



RESEARCHPAPER

Jaggery and Coconut Sugar as Alternative Sweeteners: A Review

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Abstract

Growing consumer demand for traditional and minimally processed sweeteners has brought sugarcane jaggery and coconut sugar back into the spotlight. Coconut sugar is made by concentrating sap extracted from the inflorescence of the coconut palm (*Cocos nucifera* L.), while jaggery is made by concentrating clear sugarcane juice. These products may retain different amounts of minerals, phenolic compounds, and other non-sugar components compared to refined sucrose. However, easily accessible carbohydrates, especially sucrose, continue to be their main source of sustenance. This narrative overview compares their production methods, chemical makeup, nutritional qualities, bioactive components, potential health effects, food applications, and quality and safety concerns. According to the literature currently available, both sweeteners have unique sensory qualities and could be used in both conventional and value-added meals. However, broad health claims are complicated by compositional diversity, little clinical evidence, processing-related risks, and uneven quality control. Clinical benefit should not be inferred from natural origin or quantifiable antioxidant activity. Both products should be evaluated in relation to the overall amount of sugar consumed in the diet, as neither is sugar-free. To determine their relative nutritional relevance, more study utilizing standardized analytical techniques, controlled glycemic-response tests, pollutant monitoring, and carefully planned human trials is required.

KEYWORDS:

Coconut sugar, jaggery, natural sweeteners, nutritional composition, phenolic compounds, food processing, quality assurance

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Introduction

Sugars significantly influence food formulation by providing sweetness, flavour, colour enhancement, texture, moisture retention, and additional technological characteristics. Processed sucrose is commonly employed in beverages, bakery items, confections, and dairy treats owing to its uniform quality and useful attributes. Nevertheless, the growing consumer enthusiasm for

traditional cuisine, natural ingredients, and minimally processed goods has prompted the examination of other sweeteners, notably jaggery and coconut sugar. Known as *gur* in India, jaggery is a traditional non-centrifugal sweetener predominantly made from the juice of sugarcane (*Saccharum officinarum* L.). The creation process usually entails extracting juice, filtering,

clarifying where needed, and concentrating through heating, followed by cooling and forming or granulating. Unlike the process of refining sugar, jaggery is usually made without the total crystallisation of sucrose and the extraction of molasses through centrifugation. Thus, it could preserve varying levels of minerals, reducing sugars, organic acids, pigments, and other elements. The unique brown colouration and caramel-like flavour are formed during heat processing. Jaffé (2015) analysed the nutritional and functional elements of non-centrifugal cane sugar, while Sharifi-Rad et al. (2023) investigated the composition and potential biological properties of jaggery and associated traditional sweeteners.

Coconut sugar is obtained by condensing the sap gathered from the blossoms of the coconut palm (*Cocos nucifera* L.). The variety of palm, environmental factors, sap collection and processing, microbial fermentation, and concentration temperature all impact its composition and quality. Due to its vulnerability to fermentation, fresh coconut sap requires sanitary collection and suitable processing to ensure the quality and safety of the product. Coconut sugar features a unique caramel-like taste and a brown colouration, and it may be found in the market in solid and granular forms. Saraiva et al. (2023) analysed its chemical composition, nutritional features, health claims, safety considerations, and prospective applications in food products.

Jaggery and coconut sugar are rich in carbs and serve as energy sources. Despite potentially including trace elements of minerals and other natural chemicals, their composition differs markedly depending on the raw materials and processing circumstances. Thus, their prospective nutritional merits ought to be examined against refined sucrose using trustworthy analytical and clinical evidence. Notably, statements of reduced glycaemic reactions or better health outcomes demand more empirical validation.

These sweeteners provide avenues for the development of classic and cutting-edge food products, encompassing beverages, baked items, confections, cereal preparations, and dairy desserts. However, discrepancies in colour, flavour, moisture content, and sugar composition might impact processing behaviour, sensory preference, and

shelf stability. Thus, the current analysis contrasts jaggery and coconut sugar in relation to their manufacturing processes, chemical and nutritional characteristics, health consequences, safety, and food uses, while highlighting research voids for quality standards and evidence-driven product advancement.

