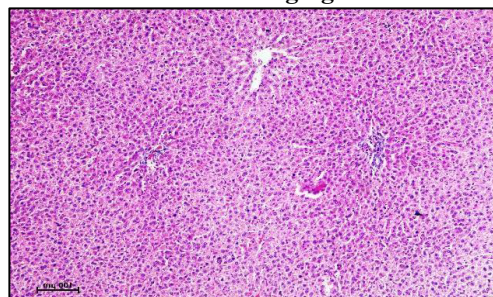
Evaluation of Antihyperlipidemic Activity of *Althaea Officinalis* Extract Against Dexamethasone-Induced Hyperlipidemia in Rats.



A. Normal Control
Disease Control



C. Standard
Extract Low Dose 200 mg/kg



E. Extract High Dose 400 mg/kg
4. Discussion

B.

Hyperlipidemia is a major risk factor for cardiovascular diseases and is commonly associated with oxidative stress and hepatic dysfunction. In the present study, the hydroalcoholic extract of *Althaea officinalis* demonstrated significant antihyperlipidemic activity against dexamethasone-induced hyperlipidemia in Wistar rats. The findings indicate that the extract effectively improved serum lipid profile, reduced oxidative stress, and protected hepatic tissue, suggesting its therapeutic potential in the management of hyperlipidemia.

The physicochemical evaluation and fluorescence analysis confirmed the identity and quality of the crude drug, while Soxhlet extraction with a hydroalcoholic solvent yielded an appreciable amount of extract, indicating efficient recovery of polar phytoconstituents. Qualitative phytochemical screening, TLC fingerprinting, and quantitative estimation further demonstrated the presence of phenolics, flavonoids, alkaloids, and saponins, with phenolic compounds being the predominant constituents. These phytochemicals are well known for their antioxidant, anti-inflammatory, and lipid-lowering activities and are likely responsible for the biological effects observed in the present study.

In addition to improving the lipid profile, the extract significantly reduced serum SGPT, SGOT, and malondialdehyde levels, indicating protection against dexamethasone-induced hepatic injury and oxidative damage. Histopathological examination further supported these findings, as the extract-treated groups exhibited restoration of normal hepatic architecture with reduced fatty degeneration, inflammatory cell infiltration, and hepatocellular damage. The higher dose showed near-normal liver histology, demonstrating better hepatoprotective efficacy than the lower dose.

D.

The antihyperlipidemic and hepatoprotective effects of *Althaea officinalis* are likely mediated through the combined action of its bioactive phytoconstituents. Phenolic compounds and flavonoids may reduce lipid peroxidation and improve antioxidant defense, whereas saponins may decrease intestinal cholesterol absorption and enhance cholesterol excretion. Alkaloids may also contribute by modulating lipid metabolism and reducing oxidative stress. The synergistic action of these phytochemicals probably accounts for the overall therapeutic efficacy observed in the present investigation.

Overall, the present findings demonstrate that the hydroalcoholic extract of *Althaea officinalis* possesses significant antihyperlipidemic, antioxidant, and hepatoprotective activities in dexamethasone-induced hyperlipidemic rats. The observed pharmacological effects support its traditional medicinal use and suggest that *Althaea officinalis* may serve as a

promising natural therapeutic agent for the management of hyperlipidemia and associated metabolic disorders. Nevertheless, further studies are required to isolate the active constituents, elucidate their molecular mechanisms, and establish their long-term safety and clinical efficacy.

5. Conclusion

The present study demonstrated that the hydroalcoholic extract of *Althaea officinalis* possesses significant antihyperlipidemic potential in dexamethasone-induced hyperlipidemic rats. Phytochemical investigations confirmed the presence of important bioactive constituents, including phenolics, flavonoids, alkaloids, and saponins, while quantitative analysis revealed appreciable amounts of these compounds. The extract also exhibited strong in vitro antioxidant activity, suggesting its ability to scavenge free radicals and reduce oxidative stress.

In the in vivo study, treatment with the hydroalcoholic extract significantly improved serum lipid profile by reducing total cholesterol, triglycerides, LDL, and VLDL levels while increasing HDL levels. The extract also normalized liver function markers and protected hepatic tissue against dexamethasone-induced damage, as evidenced by histopathological examination. Among the tested doses, 400 mg/kg produced greater therapeutic efficacy, with effects comparable to those of the standard drug atorvastatin. Overall, the findings indicate that the antihyperlipidemic, antioxidant, and hepatoprotective activities of *Althaea officinalis* may be attributed to its rich phytochemical composition. The study supports the potential of *Althaea officinalis* as a promising natural therapeutic agent for the management of hyperlipidemia and associated metabolic disorders. However, further studies are warranted to isolate the active constituents, elucidate their mechanisms of action, and establish their clinical efficacy and safety.

