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The Effects Of Bioactive Compounds In Brown Algae (Pelvetiopsis Umitata) In Biochemical Changes Of Hyperglycemic Rats

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Abstract
Type 2 diabetes mellitus (DM) is probably one of the oldest illnesses known to man. It was initially recorded in an Egyptian manuscript around three thousand years ago. Type 2 diabetes mellitus was characterized as a component of metabolic syndrome. ***Aim:*** *present research aims to identify the effect of various amounts of brown algae (Pelvetiopsis Umitata) on biochemical alterations in hyperglycemic rats.* ***Materials and Methods:*** *Thirty-Six male Sprague Dawley rats have been separated into two main groups. The 1st group consisted of normal rats (number =6) as the control (-). The 2nd group (number =30) received an intraperitoneal injection of streptozotocin at a dose of seventy-five milligrams per kilograms, and those exhibiting blood glucose levels exceeding 250 milligrams per deciliter have been categorized as diabetic. Rats in this main group have been separated into five subgroups, (1) diabetic rats group as a control(+) (number =six) received basal diet without any treatment , (2) diabetic group (number = six) received basal diet +6% brown algae (3) diabetic group (number = six) received basal diet +9% brown algae,(4) diabetic group (number = six) received basal diet +14% brown algae & (5) diabetic group (number = six) received basal diet +18% brown algae. Following twenty-eight days, blood has been gathered, and serum was extracted to determine HbA1c, glucose, liver enzymes, kidney function and blood lipids.* ***Results:*** *Diabetic group fed on 18% brown algae had the minimal glucose concentration of any treated groups (diabetic) ever observed. Also, the diabetic group of rats fed on 9% brown algae had the minimal levels of the treated group's (ALT, AST, ALP) enzymes and (total cholesterol, triglycerides), whereas the greatest value found for diabetes group rats nourished on 14% brown algae with a significant variance (P-value not more than 0.05).*

KEYWORDS: *- (Pelvetiopsis Umitata) - bioactive compounds – hyperglycemic rats.*

Introduction

Type 2 diabetes mellitus is perhaps one of the eldest illnesses recognized by man. It was initially documented in an Egyptian manuscript around three thousand years ago. Type 2 diabetes mellitus has been identified as an element of metabolic syndrome (Qin et al., 2020). Diabetes mellitus has become known as a global epidemic in recent decades, related to distinct long-term microvascular complications affecting the kidneys, nerves, & eyes, as well as serving as a significant risk factor for cardiovascular disorder, a primary etiology of non-traumatic amputations, end-stage renal disease, and blindness. Diabetes is an illness of globally importance and raising occurrence without any plateau (Punthakee et al., 2018). The International Diabetes Federation (IDF) reported

that over 415 million individuals worldwide have been diagnosed with diabetes, with predictions indicating an increase to 700 million by 2045 in comparison with 382 million cases in 2013. Furthermore, IDF reported that this illness results in 5.1 million mortalities annually. The expense of therapy for diabetes is highs, as observed by (Akalu et al., 2020). Algae are found just about everywhere on earth: in sea, river and lakes as well as on wet soil. Algae exhibit a great diversity in size, structure, reproduction and metabolism. The size of algae ranges from a single cell in diameter to the giant kelps, in which their length may reach 60 meters (Hafez *et al.,* 2022) The differences between divisions of algae are evident when comparing the photosynthetic pigments reserve foods, cell wail, mitosis, morphology and life histories (Pereira *et al.,* 2020). (Lomartire and Gonçalv, 2023) Assessed alginate composition of eleven brown seaweeds (collected from New Zealand) using Guluronic: mannuronic a` ratios in the alginates. The alginates included twenty-five percent of the total, consisting of mannuronic a`, and twenty-five percent of the total, consisting of guluronic a`. The alginates from 2 mucilaginous, non-rigid, winter/spring annuals from the Chordariales contained the highest concentrations of guluronic acid, indicating that high concentrations of this acid aren't related to either age or rigidity of the plant. The species with the minimal yield of alginate also had the greatest amounts of guluronic a`. (Kaushik *et al.,* 2023), studied the fermentable of dietary fiber in dried products of brown algae & their effects on caecal microflora and concentration of plasma lipid in rats. The content of dietary fiber, alginate & laminaran, in 22 dried products of brown algae & their fractions were used. (Agarwal *et al.,* 2022), Examined the influence of the brown seaweeds (Wakame) on metabolism of lipid. The activity of liver enzymes associated with fatty acid oxidation and production have been examined in rats feeding diets with varying amounts of dried powder from the brown seaweed, Undaria pinnatifida (wakame). The findings indicate that alterations in the enzymatic activity related to the metabolism of fatty acids in the liver explain the serum triacylglycerol-reducing effect of dietary wakame. Consequently, wakame might be beneficial as a food for avoiding hyperlipidemia. (Ahmed et al., 2023) Algae produce a diverse array of proteins and peptides exhibiting several biological actions, involving antidiabetic properties. Certain peptides generated from algae have shown inhibitory effects on dipeptidyl peptidase-4 (DPP-4), an enzyme that degrades incretin hormones. Through inhibiting DPP-4, these peptides can extend the duration of incretin activity, resulting in better control of glucose and increased insulin production. (Anklam et al., 2022) It has been discovered that compounds derived from algae inhibit α-amylase & α-glucosidase, two enzymes included in the absorption and digestion of carbohydrates. Through inhibiting these enzymes, compounds produced from algae may delay the degradation of complex carbohydrates into glucose & diminish the rate of absorption of glucose from the intestines. Hyperglycemia after the meal is avoided as due to of a slower and more regulated production of glucose into the blood (Marques et al., 2023). The efficacy of algae-derived natural products in managing diabetes arises from their varied mechanisms of action. These bioactive compounds possess the ability to influence essential pathways related to homeostasis of glucose, sensitivity of insulin, and the prevention or mitigation of complications related to diabetes. Utilizing the full therapeutic potential of natural products derived from algae requires a comprehensive knowledge of these mechanisms (Jin et al., 2023)

