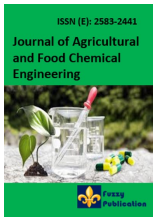
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Research Article

Effect of *Schanginia aegyptiaca* Plant Extract from the Saline Environment of Babylon on Lipid Profile and Obesity Indicators in Laboratory Rats on a High-Fat Diet

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Abstract

Background: Obesity and related metabolic complications such as dyslipidemia, oxidative stress and inflammation are a world-wide health problem. **Objective:** This study was conducted to evaluate the effects of *Schanginia aegyptiaca* extract on obesity, hyperlipidaemia, antioxidant and anti-inflammatory activity in obese rats fed with a high fat diet. **Methodology:** Male Wistar rats were randomized into HFD, positive control (Orlistat) and two high and low doses of *S. aegyptiaca* extract groups. The treatment consisted of an HFD for 12 weeks to induce obesity followed by 6 weeks of treatment. Body weight, food intake, BMI, Lee Index, adipose tissue weights, other biochemical and immunological indicators. **Results:** The extract of *S. aegyptiaca* significantly inhibited body weight gain, BMI and Lee Index and also reduced epicardial fat pad, perirenal fat pad and mesenteric fat pad weights showing its potent anti-obesity effects. It was highly effective in the correction of dyslipidemia, decreasing levels of TC, TG, LDL-C and VLDL-C and increasing HDL-C. In addition, the extract effectively improved insulin resistance by decreasing fasting glucose, insulin and HOMA-IR. Oxidative stress was reduced by the reduction in the level of MDA and increase in SOD and CAT. Furthermore, inflammatory responses were inhibited, where particularly TNF-α and CRP were reduced significantly. **Conclusion:** The extract of *Schanginia aegyptiaca* has anti-obesity, hypolipidemic, antioxidant and anti-inflammatory properties that prevent HFD-induced obesity and metabolic complications. These results may be beneficial for its utilization as a natural therapeutic agent for metabolic syndrome and its possible clinical applications.

1. Introduction

Obesity, a complex and multifactorial metabolic disorder, is currently a significant health issue in the 21st century, affecting populations globally in epidemic proportions [1]. This state is not only an aesthetic issue, but a serious medical state that is associated with a high risk of developing many chronic NCDs such as heart disease and stroke (CVDs), type 2 diabetes mellitus (T2DM), some types of cancer, hypertension, and dyslipidemia [2]. Since 1975, there has been an almost threefold increase in global obesity and by 2016, there were greater than 1.9 billion overweight adults and more than 650 million obese [3]. The concerning trend necessitates novel approaches to prevention and treatment.

Dyslipidemia is a primary characteristic of the metabolic syndrome, and manifests as abnormalities of blood lipids. This commonly involves elevated total cholesterol (TC), diminished levels of the "good" cholesterol, known as high-density lipoprotein cholesterol (HDL-C) and elevated levels of low-density lipoprotein cholesterol (LDL-C) and trinylglycerides (TG) [4]. These lipid imbalances represent a significant factor in the pathogenesis of atherosclerosis, a chronic inflammatory disease characterized by the accumulation of lipid deposits in the inner lining of the arteries and which increases the risk of myocardial infarction and stroke [5]. Obesity and dyslipidemia are interconnected conditions, with obesity contributing to systemic chronic inflammation and/or insulin resistance leading to increased cardiovascular risk, which, in turn, exacerbates the progression of lipid abnormalities and obesity [6]. These integrated pathways are essential for understanding to develop an integrated treatment plan. High fat diets (HFD) are recognized as a causative factor for obesity and metabolic disorders in humans and animal models [7]. In experimental studies, HFDs are commonly utilized to model obesity, dyslipidaemia and thus serve as a well-controlled setting for investigating disease progression and the efficacy of therapeutic interventions. Chronic HFD consumption precipitates a cascade of pathophysiological changes such as weight gain, ectopic lipid disposition in organs other than adipose (e.g., liver, muscle), significant perturbations in blood lipid profiles, decreased glucose tolerance and insulin resistance, and sustained low-grade inflammatory response [8]. Many of the characteristics of human obesity and metabolic syndrome are accurately replicated in these animal models and crucial for preclinical research [9]. The exact mechanisms by which HFD causes its harmful effects are complex and multiple molecular pathways have been implicated, such as activation of inflammatory signaling, generation of oxidative stress, and dysregulation of lipid metabolic enzymes [10].

Over the past few years, the focus has switched back to the promising anti-obesity and lipid lowering properties of natural compounds, especially botanical medicinal plants [11]. The newer interest is due to the need for a more safe and sustainable approach or alternative to conventional drug therapy, which has undesirable effects. Salinity adapted plants, known as halophytes, are one of the most diverse group of plants and a new source of novel bioactive compounds has appeared [12]. Plants under salt stress have developed complex strategies to deal with these elevated salt levels, such as the production and storage of a plethora of secondary metabolites. These include flavonoids, polyphenols, alkaloids, saponins and some specific chemicals which provide protective effects against stress of environment [13]. Remarkably, numerous of the compounds were found to have strong pharmacological properties like anti-inflammatory, anti-cancer, antioxidant and also they are lipid-modulators [14]. Extracts of different species of halophytes have been shown to have therapeutic uses in metabolic disorders as they have the ability to improve blood lipid profiles and decrease adipose tissue accumulation [15].

The *Suaeda aegyptiaca* or *Schanginia aegyptiaca (S. aegyptiaca)* is a prominent halophytic species which grows best in saline environments and is very frequent throughout arid and semi-arid areas; in particular on part of the territories of Iraq [6]. The plant can withstand in extreme conditions which relates to its rich phytochemical composition; some of this has been surrounded in preliminary testing. Data suggested that *S. aegyptiaca* contains a number of phytochemicals which include essential oils and flavonoids with a variety of biological activities [6]. In the case of *S. aegyptiaca*, extracts are reported to possess very good antidiabetic and antioxidant effects, suggesting the extracts might have therapeutic possibilities [13]. Moreover, there are many species closely related to Suaeda, such as Suaeda japonica, which have been thoroughly examined for their anti-obesity effects. In these studies high capacities of Suaeda japonica extracts were established for desirable effects on the body weight, improvement of various blood biochemical parameters, and reduction of fat accumulation in animal models of obesity [1]. The overall results demonstrate the therapeutic potential of the Suaeda genus for metabolic health and provide a body of evidence for their anti-metabolic effects.

