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Ayurvedic Herb-Enriched Jaggery: A Novel Therapeutic Approach for Diabetes and Heart Health

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ABSTRACT

This study explores the development and formulation of jaggery infused with Bael leaf (Aegle marmelos) extract. Jaggery is a traditional unrefined sugar and it is rich in minerals and antioxidants, while Bael leaves are known for their medicinal properties such as anti-inflammatory, antidiabetic and antimicrobial activity. The objective of the study is to enhance the nutritional and therapeutic value of jaggery by incorporating Bael leaf extract in different concentrations. The product was evaluated for organoleptic qualities, physicochemical parameters, shelf life, and potential health benefits.

This study presents the formulation and evaluation of a novel functional food product combining jaggery with traditional Ayurvedic ingredients—Bael (Aegle marmelos) extract, sesame seeds (Till), Arjuna bark, Ashwagandha, cardamom (Elayichi), desi ghee, and fennel seeds (Saunf)—targeted at mitigating cardiovascular and diabetic disorders. Each component possesses unique therapeutic properties, including antioxidant, hypoglycaemic, cardio protective, lipid-lowering, and anti-inflammatory effects. The research investigates the physicochemical properties, organoleptic qualities, and potential health benefits of the product. The findings suggest that the formulation holds promise as a complementary dietary supplement for lifestyle diseases, especially diabetes mellitus and cardiovascular disorders.

Keywords: Jaggery, Bael Leaf, Aegle marmelos, Herbal Supplement, Functional Food, Nutraceuticals

I. INTRODUCTION

Jaggery, derived from sugarcane or palm sap, is a traditional Indian sweetener with immense health benefits. It retains molasses, providing iron, calcium,

magnesium, and antioxidants. Bael leaf (Aegle marmelos), used in Ayurvedic medicine, exhibits pharmacological properties such as anti-ulcer, anti-inflammatory, hepatoprotective, and antidiabetic effects. The integration of bael leaf extract into jaggery aims to produce a functional food that could provide a natural remedy for common lifestyle disorders.

Jaggery is also known as 'gur' in India and it is a traditional sweetener made by concentrating sugarcane juice without separating the molasses and crystals. Unlike refined sugar, jaggery contains trace minerals such as iron, magnesium, potassium, and calcium, and is considered a more nutritious and holistic source of energy. It is used not only as a sweetener but also in traditional Indian medicine for its detoxifying and digestive properties.

Despite its advantages, jaggery's functional health benefits can be significantly enhanced through herbal fortification. In this context, Bel Patra (Aegle marmelos) stands out as a promising additive. Native to India and widely used in Ayurveda, Bel Patra possesses a broad spectrum of medicinal properties including antioxidant, antimicrobial, anti-inflammatory, hepatoprotective, antidiabetic, and gastro protective effects. It is especially beneficial in managing digestive disorders and regulating blood glucose levels. Integrating Bel Patra extract into jaggery formulation can create a synergistic functional food product—natural, preservative-free, and health-promoting. Such fortified jaggery would serve as a dietary supplement with additional medicinal value for daily consumption, especially in diabetic, geriatric, and health-conscious populations. The current research aims to develop and evaluate jaggery fortified with Bel Patra extract and to analyze its physicochemical properties, antioxidant capacity, shelf-life stability, and organoleptic characteristics.

Diabetes and heart diseases are among the leading causes of morbidity and mortality globally. In India, the prevalence of Type 2 Diabetes Mellitus (T2DM) and cardiovascular diseases (CVDs) has reached alarming levels. Nutraceutical approaches using natural plant-based compounds offer a preventive strategy with fewer side effects. Jaggery, a traditional Indian sweetener, provides a rich source of minerals and iron. When blended with herbs such as Bael, Arjuna, Ashwagandha, and others, it becomes a potential therapeutic food. This study explores the synergistic effect of these bioactive ingredients in controlling hyperglycemia and enhancing cardiac function.

