



(RESEARCH ARTICLE)



BIOCHEMICAL EVALUATION OF THE SYNERGISTIC EFFECTS OF A MIXTURE OF SOME PLANT AQUEOUS EXTRACTS ON LIVER AND KIDNEY FUNCTION BIOMARKERS IN MALE ALBINO RATS

Shahad Imad Hameed ^{1,*}, Alaa M. Dh. Al-Haidari ¹ and Rayaheen Mohammed Tamkeen ²

¹ Department of Biology, College of Science, University of Baghdad, Baghdad, Iraq.

² College of Science, University of Baghdad, Baghdad, Iraq.

* Corresponding Author; Email: shahad.emad@sc.uobaghdad.edu.iq

ORCID Details

Shahad Imad Hameed: <https://orcid.org/0000-0001-8154-6440>

Alaa M. Dh. Al-Haidari: <https://orcid.org/0009-0007-3477-0088>

Rayaheen Mohammed Tamkeen: <https://orcid.org/0009-0001-2880-6626>

Magna Scientia Advanced Biology and Pharmacy, 2026, 19(01), 021–030

Publication history: Received on 12 August 2026; revised on 20 September 2026; accepted on 22 September 2026

Article DOI: <https://doi.org/10.30574/msabp.2026.19.1.0072>

Copyright © 2026 Author(s) retain the copyright of this article. This article is published under the terms of the Creative Commons Attribution License 4.0

ABSTRACT

This study evaluated the effects of aqueous extracts from *Apium graveolens*, *Petroselinum crispum*, *Mentha spicata*, and *Ocimum basilicum* on liver and kidney functions in male albino rats. Using two experimental models (78 rats), Model 1 tested individual concentrations (25, 50, and 100 mg/kg), while Model 2 focused on synergistic combinations. Key parameters included AST, ALT, ALP, bilirubin, albumin, creatinine, BUN, and electrolytes (Na⁺, K⁺, Cl⁻).

Results indicated that *Mentha spicata* and *Ocimum basilicum* at 100 mg/kg were the most effective, significantly reducing liver enzymes and kidney biomarkers within healthy physiological ranges. Specifically, the combination of these two plants showed the most potent synergistic effect in optimizing biochemical profiles. Conversely, *A. graveolens* and *P. crispum* exhibited inconsistent results, sometimes causing fluctuations outside normal ranges, likely due to chemical interactions or dosage levels. The study concludes that the combination of *M. spicata* and *O. basilicum* (100 mg/kg) serves as a superior hepatoprotective and nephroprotective formula compared to the other tested extracts.

Keyword: Liver Parameters, Kidney Functions, *Apium Graveolens*, *Petroselinum crispum*, *Mentha spicata*, *Ocimum basilicum*.

1 INTRODUCTION

The kidneys are crucial to human physiology because they filter and eliminate nitrogenous and other waste materials, control blood pressure, erythrocyte formation, bone density, and hormone balance. They also maintain fluid homeostasis [1]. A reliable test to measure renal function is the measurement of blood urea nitrogen (BUN) and creatinine [2].

A protein called creatinine is produced from creatinine in muscle. Without catalysts and after being dehydrated in the muscles, creatinine is changed into creatinine and goes into the bloodstream. Most skeletal muscle produces creatinine, which the kidneys are the only organs that can eliminate it; therefore, serum creatinine levels rise in response to impairments in renal function, as indicated by the assessment of this biomarker [3]. Blood urea nitrogen (BUN), which is thought to be the main nitrogen-containing material in mammal urine, is crucial for the metabolism of nitrogen-containing molecules in animals. As part of the urea cycle, urea is created through the oxidation of ammonia or amino acids. The blood contains 2.1 to 8.5 mmol/L of dissolved urea, which the kidneys eliminate as part of urine. An essential component of human body metabolism is the kidneys' control of the urea level [3].

The liver is essential for the control, synthesis, storage, and secretion of nutrients, proteins, and other substances [4]. The liver is also the hub for detoxification procedures and the metabolic conversion of medications and other xenobiotic. According to [5], oxidative stress has been shown to be a major factor in the onset and progression of a number of chronic liver disorders by causing damage to liver cells and contributing to ischemia, regeneration, necrosis, and apoptosis. Elevations in liver function tests for aspartate aminotransferase (AST) and alanine aminotransferase (ALT) have been detected [6].

Due to a growing interest in natural medicines and their possible health benefits. The safety of these herbal substances has drawn criticism, mainly because of hepatotoxicity and nephrotoxicity, despite their possible therapeutic benefits [7].

Apium graveolens (celery), *Petroselinum crispum* (parsley), *Mentha spicata* (spearmint) and *Ocimum basilicum* (basil) are important medicinal plants, they are widely utilized in traditional medicine due to its main components in (Celery and parsley) are limonene, flavonoids, selenene, steroids, alkaloids, carbohydrates, carotenoids, coumarins and apiole [7]. Celery can help avoid rheumatoid arthritis-related ailments, liver problems, cardiovascular illnesses, and jaundice [8]. While parsley is used to cure rheumatism, edema, colic, flatulence, jaundice, and liver and prostate disorders, also used as an antihyperlipidemic, as an antihep-atotoxic, and as a laxative [9].