Although the study of halophytes and their bioactive compounds has increased, there is still a lack of knowledge of the specific effects and action mechanisms of *S. aegyptiaca* extract especially when harvested from a favorable saline habitat that exists in the city of Babylon in Iraq. Different climatic conditions and soil salinity levels are believed to affect the concentration and distribution of plant phytochemicals and active compounds in the plant in Babylon, located in a specific geographic and climatic region [14]. Chemotypic differences result from such environmental variations and might result in a change in the biological activity of the plant extract. So, a specific study concerning the extract of *S. aegyptiaca's* geographical source is recommended. This specific study is important in fully understanding its pharmacological use as a natural resource in obesity and obesity related dyslipidaemic management and treatment. Specific effects of this extract, which reflects its geographical uniqueness, can provide key insight into its mechanisms of action and offer opportunities for the discovery of new, plant based interventions applicable for metabolic health. The goal of this study is to review the effect of *S. aegyptiaca* plant extract from salty environment of Babylon on lipid profile (total cholesterol, low density lipoproteins, high density lipoproteins and triglycerides) and obesity indicators (body weight, body mass index and fat accumulation) in laboratory rats fed with high-fat diet.

2. Methodology

2.1. Plant Material Collection and Preparation

The aerial parts of *Schanginia aegyptiaca* (syn. *Suaeda aegyptiaca*) fresh aerial parts was collected when it is at the peak growth period (such as late spring, early summer), from the saline environment of Babylon Province, Iraq. The plant identification was approved by a qualified botanist from the Department of Biology, University of Babylon. Following harvesting, the plant material was washed meticulously to wash off the soil, dust, and debris holding in the plants. This was then cleaned and air dried at ambient temperature (25 $\pm$ 2 °C) in a well-ventilated and shaded area till a constant weight is obtained (7-10 days). The dried plant materials was ground into fine powder using mechanical grinder and then kept in a sealed container at 4 °C between procedures for the extraction.

2.2. Preparation of Plant Extract

The powdered *S. aegyptiaca* material was extracted using an appropriate solvent which is ethanol that has been known to be able to extract a wide range of phytochemicals. About 500 g of the dried plant powder was macerated with 2.5L of 80% ethanol in a dark and cool place for 72 hours, shaking from time to time. The mixture will then be filtered through whatman no.1 filter paper. Residue was re-extracted twice with the same extraction conditions to achieve maximum extraction of active compounds. The concentrated combined filtrates was subjected to rotary evaporator under reduced pressure and the temperature will not exceed 40 °C to extract crude ethanolic extract. The viscous extract was lyophilized to yield a dry powder and was stored at -20 °C until use for in vivo and phytochemical experiments. The yield of the extract

was calculated [16].

2.3. Phytochemical Screening and Characterization

Qualitative phytochemical screening of *S. aegyptiaca* extract was done for the preliminary identification of the major classes of secondary metabolites, which are flavonoids, polyphenols, alkaloids, saponins, tannins and glycosides, by the use of standard chemical tests. Moreover, quantitative analysis was also carried out to identify the total phenolic content by the Folin-Ciocalteu method, and total flavonoid content by the aluminium chloride colorimetric method.

2.4. Experimental Animals and Ethical Considerations

Approximately 40-50 male Wistar rats weighing 180-220 g at 6-8 week old purchased from a reputable animal breeding facility were used. Male rats are often preferred over female rats to mitigate potential variations induced by the female estrous cycle. The rats were kept in standard polypropylene cages (5 rats/cage) under a controlled environmental conditions: temperature of 22 $\pm$ 2 °C, relative humidity (50-60%) and a 12-hour day/night cycle. Food and water were provided ad libitum to them unless otherwise stated in the experimental protocol.

2.5. Induction of Obesity and Experimental Design

Rats were then randomly assigned into several experimental groups after a 1 week acclimatization (n = 8-10 rats per group). Obesity and dyslipidemia was induced by a high fat diet (HFD). Typically, the HFD contained 45-60% fat, 20-35% carbohydrate, 15-20% protein, and an extra cholesterol and cholic acid to help the metabolic disturbances begin to develop. Rats fed a high-fat diet are typically divided into the following groups: Group I (Normal Control): Rats fed a normal diet and drinking distilled water; Group II (HFD Control): Rats fed a high-fat diet and drinking distilled water; Group III (Positive Control): Rats fed a high-fat diet and dministered with Orlistat at a therapeutic dose; Group IV (Low Dose Extract): Rats fed a high-fat diet and then given *S. aegyptiaca* extract at a lower dose (e.g., 100 to 200 mg/kg body weight orally); Group V (High Dose Extract): Animals fed a high-fat food diet and that receive *S. aegyptiaca* extract at a higher dose (e.g., 400 to 500 mg/kg body weight orally). The basis for the 8-12 weeks of the HFD feeding period are that obesity and dyslipidemia must be established. From here on, the treatment with the plant extract and positive control drug was started and will continue for the next 4-6 weeks with all groups having their respective diets. During the whole experimental period body weight and feed intake was recorded weekly.

2.6. Sample Collection

After an overnight fast (12-14 hours), all rats were humanely euthanized at the end of the experimental period under light anesthetic by xylazine. Serum was separated and plasma was collected by cardiac puncture of blood into plain tubes and EDTA tubes, respectively. Serum and plasma was separated by centrifugation for 15 minutes at 3000 rpm at 4 °C and frozen at -80 °C until biochemical analyses are performed. After careful removal, livers and adipose tissues (epididymal, perirenal, and specifically the mesenteric fat pads) and other pertinent organs was weighed and snap frozen in liquid nitrogen.

2.7. Biochemical Analysis

2.7.1. Lipid Profile Assessment

Blood concentrations of total cholesterol (TC) was determined using commercially available enzymatic colorimetric kit method and triglycerides (TG) would be determined using enzymatic colorimetric method, all according to the kit manufacturers' instructions. High-density lipoprotein cholesterol (HDL-C) was measured directly by using an enzymatic assay, and low-density lipoprotein cholesterol (LDL-C) was determined using specific assay kit. VLDL-C (very low-density lipoprotein cholesterol) was calculated as TG/5 and also the "atherogenic index" (AI) was calculated as (TC-HDL-C)/HDL-C, which will act as a cardiovascular risk factor marker [17].

2.7.2. Obesity Indicators

In addition to body weight, the degree of obesity was evaluated with the body mass index (BMI) which is body weight expressed in grams and naso-anal length expressed in square centimeters. Various adiposity depots like epididymal, perirenal and mesenteric fat pads was weighed and expressed as % of BW; in addition, the Lee index was calculated (cube root of BW/NA) as a further anthropologic indicator of obesity [18].

