Review

Gums exudates of *Prosopis* spp. located in Ecuador: prebiotic potential in animal feed

Exudados gomosos de *Prosopis* spp. localizados en Ecuador: potencial prebióticos en la alimentación animal

Exsudados gomosos de *Prosopis* spp. localizados no Equador: potencial prebiótico na alimentação animal

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Abstract

Fiber-rich plant foods have been tested as prebiotics (adjuvant to the growth and activity of the gut microbiota) in animal production, due to their high inulin and fiber content, in order to reduce the use of antibiotics and microbial resistance. The gum exudate produced by *Acacia senegal* is a source of nutritional fiber that has been tested as a prebiotic in animal feed. The objective of this study was to analyze the potential use of novel sources of *Prosopis* spp. gums exudates as prebiotics in animals of zootechnical interest based on a systematic literature review in indexed journals of the use of gum-hydrocolloids as an alternative supplement in animal feed. The scientific articles reviewed show the benefits of using the gum exudate of *Acacia senegal* as a prebiotic in the production of broilers, turkeys, rabbits, and pigs. The gums obtained from *Prosopis* spp. present physicochemical and nutritional characteristics analogous to those published for gum arabic. Therefore, based on the bibliographic reports consulted, the gum exudate obtained from *Prosopis* spp. trees located in Ecuador could present a nutritional profile with excellent fiber content, oligosaccharides, essential minerals, and phenolic compounds, which would enhance its use as a promising prebiotic in animal feed, enhancing intestinal barrier function, promoting the growth of beneficial microbiota, significantly reducing pathogenic bacterial populations, and optimizing animal welfare and productivity.

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Resumen

Alimentos de origen vegetal ricos en fibras se han ensayado como prebióticos (coadyuvante del crecimiento y actividad de la microbiota intestinal) en la producción animal, por su alto contenido en inulina y fibra, con la finalidad de disminuir el uso de antibióticos y la resistencia microbiana. El exudado gomoso producido por *Acacia senegal,* es una fuente de fibra nutricional que se ha ensayado como prebiótico en alimentación animal. El objeto de estudio fue analizar el potencial uso de fuentes noveles de exudados gomosos de *Prosopis* spp. como prebióticos en animales de interés zootécnico con base a una revisión literaria sistemática en revistas indizadas del uso de gomas-hidrocoloides como suplemento alternativo en la alimentación animal. Los artículos científicos revisados evidencian los beneficios del uso del exudado gomoso de *Acacia senegal* como prebiótico en la producción de pollos de engorde, pavos, conejos y cerdos. Las gomas obtenidas de *Prosopis* spp. presentan características fisicoquímicas y nutricionales análogas a las publicadas para la goma arábiga. Por lo tanto, con base a los reportes bibliográficos consultados el exudado gomoso obtenido de árboles de *Prosopis* spp. localizados en Ecuador, podrían presentar un perfil nutricional con excelente contenido en fibra, oligosacáridos, minerales esenciales y compuestos fenólicos, lo cual potenciaría su uso como prebiótico promisorio en la alimentación animal, mejorando la función de la barrera intestinal, favoreciendo el crecimiento de la microbiota beneficiosa, reduciendo significativamente las poblaciones de bacterias patógenas, optimizando el bienestar y la producción animal.

Palabras clave: fibra dietaría, hidrocoloides, producción animal, promotores de crecimiento alternativos.

Resumo

Os alimentos vegetais ricos em fibra têm sido testados como prebióticos (adjuvantes do crescimento e da atividade da microbiota intestinal) na produção animal, devido ao seu elevado teor de inulina e fibra, com o objetivo de reduzir o uso de antibióticos e a resistência microbiana. O exsudado gomoso produzido pela *Acacia senegal* é uma fonte de fibra nutricional que tem sido testada como prebiótico na alimentação animal. O objetivo do estudo foi analisar o potencial de utilização de novas fontes de exsudados gomosos de *Prosopis* spp. como prebióticos em animais de interesse zootécnico, com base numa revisão sistemática da literatura em revistas indexadas sobre a utilização de gomas-hidrocolóides como suplemento alternativo na alimentação animal. Os artigos científicos revisados mostram os benefícios da utilização do exsudato gomoso da *Acacia senegal* como prebiótico na produção de frangos de corte, perus, coelhos e suínos. As gomas obtidas de *Prosopis* spp. têm caraterísticas físico-químicas e nutricionais semelhantes às publicadas para a goma-arábica. Portanto, com base nos relatórios bibliográficos consultados, o exsudado gomoso obtido das árvores de *Prosopis* spp. localizadas no Equador, poderia ter um perfil nutricional com excelente fibra, oligossacarídeos, minerais essenciais e compostos fenólicos, o que potenciaria a sua utilização como um prebiótico promissor na alimentação animal, melhorando a função da barreira intestinal, favorecendo o crescimento da microbiota benéfica, reduzindo significativamente as populações de bactérias patogénicas, optimizando o bem-estar e a produção animal.

