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An *in vivo* Evaluation of Antihyperlipidaemic Activity of Ethanolic Extract of *Amaranthus spinosus* Leaves on Dexamethasone Induced Hyperlipidaemic Rats

Raphael Dzinyela[1], Emmanuel Kwesi Asomaning[2], Abdul-Nasir Abdul-Baasit[3], Abdul Razak Alhassan[1], Ali Movahedi[1, *]

[1]College of Biology and the Environment, Co-Innovation Center for Sustainable Forestry in Southern China, Key Laboratory of Forest Genetics & Biotechnology, Ministry of Education, Nanjing Forestry University, Nanjing, China

[2]Department of Clinical Laboratory, Health Square Medical Center, Accra, Ghana

[3]Department of Molecular Biology and Genetics, Mugla Sıtkı Kocman University, Mugla, Turkey

Email address:

dzinyelar@gmail.com (R. Dzinyela), kuecyasomaning@live.com (E. K. Asomaning), abdulbaasit17@yahoo.com (Abdul-Nasir Abdul-Baasit), nanakwame3356@gmail.com (A. R. Alhassan), ali_movahedi@njfu.edu.cn (A. Movahedi)

[*]Corresponding author

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Abstract: Natural products derived from plants play a vital part in preventing or treating various diseases or disorders in humans. Hyperlipidemia is one of the main pathological features of diseases affecting the circulatory system and diabetes mellitus. Presently available lipid-lowering drugs have been linked with some side effects. Herbal treatment for hyperlipidaemia has significantly fewer or no side effects and is reasonably inexpensive and locally accessible. *Amaranthus spinosus* belongs to the family *Amaranthaceae* is well known by many researchers for its various medicinal properties and is also known as "pigweed." The present study sought to assess the antihyperlipidaemic activity of the leaf extract by in vivo animal models. Here, acute hyperlipidemia was induced by intraperitoneal administration of dexamethasone (10 $mgkg^{-1}$). The ethanol extract of *A. spinosus* leaf (EEASL) was administered daily at single doses of 250 and 500 mgkg-1, to dexamethasone-induced hyperlipidaemic rats for 8 days. The effect of EEASL on serum lipid profiles (total cholesterol, triglycerides low-density, very low-density, and high-density lipoprotein) were determined. EEASL was established to significantly decrease total serum cholesterol, triglycerides, low-density lipoprotein, Very low-density lipoprotein, and increased serum high-density lipoprotein compared to the hyperlipidaemic and vehicle only control models. The activities were also paralleled to the outcome exhibited by a standard antihyperlipidaemic agent, atorvastatin. The present investigation established pharmacological evidence to support the claim that EEASL contains active antihyperlipidaemic agents.

Keywords: *Antihyperlipidaemic*, *Amaranthus spinosus*, *in vivo*, Lipid Profile, Atorvastatin, Dexamethasone

1. Introduction

Hyperlipidaemia, a condition where abnormally high levels of lipids are found in the blood. It is deemed a metabolic disorder arising from particular alterations occurring in serum lipid and lipoprotein profile owing to augmented concentrations of Total Cholesterol (T. C.), Low-Density Lipoprotein Cholesterol (LDL-C), Very low-density lipoprotein cholesterol (VLDL-C), and triglycerides (T. G.) with a simultaneous reduction in the concentrations of High-Density Lipoprotein Cholesterol (HDL-C) in blood circulation [1].

Lipids are necessary for the normal functioning of a system. They cushion vital organs in the body and also insulates the body. They move in the bloodstream as

cholesterol and triglycerides; as cholesterol, they are involved in the structure and role of cells, and as triglycerides, they are preeminently regarded as the energy that is either utilized instantaneously or stored in fat cells [2]. However, excessive amounts of lipids in the blood bring about hyperlipidaemia. This condition can be categorized into two, cantred on the main cause or origin, these are; familial or primary hyperlipidaemia, which is caused by genetic abnormalities, and acquired or secondary hyperlipidaemia, which is also associated with other underlying disorders such as diabetes, chronic alcoholism, the use of drugs such as; oral contraceptives, diuretics, beta-blockers, etc. [2]. Despite the above classification, one major cause of hyperlipidaemia is an unhealthy lifestyle that encompasses a high-fat diet and alcohol intake. Hyperlipidemia has been rated as one of the paramount risk factors backing the frequency and sternness of coronary heart diseases. World Health Organization reports that high blood cholesterol contributes to just about 56% of cases of cardiovascular diseases globally and causes roughly 4.4 million demises each year [1]. Evaluation of plant products to treat hyperlipidaemia is of growing interest as their phytochemical studies show many bioactive substances with therapeutic potentials. Several authors have reported the antihyperlipidaemic potential of conventionally used therapeutic plants using experimental animals in recent years. From the emergence of advancement, medicinal plants have aided humans in the quest to combat diseases. The availability of these plants and their efficiency have made them an essential tool in disease treatment despite the modern development of sophisticated pharmaceutical chemicals [3].

