Chapter 8
Print ISBN: 978-93-48006-12-7, eBook ISBN: 978-93-48006-54-7

Determination of Anti-inflammatory Properties of *Asparagus officinalis* Extract

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DOI: https://doi.org/10.9734/bpi/ibs/v10/1975

Peer-Review History:
This chapter was reviewed by following the Advanced Open Peer Review policy. This chapter was thoroughly checked to prevent plagiarism. As per editorial policy, a minimum of two peer-reviewers reviewed the manuscript. After review and revision of the manuscript, the Book Editor approved the manuscript for final publication. Peer review comments, comments of the editor(s), etc. are available here: https://peerreviewarchive.com/review-history/1975

ABSTRACT

Aim: The present work was designed to evaluate the anti-inflammatory properties of *Asparagus officinalis* (AO) extract on liver inflammation CGN-induced.
Background: Inflammation itself results in more hepatic cell damage, and a flow of cytokines and chemokines called inflammatory mediators is released, which in turn leads to the accumulation of leukocytes, mast cells, and macrophages in the inflammation site.
Materials and Methods: Forty male Swiss albino mice were divided randomly into four groups, 10/each. The first group acted as untreated control, the second group was treated daily with an oral dose of (500 mg/kg) AO extract for one week, the third group was treated with a single dose of 2%W/V carrageenan (CGN) intraperitoneally, and left for one week, the fourth group treated with carrageenan as a third group and AO extract as the second group.
Results: CGN injection resulted in a significant increase of WBCs and platelets, elevation of liver enzymes, and proinflammatory cytokines (TNF-α and IL6). Morphological features of the tails showed severe necrosis, and histopathological examination of tail tissue displayed a heavy incidence of inflammatory cells in the dermis layer and liver revealing severe inflammation, steatosis, and ballooning. The present study showed that a single dose of carrageenan could induce severe hepatic inflammation represented by an increase in liver enzyme activities (ALT, AST, and ALP) which due to hepatocellular degeneration leads to the draining of enzymes in the bloodstream. Several studies declared that AO extracts improved the elevated liver enzymes by bisphenol A. Meanwhile, post-treatment with AO extract after CGN showed a significant decrease in WBCs, platelets, and physiological parameters. Histopathological analysis revealed less incidence of inflammation in the tail and liver tissue besides improvement of tissues and pathological score.

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Conclusion: Post-treatment with AO extract after CGN injection showed significant improvement manifested by lowering liver enzymes, cytokines, and liver inflammation.

Keywords: Asparagus officinalis; extract; carrageenan; inflammation; histopathology.

1. INTRODUCTION

Environmental pollution increases the level of hazardous chemicals, which adversely affect humans and wildlife. Numerous chemicals have been associated with oxidative stress, and the subsequent pathogenesis leads to the production of unregulated free radicals and reactive oxygen species (ROS); these cytotoxic agents induce cell death. Inflammation is the body's way of defense against hazards such as toxins, infections, and allergens [1]. Inflammation is a biological response of the immune system that can be triggered by a variety of factors, including pathogens, damaged cells, and toxic compounds. These factors may induce acute and/or chronic inflammatory responses in the heart, pancreas, liver, kidney, lung, brain, intestinal tract, and reproductive system, potentially leading to tissue damage or disease [2]. Inflammation happens normally during the day as a response to the activities of the body; as the cells are subjected to more physical and chemical changes or diseases, the inflammation becomes more intense [3]. When the process of inflammation became uncontrolled, it resulted in inflammatory disease accompanied by dysfunction of the organ. Inflammation consists of several components, such as leukocytes and macrophages, in addition to mediators like interleukins, prostaglandins, and tumor necrosis factors [4,5]. In the liver, many factors, such as toxins, drugs, etc., can stimulate hepatic cell damage, leading to inflammation and even fibrosis. At the same time, inflammation itself results in more hepatic cell damage, and a flow of cytokines and chemokines called inflammatory mediators is released, which in turn leads to the accumulation of leukocytes, mast cells, and macrophages in the inflammation site [6,5].

