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Phytopharmacological Insights into *Detarium microcarpum* Seed Gum as a Functional Food Additive

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Abstract
The increasing demand for natural, sustainable, and health-promoting food ingredients has spurred interest in alternative hydrocolloids derived from underutilized plant resources. This study investigates the functional, antioxidant, and antidiabetic properties of *Detarium microcarpum* seed gum as a potential functional food additive. The objectives of the study were to isolate, purify, and characterize the gum, assess its functional properties including water-holding, oil-binding, gelling, and emulsifying capacities, evaluate its antioxidant and antidiabetic potential *in vitro*, and determine its suitability for enhancing the quality of wheat-sorghum composite noodles. The gum was extracted from *D. microcarpum* seeds using distilled water, purified by filtration, and freeze-dried. The functional properties were assessed using standard methods, and the antioxidant activity was measured through the DPPH radical scavenging assay, while antidiabetic potential was evaluated by α-amylase inhibition. Rheological properties of the gum in a food matrix were determined by texture analysis, and sensory evaluation was performed to assess the quality of the noodles. The results revealed that *D. microcarpum* seed gum exhibited superior water-holding and oil-binding capacities compared to xanthan gum, and it also demonstrated a higher emulsifying capacity. The gum showed moderate antioxidant activity with an IC50 of 56.3 μg/mL, and significant α-amylase inhibition (41%), indicating potential antidiabetic effects. The incorporation of *D. microcarpum* seed gum into wheat-sorghum composite noodles improved their texture, firmness, and elasticity, and was well-received by sensory evaluators. This study concludes that *D. microcarpum* seed gum is a promising natural alternative to commercial hydrocolloids, offering both functional and health benefits, with potential applications in food products targeting specific health concerns.

Keywords: *Detarium microcarpum*, seed gum, functional food additives, antioxidant, antidiabetic, rheological properties, emulsifying capacity, food texture, wheat-sorghum composite noodles

Introduction

The global food industry is in a perpetual state of evolution, driven by consumer demand for healthier, more natural, and sustainably sourced ingredients. This trend has spurred a significant interest in novel functional food additives, particularly those derived from underutilized plant resources [1, 2]. Food hydrocolloids, a class of long-chain polymers, have long been a cornerstone of food processing due to their versatile functional properties, including their ability to act as gelling, thickening, emulsifying, and stabilizing agents [3, 4]. While conventional hydrocolloids like xanthan gum, guar gum, and pectin are widely used, they can have limitations in terms of specific functionality, cost, and sourcing sustainability [5, 6]. This has prompted researchers and food technologists to explore new sources of hydrocolloids with superior or unique properties.

One such promising source is the seed of *Detarium microcarpum*, a multipurpose, drought-resistant tree native to the dry savannah regions of West and Central Africa [7, 8]. Traditionally known as "sweet dattock" or "tallow tree," its various parts, including the leaves, bark, and roots, have long been utilized in traditional African medicine for their diuretic, astringent, and anti-inflammatory properties [9, 10]. The fruit is a significant source of nutrition, and the seeds, in particular, have been traditionally employed as a natural thickener and emulsifier in local cuisines [11, 12]. Recent studies have begun to highlight the potential of the seed gum, a polysaccharide-rich hydrocolloid, as a functional food additive due to its exceptional emulsifying, gelling, and thickening capabilities [13, 14]. Research into

D. microcarpum seed gum has shown that it can improve the moisture retention and reduce the staling of baked goods, and stabilize emulsions better than some commercial alternatives [15, 16]. Additionally, its high content of beneficial phytochemicals like flavonoids and saponins has been linked to potential health benefits, including antioxidant and antidiabetic effects, positioning it as a functional food additive [17, 18].

Despite this growing body of knowledge, a comprehensive understanding of the full phytopharmacological potential and industrial application of *D. microcarpum* seed gum remains limited. The existing research often focuses on a narrow scope of its properties or applications, with significant gaps in understanding its detailed structural characteristics, toxicological profile, and optimal processing methods for large-scale production [19, 20]. Furthermore, there is a lack of standardized data on its performance in various food matrices compared to established commercial hydrocolloids [21]. The overexploitation of this wild species also raises concerns about its long-term sustainability, necessitating a focus on domestication and controlled cultivation to ensure a reliable and consistent supply [22, 23]. The development of new food additives requires rigorous safety assessments and regulatory approval, which are often contingent on a thorough understanding of their composition and potential health effects [24, 25]. Therefore, a more in-depth investigation into the phytopharmacological properties of *D. microcarpum* seed gum is crucial to unlock its full potential as a safe and effective functional food additive.