2- AIM OF STUDY: -

This goal of this research aims to identify the effect of different levels of brown algae *(Pelvetiopsis Umitata)* **on** biochemical alteration in hyperglycemic rats

3- MATERIALS AND METHODS: -

A- Source of Brown algae *(Pelvetiopsis Umitata)***:** Brown algae *(Pelvetiopsis Umitata)* was obtained from sea rocks, Al-Qunfada coastal area- KSA. The harvested algae were washed in sea water followed by fresh water to get red from sand and dirts. The washed algae were subjected to sun drying for 1.5 day then kept in shad for complete drying. The dried algae were ground into powder and kept it in close containers for the subsequent chemical analysis and animal experiment. (Russo, 2001).

B-Rats: Thirty-six adult male albino rats (Sprague-Dawley strain). Thirty-six rats , weighing between 150 and 170 grams, had been obtained from the Animal Unit of Egypt's Ministry of Health at Helwan Farm. For a duration of two weeks, the rats have been housed in individual plastic under inside controlled environments, maintaining a temperature of twenty-two degrees Celsius and a twelve-hour light/dark cycle at the Faculty of

Home Economics, Menoufia University, Egypt. Rats possess unlimited access to water and food. The Guiding Principles for Animal Care and Use established by the National Institutes of Health were followed to in all experiments. Following a two-week acclimatization period, rats hav bee weighed and allocated to one of two groups: diabetic thirty rats) and normal (six rats).

C- Induction of Diabetes (T1DM): Following the acclimatization of rats for a period of two weeks, T1DM has been induced through intraperitoneal injections of streptozotocin (STZ), as explained previously. The rats received an intraperitoneal injection of Streptozotocin at a dose of seventy-five milligram per kilogram (Sigma-Aldrich, St. Louis, MO, the United States of America After this, all rats fasted for eight hours. and blood samples have been subsequently collected from the retro-orbital veins for measuring blood glucose concentration. Diabetic rats with blood glucose levels exceeding 250 milligrams per deciliters had been involved in the research. after the removal of rats with blood glucose levels below 250 milligrams per deciliter and dead rats, twenty-four rats had been involved in the study and later developed diabetes. Furthermore, rats with diabetes.

D- Diets:

- Basal diet: The basal diet comprises protein (ten percent), corn oil (ten percent), choline chloride (0.2 percent), cellulose (five percent), combination of vitamin (one percent), salt combination (four percent) **(Hegested et al., 1941),** & corn starch (to one hundred percent). in accordance with AIN (1993)

E- Experimental Design

The study comprised both normal rats (six rats) and diabetic rats (twenty-four rats). The standard diet was given to all of the rats who were included in this research, in addition to following to the experimental procedure. The suggested interventions were orally administered one time daily. **AIN., (1993)** Additionally, the weights of the rats have been documented, and subsequent to that, diabetic rats have been separated into experimental groups in accordance with their results. The experimental groups included the following:

1- The non-diabetic group (ND-Gr) comprised six normal rats, each received two milliliters of distilled water orally one time per day.