Carrageenan CGN is a polysaccharide obtained from some seaweeds that belong to the *Rhodophyceae* family well-known for with high content of polysaccharides, minerals, and vitamins [7]. Chemically, CGN is composed of a linear backbone of galactose with 15% to 40% sulfatation, according to the chemical composition CGN is classified into kabba, lamda, lota, and theta [8,5]. CGN is considered an important food additive but with no nutritional impact. CGN is used in the food industry as an emulsifier because of its gelling and thickness properties [9]. Experimentally, CGN is used as an inflammatory inducer model to stimulate acute inflammation in the paw, tail, or visceral organs [10,5].

Asparagus officinalis AO is a perennial vegetable with swollen and thick short joints, its stem is needle-like about 60-150 cm in height, The most popular producer of AO is China followed by Spain and then Italy and France [11]. AO vegetable color changes from green to purple and used to be eaten before becomes dark. It is the main source of vitamins, especially vitamins B and K, and also contains the amino acid asparagine and high content of minerals such as calcium, magnesium,

and iron besides fibers and water [12,5]. Furthermore, It was approved that AO contained many vital components such as steroidal saponins, Fe, Ca, and folic acid besides primary chemical constituents like sparagine, arginine, flavonoids (kaempferol, quercetin, and rutin), tannin and resin [13,14]. Several studies demonstrated that *asparagus* had many important properties such as anti-fungal and anti-inflammatory effects due to its bioactive components such as steroids, saponins, oligosaccharides, and flavonoids [15]. On the other hand, other studies declared that *asparagus* possesses hepatoprotective effects against hypercholesterolemia [16] and hepatotoxicity by paracetamol [17,5]. As shown in the previous studies AO contains a lot of active biocomponents leading to several roles and may be used to inhibit inflammation induced by allergens, so the current study aimed to investigate the effect of *Asparagus officinalis* extract on liver inflammation carrageenan-induced in male albino mice.

2. MATERIALS AND METHODS

2.1 Materials

Asparagus officinalis rhizome extract was purchased from Solaray Company (USA). Carrageenan powder was purchased from Fit Lane Nutrition (USA).

2.2 Animals

Forty healthy male Swiss albino mice of about (30±5 g) of weight, aged 14 weeks were obtained from the Animal House of Zoology Department, King Saud University, Riyadh. Animals were kept in healthy cages under controlled temperature (23± 5℃) and maintained under a 12 / 12hrs light-dark cycle. Animals were given free access to a commercial pellet diet and tap water. Animals were acclimatized for one week before the experiment [5].

2.3 Experimental Design

Forty male Swiss albino mice were divided randomly into four groups, 10/each. 1st group was kept as untreated control, 2nd group was treated daily with an oral dose of (500 mg/kg) AO extract for one week, 3rd group was treated with an intraperitoneal single dose of 2%W/V carrageenan and left for one week, 4th group treated with carrageenan as group 3 and AO extract as group 2 [5].

2.4 Samples Collection

At the end of the experiment, animals were anesthetized with CO_2 flow. Tails were imaged and blood samples were collected directly from the heart, drained in EDTA tubes, and subjected to CBC analysis**.** Liver samples were removed and cut into small pieces, fixed in 10% neutral buffered formalin (NBF) for histopathological study. The rest of the liver was kept at -80℃ for homogenizing [5].

2.5 Liver Index

Each mouse was weighed to get total body weight and its liver also was weighed, liver weight was divided by total body weight multiplied by 100,

2.6 Biochemical Analysis

The liver was homogenized in cold PBS with a ratio of 1:3 for 3 min. then centrifuged for 15 min. at 4˚C twice then filtered, the supernatant was separated and stored at -80˚C till assay [5].

2.7 Liver Function Analysis

Liver enzymes were estimated in the homogenized liver (ALT, AST, and ALP) using commercial kits (Biosystem-Spain).

2.8 Inflammatory Cytokines Determination

Tumor necrosis factor-alpha (TNF-α) and Interleukin 6 (IL6) were determined in the liver homogenate using commercial kits of Enzyme-Linked Immunosorbent Assay (ELISA) [5].

2.9 Histopathological Analysis

Liver and tail samples were fixed in 10% formalin and then dehydrated by ascending grades of ethanol. Samples were embedded in paraffin wax, then sectioned at 6µm and stained by hematoxylin and eosin. Photomicrographs of the sections were taken (Nikon-Japan) [5].