Amaranthus spinosus, commonly known as pigweed or spiny amaranth, is an erect spinous annual or perennial herb varying in color from green to purple, up to 1m, and belongs to the family *Amaranthaceae*. It is disseminated all over Asia's warm and temperate regions, the Pacific islands, intrinsic to tropical America and Australia as a weed. It is a common weed of waste places, waysides, and near rivers in Ghana. The plant has a protracted past of usage in traditional medicine against various ailments worldwide, with recent phytochemical analysis proving that. Studies carried out on this herb prove that it has a broad spectrum of pharmacological actions, including antidiabetic, analgesic, antitumor, antimicrobial, anti-inflammatory, spermatogenic, antimalarial properties, etc. Many researchers have known the herb to be rich in alkaloids, flavonoids, glycosides, phenolic acids, steroids, amino acids, terpenoids, rutin, catechuic tannins, saponins, betalains, linoleic acids, lipids, carotenoids, and others. If not all, some of these metabolites fortify the herb to perform the aforementioned pharmacological actions [3]. Day in day out, individuals live certain lifestyles that threaten their health or keep them healthy; Hyperlipidaemia majorly arises from confident lifestyle choices an individual makes, such as excessive consumption of alcohol, unbalanced diet, lack of regular exercise, etc. Hyperlipidaemia poses a pivotal danger to the health of individuals. Although many efficacious lipid-lowering synthetic drugs exist, none is effective for all lipoprotein disorders, and all such agents are allied with some level of adverse effects [4]. Hence, there is the need to research natural sources majorly from less toxic plants, less expensive, and provide safety and efficacy over a prolonged usage [4]. Lately, much preference has been given to herbal medicine than synthetic drugs, with some basic reasons being its affordability and availability; extracts of some specific plants can be used to lower the blood serum lipid levels, with recent studies indicating *A. spinosus* as potential medicinal plants [2]. The study seeks to delve into the content of the extract of *A. spinosus* leaves, their part in lowering blood lipids after being administered to dexamethasone-induced hyperlipidaemic experimental rats, and also their toxicity in the rats. The results of this study if positive will enable conclusions to be made on the potential of the plant and also exploit this potential as a source of active antihyperlipidaemic agents. We determined the phytochemicals present, the lethal and therapeutic doses of the extract of the leaves of *A. spinosus.* We evaluated the effect of *A. spinosus* leaf extract on some biochemical parameters in the serum of the adult albino rats. Assessment of the efficacy of the extract to the standard synthetic drug (Atorvastatin) was also performed.

2. Materials and Methods

2.1. Equipment and Apparatus Used

Beakers, syringes, gel vacuum tubes, funnel, gauze, stirrer, volumetric flasks, filter paper, test tubes, mortar pestles, falcon tubes, OHAUS electronic balance, EYELA pre-freezer and rotary evaporator, NORD refrigerator, Heto power dry freeze dryer, ROYAL- M. E. K. U. K. centrifuge,

2.2. Reagents, Chemicals and Drugs Used

Distilled water, ferric chloride, Chem lab absolute ethanol 100%, Lipitor atorvastatin calcium tablets, Dexamethasone sodium phosphate injection, magnesium ribbon, hydrochloric acid, bench ammonium solution, acetic anhydride, chloroform, sulphuric acid, acetone, Fehling's solutions A and B. All reagents were of laboratory grade.

2.3. Animals

Rats of both sexes aged 12weeks belonging to the Wistar strain, weighing nearly 170 to 260 g, were utilized for the study. The rats were accommodated under standard laboratory conditions of light, temperature, and humidity and acclimatized to the conditions where the study was carried for a period. Standard pellets rat feed was used as a basal intake throughout the experimental period. The control and experimental rats were fed food and drinking water *ad libitum*.

2.4. Sampling and Authentication of Plant Material

Fresh leaves of *Amaranthus spinosus* were collected from

Achimota in the Greater-Accra Region, Ghana. The leaves collected were authenticated by the Centre for Plant Medicine Research.

2.5. Preparation of Plant Extract

The fresh leaves collected were washed and dried at room temperature away from sunlight for a week. The dried mass was then pulverized and sieved to obtain excellent particles to facilitate complete extraction. Next, 300g of the sieved mass was weighed and transferred into a clear plastic container. The sample was extracted by cold maceration using 70% ethanol which was prepared by diluting the absolute ethanol with a corresponding volume of distilled water. The sample evenly distributed in the solvent by occasional stirring was leftover 72 hours, followed by filtration, rotary evaporation, and freeze-drying to obtain a dry mass of the sample [5].

2.6. Qualitative Phytochemical Screening

Phytochemical screening of the ethanolic extract of *A. spinous* was carried out qualitatively to ascertain the presence of certain phytochemicals using standard procedures described by [6-8]. Phytochemicals tested included; saponins, reducing sugars, flavonoids, phenolics, polyuronides, alkaloids, anthocyanosides, triterpenoids, phytosterols, and cyanogenic glycosides.

2.6.1. Phenolics

Five percent Ferric chloride ($FeCl_3$) was added to 2ml of the *A. spinosus* leaf extract. Blue-black or dark green coloration indicated the presence of phenolics.

2.6.2. Polyuronides

Acetone was added to the sample. The formation of precipitate sticking along the walls of test tubes showed the presence of polyuronides.

2.6.3. Saponins

About 2ml of the *A. spinosus* leaf extract was mixed with 5ml of distilled water in a test tube. The mixture was well shaken and observed for 15mins. The persistence of froth (foam) indicated a positive result for saponins.

2.6.4. Phytosterols

The ethyl ether extract was evaporated to dryness. Next, chloroform was added (divided into two for control). Next, acetic anhydride was added, followed by the addition of H_2SO_4 concentration. The formation of a green color ring indicated the presence of phytosterols.

2.6.5. Cyanogenic Glycoside

Chloroform was added to the sample and heated; vapor was exposed to picric paper. Pink coloration of picric paper showed the presence of cyanogenic glycoside.

