Nutritional and anti-gastro ulcerative role of the gum Arabic (*Acacia senegal* L.) compared to a reference drug

Qaswaa Yousif Jameel[1], Mohammed Abdullah Ajeel[2], Nameer Khairullah Mohammed[3*]

[1]Department of Food Science, Colleges of Agricultural and Forestry, University of Mosul, Mosul, Iraq; [2]Colleges of Pharmacy, University of Mosul, Mosul, Iraq; [3]Department of Food Science, College of Agriculture, Tikrit University 3400, Tikrit, Iraq

***Corresponding author:** Nameer Khairullah Mohammed, PhD, Assistant Professor, Department of Food Science, College of Agriculture, Tikrit University 3400, Tikrit, Iraq.

ABSTRACT

Background: As alcohol consumption increases, ethanol impacts ulcers as a factor that causes stomach mucosal invasion, which leads to stomach ulcers. Alcohol damages the stomach through a number of processes, including increased gastric secretion, the release of pro-inflammatory cytokines, and ethanol induces a variety of pathogenic events as it is associated with the formation of stomach ulcers.
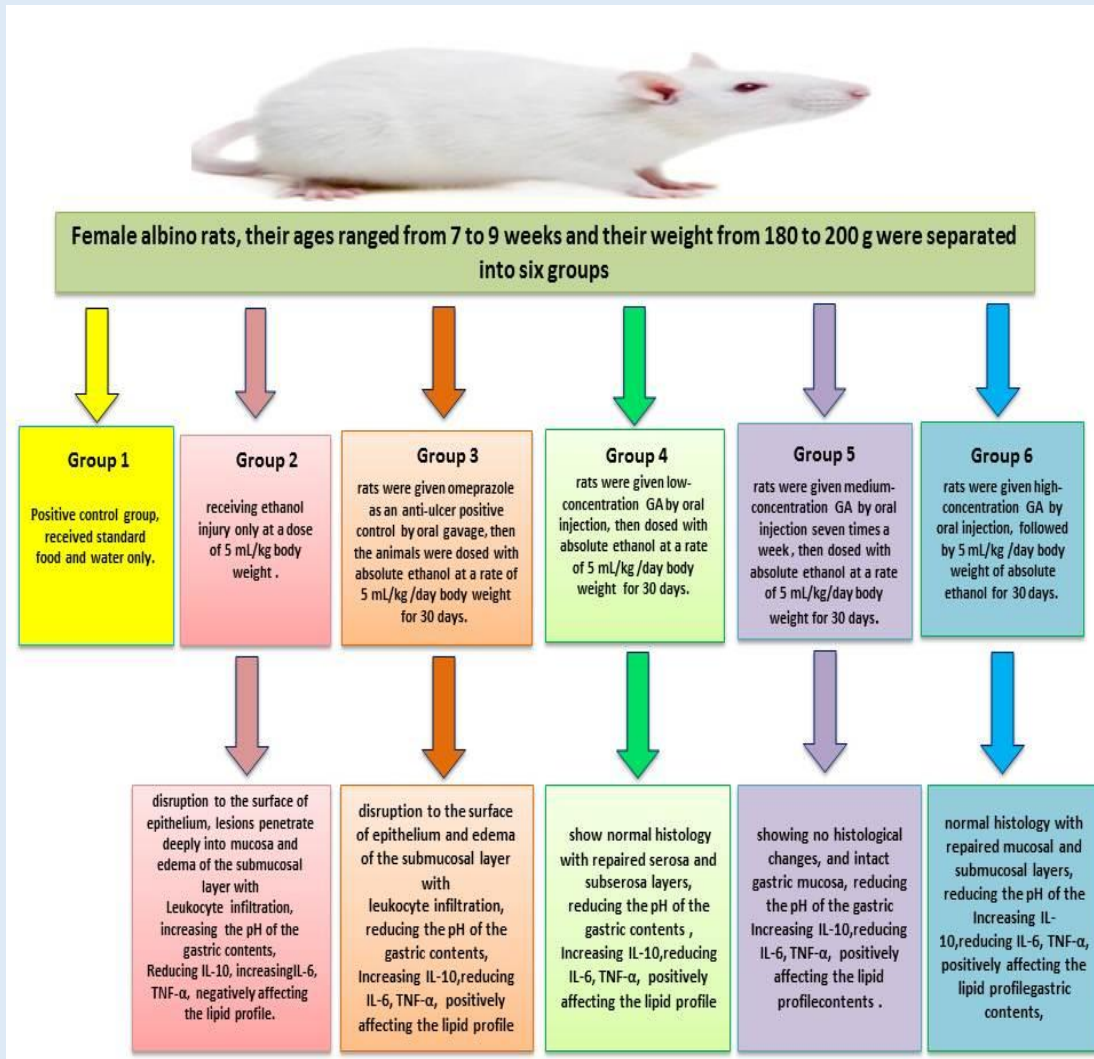
Objective: The goal of this study was to see if gum Arabic as a functional food could protect albino rats against ethanol-induced stomach damage.