2.10 Nonalcoholic Fatty Liver Disease (NAFLD) Pathological Score

Item Definition Score: Steatosis, <5% = 0, 5 – 33% = 1, 33 – 66% = 2, >66% = 3. Inflammation, No foci = 0, < 2 foci per field = 1, 2 – 4 foci per field = 2, > 4 foci per field = 3. Hepatocyte ballooning, None = 0, few ballooned cells = 1, many cells/prominent ballooning = 2. NAFLD Activity Score Sum of steatosis, lobular inflammation, and ballooning scores 0–8 [18,5].

2.11 Statistical Analysis

Data was shown as mean± SEM, and the differences between the treated and control mice were evaluated using the one-way ANOVA, the differences were statistically significant when the value of $p \leq 0.05$ [5].

3. RESULTS

3.1 *Asparagus* Extract Significantly Decreased WBCs and Platelets

As shown in (Table 1) the mice group 3 received a single dose of carrageenan and left for one week displayed a significant change in hematological parameters

compared to the control group, particularly WBCs count as a result of inflammation. Whereas the post-treated group with *asparagus* extract to carrageenan postulated a marked significant improvement referred to decreasing inflammation [5].

Table 1. Effect of *asparagus* extract post-treatment to carrageenan on hematological parameters

CBC	Con	Asp	CGN	CGN+ Asp
WBCs	4.5±0.04	6±0.07	18±0.3^{*a}	12±0.3^{*a,b}
Lymph	3±0.05	4±0.07	14±0.2^{*a}	7±0.1^{*a,b}
Mon	0.22±0.07	0.22±0.06	0.80±0.04^{*a}	0.23±0^{*b}
Gran	1.3±0.2	1.7±0.2	4.6±0.2^{*a}	1.5±0.2^{*b}
RBC	6.4±0.7	8.2±0.2	7±0.7	8.6±0.4
HGB	13.6±0.03	13±0.03	11±0.1	12.9±0.07
PLT	675±1	680±1	960±2^{*a}	690±1^{*b}

*Data= Mean ± SEM, p=0.05, *a significant against control group, *b significant against carrageenan group*

3.2 Liver Index

Mice group treated with *asparagus* extract showed no difference in liver index compared to the control group. Whereas, the mice group injected with a single dose of carrageenan revealed a high increase in liver compared to the control group. Furtherly, the group post-treated with *asparagus* extract to carrageenan displayed a significant decrease in liver index compared to the group that received carrageenan only (Table 2) [5].

3.3 *Asparagus* Extract Lowered the Liver Enzymes and Inflammatory Cytokines Elevated by CGN

It was observed that no significant difference in liver enzyme (ALT, AST, and ALP) activity levels of the group treated with *asparagus* extract for one week compared to the control group. Contrastingly, the group that received a single dose of carrageenan and left for a week revealed a highly significant increase in liver enzymes compared to the control group [5]. Moreover, the post-treated group with *asparagus* extract to carrageenan showed a significant decrease compared to the carrageenan group (Table 2). Additionally, CGN as an inflammatory inducer elevated levels of inflammatory cytokines TNF-α and lL6 but post-treatment with AO extract to CGN resulted in a significant decrease of cytokines compared to the group that received a single dose of CGN (Table 2) [5].

3.4 Histopathological Analysis

3.4.1 *Asparagus* extract decreased pathological effects of tail CGN-induced

Tails of untreated control animals and those treated with AO extract showed normal features (Fig. 1A & B). Whereas, animals treated with 2% w/v of carrageenan revealed severe necrosis of tails (Fig. 1C) [5]. However, post-

treatment with asparagus extract to CGN led to less necrotic region in the tail (Fig. 1D). Histopathological examination of untreated control mice and the group treated with AO extract tails showed normal structure (Figs. 2A & B). Whereas, the tail of the mice group treated with CGN exhibited severe inflammation in the dermis region (Fig. 2C). Moreover, treatment with AO extract after CGN displayed less inflammation (Fig. 2D) [5].