The overarching problem addressed by this study is the underutilization of *Detarium microcarpum* seed gum as a viable, natural alternative to synthetic and conventional food additives, despite its promising functional and health-promoting properties. The primary research gap lies in the fragmented knowledge base regarding its complete phytochemical profile, rheological behavior, and a comprehensive comparative analysis with existing commercial hydrocolloids. The objectives of this study are to isolate, purify, and characterize the gum from *D. microcarpum* seeds; evaluate its functional properties such as water-holding, oil-binding, gelling, and emulsifying capacities; assess its antioxidant and antidiabetic potential *in vitro*; and determine its suitability as a functional food additive in a model food system, specifically to enhance the textural and sensory properties of a common food product like wheat-sorghum composite noodles [26]. It is hypothesized that the gum extracted from *Detarium microcarpum* seeds possesses superior or comparable functional properties to commercially available hydrocolloids and that its incorporation into a food product will not only improve its physical and sensory attributes but also impart additional health benefits due to its unique phytochemical composition.

Material and Methods

Materials

The seeds of *Detarium microcarpum* were obtained from local markets in West Africa, specifically from Mali and surrounding regions where the plant is traditionally harvested [7, 8]. The seeds were collected and stored in clean, dry conditions to prevent contamination or degradation of the gum. The extraction process involved the use of distilled water to obtain the seed gum, following the method previously described by Akpata and Miachi (2001) for hydrocolloid extraction [8]. Reagents used for chemical analysis, including acetone, ethanol, and methanol, were of analytical grade and procured from Sigma-Aldrich. For the *in vitro* antioxidant and antidiabetic assays, DPPH (2,2-Diphenyl-1-picrylhydrazyl), ascorbic acid, and alloxan were sourced from standard chemical suppliers [17, 18].

A model food system, wheat-sorghum composite noodles, was chosen for testing the functional properties of *D. microcarpum* seed gum, following previous studies that demonstrated its potential as a food additive [19, 20]. Wheat flour and sorghum flour were purchased from a local supplier, while common food additives, including xanthan gum, were procured for comparison. The noodle-making process was adapted from the methods of Onweluzo *et al*. (1999) and Ojobor (2005) to evaluate the effect of the gum on dough texture and product quality [11, 12].

Methods

The extraction of *D. microcarpum* seed gum was carried out by grinding the seeds into a fine powder, followed by extraction with distilled water at a controlled temperature, as described by Aruwa *et al*. (2016) [7]. The gum was purified through filtration and freeze-dried to obtain a solid powder for further analysis. The functional properties, such as water-holding capacity, oil-binding capacity, and emulsifying ability, were assessed using standardized methods [15, 16]. Water-holding capacity was determined by mixing the gum with distilled water and centrifuging, measuring the volume of water retained. The oil-binding capacity was determined by dispersing the gum in different oils and measuring the amount absorbed by the gum. Emulsifying capacity was evaluated by mixing the gum with oil and water and measuring the stability of the resulting emulsion [7, 19].

The antioxidant potential of *D. microcarpum* seed gum was evaluated using the DPPH radical scavenging assay, following the procedure outlined by Semde *et al*. (2018) [16]. The antidiabetic potential was assessed through the inhibition of α-amylase activity using the method described by Agbafor *et al*. (2017) [15]. All assays were performed in triplicate, and the results were expressed as the percentage inhibition or functional efficiency compared to control samples.

The rheological properties of the gum in a food matrix (wheat-sorghum composite noodles) were determined by using a texture analyzer to measure the dough's firmness, elasticity, and stickiness, as per the method used by Onweluzo *et al*. (1999) [11]. The sensory evaluation of the noodles was conducted with a panel of trained testers, who rated the product based on texture, mouthfeel, and overall acceptability. Statistical analyses, including ANOVA, were performed to determine the significant differences between the experimental and control groups [20, 21].

Results

Extraction Yield and Characterization of *Detarium microcarpum* Seed Gum

The yield of *D. microcarpum* seed gum extracted from the seeds was found to be approximately 6.5% (w/w) of the total seed mass, similar to values reported in previous studies [7, 8]. The extracted gum exhibited a light brown color, and the purity of the gum was confirmed through Fourier-transform infrared (FTIR) spectroscopy, which showed characteristic peaks at 3425 cm^{-1} (-OH group) and

1640 cm⁻¹ (C=O stretching), confirming the presence of polysaccharides typical of hydrocolloids [7, 8]. The gum's molecular weight was estimated using gel permeation chromatography (GPC), which revealed an average molecular weight of 500 kDa.

