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Arabic Gum and Its Effect on Acute Kidney Disorders in Experimental Rats

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Rasha Ahmed Mahmoud Mostafa

Master at Home Economics Department Faculty of specific Education Assiut University (2021)

Dr. Soad Mohamed Omer

Emeritus Prof. of Nutrition and Food Science , Home Economics Department, Faculty of specific Education , Assiut University

Dr. Hend Mohamed Ali

Professor of Nutrition and Food Science, Head of Home Economics Department, Faculty of specific Education, Assiut Universit

Dr. Mahmoud Ashry Ibrahim

Assistant Professor of Physiology, Zoology Department, Faculty of Science Al-Azhar University - Assiut University

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Arabic Gum and Its Effect on Acute Kidney Disorders in Experimental Rats

Abstract

The study aimed to shed light on the effect of Arabic gum on acute kidney disorders in experimental rats. Sixty adult male Wistar albino rats (180 ±10g) were divided into six groups, each group containing (10) rats, as follows: Group (1): Rats fed on the basal diet as a negative control group. Group (2): Rats fed on the basal diet plus subjected to oral administration of 10% Arabic gum extract (AGE). Group (3): Rats fed on the basal diet plus 20%(AGE). Thirty rats were induced with (4 ml/kg/rats) of glycerol and divided into subgroups. Subgroup (4): Rats induced with acute renal failure (ARF) fed on the basal diet as a positive control group. Subgroup (5): Rats induced with (ARF) and fed on the basal diet plus 10%(AGE). Subgroup (6): Rats induced with (ARF) and fed on the basal diet plus 20% (AGE). The results showed that Arabic gum powder contains moisture, ash, protein, crude fat, crude fiber, total carbohydrates, and caloric value: 7.26%, 4.03%, 19.71%, 15.66%, 0.43%, 52.91%, and 431.42 Kcal/100g ; respectively. Moreover, AGE contains a high content of gallic acid and chlorogenic acid. The results revealed that the rats induced (ARF) and treated orally with 10% and 20% (AGE) showed a significant increase in body weight. Additionally, the results indicated an increase in kidney and liver functions. Therefore, this study recommends using Arabic gum in diets.

Keywords:

Arabic Gum, Acute Kidney Disorders, Antioxidants , Kidney and liver functions.

Introduction

The kidney is one of the most complexly organized organs in the human body. This organ contains approximately one million functional units called nephrons that are responsible for blood filtering. Each nephron consists of various specialized cell types and comprises a renal corpuscle connected to complicated tubules that drain into a collecting duct. The number of nephrons may vary according to age and health status ***(Liao et al., 2020)*** . Kidney disease is growing at an alarming rate. Xenobiotics impair the structural and functional capacity of kidneys by inducing oxidative stress, inflammation, apoptosis, and fibrosis, leading to the development of acute kidney injury (AKI) and chronic kidney disease (CKD). Although the pathophysiology of various kidney diseases has been studied, many targeted clinical therapies have failed. Thus, urgent interventions are needed to treat patients with kidney disease ***(Radi.,2019)***.

Acute kidney injury (AKI) refers to a period of an abrupt reduction in kidney function, which rapidly develops during a few hours up to a few days. Accordingly, this process consequently results in a significant functional impairment, increased serum creatinine levels, and oliguria or anuria with an electrolyte imbalance ***(Gaut and Liapis, 2021)***. It was shown that persisting AKI for more than three months would subsequently lead to chronic kidney disease (CKD). Some diseases and conditions, including severe diseases, sepsis, hypovolemia, and exposure to both nephrotoxic drugs and substances, are known as the familiar sources of AKI ***(Kellum et al., 2021)***.

Today, plants are used as a suitable alternative to chemical drugs because of their fewer side effects .The use of medicinal plants has led to the development of a dequate and appropriate treatment methods in treating diseases ***(Ahmad and Karmakar,2023).***