Table 2. The differences between liver enzyme activity levels of experimental groups compared to control

Items	Con	Asp	CGN	CGN+ Asp
Liver index	7.5±0.05	7±0.02	12±0.1^{*a}	8±0.04^{*b}
ALT	279±0.1	284±0.08	499±0.6^{*a}	321±0.2^{*a,b}
AST	152±0.8	150±0.8	260±0.7^{*a}	163±0.2^{*b}
ALP	228±0.7	228±0.9	448±2^{*a}	388±1^{*a,b}
TNF-α	586±18	598±55	853±20^{*a}	741±10^{*a,b}
IL6	240±13	243±27	372±28^{*a}	295±20^{*a,b}

*Data= Mean ± SEM, p=0.05, *a significant against control group, *b significant against carrageenan group*

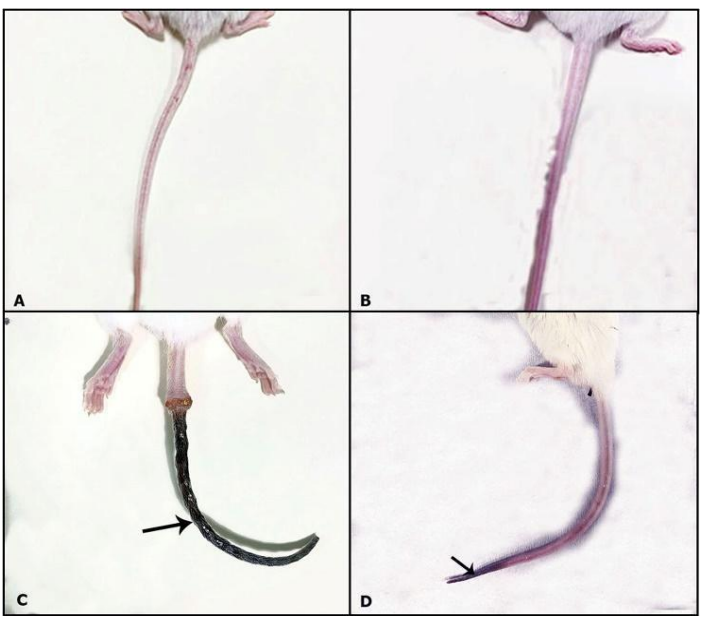

Fig. 1. Photomicrograph of mice tails (A) untreated control showing normal appearance of the tail, (B) mice treated with 500 mg/kg of AO extract revealing normal appearance of the tail, (C) mice treated with CGN exhibiting severe necrosis, (D) mice treated with CGN and AO extract showing less necrosis

3.4.2 *Asparagus officinalis* extract suppressed inflammation and lowered liver pathological score increased by CGN

Microscopic examination of untreated control liver showed a normal structure consisting of central veins surrounded by an anastomose network of hepatocytes separated from each other with blood sinusoids (Figs. 3A & 4A). Moreover, the liver tissue of mice treated with AO extract revealed no pathological signs (Figs. 3B & 4B) [5]. Whereas, the liver of the mice group that received ip single dose of 2%w/v exhibited marked inflammatory observations represented by great inflammatory nodules consisting of leukocytic inflammatory cells mixed with extra-cellular matrix and collagenous fibers, besides dilatation and congestion of veins, also the destruction of some vein walls leading to hemorrhage [5]. Hepatocytes showed degeneration and steatosis (Figs. 3C & 4C), and NAFLD pathological score registered high levels due to increasing steatosis, inflammation, and ballooning of hepatocytes (Table 3). Furtherly, the liver of the group post-treated with 500 mg/kg of *asparagus* extract to carrageenan displayed marked improvement manifested by no nodules but some aggregations of inflammatory cells in addition to dilatation of veins and steatosis of hepatocytes (Figs. 3D & 4D), NAFLD pathological score posted fewer values compared with the previous group (Table 3) [5].