The existence of active ingredients such carvone, menthol, rosmarinic acid, and menthol is what causes these effects of *M. spicata* [10]. Spearmint oil possesses antioxidant, anti-inflammatory, anti-tumor, anti-microbial, and anti-fungal properties [11, 12]. *O. basilicum* (basil) exhibit strong antiviral, anticancer, anti-aging, and antibacterial qualities [13, 14]. Basil is used in a wide range of pharmacological actions. Strong antioxidant, anti-aging, anticancer, antiviral, and antibacterial qualities can be found in basil leaf extracts [15, 16], lipoprotein, triglycerides, and total cholesterol have all been shown to decrease when basil oil is consumed [16].

This research aimed to evaluate the effects of aqueous extracts of some plants alone and in combination on albino rat liver and kidney functions.

2 MATERIALS AND METHODS

2.1 Collection of plant samples

Plant samples, including fresh leaves of *Mentha spicata*, *Ocimum basilicum*, *Petroselinum crispum*, and *Apium graveolens* were collected from the nursery in Baghdad, Iraq. Each sample was pulverized into tiny pieces (2 cm) with a blender prior to the extraction procedure, and it was then kept in glass containers at room temperature in a dry, dark place.

2.2 Preparation the aqueous extracts of plants

An aqueous extract was prepared for each plant using a distinct method based on the plant sections [17]. Each extract was then refrigerated until required. Different concentrations of each plant were produced by dissolving a specified weight of each plant extract powder in D.W. at the necessary concentration, then different plant extract concentrations (mg/ml) were prepared according the following Eq. (1)[18]:

$$\text{Concentration} \frac{\text{mg}}{\text{ml}} = \frac{\text{weight}}{\text{volume} \times 1000} \quad (1)$$

2.3 Laboratory animals

Seventy-eight male albino rats, ranging in age from eight to ten weeks and weighing between 60-100 grams, were obtained from the National Centre for Drug Control and Research. They were housed according to an experimental protocol devised by OCED and maintained within a temperature range of $27 \pm 2^\circ\text{C}$ [19]. The Research and Production Centre for Veterinary Drug was the site of the research, all of which followed ethically approved methods. The rats were randomly divided into 12 groups, and each group with 6 rats which was kept in a separate plastic cage. Rats were housed

in normal humidity, temperature, and ventilation conditions. There were food and water for everyone. Every animal was sacrificed at the investigation's end.

2.4 Experimental Design

2.4.1 Model 1

This model includes evaluating the effect of each plant extract on the liver and kidney functions of male albino rats and then testing these parameters. The parameters were analysed following a month-long trial. Rats were given three different oral doses (mg/kg) and were split into 12 groups, each with six rats, and the control group was treated with only normal saline. Based on previous research, the dosages for each plant extract were determined.

2.4.2 Model 2

This experiment was conducted to evaluate the effect of the mixture of plant extracts on the liver and kidney functions of male albino rats by choosing the best dose that reduced the levels of these parameters in model 1.

2.5 Collection of blood samples

At the end of the experimental period, a medical syringe was used to directly remove five milliliters (ml) of blood through cardiac puncture from the animals' hearts. In order to extract serum, each blood sample was put in a tube with an anticoagulant-free gel. The tube was then spun for 15 minutes at 3000 rpm to extract an adequate amount of serum free of red blood cells. Once removed, the serum was put in a unique plastic tube that was kept sterile and kept at -20 °C until it was needed [20]. To measure the levels of alkaline phosphate, aspartate transaminase (AST), alanine transaminase (ALT) total bilirubin, albumin, creatinine, BUN, and level of electrolytes Na⁺, K⁺ and Cl⁻, blood sera were obtained. Liver function parameters including alanine aminotransferase (ALT), aspartate aminotransferase (AST), alkaline phosphatase (ALP), total bilirubin, and albumin were determined using commercially available diagnostic kits on a semi-automated clinical chemistry manufacturer's instruction. ALT and AST were measured by kinetic UV methods based on NADH oxidation at 340 nm (IFCC principle), ALP was determined by the kinetic colorimetric p-nitrophenyl phosphate method, total bilirubin was measured by a colorimetric diazo or oxidation-based method depending on kit design, and albumin was measured by the bromocresol green (BCG) dye-binding method.

Kidney function parameters including serum urea (or BUN), creatinine, and electrolytes (Na⁺, K⁺, and Cl⁻) were also analyzed using standard commercial kits. Urea was determined by the enzymatic urease method; creatinine by either the Jaffe alkaline picrate or enzymatic method according to kit availability, and electrolytes by ion-selective electrode (ISE) methodology using an automated electrolyte analyzer [21].

2.6 Statistical analysis

The Statistical Packages of Social Sciences -SPSS [21]. program was used to detect the effect of difference groups and concentration in study parameters. T-test and least significant difference-LSD was used to significant compare between means in this study.

