

Review Article

The protective and antioxidant effects of gum arabic: a review of recent evidence using the new PubMed system

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ABSTRACT

Gum arabic (GA) is an exudate from acacia seyal and acacia senegal trees, which belong to the leguminosae family. There are many applications for GA, such as use as a food additive, shelf-life enhancement, microencapsulation, satiety induction, use as anti-obesity, antimicrobial, and anti-inflammatory agent, use as an anticoagulant, and applications in tumor imaging and nanotechnology. Little has been described about the mechanisms by which GA provides its protective effects, especially its role as an antioxidant, to different body tissues and organs. The aim of this study was to review the recent evidence of the antioxidant effects of GA on different body organs and tissues. The new PubMed system, which was recently released in October 2019, was used to collect and analyze data for this review. There were only seven articles in PubMed that described the antioxidant and protective effects of GA on different body organs and tissues in the period from January 2015 to November 2019; there be four articles from 2019. The results of these studies revealed the protective and antioxidant effects of GA on the liver, kidney and blood and cardiovascular system in experimentally induced injuries of these organs and tissues. Further studies are required to study the protective and antioxidant effects of GA on other body organs and tissues. The new PubMed system is a powerful and smart tool for searching and collecting data and for saving researchers time and effort; it is highly recommended to be widely used.

Keywords: Gum arabic, Antioxidant, Protective

INTRODUCTION

Gum arabic (GA) is an exudate from the *Acacia seyal* and *Acacia senegal* trees, which belong to the Leguminosae family. It is a branched heteropolysaccharide complex, either slightly acidic or neutral, and composed of 1,3-linked β -D-galactopyranosyl units. L-rhamnose, D-glucuronic acid, and L-arabinose have also been detected among its polymer constituents.¹

The side chains are composed of two to five 1,3-linked β -D-galactopyranosyl units, which connect to the main chain by 1,6-linkages.

The pale-white or light-orange pieces of GA are water soluble. GA is geographically distributed from the Indian peninsula to west of Africa. Most GA is harvested from the arid lands of Sudan, Nigeria, Senegal, Ethiopia, and Chad. Sudan is considered its largest exporter, as it accounts for up to 80% of the trade, followed by Nigeria.²

There are many applications for GA, such as use as a food additive, shelf-life enhancement, microencapsulation, satiety induction, use as an anti-obesity, antimicrobial, and anti-inflammatory agent, use as an anticoagulant, and applications in tumor imaging and nanotechnology. There is a plethora of research about the protective effects of GA on different body organs and tissues, such as the cardiovascular, gastrointestinal, and renal systems and the teeth. These protective effects are mediated through the following mechanisms: decreased systolic blood pressure, decreased urea concentrations and plasma phosphate, increased urinary antidiuretic hormone excretion and creatinine clearance, decreased Na⁺ excretion, increased renal and intestinal excretion of Mg²⁺ and Ca²⁺, and enhanced remineralization of the teeth, which protects against the harshness of acids.³⁻⁶ Little has been described about the mechanisms by which GA provides its protective effects, especially its role as an antioxidant, to different body tissues and organs.⁷

The aim of this study was to review the recent evidence of the antioxidant effects of GA on different body organs and tissues. The new PubMed system, which was recently released in October 2019, was used to collect and analyze data for this review.

METHODS

A comprehensive search was conducted on the new PubMed database (<https://pubmed.ncbi.nlm.nih.gov/>)

using all its utilities to retrieve the most specific and relevant data according to the selected key words, (Figure 1). The search was conducted in November 2019. Time limitations were applied by the year of publication from 2015 to 2019, and the articles were limited to only articles in the English language that studied both animal models and humans. All retrieved titles and abstracts were verified to have met the key words, and full publications were reviewed, when necessary. The PubMed search included the following terms: gum arabic (GA) and antioxidant(s). In addition, alternative key words, such as arabic gum and antioxidative(s), were used. A combination of these key words using different search strategies like Boolean operators (e.g., AND, OR) and parentheses were used to retrieve the most specific data.

RESULTS

Based on the smart search in the new PubMed, Figure 2 and Table 1 illustrate that over the previous 5 years, 171 articles were published with the words GA in their titles. With the use of the Boolean operators OR and AND and parentheses to combine these words with the words antioxidant, antioxidants, and antioxidative, the search retrieved 32 articles from January 2015 to November 2019. The final list of articles was reviewed to include research articles that described the protective antioxidant effects of GA on different body organs or tissues. We retrieved only seven articles to form the final list, which is shown in Figure 2.

