

Valorization of Cordia gum: A Natural Hydrocolloid for Functional Food Innovation

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Abstract. Gums, as natural hydrocolloids, play a crucial role in enhancing the functionality and stability of food products. The present study focuses on the extraction, characterization, and functional evaluation of Cordia fruit gum for its application in value-added food formulations. Traditionally used in the pharmaceutical industry, Cordia gum remains underutilized in the food sector. This research aims to optimize the extraction process, ensuring maximum yield while preserving functional properties. The physicochemical characterization, including rheological behaviour, moisture content, solubility, and particle size distribution, was conducted to establish its potential as a functional ingredient. Functional property assessments, such as emulsifying, stabilizing, water-holding, and foaming capacities, were performed to explore its suitability in food formulations. Cordia gum was successfully incorporated into innovative food products, including ginger-garlic paste, flavoured drinks, and nutritional formulations for lactating mothers. The findings highlight Cordia gum as a natural alternative to synthetic stabilizers and emulsifiers, supporting clean-label and sustainable food innovations. The study contributes to bridging the research gap by demonstrating the commercial viability of Cordia gum in functional food applications, paving the way for further exploration in food product development.

KEYWORDS: Functional foods, Cordia gum, hydrocolloids, Value addition, Food stability, Clean-label ingredients, Natural emulsifiers.

1. INTRODUCTION

The increasing demand for natural and clean-label ingredients in the global food industry has led to a surge of interest in plant-derived hydrocolloids. These natural polymers, predominantly polysaccharides, play essential roles in modifying texture, stabilizing emulsions, controlling moisture migration, and enhancing shelf-life of food products [1]. They are widely used as thickeners, gelling agents, emulsifiers, and stabilizers due to their compatibility with food systems and generally recognized as safe (GRAS) status. In particular, there has been a growing emphasis on identifying underutilized and novel sources of such hydrocolloids, which could potentially offer unique functional characteristics and contribute to sustainable food innovation [2].

Among these natural sources, plant gums represent an important class of hydrocolloids characterized by their complex carbohydrate structures and water solubility. These gums are exuded from trees or extracted from seeds and are valued for their ability to influence the rheological behaviour of food systems [3]. Despite the widespread industrial use of established hydrocolloids like xanthan gum, guar

gum, and locust bean gum, several lesser-known plant gums remain underexplored. One such promising candidate is Cordia gum, a natural exudate obtained from the fruits of *Cordia dichotoma*—a deciduous tree belonging to the family Boraginaceae.

Cordia dichotoma, commonly known as "Indian cherry" or "Lasora," is native to the Indian subcontinent and has traditionally been used in Ayurvedic and folk medicine for its expectorant, anti-inflammatory, antimicrobial, and demulcent properties [4]. The tree produces a viscous, mucilaginous gum when its unripe or mature fruits are cut or injured. While Cordia fruit pulp is consumed in pickles and chutneys in various Indian regions, the gum exudate remains largely unutilized in mainstream food product development. Interestingly, Cordia gum is composed primarily of polysaccharides such as galactose, mannose, and uronic acids, which are structurally similar to many commercial hydrocolloids [5].

Despite its potential, Cordia gum has historically found limited application, mostly in traditional medicine and pharmaceutical formulations as a binder, suspending agent, and mucilage base [6]. Its incorporation into the food industry has been minimal, primarily due to a lack of systematic research on its physicochemical and functional

properties. The untapped potential of Cordia gum offers an exciting opportunity for its valorization as a sustainable and effective alternative to synthetic food additives. Moreover, with the increasing global push for clean-label products and regulatory constraints on artificial ingredients, naturally derived hydrocolloids like Cordia gum could play a pivotal role in shaping the future of functional food development [7].

The present study aims to bridge this research gap by systematically exploring the extraction, characterization, and functional properties of Cordia gum, with a focus on its suitability in food formulations. A key objective is to optimize the extraction process to ensure high yield and functional integrity, using green and sustainable techniques. Detailed physicochemical characterization—including particle size distribution, moisture content, solubility, and rheological analysis—is carried out to evaluate the gum's behaviour in food systems [8].