3 RESULTS

3.1 Liver parameter assay

3.1.1 The effect of plant extracts alone on liver functions

Table 1 reveals the effect of each plant extract on the level of AST, ALT, ALP, total bilirubin, and albumin of each treated group. The below results indicated that all plant extracts reduced the levels of these parameters, but in different ratios. The highest reduction was in *M. spicata* in concentration 100 mg/kg, which was 14.00 ± 0.03 in comparison to the control group, which was 24.67 ± 0.21 . On the other hand, the best extract reducing the level of ALT was *M. spicata* in a concentration of 100 mg/kg, which decreased the ALT to 15.67 ± 0.33 compared to the control group, which was 32.50 ± 0.72 . Also, reducing the level of ALP to 52.00 ± 0.68 in comparison to the control group, which was 90.58 ± 0.20 . Also, the level of total bilirubin showed the highest reduction after the oral administration with *M. spicata* in a concentration of 100 mg/kg, which was 0.445 ± 0.01 compared to the control group, which was 0.910 ± 0.01 . While the level of albumin showed a higher decrease after the oral treatment with *M. spicata* in a concentration of 100 mg/kg, which was 3.50 ± 0.03 , in comparison with the control group, which was 4.65 ± 0.02 .

Table 1: Effect of the plant extracts alone on liver functions.

Group	Conc. mg/kg	Mean ±SE				
		AST (U/L)	ALT (U/L)	ALP (U/L)	Total bilirubin (g/L)	Albumin (g/L)
Control		24.67 ±0.21 a	32.50 ±0.72 a	90.58 ±0.20 g	0.910 ±0.01 e	4.65 ±0.02 f
<i>M. spicata</i>	25	22.83 ±0.17 b	24.17 ±0.47 c	83.67 ±0.55 h	0.761 ±0.01 g	3.91 ±0.3 h
	50	19.16 ±0.60 d	20.33 ±0.21 e	75.83 ±0.48 j	0.661 ±0.01 i	3.80 ±0.03 hi
	100	14.00 ±0.36 e	15.67 ±0.33 g	52.00 ±0.68 l	0.445 ±0.01 j	3.50 ±0.03 j
<i>O. basilicum</i>	25	21.67 ±0.21 c	25.50 ±0.22 b	81.33 ±0.49 i	0.833 ±0.01 f	4.16 ±0.02 g
	50	19.67 ±0.21 d	22.67 ±0.21 d	75.16 ±0.47 j	0.698 ±0.01 h	3.71 ±0.04 i
	100	14.67 ±0.84 e	17.00 ±0.26 f	57.50 ±0.62 k	0.451 ±0.01 j	3.54 ±0.03 j
<i>P. crispum</i>	25	8.17 ±0.31 f	9.16 ±0.11 h	123.50 ±0.62 e	1.28 ±0.02 d	5.25 ±0.11 c
	50	5.67 ±0.21 g	9.17 ±0.11 h	130.00 ±0.73 c	1.361 ±0.01 b	5.33 ±0.04 bc
	100	4.33 ±0.17 h	6.58 ±0.15 i	142.33 ±0.67 b	1.425 ±0.006 a	5.58 ±0.05 a
<i>graveolence</i>	25	8.16 ±0.11 f	8.50 ±0.22 h	118.00 ±0.45 f	1.336 ±0.01 c	4.81 ±0.02 e
	50	5.33 ±0.21 g	5.25 ±0.44 j	126.67 ±0.56 d	1.358 ±0.003 b	5.05 ±0.03 d
	100	3.58 ±0.20 h	4.00 ±0.26 k	146.50 ±0.67 a	1.445 ±0.01 a	5.43 ±0.04 b
L.S.D. (P-value)		0.998 ** (0.0001)	0.933 ** (0.0001)	1.609 ** (0.0001)	0.022 ** (0.0001)	0.123 ** (0.0001)

*Means having with the different letters in same column differed significantly.; ** (P $\leq$ 0.01).**3.1.2 The effect of the mixture of *M. spicata* and *O. basilicum* on liver functions**

The results in Table 2 demonstrated the synergistic effect of *M. spicata* and *O. basilicum* in a concentration of 100 mg/kg on the biomarkers of liver functions because these extracts showed the best reduction in these parameters within the normal ranges. The level of AST was reduced to 14.83 $\pm$ 0.17 after the oral treatment with the mixture of these plants in comparison with the control group, which was 24.83 $\pm$ 0.17, while the level of ALT was decreased to 13.25 $\pm$ 0.17 compared to the control group, which was 20.50 $\pm$ 0.22. Also, the level of ALP was reduced to 54.00 $\pm$ 0.52 in comparison with the control group, which was 91.17 $\pm$ 0.31. But the level of total bilirubin was decreased to 0.431 $\pm$ 0.02, compared with the control group, which was 0.935 $\pm$ 0.01. Also, the level of albumin showed a higher reduction to 3.59 $\pm$ 0.03 compared with the control group, which was 4.53 $\pm$ 0.2.

Table 2: The effect of the mixture of *M. spicata* and *O. basilicum* on liver functions.

