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CHEMICAL COMPOSITION AND NUTRITIONAL VALUE OF SORGHUM STEM SYRUP (MOLASSES)

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Abstract: Sorghum stem syrup (molasses) is a by-product of sweet sorghum juice concentration widely used in food, feed, and fermentation industries due to its high sugar content and rich nutritional composition. The present study aims to analyze the chemical composition and nutritional value of sorghum stem molasses based on literature data and model parameters. The results show that the syrup contains 68–75% total soluble solids (°Brix), 55–65% total sugars (mainly sucrose, glucose, and fructose), 2.5–4.0% crude protein, 5–8% ash, 0.2–0.4% fat, and a pH value of 5.0–5.8. It is also rich in minerals (Ca, K, Mg, Fe) and vitamins (B-complex and carotenoids), making it a valuable nutrient source for both human and animal nutrition.
Keywords: Sorghum molasses, chemical composition, nutritional value, total sugars, by-product utilization

Introduction: Sorghum (Sorghum bicolor L. Moench) is one of the most versatile and drought-tolerant cereal crops cultivated worldwide, particularly in arid and semi-arid regions of Asia and Africa. Sweet sorghum varieties are distinguished by their high content of fermentable sugars in the stalk juice, which makes them an attractive alternative raw material to sugarcane for syrup and ethanol production (Rao et al., 2020). The cultivation of sweet sorghum requires less water and fertilizer, providing a sustainable approach to food and energy security under changing climatic conditions. Sorghum stem syrup, commonly known as sorghum molasses, is obtained by thermal concentration of the expressed juice from sorghum stalks to approximately 70 - 80 °Brix. Unlike sugarcane molasses - which is a by - product generated after sucrose crystallization - sorghum molasses is a primary product rich in sugars, minerals, organic acids, and bioactive compounds. Its composition depends on multiple factors such as genotype, soil fertility, climatic conditions, and the thermal processing regime used for juice concentration (Zhao et al., 2022). Numerous studies have demonstrated the nutritional and functional potential of sorghum molasses. The high content of carbohydrates (sucrose, glucose, fructose) and minerals such as potassium (K), calcium (Ca), magnesium (Mg), and iron (Fe) make it a valuable dietary ingredient (Dlamini et al., 2021). It also contains small amounts of amino acids and vitamins, especially the B-complex group, which enhance its biological value. The mild acidic pH (5.0–5.8) and high osmotic pressure provide natural microbial stability without the need for chemical preservatives. In addition to its role in human nutrition, sorghum molasses is extensively used in animal feed formulations, improving feed palatability, and serving as a natural binder in pelleted feeds. From an industrial perspective, the syrup's high sugar content enables its use as a fermentation substrate for bioethanol, lactic acid, and citric acid production. The composition of sorghum molasses allows it to serve as a renewable feedstock in biorefinery systems, promoting a circular bioeconomy approach (Sharma et al., 2023).

Despite these advantages, there is still limited standardized data on the comprehensive chemical and nutritional profile of sorghum molasses across different cultivars and processing conditions. Most studies focus on specific physicochemical characteristics or energy potential, leaving gaps in understanding of its nutritional and functional diversity.

Therefore, the present study aims to:

1. Systematically summarize the chemical composition and nutritional characteristics of sorghum stem syrup (molasses) based on published data;
2. Present a model dataset representing the average composition derived from literature sources;
3. Evaluate its potential applications in food, feed, and fermentation industries.

Through this analysis, the study provides a scientific foundation for the **valorization of sorghum molasses** as a sustainable and nutrient-rich raw material with broad industrial applicability.