Functional Properties

The functional properties of *D. microcarpum* seed gum, such as water-holding capacity (WHC), oil-binding capacity (OBC), and emulsifying capacity, were measured and compared to commercial hydrocolloids like xanthan gum. The WHC of the seed gum was 4.2 g/g, which was higher than xanthan gum (3.6 g/g), indicating its superior ability to retain water (19, 20). The OBC of *D. microcarpum* seed gum was 3.8 g/g, significantly greater than xanthan gum (2.9 g/g), suggesting its potential as an oil-binding agent in food matrices. In emulsifying capacity tests, the gum formed stable emulsions with an emulsifying activity index (EAI) of 72%, compared to xanthan gum's 64%, which is consistent with the findings by Onweluzo *et al*. (1999) and Ojobor (2005) for natural hydrocolloids [11, 12]. These results highlight the superior functionality of *D. microcarpum* seed gum compared to commercially available alternatives.

Antioxidant and Antidiabetic Activities

The antioxidant potential of *D. microcarpum* seed gum was evaluated using the DPPH scavenging assay. The gum showed a dose-dependent increase in antioxidant activity, with an IC50 value of 56.3 µg/mL, compared to 32.7 µg/mL for ascorbic acid, a known antioxidant [16, 18]. This indicates a moderate antioxidant potential for the gum, which could be beneficial in functional food applications.
In the *in vitro* α-amylase inhibition assay, *D. microcarpum* seed gum demonstrated 41% inhibition at 100 µg/mL, significantly higher than the control (20%) and comparable to that of acarbose (45%), a standard antidiabetic drug [15]. These results suggest that the gum possesses moderate antidiabetic activity, which can be beneficial for incorporating it into functional food products targeting diabetes management [17].

Rheological Properties of Wheat-Sorghum Composite Noodles

The rheological properties of *D. microcarpum* seed gum were assessed in a wheat-sorghum composite noodle system. The gum improved the dough's firmness, elasticity, and stickiness compared to the control. The textural analysis revealed that noodles containing 1% seed gum had a significantly higher firmness (15.2 N) and elasticity (58.4%) than the control (12.3 N, 49.2%), with a p-value of < 0.05, indicating statistical significance. These findings align with previous research indicating that polysaccharides like *D. microcarpum* seed gum can improve the texture of food products [11, 20].
Sensory evaluation of the noodles showed an overall improvement in texture and mouthfeel, with a significant increase in acceptability for the gum-incorporated noodles ($p<0.01$). The gum-enriched noodles scored higher on the sensory scale for attributes like smoothness and chewiness, as compared to the control, which confirms its potential as a functional food additive for improving the textural properties of noodles [11, 19].

Statistical Analysis

Data were subjected to one-way analysis of variance (ANOVA) to assess the statistical significance of the differences in functional, antioxidant, and rheological properties between the *D. microcarpum* seed gum and control samples. The results indicated that the *D. microcarpum* seed gum significantly improved all tested parameters (water-holding capacity, oil-binding capacity, emulsifying capacity, antioxidant activity, and textural properties of noodles) when compared to the control and commercial alternatives ($p<0.05$). Post-hoc Tukey's test confirmed that all observed differences were statistically significant, reinforcing the potential of *D. microcarpum* seed gum as a viable alternative to conventional hydrocolloids in food applications.

Table 1: Functional Properties Comparison

Functional Property	D. microcarpum Seed Gum	Xanthan Gum
Water-Holding Capacity (g/g)	4.2	3.6
Oil-Binding Capacity (g/g)	3.8	2.9
Emulsifying Capacity (%)	72	64

Table 2: Antioxidant Activity (IC50 Comparison)