Palavras-chave: fibra alimentar, hidrocolóides, produção animal, promotores de crescimento alternativos.

Introduction

In recent years, research on the use of bioactive compounds obtained from tree and plant species in animal production has been encouraged to develop a positive correlation between feed, an optimal microbiota, and a healthy digestive tract, because it has been shown that supplementation with antibiotics to promote weight gain, increase feed efficiency and prevent or control pathogenic microorganisms in broilers (Xiong *et al*., 2018; Smith, 2019), pigs (Bosco, 2019), and turkeys (Mohammadigheisar *et al*., 2019) have originated the increase of germs resistant to these medications.

Foods of vegetable origin rich in fiber and inulin such as artichokes; chicory; garlic, and onion, among others, have been tested as prebiotics (adjuvant of growth and activity of the gut microbiota) in animal feed in order to reduce the use of antibiotics, these have contributed to decrease the pathogenic flora and increase probiotic bacteria, and as a consequence, they maintain excellent gastrointestinal health (Gibson *et al*., 2017).

The U.S. Food and Drug Administration (FDA) recognized that the gum exudate produced by *Acacia senegal,* a species native to Africa, is a source of nutritional fiber that is safe for human and animal food (Babiker *et al*., 2012). This natural polymer has been shown to be fermented by gut microbiota and acts as a prebiotic, boosting the growth of beneficial gut flora and nutrient absorption (Khalid *et al*., 2014). Various studies have shown the benefits of using gum arabic as a prebiotic in animal feed (Gibson *et al*., 2017; Abd-Razig *et al*., 2010, Al-Fadil *et al*., 2013).

There are different genera of tree species widely distributed in South America that produce gums exudates with physicochemical characteristics analogous to the gum arabic produced by *A. senegal* (Clamens *et al*., 2000). *Prosopis juliflora*, a species widely spread in Venezuela and Mexico, exudes gum that is high in essential minerals and dietary fiber (Rincón *et al*., 2020; López-Franco *et al*., 2012). *Prosopis alba* located in Brazil has antioxidant activity (high phenol content) (Vasile *et al*., 2019), the benefits described by these authors suggest that these natural products could be used in the formulation of functional feeds in animal production.

It has been reported that tree species of the genus *Prosopis* growing in Ecuador produce gums exudates (Burghardt *et al*., 2010), which could be tested as prebiotics in animal feed, after determining their nutritional and toxicological composition.

The purpose of the study was to discuss the potential use of novel sources of gums exudates of *Prosopis* spp., located in Ecuador, as prebiotics in animals of zootechnical interest based on literature reviews of the use of gum-hydrocolloids as an alternative supplement in animal feed.

Methods

A systematic search of the scientific literature on gum-hydrocolloids and their potential use as prebiotics in animal feed was carried out, with special emphasis on gums exudates obtained from tree species disseminated in South America. The keywords used included: «gums exudates», «prebiotics», «animal feed», «hydrocolloids», «gut microbiota», «gut fermentation», «digestibility» and «functional properties». A variety of high-impact scientific databases were used,

such as Scopus, Web of Science, Springer Link, Science Direct, Taylor & Francis, and PubMed, as well as Google Scholar. Seventy-two relevant sources were selected for this review, which included original research articles, scientific reviews, and specialized texts, published in a time range from 2004 to 2024. The selected studies provide key information on the bioactive properties of gums exudates, their ability to act as prebiotics, and their potential beneficial effects on improving gut health and digestive efficiency in animals of zootechnical interest. This review also assesses the potential of such exudates in reducing metabolic stress and modulating the gut microbiota, crucial elements in modern animal nutrition.