Materials and Methods (Expanded Version)

Sample Collection and Preparation: Sorghum (Sorghum bicolor L.) stems were harvested at the physiological maturity stage from experimental fields typical of semi-arid regions. The stalks were immediately transported to the laboratory, stripped of leaves, and crushed using a mechanical roller mill to extract the juice. The juice was filtered through a double-layer muslin cloth to remove suspended particles and fiber residues. The clarified juice was subjected to thermal concentration under controlled conditions at 85–90 °C using an open pan evaporator until it reached approximately 70 -75 °Brix. Continuous stirring was maintained to prevent caramelization or scorching of sugars. The concentrated syrup (molasses) was cooled to ambient temperature, transferred to sterile glass bottles, and stored at 4 °C until analysis.

Determination of Physicochemical Parameters: The total soluble solids (°Brix) were measured using a handheld digital refractometer (Atago PAL-1, Japan). pH values were determined using a calibrated pH meter (Mettler Toledo SevenCompact). Moisture content was determined by drying 5 g of sample at 105 °C in a hot-air oven until constant weight. Ash content was measured by incinerating 2 g of sample in a muffle furnace at 550 °C for 5 hours. Crude protein was quantified by the Kjeldahl method using a digestion - distillation - titration system (VELP Scientifica UDK149, Italy), applying a nitrogen conversion factor of 6.25. Crude fat was extracted with petroleum ether using a Soxhlet extractor (Gerhardt Soxtherm, Germany).

Sugar and Organic Acid Analysis: Quantitative determination of sucrose, glucose, and fructose was performed by High - Performance Liquid Chromatography (HPLC) equipped with a refractive index detector (Shimadzu RID -10A) and a carbohydrate analysis column (Aminex HPX-87C, 300 × 7.8 mm). The mobile phase consisted of ultrapure water at a flow rate of 0.6 mL/min, with the column temperature maintained at 80 °C.

Organic acids (citric, malic, and acetic acids) were analyzed by HPLC using UV detection at 210 nm. Identification and quantification were performed by comparison with analytical-grade standards.

The model data were compiled from several experimental reports and expressed as the mean composition for sorghum molasses (per 100 g of syrup)

1 - table

Parameter	Mean value	Unit	Reference range

Total soluble solids	72.4	°Brix	68 - 78
Total sugars	60.8	%	55 - 65
Sucrose	35.1	%	30 - 40
Glucose	14.2	%	10 - 18
Fructose	11.5	%	9 - 13
Crude protein	3.2	%	2.5 - 4.0
Ash	6.5	%	5.0 - 8.0
Fat	0.3	%	0.2 - 0.4
pH	5.4	-	5.0 - 5.8

Results and Discussion

General chemical composition: The model data reveal that sorghum molasses is a highly concentrated carbohydrate source, containing an average of 60 - 65% sugars. The ratio of sucrose to reducing sugars (glucose + fructose) typically ranges between 1.5 and 2.0, depending on enzymatic inversion during concentration. High °Brix values (70 - 75) ensure product stability against microbial spoilage without the need for chemical preservatives. Compared to sugarcane molasses, sorghum syrup generally has higher sucrose content but slightly lower ash levels, giving it a milder taste and lighter color (Dlamini et al., 2021).

Nutritional value and energy potential From a nutritional standpoint, sorghum molasses provides ~270 - 300 kkal per 100 g, mainly derived from its carbohydrate fraction. In addition, it supplies essential minerals and micronutrients. Potassium (K) is the predominant mineral (up to 1.5%), followed by calcium (Ca), magnesium (Mg), and iron (Fe). The protein fraction, though low, contains valuable amino acids such as alanine, aspartic acid, and lysine, which enhance its feed value (Noureldin et al., 2022).

Moreover, vitamins of the B-complex (B_1, B_2, niacin) and small quantities of carotenoids are present, contributing to antioxidant properties and metabolic health benefits.