Group	Conc.	Mean ±SE				
		AST (U/L)	ALT (U/L)	ALP (U/L)	Total bilirubin (g/L)	Albumin (g/L)
Control		24.83 ±0.17 a	20.50 ±0.22 a	91.17 ±0.31 a	0.935 ±0.01 a	4.53 ±0.2 a
<i>M. spicata</i> and <i>O. basillicam</i>	100 mg/kg	14.83 ±0.17 b	13.25 ±0.17 b	54.00 ±0.52 b	0.431 ±0.02 b	3.59 ±0.03 b
T-test (P-value)		0.525 ** (0.0001)	0.627** (0.0001)	1.338 ** (0.0001)	0.0482** (0.0001)	0.076** (0.0001)

*Means having with the different letters in same column differed significantly.;** (P $\leq$ 0.01).**3.2 Kidney parameter assay****3.2.1 The effect of plant extracts alone on kidney functions**

The results in Table 3 revealed the effect of each plant extract on the level of creatinine, BUN, and the electrolytes (Na⁺, K⁺, and Cl⁻) on the biomarkers of kidney functions. The level of creatinine showed a higher reduction to 0.653 $\pm$ 0.01 after the oral treatment with *M. spicata* extract compared to the control group, which was 1.066 $\pm$ 0.3. While the best decrease in the level of BUN was 7.83 $\pm$ 0.21 after the oral administration with *O. basilicum* in comparison to the control

group, which was 17.83 ± 0.40 . Also, the best reduction in the level of electrolytes was shown (135.33 ± 0.21) for Na^+ after the treatment with *O. basilicum* compared with the control group, which was (143.00 ± 0.36), and for K^+ and Cl^- , it was (3.53 ± 0.02) and (98.50 ± 0.22) when treated with *M. spicata* compared with the control group, which was (4.30 ± 0.09) and (103.50 ± 0.22), respectively.

Table 3: Effect of the plant extracts alone on kidney functions.

Group	Conc. mg/kg	Mean ±SE				
		Creatinine (mg/dl)	BUN	Na+	K+	Cl-
Control		1.066 ±0.3 a	17.83 ±0.40 d	143.00 ±0.36 e	4.30 ±0.09 e	103.50 ±0.22 g
<i>M. spicata</i>	25	0.818 ±0.01 c	13.83 ±0.17 e	142.17 ±0.31 ef	4.08 ±0.04 f	102.33 ±0.21 h
	50	0.787 ±0.01 c	12.00 ±0.22 f	141.67 ±0.21 f	3.63 ±0.02 h	100.83 ±0.31 hi
	100	0.653 ±0.01 e	8.17 ±0.17 h	136.00 ±0.51 i	3.53 ±0.02 h	98.50 ±0.22 k
<i>O. basilicum</i>	25	0.873 ±0.01 b	13.50 ±0.34 e	139.17 ±0.31 g	4.10 ±0.05 f	101.33 ±0.21 i
	50	0.801 ±0.01 c	10.66 ±0.21 g	137.67 ±0.21 h	3.87 ±0.02 g	100.33 ±0.21 j
	100	0.715 ±0.01 d	7.83 ±0.21 h	135.33 ±0.21 i	3.56 ±0.03 h	98.83 ±0.17 k
<i>P. crispum</i>	25	0.526 ±0.01 f	23.67 ±0.61 c	148.67 ±0.21 cd	5.00 ±0.02 cd	105.83 ±0.31 f
	50	0.408 ±0.02 g	28.16 ±0.31 b	149.83 ±0.40 b	5.20 ±0.07 b	107.83 ±0.16 e
	100	0.333 ±0.02 h	32.67 ±0.61 a	154.33 ±0.49 a	5.51 ±0.04 a	109.67 ±0.21 d
<i>graveolence</i>	25	0.628 ±0.01 e	23.67 ±0.71 c	147.67 ±0.33 d	4.87 ±0.02 d	115.33 ±0.56 c
	50	0.518 ±0.01 f	28.67 ±0.21 b	149.33 ±0.21 bc	5.03 ±0.02 c	121.00 ±0.26 b
	100	0.343 ±0.1 h	33.00 ±0.45 a	153.33 ±0.56 a	5.50 ±0.07 a	123.17 ±0.31 a
L.S.D. (P-value)		0.035 ** (0.0001)	1.129 ** (0.0001)	1.003 ** (0.0001)	0.135 ** (0.0001)	0.781 ** (0.0001)

*Means having with the different letters in same column differed significantly.; ** ($P \leq 0.01$).

3.2.2 The effect of the mixture of *M. spicata* and *O. basilicum* on kidney functions

The results in Table 4 indicated the synergistic effect of *M. spicata* and *O. basilicum* in concentration 100 mg/kg on the biomarkers of kidney functions because these extracts showed the best reduction in these parameters within the normal ranges. The level of creatinine was reduced to 0.758 ± 0.01 compared with the control group, which was 1.033 ± 0.02 , while the level of BUN was decreased to 7.67 ± 0.21 compared to the control group, which was 17.33 ± 0.33 . Also, the levels of electrolytes (Na^+ , K^+ , and Cl^-) were reduced to 135.17 ± 0.16 , 3.50 ± 0.01 , and 98.50 ± 0.18 compared with the control group, which was 141.17 ± 0.31 , 4.56 ± 0.02 , and 100.67 ± 0.33 , respectively.

Table 4: The effect of the mixture of *M. spicata* and *O. basilicum* on kidney functions.

Group	Conc.	Mean ±SE				
		Creatinine (mg/dl)	BUN	Na+	K+	Cl-
Control		1.033 ±0.02 a	17.33 ±0.33 a	141.17 ±0.31 a	4.56 ±0.02 a	100.67 ±0.33 a
Mentha +Ocimum	100	0.758 ±0.01 b	7.67 ±0.21 b	135.17 ±0.16 b	3.50 ±0.01 b	98.50 ±0.18 b
T-test (P-value)		0.0482** (0.0001)	0.878** (0.0001)	0.779** (0.0001)	0.047** (0.0001)	0.846** (0.0001)

*Means having with the different letters in same column differed significantly.; ** ($P \leq 0.01$).