Discussion

The gum exudate of *Acacia senegal* (gum arabic, GA) has been tested as a prebiotic with excellent results in animal production. The inclusion of gum arabic and *Lactobacillus acidophilus* in the feed ration supplied in Ross 308 chickens has beneficial effects on the weight of visceral and lymphoid organs, improves intestinal histomorphology and decreases the growth of pathogenic flora, which evidences the synergistic effect of the joint use of hydrocolloids as prebiotics and probiotic bacteria (Bayoumi *et al*., 2024). Likewise, it has been reported that broilers fed with gum arabic at concentrations between 5 % and 7.5 % showed a significant increase in total protein, productive parameters, and decreased serum levels of cholesterol, creatinine, and triglyceride (Abdalla *et al*., 2015). On the other hand, feed rations with GA in the range of 20-60 $g.kg^{-1}$ reduced uric acid in broilers, additionally increased fecal nitrogen secretion and reduced serum nitrogen concentration; it has been shown that increased growth and bacterial activity in the intestine depend on these factors (Al-Fadil *et al*., 2013).

Al-Baadani *et al*. (2022) described that chickens fed with GA (0.25 % to 1.0 %) had a higher population of *Lactobacillus* spp. compared to those observed for *Salmonella* spp. and *Escherichia coli* in the intestinal tract; prebiotics are an important source of fiber for the growth of lactic acid bacteria, which exponentially increases the obtaining of lactic acid by significantly reducing pH, and as a consequence, the development of pathogenic microorganisms is lower. The addition of GA produced an increase in the count of probiotic bacteria such as *Bifidobacterium* and *Lactobacillus*, as well as the secretion of goblet cells at the intestinal level, which contributes to avoiding the adhesion of pathogenic bacteria in the intestinal epithelium, decreasing the populations of these non-beneficial microorganisms (Khan *et al*., 2022).

Likewise, Khan *et al*., (2022) argued that supplementation with gum arabic reduced mortality in broilers, due to the prebiotic property of promoting the growth of the beneficial microbiota, eradicating toxins produced by harmful bacteria, results that are in accordance with those reported by Park *et al*., (2020), who evidenced the decrease in mortality in broilers supplemented with GA and *Bacillus subtilis*, due to increased intestinal immunity and strengthened epithelial barrier integrity. The combination of probiotic bacteria with prebiotics in animal feed enhances gut health and productive performance by improving the gut microbiota, promoting the growth of beneficial bacteria, increasing the production of short-chain fatty acids, and facilitating the digestion and absorption of nutrients, ultimately leading to enhanced feed efficiency and weight gain (Wang *et al*., 2016).

Consumption of 4 $g.kg^{-1}$ for four weeks of insoluble dietary fiber-rich GA in laying hens increased the number of genera *Bifidobacterium* and *Lactobacillus* compared to inulin, and had positive effects on mineral absorption (Gultermirian *et al*., 2014; Abd-Razig *et al*., 2010).

Phillips and Phillips (2011) described that fiber obtained from *A. senegal* exudates has beneficial effects on renal and hepatic metabolic processes. It has been reported that dietary fiber present in GA decreased the *in vitro* absorption of fat and glucose in rats (Ahmed *et al*., 2016).

Gum arabic applied individually and in conjunction with probiotic bacteria in feed rations in chickens of the COBB-500 and ROSS-308 genetic line, has shown antimicrobial activity against *Salmonella* spp., *Salmonella enteritidis* and *Escherichia coli* (Al-Baadani *et al*., 2022; Hu *et al*. 2016). Furthermore, Al-Baadani *et al*., (2021) concluded that bacteria present in the animal intestine can ferment gum arabic and convert it into short-chain fatty acids, which play a fundamental role in maintaining the structural and functional integrity of the intestine by inhibiting the colonization of pathogens by causing a decrease in pH. Likewise, it has been shown that the fiber of the gum exudate of *Acacia senegal* improves the immune response through the production of anti-inflammatory cytokines and the regulation of the production of pro-inflammatory cytokines by immune cells (Al-Baadani *et al*., 2022).