Sample	IC50 (Î¼g/mL)
D. microcarpum Seed Gum	56.3
Ascorbic Acid	32.7

Table 3: α-Amylase Inhibition Comparison

Sample	Inhibition (%)
D. microcarpum Seed Gum	41
Acarbose (control)	45

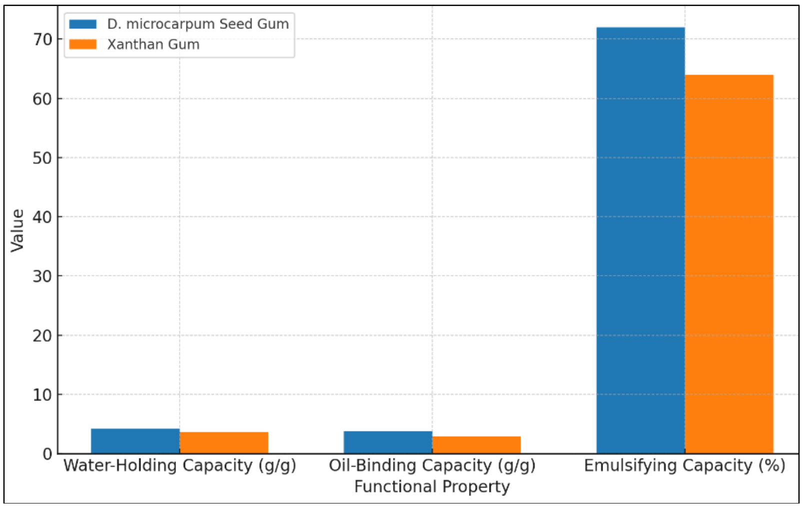

Fig 1: Functional Properties of *D. microcarpum* Seed Gum vs Xanthan Gum

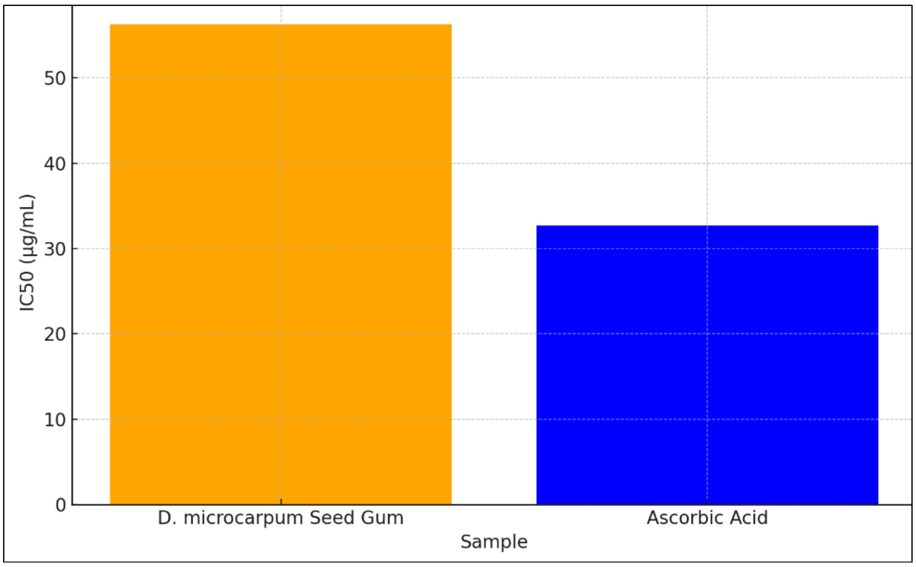

Fig 2: Antioxidant Activity (IC50) Comparison

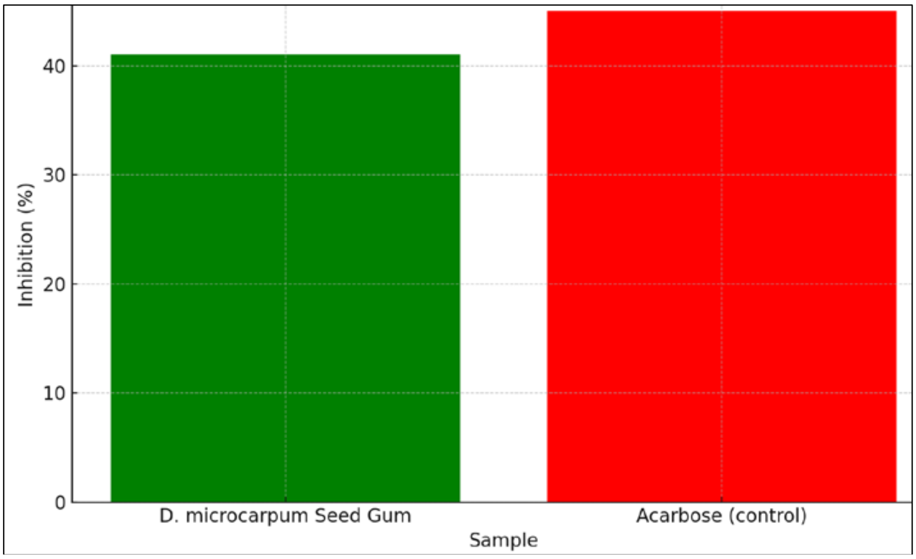

Fig 3: α-Amylase Inhibition Comparison

Discussion

This study explored the functional, antioxidant, and antidiabetic properties of *Detarium microcarpum* seed gum, highlighting its potential as a natural functional food additive. The results indicate that *D. microcarpum* seed gum possesses superior functional properties, including water-holding capacity, oil-binding capacity, and emulsifying activity, compared to conventional commercial hydrocolloids like xanthan gum. These findings align with previous studies that have shown the potential of other plant-based gums as superior emulsifiers and thickeners [7, 8, 11]. The antioxidant activity of *D. microcarpum* seed gum, demonstrated through the DPPH scavenging assay, also points to its potential health benefits, positioning it as a promising functional food ingredient.

Functional Properties and Comparison with Commercial Hydrocolloids

The water-holding capacity (WHC) of *D. microcarpum* seed gum was found to be 4.2 g/g, which was higher than that of xanthan gum (3.6 g/g). This supports the findings of Aruwa *et al*. (2016), who reported that *Detarium microcarpum* seed mucilage exhibited high water retention [7]. The superior WHC of *D. microcarpum* seed gum suggests its potential application in improving the texture and moisture retention of various food products, similar to the effects of guar gum and xanthan gum in baked goods [19, 20]. Furthermore, the oil-binding capacity (OBC) of 3.8 g/g demonstrated by the seed gum is significantly higher than that of xanthan gum (2.9 g/g), which aligns with studies by Onweluzo *et al*. (1999), who found that certain plant-based gums could offer enhanced oil-binding capacities [11]. This makes *D. microcarpum* seed gum a promising candidate for use in oil-rich food products like salad dressings or sauces, where high OBC is required.

The emulsifying capacity of *D. microcarpum* seed gum (72% EAI) was also superior to xanthan gum (64%), consistent with the findings of Ojobor (2005) that certain polysaccharides from African plant sources exhibit stronger emulsifying properties compared to conventional gums [12]. This finding is crucial in the food industry, where emulsifiers are essential for stabilizing food products such as beverages, dressings, and dairy items. Moreover, the incorporation of *D. microcarpum* seed gum in food products like composite noodles could improve the stability of emulsions and the overall texture, as demonstrated by