Materials and Methods: Six groups of 30 female albino rats were formed: normal control, ulcer control, omeprazole + ethanol, and groups 4, 5, and 6, which were given GA at 7.5, 12, 25 g/ kg/ day (bw), then lab rat were given 5 mL/kg /day (bw) ethanol orally for 30 days to cause stomach mucosal damage.

Results: GA suppressed gastric inflammation by lowering TNF-α and IL-6 levels while increasing IL-10 levels. GA also improved HDL, total protein, albumin, and globulin levels while lowering cholesterol, triglycerides, VLDL-C, LDL-C, and phospholipids.

Conclusion: These findings demonstrate that GA plays a protective role toward gastric mucosal injury in rats induced by ethanol, which in turn reduced the inflammatory response, and significantly reduced the hemorrhagic gastric lesions and the pH of the gastric contents.

Female albino rats, their ages ranged from 7 to 9 weeks and their weight from 180 to 200 g were separated into six groups

Group 1
Positive control group, received standard food and water only.

Group 2
receiving ethanol injury only at a dose of 5 mL/kg body weight .

Group 3
rats were given omeprazole as an anti-ulcer positive control by oral gavage, then the animals were dosed with absolute ethanol at a rate of 5 mL/kg /day body weight for 30 days.

Group 4
rats were given low-concentration GA by oral injection, then dosed with absolute ethanol at a rate of 5 mL/kg /day body weight for 30 days.

Group 5
rats were given medium-concentration GA by oral injection seven times a week, then dosed with absolute ethanol at a rate of 5 mL/kg/day body weight for 30 days.

Group 6
rats were given high-concentration GA by oral injection, followed by 5 mL/kg /day body weight of absolute ethanol for 30 days.

disruption to the surface of epithelium, lesions penetrate deeply into mucosa and edema of the submucosal layer with Leukocyte infiltration, increasing the pH of the gastric contents, Reducing IL-10, increasing IL-6, TNF-α, negatively affecting the lipid profile.

disruption to the surface of epithelium and edema of the submucosal layer with leukocyte infiltration, reducing the pH of the gastric contents, Increasing IL-10, reducing IL-6, TNF-α, positively affecting the lipid profile

show normal histology with repaired serosa and subserosa layers, reducing the pH of the gastric contents , Increasing IL-10, reducing IL-6, TNF-α, positively affecting the lipid profile

showing no histological changes, and intact gastric mucosa, reducing the pH of the gastric Increasing IL-10, reducing IL-6, TNF-α, positively affecting the lipid profile contents .

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INTRODUCTION

Nonsteroidal anti-inflammatory medicines, alcohol consumption, and *Helicobacter pylori* commonly cause mucosal destruction leading to gastric ulcers [1]. As alcohol consumption is increasing, ethanol impacts ulcers as a factor that causes stomach mucosal invasion, which leads to stomach ulcers [2]. Alcohol consumption was the main reason for 3 million deaths (2.3 million male and about 700,000 female) in 2016, as specified by the World Health Organization (WHO) [3]. When the protective and aggressive forces, particularly at the luminal surface of epithelial cells, are out of balance, a stomach ulcer forms

[4]. Alcohol damages the stomach through a number of processes, including increased gastric secretion, the release of pro-inflammatory cytokines, and oxidative stress [5–7].

In addition, ethanol induces a variety of pathogenic events as it is associated with the formation of ulcers. It causes mucosal capillary damage, increased blood vessel permeability, congestion, sub-epithelial microvasculature thrombosis, and disruption of the stomach mucosal barrier, leading to the production of several inflammatory cytokines, including tumor necrosis factor, according to earlier research [8–9]. These mentioned factors play a significant role in the ethanol-induced excessive inflammatory process, oxidative stress-induced damage, cell tissue necrosis, and gastric mucosal cells apoptosis, plus direct injury to the mucosa [10]. Despite the fact that there are numerous drugs for the treatment of gastric ulcers, including antacids, pump inhibitors, and antihistaminics, most of these medications have negative side effects such as arrhythmias, hematopoietic alterations, impotence, and gynecomastia [11–12]. As a result, interest in discovering safe and effective gastric ulcer medicines with the maximum advantage and lowest risk profile has grown due to their many physiological roles, including immunomodulatory, anti-inflammatory, anti-oxidation, and anti-apoptosis pathways. Recently, there has been a rising understanding that several naturally occurring plant chemicals may have potential effects in the treatment of stomach ulcers [13].