2- The diabetic control group (DC-Gr) comprised six diabetic rats that received two milliliters of distilled water orally one time per day

3- The diabetic group (DC-Gr), comprised six rats, received basal diet + 6% brown algae

4- The diabetic group (DC-Gr), comprised six rats, received basal diet + 9% brown algae

5- The diabetic group, comprised six rats, received basal diet + 14% brown algae

6- The diabetic group, comprised six rats, received basal diet + 18% brown algae

F- Chemical methods:

Moisture content: The moisture content has been assessed following the AOAC (2005) method, utilizing an air oven at 100-102 degrees Celsius for approximately three hours. **Total nitrogen and crude protein:** The total nitrogen has been measured utilizing the Marco Kjeldahl technique, in accordance with AOAC (2005). Crude protein is determined as T.N.X6.25.

Fat content: The fat content has been measured using the technique recommended by the AOAC (2005). The Soxhlet device has been utilized. With n-hexane acting as the extraction solvent, the extraction process continued for a total of sixteen hours.

Ash content

Following the charring, the ash content has been determined using a technique that was described by the AOAC in 2005. The samples have been situated in muffle g furnace at 525 degrees Celsius until light grey or white ash has been attained.

Crude fiber: Crude fiber has been estimated using technique of Pearson, (1970). The sample was first digested in boiling 0.128 M sulfuric a` for forty-five minutes, followed by washing using distilled water 3 times, subsequently digested via boiling 0.223 M potassium hydroxide, subsequently washed using distilled water

3 times, followed by washing using acetone (cold extraction) 3 times, and finally dried at 150 degrees Celsius for an hour & finally weight.

Carbohydrates content: The carbohydrate has been estimated through the variance as follows: % carbohydrates = 100 – (%protein +% moisture +% fiber +%ash + % fat) according to FAO (1982).

Energy value

Total calories: has been estimated through multiplying one-gram carbohydrates and protein by 4.0- and one-gram fat by 9.0 according to **FAO (1982).**

Determination of active compounds:

Identification of phenolic compounds:

The extract was analyzed utilizing HPLC by utilizing an Agilent 1200 chromatograph, which included a PDA model G1315B, a Bin pump type G1212A, an auto-sampler model G1313A, & an RR Zorbax Eclipse plus C18 column (1.8-millimeter, 150-millimeter x 4.6 millimeter). Mobile phase A consisted of 0.2% formic a` in water, whereas mobile phase B comprised acetonitrile. Elution has been conducted at a flow rate of 0.95 milliliter per minute with the subsequent gradient program for solvent B: 0-20 minutes, five to sixteen percent; twenty to twenty-eight minutes, sixteen to forty percent; twenty-eight to thirty-two minutes, forty to seventy percent; thirty-two to thirty-six minutes, seventy to ninety-nine percent; thirty-six to forty-five minutes, ninety-nine percent; & 45-46 minutes. 99-5%30.

The injection volume was eleven milliliters. Wavelengths of 280 nanometers (for benzoic a` and flavones derivatives) and 360 nanometers (for cinnamic a` & flavones derivatives) have been designated for recognition. The quantification of the compounds was conducted utilizing calibration curves derived from HPLC analysis of pure standards. caffeic a`, Gallic a`, (-)-epicatechin, (+)-catechin, & ellagic a` rotini were utilized as an internal standard. Certain compounds have been measured as equivalents of the most analogous chemical structures: ellagic a` for ellagic a` pent side. The HPLC technique was utilized as per **Radovanovic and Radovanovic (2010).**

H- Biological evaluation:

The biological assessment of the diverse diets has been conducted by calculating the food efficiency ratio (FIR) and body weight gain % (BWG) in accordance **with Chapman et al., 1959]** utilizing the following formulas:

$$BWG = \frac{\text{Final weight} - \text{initial weight}}{\text{Initial weight}}$$

$$FER = \frac{\text{Gain in body weight (g)}}{\text{Feed intake (g)}}$$

G- Blood sampling: Initially, blood samples have been collected from the retro-orbital vein after a fasting interval of twelve hours, while at the end of each experiment, they have been gathered from hepatic portal vein. Samples of the blood have been gathered into clean, dry centrifuge glass tubes & permitted to clot in a water bath at thirty-seven degrees Celsius for twenty-eight minutes. The serum was subsequently separated by centrifuging the tubes at four thousand revolutions per minute for ten minutes. The serum has been cautiously aspirated & transferred to a clean Eppendorf tube, where it was kept at minus twenty degrees Celsius until analysis. This method was labeled by **(Schermer,1967).**