2.6.6. Anthocyanosides

Ethyl ether extract + 25% ammonium solution (Borntrager's test). The formation of red coloration indicated the presence of anthocyanosides.

2.6.7. Reducing Sugars

Freshly prepared Fehling's solution A and B was added to the sample and heated for 15mins. The formation of a brick-red precipitate indicated the presence of reducing sugars.

2.6.8. Triterpenes

The ethyl ether extract was evaporated to dryness. Next, chloroform was added (divided into two for control). Next, acetic anhydride was added, followed by the addition of H_2SO_4 concentration. The formation of brownish-red or violet rings indicated the presence of triterpenes.

2.6.9. Alkaloids

Twenty-five percent NH_4OH was added to the extract to basify it. Chloroform has then added to the sample in the separatory funnel, well agitated, and chloroform layer was collected and dissolved with 2N HCl and followed by the addition of Mayer's reagent. The formation of a milky white or yellow precipitate indicated the presence of alkaloids.

2.6.10. Flavonoids

Ethyl ether extract evaporated to dryness + methanol (divided into two for control, add magnesium ribbon followed by HCl concentration). The formation of red or orange coloration showed the presence of flavonoids.

2.7. Acute Oral Toxicity Studies

This study was undertaken to certify the lethal dose of the extract. A selected few of the animals were used for this study. It was conducted based on the guidelines of the Organization of Economic Cooperation and Development (OECD). The animals were grouped into three, with each group containing two rats. The animals in Groups 1, 2, and 3 were administered 1000, 3000, and 5000 $mgkg^{-1}$ of *A. spinosus* leaf extract, respectively, and observed for 72 hours [9].

Table 1. *Grouping of animals for pharmacological screening.*

Details	**Group a**	**Group b**	**Group c**	**Group d**	**Group e**
Group title	**Normal control**	**Negative control**	**Positive control**	**Test group i**	**Test group ii**
Number of animals	6	6	6	6	6
Treatment	Normal saline	10 $mgkg^1day^{-1}$ of dexamethasone for 8 days	10 $mgkg^1day^{-1}$ of Atorvastatin along with dexamethasone treatment	*A. spinosus* ethanolic extract (250 $mgkg^1day^{-1}$) with dexamethasone treatment	*A. spinosus* ethanolic extract (500 $mgkg^1day^{-1}$) with dexamethasone treatment

2.8. Design of the Experiment

Thirty rats were grouped in five containing six members each. Group A, which served as a standard control, received saline alone. Group B was treated with Atorvastatin (10 $mgkg^{-1}$) and dexamethasone treatment and served as a positive control. Groups C were administered only dexamethasone treatment and served as a hyperlipidaemic or negative control. Groups D and E were treated with high (500 $mgkg^{-1}$) and low (250 $mgkg^{-1}$) doses of ethanolic extracts of the *A. spinosus* leaves respectively for the entire eight days along with the dexamethasone treatment. The baseline readings, which involved body weights and blood serum lipid levels, were taken before the commencement of the study [10]. Table 1 is a tabular representation of the grouping of the experimental animals.

2.9. Body Weight Measurement and Lipid Profiling

Blood and body weight was taken on the first and ninth day of the study through tail bleeding. The animals were kept under fasting condition overnight before the collection of the blood. The collected blood was kept in heparinized vacuum tubes. The blood was allowed to clot for 2 hours and later centrifuged at 3000rpm for 5mins, after which serum was collected for analysis. The total cholesterol, high-density lipoprotein, low-density lipoprotein, very low-density lipoprotein, and triglyceride were acquired using Uri semi-automated chemistry analyzer (URIT-810 chemical analyzer) [11].

2.10. Statistical Analysis

All values were expressed as Mean ± Standard Error of Mean (Mean ± S. E. M.). Data were analyzed by one-way analysis of variance (ANOVA) using Graph Pad Prism software for Windows. A P value < 0.05 was considered statistically significant.

3. Results

3.1. Yield of Plant Material

Three hundred grams of the powdered sample macerated in 2100ml of ethanol and 900ml of distilled water yielded a mass of 48.7g of pure extract, representing a percentage yield of 16.23% (Table 2).

Table 2. *Percentage yield of Amaranthus spinosus.*

Plant sample	Solvent	Mass of Dry powder (g)	Solvent (ml)	Mass of extract (g)	Percentage yield
Amaranthus spinous	Ethanol 70%	300	2100	48.7	16.23

3.2. Qualitative Phytochemical Screening

The phytochemical screening of ethanolic extract of *A. spinosus* leaves (EEASL) is illustrated in the Table 3 below. The results from the phytochemical analysis were similar to results obtained in studies undertaken by Girija and Lakshman [12].

Table 3. *Indicates the result of phytochemical screening of EEASL.*

S. No.	Phytoconstituents	*Amaranthus spinosus* leaves
1	Saponins	+
2	Flavonoids	+
3	Phenolic compounds	+
4	Alkaloids	+
5	Cyanogenic glycosides	-
6	Anthocyanosides	+
7	Phytosterols	+
8	Reducing sugars	+
9	Polyuronides	+
10	Triterpenes	-

KEY: (+) =present, (-) =absent.