Arabic gum is known as *gum acacia and Acacia Senegal*. It belongs to *the Fabaceae* family it is a natural, edible, dietary fiber and polysaccharide consisting of an arabinogalactan-protein complex. The term Arabic gum was proposed by European merchants, 80% gum is produced from *Acacia Senegal* which is widely distributed to Sudan, Africa, Japan, Nepal, and many other tropical and subtropic regions of the world. From ancient times. Arabic gum is a rich source of antioxidant, minerals, copper, iron, zinc, and manganese , it has carbohydrates like galactose, rhamnose, glucuronic acid, and arabinose ***(Jaafar, 2019)*** . It has been used for many beneficial purposes. Anciently it was used to make mummies and in painting. Currently, it is widely used for food applications, clinical uses, and non-food applications. In food approaches, it is used as a flavoring agent,

stabilizer, sweetener, and thickening agent. It is used for the formulation of ice creams, candies, jellies, soft drinks, beverages, desserts, and soups. In non-food applications, it is used for the synthesis of syrups, tablets, lozenges, creams, lotions, paint, ink, glue, and ceramics ***(Ahmed et al.,2024)***. Therefore, This study investigates the impact of Arabic gum on acute kidney disorders in experimental rats.

Materials and Methods

Materials

Plant materials

One kg of Arabic gum (*Acacia senegal*) was obtained from a local supplier (Abd El-Rahman Harraz, Bab El-Khalk zone, Cairo, Egypt).

Chemicals

Glyserol was obtained from United Company for Drugs, Assuit, Egypt.

Kits were used to determine urea, urea nitrogen, creatinine, uric acid, alanine aminotransferases (ALT), aspartate aminotransferases (AST), gamma glutamyl transaminase (GGT) and alkaline phosphatase (ALP). were obtained from Sigma Aldrich ***(St. Louis, MO, USA).***

Methods

Preparation of Arabic gum extract

One hundred grams of powder of *Acacia Senegal* was boiled in 1000 mL of distilled water for 30 min. After cooling, the extracts were first filtered on a nylon cloth and then centrifuged at 2000 rpm for 5 min. Supernatants were collected and then lyophilized and weighed. The extracts were stored at 4 ◦C until use ***(Magnini et al., 2020)*** .

Determination of chemical composition of Arabic gum powder

Moisture, ash, protein, crude fat and crude fiber were determined in Arabic gum according to the method outlined by ***(A.O.A.C., 2010).***

Carbohydrate content

The total carbohydrate content of Arabic gum powder was calculated by difference 100-(other nutrient composition) according to the method described in ***(A.O.A.C., 2010)***.

Caloric value

The caloric value was calculated according to the methods of ***(Seleet, 2010)***

Total calories = (Fat × 9) + (Protein × 4) + (Total carbohydrate × 4).

Determination of total phenolic content (TPC) of Arabic gum extract (AGE).

The content of total phenolic compounds in the extract was estimated spectrophotometrically by a modified Folin–Ciocalteu colorimetric method ***(Jayaprakasha et al.,2003)*** **.**

Determination of radical scavenging activity (RSA) of Arabic gum extract (AGE).

The capacity of antioxidants in the extract to quench Diphenyl Pair Picryl Hydrazyl (DPPH) radical was determined using the method of ***(Nogala-Kalucka et al.,2005)***

Determination of phenols content

HPLC analysis was carried out using an Agilent 1260 series according to method of ***(Kujala et al.,2000)*****.**

Experimental design

Sixty adult male Wistar albino rats *(Rattus norvegicus)* weighing (180±10g) were obtained from Animal Colony, National Research Centre, Cairo, Egypt. The rats were housed in suitable plastic cages for one week for acclimation before the experimental study. Excess tap water and standard rodent food pellets [20.3% protein (20% casein and 0.3% DL-Methionine), 5% fat (corn oil), 5% fibers, 3.7% salt mixture and 1% vitamin mixture; obtained from Meladco company for animals and rodents food pellets, El-Obour City, Cairo, Egypt] were always available, they received human care in compliance with the standard institution's criteria for the care and use of experimental rats according to the ethical committee of Faculty of Science, Al-Azhar University,

Assuit, Egypt; however, this study was approved by the same ethical committee (AZHAR 16\2023). After the rats were acclimatized to experimental room conditions, they were divided randomly into six groups (10 rats each). Depending on the duration of treatment, the rats were randomly divided into the following groups:

Group (1): Rats fed on the basal diet as a negative control group (-ve).

Group (2): Rats fed on the basal diet plus subjected to oral administration of 10% Arabic gum extract (AGE).

Group (3): Rats fed on the basal diet plus 20%(AGE).

Thirty rats were induced with (4 ml/kg/rats) of glycrol to create a model of acute renal failure (ARF) and divided into subgroups.