Gum Arabic (GA) is a natural dried transparent sticky exudate produced by Acacia plants that includes the most natural non-viscous soluble fiber. It is an edible fiber that is primarily employed as an emulsifier and/or preservation factor in food and medicinal formulations [14]. The property of gum Arabic as high dietary fiber could be considered as a functional food. "Functional foods are foods that have a potentially positive effect on health and help reduce the risk of diseases" [15–16]. GA has health-promoting effects, such as anti-obesity effects

by reducing body mass index [17] and reducing the glycemic index [18], and is widely used as an additive in food processing [19]. However, there is a need for evidence that GA has a protective gastroprotective effect. This motivated us to hypothesize that GA may be applied to heal ethanol-induced gastric mucosal injury and to determine a plausible mechanism of action. This study aimed to quantify and understand the nutritional and anti-gastroulcerative role of GA in comparison to a reference drug.

MATERIALS AND METHODS

Experimental design and Ethical aspects: Female albino rats (30 rats) were bred in the Central Animal House Facility of Mosul University; their ages ranged from 7 to 9 weeks and their weight from 180 to 200 g. The study has been approved by the Ethics Committee of the University of Mosul, College of Veterinary Medicine, Institutional Committee of Animal Protection and Use, No. UM.VET.2021.013. The rats were acclimatized to laboratory conditions at a temperature of 21–25°C, humidity of 50–60%, and a 12-h photoperiod. After a week of acclimation, the animals were separated into six groups of five animals each. Group 1 (the control group) received standard food and water. Group 2 was the ulcer control group, receiving ethanol injury only at a dose of 5 mL/kg body weight [12]. Group 3 (omeprazole + ethanol) rats were given omeprazole (20 mg /kg body weight) [20] as an anti-ulcer positive control by oral gavage, then the animals were dosed with absolute ethanol at a rate of 5 mL/kg /day body weight for 30 days. Group 4 (low-concentration GA + ethanol) rats were given low-concentration GA (7.5 g/kg/day) [21] by oral injection, then dosed with absolute ethanol at a rate of 5 mL/kg/day body weight for 30 days. Group 5 (medium-concentration GA + ethanol) rats were given medium-concentration GA (12 g/kg/day) [22] by oral injection seven times a week throughout the study, then dosed with absolute ethanol at a rate of 5 mL/kg/day body weight for 30 days. Group 6 (high-concentration GA +

ethanol) rats were given high-concentration GA (25 g/ kg/day) [23] by oral injection, followed by 5 mL/kg /day body weight of absolute ethanol for 30 days. Sigma provided the GA powder (St Louis, MO, USA). Absolute ethanol was obtained from Scharlab S.L. (Spain), and omeprazole from Julphar Pharmaceutical, Gulf Pharmaceutical Industries, Ras Al Khaimah, United Arab Emirates.

Animal anesthesia and dissection: Finally, on day 31, after the final administration, all rats fasted for 24 hours but were allowed free access to water. The animals were then anesthetized with chloroform, blood samples were collected intracardially and centrifuged at 4000 rpm for 15 minutes to obtain serum, which was then stored at 80 °C. Then the gastric juice was collected after excision of the stomach along the larger curvature, and the pH of that juice was measured with a pH meter . An expert gastroenterologist rated stomach mucosal damage after washing the mucosa with cold phosphate-buffered saline. The stomach tissue was then transferred to a 10% formalin solution for later preparation of the histological sections.

Histological preparations: The stomach tissue of the rats was prepared for histological examination according to Gwaram et al. (2012). The tissue was cut into parts (less than 1 cm), then submitted to a fixation process using 10% formalin for 24 h. After that, the tissue parts were transferred to escalated concentrations of alcohol (30%, 50%, 70%, 80%, 90%, 96%, and 100%) for dehydration, transferred into xylene for less than 2 min, then infiltration was performed by transferring the tissue parts to paraffin wax in an oven at 62°C for 2 h. After that, the tissue sample was poured into molds of paraffin wax. The molds were then sectioned using a microtome; the resulting slice from the microtome was transferred to a 37°C water bath, loaded into glass slides then transferred to xylol until the wax was removed. After that, samples were transferred to descending alcohol concentrations for rehydration, stained using hematoxylin stain for 5 min, then transferred to eosin stain for 2 min. Microscopy

was performed using an Olympus digital microscope (CX31-106-HD).

Measurement of study parameters in blood serum: The concentrations of total protein, albumin, high-density lipoprotein, triglycerides, and cholesterol were measured using a Roche/Hitachi cobas c 501/502 module, while IL 6 levels were assessed using a Roche/Hitachi cobas e 601 analyzers according to the manufacturer's instructions. Sandwich ELISA kits were used to measure the levels of TNF-α and IL-10 according to the manufacturer's instructions (Elabscience, USA).