4 DISCUSSION

The current study showed how plant extracts, both alone and in combination, can affect liver and kidney parameters. Table 1 results were consistent with those of [22], who discovered that *M. spicata*'s presence of chemical compounds like monoterpene ketones, monoterpene hydrocarbons, carvone, methone, piperitenone, and isothone caused a

significant drop in transaminase (ALT, AST) activity when compared to the control group. Additionally, discovered that *O. basilicum* treatment lowers AST and ALT levels. These two cytosolic enzymes may be released from the cytoplasm once the plasma membrane is destroyed and the cell is under stress, which is why their serum content has increased. The α -amino group is transported from alanine or aspartate to the α -keto group of ketoglutaric acid by the enzymes ALT and AST. This process is what produces the pyruvic and oxalosuccinic acids that are involved in the Krebs cycle. The liver contains large amounts of both aminotransferases. ALT is a more precise marker of liver injury because AST is shown to be adequate in cardiomyocytes, neurons, nephrons, myocytes, and red blood cells. Enzyme changes can be modest (transferase values up to five times higher than the reference value), moderate (5–10 times higher), or marked (more than ten times the elevated value) depending on the degree of liver injury [23].

Table 2 showed the combination of *M. spicata* (100 mg/kg) and *O. basilicum* (100 mg/kg), which is designated because these plant extracts gave the best reduction in liver and kidney parameters than the remaining plants. Also, this mixture was better than the treatment of *M. spicata* and *O. basilicum* alone. These findings are due to the synergistic effect between the active compounds of both plants.

Typically, mint is used to treat inflammatory bowel illness, biliary system diseases, liver issues, and irritable bowel syndrome. The effects of mint are linked to how it affects liver function and bile flow [24].

The effects of giving mint juice twice a day for 30 days on a number of biochemical parameters in humans were examined by [25]. The findings indicated that blood sugar levels decreased by 41.5%, triacylglycerides by 58.5%, total cholesterol by 66.9%, LDL indices by 52.3%, AST levels by 70%, and ALT levels by 74.5%. Additionally, the administration of *M. spicata* has been shown to have a protective effect on liver tissue, which may be explained by the chelating and antioxidant properties of its phenolic components, which significantly reduce the free radicals produced by intoxication that damage liver tissue cells.

In 2016, Srinivasan and Muruganathan [26] our findings are consistent with those of [27], who found that carvone improves enzymatic antioxidant activity in rats poisoned by 1,2-dimethylhydrazine, hence reducing oxidative stress. Other authors, however, have demonstrated that carvone therapy preserved liver cell integrity and function by restoring blood ALT, AST, and ALP levels in rats given streptozotocin [28].

According to another study, peppermint alcohol extract was administered in vivo to lessen the negative effects of CCl₄ on liver function [29].

Menthol and iso-menthone found at relatively high concentrations in the *M. spicata* extract, have been reported to exhibit anti-inflammatory activity [30], making this extract use a promising candidate against oxidative damage of the liver and kidney.

Found that the contents of *M. spicata* extract not only protect the integrity of plasma membrane but, at the same time, increased the regenerative and reparative capacity of the liver and kidney. These results suggest that the compound present in MsEO has hepatorenal protective effects against oxidative stress in rats [26].

Basil's potent antioxidant properties are a result of its high phenolic acid content. The most common phenolic component found in basil is rosmarinic acid. But there are also large levels of other derivatives of caffeic acid, like chicoric acid [31, 32].

Serum AST and ALT activity, which are indicators of hepatocellular injury, were used to assess the hepatoprotective benefits of basil extract. Serum levels of these two enzymes can be used as a marker of liver injury because they are found in high concentrations in hepatocytes [33, 34].

It is known that the main active phenolic components that were separated from celery seeds, such as phthalide glycosides, apigenin, and limonene, have various pharmacological effects [35, 36]. In the mouse liver, phthalides and limonene have demonstrated strong activity in inducing glutathione S-transferase, a detoxifying enzyme [37].

Basil extract decreases the activities of serum AST and ALT due to it increase the level of antioxidant enzymes that may protect liver against the damaging effects and inhibit LPO [38]. Basil is a rich source of flavonoids, and the hepatoprotective effect of *O. basilicum* may be attributed to the antioxidant activity of its flavonoids [39].

The inclusion of the flavonoids apigenin, rosmarinic acid, and carnosol as active ingredients may be the reason for celery's effectiveness.

According to [40] *P. crispum*, is a natural source of vitamins and minerals with significant therapeutic benefits, including anti-inflammatory, anti-apoptotic, antioxidant, and anti-diabetic effects, in addition to its nutritional value. It has antioxidants such as ascorbic acid, carotenoids, and flavonoids (luteolin, apigenin) [9]. The additional antifibrotic mechanism implicated in *P. crispum*'s hepatoprotection is explained by the fact that therapy with the plant effectively prevented hepatotoxicity by dramatically lowering the level of collagen.