2.7.3. Glucose Metabolism and Liver Function

Measurement of fasting blood glucose was done by a glucometer and serum insulin levels was measured using enzyme linked immunosorbent assay (ELISA) kits with insulin resistance calculated as Homeostatic Model Assessment for Insulin Resistance (HOMA-IR). The function of liver was estimated by measuring the concentration of serum alanine aminotransferase (ALT), aspartate aminotransferase (AST) and alkaline phosphatase (ALP) by means of calorimetric assays and the use of standard reagent kits [19].

2.7.4. Markers for oxidative Stress and Inflammation

Serum and liver tissue homogenates was analyzed for oxidant and inflammatory markers, in addition to malondialdehyde (MDA) as a marker of lipid peroxidation, reduced glutathione (GSH), and antioxidant enzymes, such as superoxide dismutase (SOD) and catalase (CAT).

Elisa kits were used to measure inflammatory markers like C Reactive-activity protein (cRP) or Tumor necrosis factor alpha (tNF-α) [20], according to the manufacturer's instructions.

2.8. Statistical Analysis

All quantitative data were presented as mean $\pm$ SEM. Data analysis derived from the data was done using appropriate software SPSS version 25.0. Initially normality was tested using Shapiro-Wilk normality test and homogeneity of variance was tested using Levene's homogeneity of variance test. To compare differences between multiple groups one-way analysis of variance (ANOVA) followed by Tukey's post hoc test was used for data which are normally distributed. In the event that the data is not normally distributed then Non parametric data (or Kruskal-wallis test followed by Dunn's post_hoc) was carried out where a p value$<$0.05 was considered statistically significant. Relations amongst different parameters can also be investigated using correlation analysis.

3. Results

3.1. Extract Yield

The extracts obtained from the *S. aegyptiaca* aerial parts showed percentage of 18.75 ± 0.5% (w/w) for ethanolic extract which revealed the potential efficiency of the extraction process. This yield is similar when compared with other extracts from plants which are obtained using a similar maceration process.

3.2. Qualitative Phytochemical Screening

Initial qualitative phytochemical investigation of the extract of *S. aegyptiaca* showed extensive occurrence of major class of phytochemical. As presented in Table 1 the results revealed a good phytochemical profile, especially in case of the flavonoids and polyphenols.

Table 1: Qualitative phytochemical screening of *S. aegyptiaca* extract

Compound Class	Result
Flavonoids	+++
Polyphenols	+++
Alkaloids	+
Saponins	++
Tannins	++
Glycosides	+

Note: +++ = strongly present,
++ = moderately present,
+ = weakly present.

3.3. Quantitative Phytochemical Analysis

Quantitative analysis was performed to determine the total phenolic content (TPC) and total flavonoid content (TFC) of the *S. aegyptiaca* extract. As shown in Table 2, the extract exhibited significant levels of these bioactive compounds.

Table 2: Quantitative analysis of total phenolic and flavonoid content

Parameter	Value (Mean ± SD)	Unit
Total Phenolic Content (TPC)	84.32 ± 3.12	mg GAE/g
Total Flavonoid Content (TFC)	42.15 ± 1.85	mg QE/g

3.4. Detailed Obesity Indicators

The weekly weight measurement during the 18 week experimental period gave insight how the body weight changed during the obesity and effects of the plant extract and positive control Figure 1. After the rats were fed differently, the rats which were fed a high fat diet(HFD) always gained more weight than the rats which were fed a normal diet(NC). After the treatment period was started at week 12, this weight gain was significantly reduced by the administration of *S. aegyptiaca* extract, especially at the higher dose (HDE group), resulting in a trend similar to the positive control (PC group).

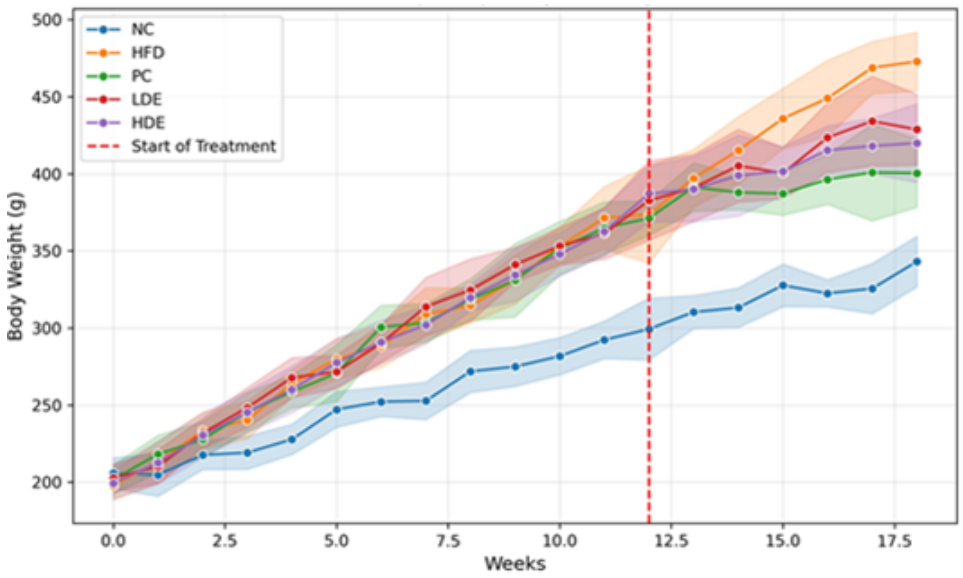


Figure 1: Weekly body weight changes (g) in experimental groups over 18 weeks. The red dashed line indicates the start of the treatment period (Week 12). NC: Normal Control, HFD: High-Fat Diet, PC: Positive Control, LDE: Low Dose Extract, HDE: High Dose Extract

3.5. Food Intake

Food intakes were recorded on a weekly basis and the average food intake of the period of treatment (weeks 12 – 18) is listed in Table 3. Food intake was also greater in the HFD group than in the NC group, which led to the body mass increase that was observed in the HFD group. Food intake was also decreased for both LDE and HDE groups as compared to HFD control, which may indicate the possibility of the extract to be helpful in eating regulation.

Table 3: Average daily food intake during treatment period (Weeks 12-18)

Group	Food Intake (g/day, Mean ± SD)
Normal Control (NC)	19.72 ± 1.32
High-Fat Diet (HFD)	35.17 ± 2.09
Positive Control (PC)	24.69 ± 1.67
Low Dose Extract (LDE)	29.24 ± 1.24
High Dose Extract (HDE)	28.28 ± 1.91

3.6. Body Mass Index (BMI) and Lee Index

Measures of obesity were taken at the end of the study. The HFD group had significantly greater BMI and Lee Index values than the NC group, denoting the successful induction of obesity as shown in Table 4. Therefore, administrations of *S. aegyptiaca* extract (particularly the HD group) significantly decreased these indices and made them more comparable with the values in PC group.

