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A study on the effect of chicory (*Cichorium intybu*) from Egypt and Jordan on Gout in experimental rats

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ABSTRACT

Gout as a disease of kings is one of the oldest joint diseases known to humans and a common metabolic disease that is caused by high serum uric acid levels. It is considered to be closely associated with the development of many chronic diseases, such as obesity, hypertension, hyperlipemia, diabetes, and cardiovascular disorders. The current study aims to investigate the effects of bioactive compounds from chicory as natural remedies for the management of hyperuricemia in different concentrations (5,15,20 g) of dry leaves of chicory from two sources (Egypt and Jordan) on gout and the possible induced changes on kidney function, polyphenol oxidase of albino rats. Sixty adult male Albino rats weighing about (140±10) g were taken and divided into 10 groups, each with six rats. The first group is the negative control (-) and fed on normal diet for 8 weeks. The other groups received injections with Mono-Sodium Urate (MSU) crystal and different dose of chicory. The results showed that the positive control group (+) and all groups had a significant increase in serum kidney function test, uric acid, creatinine, urea and polyphenol oxidase as compared to the negative control group (-) and as well as damage in the kidney and bow tissue, however the other groups that fed on different ratios of chicory showed improvement in kidney function, polyphenol oxidase compared to the positive control group (+). The authors concluded that Chicory can be used in the management of hyperuricemia and gout

Keyword: Chicory, MSU, Albino rats, Kidney functions, Bow, Histopathology.

INTRODUCTION

Gout as the king of diseases is one of the oldest joint diseases known to human. It is caused by the chronic elevation of serum uric acid levels above the saturation point for monosodium urate crystal formation. Individuals suffering from gout often have a complex profile of comorbidities (Bernal *et al.*, 2021).The role of genetics in gout is unraveled (Treviño-Becerra, 2018). Genetic factors play an important role in the pathogenesis of gout and regulation of serum uric acid levels. Segregation analysis in families has shown that serum uric acid levels also have a significant heritable component with an overall pattern of inheritance that is consistent with a complex trait, regulated by an interaction between more than one major gene, several modifying genes and environmental factors (Kiær *et al*., 2007). Nonsteroidal anti-inflammatory drugs (NSAIDs), analgesic drugs, corticosteroids, and colchicine are commonly prescribed to quickly relieve inflammatory pain from gout attacks (Bian *et al*., 2020). However, these agents present several serious adverse effects,

including renal toxicity and gastrointestinal bleeding. Therefore, it is necessary to exploit promising agents that are safe and effective for gout therapy (Wang *et al*., 2019).

Chicory contains manycompounds that are considered functional food polyphenols, inulin, oligofructose and sesquiterpene lactones (Perovic *et al.*, 2021). Chicory could significantly decrease serum uric acid, through the inhibition of urate formation by suppressing xanthine oxidase activity and the promotion of urate excretion by regulating transporter expression (Zhu *et al*., 2021).

The present study aimed to investigate the impact of water extract of chicory leaves collected from Egypt and Jordan in treatment of induced Gout disease in male rats.

MATERIALS AND METHODS

Materials-

Leaves of chicory (10kg) used in this study were obtained from Egypt and Jordan. Monosodium Urate Crystals (MSU) were obtained from SIGMA pharmaceutical industries, Nasser city. Sixty male albino rats of Sprague Dawley strains (60 rats) weighing (140 ±10g) were obtained from the Animal House Colony of the National Research Center, Dokki, Cairo, Egypt. Basal diet of rat was prepared according to (Reeves *et al.*, 1993).

Methods

Preparation of extract:

The chicory leaves were washed and dried in an oven at 60 °C for 8 h (Rasmussen *et al.*, 2012). Dried chicory plant (1 kg) was grounded into powder and extracted with water (10 L) by heating to reflux for 1 hour to time. Then, the decoction was filtered and concentrated under low pressure (Wang *et al.*, 2019).

All rats were anesthetized with 2.5% isoflurane, followed by injection of 50 μL MSU crystals (25 mg/mL) or normal saline into the medial side of the right ankle of each rat to further establish the model of acute gouty arthritis with hyperuricemia according to (Yao *et al*., 2020).