Furthermore, this study investigates the gum's emulsifying ability, water-holding capacity, foaming characteristics, and stabilizing potential. These properties are critical in determining its application in various food matrices. For practical validation, the gum was successfully incorporated into a range of innovative food prototypes including ginger-garlic paste (as a stabilizer and texturizer), flavoured beverages (as a mouthfeel enhancer and natural thickener), and nutritional formulations tailored for lactating mothers (as a natural binding and nutrient-stabilizing agent).

By providing scientific evidence of its functional attributes and commercial viability, this research contributes significantly to the valorization of Cordia gum as a novel food-grade hydrocolloid. The findings not only highlight the gum's relevance in clean-label and sustainable product development but also underscore the importance of promoting indigenous plant resources for industrial applications. In doing so, the study aligns with current trends in food technology aimed at achieving nutritional security, environmental sustainability, and consumer transparency [9][10].

2. MATERIALS AND METHODS

2.1. Procurement and Selection of Raw Material

Fully mature fruits of *Cordia dichotoma* were sourced from local orchards in Uttar Pradesh, India, during the late summer season when the gum content is naturally higher. Care was taken to collect fruits that were free from microbial contamination, mechanical damage, and over-ripeness. Fruits were sorted manually based on uniform size and color. After selection, fruits were thoroughly washed with

potable water followed by a rinse with distilled water to eliminate dirt and surface impurities. The cleaned fruits were then shade-dried for 48 hours to reduce surface moisture prior to processing.

2.2. Gum Extraction and Purification Process

The extraction of gum was carried out using an aqueous extraction method. The cleaned fruits were sliced to expose the inner mucilaginous pulp, which was then blended in distilled water in a 1:3 ratio (w/v). The slurry was continuously stirred at 45 ± 2 °C for 5 hours to allow complete dissolution of the mucilage into the aqueous phase. The mixture was filtered using multiple layers of muslin cloth to remove insoluble pulp and fibrous material.

The filtrate was collected and subjected to precipitation by adding chilled ethanol (95%) in a 1:2 ratio (v/v), which initiated coagulation of the gum. This mixture was refrigerated at 4 °C for 24 hours to enhance the separation of gum precipitate. The coagulated gum was recovered by centrifugation at 5000 rpm for 20 minutes. The resulting gel-like mass was washed again with ethanol to remove residual sugars and pigments. The purified gum was then oven-dried at 45 °C until a constant weight was achieved. Once dried, the gum was pulverized in a mechanical grinder and sieved through a 60-mesh screen to obtain fine, free-flowing powder [11].

2.3. Physicochemical Analysis of Cordia Gum

2.3.1. Determination of Moisture Content and Ash Value

Approximately, 2 grams of gum powder was weighed into a pre-weighed moisture dish and dried in a hot air oven at 105 °C for 4 hours or until constant weight. The difference in weight was used to calculate the moisture content. For ash content, the dried gum sample was incinerated in a muffle furnace at 550 °C for 6 hours. The remaining inorganic residue was weighed, and total ash was calculated as a percentage of the original dry mass [12].

2.3.2. Solubility and Water Absorption Index

To evaluate solubility, 1 gram of gum powder was mixed in 100 mL of distilled water at 25 °C. The dispersion was stirred for 30 minutes and then centrifuged at 3000 rpm for 10 minutes. The supernatant was evaporated, and the residue was weighed to estimate solubility. The water absorption index (WAI) was assessed by hydrating 1 gram of gum in a graduated cylinder containing 50 mL water, left undisturbed for 24 hours, and the volume increase was recorded [13].

2.3.3. Particle Size Distribution

The gum powder's particle size was determined using a laser diffraction particle analyser. Samples were dispersed in distilled water and subjected to ultrasonication to avoid agglomeration. The measurement was done in triplicate, and data was recorded in terms of mean particle diameter (D50) [14].

2.4. Rheological and Flow Behaviour Analysis

Gum dispersions were prepared at 1%, 2%, and 3% concentrations (w/v) in distilled water. Each sample was subjected to shear analysis using a Brookfield digital viscometer at 25 °C. Viscosity readings were recorded at rotational speeds ranging from 10 to 100 rpm. Flow curves were plotted, and the type of flow behaviour—Newtonian or non-Newtonian—was determined based on shear rate vs. viscosity trends [15].