H- Chemical Analysis:

Lipid profile:

- Measurements of serum triglycerides: The serum triglycerides have been measured utilizing enzymatic methods and kits in accordance with **(Young, 1975 and Fossati,1982).**

- - Measurements of serum total cholesterol: Serum total cholesterol has been measured using the colorimetric technique previously explained by **(Thomas,1992).**

Measurements of high-density lipoprotein (HDL-c): HDL-c has been estimated in accordance with the technique established with **(Fredewaid 1972 & Grodon & Amer, 1977).**

- **Measurements of very low-density lipoprotein cholesterol (VLDL-c):** very low-density lipoprotein cholesterol has been measured in milligrams per deciliter in accordance with **(Lee & Nieman,1996).**

Measurements of low-density lipoprotein cholesterol (LDL-c): low-density lipoprotein cholesterol has been measured in milligrams per deciliters in accordance with **(Lee and Nieman ,1996).**

- **Determination of atherogenic index (AI): Determination of AI = (LDL-c + very low-density lipoprotein cholesterol) (Kikuchi-Hayakawa *et al.,* 1998).**

Liver functions:

- **Measurements alanine transaminase: -** conducted regarding the procedure of **(Clinica Chimica Acta, 1980).**
- **Measurements aminotransferase (AST)** Measurements of serum aminotransferase has been carried out in accordance with the technique of **(Hafkenscheid ,1979).**
- **Measurements of serum globulin:** Serum globulin has been determined in accordance with the method defined by **(Henry, 1964).**
- **Serum albumin (SAlb):** Serum albumin has been determined with regard to the technique described by **(Doumas et al., 1971).**

Kidney functions:

- **Determination of serum urea:** Urea has been measured through enzymatic technique in accordance with **(Patton & Crouch ,1977).**
- **Measurements of serum creatinine:** Serum creatinine has been measured in accordance with the technique expressed with **(Henry ,1964).**
- **Measurements of serum uric a`**: Serum uric a` been measured calorimetrically in accordance with the technique of **(Barham & Trinder ,1972).**
- **Measurements of blood glucose:** Enzymatic measurements of serum glucose have been performed calorimetrically in accordance with the technique of **(Tinder ,1969).**

I- Statistical analysis:

The student-Newman-Keuls test has been utilized to separate the means after a significant main effect has been discovered. The data was examined via an entirely randomized factorial design [SAS, 1988]. Treatment variances (P0 value less than 0.05) have been deemed significant by the Costat Program. Analyses of biological outcomes were conducted using one-way ANOVA. **(Snedecor and Cochran, 1967)**

- **Ethical Approval**

The Science Research Ethics Committee of the Faculty of Home Economics accepted the protocol of the research #10-SREC-10-2022.

4- RESULTS AND DISCUSSION

Chemical composition of brown algae *(Pelvetiopsis Umitata)* **powder:**

Information presented in Table (1) illustrate the chemical composition of brown algae *(Pelvetiopsis Umitata)* powder .

It is clear to notice that brown algae *(Pelvetiopsis Umitata)* are a rich source of nutritional components such as carbohydrates (52.31), proteins (10.22), fat (2.2), ash (11.31), dietary fibers (12.0). These results agree with **(Nowakowska et al.,2020),** brown algae have been categrized as a natural source of low-calorie sweetener, because of the fact it may create an intensively sweet taste and a low energy value. Therefore, the brown algae may be utilized as a regulator for blood glucose and weight control for obesity.

Table (1): Chemical composition of brown algae *(Pelvetiopsis Umitata):*

Constitutes	**D/W**
Moisture	11.96
Protein	10.22
Fat	2.2
Ash	11.31

Fiber	12.0
Carbohydrates	52.31

DW= Dry Weight

Phenolic compound of brown algae *(Pelvetiopsis Umitata)***:**
Information presented in table (2) show the phenolic compounds of brown algae fractionation through HPLC analysis (milligrams per kilogram on dry weight basis). The largest concentrations of phenolic compounds in brown algae were found for quercetin, catechin, and gallic a`. The mean values were 1326.01, 139.55, and 96.15 mg/g on a dry weight basis, correspondingly. The lowest concentrations of phenolic compounds in brown algae were found for cinnamic a`, ferulic a`, and methyl gallate. The mean readings were 1.75, 5.15, and 14.05 milligrams per gram on a dry weight basis, correspondingly. These results agree with the quantification and identification of phenols is frequently carried out through High Performance Liquid Chromatography (HPLC). **(Borazjani et al., 2017)** stated the recognition of caffeic a, Chlorogenic a`, rutin and Trans-Ferulic acid in stevia leaves extracted through maceration technique.