Chemical analysis:

- Inulin was isolated from chicory(Gupta *et al.*, 2019).
- Moisture, ash, crude protein, carbohydrate, fat and inulin were determined according the method AOAC (2000).
- Antioxidant activity measurement was carried out as DPPH (α, α-diphenyl-β-picrylhydrazy) method after Burda and Oleszek (2001).
- Total Flavonoids and total phenolic content was estimated quantitatively using the method described by Jindal and Singh (1975).

Biological Experiment:

Sixty male albino rats of Sprague Dawley strains weighing (140 ± 10g) were kept in aerated wire cages under hygienic conditions. All rats were fed on basal diet for one week before starting of the experiment.Groups1-8 and positive group were injected by 50 µl Monosodium urate crystals (25mg/ml) to induce gout, while control negative group was injected normal saline into the medial side of the right ankle once daily for 7 days.

Control (-): 6 rats were kept under controlled conditions and feed basal diet.

Control (+):6 rats were injected with MSU and feed basal diet.

48 rats were injected with MSU and were divided into 8 groups (each of 6 rats) and feed on:

Group 1: extract of chicory from Egypt (5g/kg body weight).

Group 2: extract of chicory from Egypt (15g/kg body weight).

Group 3: extract of chicory from Egypt (20g/kg body weight).

Group 4: extract of chicory from Jordan (5g/kg body weight).

Group 5: extract of chicory from Jordan (15g/kg body weight).

Group 6: extract of chicory from Jordan (20g/kg body weight).
Group 7: Mix of chicory extracts from the two sources (7.5 from Egypt +7.5 from Jordan) g/kg body weight
Group 8: Mix of chicory extracts from the two sources (10 from Egypt +10from Jordan) g/kg body weight.

Body weight gain

The biological value of different diets was assessed by determination of body weight gain percent according to the method of Chapman *et al.* (1959).

Blood samples:

Blood samples were collected form orbital sinus veins by non-heparinized capillary tubes (1.5ml) (Bancroft *et al*., 1996) to determine:
Serum uric acid: according to the method described by (Fossatti *et al.*1980).
Serum creatinine: according to the method of Henry (1974).
Serum urea according to the method described by Garaway (1980)

Estimation of organs weight:

Careful dissection and plotted free of adhering blood immediately after sacrificing the rats. The organs were washed with cold saline solution, dried between filter paper and then weighed.

Tissue samples:

Animals were narcotized by ether then scarified and dissected the end of the experimental period, then livers, kidney and bow were removed (Wang *et al.*, 2019).

Histopathological Examination:

Specimens were treated for light microscope using the Haematoxylin and Eosin stain. Histopathological examination was carried out according to the method described by Bancroft *et al*. (1996).

Statistical analysis:

To ascertained the significance among means of the treatment Duncan's multiple range test at significant level of ($P < 0.05$) was applied, using the SPSS statistical program (SAS, 1996). One way ANOVA followed by post Duncan test was also used (Snedecor and Cochran, 1989).

RESULTS AND DISCUSION

Nutrient composition of chicory:

It was obvious from Table (1) that the moisture and carbohydrate content of the chicory leaves from Jordan (6.6g/100g; 55.45g/100g) were higher than from Egypt (5.7g/100g; 40.94g/100g), respectively. The highest ash, fat and protein contents of chicory were from Egypt (30.89, 21.17 and 1.3g/100g, respectively).However the plant from Jordan has highest inulin which content increases relatively in cold areas (Kreuzberger *et al.*, 2016). Tawfick *et al*. (2022) found that the gut symbiosis sustained by inulin supplementation among other dietary fibers exerts preventive and/or therapeutic options for many metabolic disorders including, cardiometabolic diseases, kidney diseases and hyperuricemia.

Table (1). Nutrient composition (dry weight) for chicory from Egypt and Jordan.