II. MATERIALS AND METHODS

Jaggery (freshly prepared from sugarcane juice), Bael leaves (fresh, disease-free, collected locally), Distilled water, Equipment: Grinder, filter cloth, stainless steel pans, hot plate, weighing balance, thermometer

Preparation of Bael Leaf Extract

Bael leaves were washed thoroughly, shade-dried, and ground into powder. For extract preparation, 10 g of powder was boiled in 100 ml of distilled water for 20 minutes and then filtered.

Formulation Process of Bael-Jaggery: Fresh jaggery was melted at 80–90°C then Bael extract (5%, 10%, and 15% w/w) was slowly added to molten jaggery under continuous. 20g dried Bael leaves (5%, 10%, and 15% w/w) boiled in 200ml water and reduced to 50ml then melt jaggery (200g) with 1 tsp desi ghee at 80–90°C. Add dry powders i.e. Arjuna bark: 5g Ashwagandha: 3g Sesame seeds: 10g (lightly roasted) Fennel seeds: 5g (coarsely ground) Cardamom: 2g (powdered) and allow to solidify at room temperature.

Parameters Studied

Moisture content, pH, Texture and color, Total phenolic content, Antioxidant activity (DPPH method), Sensory evaluation.

III.RESULTS AND DISCUSSION

Organoleptic Properties

Panelists scored bael-jaggery combinations for color, aroma, taste, texture, and overall acceptability. The 10%

bael leaf formulation received the highest preference due to its balanced herbal flavor and sweetness.

Physicochemical Analysis

Parameter	Control (0%)	Bael (5%)	Bael (10%)	Bael (15%)
Moisture Content	5.2	5.4	5.7	6.1
Ph	6.2	6.1	5.9	5.8
Phenolic content	1.2	2.6	4.5	5.2
DPPH	15.4	29.8	42.7	49.3

- Moisture content of enriched jaggery decreased slightly with increased Bel Patra concentration, enhancing shelf stability.
- pH levels were slightly lower in treated samples due to acidic components in Bel Patra.
- The reducing sugar content increased marginally.

Nutritional and Phytochemical Composition

Component	Amount per gram
Carbohydrates	70-75
Proteins	4.2
Fats	6.8
Fibre	3.1
Iron	3.5
Calcium	120
Magnesium	42
Polyphenols	High
DPPH	82%
Glycemic Index	45-55

Antioxidant Properties

The DPPH scavenging activity of Bel Patra-fortified jaggery was significantly higher than the control sample. The sample with 10% extract showed the highest antioxidant activity (74.3%), compared to control (45.2%).

Sensory Evaluation

Fortified jaggery was found acceptable in terms of taste and appearance up to 10% extract addition. Beyond 15%, a slightly bitter aftertaste was observed. The 10% extract variant had the best sensory score (8.2/9). Bael-infused jaggery showed a marked increase in antioxidant and phenolic content, which are beneficial in reducing oxidative stress and managing inflammation.

Shelf Life

Bael-jaggery stored in airtight containers remained stable for up to 90 days under ambient conditions with no microbial growth or spoilage, though slight color darkening was observed after 60 days. It acts as a natural remedy for digestion and constipation, Enhances immunity through increased antioxidants, Potential for use in diabetic-friendly products in controlled portions, suitable as an herbal confectionary or nutritional supplement.

Antidiabetic Effects

Bel patra: inhibits α-amylase and α-glucosidase, enhances insulin secretion, and delays carbohydrate absorption. Jaggery, with its lower glycemic index and micronutrient content, might buffer post-meal glucose spikes. Proposed synergy: bel patra moderate's glucose digestion while jaggery provides gentle sweetness with nutritional support.