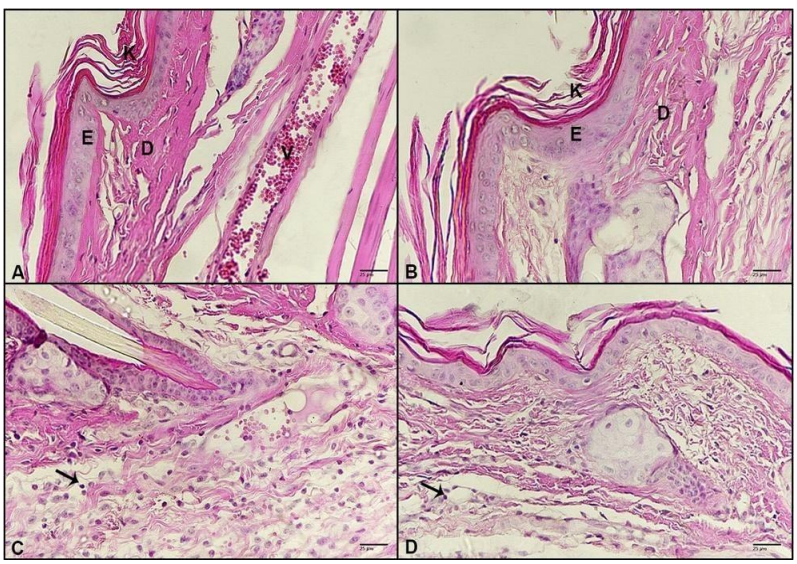

Fig. 2. Photomicrographs of tail histopathological changes (A) untreated control showing normal structure, (B) animals treated with 500 mg/kg of AO revealing normal structure, (C) animals treated with CGN exhibiting severe inflammation (D) animals treated with CGN and AO extract displaying less inflammation. (H&E-400X) (K) Keratin, (E) Epidermis, (D) Dermis, (arrow) inflammation

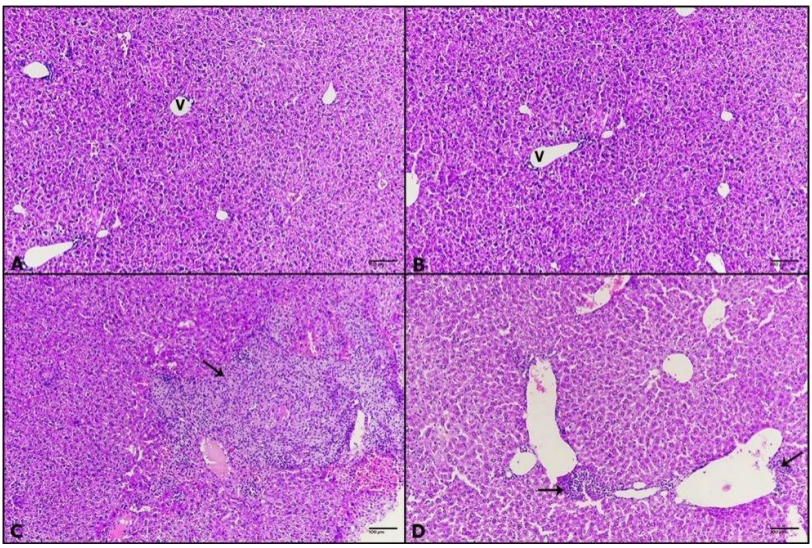

Fig. 3. Photomicrographs of mice liver (A) untreated control showing normal hepatic structure (V) vein, (B) group treated with 500 mg/kg of *asparagus* extract revealing normal liver appearance (V) vein, (C) group treated with ip single dose of 2%w/v of carrageenan exhibiting wide nodule of inflammatory granuloma (black arrow), (D) group post-treated with *asparagus* extract to carrageenan displaying small foci of inflammation (black arrow). (HE-100X)

Table 3. *Asparagus officinalis* lowered NAFLD pathological score increased by CGN

Items	C	AO	CGN	CGN+AO
Steatosis	0	0	2	1
Inflammation	1	1	3	2
Ballooning	0	0	2	1
Score	1	1	7	4

4. DISCUSSION

Many studies confirmed that carrageenan could induce animal paw edema dose-dependently as a result of inflammation that affects the count of leukocytes [19]. GCN mainly stimulates the generation of histamine, prostaglandins, and neutrophils leading to the production of acute inflammation [20]. Accordingly, the present work revealed that CGN ip injection resulted in a significant increase in the total count of WBCs and platelets. Additionally, it was observed that treatment with AO extract could significantly reduce the elevated count of WBCs and platelets due to CGN injection [5].