3.3. Acute Oral Toxicity Studies

The high doses of extract given to the three groups of rats showed no signs and symptoms of distress, coma, or death within 72 hours. The animals were further observed for the next eight days, and they still showed no adverse symptoms as they usually responded to food and water and experienced no impairment in their breathing. It was then concluded that the absence of death and any adverse symptoms at doses up to 5000 mg kg^{-1} indicated that the LD_{50} of *A. spinosus* is greater than 5000 $mgkg^{-1}$. $1/10^{th}$ and $1/20^{th}$ portions of the 5000 $mgkg^{1}$ were taken to represent high and low doses of the extract for administration.

3.4. Effect of Amaranthus Spinosus Leaf Extract on Biochemical Parameters in Serum

The effect of *A. spinosus* leaf extract on biochemical parameters in the serum of 10 $mgkg^{-1}$ dexamethasone-induced Wistar rats is illustrated in Tables 4 and 5 below, with the former showing the baseline lipid profiling results and the latter indicating lipid profile results after termination. Blood samples were collected from four randomly selected

rats in each group and analyzed for T. C., T. G., HDL-C, LDL-C, and VLDL-C. The values of blood serum lipid levels are given in mean ± S. E. M.

Table 4. *Results for baseline lipid profile.*

GROUP	TREATMENT	TC mmol/L	T. G. mmol/L	HDL-C mmol/L	LDL-C mmol/L	VLDL-C mmol/L
A	Normal control	3.108 ±0.175	1.845 ±0.097	1.067 ±0.117	1.442 ±0.236	1.393 ±0.255
B	Negative control Dexamethasone (10mgkg^{-1})	3.528 ±0.146	1.947 ±0.038	1.060 ±0.121	1.217 ±0.084	1.530 ±0.162
C	Positive control Atorvastatin (10 mgkg^{-1})	3.118 ±0.290	1.857 ±0.095	1.253 ±0.144	1.550 ±0.235	1.628 ±0.147
D	*EEASL* (250 mgkg^{-1})	3.642 ±0.117	2.168 ±0.060	1.043 ±0.112	1.447 ±0.131	1.587 ±0.091
E	*EEASL* (500 mgkg^{-1})	3.485 ±0.128	1.975 ±0.052	1.197 ±0.017	1.580 ±0.312	1.590 ±0.060

Values are represented in mean ± S. E. M. (n=4)
EEASL denotes Ethanolic Extract of *A. spinosus* Leaves.

Table 5. *Results for lipid profile results after termination.*

GROUP	TREATMENT/DOSE	TC mmol/L	T. G. mmol/L	HDL-C mmol/L	LDL-C mmol/L	VLDL-C mmol/L
A	Normal control	2.673 ±0.120***	1.763 ±0.111***	1.360 ±0.054*	1.225 ±0.101**	1.357 ±0.248*
B	Negative control Dexamethasone (10 mgkg^{-1})	6.217 ±0.171	4.485 ±0.200	0.365 ±0.086	4.722 ±0.169	3.223 ±0.060
C	Positive control Atorvastatin (10 mgkg^{-1})	1.273 ±0.031*** (59.17%) ↓	0.762 ±0.127*** (58.96%) ↓	2.027 ±0.091*** (61.45%) ↑	0.605 ±0.071*** (74.83%) ↓	0.560 ±0.077*** (65.60%) ↓
D	*EEASL* (250 mgkg^{-1})	2.270 ±0.058 *** (37.67%) ↓	1.730 ±0.039*** (20.23%) ↓	1.885 ±0.081*** (80.72%) ↑	1.210 ±0.030*** (23.41%) ↓	0.945 ±0.092*** (40.45%) ↓
E	*EEASL* (500 mgkg^{-1})	1.862 ±0.030*** (46.57%) ↓	1.125 ±0.043*** (43.03%) ↓	2.278 ±0.062*** (90.30%) ↑	0.743 ±0.121*** (52.97%) ↓	0.837 ±0.046*** (47.35%) ↓

Values represent mean ± S. E. M. (n=4), ***Values meaningfully dissimilar from Negative control; P< 0.001, **Values meaningfully dissimilar from Negative control; P< 0.01, *Values meaningfully dissimilar from Negative control; P< 0.05, Values in parentheses indicates percentage increase or decrease in the respective serum level, ↑ denotes increase, ↓ denotes decrease, EEASL denotes ethanolic extract of *A. spinosus* leaves.

3.4.1. Effect on Total Cholesterol (T. C.)

Estimation of serum total cholesterol was done for all animals before and after induction and treatment. This increased T. C. levels in hyperlipidaemic control models (Group B) from (3.528 ±0.146 to 6.21 ±0.171 mmol/L). Animals treated with atorvastatin (Group C) and different doses of *EEASL* leaf extract (Groups E and D) saw a significant (P < 0.05) decrease in T. C., these reductions were represented by (1.273 ±0.031, 2.270 ±0.058 and 1.862 ±0.030) respectively with animals treated with standard drug (atorvastatin) recording the least reduction followed by the high and low doses (500 mgkg^{-1} and 250 mgkg^{-1}). Figure 1 illustrates the graphical presentation of *EEASL* on T. C.