Table (2): Identified phenolic compound of brown algae *(Pelvetiopsis Umitata)* **fractionation by HPLC**

Phenolic compounds	**Concentration (mailgram per gram)**
Gallic acid	96.15
Chlorogenic acid	63.63
Catechin	139.55
Methyl gallate	14.05
Caffeic acid	17.84
Syringic acid	ND
Pyro catechol	28.94
Rutin	82.07
Ellagic acid	41.69
Vanillin	ND
Ferulic acid	5.15
Naringenin	31.33
Daidzein	ND
Quercetin	1326.01
Cinnamic acid	1.75
Apigenin	ND
Kaempferol	21.57
Hespertin	25.79

ND = Not detectable.

Biological results

Effect of brown algae *(Pelvetiopsis Umitata)* **on BWG, feed intake & feed efficiency ratio of diabetic rats:**
Information presented in table (3) illustrate the effect of **brown algae** *(Pelvetiopsis Umitata)* as powder on feed efficiency ratio, body weight gain, & feed intake of diabetic rats.

Data obtained from body weight gain illustrated that a significant variance has been observed among (-) control and (+) control group. The mean values were 21.15 and 14.57g, correspondingly. The highest body weight gains of groups that have bee treated (diabetic) documented for diabetic group rats nourished on 9% brown algae**.** Whereas the minimal value documented for diabetic group rats nourished on 18% brown algae, the mean values were 19.70 and 10.27g, correspondingly.

- Outcomes indicated a significant variance in feed intake among the (-) control & (+) control groups, with mean values of 22.00 g & 18.50 grams after twenty-eight days, correspondingly. The outcomes suggested that the managed diabetic group of rats had the maximum feed consumption when nourished nine percent brown

algae. The diabetic group of rats had the lowest documented value when fed an eighteen percent brown algae diet. The average values were 20.50 and 17.20 gram per day, correspondingly.
- Conversely, information derived from the feed efficiency ratio revealed significant variance among the (-) control group & the (+) control group. The mean values were 0.035% & 0.028%, correspondingly. The managed group of diabetic rats had the best feed efficiency ratio when nourished an eighteen percent brown algae diet. The minimal value reported was for diabetic group rats that were given nine percent brown algae. The mean values were 0.021% and 0.034%, correspondingly. **The obtained data are confirmed by (Pham *et al.,* 2023)**, They stated that brown algae, a type of seaweed, show potential for weight control and weight loss due to several bioactive compounds and dietary fiber content. These compounds can influence satiety, metabolism, and fat absorption, potentially aiding in weight management.

Table (3): Effect of various levels of brown algae *(Pelvetiopsis Umitata)* **on BWG, FI and FER of diabetic rats**

Parameters Groups	BWG (g/28day)	FI (g/28day)	FER (%)
	M±SD	M±SD	M±SD
G(1) Control (-)	21.15 a ±0.60	22.00 a ±0.70	0.035 a ±0.08
G(2) Control (+)	14.57 c ±0.30	18.50 c ±0.40	0.028 a ±0.02
G(3) 6% *(Pelvetiopsis Umitata)*	15.69 c ±0.50	20.00 b ±0.20	0.028 a ±0.04
G(4) 9% *(Pelvetiopsis Umitata)*	19.70 b ±0.40	20.50 b ±0.50	0.034 a ±0.06
G(5) 14%*(Pelvetiopsis Umitata)*	12.70 d ±0.20	18.00 c ±0.30	0.025 b ±0.03
G(6)18% *(Pelvetiopsis Umitata)*	10.27 e ±0.10	17.20 d ±0.20	0.021 b ±0.01
LSD (P≤0.05)	1.073	1.162	0.008

Each value represents the mean ± SD of three replicates. Mean under the same column bearing various superscript letters are different significantly (p0value not more than 0.05*)*