2. Review Methodology

This article employs a narrative literature review methodology. Relevant literature was sourced from scientific databases and journal websites utilizing keywords such as “sugarcane jaggery,” “non-centrifugal cane sugar,” “coconut sugar,” “coconut palm sap,” “nutritional composition,” “phenolic compounds,” “antioxidant activity,” “glycemic response,” “food applications,” and “food safety.” Emphasis was placed on peer-reviewed articles and studies focusing on processing, composition, functionality, and safety. The findings were qualitatively synthesized due to variations in raw materials, analytical techniques, and product categories. This draft does not constitute a systematic review, as a reproducible database search, established eligibility criteria, and formal screening processes have not been conducted.

3. Production and Processing Technologies

3.1. Sugarcane jaggery

Jaggery production generally involves selection and cleaning of mature sugarcane, mechanical juice extraction, filtration, clarification, thermal concentration, endpoint determination, cooling and moulding. Depending on the product, the concentrated mass may be formed into solid blocks or further processed into granules or powder. Traditional open-pan heating remains common, while improved clarification, controlled heating and moisture management can help improve consistency. Heating conditions affect colour, flavour, moisture, sugar composition and the formation of thermal reaction products. The quality of the incoming cane, juice acidity, clarification agents, equipment hygiene and packaging also contribute to the final product. Consequently, values reported for one jaggery sample should not be generalized to all products (Jaffé, 2015; Sharifi-Rad et al., 2023).

3.2. Coconut sugar

Coconut sugar is derived from the sap obtained from coconut blossoms. Common activities involve sap harvesting, filtering, fermentation management, concentration by heating, solidification or crystallization, drying when necessary, and moisture-proof packaging. The sap's fermentable carbohydrates mean that delays or improper temperature management while handling might affect acidity, taste, and processing efficiency. Thus, the upkeep of collection cleanliness and swift processing are vital for product consistency (Saraiva et al., 2023).

3.3. Key processing differences

Jaggery is derived by the extraction of sugarcane juice, while coconut sugar is produced from harvested palm sap. Both are intensified through heat and can acquire a brown hue and caramel-like flavours; nevertheless, their ultimate attributes are influenced by the composition of the raw materials and the processing methods employed. The botanical source by itself cannot determine nutritional superiority, safety, or ecological benefit.

4. Chemical and Nutritional Composition

4.1. Carbohydrates

Carbohydrates are the chief constituents of both sweeteners. Sucrose is predominantly the primary sugar, with fluctuating quantities of glucose and fructose. In jaggery, the ratios are determined by the original juice's composition, acidity, and processing conditions, which may involve sucrose inversion. In coconut sugar, the sugar profile is similarly affected by sap composition, fermentation, and heating. These distinctions can impact sweetness, hygroscopicity, crystallization, browning, and compatibility with certain foods. Both products are concentrated sources of dietary sugars, and their utilization does not eliminate the requirement to regulate total sugar consumption.

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sweeteners. Sucrose is predominantly the primary sugar, with fluctuating quantities of glucose and fructose. In jaggery, the ratios are determined by the original juice's composition, acidity, and processing conditions, which may involve sucrose inversion. In coconut sugar, the sugar profile is similarly affected by sap composition, fermentation, and heating. These distinctions can impact sweetness, hygroscopicity, crystallization, browning, and compatibility with certain foods. Both products are concentrated sources of dietary sugars, and their utilization does not eliminate the requirement to regulate total sugar consumption.

4.3. Phenolic compounds and antioxidant activity

Jaggery has the ability to retain phenolic chemicals and other elements derived from sugarcane juice. Various studies demonstrate antioxidant properties in experimental assays, although findings are influenced by the content of the samples and the methods of analysis utilized (Sharifi-Rad et al., 2023). Coconut sugar could potentially have non-sugar elements; however, the concentrations and biological importance need to be evaluated on a product-specific basis. Heat processing can change these chemicals and generate colorful reaction products.

The existence of chemical antioxidant properties does not demonstrate that a sweetener averts chronic illness. Such tests fail to evaluate absorption, metabolism, effective nutritional intake, or clinical consequences in humans.

4.4. Moisture, ash and physicochemical characteristics

Humidity, ash content, pH level, sucrose concentration, reducing sugars, hue, and solubility serve as valuable quality indicators. Humidity affects texture, adhesiveness, and preservation longevity. Ash assesses the overall inorganic residue but fails to specify particular minerals or their bioavailability. Thermal conditions influence hue and taste; overexposure to heat may result in charred or too dark flavors, whereas inadequate concentration might yield undesirable moisture and consistency.