Nutrient composition	Egypt g/100 g	Jordan g/100 g
CHO	40.94	55.54
protein	21.17	15.15
Fat	1.3	1.1
Inulin	8.9	10.1
Ash	30.89	21.56
Moisture	5.7	6.6

It was clear from Table (2) that chicory from Egypt has the highest content of total phenols and total flavonoids, reaching 26.4 and 9.50 mg/g, respectively than from Jordan (23.2mg/g) and (7.1mg/g), respectively. The climate and water availability enhance high percentage of antioxidants in herbs (Iqbal *et al.*, 2021). The result of DPPH scavenging activity was 47.4 % in chicory from Egypt and 44.5% for that from Jordan .

Table (2). Comparison between total phenols, total flavonoids and antioxidant activity of chicory leaves powder from Egypt and Jordan.

Antioxidant activity	Egypt %	Jordan %
Total flavonoids mg/g	9.50	7.1
Total phenols mg/g	26.4	23.2
Antioxidant activity (DPPH inhibition %)	47.4	44.5

Table (3) shows that (BWG) among groups treated with chicory with group (6) has the highest value (51.0±3.7g) comparing with control (-) group and group 2recorded the lowest BWG (29.5 ± 14.1g). The current results agree with Wang *et al*. (2019) who found a body weight increased steadily throughout the experimental period.

Table (3). Body weight gain of experimental rats treated with different ratio of chicory.

Groups	BWG (g)	IBW (g)	FBW (g)
Control (-)	55.0 ± 3.7 [b]	139.0 ± 3.7 [b]	262.2 ± 15.0 [b]
Control (+)	33.3 ± 5.3 [a]	141.0 ± 2.7	174.3 ± 6.6 [a]
G1 (5g Egypt)	50.0 ± 3.7[a,b]	140.0 ± 2.3	190.0 ± 4.5[a,b]
G2 (15g Egypt)	29.5 ± 14.1	140.0 ± 1.4	168.8 ± 15.4 [a]
G3 (20g Egypt)	42.2 ± 5.0 [a]	141.0 ± 3.1	182.2 ± 6.1 [a]
G4 (5g Jordan)	48.7 ± 5.8 [a]	140.5 ± 1.1	189.8 ± 5.9 [a]
G5 (15g Jordan)	34.0 ± 6.6 [a]	141.0 ± 2.5	175.0 ± 5.73 [a]
G6 (20g Jordan)	51.0 ± 3.7[a,b]	141.0 ± 3.2	196.0 ± 3.1[a,,b]
G7 (7.5 Egypt & 7.5 Jordan)	45.7 ± 5.8 [a]	140.0 ± 2.3	194.0 ± 4.5[a,b]
G8 (10 Egypt & 10 Jordan)	48.7 ± 5.8 [a]	140.5 ± 1.1	189.8 ± 5.9 [a]

* Data are presented as means ± SDM (n=5).
Data in Columns with different superscript letters are statistically different ($P \leq 0.05$)
IBW= Initial body weight; FBW= Final body weight; BWG= Body Weight gain

Kidney function test uric acid, creatinine, urea and polyphenol oxidase levels of examined groups

Table (4) indicated that uric acid level of the negative control group was normal (3.5±0.4mg/dl). By comparing uric acid levels among groups, group (8) had significantly lower uric acid level (5.7 ±0.4mg/dl) followed by group (7) (7.1±0.5mg/dl) than all other groups ($p<0.05$). The present result is in agreement with (Jin *et al*., 2018) who found that high dose chicory (13.2g/kg) reduces serum uric acid in hyperuricemia rats more than low doses of chicory (6.6g/kg).

It was obvious from data in Table (4) creatinine and urea were highest in the positive control group (44.3±3.4 nmol/ml and 36.1±1.6mg/dl, respectively), however their levels were the lowest in group (8) (10.6±1.8 nmol/ml and 6.8±1.1mg/dl). Wang *et al*. (2019) found that Chicory decreased serum levels of urate and creatinine significantly, and promoted the clearance of creatinine and urate, as well as

improving renal pathologic changes due to hyperuricemia. Hyperuricemia leads to urate crystal deposition in between the joints, thus becoming a prime risk factor in the development of gout. In addition to this, it also leads to other clinical diseases, such as cardiovascular and cerebrovascular conditions. Elevated concentration of uric acid is linked to increased rates of creatinine and urea (Singh *et al* ., 2019).