Calculation of study parameters: The concentrations of globulin, VLDL-C, LDL-C, and phospholipids were calculated according to the following equations:

Globulin (g/dL) = Total Protein concentration – Albumin concentration [23 –24].

$$\text{VLDL-C (mg/100 mL)} = \frac{Triglyceride\ concentration}{5}\ [27].$$

LDL-C (mg/100 mL) = Total cholesterol – (HDL+ 0.20(TG)) [25–26].

Phospholipids (mg/100 mL) = (Total cholesterol concentration × 0.89) + 68 [29].

Calculation of atherogenic indices: Atherogenic indices of plasma 1, 2, and 3 in blood serum were calculated according to the following equations [30]:

$$\text{Atherogenic index 1 (AIP1)} = \frac{Total\ Cholestrol}{HDL-C}$$

$$\text{Atherogenic index 2 (AIP2)} = \frac{LDL-C}{HDL-C}$$

$$\text{Atherogenic index (AIP3)} = \frac{(LDL-C)+(VLDL-C)}{(HDL-C)}$$

Statistical analysis: All of the data were evaluated in terms of means and standard deviations. One-way analysis of variance (ANOVA) was used to calculate the statistical significance of group differences. A statistically significant value was determined to be **(p ≤ 0.05).**

RESULTS AND DISCUSSION

Functional food is considered an attractive research area for the researchers because of its biological activity [31], simple availability, and low price should be viewed as innovative and promising natural resources of natural antioxidants for application in foods and medications [29–30]. GA has been shown in studies to have antioxidant properties and to protect rats from hepatic, renal, and cardiac toxicity, as well as to improve important cardiovascular risk indicators such as metabolic syndrome, alleviate the negative effects of chronic renal failure in humans, and lower plasma cholesterol levels in rats [14–17]. Gum Arabic is fermented in the colon and small intestine by colon bacteria, this causes the production of short-chain fatty acids and a drop in the pH. As this decrease in pH will promote the growth of probiotic bacteria, which are important in inhibiting pathogenic bacteria [34]. Oral gavage was used to treat albino rats with GA to see if it could protect them from the mucosal damage caused by 100% ethanol. Omeprazole is used as a treatment to prevent the cells from secreting gastric acid. It is also used to treat gastric ulcers, gastroesophageal reflux disease, and stomach infections caused by the bacteria *H. pylori* [35].The majority of investigations on stomach mucosal injury induced by ethanol have been conducted in rat lab animal models, yet there is no reference gavage dose of alcohol currently approved. However, works in the literature have demonstrated that a dose of 5 mL/kg in rodents is enough to induce mucosal injury after 30 min of alcohol consumption and generally peaks 60 min later, with consideration to the variations between rodents and humans in terms of alcohol metabolism [32 –33].

Macroscopic appearance: The evaluation of macroscopic appearance in Fig. 1 shows that the stomach of rats in the normal group (G1) had no visible lesions, there were no apparent lesions on the stomach's surface, and the gastric mucosa was intact, regular, and smooth. The stomachs of lab animals in all of the absolute ethanol-dosed groups showed different levels of hemorrhagic lesions and the injury rate was 100%, which leads us to conclude that ethanol caused the mucosal gastric injury [12–18]. The G2 group (ethanol group) had the most damage to the stomach mucosa, with several lesions that appeared in the form of prolonged hemorrhagic bands, whereas the omeprazole + ethanol group (G3) had milder damage than the ethanol group. Compared to the ethanol group, the three groups administered GA (low-concentration GA + ethanol (G4), medium-concentration GA + ethanol (G5), and high-concentration GA + ethanol (G6)) showed mild gastric mucosal damage.
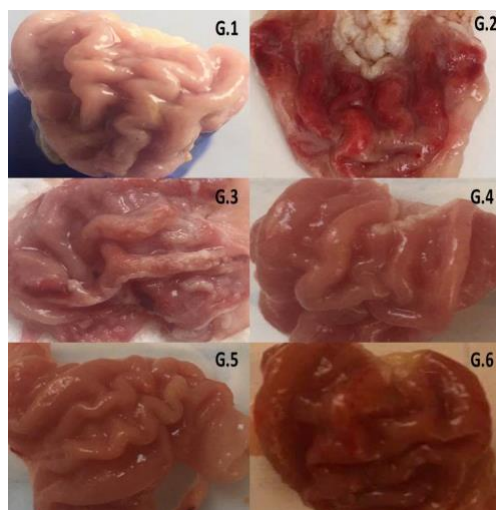

Figure 1. Macroscopic appearance evaluation of gastric mucosa in Rats. G.1: (normal control group) G.2: (ulcer control group), G.3: (omeprazole + Ethanol), G.4: (GA-low concentration + Ethanol), G.5: (GA-medium concentration + Ethanol), G.6: (GA-high concentration + Ethanol).