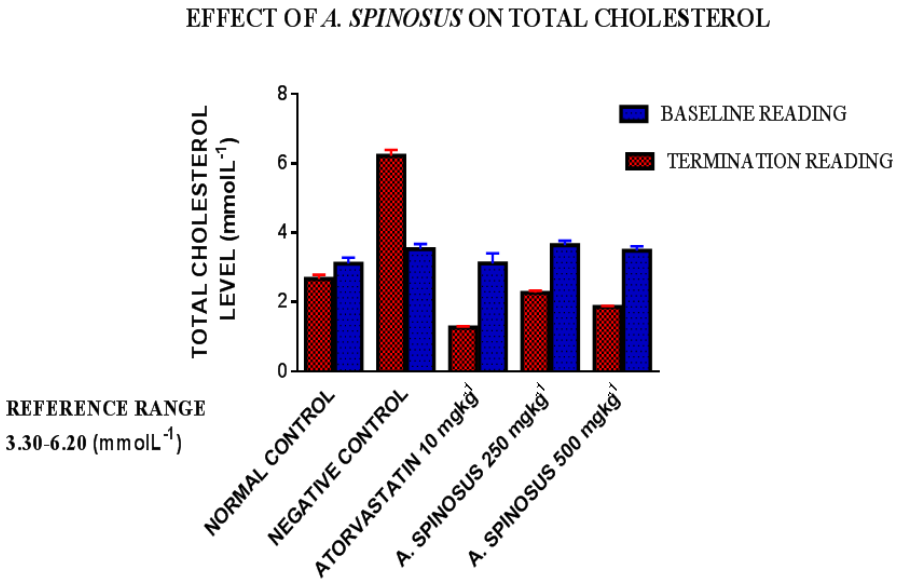

Figure 1. *Effect of EEASL on serum total cholesterol in dexamethasone-induced hyperlipidaemic rats.*

3.4.2. Effect on Triglycerides (TG)

Triglyceride levels peaked after eight days of induction in the group induced with dexamethasone but left untreated (hyperlipidaemic control) with readings of (4.485 ±0.200). Treatment groups (Groups D and E) together with the group

treated with atorvastatin (Group C) saw a decline in triglyceride levels with readings of (1.730 ±0.039, 1.125 ±0.043, and 0.762 ±0.127) respectively. Figure 2 illustrates the graphical presentation of *EEASL* on T. G.

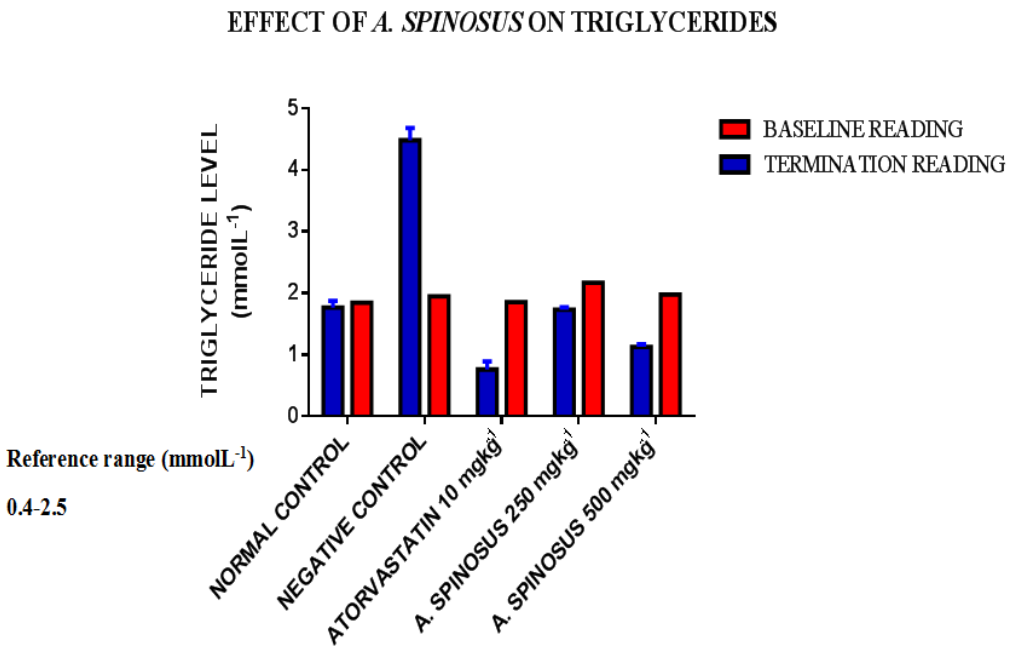

Figure 2. *Effect of EEASL on serum triglycerides in dexamethasone-induced hyperlipidaemic rats.*

3.4.3. Effect on High-Density Lipoprotein Cholesterol (HDL-C)

HDL-C increased significantly in atorvastatin treated group, Group C (2.027 ± 0.091) with the group treated with *A. spinosus* leaf extract at a dose of 250 mgkg^{-1}, Group D also recording an elevation in HDL-C (1.885 ±0.081). Group treated with EEASL at a dose of 500 mgkg^{-1} recorded the highest increment in HDL-C (2.278 ±0.062). All these elevations were compared to the negative control, which decreased HDL-C (0.365 ±0.086). Figure 3 illustrates the graphical presentation of EEASL on HDL-C.