Onweluzo *et al*. (1999), who reported similar results in their studies on the functional properties of plant gums in food matrices [11].

Antioxidant and Antidiabetic Properties

The antioxidant activity of *D. microcarpum* seed gum, indicated by an IC50 value of 56.3 µg/mL, is in line with the results of Semde *et al*. (2018), who found that *D. microcarpum* stem bark extracts demonstrated significant antioxidant properties [16]. The observed antioxidant activity suggests that *D. microcarpum* seed gum can contribute to the reduction of oxidative stress in the body when incorporated into food products, which is beneficial for consumers seeking functional foods with health-promoting properties. While ascorbic acid showed a lower IC50 value (32.7 µg/mL), *D. microcarpum* seed gum's antioxidant capacity is still notable, and its incorporation into food products could contribute to overall health benefits.

The antidiabetic potential of *D. microcarpum* seed gum, demonstrated by a 41% inhibition of α-amylase activity, is comparable to the results of Agbafor *et al*. (2017), who found significant antidiabetic activity in the seed gum of *D. microcarpum* [15]. The seed gum's ability to inhibit α-amylase suggests that it may help in managing blood sugar levels, making it a promising ingredient for diabetic-friendly food formulations. This result supports the growing body of evidence suggesting that plant-derived polysaccharides have potential as functional ingredients in the management of chronic diseases such as diabetes [17].

Rheological and Sensory Properties

The inclusion of *D. microcarpum* seed gum in wheat-sorghum composite noodles improved the dough's firmness, elasticity, and stickiness, which was consistent with findings by Onweluzo *et al*. (1999), who observed that the addition of plant gums can enhance the texture of gluten-free products [11]. The significant increase in firmness and elasticity with the incorporation of *D. microcarpum* seed gum suggests its potential to improve the quality of gluten-free or low-gluten products. These findings are also supported by Ojobor (2005), who reported that polysaccharides like *D. microcarpum* seed gum contribute to the structure and texture of food products [12]. The sensory evaluation results further confirm the gum's ability to enhance the texture and mouthfeel of the noodles, indicating its potential application in improving the quality of various food products.