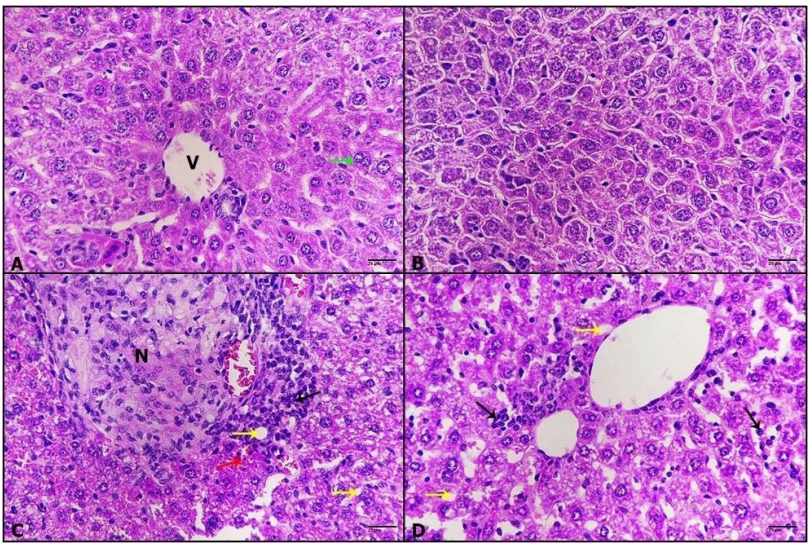

Fig. 4. Photomicrographs of mice liver (A) untreated control showing normal liver view (V) vein, (green arrow) binucleated cell, (B) group treated with 500 mg/kg of *asparagus* extract displaying normal liver appearance, (C) group treated with ip single dose of 2%w/v of carrageenan presenting large nodule of inflammatory granuloma (N) aggregated leukocytic inflammation (black arrow), hemorrhage (red arrow), steatosis (yellow arrows), (D) group post- treated with *asparagus* extract to carrageenan posting minimized aggregation of inflammatory cells (black arrow), steatosis (yellow arrows). (HE-400X)

Moreover, several investigations observed that a single dose of inflammatory inducer carrageenan mainly affected liver functions and caused a highly significant rise in liver enzyme activities [21,22]. The present study showed that a single dose of carrageenan could induce severe hepatic inflammation represented by increasing liver enzyme activities (ALT, AST, and ALP) due to hepatocellular degeneration leading to the draining of enzymes in the bloodstream [5]. Several studies declared that AO extract improved the elevated liver enzymes by bisphenol A [15]. Moreover, AO extract significantly reduced liver enzymes increased by paracetamol [17]. Accordingly, the present study indicated that post-treatment with AO extract decreased liver enzymes that were disturbed due to CGN injection, which may be attributed to the heavy content of steroidal saponins, flavonoids, and polyphenols [23,5].

Additionally, CGN injection resulted in an increase of inflammatory cytokines TNF-α and IL6 [20,22]. Currently, the present work displayed a significant increase of proinflammatory cytokines TNF-α and IL6 that is attributed to the stimulation of macrophages, monocytes fibroblasts, and hepatocytes resulting in the overproduction of these proinflammatory cytokines. On the other hand, it was

mentioned that AO extract could suppress proinflammatory cytokines produced due to COVID-19 [24,5]. The present study posted that post-treatment with AO extract to CGN also decreased TNF-α and IL6, which might be a result of the inhibition of inflammation by AO extract.

The current work displayed that CGN injection resulted in severe necrosis of the tail and intense inflammation in the dermis layer of the tail skin. It was declared that injection of CGN in rats' paws resulted in edema and a heavy incidence of neutrophils [20,5]. It was reported that CGN injection induced intense liver injury [21]. Additionally, the present work postulated that CGN induced extreme hepatic inflammation, steatosis, and ballooning with high liver pathological scores that may be attributed to strong bioactive constituents of *asparagus* [22,23,25-28,5].

5. CONCLUSION

The present study indicated that ip injection of CGN induced an increase in WBCs and platelets. Additionally, CGN increased liver enzymes, proinflammatory cytokines and severe liver inflammation with high pathological scores. Post-treatment with AO extract after CGN injection showed significant improvement manifested by lowering liver enzymes, cytokines, and liver inflammation [5].

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of manuscripts.