Table 4: Body Mass Index (BMI) and Lee Index at the end of the study

Group	BMI (Mean ± SD)	Lee Index (Mean ± SD)
Normal Control (NC)	0.56 ± 0.02	0.30 ± 0.01
High-Fat Diet (HFD)	0.82 ± 0.05	0.38 ± 0.01
Positive Control (PC)	0.66 ± 0.03	0.32 ± 0.01
Low Dose Extract (LDE)	0.76 ± 0.05	0.35 ± 0.01
High Dose Extract (HDE)	0.68 ± 0.03	0.33 ± 0.01

3.7. Adipose Tissue Weights

The weights of various adipose tissue depots (epididymal, perirenal, and mesenteric fat pads) were measured as indicators of fat accumulation. Table 5 illustrates that the HFD group had significantly heavier fat pads compared to the NC group. Both doses of *S. aegyptiaca* extract, particularly the high dose, resulted in a significant reduction in the weights of these adipose tissues, indicating an anti-obesity effect.

Table 5: Adipose tissue weights (g) at the end of the study

Group	Epididymal Fat (Mean ± SD)	Perirenal Fat (Mean ± SD)	Mesenteric Fat (Mean ± SD)
Normal Control (NC)	2.10 ± 0.16	1.54 ± 0.09	1.19 ± 0.10
High-Fat Diet (HFD)	6.36 ± 0.36	5.01 ± 0.54	3.49 ± 0.22
Positive Control (PC)	3.33 ± 0.34	2.08 ± 0.18	1.78 ± 0.09
Low Dose Extract (LDE)	4.91 ± 0.41	3.47 ± 0.32	2.54 ± 0.27
High Dose Extract (HDE)	3.68 ± 0.30	2.56 ± 0.20	1.93 ± 0.19

3.8. Metabolic and Inflammatory Markers

The serum lipid profile, including Total Cholesterol (TC), Triglycerides (TG), High- Density Lipoprotein (HDL), Low-Density Lipoprotein (LDL), and Very Low-Density Lipoprotein (VLDL), was significantly altered in the HFD group. As shown in Figure 2 and summarized in Table 6, the HFD group exhibited elevated TC, TG, LDL, and VLDL, and reduced HDL levels compared to the NC group. Treatment with *S. aegyptiaca* extract, especially the high dose, significantly improved the lipid profile, normalizing these parameters towards the NC and PC groups.

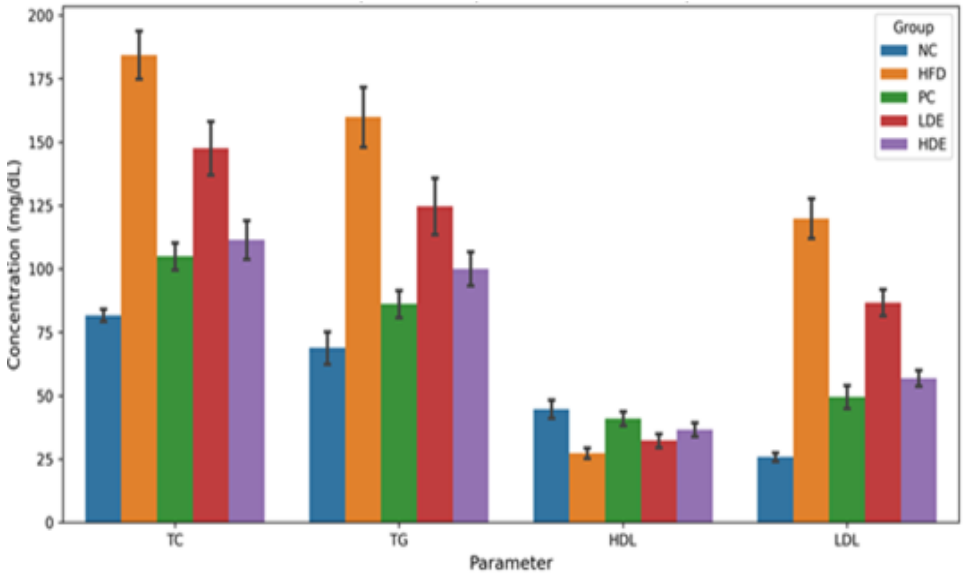


Figure 2: Comparison of serum lipid profile parameters (TC, TG, HDL, LDL) across experimental groups. Values are expressed as Mean ± SD

Table 6: Serum lipid profile at the end of the study

Group	TC (mg/dL) (Mean ± SD)	TG (mg/dL) (Mean ± SD)	HDL (mg/dL) (Mean ± SD)	LDL (mg/dL) (Mean ± SD)	VLDL (mg/dL) (Mean ± SD)
Normal Control (NC)	81.72 ± 2.43	68.81 ± 6.33	44.67 ± 3.59	25.78 ± 1.74	13.66 ± 1.36
High-Fat Diet (HFD)	184.35 ± 9.50	159.91 ± 11.82	27.33 ± 2.09	119.89 ± 7.86	31.48 ± 2.55
Positive Control (PC)	104.95 ± 5.40	86.15 ± 5.35	41.02 ± 2.78	49.48 ± 4.51	17.25 ± 1.58
Low Dose Extract (LDE)	147.56 ± 10.55	124.64 ± 11.16	32.27 ± 2.76	86.71 ± 5.26	25.28 ± 2.19
High Dose Extract (HDE)	111.46 ± 7.66	100.08 ± 6.69	36.63 ± 2.67	56.88 ± 3.17	18.92 ± 1.59

3.9. Glucose Metabolism

Fasting blood glucose, insulin levels, and the Homeostatic Model Assessment for Insulin Resistance (HOMA-IR) index were evaluated. As presented in Figure 3 & Table 7, the HFD group exhibited significantly elevated glucose and insulin levels, leading to a higher HOMA-IR index, indicative of insulin resistance. Treatment with *S. aegyptiaca* extract, particularly the high dose, significantly improved these parameters, suggesting a beneficial effect on glucose metabolism and insulin sensitivity.