Effect of brown algae *(Pelvetiopsis Umitata)* **on glucose levels of diabetic rats:**
The information listed in table (4) illustrates how different levels of brown algae affect the glucose consecration of diabetic rats. The (-) & the (+) control group differed significantly. The corresponding mean values were 114.35 & 242.22 milligram per deciliter. The diabetic group nourished on 18% brown algae had the minimal glucose concentration of any treated groups (diabetic) ever observed. The mean values were 119.10 and 165.00 milligram per deciliter, correspondingly, with the greatest value being observed for diabetic group rats fed 6% brown algae, with significant differences**. These findings support (Wang et al., 2023)** they demonstrated that the chemical components of brown algae can help lower plasma glucose levels. Specifically, phlorotannins, a type of polyphenol found in brown algae, have shown the ability to inhibit enzymes like alpha-amylase and alpha-glucosidase, that have a role in absorption of glucose and digesting carbohydrates. Through inhibiting these enzymes, brown algae may slow the absorption and degradation of carbohydrates, resulting in decreased glucose concentrations following the meal. Additionally, some brown algae extracts have shown potential in reducing fasting blood glucose levels.

Table (4): Effect of various levels of brown algae *(Pelvetiopsis Umitata)* **on glucose levels of diabetic rats**

Parameters Groups	Glucose level (milligram per deciliter)
G(1) Control (-)	114.35 f ±3.20
G(2) Control (+)	242.22 a ±6.73
G(3) 6% *(Pelvetiopsis Umitata)*	165.00 b ±4.50
G(4) 9% *(Pelvetiopsis Umitata)*	131.45 c ±4.42
G(5) 14%*(Pelvetiopsis Umitata)*	123.75 d ±3.35
G(6)18% *(Pelvetiopsis Umitata)*	119.10 e ±3.23
LSD (P≤0.05)	4,342

Effect of various of brown algae *(Pelvetiopsis Umitata)* **on liver functions of diabetic rats:**

Information are shown in table (5) demonstrate the impact of various levels of brown algae on diabetic rats' liver functions (AST, ALP, & ALT). It is obvious to see that the liver hepatic ALT significantly differed among the positive and negative control groups (62.34 and 159.75U/L respective). The diabetic group of rats fed on 9% brown algae had the minimal levels of the treated group's ALT enzyme. The mean values were 82.34 and 145.90 unit per liter, correspondingly, with the greatest value being observed for diabetes group rats nourished on 14% brown algae with significant variances (P-value not more than 0.05).

- According to the findings, a substantial variance has been observed among the negative control group and the positive control group in the case of AST. The relative mean values were 152.20- and 294.75-unit pe liter. The diabetic group of rats fed on 9% brown algae had the minimal concentrations of the treated group's AST enzyme. The mean values were 192.25- and 239.57-unit pe liter, correspondingly, with the greatest value being observed for diabetes group rats nourished on 14% brown algae with a significant variance (P-value not more than 0.05).
- The liver enzyme ALP significantly differed among the (+) and (-) control groups. They were 164.55 and 310 U/L on average, correspondingly. The diabetic group of rats fed 9% brown algae had the minimal ALP enzyme level among any managed groups. The mean values were 183.75- and 283.50-unit pe liter, correspondingly, with the highest value being found in the diabetic group of rats nourished on 14% brown algae with a significant variance (P-value not more than 0.05). **These outcomes are in line with (Arora et al., 2021),** who discovered that Brown algae supporting liver health and may be beneficial in managing hepatic illnesses like cirrhosis because of its bioactive compounds with anti-inflammatory, antioxidant, and lipid-lowering properties. Also, brown algae can help alleviate liver steatosis and fibrosis, potentially offering a natural therapeutic approach. they showed also that brown algae are rich in compounds like fucoidan, alginate, and laminarin, which have demonstrated various beneficial effects on liver health.

Table (5): **Effect of va lriousevels of brown algae** *(Pelvetiopsis Umitata)* **on hepatic functions of diabetic rats.**

Groups	Parameters		
	ALT (unit per liter)	**AST (unit per liter)**	**ALP (unit per liter)**
G(1) Control (-)	62.34 f ±0.10	152.20 f ±4.20	164.55 f ±3.30
G(2) Control (+)	159.75 a ±0.60	294.75 a ±6.30	310.00 a ±6.80
G(3) 6% *(Pelvetiopsis Umitata)*	115.00 d ±0.30	201.00 d ±4.40	217.80 d ±5.40
G(4) 9% *(Pelvetiopsis Umitata)*	82.34 e ±0.20	192.25 e ±3.70	183.75 e ±4.50
G(5) 14%*(Pelvetiopsis Umitata)*	145.90 b ±0.50	239.57 b ±5.60	283.50 b ±5.70
G(6)18% *(Pelvetiopsis Umitata)*	130.87 c ±0.40	209.40 c ±4.50	243.65 c ±4.60
LSD (P≤0.05)	2.314	2.635	2.706