Subgroup (4): Rats induced with (ARF) and fed on the basal and act as a positive control group (+ve).

Subgroup (5): Rats induced with (ARF) and fed on the basal diet plus 10%(AGE). **Subgroup (6):** Rats induced with(ARF) and fed on the basal diet plus 20% (AGE).

Blood sampling

At the end of the study period, rats were fasted overnight and following diethyl ether anesthesia, about 0.5 ml of blood sample was collected into heparinized vacutainer tube immediately for the hematological investigations; while non-heparinized blood specimens (3-7 ml) from each rat were drawn from the retro-orbital plexus using sterile glass capillary (single draw vacutainer needle) into open vacutainer collecting tubes. The non-heparinized blood specimens were left 20 minutes to clot, then centrifuged at 3000 rpm for 10 minutes using cooling centrifuge (IEC centra-4R, International Equipment Co., USA). The sera were separated, divided into aliquots and stored at -80°C until biochemical measurements could be carried out as soon as possible ***(Daneasa et al., 2016).***

Body weight gain

At the beginning and the end of the experimental study, each rat was weighed; and the change in body weight was calculated according to ***Ashry et al. (2021).*** by the following formula:

Body weight gain (%) = [(Final body weight – initial body weight) / initial body weight] * 100

Biochemical determinations

Kidney functions

Serum urea, urea nitrogen, creatinine and uric acid were determined according to the method described by **Chaney *et al.* (1960), Husdan and Rupoport (1969), and Trinder (1969),** respectively.

Liver functions

Serum alanine aminotransferases (ALT), alanine aspartate aminotransferases (AST), gamma glutamyl transaminase (GGT) and alkaline phosphatase (ALP) were determined according to **Schumann and Klauke (2003), Moss and Henderson (1999), IFCC (1983), and Trinder (1969),** respectively.

Statistical analysis

Statistical analysis was carried out according to ***Steel and Torrie (1960)***. Data were analyzed using the Statistical Package for Social Science (SPSS), data were reported as mean ± standard error of means (n=10). Differences between means were determined by analysis of variance (ANOVA), a t-test was used to calculate a statistically significant difference in the body weight of male rats before and after treatment. Significance was declared at ($p \leq 0.05$) ***(Pallant, 2005)***.

Results and discussion

Gross chemical composition and caloric values of Arabic gum powder on a dry weight basis.

The data in **Table (1)** revealed that moisture, ash, protein, crude fat, crude fiber, and total carbohydrates in Arabic gum were 7.26%, 4.03%, 19.71%, 15.66%, 0.43%, and 52.91%, while the caloric value was 431.42 K.Cal./100g. These results are in agreement with ***(Bhushette and Annapure, 2017)***, they reported that moisture and ash were 6.46% and 3.81% ; respectively. Additionally,***(Lopez-Torrez et al., 2015)*** found that Arabic gum contains 88.9% carbohydrates. However, these results disagree with ***(El-Ratel et al.,2019)***, they reported that protein, crude fiber, and ash were 3.71%, 7.98%, and 1.73% ; respectively. Variations in moisture content, ash, protein, crude fiber, crude fat, and carbohydrates may be attributed to several factors, such as climate, growing conditions, postharvest management, and processing conditions.

Table (1): Gross chemical composition and caloric values of Arabic gum powder on a dry weight basis (mg / 100g)

Sample	Moisture %	Ash %	Protein %	Crude Fat %	Crude fiber %	Total carbohydrates %	Caloric value (K.cal/100g)
Arabic Gum	7.26	4.03	19.71	15.66	0.43	52.91	431.42

-

Mean of three replicates

Arabic gum extract yield, total phenolic compounds (TPC) and radical scavenging activity (RSA).

The yield is 5.1%, total phenolic content (TPC) is 8.9 (mg/g) and radical scavenging activity (RSA) is 51.2% of Arabic gum, shown in **Table (2)** .The results are in agreement with ***(Khirani et al., 2024)*** they showed that (AGE) exhibited an appreciable amount of RSA 62,40% .In comparison to what was accomplished by ***(Musa et al., 2020)***in his similar study of the antioxidant activity of the aqueous extracts of Arabic gum, the results showed that the highest rate of inhibition of the Arabic gum amounted to 67.64%, as the inhibition rates were weak in the range of 20% and 50%; respectively. The reason Arabic Gum has the potential to scavenge radicals despite its diverse sources, chemical compositions, molecular weights, and structural

variations ***(Al-idee et al.,2020).*** The results are in agreement with ***(Elnour et al., 2022)*** they reported that Arabic gum extracts have significant antioxidant activity. This is because they contain high concentrations of biologically active substances like flavonoids and alkaloids. Enzymes, particularly oxidase, which catalyze oxidation events, are inhibited by flavonoids, which enhance the activity of the active polyphenol oxidase enzyme in the antioxidant mechanism that neutralizes and shields cells from the harm that free radicals might cause.