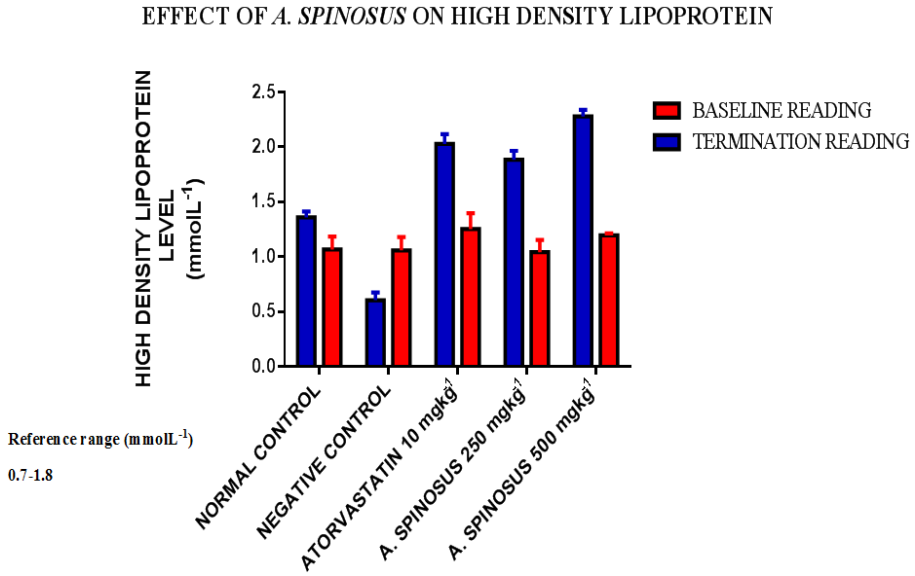

Figure 3. *Effect of EEASL on serum High-density lipoprotein cholesterol in dexamethasone-induced hyperlipidaemic rats.*

3.4.4. Effect on Low-Density Lipoprotein Cholesterol (LDL-C)

LDL-C increased at the end of the eight days in the hyperlipidaemic control at levels of (4.722 ±0.169), the normal also decreased in LDL-C at levels of (1.225 ±0.101) not as significant as those of the treatment groups. Groups C, D, and E, unlike Group B, recorded significant decreases in LDL-C at levels (0.605 ±0.071, 1.210 ±0.030, 0.743 ±0.121). Figure 4 illustrates the graphical presentation of *EEASL* on LDL-C.

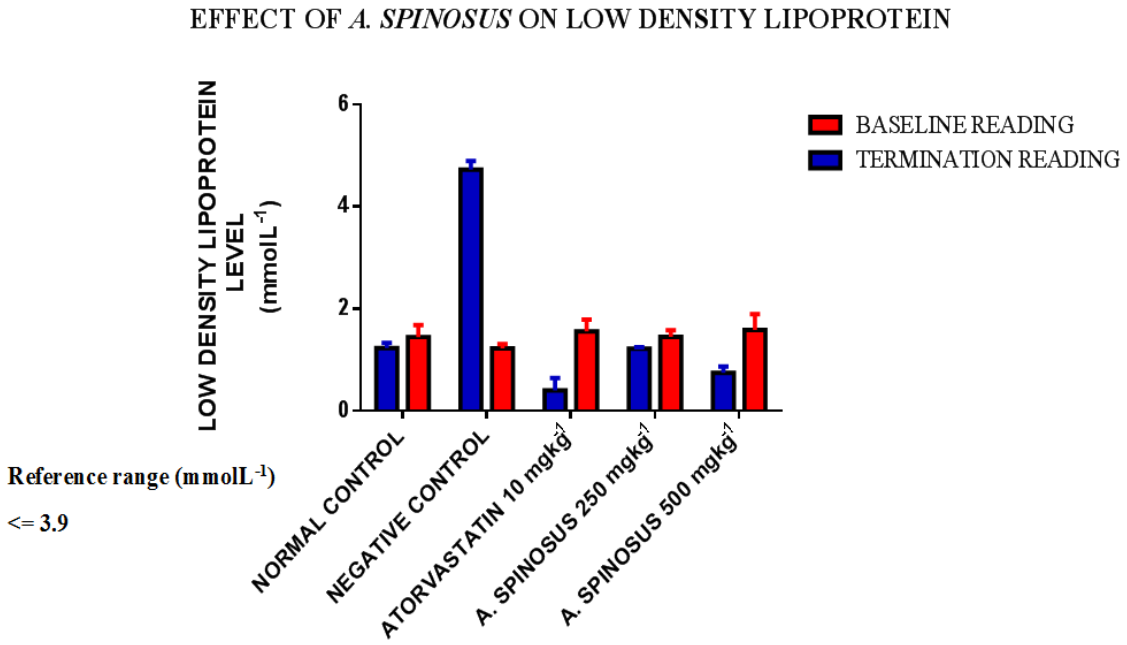

Figure 4. *Effect of EEASL on serum Low-density lipoprotein cholesterol in dexamethasone-induced hyperlipidaemic rats.*

3.4.5. Effect on Very Low-Density Lipoprotein Cholesterol (VLDL-C)

After the experimental period, VLDL-C levels of 3.223 ±0.060 showed a substantial increase in VLDL-C levels in hyperlipidaemic control following dexamethasone induction. Levels declined for treatment groups significantly, with the atorvastatin group recording the lowest at readings of 0.560 ±0.077, followed by EEASL treatment at dose 500 $mgkg^{-1}$ recording decrement at levels of 0.837 ±0.046 and treatment of EEASL at dose 250 $mgkg^{-1}$ recording its decreased VLDL-C levels at 0.945 ±0.092. Figure 5 illustrates the graphical presentation of *EEASL* on VLDL-C.