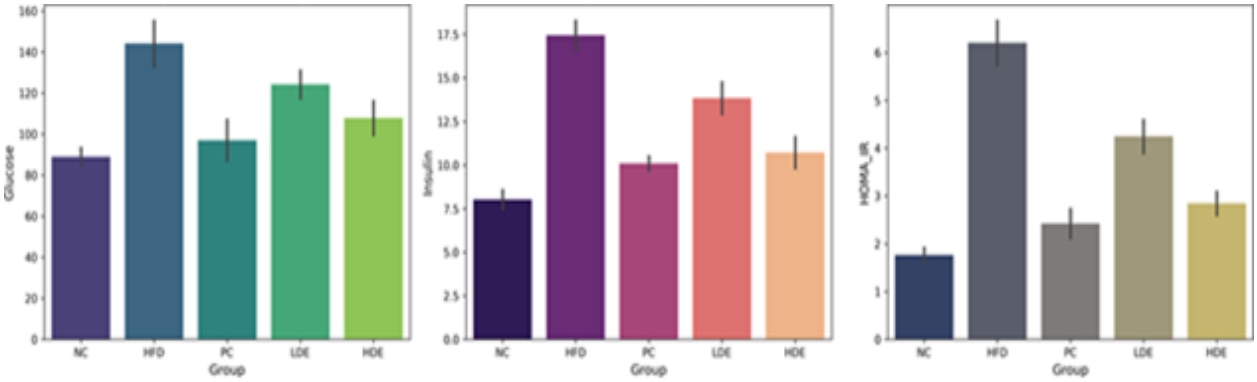


Figure 3: Fasting glucose levels (mg/dL), fasting insulin levels (µIU/mL), and HOMA-IR index across experimental groups. Values are expressed as Mean ± SD

Table 7: Fasting glucose, insulin, and HOMA-IR levels at the end of the study

Group	Glucose (mg/dL) (Mean ± SD)	Insulin (µIU/mL) (Mean ± SD)	HOMA-IR (Mean ± SD)
Normal Control (NC)	89.02 ± 4.27	8.03 ± 0.55	1.76 ± 0.15
High-Fat Diet (HFD)	144.17 ± 11.06	17.44 ± 0.83	6.20 ± 0.46
Positive Control (PC)	97.07 ± 10.03	10.10 ± 0.41	2.42 ± 0.31
Low Dose Extract (LDE)	124.23 ± 6.79	13.84 ± 0.91	4.24 ± 0.34
High Dose Extract (HDE)	107.86 ± 8.27	10.71 ± 0.89	2.85 ± 0.25

3.10. Oxidative Stress and Antioxidant Status

Oxidative stress markers, including malondialdehyde (MDA), and antioxidant enzyme activities including superoxide dismutase (SOD) and catalase (CAT) were determined. As presented in Figure 4 & Table 8, the HFD group was significantly higher for MDA, but significantly lower for SOD and CAT activity, thereby showing an increase in oxidative stress. The *S. aegyptiaca* extract, high dose in particular, significantly reversed these alterations, improving the antioxidant defence and decreasing the oxidative damage.

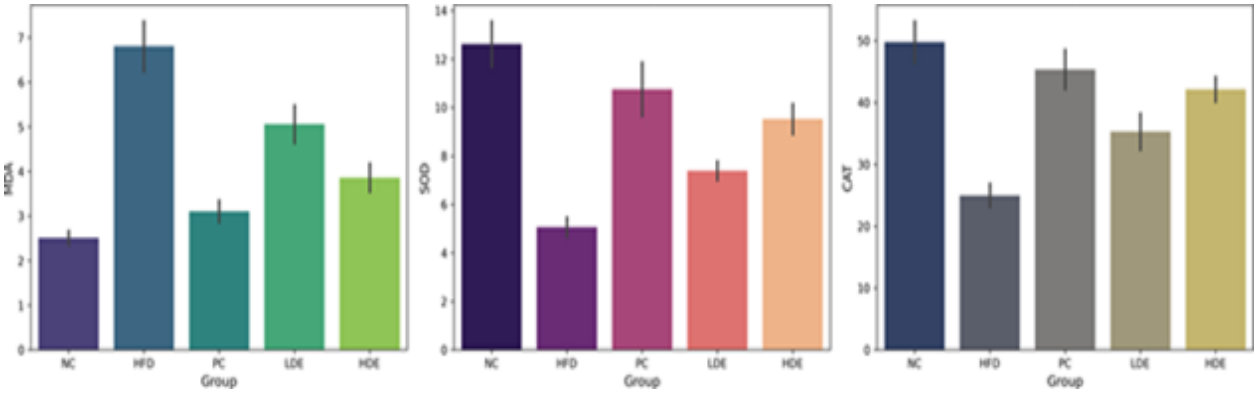


Figure 4: MDA levels (nmol/mL), SOD activity (U/mL), and CAT activity (U/mL) across experimental groups. Values are expressed as Mean ± SD

Table 8: Oxidative stress and antioxidant enzyme activities at the end of the study

Group	MDA (nmol/mL) (Mean ± SD)	SOD (U/mL) (Mean ± SD)	CAT (U/mL) (Mean ± SD)
Normal Control (NC)	2.51 ± 0.16	12.62 ± 0.94	49.78 ± 3.35
High-Fat Diet (HFD)	6.81 ± 0.56	5.07 ± 0.40	24.98 ± 1.87
Positive Control (PC)	3.10 ± 0.25	10.76 ± 1.10	45.35 ± 3.15
Low Dose Extract (LDE)	5.06 ± 0.42	7.39 ± 0.39	35.28 ± 2.93
High Dose Extract (HDE)	3.86 ± 0.32	9.53 ± 0.62	42.14 ± 2.02

3.11. Inflammatory Markers

Serum levels of inflammatory markers, including Tumor Necrosis Factor-alpha (TNF-α) and C-reactive protein (CRP), were assessed. As shown in Figure 5 & Table 9, the HFD group displayed significantly elevated levels of both TNF-α and CRP, indicating a state of chronic

inflammation. Treatment with *S. aegyptiaca* extract, especially the high dose, significantly reduced these inflammatory markers, suggesting potent anti- inflammatory effects.