The polyphenol oxidase with highest level was in the positive control group (7.3±0.43ng/ml) and the lowest level was in negative control group (0.4±0.0ng/ml). By comparing polyphenol oxidase levels among groups, group (8) had significantly lower level (1.34 ± 0.3ng/ml) than all other groups ($p<0.05$).

Table (4). Kidney function test uric acid, creatinine, urea and polyphenol.

Groups	Uric acid (mg/dl)	Creatinine (nmol/ml)	Urea (mg/dl)	Polyphenol oxidase (ng/ml)
Control (-)	3.5 ± 0.4b	5.4 ± 0.4 b	2.5 ± 0.6b	0.4 ± 0.02b
Control(+)	18.4 ± 1.1a	44.3 ± 3.4a	36.1 ± 1.6a	7.3 ± 0.43 a
G1 (5g Egypt)	12.1 ± 0.83a,b	31.8 ± 1.5a,b	26.2 ± 2.7a,b	5.6 ± 0.8a,b
G2 (15g Egypt)	14.6 ± 1.1a,b	35.1 ± 1.8a,b	26.7 ± 1.6 a,b	5.6 ± 0.5a,b
G3 (20g Egypt)	10.9 ± 1.02a,b	30.0 ± 0.93a,b	20.5 ± 1.1a,b	4.4 ± 0.5a,b
G4 (5g Jordan)	9.4 ± 0.8a,b	26.0 ± 0.95a,b	16.7 ± 0.93a,b	3.7 ± 0.2a,b
G5 (15g Jordan)	12.0 ± 0.7b	26.7 ± 1.6a,b	20.0 ± 1.2 b	4.19 ± 0.7a,b
G6 (20g Jordan)	8.7± 0.9a,b	19.7 ± 1.5a,b	16.1 ± 1.5a,b	2.6 ± 0.11 a,b
G7 (7.5 Egypt & 7.5 Jordan)	7.1 ± 0.5 a,b	15.1 ± 1.3a,b	10.5 ± 1.3a,b	2.0 ± 0.22a,b
G8 (10 Egypt & 10 Jordan)	5.7 ± 0.4a,b	10.6 ± 1.8a,b	6.8 ± 1.1a	1.34 ± 0.3a,b

* Data are presented as means ± SDM (n=5).
Data in Columns with different superscript letters are statistically different ($P \leq 0.05$)

It was clear from data in Table (5) that weights of kidney and bow had significant increasing after suffering from gout , treatment with different doses of chicory from Egypt and Jordan led to less weight gain in kidney and bow in group 8 (0.79± 0.06, 2.00± 0.15g) respectively.

Liver, kidney and bow weight of treated experimental rats

It was clear from data in Table (5) that weights of liver, kidney and bow had significant increasing after treatment with different doses of chicory from Egypt or Jordan compared with negative control group ($P\leq0.05$) except for weight of liver in group 8 (5.75±0.62g) which treated with a mixture of 10g of chicory from Egypt and 19g from Jordan. The highest increase in liver, kidney and bow weight in treated rats was found in group (1) treated with low dose chicory (5g) from Egypt. Yao *et al.* (2020) reported that the treatment with chicory significant attenuated the degree of ankle swelling, inflammation, and dysfunction index.

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Table (5). Kidney and bow weight (g) of experimental rats treated with different ratio of chicory.

Groups	Kidney (g)	Bow (g)
Control (-)	0.65 ± 0.06^{b}	1.9 ± 0.25^{b}
Control (+)	1.62 ± 0.102^{a}	2.88 ± 0.21^{a}
G1(5g Egypt)	1.64 ± 0.05^{a}	2.79 ± 0.41^{a}
G2 (15g Egypt)	1.41 ± 0.11^{a}	2.70 ± 0.13^{a}
G3 (20g Egypt)	$1.25 \pm 0.16^{a,b}$	2.67 ± 0.12^{a}
G4 (5g Jordan)	1.79 ± 0.06^{a}	2.71 ± 0.31^{a}
G5 (15g Jordan)	1.36 ± 0.303^{a}	2.51 ± 0.11^{a}
G6 (20g Jordan)	1.32 ± 0.22^{a}	2.37 ± 0.11
G7(7.5 Egypt& 7.5 Jordan)	$1.16 \pm 0.28^{a,b}$	2.21 ± 0.82
G8 (10 Egypt& 10 Jordan)	0.79 ± 0.06^{b}	2.00 ± 0.15^{b}