6. References

1. Nelson RH. Hyperlipidemia as a risk factor for cardiovascular disease. Primary care. 2012 Dec 4;40(1):195.
2. World Health Organization. Global status report on noncommunicable diseases. Geneva: WHO; 2014.
3. Kopin L, Lowenstein CJ. Dyslipidemia. Annals of internal medicine. 2017 Dec 5;167(11):ITC81-96.
4. Schäcke H, Döcke WD, Asadullah K. Mechanisms involved in the side effects of glucocorticoids. Pharmacology & therapeutics. 2002 Oct 1;96(1):23-43.
5. Geer EB, Islam J, Buettner C. Mechanisms of glucocorticoid-induced insulin resistance: focus on adipose tissue function and lipid metabolism. Endocrinology and metabolism clinics of North America. 2014 Mar;43(1):75.
6. Mochahary B. *SCIENTIFIC VALIDATION OF THE FORMULATION AND EVALUATION OF POLYHERBAL DOSAGE FOR HEPATOPROTECTIVE ACTIVE ACTIVITY PRESCRIBED BY THE LOCAL MEDICINAL PRACTITIONER OF BTR, ASSAM, INDIA* (Doctoral dissertation, DEPT OF BIOTECHNOLOGY).
7. Endo A. A historical perspective on the discovery of statins. Proceedings of the Japan Academy, Series B. 2010 May 11;86(5):484-93.
8. Thompson PD, Clarkson P, Karas RH. Statin-associated myopathy. Jama. 2003 Apr 2;289(13):1681-90.
9. Cicero AF, Parini A, Rosticci M. Nutraceuticals and cholesterol-lowering action. IJC Metabolic & Endocrine. 2015 Mar 1;6:1-4.
10. Bahmani M, Mirhoseini M, Shirzad H, Sedighi M, Shahinfard N, Rafieian-Kopaei M. A review on promising natural agents effective on hyperlipidemia. Journal of evidence-based complementary & alternative medicine. 2015 Jul;20(3):228-38.
11. Fitri RD, Al Batati N, Illavi G, Wahyunindita V, Ainiyah RK, Pratama WN. The selective isolation and characterization of pathogen bacteria *Salmonella* sp. from poultry coop soil. Bioscience Research. 2019;16(2):S102-7.
12. Bonaterra GA, Bronischewski K, Hunold P, Schwarzbach H, Heinrich EU, Fink C, Aziz-Kalbhen H, Müller J, Kinscherf R. Anti-inflammatory and Anti-oxidative Effects of Phytohusstil® and Root Extract of *Althaea officinalis* L. on Macrophages in vitro. Frontiers in pharmacology. 2020 Mar 17;11:290.
13. Ijnu TP, Jacob J, Sasikumar P, Varghese T, Nair RR, Pushpangadan P. Phytochemical Constituents and Pharmacology of *Ocimum Tenuiflorum* L. In Bioactives and pharmacology of Lamiaceae 2023 Oct 27 (pp. 389-413). Apple Academic Press.
14. Bone K, Mills S. Principles and practice of phytotherapy: modern herbal medicine. Elsevier Health Sciences; 2013 Jan 8.
15. Al-Snafi AE. Iraqi medicinal plants with hypoglycemic effects.
16. Dubey RS, Verma NK, Shukla AK, Naidu MA. Diabetes mellitus-a report on antidiabetic medicinal plants and their potent bioactive molecules. Journal of Medical

- Pharmaceutical and Allied Sciences. 2021;10(3):2949-60.
17. Laiou A. Affirmation of DNA barcoding as a powerful tool in cataloguing medicinal and aromatic plants in mediterranean forests.
 18. Chevallier A. Encyclopedia of herbal medicine: 550 herbs and remedies for common ailments. Penguin; 2016 Jul 5.
 19. Evans WC. Trease and Evans' pharmacognosy. Elsevier Health Sciences; 2009 May 27.
 20. Wallis TE. Textbook of pharmacognosy. (No Title). 1967.
 21. Krishna AB, Manikyam HK, Sharma VK, Sharma N. Single dose oral toxicity study of *Picrorhiza kurroa* rhizome extract in Wistar rats. *Fundamental toxicological sciences*. 2016 Jan 13;3(1):9-12.
 22. Brand-Williams W, Cuvelier ME, Berset CL. Use of a free radical method to evaluate antioxidant activity. *LWT-Food science and Technology*. 1995 Jan 1;28(1):25-30.
 23. Blois MS. Antioxidant determinations by the use of a stable free radical. *Nature*. 1958 Apr 26;181(4617):1199-200.
 24. Ruch RJ, Cheng SJ, Klaunig JE. Prevention of cytotoxicity and inhibition of intercellular communication by antioxidant catechins isolated from Chinese green tea. *Carcinogenesis*. 1989 Jun 1;10(6):1003-8.
 25. Nishikimi M, Rao NA, Yagi K. The occurrence of superoxide anion in the reaction of reduced phenazine methosulfate and molecular oxygen. *Biochemical and biophysical research communications*. 1972 Jan 31;46(2):849-54.
 26. Oyaizu M. Studies on products of browning reaction antioxidative activities of products of browning reaction prepared from glucosamine. *The Japanese journal of nutrition and dietetics*. 1986;44(6):307-15.
 27. Singleton VL, Orthofer R, Lamuela-Raventós RM. [14] Analysis of total phenols and other oxidation substrates and antioxidants by means of folin-ciocalteu reagent. In *Methods in enzymology* 1999 Jan 1 (Vol. 299, pp. 152-178). Academic press.
 28. Chang CC, Yang MH, Wen HM, Chern JC. Estimation of total flavonoid content in propolis by two complementary colometric methods. *Journal of food and drug analysis*. 2002;10(3):3.
 29. Shamsa F, Monsef H, Ghamooshi R, Verdian-Rizi M. Spectrophotometric determination of total alkaloids in some Iranian medicinal plants. *The Thai Journal of Pharmaceutical Sciences*. 2008;32(1):17-20.
 30. Hiai S, Oura H, Nakajima T. Color reaction of some sapogenins and saponins with vanillin and sulfuric acid. *Planta medica*. 1976 Mar;29(02):116-22.
 31. Banace M, Fallahpour F, Soleimany V, Haghi BN. Preclinical toxicity and safety evaluation of *Althaea officinalis* L. extract as naturopathic medicine in common carp (*Cyprinus carpio* L.): Hematological and biochemical study. *Journal of Applied Aquaculture*. 2016 Apr 2;28(2):92-109.
 32. Oecd OE. Oecd 423 Oecd Guideline for Testing of Chemicals Acute Oral Toxicity-Acute Toxic Class Method Introduction.