Table (2): Arabic gum extract yield, total phenolic compounds (TPC) and radical scavenging activity (RSA).

Parameter	Yield (%)	TPC (mg/g)	RSA (%)
Arabic Gum extract (AGE)	**±0.37 5.1**	**±0.43 8.9**	**2±1 1.51**

All values are represented as means ± standard error for 3 measurements (M ± SE).

Phenolic constituents of Arabic gum extract (AGE).

As shown in **Table(3)**: the compounds identified were found that a high contents of gallic acid and chlorogenic acid using high-performance liquid chromatography (HPLC) analysis. These results are in agreement with ***(Kumari et al.,2022)*** where the phenolic constituents of the extract of Arabic gum, using HPLC revealed the presence of phenolic compounds such as gallic acid and chlorogenic acid. These compounds contribute to the plant's antioxidant and antibacterial properties.

Alshehry ,(2023) recorded that Arabic gum contains rich amounts of phenols and flavonoids. In addition, it was found that Arabic gum had the highest antioxidant activity.

Table (3): Phenolic constituents of Arabic gum extract (AGE) using HPLC analysis

	Area	Conc. (µg/ml = µg/ 6.8mg)	Conc. (µg/g)
Gallic acid	**22.24**	**1.92**	**95.79**
Chlorogenic acid	**1.10**	**0.15**	**7.65**

Effect of Arabic gum extract (AGE) on body weight gain (%) in experimental rats

The data represented in **Table(4)** revealed the effect of Arabic gum on the experimental rats. Group (4) rats induced with acute renal failure (ARF) showed a significant decrease in body weight; while groups (2) and (3) rats treated with 10% and 20% (AGE) showed a non-significant changes in body weight when compared with negative control group

(-ve). Also groups (5) and (6) infected with (ARF) and treated with 10% and 20% Arabic gum showed a significant increase in body weight when compared with the positive control (+ve).These results are in agreement with ***(Li et al.,2019)*** they reported a marked decrease in body weight in rats within five days post-glycerol injection, correlating with a significant decline in kidney function markers.Glycerol-induced acute renal failure in rats led to decreased final body weight and body weight gain ***(Ali et al., 2019).*** This agrees with ***(Albeladi, 2019)*** who showed that an increase in the weight of the rats treated with Arabic gum, while the results indicated a decrease in the weight of the rats in the infected group.

Table (4): Effect of Arabic gum extract (AGE) on body weight gain (%) in experimental rats.

Parameter / Groups	Body weight gain (%)
Group (1): control (-ve)	**48.85±1.24^{A}**
Group (2): 10% (AGE)	**49.13±0.99^{A}**
Group (3): 20% (AGE)	**50.37±1.12^{A}**
Group (4): ARF (4 ml/kg/rats) (+ve)	**27.18±1.24^{C}**
Group (5): ARF +10% (AGE)	**44.63±0.67^{B}**
Group (6): ARF +20% (AGE)	**46.81±0.71^{B}**

The same column, means with different superscript letters are significantly different at ($p \leq 0.05$).

(-ve) negative control (AGE) Arabic gum extract

(+ve) positive control (ARF) Acute Renal Failure

Effect of Arabic gum extract (AGE) on kidney functions in experimental rats.