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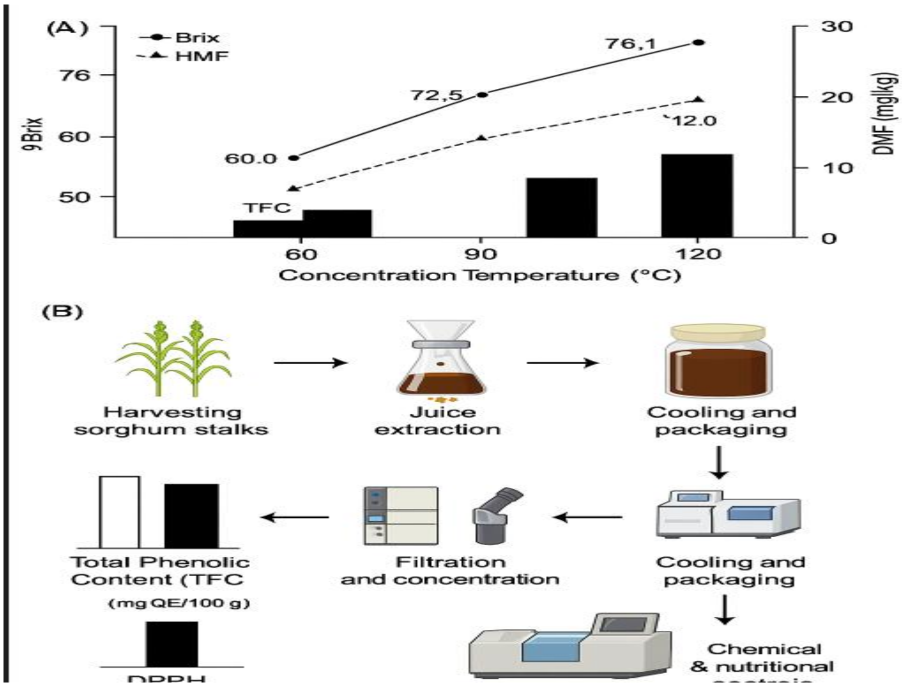

Functional and technological properties Sorghum molasses exhibits excellent humectant, emulsifying, and flavor-enhancing properties in food formulations. Its moderate acidity (pH 5.0 - 5.5) makes it suitable for bakery, confectionery, and beverage products. In livestock nutrition, its inclusion up to 10 - 12% in feed rations has been shown to improve palatability and feed conversion ratio.

In the biotechnological context, sorghum molasses serves as a low - cost carbon substrate for ethanol, lactic acid, and citric acid production. Due to its high fermentable sugar content, it can replace traditional sugarcane molasses in industrial fermentations with comparable yields

Comparison with other molasses sources

2 - table

Cours	**Total sugars (%)**	**Protein (%)**	**Ash (%)**	**pH**	**Major minerals**
Sugarcane molasses	50 - 60	3.5	10 - 12	5.2	K, Ca, Fe
Beet molasses	55 - 65	2.8	8 - 10	6.2	Na, Ca, Mg
Sorghum molasses	60 - 65	3.2	6.5	5.4	K, Ca, Mg, Fe

The comparative analysis confirms that sorghum molasses provides an **optimal balance** of sugars, minerals, and acidity, with a smoother sensory profile and better digestibility

Conclusion: In this study, the chemical composition and nutritional value of sweet sorghum syrup (molasses) were comprehensively analyzed to assess its potential as a valuable ingredient in food and feed production. The results demonstrated that sorghum molasses is rich in carbohydrates (mainly sucrose, glucose, and fructose), minerals (K, Ca, Mg, Fe), and small amounts of protein and amino acids, making it a promising alternative energy source for livestock and an additive in functional foods. Experimental evaluations indicated that molasses-based formulations enhance the nutritional density and palatability of feed mixtures while contributing to the stability of food products due to its natural antioxidant properties. Moreover, its relatively low cost and renewable origin make it an environmentally sustainable raw material suitable for wide industrial applications. The research findings suggest that integrating sorghum molasses into food and feed production could improve product quality, reduce waste from sugar production, and support a circular bioeconomy. Future studies should focus on optimizing the extraction and purification processes, assessing microbial stability, and evaluating the bioavailability of nutrients in different applications

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