Histopathological evaluation: The histopathological evaluation in Fig. 2 shows that Group 1 (control) rats had normal histology of the stomach, showing no necrosis of the surface epithelium, edema, or leukocyte infiltration; Group 2 rats had surface epithelial rupture, lesions that reached deep into the mucosa (orange arrow), and submucosal edema (white arrow) with leukocyte infiltration; Group 3 had edema of the submucosal layer and rupture of the epithelial surface with leukocyte infiltration; Group 4 showed normal histology with repaired serosal and sub serosal layers; Group 5 showed no histological changes and intact gastric mucosa; and Group 6 showed normal histology with repaired mucosal and submucosal layers. Injury of the gastric mucosa is a pathological process with multiple factors, both exogenous and endogenous; the basic mechanism includes misbalance of defensive factors (like mucosal blood flow, bicarbonate barrier and some cytokines) and some pro-inflammation factors [34-35].
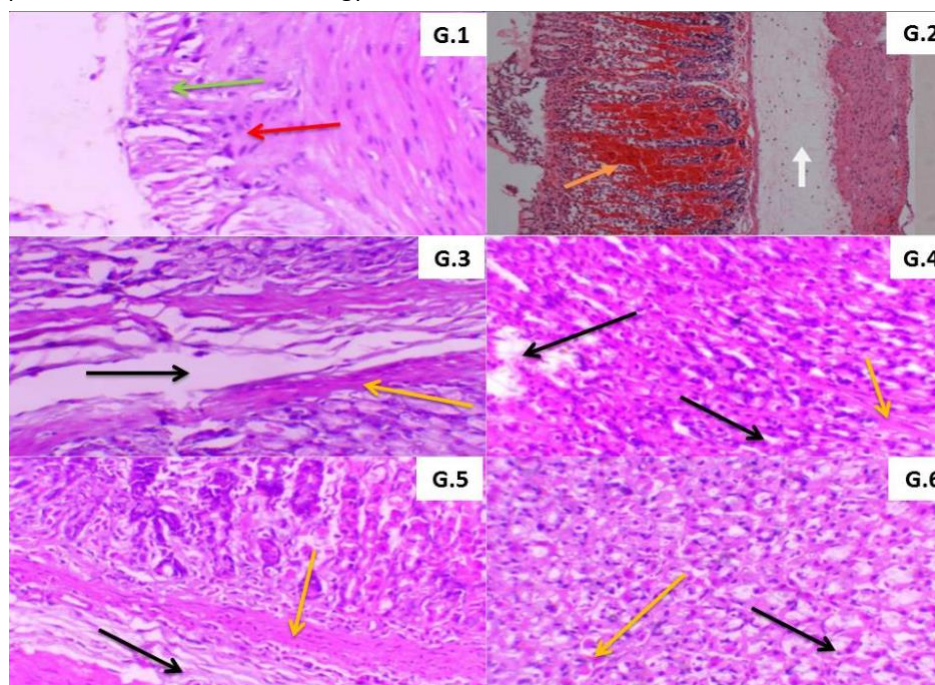

Figure 2. Histopathological evaluation, G.1: Control rats showing normal histology of stomach showing no necrosis of the surface epithelium (green arrow) with absence of edema and leukocyte infiltration (red arrow), G.2: disruption to the surface of epithelium, lesions penetrate deeply into mucosa (orang arrow) and edema of the submucosal layer (white arrow) with leukocyte infiltration, G.3: disruption to the surface of epithelium (orang arrow) and edema of the submucosal layer with leukocyte infiltration (black arrow), G.4: show normal histology with repaired serosa (orang arrow) and subserosa layers (black arrow), G.5: showing no histological changes (orang arrow) and intact gastric mucosa (black arrow), G.6: normal histology with repaired mucosal (orang arrow) and submucosal layers (black arrow), magnification of the micrographs × 400 pixels

Effect of gum Arabic and ethanol on gastric content pH: Table 1 shows that oral consumption of absolute ethanol increased the pH of the gastric contents compared with the normal control group ($p < 0.05$), while animals administered GA had significantly decreased pH levels, whereas the gastric contents of omeprazole group rats showed a higher pH compared to other groups: medium-concentration GA + ethanol (G5), low-concentration GA + ethanol (G4), and high-concentration GA + ethanol (G6). In comparison to the ethanol group, however, The GA therapy only partially reversed these changes.