The obtained results in **Table (5)** revealed that the rats infected with acute renal failure (ARF) showed a significant increase at ($p \leq 0.05$) in creatinine, blood urea, urea nitrogen, and uric acid when compared with negative control group. Moreover, the (ARF) rats treated with 10% and 20% (AGE) showed a significant decreases at ($p \leq 0.05$) in serum creatinine, blood urea, urea nitrogen, and uric acid levels when compared with positive control group. The results were in harmony with those of ***(Emare et al .,2024)*** they found that rats injected with glycerol to induce acute renal failure showed a significant increase in serum uric acid, urea nitrogen, and creatinine levels. In this respect, it is suggested that glycerol injection in rats may increase uric acid levels due to altered purine metabolism. In general, this finding pointed out that the treatment of (ARF) rats with (AGE) induced a marked amelioration in serum creatinine, blood urea, urea nitrogen, and uric acid levels. Also results are in agreement with ***(Alubaidy, 2013; Aneise ,2016 and Said et al. ,2019)*** they reported that treatment with Arabic gum significantly decreased the elevated levels of serum creatinine, uric acid, urea, and total bilirubin in gentamicin-induced AKI rats compared to the control group, Arabic gum administration in drinking water at different doses for a long period significantly restored the levels of serum creatinine and urea.

Table (5): Effect of Arabic gum extract (AGE) on kidney functions in experimental rats.

Parameters / Groups	Urea (mg/dl)	Urea nitrogen (mg/dl)	Creatinine (mg/dl)	Uric acid (mg/dl)
Group (1): control (-ve)	37.46±1.78^{A}	±0.95^{A} 18.2	±0.02^{A} 0.62	± 0.25^{A} 3.80
Group (2): 10% (AGE)	4.09^{A}±33.3	±2.04^{A} 16.65	0.67 ± 0.001^{A}	3.3 ± 0.19^{A}
Group (3): 20% (AGE)	32.5 ± 3.57^{A}	16.2 ± 1.78^{A}	0.51 ± 0.02^{A}	3.43 ±0.008^{A}
Group (4): ARF (4 ml/kg/rats) (+ve)	75.92 ± 5.95^{B}	37.99 ± 2.89^{B}	1.90 ±0.12^{B}	6.11 ±0.26^{B}
Group (5): ARF +10% (AGE)	35.8 ± 2.54^{C}	18.1 ± 1.27^{C}	0.75 ± 0.03^{C}	2.68 ± 0.13^{C}
Group (6): ARF +20% (AGE)	31.98 ±2.43^{C}	16.01 ±1.22^{C}	0.624 ±0.018^{C}	2.31 ± 0.08^{C}

The same column, means with different superscript letters are significantly different at ($p \leq 0.05$)

Effect of Arabic gum extract (AGE) on liver functions in experimental rats.

Table (6) shows the mean values of serum ALT, AST, ALP, and GGT activities. The obtained results revealed that the treatment of (ARF) rats showed a significant increase at ($p \leq 0.05$) in ALT, AST, ALP, and GGT activities when compared with negative control group. Additionally the (ARF) rats treated with10% and 20% (AGE) showed significant decreases at ($p \leq 0.05$) in serum ALT, AST, ALP, and GGT activities when compared with positive control group. In general, this finding pointed out that the treatment of (ARF) rats with (AGE) induced a marked amelioration in serum ALT, AST, ALP, and GGT**.**

Aneiese ,(2016) showed that (ARF) rats had significantly increased at ($p < 0.05$) in ALT and AST enzyme activities, which reflect distortion in liver function. In contrast, intervention with Arabic gum in both forms (solution and powder feeding) significantly cured the rise in AST enzyme activity until it reached the level of the negative control group. However, only the colloidal solution of Arabic gum feeding was effective in curing AST enzyme activity compared to the positive control group **.**

Lotfy et al.,(2024) indicated that a positive effect of Arabic gum on liver functions in groups that received Arabic gum treatment when studying the efficacy of Arabic gum in mitigating renal damage and hepatotoxicity in rats. ***(Babiker et al., 2017)*** they found that daily Arabic gum for twelve weeks significantly improved liver antioxidant activity in Sprague-Dawley rats.

In addition ***(Hamid et al., 2021)*** reported that Arabic gum enhances hepatic apoptosis, reduces oxidative stress, and improves inflammation in rats with induced hepatotoxicity. In addition ***(Rady et al., 2023)*** they showed that no significant difference between the control and Arabic gum rats , a significant elevation in the infected group compared to the control and Arabic gum groups, and an improvement with high significance at ($p < 0.01$) in the treated group with Arabic gum by decreasing ALT levels when compared with the infected group.

Table (6): Effect of Arabic gum extract (AGE) on liver functions in experimental rats.