*Data are presented as means ± SDM(n=5) .
Data in a columns with different superscript letters are statistically different ($P \leq 0.05$)

Histopathological examination

Kidneys

Microscopic examination of kidneys sections from the negative control group of rats revealed normal histology of both renal cortex and medulla (Fig. 1). The renal cortex contains glomeruli , proximal convoluted tubules and distal convoluted tubules and renal tubules, while the renal medulla has renal tubules. The positive control group showed spectrum of histopathological alterations. The renal tubular epithelium suffered from degeneration and necrotic changes with perivascular edema and inflammatory cells infiltration (Fig. 2). Concerning, rats of group (1) there was some histopathological changes where renal cortex tubules suffered from mild necrobiotic changes in some instances accompanied by moderate congestion of cortical blood vessels (Fig. 3). Sections of kidney of Rats of Group (2) indicated the presence of some histopathological changes as mild necrobiotic changes in the renal cortex tubular epithelium (Fig. 4).There was congestion of the renal cortex of kidney in rats of group (3) (Fig.5). The kidney of rats of group (4) showed normal structure of the renal cortex (Fig. 6).While, kidney of rats of group (5) showed swelling of some renal tubular epithelium (Fig. 7).Also, kidney of rats of group (6) showed swelling of the renal tubular epithelium with narrowing of tubular lumen (Fig. 8).Rats of group (7) have kidney with mild vacuolation of renal tubular epithelium renal cortex (Fig. 9). However, kidney of rats of group (8) showed vacuolar degeneration in the renal tubules of the renal cortex (Fig. 10). Kang *et al*. (2002) found that hyperuricemic rats had more renal hypertrophy and greater glomerulosclerosis and interstitial fibrosis. Hyperuricemic rats developed vascular disease consisting of thickening of the preglomerular arteries with smooth muscle cell proliferation; these changes were significantly more severe chicory significantly reduced uric acid levels and blocked the renal functional and histologic changes.