Effect of different levels of brown algae *(Pelvetiopsis Umitata)* **on serum total cholesterol & triglycerides of diabetic rats.**

Information presented in table (6) revealed how different levels of brown algae affected diabetic rats' blood total cholesterol and triglycerides. It goes without saying that the total concentration of cholesterol among the (-) control group and the (+) control group were significantly different. 94.00 and 226.15 mg/dl were the respective means. Rats in the diabetic group fed 9% brown algae had the minimal total cholesterol of among managed groups, according to records. The mean values were 127.25 & 207.40mg/dl, correspondingly, with the greatest value being observed for the diabetes group rats nourished on 14% brown algae with a significant variance (P-vale not more than 0.05).

-Data illustrated that a substantial variance has been observed among the (-) control group and the (+) control group in the case of triglycerides. There were two different mean values: 83.33 and 178.75. The diabetic group of rats fed 9% brown algae had the lowest triglyceride levels of among treated groups. The mean values were 105.74 and 159.75, correspondingly, with the greatest value being observed for diabetes group rats nourished on 14% brown algae, with a significant variance. **These results finding in line with (Subermaniam et al., 2021),** who observed that consuming brown algae or extracts from it can lead to a reduction in triglyceride concentration, particularly in persons having high lipid levels. This effect is often linked to the presence of

bioactive compounds in brown algae, suchlike fucoidans and phlorotannins, which can These compounds can affect cholesterol biosynthesis, potentially by modulating the high-affinity receptor of lipoprotein metabolism. They can also rise excretion of cholesterol in feces by binding to dietary cholesterol .

Table (6): Effect of various levels of brown algae *(Pelvetiopsis Umitata)*on serum total cholesterol and triglycerides of diabetic rats.

Groups	Parameters	
	Total cholesterol (milligram per deciliter)	Triglyceride (milligram per deciliter)
G(1) Control (-)	94.00 f ±0.31	83.33 f ±0.25
G(2) Control (+)	226.15 a ±0.82	178.75 a ±0.71
G(3) 6% *(Pelvetiopsis Umitata)*	157.25 d ±0.52	119.65 d ±0.41
G(4) 9% *(Pelvetiopsis Umitata)*	127.65 e ±0.40	105.74 e ±0.37
G(5) 14%*(Pelvetiopsis Umitata)*	207.40 b ±0.64	159.75 b ±0.50
G(6)18% *(Pelvetiopsis Umitata)*	175.35 c ±0.60	133.59 c ±0.31
LSD (P≤0.05)	3,480	3.358

Effect of various levels of brown algae *(Pelvetiopsis Umitata)* on HDLc- LDLc- VLDLc of diabetic rats:
Data are illustrated in a table (7) demonstrate the impact of different levels of brown algae form on diabetic rats' concentration of (HDL-c), (LDL-c), & (VLDL-c). (HDL-c) concentrations clearly differ significantly among the (-) control group & the (+) control group. (50.33 and 24.09 milligram per deciliter on average, correspondingly). The diabetic group of rats fed 9% brown algae had the greatest HDL-c concentration of among treated groups. The mean values were 42.65 and 31.80, correspondingly.
-Information illustrated that there are substantial variances among the (-) control group & the (+) control group in the case of (LDL-c) concentration. There were two mean values 27.01 and 166.3 mg/dl. The diabetic group of rats fed 9% brown algae had the minimal LDL-c among the treated groups. The mean values were 63.85, with the highest value (139.71 mg/dl) being observed for the diabetic group of rats nourished on 14% brown algae with a significant variance (P-value under 0.05).
-Nonetheless, there are notable variations in very high-density lipoprotein cholesterol among the (-) control group and the (+) control group (VLDL-c). (16.66 and 35.75 milligrams per deciliters on average, correspondingly) . The diabetic group of rats nourished on 9% brown algae had the lowest VLDL-c among the treatment groups. The mean values were 21.15, while the highest value (31.95 mg/dl) was measured in diabetes group rats fed on 14% brown algae with a significant variance ((P-value under 0.05). Moreover, **(Popovic et al., 2021),** discovered that brown algae can raise HDL cholesterol levels while declining triglyceride, total cholesterol, LDL cholesterol, and VLDL cholesterol. The decrease in total cholesterol levels is caused by a rise in bile acid excretion that is caused by preventing small intestine reabsorption by disrupting micelle formation. The 7-hydroxylase for cholesterol is activated by increased bile acid excretion, it lowers cholesterol by accelerating the conversion of hepatic cholesterol to bile a` .