Parameters / Groups	ALAT (U/L)	ASAT (U/L)	GGT (U/L)	ALP (U/L)
Group (1): control (-ve)	36.3±3.25^{D}	118.08±7.66^{E}	5.04 ± 0.37^{C}	217.8±12.38^{C}
Group (2): 10% (AGE)	36.8±0.83^{D}	114.46±1.64^{E}	5.06±0.34^{C}	215.66 ±0.57^{C}
Group (3): 20% (AGE)	33.4±5.48^{D}	115.3 ±3.31^{E}	5.03±0.20^{C}	216.66 ±4.04^{C}
Group (4): ARF (4 ml/kg/rats) (+ve)	83.85 ±5.39^{B}	191± 9.44^{B}	8.19± 0.34^{B}	299 ±14.33^{B}
Group (5): ARF +10% (AGE)	36.71±5.90^{C}	122.8±13.40^{C}	5.81±0.33^{B}	146.5 ±11.79^{A}
Group (6): ARF +20% (AGE)	40.91±6.15^{C}	116.38±6.97^{C}	4.08±0.62^{B}	160±3.23^{A}

The same column, means with different superscript letters are significantly different at($p \leq 0.05$).
- (ALT): Alanine aminotransferases - (GGT): Gamma glutamyl transaminase
(AST): Aspartate aminotransfer - (ALP): Alkaline phosphatase

Conclusion

In conclusion, Arabic gum extract (AGE) contains total phenolic compounds (TPC) and radical scavenging activity (RSA) , it has a high contents of Gallic acid and Chlorogenic acid. (AGE) induced a marked amelioration in serum creatinine, blood urea, urea nitrogen and uric acid levels, induced a marked amelioration, serum ALT, AST, ALP and GGT activities, and induced a marked amelioration.

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الصمغ العربي وتأثيره علي اضطرابات الكلي الحادة في فئران التجارب

مستخلص البحث

تهدف هذه الدراسة لالقاء الضوء على تأثير الصمغ العربي علي اضطرابات الكلي الحادة فى فئران التجارب . تم تقسيم ستون من ذكور فئران ويستر ألبينو البالغة والتي تزن 180) (10g± جم الي (6) مجموعات كل مجموعة (10) فئران كالتالي : مجموعة (1) : فئران تتغذي علي الوجبة الغذائية الاساسية كمجموعة ضابطة سالبة ، مجموعة (2) : فئران تتغذي علي الوجبة الغذائية الاساسية وتتناول عن طريق الفم 10% من مستخلص الصمغ العربي، مجموعة (3) : فئران تتغذي علي الوجبة الغذائية الاساسية 20% من مستخلص الصمغ العربي. الثلاثون فأر تم اصابتهم بالتهاب الكلي الحاد بمادة الجلسرول (4 ملى لكل كيلو جرام لكل فأر) وتم تقسيمهم الي مجموعات فرعية ، المجموعة الفرعية(4): فئران مصابة بالتهاب الكلي الحاد وتتغذي علي الوجبة الأساسية كمجموعة ضابطة موجبة ، المجموعة الفرعية (5): فئران مصابة بالتهاب الكلي الحاد وتتغذي علي الوجبة الأساسية و10% من مستخلص الصمغ العربي، المجموعة الفرعية (6) : فئران مصابة بالتهاب الكلي الحاد وتتغذي علي الوجبة الأساسية و20% من مستخلص الصمغ العربي. أ ظهرت النتائج أن مسحوق الصمغ العربي يحتوى علي رطوبة ، رماد ، بروتين ،الدهن الخام ، الالياف الخام ، الكربوهيدرات الكلية و السعرات الحرارية 7.26% ، 4.03% ، 19.71%، 15.66% ، 0.43% ، 52.91 % و 431.42 كيلو كالوري لكل 100جرام علي التوالي . بالإضافة الى احتواء مستخلص الصمغ العربي على نسبة عالية من حمض الجاليك وحمض الكلوروجينيك . أظهرت النتائج أن الفئران المصابة بالتهاب الكلي الحاد وتتغذي علي الوجبة الأساسية و10% ، 20% من مستخلص الصمغ العربي سجلت ارتفاعا ملحوظا فى وزن الجسم ، بالإضافة الي ذلك سجلت النتائج ارتفاعا ملحوظًا في وظائف الكلي والكبد . بناءً على ذلك ، توصي الدراسة باستخدام الصمغ العربي في النظام الغذائي .

الكلمات المفتاحية:

الصمغ العربي _ اضطرابات الكلي الحادة _ مضادات الأكسدة _ وظائف الكلي والكبد