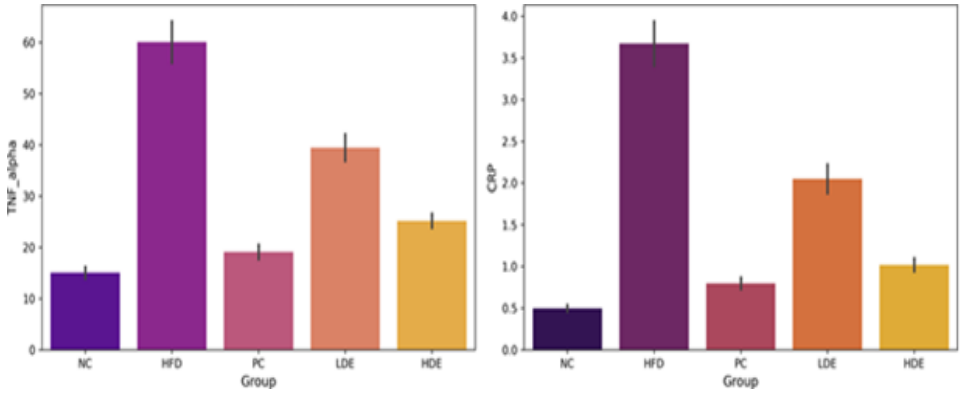


Figure 5: TNF-α levels (pg/mL) and CRP levels (mg/L) across experimental groups. Values are expressed as Mean ± SD

Table 9: Inflammatory markers at the end of the study

Group	TNF-α (pg/mL) (Mean ± SD)	CRP (mg/L) (Mean ± SD)
Normal Control (NC)	15.06 ± 1.11	0.50 ± 0.04
High-Fat Diet (HFD)	60.05 ± 4.03	3.67 ± 0.27
Positive Control (PC)	19.10 ± 1.40	0.80 ± 0.07
Low Dose Extract (LDE)	39.45 ± 2.60	2.05 ± 0.17
High Dose Extract (HDE)	25.19 ± 1.38	1.02 ± 0.08

4. Discussion

In this study, the saline environment of Babylon was used to extract *S. aegyptiaca*, which is believed to have an impact on obesity indicators and lipids level profile in laboratory rats fed with high-fat diet (HFD). This study demonstrated promising anti-obesity and hypolipidemic properties of *S. aegyptiaca* extract, as well as great antioxidant and anti-inflammatory activity, making it one of the possible therapeutic agents for metabolic syndrome treatment. The phytochemical composition of the extract corroborates earlier studies on the quality of bioactive substances in halophytes including flavonoids, polyphenols, in Suaeda genus [21, 22]. An anti-inflammatory activity can be attributed to these compounds, as is the antioxidant protective activity from other plants [23, 24]. The forest's unique environment, which may be in a saline climate, is thought to contribute to perhaps changes in the phytochemical profile and concentration of the active compounds in the plant, which can ultimately increase its biological efficacy [25].

Rats fed *S. aegyptiaca* extract exhibited considerable weight loss, with a greater reduction in weight loss seen at the high dose compared with the HFD. Rats fed *S. aegyptiaca* extract also showed a significantly greater reduction in body mass index (BMI) and Lee Index when compared with the HFD control group. In conclusion, the results supported the hypothesis that the extract has anti-obesity properties and warrants considering as a nutraceutical. The findings are in accordance with other works that demonstrated that extracts of other Suaeda species such as Suaeda japonica has anti-obesity effects in the HFD-induced obese rats [22]. These effects may be explained by the fact that the extract affects the appetite, inhibits the absorption of lipids or enhances the energy expenditure [26]. Many plant extracts are rich in polyphenols, which has been reported to selectively inhibit adipocyte generation, resulting in anti-obesity properties and lessening negative effects such as inflammatory response and insulin resistance [24].

Moreover, decreased total cholesterol (TC), triglycerides (TG), low density lipoprotein cholesterol (LDL-C) and very low density lipoprotein cholesterol (VLDL-C) and increased high density lipoprotein cholesterol (HDL-C) in the extract treated groups was observed, indicating a noteworthy amendment of the serum lipid profile. The results observed are suggesting a potent hypolipidemic action of the plant extract very important for the control of other obesity related cardiac problems [27]. This is consistent with polyphenols from plant extracts having the ability to help regulate lipid metabolism through inhibition of cholesterol and triglyceride production, enhance excretion of cholesterol and the oxidation of fatty acid [28, 29]. Improvements with lipid parameters observed are very important and dyslipidaemia plays a major role in atherosclerosis and elevated cardiovascular risk in obese individuals. The normalization of such parameters towards normal control and positive control group indicates the therapeutic potential of *S. aegyptiaca*.

Furthermore, *S. aegyptiaca* extract demonstrated the strong antioxidant and anti-inflammatory activities. Treatment led to a reduction in malondialdehyde (MDA) levels and an increase in the activity of antioxidant enzymes such as superoxide dismutase (SOD) and catalase (CAT). Other parameters, such as cytokines (tumor necrosis factor alpha (TNF-α) and C-reactive protein (CRP) levels, were also lowered. These findings are particularly significant as oxidative stress and chronic inflammation are one of the features of obesity and metabolic syndrome, both of which have a role in the pathogenesis of complications associated with obesity [30, 31]. Such beneficial effects can be considered as the result of presence of phenolic compounds, flavonoids and their antioxidants and anti-inflammatory properties in the extract [32, 33]. For example, antioxidant and anti-inflammatory properties, which concur with these results, were reported for *S. aegyptiaca* essential oil [25]. Considering how oxidative stress contributes to worsening metabolic changes and insulin resistance in obesity makes this antioxidant defense and oxidative damage reducing beneficial effects particularly relevant for the extract.

The study also showed positive impact on the glucose metabolism rates, as the high dose result when compared with the control resulted in the following: fasting blood glucose and insulin levels have improved significantly, and Homeostatic Model Assessment for Insulin Resistance (HOMA-IR) index was also significantly improved. This indicates an increase in insulin sensitivity, an important factor in some of the metabolic syndrome treatments. Insulin resistance was observed throughout HFD-induced obesity and this finding could drive another important therapeutic pathway after the insulin resistance was alleviated by the *S. aegyptiaca* extract. Similar results obtain by the overall concept of induction of anti-diabetic activity by multiple pathways associated with glucose homeostasis by naturally-occurring bioactive compounds [27].

Overall, this study underscores the potential therapeutic importance of *S. aegyptiaca* as a natural source of bioactive compounds that can aid in combating obesity and its associated metabolic disorders. This special saline soil type of its geographical origin may bring special phytochemicals that makes the plant more effective in its use [34]. However, further investigation is warranted to find out exactly what components are active and exactly how these components act as well as the safety and effectiveness in humans [35]. Further, dose responses, long-term toxicity and potential synergy represent valuable areas for future research. The results will provide a robust foundation for the development of new plant-based interventions for metabolic health, an alternative or complementary treatment to drugs.