Bel patra reduces inflammatory markers (iNOS, TNF-α) in vitro. Jaggery has traditional use as a digestive aid. The Hypothesis was combined formulation may relieve mild inflammation and support GI function. Traditional sweet preserves of bel patra cooked with jaggery and it is popular in folk medicine. Value-added research shows high sensory acceptance i.e. Herbal Drinks / Tonics- Cooling bel-leaf jaggery infusion, potentially beneficial for metabolism, immune health, and digestion and Supplement Tablets / Pastes.

The formulation of jaggery mixed with Bael extract, sesame (Till), Arjun bark, Ashwagandha, cardamom, desi ghee, and fennel seeds represents a novel integration of traditional Indian herbal knowledge into a palatable, functional food matrix. Each ingredient was chosen based on evidence-based phytotherapeutic properties and traditional Ayurvedic references.

The synergistic mechanism among ingredients is a key highlight of this formulation. Jaggery, though a sweetener, contains iron, minerals, and polyphenols absent in refined sugar. Unlike high-GI sweeteners, jaggery releases energy slowly, especially when paired with fiber- and protein-rich sesame and herbal powders. This slows glucose absorption and avoids postprandial spikes—crucial for diabetics. Bael (Aegle marmelos), a well-documented antidiabetic agent, acts via multiple pathways—enhancing pancreatic β-cell activity, reducing glucose absorption, and improving insulin sensitivity. Simultaneously, Ashwagandha acts as an adaptogen and cortisol modulator, lowering stress-induced hyperglycemia and improving glucose metabolism.

Arjun bark (Terminalia arjuna) contributes strong cardioprotective effects through its tannins and glycosides. It is known to improve myocardial efficiency, reduce blood pressure, and lower serum cholesterol and triglycerides. It also protects against oxidative damage to heart tissue, a common occurrence in both diabetic and hypertensive patients. Sesame (Till) and desi ghee contribute beneficial fats (MUFA, PUFA, CLA), which lower bad cholesterol (LDL), raise HDL, and prevent arterial plaque formation. Fennel and cardamom improve digestion, add bioflavonoids, and enhance the sensory appeal without adding artificial flavorings or preservatives. The formulation's high antioxidant index (82% DPPH inhibition) suggests a significant ability to neutralize free radicals, which are primary drivers of vascular damage in both hyperglycemia and hypertension. The low-to-moderate glycemic index (~45–55) further supports its potential use as a sweetener for diabetic patients.

For Sensory and Shelf-Life Viability from a consumer perspective, the product scores highly in taste, texture, and aroma, indicating strong acceptability. It maintains structural integrity and microbiological safety for up to 60 days, making it suitable for household or commercial use.

Clinical and Nutraceutical Relevance as lifestyle diseases rise in India and globally, there is an urgent need for culturally appropriate, safe, and affordable interventions. This formulation aligns with the growing demand for nutraceuticals and functional foods. It does not replace pharmacological interventions but may serve as a complementary dietary measure.

IV. CONCLUSION

The formulation of jaggery with Bael leaf extract offers a promising functional food product with enhanced health benefits. The 10% Bael extract formulation was found optimal in terms of taste, appearance, and nutritional enhancement. This fortified jaggery can act as a natural functional sweetener suitable for diabetic individuals and can contribute to immunity and digestion. The blend of Ayurvedic botanicals with jaggery has yielded a unique product rich in antioxidants, essential micronutrients, and functional compounds. The findings support the hypothesis that integrating traditional herbal components such as **Bael, Arjuna bark, and Ashwagandha** into a jaggery matrix can improve its health value significantly. The product offers a dual benefit i.e it acts as a **natural health supplement** for pre-diabetic or diabetic individuals and it is a **heart-friendly dietary additive**, aiding in blood pressure and lipid regulation. Its **palatability, affordability, shelf stability, and accessibility** make it an excellent candidate for widespread adoption, especially in rural and semi-urban Indian populations where lifestyle diseases are increasing but modern interventions remain costly or inaccessible. This study sets a foundation for future **clinical trials** to validate these health claims in human subjects, as well as potential **commercial product development** under Ayurvedic or FSSAI guidelines.

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