Flavonoids and phenolic compounds are the main medicinal plants active constituents. According to Gabal. The analysis of aqueous basil extract (ABE) and aqueous celery extract (ACE) revealed that both plants extracts contain valuable amount of flavonoids and polyphenols in comparison with their price. The aqueous basil extract contained (2.59mg flavonoids/100mg extract) and (4.86 mg polyphenols/100mg extract) while the aqueous celery extract contained (1.87 mg flavonoids/100mg extract) and (3.95 mg polyphenols/100mg extract) [41]. The results proved by [42] showed that an aqueous extract of basil and celery counteracted and ameliorated urinary stones formation and renal deteriorations due to their contents of flavonoids and polyphenols. Basil and celery extract supplementation to urolithiatic rats, counteracted kidney tissues deteriorations and improved kidney function as well as glomerular filtration rate significantly ($p \leq 0.01$) in all treated groups especially the group that supplemented with both extracts as basil and celery active constituents prevented salts precipitation and increased urine flow that maintained normal kidney functions [43].

[11] found that the aqueous extract of *P. crispum* showed a direct diuretic effect in rats, mediated by inhibition of renal Na^+/K^+ -ATPase, which reduces tubular reabsorption of sodium and potassium and enhances urine output. Therefore, parsley is the strongest candidate among the tested plants for influencing electrolyte handling, particularly Na^+ and K^+ . These results disagree with the findings of the current research, which showed that *P. crispum* causes an elevation in the level of electrolytes (Na^+ , K^+ , and Cl^-). This may be due to the high concentration of the plant extract dose or due to the interaction between the chemical compounds in the plant [42].

The current study showed that *A. graveolens* revealed a high reduction in the levels of creatinine and BUN, but this reduction was below the minimum normal range and an increase in the level of electrolytes; these variable results disagree with the findings of [44] which found available evidence suggests that *A. graveolens* may support electrolyte homeostasis indirectly through nephroprotective and urinary-modulating effects; however, direct evidence for significant changes in serum Na^+ , K^+ , or Cl^- remains limited in the available literature [45].

The best reduction in the levels of creatinine, BUN, and the electrolytes was after the oral administration with *O. basilicum* in the concentration of 100 mg/kg. These results agree with the findings of [46] which found that *O. basilicum* is more likely to preserve electrolyte balance indirectly by protecting renal tissue and tubular function from toxic injury rather than by producing a strong primary electrolyte-shifting effect in healthy animals. This protective effect is mainly attributed to its antioxidant and nephroprotective properties, which help maintain renal integrity and normal tubular handling of electrolytes under conditions of oxidative or toxic stress [47].

Also, *M. spicata* showed a high decrease in the level of creatinine, BUN, and the electrolytes in the concentration of 100 mg/kg, and these results agreed with the findings of [48] which found that *Mentha* is more likely to improve electrolyte homeostasis indirectly by attenuating renal tubular injury and preserving kidney function in nephrotoxic conditions rather than by producing a strong primary electrolyte-shifting effect in healthy animals. Thus, any stabilization of serum potassium, sodium, or calcium is likely secondary to its renoprotective and antioxidant actions [44].

5 CONCLUSION

From these results, it was concluded that the best plant extracts were *M. spicata* and *O. basilicum* in a concentration of 100 mg/kg alone and in the synergistic combination between them because they gave the highest reduction in the values of the biomarkers of liver and kidney functions, while the other extracts of *A. graveolens* and *P. crispum* showed variable effects, either by reduction below the minimum normal range or by elevation of the value above the normal range, which may be due to their interaction between the chemical compounds present in them or due to the concentration of the dose. Hence, further work needs to be done using high concentrations of these extracts and studying the histopathological effects of it.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

Disclosure of conflict of interest

There is no conflict of interest among the authors.

Statement of ethical approval

Ref.: CSEC/0825/0095, university of Baghdad, college of science, Ethics Committee. csec@sc.uobaghdad.edu.iq