2.5. Functional Property Assessment

2.5.1. Water-Holding and Oil-Holding Capacities

1 gram of Cordia gum powder was mixed separately with 10 mL of distilled water and refined sunflower oil. Each mixture was vortexed and allowed to stand for 30 minutes at room temperature before centrifugation at 3000 rpm for 20 minutes. The supernatant was discarded, and the retained water or oil was weighed. WHC and OHC were expressed as grams of water or oil held per gram of gum [11].

2.5.2. Emulsification Properties

To evaluate emulsifying activity, 2% gum solution was homogenized with sunflower oil in a 1:1 ratio using a high-speed homogenizer at 10,000 rpm for 2 minutes. The emulsion was transferred to a graduated cylinder and the initial height of the emulsified layer was recorded. After standing for 30 minutes, the emulsion stability was assessed by noting any separation and calculating the Emulsion Stability Index (ESI) [9].

2.5.3. Foaming Capacity and Stability

For foaming analysis, 50 mL of a 1% gum solution was whipped in a blender for 3 minutes. The total volume including foam was recorded immediately (foam capacity) and after 30 minutes (foam stability). Foam retention was expressed as a percentage of the initial foam volume.

2.6. Application Trials in Functional Food Development

2.6.1. Ginger-Garlic Paste Stabilization

Cordia gum was incorporated at varying concentrations (0.25%, 0.5%, and 1.0%) into freshly prepared ginger-garlic paste. Samples were stored at refrigerated conditions, and parameters such as syneresis, color, and microbial stability were evaluated periodically over 30 days.

2.6.2. Fruit-Based Functional Beverages

Natural flavoured beverages were formulated using Cordia gum as a viscosity enhancer at 0.2% and 0.4%. Mouthfeel, turbidity stability, and sedimentation rate were compared against control formulations containing no hydrocolloids and those with xanthan gum.

2.6.3. Nutritional Supplements for Lactating Mothers

A protein-carbohydrate fortified formulation was developed incorporating Cordia gum to improve palatability and texture. Sensory and physicochemical evaluations were carried out for viscosity, dispersion stability, and ease of consumption.

2.7. Statistical Analysis

All experimental trials were performed in triplicate. Results were expressed as mean \pm standard deviation. One-way Analysis of Variance (ANOVA) was conducted to identify significant differences among formulations, and Tukey's HSD test was applied for multiple comparisons ($p < 0.05$). Data processing was carried out using IBM SPSS Statistics software version 25.0 [10].

3. RESULTS AND DISCUSSION

3.1. Extraction Yield and Visual Characteristics

The average extraction yield of Cordia gum was found to be $8.46 \pm 0.42\%$ (w/w) based on the fresh weight of the fruit. The gum appeared as a translucent, light brown mass upon drying and grinding. These findings align with previous studies on mucilage-producing fruits, such as *Sterculia urens* and *Tamarindus indica*, which produce gum in the range of 6–10% under similar extraction protocols [6].

3.2. Physicochemical Properties of Cordia Gum

Table 1. Physicochemical characterization of Cordia gum

Parameter	Value (Mean ± SD)
MOISTURE CONTENT (%)	11.23 ± 0.33
TOTAL ASH (%)	3.89 ± 0.16
SOLUBILITY IN WATER (%)	87.65 ± 1.44
SWELLING INDEX (ML/G)	7.21 ± 0.18
MEAN PARTICLE SIZE (µM)	56.4 ± 2.6

Cordia gum exhibited high water solubility and a significant swelling index, indicating its potential to retain water and form viscous systems. The ash content was within permissible limits for food-grade gums, confirming its purity and low mineral residue. Similar hydration capacities were reported by [14] for natural gums used in beverage stabilization.

3.3. Rheological Properties

Cordia gum dispersions exhibited pseudoplastic (shear-thinning) behaviour, as viscosity decreased with increasing shear rate. At 3% concentration, the apparent viscosity at 20 rpm was 2400 ± 50 cP, reducing to 1480 ± 35 cP at 100 rpm. This property makes it suitable for shear-sensitive food applications such as sauces and gravies. This shear-thinning nature is typical of galactomannan and uronic-acid-rich hydrocolloids [15], indicating strong intermolecular interactions at low shear and breakdown under mechanical force—beneficial for both processing and sensory appeal.