Table 1. Qualitative comparison of sugarcane jaggery and coconut sugar

Parameter	Sugarcane jaggery	Coconut sugar
Botanical source	Sugarcane (Saccharum spp.)	Coconut palm (Cocos nucifera L.)
Raw material	Extracted sugarcane juice	Sap from coconut inflorescences
Main carbohydrate	Usually sucrose; variable reducing sugars	Usually sucrose; variable glucose and fructose
Main processing	Extraction, filtration/clarification and concentration	Sap collection, filtration and concentration
Sensory properties	Brown colour; caramel/molasses-like notes	Golden-brown to dark brown; characteristic caramel-like notes
Non-sugar constituents	Variable minerals, phenolics and other compounds	Variable minerals, phenolics and other compounds
Quality concerns	Moisture, adulteration, contaminants and process variability	Sap fermentation, moisture, authenticity and contaminants
Applications	Traditional sweets, beverages, confectionery, bakery and dairy foods	Beverages, desserts, bakery, confectionery and specialty foods
Nutritional limitation	High sugar content; composition varies	High sugar content; composition varies

Note: This is a qualitative comparison, not a standardized compositional analysis. Numerical comparisons should be made only when original studies and analytical bases have been verified

5. Potential Health Implications

5.1. Antioxidant potential

The antioxidant capabilities of jaggery have been examined in various reviews, with certain activities linked to phenolic compounds and other elements preserved during its processing. The extent differs across products and techniques (Sharifi-Rad et al., 2023). Coconut sugar has also attracted interest because of its non-sugar constituents, but the presence of antioxidant compounds does not prove a clinically meaningful effect from normal dietary consumption. Research should distinguish chemical antioxidant capacity from bio accessibility, absorption, and health outcomes.

5.2. Glycemic response and metabolic health.

The glycemic reaction elicited by a sweetener is contingent upon the quantity taken, the composition of carbohydrates, the concomitant foods, and individual physiological characteristics. Claims made in marketing about coconut sugar being a low-glycemic option demand thorough analysis, given that the figures presented may fluctuate according to the product and the study design. A

product with a consistently reduced glycaemic index is not always sugar-free or fit for unrestricted consumption. One should not take for granted that jaggery has a clinically relevant glycemic advantage over refined sugar. Systematic human research is required for valid comparisons.

5.3. Weight management and dental health

Both sweeteners supply energy chiefly through carbs. Utilising either substance in place of refined sugar, without lowering overall sugar levels, is not expected to offer meaningful weight management benefits. Their inherent origin does not diminish the likelihood of dental caries connected to frequent intake of fermentable sugars. The aggregate intake, consumption rates, dietary framework, and oral hygiene persist in being vital.

5.4. Traditional use and clinical evidence

Jaggery has a long history in traditional foods and preparations, but traditional use alone cannot establish therapeutic efficacy. Claims that either sweetener treats anaemia, diabetes, obesity or other diseases require

appropriate clinical evidence. At present, both are best considered culinary sweeteners rather than established therapeutic ingredients.

6. Food Applications and Technological Functionality

6.1. Traditional and contemporary foods

Jaggery is used in traditional sweets, cereal preparations, beverages, confectionery and dairy desserts, including chikki, laddoo, kheer and payasam. Coconut sugar is used in beverages, bakery products, desserts and confectionery where its flavour is desired. Both can support product diversification, but substitution for refined sugar may require adjustments to formulation and processing.

6.2. Bakery and confectionery

Sugar affects sweetness, browning, moisture retention, spread and texture in bakery products. Jaggery and coconut sugar may alter these attributes because of differences in moisture, reducing sugars, particle size and composition. Thermal reactions can contribute desirable colour and flavour, but excessive heating may produce undesirable sensory changes or unwanted compounds. Product trials should evaluate replacement level, moisture, colour, texture, sensory acceptability and storage stability.

6.3. Dairy products and traditional desserts

Both sweeteners can be investigated in flavoured milk, khoa-based sweets, milk puddings, ice cream and ready-to-prepare dessert mixes. Jaggery may impart darker colour and caramel-like notes, while coconut sugar contributes its own flavour profile. Depending on the formulation, acidity and mineral constituents may influence protein stability or appearance. Trials should measure heat stability, colour, texture, microbiological quality and sensory acceptance.