Table 1: PubMed search history using different key words.

| Search number | Query | Sort by | Filters | Results |
|---------------|--|------------|------------------|---------|
| 13 | (((((Gum Arabic [title]) OR (Arabic Gum [title])) AND (antioxidant OR antioxidants Or antioxidative [title]))) | Best match | from 2015 - 2019 | 32 |
| 12 | (((((Gum Arabic [title]) OR (Arabic Gum[title])) AND (antioxidant OR antioxidants OR antioxidative [title]))) | Best match | | 56 |
| 10 | Antioxidative [title] | Best match | from 2015 - 2019 | 1,476 |
| 9 | Antioxidative [title] | Best match | | 4,724 |
| 8 | Antioxidants [title] | Best match | from 2015 - 2019 | 1,815 |
| 7 | Antioxidants [title] | Best match | | 9,226 |
| 6 | Antioxidant [title] | Best match | from 2015 - 2019 | 16,229 |
| 5 | Antioxidant [title] | Best match | | 46,234 |
| 4 | Arabic Gum [title] | Best match | from 2015 - 2019 | 17 |
| 3 | Arabic Gum [title] | Best match | | 32 |
| 2 | Gum Arabic [title] | Best match | from 2015 - 2019 | 154 |
| 1 | Gum Arabic [title] | Best match | | 383 |



Figure 1: New PubMed website.

Source: <https://pubmed.ncbi.nlm.nih.gov/>.

The screenshot displays the PubMed search interface. At the top, there is a search bar with a dropdown menu set to 'All Fields' and a text input field labeled 'Enter a search term'. To the right of the search bar are two buttons: 'ADD' and 'Show Index'. Below the search bar is a 'Query box' with a text input field labeled 'Enter / edit your search query here' and a 'Search' button. The main section is titled 'History and Search Details' and includes a 'Download' button and a 'Delete' button. Below this is a table listing search history.

| Search | Actions | Details | Query | Results | Time |
|--------|---------|---------|--|---------|----------|
| #17 | ... | > | Search: (((Gum Arabic[Title] OR (Arabic Gum[Title])) AND (Antioxidant OR Antioxidants Or Antioxidative[Title]))) Filters: from 2015 - 2019 | 32 | 08:07:11 |
| #16 | ... | > | Search: (((Gum Arabic[Title] OR (Arabic Gum[Title])) AND (Antioxidant OR Antioxidants Or Antioxidative[Title]))) | 56 | 08:06:54 |
| #12 | ... | > | Search: Antioxidative[Title] Filters: from 2015 - 2019 | 1,476 | 07:59:18 |
| #11 | ... | > | Search: Antioxidative[Title] | 4,724 | 07:59:06 |
| #9 | ... | > | Search: Antioxidants[Title] Filters: from 2015 - 2019 | 1,815 | 07:57:40 |
| #8 | ... | > | Search: Antioxidants[Title] | 9,226 | 07:57:30 |
| #7 | ... | > | Search: Antioxidant[Title] Filters: from 2015 - 2019 | 16,229 | 07:57:04 |
| #6 | ... | > | Search: Antioxidant[Title] | 46,234 | 07:56:54 |
| #4 | ... | > | Search: Arabic Gum[Title] Filters: from 2015 - 2019 | 17 | 07:55:39 |
| #3 | ... | > | Search: Arabic Gum[Title] | 32 | 07:55:28 |
| #2 | ... | > | Search: Gum Arabic[Title] Filters: from 2015 - 2019 | 154 | 07:54:51 |
| #1 | ... | > | Search: Gum Arabic[Title] | 383 | 07:54:38 |

Figure 2: Screen shot for the retrieved data from new PubMed system.

Source: Author's search history from the new PubMed: <https://pubmed.ncbi.nlm.nih.gov/advanced/#>

DISCUSSION

The aim of this review was to review the recent evidence about the protective and antioxidant effects of GA on different body organs and tissues. The new PubMed system, which was recently released in October 2019, was used for collecting and analyzing data for this review. The new PubMed system has rich features, including improved advanced search, a search history, search details, and filters. It is user-friendly with the options to download and save retrieved data in different and flexible formats.

Based on the PubMed search and review of the collected research articles, there were only seven articles that described the antioxidant and protective effects of GA on different body organs and tissues from January 2015 to November 2019; there were four from 2019 (Table 2).

Kaddam et al studied the antioxidant effects of GA in sickle cell anemia.⁹ The authors measured malondialdehyde (MDA) levels, the total antioxidant capacity (TAC), and hydrogen peroxide (H₂O₂) levels. The results of this study showed a significantly increased TAC and a decrease in the oxidative marker MDA.⁹ In addition, Kadaam et al studied the effects of GA supplementation in cases of sickle cell anemia.¹² The results of their study showed significant improvement in the liver and renal function of patients treated with GA. However, the improvement was not sustained after the first month of the study, and the effects of GA on antioxidant status in those patients were not studied.