Table 1: Effect of gum Arabic and Ethanol on gastric content pH.

Groups	pH of the gastric content
Normal control group (G1)	2.44 ± 0.01^f
Ulcer control group (G2)	6.56 ± 0.01^b
Omeprazole + Ethanol (G3)	5.12 ± 0.01^a
GA-low concentration + Ethanol(G4)	3.38 ± 0.01^d
GA- medium concentration + Ethanol(G5)	3.15 ± 0.01^e
GA- high concentration + Ethanol(G6)	4.43 ± 0.01^c

Note: Different letter (a,b,c..) within each column indicate significant differences
(p ≤ 0.05), Data are presented as the means ± standard deviation.

Effect of gum Arabic and ethanol on tumor necrosis factor alpha (TNF-α), interleukin-6 (IL-6), and interleukin-10 (IL-10), levels in blood serum:
Inflammation is characterized by a burst of cytokines, which are small, secreted proteins produced by practically every cell to control and influence immune responses. The simultaneous release of pro-inflammatory and anti-inflammatory cytokines is essential in any immune response. Immune cells get engaged and create more cytokines like TNF- α and IL-6 when pro-inflammatory cytokines are released, while anti-inflammatory cytokines like IL-10 are inhibited [36–37]. TNF- α is a cytokine generated by macrophages and T cells that promotes inflammation. TNF- α seems to play a significant role in the genesis of inflammatory diseases, as it is involved in both apoptosis and inflammation [39–40]. IL-10 is one of the tolerogenic cytokines because it reduces the production of the other pro-inflammatory cytokine and reduces the stimulatory capacity of the T cells of myeloid cells such as dendritic cells and macrophages. As a result of reducing the production of inflammatory cytokines, it is critical for reducing ethanol-induced stomach mucosal damage [37]. The effects of GA on TNF- α, IL-6, and IL-10 in the serum of lab animals were significantly different (p ≤ 0.05), according to statistical analysis (Table 2). The levels of TNF-α after ethanol exposure in the negative group (G2) were markedly higher than in the normal group (G1) and the three groups treated with GA (G5, G4, and G6). The ethanol group, on the other hand, had a substantial increment in serum IL-6 levels in comparison to the control group (untreated rats) (p ≤ 0.05). Generally, increased levels of IL-6 were dramatically lowered in the three groups of rats given GA (G5, G4, and G6) compared with negative group (G2). In comparison to the rats in the control group, IL-10 levels were considerably lower (p ≤ 0.05). In general, animals given GA (G4, G5, and G6) had significantly higher levels of IL-10 than those in the control group (G2). These findings suggest that GA has a strong ability to reduce the imbalance caused by absolute ethanol. The levels of IL-6 and TNF- α were considerably greater in G2 (ethanol group) rats than in the control group, but the levels of IL-10 were lower, suggesting the great role of the inflammatory response in gastric mucosal injury induced by ethanol [42]. Simultaneously, when compared to the ethanol group, GA therapy considerably lowered the levels of these inflammatory cytokines. The findings suggest that GA-treated rats had a significant reduction in ethanol-induced inflammation by lowering TNF-α and IL-6 and boosting IL-10 levels (Table 2).

Table 2: Effects of gum Arabic on tumor necrosis factor alpha (TNF-α), Interleukin-6 (IL-6), and Interleukin-10 (IL-10), levels in ethanol-induced rats.

Groups	TNF-α (ng/mL)	IL-6 (Pg/mL)	IL-10 (Pg/mL)
G1	2.37±0.01[f]	1.31±0.01[f]	**48.78±0.01[a]**
G2	4.37±0.01[a]	5.24±0.01[a]	**22.83±0.01[f]**
G3	2.84±0.01[e]	1.51±0.01[e]	**42.16±0.01[b]**
G4	3.81±0.01[c]	1.98±0.01[c]	**37.77±0.01[d]**
G5	3.23±0.01[d]	1.81±0.02[d]	**39.22±0.01[c]**
G6	3.84±0.01[b]	2.81±0.01[b]	**24.72±0.01[e]**

Note: Different letter (a,b,c..) within each column indicate significant differences ($p \leq 0.05$), Data are presented as the means ± standard deviation, (G1) normal control group, (G2) ulcer control group, (G3) omeprazole + Ethanol, (G4) GA-low concentration+ Ethanol, (G5) GA- medium concentration+ Ethanol, (G6) GA- high concentration+ Ethanol.