REFERENCES

- [1] Sujana D, Saptarini NM, Sumiwi SA, Levita J. Nephroprotective activity of medicinal plants: A review on in silico-, in vitro-, and in vivo-based studies. *Journal of Applied Pharmaceutical Science*. 2021;11(10):113-27.
- [2] Sang S, Wang L, Liang T, Su M, Li H. Potential role of tea drinking in preventing hyperuricaemia in rats: biochemical and molecular evidence. *Chin Med*. 2022;17(1):108.
- [3] ÖZTÜRK N. *Current Approaches in Physiotherapy*: Akademisyen Kitabevi; 2019.
- [4] Wang X, Wu Q, Liu A, Anadón A, Rodríguez J-L, Martínez-Larrañaga M-R, et al. Paracetamol: overdose-induced oxidative stress toxicity, metabolism, and protective effects of various compounds in vivo and in vitro. *Drug metabolism reviews*. 2017;49(4):395-437.
- [5] Rašković A, Ćučuz V, Torović L, Tomas A, Gojković-Bukarica L, Čebović T, et al. Resveratrol supplementation improves metabolic control in rats with induced hyperlipidemia and type 2 diabetes. *Saudi Pharmaceutical Journal*. 2019;27(7):1036-43.
- [6] Lebovitz HE, Kreider M, Freed MI. Evaluation of liver function in type 2 diabetic patients during clinical trials: evidence that rosiglitazone does not cause hepatic dysfunction. *Diabetes Care*. 2002;25(5):815-21.
- [7] Touiti N, Houssaini TS, Achour S. Overview on pharmacovigilance of nephrotoxic herbal medicines used worldwide. *Clinical Phytoscience*. 2021;7(1):9.
- [8] Kooti W, Ghasemiboroon M, Asadi-Samani M, Ahangarpour A, Abadi MNA, Afrisham R, et al. The effects of hydro-alcoholic extract of celery on lipid profile of rats fed a high fat diet. 2014.
- [9] Tunali T, Yarat A, Yanardag R, Özçelik F, Özsoy Ö, Ergenekon G, et al. Effect of parsley (*Petroselinum crispum*) on the skin of STZ induced diabetic rats. *Phytotherapy Research: An International Journal Devoted to Pharmacological and Toxicological Evaluation of Natural Product Derivatives*. 1999;13(2):138-41.
- [10] Sowbhagya H, Srinivas P, Krishnamurthy N. Effect of enzymes on extraction of volatiles from celery seeds. *Food chemistry*. 2010;120(1):230-4.
- [11] Kreydiyyeh S, Usta J, Kaouk I, Al-Sadi R. The mechanism underlying the laxative properties of parsley extract. *Phytomedicine*. 2001;8(5):382-8.
- [12] Kumar A, Chattopadhyay S. DNA damage protecting activity and antioxidant potential of pudina extract. *Food Chemistry*. 2007;100(4):1377-84.
- [13] Guimarães R, Barreira JC, Barros L, Carvalho AM, Ferreira IC. Effects of oral dosage form and storage period on the antioxidant properties of four species used in traditional herbal medicine. *Phytotherapy Research*. 2011;25(4):484-92.
- [14] Lixandru Ba-E, Drăcea NO, Dragomirescu CC, Drăgulescu EC, Coldea IL, Anton L, et al. Antimicrobial activity of plant essential oils against bacterial and fungal species involved in food poisoning and/or food decay. *Roum Arch Microbiol Immunol*. 2010;69(4):224-30.
- [15] Akujobi C, Anyanwu B, Onyeze C, Ibekwe V. Antibacterial activities and preliminary phytochemical screening of four medicinal plants. *J Appl Sci*. 2004;7(3):4328-38.
- [16] Manosroi J, Dhumtanom P, Manosroi A. Anti-proliferative activity of essential oil extracted from Thai medicinal plants on KB and P388 cell lines. *Cancer Lett*. 2006;235(1):114-20.
- [17] Noor ZI, Ahmed D, Rehman HM, Qamar MT, Froeyen M, Ahmad S, et al. In vitro antidiabetic, anti-obesity and antioxidant analysis of *Ocimum basilicum* aerial biomass and in silico molecular docking simulations with alpha-amylase and lipase enzymes. *Biology*. 2019;8(4):92.
- [18] Harnafi H, Aziz M, Amrani S. Sweet basil (*Ocimum basilicum* L.) improves lipid metabolism in hypercholesterolemic rats. *E Spen Eur E J Clin Nutr Metab*. 2009;4(4):e181-e6.
- [19] Harborne A. *Phytochemical methods a guide to modern techniques of plant analysis*: springer science & business media; 1998.
- [20] Al-Naqqash Z. Evaluation of Three Plant Extracts Activity to the Stopping of Bleeding in Albino Mice: M. Sc. thesis; 2013.