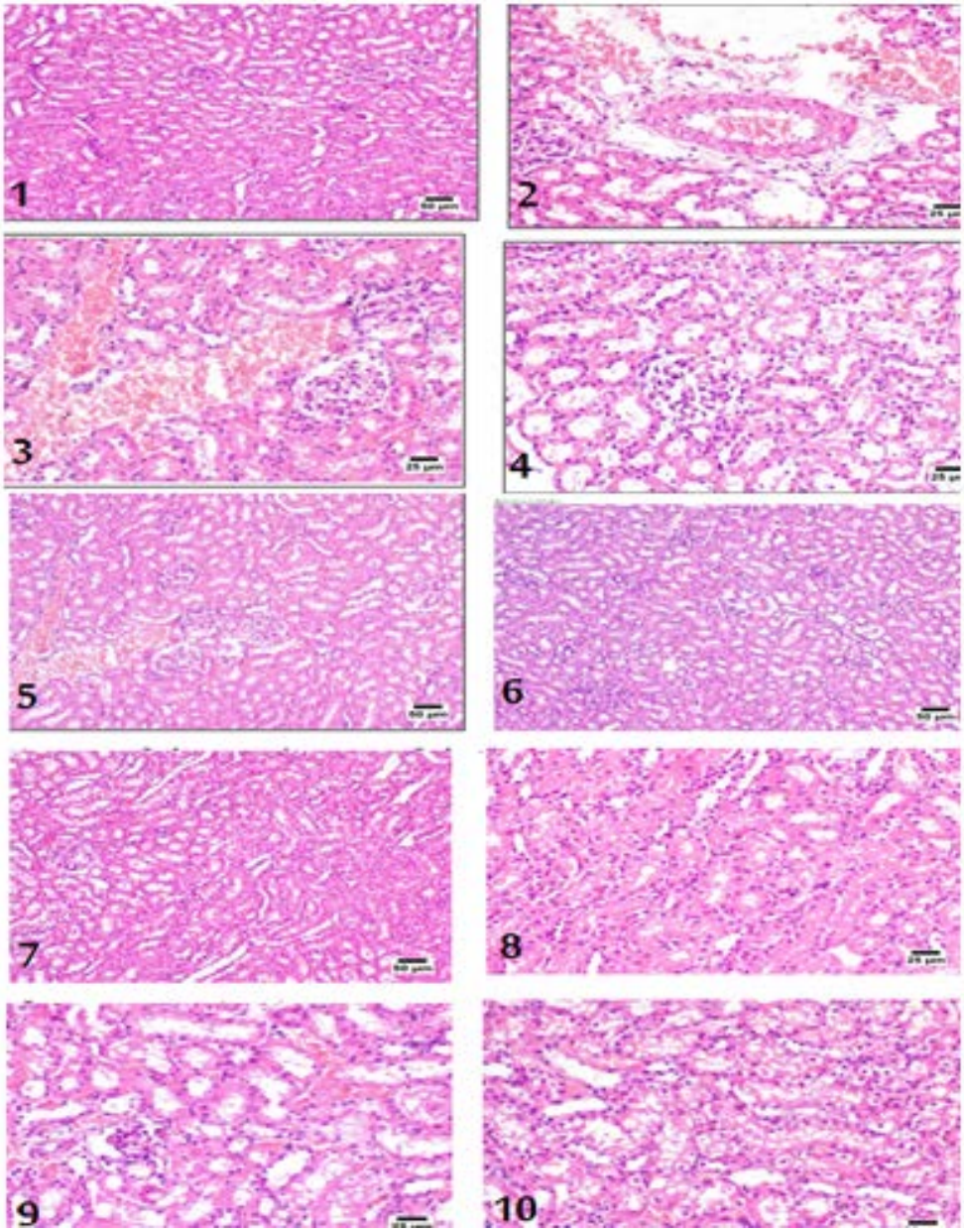
Bow (Ankle)

Histopathological examination of bones and surrounding soft tissues from negative control group (Fig. 11) revealed normal articular surfaces, joint capsule, and periarticular tissues. Skin and subcutaneous tissues were histologically normal as well. Severe diffuse periarticular inflammatory cells infiltration extending into the joint capsule with marked edema and necrosed synovial surface was noticed in Control (+), marked edema was observed as well. Also, the inflammatory reaction was extending deep into the joint capsule that appeared with damaged

synovial surface. Inflammatory cells were infiltrating the subcutaneous tissue (Figs. 12 & 13). Rats of groups (1, 2) showed periarticular edema with mild inflammatory cells infiltrations around the joint and in the subcutaneous tissue (Figs. 14 & 15), the joint capsule and articular surfaces were apparently normal.

Groups (3 & 4) (Figs. 14 & 15) showed great improvement as the only detectable lesion was represented by mild edema in the periarticular and subcutaneous tissues with mild inflammatory cells infiltration. Subcutaneous tissues exhibited mild inflammatory edema.

Marked improvement was noticed in groups (5 & 6) (Figs. 18 & 19) as an apparently joints and periarticular tissues were seen with minimal or without inflammatory reactions. Similarly skin and subcutaneous tissues were improved as limited inflammatory reaction was seen in the subcutaneous tissue. Single severely affected individual showed marked periarticular edema and inflammatory cells infiltration. Group (7) showed intense perivascular inflammatory cells (Fig. 20), while group (8) showed normal skin and subcutaneous tissue (Fig. 21). Similar results were obtained by Wang *et al*. (2019) who found that chicory reduces edema in joints, and also inhibit the inflammatory response induced by gout.



Figs. (1-10): Photomicrographs of sections of kidney of rats from different groups. Stained with (H&E) showing:

Fig. (1): Control (-) group with normal renal cortex.