Effect of gum Arabic and Ethanol on total protein, albumin, and globulin levels in blood serum: As shown by the results in Table 3, there was a considerable reduction in total protein, albumin, and globulin levels in the absolute ethanol group in comparison with the normal control group ($p \leq 0.05$), while these markers remain stable in GA-treated animals compared to rats in the ethanol group (G2). The results are in agreement with Azeez (2016) and Hozayen, Seif, and Amin (2014) who reported that serum albumin level was considerably reduced due to the oxidative stress caused by γ-irradiation in rats. In the current study, the decrease in total protein may be attributed to the fact that animals exposed to oxidative stress by ethanol have resorted to using alternative sources of energy in the body from fat and protein stores, as the process of catabolism of amino acids to produce energy increases. The decrease in albumin and globulin is due to the breaking of the peptide bonds between protein molecules by the effect of oxidative stress and the generation of free radicals, which leads to the decomposition of albumin and a decrease in its concentration in the blood serum [45]. On the other hand, the administration of GA significantly improved the levels of total protein, albumin, and globulin compared to the rats in the ethanol group (G2). This indicates that GA removes free radicals, prevents protein oxidation, and stimulates insulin secretion from pancreatic beta cells [42]. GA stimulates insulin secretion from pancreatic beta cells because gum Arabic is a soluble and edible fiber consisting of mixture of polysaccharides and glycoproteins, such as arabinogalactan, arabinose, galactose, rhamnose, and glucuronic acid. These fibers are digested in a slow and orderly manner in the small intestine by alpha amylase and releasing the sugars mentioned earlier in a slow and orderly manner. This caused increases the secretion of insulin from beta cells of pancreas to compensate for increased insulin need without raising the plasma glucose concentration [48].

Table 3: Effects of gum Arabic on total protein, albumin, and globulin levels.

Groups	Total Protein (g/dL)	Albumin (g/dL)	Globulin (g/dL)
G1	6.36±0.01[a]	4.67±0.01[a]	**1.69±0.01[c]**
G2	4.85±0.01[f]	3.62±0.01[e]	**1.23±0.02[e]**
G3	6.31±0.01[b]	4.62±0.01[b]	**1.69±0.01[c]**
G4	6.08±0.01[d]	3.71±0.01[d]	**2.37±0.02[a]**
G5	6.21±0.01[c]	4.21±0.01[c]	**1.99±0.02[b]**
G6	5.07±0.01[e]	3.57±0.02[f]	**1.50±0.03[d]**

Note: Different letter (a,b,c..) within each column indicate significant differences ($p \leq 0.05$), Data are presented as the means ± standard deviation, (G1) normal control group, (G2) ulcer control group, (G3) omeprazole + Ethanol, (G4) GA-low concentration+ Ethanol, (G5) GA- medium concentration+ Ethanol, (G6) GA- high concentration + Ethanol.

Effect of gum Arabic and Ethanol on cholesterol, triglycerides, high density lipoprotein cholesterol, very low-density lipoprotein cholesterol concentration, low density lipoprotein cholesterol concentration, and phospholipids levels in blood serum: According to statistical analysis shown in (Table 4), the effects of GA on the lipid profile and phospholipids in serum were significant ($p \leq 0.05$). The finding in the current study demonstrated that 5 mL/kg absolute ethanol decreased HDL-C levels. In rats fed ethanol, it increased cholesterol, triglycerides, VLDL-C, LDL-C, and phospholipids. Triglycerides, VLDL-C, LDL-C, and phospholipids were all dramatically reduced after GA was given. Furthermore, when compared to the ethanol group, the GA intervention significantly increased HDL levels. These data imply that GA has the ability to dramatically reduce the absolute ethanol-induced imbalance. When compared to the control group, which is consistent with

other related studies. GA has been shown to reduce LDL and VLDL in animal models, while having no effect on HDL or triglycerides [14]. It has also been shown to reduce blood pressure and calorie intake in rats, probably due to increased dietary fiber intake boosting satiety [49]. Dyslipidemia indicators and irregular lipoprotein levels suggest excess cholesterol in the circulatory system, which can be managed by adding fractional esters to cholesterol (esterification) and reversing cholesterol transportation [50]. Cholesterol in the gut is first absorbed as chylomicron (triglyceride-rich complex), then changed and packed as HDL-C.

As a result, the triglyceride to HDL ratio indicates the amount of cholesterol present in the peripheral circulatory system. Dyslipidemia is caused by irregular cholesterol esterification ratios in apolipoprotein B-depleted plasma and the partial size of lipoprotein in animal models, specifically rats in the ethanol group [51].

Table 4: Effects of gum Arabic on cholesterol, triglycerides, high density lipoprotein cholesterol (HDL), very low-density lipoprotein cholesterol concentration (VLDL-C), low density lipoprotein cholesterol concentration (LDL-C) and phospholipids levels.