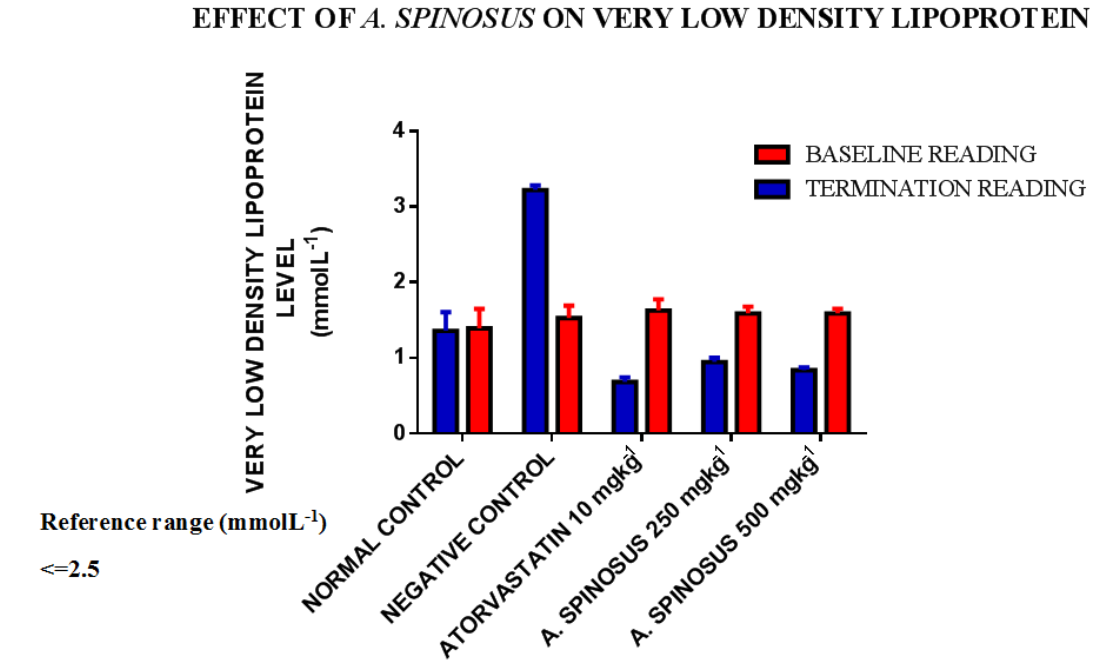

Figure 5. *Effect of EEASL on serum Very Low-density lipoprotein cholesterol in dexamethasone-induced hyperlipidaemic rats.*

3.4.6. Bodyweight Measurement

Body weights of all animals were taken before and after the experiment. The results are displayed in Table 6 below. All values are expressed in the mean ± standard error of the mean. Figure 6 also illustrates the graphical representation of the bodyweights.

Table 6. *The bodyweight measurement before and after the experimental period.*

GROUP	TREATMENT/DOSE	DAY 0	DAY 8
A	Normal control	220.667 ±8.678	246.333 ±13.144
B	Negative control Dexamethasone (10 $mgkg^{-1}$)	226.000 ±4.344	169.500 ±6.125
C	Positive control Atorvastatin (10 $mgkg^{-1}$)	218.333 ±6.070	187.667 ±8.007
D	*EEASL* (250 $mgkg^{-1}$)	226.167 ±7.761	185.500 ±2.884
E	*EEASL* (500 $mgkg^{-1}$)	216.833 ±10.190	177.667 ±6.576

Values are represented in mean ± S. E. M. (n=4)
EEASL denotes ethanolic extract of *A. spinosus* leaves.

Bodyweight slightly increased in the normal control rats compared to initial body weight, whereas in hyperlipidaemic control rats, there was a significant decrease in body weight. Groups treated with atorvastatin (500 $mgkg^{-1}$) and EEASL (250 and 500 $mgkg^{-1}$) showed a significant reduction in body weights. The final body weights of treated groups were significantly lower than the final weights of the regular control group (Table 6).

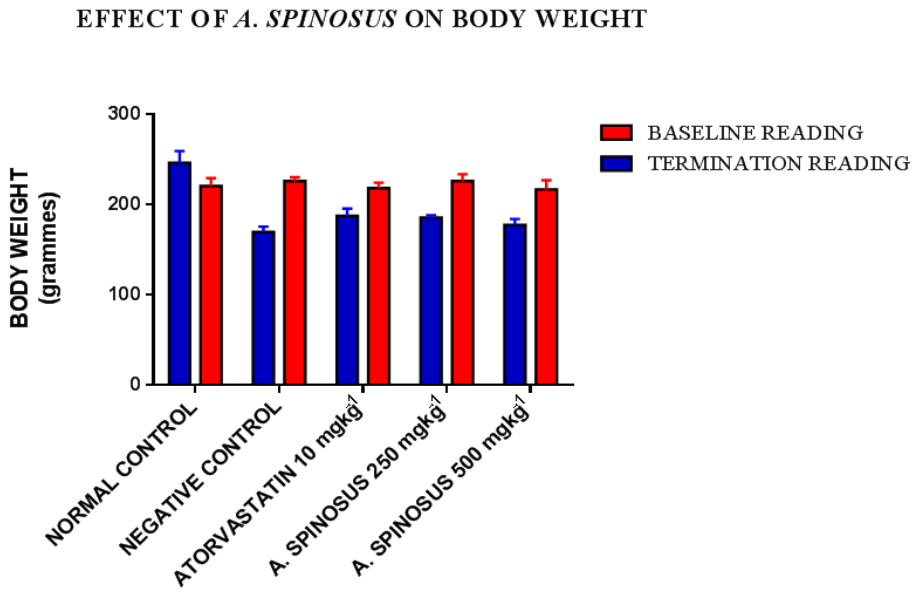

Figure 6. *Effect of EEASL on body weight of dexamethasone-induced hyperlipidaemic rats.*