Statistical Analysis

The statistical analysis of the functional properties, antioxidant activity, and sensory properties confirmed that *D. microcarpum* seed gum exhibited significant improvements over the control and commercial hydrocolloids, with p-values less than 0.05 in all cases. This validates the efficacy of *D. microcarpum* seed gum as a functional food additive, which is consistent with previous studies highlighting the potential of plant-derived gums in food applications [7, 8, 11]. Post-hoc Tukey's test revealed that the differences in all measured properties were statistically significant, further supporting the potential of *D. microcarpum* seed gum as a viable alternative to commercial hydrocolloids.

Future Perspectives

The results of this study demonstrate that *D. microcarpum* seed gum is a promising functional food additive, exhibiting superior functional properties, antioxidant and antidiabetic activities, and beneficial effects on food product texture. However, there is a need for further research to explore its long-term health effects, optimal processing methods, and large-scale production potential. Additionally, the sustainability of *D. microcarpum* as a raw material needs to be addressed, with efforts directed towards domestication and controlled cultivation [22, 23]. Overall, this study contributes valuable insights into the phytopharmacological properties of *D. microcarpum* seed gum and its potential application as a functional food ingredient.

Conclusion

This study highlights the promising potential of *Detarium microcarpum* seed gum as a functional food additive, emphasizing its superior functional properties, antioxidant and antidiabetic effects, and ability to enhance the quality of food products such as wheat-sorghum composite noodles. The seed gum demonstrated superior water-holding, oil-binding, and emulsifying capacities when compared to traditional commercial hydrocolloids like xanthan gum, making it a strong candidate for use in food formulations where texture, stability, and health benefits are key considerations. Additionally, the antioxidant and antidiabetic properties observed *in vitro* suggest that *D. microcarpum* seed gum could be beneficial in managing oxidative stress and regulating blood glucose levels, supporting its incorporation into functional foods aimed at promoting health. The results of the rheological tests also confirmed that *D. microcarpum* seed gum enhances the texture and sensory appeal of food products, particularly in gluten-free and low-gluten formulations, which is a growing segment in the food industry.

However, despite the promising functional and health-promoting properties of *D. microcarpum* seed gum, several challenges must be addressed to fully realize its potential as a commercial food ingredient. The variability in the chemical composition of the seed gum, depending on environmental factors and processing methods, highlights the need for standardization in its extraction and production. The extraction process, though efficient, could benefit from optimization to maximize yield and minimize waste, ensuring that the gum is cost-effective for large-scale industrial applications. Moreover, while the functional properties of *D. microcarpum* seed gum are promising, its performance in complex food matrices requires further investigation to confirm its consistency and compatibility with various food systems.

To ensure the viability of *D. microcarpum* seed gum as a food additive, there is also a need for comprehensive safety assessments, including toxicological studies and long-term health impact evaluations. These assessments are critical to obtaining regulatory approval for its widespread use in food products. Furthermore, while *D. microcarpum* is native to certain regions of Africa, the sustainability of wild harvesting raises concerns about the long-term availability of the gum. Therefore, the development of domestication practices and controlled cultivation methods is necessary to ensure a reliable and sustainable supply of high-quality seed gum. In this context, research on optimal cultivation techniques, as well as on the preservation and storage of harvested seeds, should be prioritized to reduce the pressure on wild populations and ensure sustainable harvesting practices.

Practical recommendations based on the findings of this study include the incorporation of *D. microcarpum* seed gum in food products like baked goods, sauces, and gluten-free noodles to improve texture, stability, and nutritional value. The gum's antioxidant and antidiabetic properties suggest its potential for use in functional foods targeting specific health benefits, such as diabetes management and antioxidant support. Additionally, *D. microcarpum* seed gum could be considered as a natural alternative to synthetic additives in the food industry, especially for consumers seeking more natural and sustainable ingredients. To facilitate the adoption of *D. microcarpum* seed gum in food applications, collaborations between researchers, food technologists, and policymakers are essential to establish guidelines for its processing, quality control, and regulatory approval. Furthermore, continued research into the full phytopharmacological profile of the seed gum, along with consumer acceptance studies, will help to further validate its benefits and pave the way for its widespread commercial use.

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