Groups	Cholesterol (mg/dL)	Triglycerides (mg/dL)	HDL (mg/dL)	VLDL-C (mg/100mL)	LDL-C (mg/100mL)	Phospholipids mg/100mL
G1	45.00±1.00[e]	47.00±1.00[e]	49.00±1.00[a]	9.40±0.20[e]	5.40±1.80[f]	**108.05±0.89[e]**
G2	74.00±1.00[a]	75.00±1.00[a]	25.00±1.00[d]	15.00±0.20[a]	64.00±0.20[a]	**133.86±0.89[a]**
G3	50.00±1.00[d]	47.00±1.00[e]	38.00±1.00[b]	9.40±0.20[e]	21.40±0.20[e]	**112.50±0.89[e]**
G4	55.00±1.00[c]	66.00±1.00[c]	33.00±1.00[c]	13.20±0.20[c]	35.20±0.20[c]	**116.95±0.89[c]**
G5	51.00±1.00[d]	52.00±1.00[d]	38.00±1.00[b]	10.40±0.20[d]	23.40±1.80[d]	**113.39±0.89[d]**
G6	61.00±1.00[b]	72.00±1.00[b]	32.00±1.00[c]	14.40±0.20[b]	43.40±0.20[b]	**122.29±0.89[b]**

Note: Different letter (a,b,c..) within each column indicate significant differences (p ≤ 0.05), Data are presented as the means ± standard deviation, (G1) normal control group, (G2) ulcer control group, (G3) omeprazole + Ethanol, (G4) GA-low concentration+ Ethanol, (G5) GA- medium concentration+ Ethanol, (G6) GA- high concentration + Ethanol.

Effect of gum Arabic and Ethanol on atherogenic index of plasma1 (AIP1), atherogenic index of plasma2 (AIP2), and atherogenic index of plasma3 (AIP3) in blood serum:

The effects of GA on AIP1, AIP2, and AIP3 were significant (p ≤ 0.05) according to statistical analysis (Table 5). The outcomes of the current study indicate that 5 mL/kg absolute ethanol elevates the dyslipidemia biomarkers AIP1, AIP2, and AIP3. As compared to the ethanol group, GA intervention significantly reduced AIP1, AIP2, and AIP3. These findings showed that GA has the potential to significantly ameliorate the imbalance caused by absolute ethanol. These findings are comparable to those of a prior study [52] in which GA was used as a treatment and substantially reduced the lipid profile. By triggering the activation of sterol-regulatory element-binding protein and alterations in LDL receptors, phytocompounds have been shown to suppress HMG-CoA reductase, an enzyme responsible for cholesterol biosynthesis, resulting in less production of cholesterol and other lipid profile biomarkers [53,54].

Table 5: Effects of gum Arabic on atherogenic index of plasma1 (AIP1), atherogenic index of plasma2 (AIP2), and atherogenic index of plasma3 (AIP3).

Groups	AIP1	AIP2	AIP3
G1	0. 92±0.04[e]	0.09±0.02[e]	**6.51±5.34[e]**
G2	2.96±0.08[a]	2.56±0.09[a]	**17.56±0.11[a]**
G3	1.32±0.01[d]	0.63±0.12[d]	**9.96±0.19[cd]**
G4	1.66±0.02[c]	1.06±0.03[c]	**14.26±0.17[ab]**
G5	1.34±0.06[d]	0.61±0.06[d]	**10.96±0.26[bc]**
G6	1.90±0.03[b]	1.35±0.04[b]	**15.75±0.16[a]**

Note: Different letter (a,b,c..) within each column indicate significant differences (p ≤ 0.05), Data are presented as the means ± standard deviation, (G1) normal control group, (G2) ulcer control group, (G3) omeprazole + Ethanol, (G4) GA-low concentration+ Ethanol, (G5) GA- medium concentration+ Ethanol, (G6) GA- high concentration+ Ethanol.

CONCLUSION

The findings demonstrated that GA plays a protective role toward the gastric mucosal injury induced in rats by ethanol, increasing IL-10 which in turn reduced the inflammatory response represented by reducing IL-6 and TNF-α, positively affecting the lipid profile and significantly reducing ethanol-induced hemorrhagic gastric lesions and the pH of the gastric contents. Large-scale trials should be conducted in the future to assess the long-term effects of GA in patients with gastroulcerative colitis, as well as to determine the best dosing methods and long-term efficacy.

Abbreviations: GA: gum Arabic, TNF-α: tumor necrosis factor alpha, IL-6: Interleukin-6, IL-10: Interleukin-10, VLDL-C: very low-density lipoprotein cholesterol, LDL-C: low density lipoprotein cholesterol, HDL-C: high density lipoprotein cholesterol, AIP1: Atherogenic index1, AIP2: Atherogenic index2, AIP3 Atherogenic index3.

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