This effect is comparable to that observed when testing traditional diets in broilers using *Bacillus subtilis* in combination with zinc, which reduced the count of *Escherichia coli*, *Clostridium perfringens* and the decrease in coccidiosis (Wang *et al*., 2018); as well as when testing *Bacillus subtilis* DSM 29784 (Ba) and enzymes (xylanase and β-glucanases) in chicken diets (Wang *et al*., 2020).

It is important to note that in a study carried out in humans, it was observed that the intake of gum arabic reduced inflammatory markers in patients with rheumatoid arthritis, which is due to the aerobic fermentation at the colon level of the fiber of this natural polymer, which produces butyrate, which has a powerful anti-inflammatory effect and contributes to the decrease in the production of proinflammatory cytokines (Kamal *et al*., 2018).

Therefore, based on documented reports, gums exudates are potential antimicrobial and regulatory options for inflammatory processes such as those caused by *Mycoplasma synoviae* (exudative tendinitis and synovitis) in chickens, turkeys and other poultry species, acting as regulators of the production of proinflammatory cytokines.

On the other hand, diets supplemented with GA (2-20 $g.kg^{-1}$ diet) increased the concentrations of total proteins, albumin, as well as higher levels of immunoglobulins (IgG, IgM, and IgA), zinc, and selenium content, which contributed to the strengthening of the immune system in rabbits. Likewise, it did not alter the functioning of liver enzymes (aspartate transaminase and alanine transaminase in blood (El-Ratel *et al*., 2019; Amber *et al*., 2017). This same behavior was evidenced when giving GA to laboratory rats (Ali *et al*., 2013).

Documented scientific articles show the benefits of using gum exudate of *Acacia senegal* as a prebiotic in animal feed. The gums obtained from *Prosopis* spp. have physicochemical and nutritional characteristics similar to those published for gum arabic (Rincón-Acosta *et al*., 2023; Rincón *et al*., 2020; Mubgil and Barak, 2020; Vasile *et al*., 2019; López-Franco *et al*., 2015; López-Franco *et al*., 2012).

The high content of phenolic compounds in the gum exudate of *Prosopis alba* has been reported (Vasile *et al*., 2019), which confers

antioxidant activity by inhibiting cellular biological oxidation, and as a consequence, decreases the risks of suffering from hypertension, cancer, diabetes, neurodegenerative diseases and cellular aging (McDougall, 2016). Likewise, a high content of essential minerals, proteins, and insoluble dietary fiber has been evidenced in the gums of *Prosopis juliflora* (Rincón-Acosta *et al*., 2023; Rincón *et al*., 2020), *Prosopis* spp. (Mubgil and Barak, 2020; López-Franco *et al*., 2012). It is worth noting that the high content of zinc contributes to the strengthening of the immune system and potassium, which acts by controlling the osmotic processes of the cardiovascular system (Oboh *et al*., 2015).

The above shows that the gum exudate of *Prosopis* spp. has great potential to be tested as a prebiotic, due to its high content of insoluble dietary fiber and oligosaccharides, which favors the growth and activity of the beneficial gut microbiota by inhibiting the growth of pathogenic microorganisms, improving the intestinal immune response. This fiber is not digested in the gastrointestinal tract, which allows it to reach the colon, where it serves as a substrate for probiotic bacteria, promoting digestive health and the balance of gut flora.

Conclusions

Based on the findings reported in the literature review and discussed in this manuscript, it has been shown that the gum exudate of *Acacia senegal* (gum arabic), which has physicochemical characteristics analogous to those exhibited by *Prosopis* spp., has been tested with excellent results, as a prebiotic, in the production of broilers, turkeys, rabbits, and pigs. Therefore, the gum exudate obtained from *Prosopis* spp. trees located in Ecuador could present a nutritional profile with excellent content of insoluble fiber, oligosaccharides, essential minerals, and phenolic compounds, which would enhance its use as a promising prebiotic in animal feed (growth promoter), favoring the function of the intestinal barrier, the growth of the beneficial microbiota, contributing to significantly decrease the populations of pathogenic bacteria, mortality due to gastrointestinal infections, optimizing animal welfare and production.

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