ETHICAL APPROVAL

The present work was approved ethically by the Institutional Review Board (IRB), Committee of Ethics, King Saud University, Riyadh, Saudi Arabia. Ethics reference no: KSU-SE-22-02.

COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

1. Zhang X, Retyunskiy V, Qiao S, Zhao Y, Tzeng C-M. Alloferon-1 ameliorates acute inflammatory responses in λ-carrageenan- induced paw edema in mice. Sci Rep. 2022;12(1):16689.
   Available: https://doi.org/10.1038/s41598- 022-20648-z
2. Chen L, Deng H, Cui H, Fang J, Zuo Z, Deng J, Li Y, Wang X, Zhao L. Inflammatory responses and inflammation-associated diseases in organs. Oncotarget. 2018 Jan 1;9(6):7204.

3. Semis HS, Gur C, Ileriturk M, Kaynar O, Kandemir FM. Investigation of the anti- inflammatory effects of caffeic acid phenethyl ester in a model of λ-Carrageenan-induced paw edema in rats. Hum Exp Toxicol. 2021;40(12_suppl):S721–38.
4. Jisha N, Vysakh A, Vijeesh V, Latha MS. Anti-inflammatory efficacy of methanolic extract of Muntingia calabura L. leaves in Carrageenan induced paw edema model. Pathophysiol Off J Int Soc Pathophysiol. 2019;26(3–4):323–30.
5. Elnagar DM. Anti-inflammatory activity of *Asparagus officinalis* extract on liver inflammation carrageenan-induced in Swiss albino mice. Uttar Pradesh Journal of Zoology. 2023;44(10):48-56.
6. Bao Y, Wang L, Pan H, Zhang T, Chen Y, Xu S, et al. Animal and organoid models of liver fibrosis. Frontiers in Physiology. 2021;12:1–13.
   Available:https://www.frontiersin.org/article s/10.3389/fphys.2021.666138
7. García Tasende M, Manriquez-Hernandez J. Carrageenan properties and applications: A review. In: Carrageenans: Sources and Extraction Methods, Molecular Structure, Bioactive Properties and Health Effects. Environmental Science, Engineering and Technology. 2016;17–50.
8. Noor H. Potential of Carrageenans in Foods and Medical Applications. Global Heal Manag Journal. 2018;30(2):32–6.
9. Necas J, Bartosikova L. Carrageenan: A review. Vet Med (Praha). 2013;58(4):187– 205.
10. Fatima H, Shahid M, Jamil A, Naveed M. Therapeutic Potential of Selected Medicinal Plants Against Carrageenan Induced Inflammation in Rats. Dose Response. 2021;19(4):155932582110-58028.
    Available:https://doi.org/10.1177/15593258 211058028
11. Pitrat M. Vegetable crops in the mediterranean basin with an overview of virus resistance. In: Loebenstein G, Lecoq HBT-A in VR, editors. Viruses and Virus Diseases of Vegetables in the Mediterranean Basin. Academic Press. 2012;1–29.
    Available:https://www.sciencedirect.com/science/article/pii/B9780123943149000014
12. Gilissen LJWJ. Food, nutrition and health in the Netherlands. In: Braun S, Zübert C, Argyropoulos D, Casado Hebrard FJBT-N and HA of F in WE, editors. Nutritional&Health Aspect-Traditional & Ethnic Food. Academic Press. 2020;85–108.
    Available:https://www.sciencedirect.com/science/article/pii/B9780128131718000068
13. Negi JS, Singh P, Joshi GP, Rawat MS, Bisht VK. Chemical constituents of Asparagus. Pharmacogn Rev. 2010;4:215-20.
14. Olas B. A Review of the Pro-Health Activity of Asparagus officinalis L. and Its Components. Foods. 2024;13:288.