- [21] Zarei MH, Lorigooini Z, Khoei HA, Bijad E. Acute oral toxicity assessment of galbanic acid in albino rat according to OECD 425 TG. *Toxicology Reports*. 2023;11:111-5.
- [22] Lala V, Zubair M, Minter DA. Liver function tests. *StatPearls* [internet]: StatPearls Publishing; 2023.
- [23] Adli D. Evaluation of the therapeutic effects of *Mentha spicata* essential oil at the liver level in developing wistar rats co-exposed to lead and manganese. *Carpathian journal of food science and technology*. 2019.
- [24] Shyamala M, Venukumar M, Latha M. Antioxidant potential of the *Syzygium aromaticum* (Gaertn.) Linn.(cloves) in rats fed with high fat diet. *Indian J Pharmacol*. 2003;35(2):99-103.
- [25] Giannini EG, Testa R, Savarino V. Liver enzyme alteration: a guide for clinicians. *Can Med Assoc J*. 2005;172(3):367-79.
- [26] Srinivasan S, Muruganathan U. Antidiabetic efficacy of citronellol, a citrus monoterpene by ameliorating the hepatic key enzymes of carbohydrate metabolism in streptozotocin-induced diabetic rats. *Chemico-biological interactions*. 2016;250:38-46.
- [27] Bouchra C, Achouri M, Hassani LI, Hmamouchi M. Chemical composition and antifungal activity of essential oils of seven Moroccan Labiatae against *Botrytis cinerea* Pers: Fr. *Journal of ethnopharmacology*. 2003;89(1):165-9.
- [28] Taylor B, Collins P, Luscombe D, Duthie H. The mechanism of the inhibitory action of menthol on gut smooth muscle. *British J Surg*. 1984;71:902-8.
- [29] Barbalho SM, Machado FMVF, Oshiiwa M, Abreu M, Guiger EL, Tomazela P, et al. Investigation of the effects of peppermint (*Mentha piperita*) on the biochemical and anthropometric profile of university students. *Food Science and Technology*. 2011;31(3):584-8.
- [30] Vinothkumar R, Sudha M, Viswanathan P, Kabalimoorthy J, Balasubramanian T, Nalini N. Modulating effect of d-carvone on 1, 2-dimethylhydrazine-induced pre-neoplastic lesions, oxidative stress and biotransforming enzymes, in an experimental model of rat colon carcinogenesis. *Cell Prolif*. 2013;46(6):705-20.
- [31] Cowan MM. Plant products as antimicrobial agents. *Clin Microbiol Rev*. 1999;12(4):564-82.
- [32] Khodadust M, Samadi F, Ganji F, Jafari AY, Asadi G. Effects of peppermint (*Mentha piperita* L.) alcoholic extract on carbon tetrachloride-induced hepatotoxicity in broiler chickens under heat stress condition. 2015.
- [33] Bellassoued K, Ben Hsouna A, Athmouni K, van Pelt J, Makni Ayadi F, Rebai T, et al. Protective effects of *Mentha piperita* L. leaf essential oil against CCl₄ induced hepatic oxidative damage and renal failure in rats. *Lipids in health and disease*. 2018;17(1):9.
- [34] Surveswaran S, Cai Y-Z, Corke H, Sun M. Systematic evaluation of natural phenolic antioxidants from 133 Indian medicinal plants. *Food chemistry*. 2007;102(3):938-53.
- [35] Lee J, Scagel CF. Chicoric acid found in basil (*Ocimum basilicum* L.) leaves. *Food chemistry*. 2009;115(2):650-6.
- [36] Lahon K, Das S. Hepatoprotective activity of *Ocimum sanctum* alcoholic leaf extract against paracetamol-induced liver damage in Albino rats. *Pharmacognosy Res*. 2011;3(1):13.
- [37] Meera R, Devi P, Kameswari B, Madhumitha B, Merlin N. Antioxidant and hepatoprotective activities of *Ocimum basilicum* Linn. and *Trigonella foenum-graecum* Linn. against H₂O₂ and CCL₄ induced hepatotoxicity in goat liver. *Indian J Exp Biol*. 2009;47(7):584.
- [38] Rašković A, Milanović I, Pavlović N, Čebović T, Vukmirović S, Mikov M. Antioxidant activity of rosemary (*Rosmarinus officinalis* L.) essential oil and its hepatoprotective potential. *BMC complementary and alternative medicine*. 2014;14(1):225.
- [39] Lawson HP, Aga MF, Niemeyer ED. Plant maturity differentially affects the phenolic composition and antioxidant properties of green Basil (*Ocimum basilicum* L.) Cultivars. *ACS omega*. 2025;10(40):47535.
- [40] Arfa M, Rashed A. The modulative biochemical effect of extract of *Ocimum gratissimum* as anti-oxidant on diabetic albino rats. *Egypt J Comp Pathol Clin Pathol*. 2008;21:69-87.
- [41] Gbadegesin M, Odunola O. Aqueous and ethanolic leaf extracts of *Ocimum basilicum* (sweet basil) protect against sodium arsenite-induced hepatotoxicity in Wistar rats. 2013.
- [42] Gabal AM. Basil (*Ocimum basilicum* L.) and/or celery (*Apium graveolens* L.) leaves aqueous extracts role in opposition to drinking contaminated water induced male rats urinary stones and renal deteriorations. *Annual Research & Review in Biology*. 2020;35(11):52-65.
- [43] Kitajima J, Ishikawa T, Satoh M. Polar constituents of celery seed. *Phytochemistry*. 2003;64(5):1003-11.

- [44] Stiani SN, Syahidah FM, Fikriani H, Subarnas A, Rusdiana T. Anticalculi activity of apigenin and celery (*Apium graveolens* L.) extract in rats induced by ethylene glycol–ammonium chloride. *Journal of Pharmacy & Bioallied Sciences*. 2019;11(Suppl 4):S556.
- [45] Sultana S, Ahmed S, Jahangir T, Sharma S. Inhibitory effect of celery seeds extract on chemically induced hepatocarcinogenesis: modulation of cell proliferation, metabolism and altered hepatic foci development. *Cancer Lett*. 2005;221(1):11-20.
- [46] Ben Mansour F, Ayadi H, van Pelt J, Elfeki A, Bellassoued K. Antioxidant and protective effect of *Ocimum basilicum* seeds extract on renal toxicity induced by carbon tetrachloride in rats. *J Med Food*. 2024;27(1):60-71.
- [47] Ozsoy-Sacan O, Yanardag R, Orak H, Ozgey Y, Yarat A, Tunali T. Effects of parsley (*Petroselinum crispum*) extract versus glibornuride on the liver of streptozotocin-induced diabetic rats. *Journal of ethnopharmacology*. 2006;104(1-2):175-81.
- [48] Ullah N, Khan MA, Khan T, Asif AH, Ahmad W. *Mentha piperita* in nephrotoxicity–a possible intervention to ameliorate renal derangements associated with gentamicin. *Indian J Pharmacol*. 2014;46(2):166.