Another study was performed by Ahmed et al on the protective effects of GA against hepatic oxidative stress in alloxan-induced diabetes in rats.¹⁵ Oxidative stress to the liver tissue was assessed by measuring the key hepatic

enzymes, lipid peroxidation, antioxidant enzymes, and oxidative stress gene expression. The activity levels of the antioxidant enzymes catalase (CAT), superoxide dismutase (SOD), and glutathione peroxidase (GPx) markedly increased in the group that received GA compared to the control and diabetic groups. In addition, GA increased glutathione (GSH) and decreased liver

MDA. In addition, GA significantly reduced the activity levels of liver enzymes, including aspartate transaminase (AST) and alanine transaminase (ALT). The results also suggested that GA may protect the liver by modulating the expression of oxidative stress genes and, thus, can overcome oxidative stress.

Table 2: Most relevant articles with evidence of the organ or tissue protective effects of GA.

| Title | Authors, reference no. | Journal/book | Publication year |
|---|----------------------------|----------------------|------------------|
| Gum arabic extracts protect against hepatic oxidative stress in alloxan induced diabetes in rats | Ahmed et al ⁸ | Pathophysiology | 2015 |
| Gum arabic as novel anti-oxidant agent in sickle cell anemia, phase II trial | Kaddam et al ⁹ | BMC Hematol | 2017 |
| The hepatoprotective effect of selenium-enriched yeast and gum arabic combination on carbon tetrachloride-induced chronic liver injury in rats | Hamid et al ¹⁰ | J Food Sci | 2018 |
| Gum arabic ameliorates impaired coagulation and cardiotoxicity induced by water-pipe smoke exposure in mice | Nemmar et al ¹¹ | Front Physiol | 2019 |
| Biochemical effects and safety of gum arabic (acacia senegal) supplementation in patients with sickle cell anemia | Kaddam et al ¹² | Blood Res | 2019 |
| The effect of arabic gum on renal function in reversible unilateral ureteric obstruction | Hammad et al ¹³ | Biomolecules | 2019 |
| Water pipe smoke exposure triggers lung injury and functional decline in mice: protective effect of gum arabic | Nemmar et al ¹⁴ | Oxid Med Cell Longev | 2019 |

The third study in this review also described the hepatoprotective effect of GA in combination with selenium-enriched yeast (SY) on carbon tetrachloride-induced chronic liver injury.¹⁰ The results of this study were similar to those obtained by Ahmed et al in reduction of elevated hepatic enzymes and the increase in the total antioxidant capacity, which was more effective with the combination of SY and GA.¹⁵ In addition to these similar findings, the GA and SY combination significantly restored the hepatic hydroxyproline concentration and the histopathological changes. Liver inflammation was further improved through the inhibition of nuclear factor-kappa B (NF- κ B), tumor necrosis factor alpha (TNF- α), monocyte chemoattractant protein-1 (MCP-1), cyclooxygenase-2 (COX-2), and toll-like receptor 4 (TLR-4). In all the study's findings, the SY and GA combination could obviously ameliorate chronic liver injury greater than SY or GA alone.

The protective and antioxidant effects of GA on the impaired coagulation and cardiotoxicity induced by waterpipe smoke exposure in mice was studied by Nemmar et al.¹¹ The obtained data show that GA ameliorates waterpipe smoke-induced oxidative stress, cardiovascular inflammation, coagulation, apoptosis, and DNA damage through a mechanism which might involve nuclear factor erythroid-derived 2-like 2 (Nrf2) activation. Nemmar et al also studied the protective effects of GA on lung injury that was induced by waterpipe smoke exposure in mice.¹⁴ They concluded that

GA significantly improved the biochemical, molecular, physiological, and histological indices of lung toxicity in mice exposed to water pipe smoke.

The last study was conducted by Hammad et al and described the protective effects of GA on kidney function in mice with induced unilateral ureteric obstruction.¹³ The results of the study revealed a significant improvement in the biochemical, molecular, histological, and physiological indices of lung toxicity in mice treated with GA. In addition, GA administration significantly decreased airway hyperreactivity, which resulted from methacholine induced by WPS.

CONCLUSION

There were only seven articles in PubMed that studied the antioxidant and protective effects of GA on different body organs and tissues from January 2015 to November 2019; there be four in 2019. The results of these studies revealed the protective and antioxidant effects of GA on the liver, kidney, blood and cardiovascular system, in experimentally induced injuries of these organs and tissues.

Recommendations

Further studies are required to study the protective and antioxidant effects of GA on other body organs and tissues and to compare with the currently available

studies to generalize these results and to prove GA's effectiveness for treating different human diseases. The new PubMed system is a powerful and smart tool for searching and collecting data and for saving researchers time and efforts; it is highly recommended to be widely used.

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