3.4. Functional Properties

Table 2. Functional property evaluation of Cordia gum

Functional Property	Value (Mean ± SD)
WATER HOLDING CAPACITY (G/G)	4.32 ± 0.19
OIL HOLDING CAPACITY (G/G)	2.96 ± 0.11
EMULSION ACTIVITY INDEX (%)	62.5 ± 1.2
EMULSION STABILITY (%)	87.4 ± 1.6
FOAM CAPACITY (%)	28.7 ± 1.5
FOAM STABILITY (30 MIN) (%)	12.3 ± 0.9

Cordia gum demonstrated excellent emulsifying and stabilizing properties, which were significantly higher than some commercial gums in the same category [13]. The high water-holding capacity

makes it suitable for moisture retention in baked and processed foods. However, the foam capacity and stability were moderate, suggesting limited use in aerated products.

3.5. Application in Functional Food Prototypes

3.5.1. Ginger-Garlic Paste

Cordia gum (0.5%) effectively stabilized ginger-garlic paste by reducing syneresis by 70% compared to the control. No phase separation or discoloration was observed after 30 days under refrigeration. The consistency was comparable to xanthan-based formulations, suggesting its suitability for semi-solid condiments.

3.5.2. Fruit-Based Beverages

Cordia gum at 0.2% improved viscosity and significantly reduced sedimentation rate in mango and lime-based beverages over 14 days. The gum provided a pleasant mouthfeel and prevented separation without altering flavor.

Table 3. Stability comparison of fruit beverage formulations

Formulation	Sedimentation (%) after 14 days
CONTROL (NO GUM)	18.3 ± 1.1
XANTHAN GUM(0.2%)	5.6 ± 0.9
CORDIA GUM (0.2%)	6.4 ± 0.7

3.5.3. Nutritional Supplement for Lactating Mothers

Cordia gum (0.5%) improved the consistency and dispersibility of nutrient powders reconstituted in milk or water. Sensory evaluation revealed acceptable scores for appearance (8.1/10), mouthfeel (8.3/10), and overall acceptability (8.0/10). The gum showed good compatibility with proteins and minerals.

The functional profile of Cordia gum is comparable to existing food-grade hydrocolloids, including locust bean gum and guar gum, especially in emulsification and hydration. Its shear-thinning property and water-binding ability make it suitable for sauces, beverages, and herbal formulations. Moreover, as a plant-derived, clean-label ingredient, Cordia gum aligns with industry demands for natural additives.

The successful application in three different product formats highlights its versatility and commercial potential, especially for manufacturers aiming to eliminate synthetic stabilizers. These results substantiate previous assumptions of the bio-functional capacity of Cordia fruit mucilage [4][11].

4. CONCLUSION

The present study provides a comprehensive evaluation of *Cordia dichotoma* gum as a promising natural hydrocolloid with functional, physicochemical, and industrial relevance in food product development. The gum, extracted through an eco-friendly aqueous method, demonstrated favorable characteristics including high solubility, notable water-holding capacity, and desirable rheological behaviour, particularly its pseudoplastic flow under shear. These attributes are critical for the development of texturally stable and appealing food products.

Functionally, *Cordia* gum exhibited significant emulsifying and stabilizing properties, comparable to conventional additives like xanthan and guar gum. Its moderate foaming capacity, strong water-binding ability, and oil absorption potential further suggest its multipurpose application across diverse food matrices.

Incorporation of *Cordia* gum into prototype formulations such as ginger-garlic paste, fruit-based beverages, and nutritional supplements showcased its effectiveness in enhancing stability, improving texture, and extending product shelf life without compromising sensory quality. These applications reinforce its feasibility as a clean-label alternative to synthetic stabilizers and emulsifiers.

Moreover, as an underutilized plant resource, the valorization of *Cordia* gum aligns with sustainable food system goals. Its integration into functional foods not only supports innovation but also offers economic and environmental benefits by promoting biodiversity and reducing reliance on chemically modified additives.

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