6.4. Product optimization

Studies focused on product development should quantify sweetness intensity, overall acceptability, moisture, water activity, colour, texture, solubility, reconstitution, total and individual sugars, mineral composition, microbiological quality, applicable pollutants, and

manufacturing costs. The application of mixture-design approaches and response-surface methodology may facilitate the **optimization** of formulations using these sweeteners in conjunction with milk solids, cereals, fruits, or various other constituents.

7. Quality Assurance, Safety and Regulatory Considerations

7.1. Raw materials and processing

The caliber of jaggery is influenced by the condition of the cane, the efficiency of juice extraction, the clarification techniques employed, the heating process, cleanliness standards, and the packaging methods. The caliber of coconut sugar is further determined by the processes of sap harvesting and the management of fermentation. Established operational guidelines, clean equipment, monitored processing, and fitting packaging help bolster uniformity.

7.2. Authenticity and adulteration.

Impurity and misleading labelling may diminish consumer assurance. Authentication ought to factor in the plant origin, specified content, and pertinent regulatory obligations. Authenticity testing may be bolstered by sugar profiling, mineral analysis, spectroscopy, and other **recognized** signs, although these procedures must be confirmed across different goods.

7.3. Contaminants and processing hazards

Likely risks involve environmental toxins, heavy metals, farming residues, microbiological contamination, and agents introduced via inadequate processing or storage. Risk analysis ought to be based on assessed concentrations, pertinent food-safety standards, and realistic dietary intake. Manufacturers must employ adequate materials for food contact, ensure cleanliness in operations, and adopt effective packaging and storage measures (Saraiva et al., 2023).

8. Sustainability and Economic Considerations

Jaggery manufacturing can increase the value of sugarcane and aid in small-scale processing. Augmented heating efficiency, clarity, minimized product losses, and

proper packaging could enhance resource efficiency. The production of coconut sugar could augment the economic benefits of coconut agriculture, although the activities involved in sap extraction, conveyance, and evaporation are often laborious and energy-consuming. Assessing environmental impacts demands a life-cycle analysis based on a clearly defined functional unit, such as one kilogram of final sweetener or an equivalent sweetness level in a particular product. The inclusion of water, energy, emissions, land use, packaging, and by-product management is essential. Neither item ought to be seen as ecologically preferable simply because it is conventional or produced from plants.

Identified Research Deficiencies and Prospective Directions

9.1. Uniform formulation

Comparative studies should evaluate moisture, ash, various sugars, minerals, and specific phenolic compounds using established procedures and clearly defined analytical principles.

9.2. Blood sugar reaction

Meticulously structured human research ought to evaluate postprandial reactions with suitable controls, uniform carbohydrate quantities, and clear participant data.

9.3. Availability in biological systems and health implications

Investigations should examine digestion, bioaccessibility, bioavailability, and pertinent physiological effects before to asserting health claims.

9.4. Enhancement of processing efficiency

Energy-efficient focus, enhanced clarity, sap stabilization, moisture control, and packing could enhance quality and longevity.

9.5. Advancement of food products

Investigations into substitutions in dairy desserts, baked goods, cereal items, and instant mixes ought to evaluate sensory approval, texture, hue, stability, and cost.

9.6. Security and veracity

Surveillance research ought to investigate potentially hazardous substances, adulteration, pollutants linked to processing, and microbiological standards across various locations.

9.7. Environmental Sustainability

Life-cycle assessment and techno-economic evaluation must investigate the environmental and financial compromises in manufacturing, processing, distribution, and storage.

10. Conclusion

Traditional sweeteners such as sugarcane jaggery and coconut sugar have diverse source ingredients, production processes, sensory qualities, and prospects for value-added food uses. Both may hold varying levels of minerals, phenolic compounds, and other non-sugar components that differentiate them compositionally from highly processed sucrose. Still, their main nutritional input is sugar, and the existence of possibly helpful substances should not be taken as confirmation of improved health results. Statements on reduced glycemic response, illness prevention, or treatment efficacy demand more substantial proof. Viewed through the lens of food technology, both sweeteners hold possibilities in traditional cuisine, dairy desserts, baked items, and unique formulations. Consistent processing, verified quality management, proper packaging, and contaminant oversight are crucial for fulfilling this promise. Subsequent study should focus on direct comparative examinations, controlled human trials, analytical standardization, and assessments of life cycles.

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