5. Conclusion

It is concluded from this study that the *S. aegyptiaca* plant extract, especially from saline environment of Babylon, has great therapeutic significance for obesity and allied metabolic complication due to high fat diet in rats. The extract significantly decreased body weight gain, lipid blood markers (cholesterol and triglyceride) and enhanced HDL-C levels markers in the blood, and also reduced insulin resistance. Additionally, the high antioxidant and anti-inflammatory activity in the form of decreased MDA, inflammatory marker levels (TNF-α, CRP) and increased antioxidant enzyme activities (SOD, CAT) suggest a comprehensive protective effect. These results highlight the potential of *S. aegyptiaca* as a natural source for the discovery of new potential bioactive compounds in obesity and metabolic syndrome care. Additional investigations are needed to identify and elucidate the individual active compounds of the plants and to confirm such actions with human clinical studies to advance metabolic health utilizing approaches.

Article Information

Ethical Approval: Animal experiments were conducted strictly in accordance with the animal use standards established by the Institutional Animal Ethics Committee at the University of Babylon, and in compliance with international animal welfare standards as per Protocol EC45 dated April 7, 2025.

Data Availability: The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Conflict of Interest: The authors declare that they have no conflict of interest.

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References

[1] A. Chandrasekaran, Y. Jeon, S. Y. Kim, D. H. Seo, H. J. Yuk, E. Son, Y. S. Kim, J. H. Kim, J. H. Park, and G. J. Lee. Therapeutic potential of *Suaeda japonica* Makino leaf extract against obesity in 3T3-L1 preadipocytes and HFD-induced C57BL/6J mice. *Applied Biochemistry and Biotechnology*, 197(4):2555–2578, 2025. URL https://doi.org/10.1007/s12010-024-05170-4.

[2] B. Saad. A review of the anti-obesity effects of wild edible plants in the Mediterranean diet and their active compounds: From traditional uses to action mechanisms and therapeutic targets. *International Journal of Molecular Sciences*, 24(16):12641, 2023. URL https://doi.org/10.3390/ijms241612641.

[3] S. Chrigui, S. Hadj Taieb, H. Jemai, S. Mbarek, M. Benlarbi, M. Feki, Z. Haouas, A. Zemmel, R. Ben Chaouacha-Chekir, and N. Boudhrioua. Anti-obesity and anti-dyslipidemic effects of *Salicornia arabica* decocted extract in Tunisian *Psammomys obesus* fed a high-calorie diet. *Foods*, 12(6):1185, 2023. URL https://doi.org/10.3390/foods12061185.

[4] N. H. Kim, J. D. Heo, J. R. Rho, M. H. Yang, and E. J. Jeong. Anti-obesity effect of halophyte crop, *Limonium tetragonum* in high-fat diet-induced obese mice and 3T3-L1 adipocytes. *Biological and Pharmaceutical Bulletin*, 40(11):1856–1865, 2017. URL https://doi.org/10.1248/bpb.b17-00296.

[5] M. Rounagh and M. Salehi. Effects of *Nigella sativa* supplementation on lipid profiles in obese rats: A systematic review. *Journal of Functional Foods*, 115:106020, 2024.

[6] E. Amin, A. Elwekeel, N. F. Alshariedh, M. S. Abdel-Bakky, and H. M. Ali. GC-MS analysis and bioactivities of the essential oil of *Suaeda aegyptiaca*. *Separations*, 9(12):439, 2022. URL https://doi.org/10.3390/separations9120439.

[7] U. W. Hawas, D. F. El-Kashef, and M. A. Al-Shehri. Phytochemical compositions of some Red Sea halophyte plants with antioxidant and anticancer potentials. *Molecules*, 27(11):3415, 2022. URL https://doi.org/10.3390/molecules27113415.

[8] H. A. Mohammed, M. G. Ewees, N. I. Mahmoud, H. M. Ali, E. Amin, and M. S. Abdel-Bakky. Involvement of PI3K/HIF-1α/c-MYC/iNOS pathway in the anticancer effect of *Suaeda vermiculata* in rats. *Pharmaceuticals*, 16(10):1470, 2023. URL https://doi.org/10.3390/ph16101470.

[9] M. Fiaz, M. F. Elsadek, K. S. Al-Numair, S. R. Chaudhry, M. Saleem, K. ur Rehman Khan, A. H. S. Yehya, and M. Asif. Down-regulation of interlinked inflammatory signalling cascades by ethanolic extract of *Suaeda fruticosa* Forssk. ex J. F. Gmel. attenuated in vivo inflammatory and nociceptive responses. *Inflammopharmacology*, 33(1):311–328, 2025. URL https://doi.org/10.1007/s10787-024-01624-7.

[10] S. C. Oliveira-Alves, F. Andrade, J. Sousa, A. Bento-Silva, B. Duarte, I. Caçador, M. Salazar, E. Mecha, A. T. Serra, and M. R. Bronze. Soilless cultivated halophyte plants: Volatile, nutritional, phytochemical, and biological differences. *Antioxidants*, 12(6):1161, 2023. URL https://doi.org/10.3390/antiox12061161.

[11] A. Hameed, S. Gulzar, and I. Aziz. Exploring the potentials of halophytes in addressing global food security and environmental challenges. *Sustainability*, 16(1):123, 2024.

[12] M. I. Alruwad and E. Al-Sayed. Exploring the biological and phytochemical potential of halophytes: A review. *Molecules*, 29(5):1160, 2024.

[13] M. Afshari, A. R. Malayeri, F. Albosuf, H. R. Khalili, and N. Bakhtiari. Antidiabetic, hepato-protective and hypolipidemic effects of Suaeda aegyptiaca extract in comparison to metformin on streptozotocin-nicotinamide induced type 2 diabetic rats. *Iraq Medical Journal*, 3(1):22–27, 2019.

[14] K. J. Farhan, S. A. Abdulrazzaq, A. F. M. Al-Enzy, and B. R. Sarheed. The efficiency of bacterial bio-fertilization and *Schanginia aegyptiaca* (Egyptian seablite) waste in reducing mineral fertilizers and in the growth and yield of cabbage. *An-Najah University Journal for Research—A (Natural Sciences)*, 40(2):173–182, 2026. URL https://doi.org/10.35552/anujr.a.40.2.2743.

[15] Y. Liu, C. Liu, X. Kou, Y. Wang, Y. Yu, N. Zhen, J. Jiang, P. Zhaxi, and Z. Xue. Synergistic hypolipidemic effects and mechanisms of phytochemicals: A review. *Foods*, 11(18):2774, 2022. URL https://doi.org/10.3390/foods11182774.

[16] N. N. Ahmed, S. S. J. Al-Touby, Y. B. A. Alrashdi, and M. A. Hossain. Isolation and characterization of cytotoxic and antioxidant compounds from *Suaeda aegyptiaca*. *Journal of King Saud University—Science*, 36(2):103058, 2024.