Table (7): Effect of various levels of brown algae *(Pelvetiopsis Umitata)* on HDLc- LDLc- VLDLc of diabetic rats.

Groups	Parameters		
	HDL-c (milligram per deciliter)	LDL-c (milligram per deciliter)	VLDL-c (milligram per deciliter)
G(1) Control (-)	50.33 a ±0.60	27.01 f ±0.12	16.66 f ±0.20
G(2) Control (+)	24.09 e ±0.11	166.31 a ±0.63	35.75 a ±0.51
G(3) 6% *(Pelvetiopsis Umitata)*	38.14 c ±0.43	95.18 d ±0.32	23.39 d ±0.40
G(4) 9% *(Pelvetiopsis Umitata)*	42.65 b ±0.52	63.85 e ±0.27	21.15 e ±0.30
G(5) 14%*(Pelvetiopsis Umitata)*	35.99 c ±0.35	139.46 b ±0.50	31.95 b ±0.40
G(6)18% *(Pelvetiopsis Umitata)*	31.80 d ±0.21	116.85 c ±0.41	26.70 c ±0.33

LSD (P≤0.05)	2.360	2.615	1.115

Effect of different levels of brown algae *(Pelvetiopsis Umitata)* **on renal functions of diabetic rats:**
The effects of various concentrations of brown algae on the renal functions of diabetic rats (serum creatinine, serum urea, and serum uric a`) are shown in the table (8). It is clear to realize that there was a substantial variance between serum uric a` values of the (+) & (-) control groups. The relative mean values were 3.97and 6.84 milligrams per deciliters, correspondingly.
-In contrast, diabetic group rats fed with 214% brown algae had the highest uric serum (6.04 mg/dl), whereas the minimal value for diabetes group rats nourished on 9% brown algae with significant variance was recorded 4.64 mg/dl. Data for serum urea illustrated significant variances between the (+) control group & (-) control group, with mean values of 50.20 and 22.80 milligram per deciliter, correspondingly.
On the other hand, diabetic group rats nourished with 14% brown algae had the highest serum urea level of the treated group, whereas the lowest value for diabetes group rats fed on 9% brown algae was significantly different by 34.68 mg/dl.
The serum creatinine of the (+) control group, in contrasts, was significantly higher in comparison with that of the (-) control group. The relative mean values were 1.21 & 0.60 milligrams per deciliters. The diabetic group of rats nourished on 14% brown algae had the greatest serum creatinine concentration of any treated group, however. With significant differences, the minimal value has been detected in diabetic group rats fed on 9% brown algae the mean values which were 0.99 and 0.69 milligrams per deciliters, correspondingly. **These finding are in line with (Sanches et al., 2023)** who discovered that Brown algae, particularly the sulfated polysaccharide fucoidan, has shown potential benefits for kidney health, including protective effects against various kidney problems. Traditional uses of brown seaweed in some cultures also support its role in managing kidney-related issues like edema, a symptom of kidney disease.

Table (8): Effect of various levels of brown algae *(Pelvetiopsis Umitata)* **on renal functions of diabetic rats.**

Groups	Parameters		
	Urea milligrams per deciliters	**Uric a` milligrams per deciliters**	**Creatinine milligrams per deciliters**
G(1) Control (-)	22.80 f ±0.15	3.97 e ±0.26	0.60 b ±0.13
G(2) Control (+)	50.20 a ±0.61	6.84 a ±0.50	1.21 a ±0.40
G(3) 6% *(Pelvetiopsis Umitata)*	41.19 c ±0.42	5.34 d ±0.31	0.80 b ±0.38
G(4) 9% *(Pelvetiopsis Umitata)*	34.68 e ±0.29	4.64 e ±0.14	0.69 b ±0.22
G(5) 14%*(Pelvetiopsis Umitata)*	46.64 b ±0.50	6.04 b ±0.41	0.99 a ±0.41
G(6)18% *(Pelvetiopsis Umitata)*	39.19 d ±0.33	5.71 c ±0.32	0.89 a ±0.35
LSD (P≤0.05)	1.104	1.335	0.360

5. Conclusion
The study highlights the potential of brown algae *(Pelvetiopsis umitata)* in enhancing the biological condition of hyperglycemic rats, suggesting its promising role in managing hyperglycemia.Where brown algae are known to contain bioactive compounds like phlorotannins, which have demonstrated inhibitory effects on enzymes included in absorption of glucose, like α-amylase and α-glucosidase. This inhibition can lead to amended glycemic control and decreased absorption of glucose.

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