4. Discussion

Hyperlipidaemia is linked with heart diseases, which are the principal cause of death in the world. The reduction of destructive lipids levels to acceptable standards has been long-established by many trial animals and interventional studies, signifying lowered morbidity and death in coronary heart diseases. More than a few studies disclose that a surge in HDL cholesterol and a decrease in total cholesterol, LDL cholesterol, and triglycerides are allied with reducing the threat of ischemic heart diseases [13]. The current study aimed to assess the antihyperlipidaemic activity of EEASL. It has been well established that nutrition plays a significant role in the etiology of hyperlipidaemia; however, the current study achieved acute hyperlipidaemia by continuous intraperitoneal injection of dexamethasone sodium phosphate, a synthetic glucocorticoid steroid known to arouse elevation of blood lipid levels [14]. The detected surge in triglycerides and cholesterol might increase hepatic lipogenesis by stimulating critical enzymes in fatty acid synthesis in the liver and increased plasma VLDL-C secretion. Dexamethasone administered to rats may have revealed decreased Lecithin cholesterol acyltransferase (LCAT) activity, while rats on co-treatment with *A. spinosus* may have maintained near normalcy in LCAT activity. There might have been a low level of lipoprotein lipase activity in the liver, an enzyme actively involved in the degradation of lipoproteins, triglycerides, and cholesterol [15]. The study confirms that all dexamethasone-induced rats exhibited hyperlipidemia as made known by their amplified levels of serum T. C., T. G., LDL, VLDL, and the reduction in the HDL level. Animals treated with different doses of EEASL showed a significant reduction in T. C., T. G., LDL, VLDL levels, and increased HDL levels doing so on a dose-dependent level. Our results were similar to Girija and Lakshman [12], who used leaf extract of the same plant to investigate the antihyperlipidaemic activity on triton WR 1339 induced hyperlipidaemic rats. A great deal of the antihyperlipidaemic drugs is causing a significant reduction in total cholesterol and increased HDL cholesterol levels, of which atorvastatin, the standard drug used, was no exception. This model is widely used for numerous different aims, particularly in rats; it has been used to screen natural or chemical hypolipidaemic drugs. Flavonoids, steroids, saponins, and anthocyanins, an assorted assembly of universal plant polyphenols, have demonstrated an assortment of

pharmacological activities, including anti hyperlipidaemia. The plant steroids decrease the uptake of cholesterol and consequently increase fecal excretion of cholesterol.

5. Conclusion

The study sought to investigate the antihyperlipidaemic activity of EEASL in dexamethasone-induced hyperlipidaemic adult albino rats of the Wistar strain. The results indicated that EEASL indeed exhibited antihyperlipidaemic property. A property characterized by the drastic decrease in specific biochemical parameters includes T. C., T. G., LDL, and VLDL and an appreciable surge in HDL. Also, the antihyperlipidaemic property of EEASL was said to have been linked to the presence of specific secondary metabolites. Phytosterols, flavonoids, saponins, reducing sugars, and a few others were secondary metabolites that tested positive in the phytochemical screening. According to Sivaelango et al. [13], the results of the present study saw a significant decrease in the level of cholesterol, triglycerides, LDL, VLDL, and an increase in the level of HDL, after administration with EEASL may have almost certainly be owing to the incidence of steroids, flavonoids, and saponins in respective amounts.

Furthermore, the oral acute toxicity studies that were carried out to determine the level of toxicity of EEASL recorded no adverse effects and/or deaths in the rats after 72 hours of administration, proving that EEASL is less toxic if not at all when ingested in large amounts. Kumaar et al. [3] mentioned therapeutic plants having enticed significant worldwide attention in modern ages. Examination of traditional medicine is essential for the well-being of rural and tribal societies to cure conservative illness. The broad survey literature reviewed that *Amaranthus spinosus* is an indispensable medicinal plant with a different pharmacological spectrum. A lot of pharmacological studies have been carried out with extract of the diverse portions of the plant. The plant is extensively used in the conventional medicinal system of India. It has been testified to possess antihyperlipidaemic, antidiabetic, antipyretic, anti-inflammatory, antioxidant, hepatoprotective, antimalarial, antibacterial, antimicrobial, antidiuretic, antiviral, hepatic disorders of which the former was further certified in dexamethasone-induced hyperlipidaemic models. Based on the lipid profile analysis results, one can firmly conclude that EEASL could be used to treat hyperlipidaemia.

6. Recommendation

Due to the medicinal properties, there is vast scope for future assessment on *Amaranthus spinosus* in several treatments and the authors recommend that:

1. Studies should be focused on the antihyperlipidaemic effect of EEASL under conditions of chronic hyperlipidaemia.
2. The histopathological study should be carried out to further investigate the toxicity of EEASL.
3. The characterization and isolation of the active phytochemical constituents should be carried out.
4. Further molecular study should be carried out to investigate the mechanism underlying the antihyperlipidaemic effect of EEASL.
5. The curative and prophylactic studies should also be carried out.
6. Pharmacological enquiry and clinical research should be conducted to consider the untapped potential of this plant for the unearthing of safer drugs.

Conflict of Interest Statement

The authors declare that they have no competing interests.

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