[17] G. A. Otunola, O. B. Oloyede, A. T. Oladiji, and A. A. Otunola. Effects of diet-induced hypercholesterolemia on the lipid profile and some enzyme activities in female Wistar rats. *African Journal of Biochemistry Research*, 4(10):256–263, 2010.

[18] B. J. Momoh, P. M. Aja, O. P. C. Ugwu, P. C. Nwosu, C. E. Odo, and C. E. Offor. The anti-obesity effect of *Allium cepa* L. leaves on high fat diet-induced obese rats. *Journal of Ethnopharmacology*, 277:114223, 2022.

[19] A. H. Hasan, M. A. Abdulzahra, and A. M. Hashim. Biochemical markers of liver function test (ALT, AST, ALP) in thyroid dysfunction (hyperthyroidism and hypothyroidism). *Journal of Biotechnology Research*, 10(1):1–7, 2024.

[20] S. Lasker, M. M. Rahman, F. Parvez, M. Zamila, P. Miah, K. Nahar, F. Kabir, S. B. Sharmin, N. Subhan, G. U. Ahsan, and M. A. Alam. High-fat diet-induced metabolic syndrome and oxidative stress in obese rats are ameliorated by yogurt supplementation. *Scientific Reports*, 9(1):20026, 2019. URL https://doi.org/10.1038/s41598-019-56538-0.

[21] X. Wang, X. Shao, W. Zhang, T. Sun, Y. Ding, Z. Lin, and Y. Li. Genus *Suaeda*: Advances in phytology, chemistry, pharmacology and clinical application (1895–2021). *Pharmacological Research*, 179:106203, 2022. URL https://doi.org/10.1016/j.phrs.2022.106203.

[22] P. B. T. Pichiah and Y.-S. Cha. *Salicornia herbacea* prevents weight gain and hepatic lipid accumulation in obese ICR mice fed a high-fat diet. *Journal of the Science of Food and Agriculture*, 95(15):3150–3159, 2015. URL https://doi.org/10.1002/jsfa.7054.

[23] M. Marrelli, M. R. Loizzo, M. Nicoletti, F. Menichini, and F. Conforti. In vitro investigation of the potential health benefits of wild Mediterranean dietary plants as anti-obesity agents with α-amylase and pancreatic lipase inhibitory activities. *Journal of the Science of Food and Agriculture*, 94(11):2217–2224, 2014. URL https://doi.org/10.1002/jsfa.6544.

[24] W. Rod-in, S. You, W. J. Park, and U. Surayot. *Suaeda maritima* polysaccharides attenuate LPS-induced inflammation of RAW264.7 cells and antioxidative activity. *International Immunopharmacology*, 137:112482, 2024. URL https://doi.org/10.1016/j.intimp.2024.112482.

[25] P. Zibaee and M.-A. Shamekhi. Physicochemical properties of Kakol (*Suaeda aegyptiaca*) essential oil nanoemulsion and its effect on the storage quality of rainbow trout (*Oncorhynchus mykiss*) during cold storage. *Food Science & Nutrition*, 11(9):5209–5222, 2023. URL https://doi.org/10.1002/fsn3.3480.

[26] L. He, Z. Su, and S. Wang. The anti-obesity effects of polyphenols: A comprehensive review of molecular mechanisms and signal pathways in regulating adipocytes. *Frontiers in Nutrition*, 11:1393575, 2024. URL https://doi.org/10.3389/fnut.2024.1393575.

[27] S. Oueslati, R. Ksouri, H. Falleh, A. Pichette, C. Abdelly, and J. Legault. Phenolic content, antioxidant, anti-inflammatory and anticancer activities of the edible halophyte *Suaeda fruticosa* Forssk. *Food Chemistry*, 132(2):943–947, 2012. URL https://doi.org/10.1016/j.foodchem.2011.11.072.

[28] S. N. Magwaza, V. Mavumengwana, and A. O. Aremu. Mechanisms behind the anti-diabetic and anti-obesity effects of seaweeds or macroalgae and their bioactive compounds. *World Journal of Diabetes*, 16(11):112847, 2025. URL https://doi.org/10.4239/wjd.v16.i11.112847.

[29] H. Benbaibeche, A. Z. Boumehira, and N. A. Khan. Natural bioactive compounds and their mechanisms of action in the management of obesity: A narrative review. *Frontiers in Nutrition*, 12:1614947, 2025. URL https://doi.org/10.3389/fnut.2025.1614947.

[30] F. Feldman, M. Koudoufio, Y. Desjardins, S. Spahis, E. Delvin, and E. Levy. Efficacy of polyphenols in the management of dyslipidemia: A focus on clinical studies. *Nutrients*, 13(2):672, 2021. URL https://doi.org/10.3390/nu13020672.

[31] M. S. Abdel-Bakky, H. A. Mohammed, N. I. Mahmoud, E. Amin, M. Alsharidah, O. Al Rugaie, and M. G. Ewees. Targeting the PI3K/pAKT/mTOR/NF-κB/FOXO3a signaling pathway for suppressing the development of hepatocellular carcinoma in rats: Role of the natural remedic *Suaeda vermiculata* Forssk. *Environmental Toxicology*, 39(6):3666–3678, 2024. URL https://doi.org/10.1002/tox.24217.

[32] A. Dharva, B. Joshi, and I. Patel. Distribution, phytochemical constituents and biological activities of halophytic genus *Suaeda*. *Medicinal Plants—International Journal of Phytomedicines and Related Industries*, 17(1):47–59, 2025. URL https://doi.org/10.5958/0975-6892.2025.00004.7.

[33] M. V. Faustino, M. A. F. Faustino, and D. C. G. A. Pinto. Halophytic grasses, a new source of nutraceuticals? A review on their secondary metabolites and biological activities. *International Journal of Molecular Sciences*, 20(5):1067, 2019. URL https://doi.org/10.3390/ijms20051067.

[34] G. Lefèvre and C. Rivière. Amaranthaceae halophytes from the French Flanders coast of the North Sea: A review of their phytochemistry and biological activities. *Phytochemistry Reviews*, 19(5):1263–1302, 2020. URL https://doi.org/10.1007/s11101-019-09636-w.

[35] N. Bazihizina, J. Papenbrock, H. Aronsson, K. Ben Hamed, Ö. Elmaz, Z. Dafku, L. Custódio, M. J. Rodrigues, G. Atzori, and K. Negacz. The sustainable use of halophytes in salt-affected land: State-of-the-art and next steps in a saltier world. *Plants*, 13(16):2322, 2024. URL https://doi.org/10.3390/plants13162322.