Fig. (2): Control (+) group with perivascular edema and inflammatory cells infiltration.

Fig. (3):Group (1) with congestion of the renal cortex.

Fig. (4): Group (2) with mild necrobiotic changes in the renal cortex.

Fig. (5):Group (3) with congestion of the renal cortex.

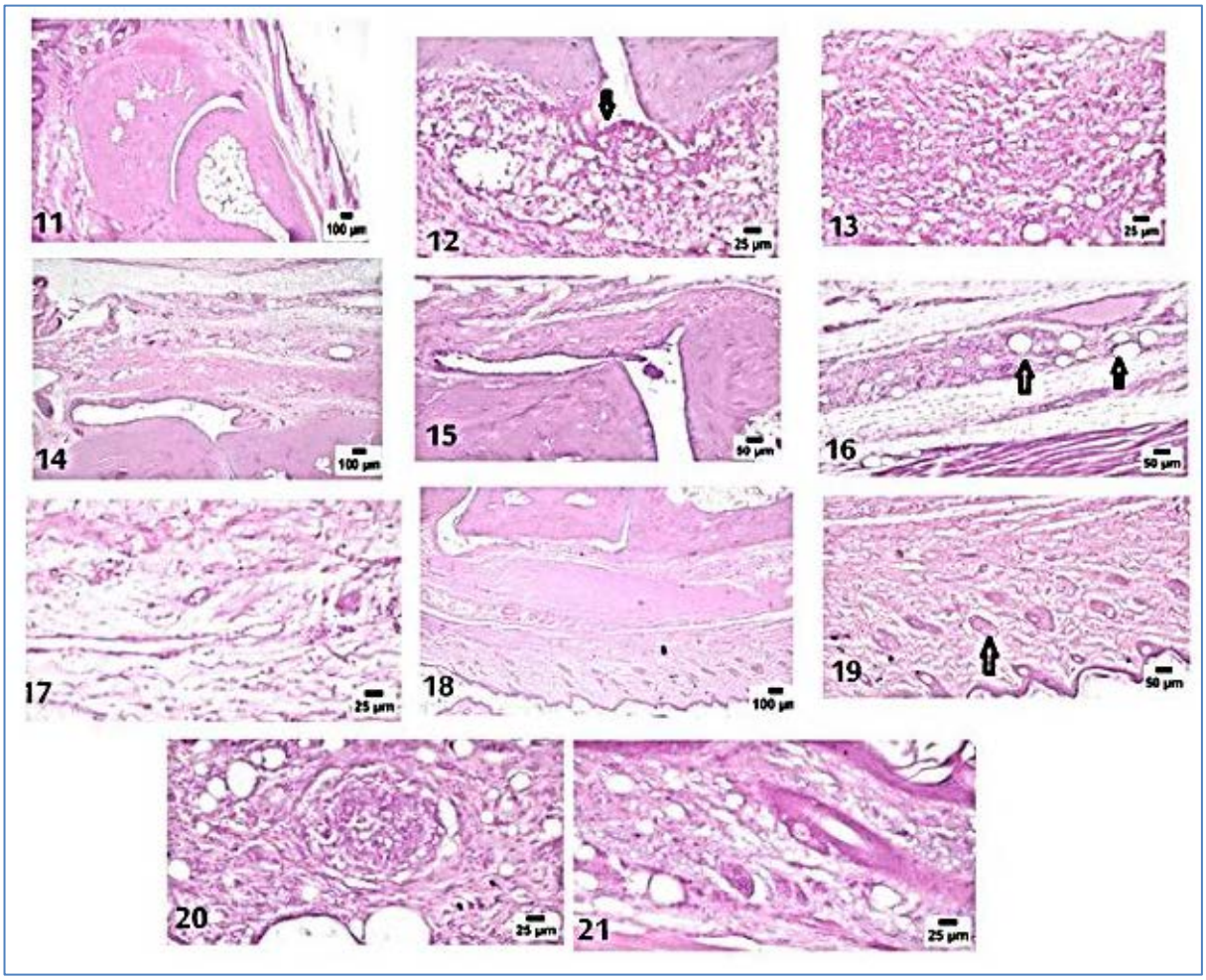
Fig. (6): Group (4) with apparently normal renal cortex.