15. Poormoosavi SM, Najafzadehvarzi H, Behmanesh MA, Amirgholami R. Protective effects of *Asparagus officinalis* extract against Bisphenol A-induced toxicity in Wistar rats. Toxicol Reports. 2018;5:427–33.
16. García MD, De la Puerta R, Sáenz MT, Marquez-Martín A, Fernández-Arche MA. Hypocholesterolemic and hepatoprotective effects of "Triguero" asparagus from andalusia in rats fed a high cholesterol diet. Wahner-Roedler D, editor. Evidence- Based Complement Altern Med. 2012;2012: 814752.
    Available:https://doi.org/10.1155/2012/814 752
17. El-Senosiy YA, Ahmad SA, Farid AS, Wessam EM. Hepatoprotective effect of asparagus racemosus in paracetamol induced hepatotoxicity in rats Hepatoprotective effect of asparagus racemosus in paracetamol induced hepatotoxicity in rats. BENHA Vet Med J. 2015;28:133–7.
18. Goodman ZD. Grading and staging systems for inflammation and fibrosis in chronic liver diseases. J Hepatol. 2007; 47(4):598–607.
19. Mariko N, Hassimotto A, Moreira V, Galvão N, Cristina P, Castro M De, et al. Inhibition of carrageenan-induced acute inflammation in mice by oral administration of anthocyanin mixture from wild mulberry and cyanidin-3-glucoside. BioMed Res Int Through. 2013;2013:1–11.
20. Mansouri MT, Hemmati AA, Naghizadeh B, Mard SA, Rezaie A, Ghorbanzadeh B. A study of the mechanisms underlying the anti-inflammatory effect of ellagic acid in carrageenan-induced paw edema in rats. Indian J Pharmacol. 2015;47(3):292–8.
21. Bignotto L, Rocha J, Sepodes B, Figueira M, Pinto R, Chaud M, et al. Anti- inflammatory effect of lycopene on carrageenan-induced paw oedema and hepatic ischaemia-reperfusion in the rat. Br J Nutr. 2009;1(102): 126–33.
22. Mansouri SM, Hemmati AA, Naghizadeh B, Mard SA, Rezaie A, Ghorbanzadeh B. A study of the mechanisms underlying the anti-infl ammatory effect of ellagic acid in carrageenan-induced paw edema in rats. Indian J Pharmacol. 2015;1(47):292–8.
23. Kim B-Y, Cui Z-G, Lee S-R, Kim S-J, Kang H-K, Lee Y-K, et al. Effects of *Asparagus officinalis* extracts on liver cell toxicity and ethanol metabolism. J Food Sci. 2009;74 (7):H204-8.
24. de Siqueira Patriota LL, de Brito Marques Ramos D, E Silva MG, Dos Santos ACLA, Silva YA, Paiva PMG, et al. Inhibition of Carrageenan-Induced Acute Inflammation in Mice by the *Microgramma vacciniifolia* frond lectin (MvFL). Polymers. 2022;14(8):1–12.
25. Shirato K, Takanari J, Kizaki T. Standardized extract of *Asparagus officinalis* stem attenuates SARS-CoV-2 spike protein-induced IL-6 and IL-1β production by suppressing p44/42 MAPK and Akt Phosphorylation in Murine Primary Macrophages. Molecules. 2022;26 (20):1-15.
26. Rahiman F, Kumar R, Mani T, Niyas M, Kumar S. Hepatoprotective activity of "Asparagus Racemosus Root" on liver damage caused by paracetamol in rats. Indian J Nov Drug Deliv. 2011;29(3):112– 7.

27. Vázquez-Castilla S, De la Puerta R, Garcia-Gimenez MD, Fernández-Arche MA, Guillén-Bejarano R. Bioactive constituents from "Triguero" *Asparagus* improve the plasma lipid profile and liver antioxidant status in hypercholesterolemic rats. International Journal of Molecular Sciences. 2013;14:21227–39.
28. Poormoosavi SM, Najafzadehvarzi H, Behmanesh MA, Amirgholami R. Protective effects of *Asparagus officinalis* extract against Bisphenol A-induced toxicity in Wistar rats. Toxicology reports. 2018 Jan 1;5:427-33.

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Uttar Pradesh Journal of Zoology, 44(10): 48-56, 2023. DOI: 10.56557/UPJOZ/2023/v44i103504

Peer-Review History:
This chapter was reviewed by following the Advanced Open Peer Review policy. This chapter was thoroughly checked to prevent plagiarism. As per editorial policy, a minimum of two peer-reviewers reviewed the manuscript. After review and revision of the manuscript, the Book Editor approved the manuscript for final publication. Peer review comments, comments of the editor(s), etc. are available here: https://peerreviewarchive.com/review-history/1975