Fig.(7): Group (5) with swelling of some renal tubular epithelium .

Fig.(8): Group (6)with swelling of the renal tubular epithelium with narrowing of tubular lumen.

Fig.(9): Group (7) with mild vacuolation of renal tubular epithelium renal cortex.

Fig.(10): Group (8) with vacuolar degeneration in the renal tubules of the renal cortex.



Figs. (11-20): Photomicrograph of bone sections of rats at different groups. Stained with. (H&E) showing:

Fig.(11): Control (-) group (1) with normal articular surface, periarticular tissue and skin.

Fig.(12): Control (+) group (2) with inflammatory cells infiltration extending into the joint capsule with marked edema and necrosed synovial surface (arrow).

Fig.(13): Control (+) group (2) with severe diffuse subcutaneous inflammatory cells infiltration.

Fig.(14): Group (1) with periarticular edema with mild inflammatory cells infiltrations.

Fig. (15): Group (2) with apparently normal joint capsule.

Fig. (16): Group (3) with perivascular inflammatory cells infiltration (arrows) with edema.

Fig.(17): Group (4) with edema with mild inflammatory cells infiltration.

Fig. (18): Group (5) with apparently normal joint and surrounding tissue.

Fig. (19): Group (6) with mild inflammatory cells infiltration (arrow).

Fig. (20): Group (7) with higher magnification showing intense perivascular inflammatory cells infiltration.

Fig. (21): Group (8) with normal skin and subcutaneous tissue.

Conclusion:

Chicory extract decreased serum levels of (Creatinine, urea ,uric acid and polyphenol oxidase) and suppressed ankle edema and gouty inflammation in experimental rats induced with MSU crystals, with the most significant

Improvement in those treated with highest dose from both Egypt and Jordan (10gm/10gm) this mixture contains the highest antioxidant activities as well as highest inulin content.

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دراسة مقارنة بين مصدرين من نبات الهندباء (مصر والأردن) وتأثيرهما على النقرس في فئران التجارب

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المستخلص

يسمى النقرس بمرض الملوك وهو أحد أقدم أمراض المفاصل المعروفة للإنسان ومرض أيضي شائع ينتج عن ارتفاع مستويات حمض اليوريك في الدم. يعتبر مرتبطًا ارتباطًا وثيقًا بتطور العديد من الأمراض المزمنة ، مثل السمنة وارتفاع ضغط الدم وفرط شحميات الدم والسكري واضطرابات القلب والأوعية الدموية. الهدف من دراسة تأثير المركبات النشطة بيولوجيا من الهندباء كعلاج طبيعي لعلاج فرط حمض يوريك الدم بتركيزات مختلفة (٢٠،١٥،٥ جم) من أوراق الهندباء الجافة من مصدرين (مصر والأردن) على النقرس و وظائف الكلى ، بولي فينول أوكسيديز للفئران البيضاء. تم أخذ ٦٠ من ذكور الجرذان البالغة وزنها حوالي (١٤٠ ± ١٠) جرام وقسمت إلى ١٠ مجموعات ، كل منها ستة فئران. المجموعة الأولى هي المجموعة الضابطة (-) وتتغذى على نظام غذائي عادي لمدة ٨ أسابيع. تلقت المجموعات الأخرى حقن بلورة أحادية الصوديوم (MSU) وجرعة مختلفة من الهندباء. أظهرت النتائج أن المجموعة الضابطة الموجبة (+) وجميع المجموعات لديها زيادة معنوية في وظائف الكلى في مصل الدم وحمض اليوريك والكرياتينين واليوريا والبولي فينول أوكسيديز مقارنة بمجموعة التحكم السلبية (-) وكذلك بالإضافة إلى تلف أنسجة الكلى والكاحل ، إلا أن المجموعات التي غذت بنسب مختلفة من الهندباء أظهرت تحسنًا في وظائف الكلى ، والبولي فينول أوكسيديز وانسجة الأعضاء مقارنة بمجموعة التحكم الإيجابية (+).