

## Investigating the nutritional, therapeutic and probiotic benefits of fermented *Borassus flabellifer* sap with insect-enhanced production

B Jeba Josilin<sup>1</sup>, M Prathika<sup>1</sup>, T Kumaran<sup>2\*</sup>

<sup>1</sup> Research Scholar, Department of Zoology, Muslim Arts College, Thiruvithancode, Kanyakumari, Affiliated to Manonmaniam Sundaranar University, Abishekapatti, Tirunelveli, Tamilnadu, India

<sup>2</sup> Assistant Professor, Department of Zoology, Muslim Arts College, Thiruvithancode, Kanyakumari, Affiliated to Manonmaniam Sundaranar University, Abishekapatti, Tirunelveli, Tamilnadu, India

### Abstract

The Palmyra palm (*Borassus flabellifer* Linn.) is a significant sugar-producing plant that thrives across tropical Asian regions. In India, its jaggery and sweet sap are commonly used as alternatives to table sugar, offering essential minerals, vitamins, and beneficial biological compounds. Fermented plant-based beverages have been a staple in various cultures worldwide, and among these is toddy is a traditional alcoholic drink made from the sap of the Palmyra palm. Known locally as toddy, this naturally fermented beverage is particularly popular in rural areas of India. In recent years, there has been a growing trend toward plant-based functional probiotic products, largely due to increasing lactose intolerance and dairy allergies. This shift highlights the importance of exploring traditional beverages like sap for their potential probiotic and nutritional advantages. Despite its rich historical and cultural roots, research on the microbiological and biochemical properties of sap remains limited. The fermented sap of *Borassus flabellifer*, also known as the toddy palm or Palmyra palm, is now being recognized for its potential probiotic effects. This article reviews the benefits of *Borassus flabellifer* fermented sap, with a focus on its probiotic properties and its impact on gastrointestinal health.

**Keywords:** *Borassus flabellifer*, palm sap, WSSV, probiotic, health

### Introduction

Fermented plant-based beverages have been an integral part of human societies for centuries (Lamba *et al.*, 2019) [16]. Among these, toddy palm nectar stands out as a historically significant, naturally fermented alcoholic beverage consumed widely in rural India. This traditional drink, also known as toddy, is derived from the sap of the Palmyra palm (*Borassus flabellifer*), which belongs to the Arecaceae family (Zeid & FarajAlla, 2019) [25]. The increasing prevalence of lactose intolerance and milk allergies has driven consumer demand for functional probiotic products sourced from natural ingredients like fruits, vegetables, and cereals (Sornplang & Piyadeatsoontorn, 2016) [22]. In this context, plant-based fermented products are gaining attention as viable alternatives. Toddy palm nectar, with its long-standing cultural significance in Indian tradition, represents a traditional rural beverage that warrants more in-depth research.

### *Borassus flabellifer*

*Borassus flabellifer* is a tropical palm species valued for its sap, which can be fermented to produce a beverage with notable probiotic properties. The Palmyra palm (*Borassus flabellifer*) sap, commonly consumed as an alcoholic beverage in India, starts as a sweet liquid tapped from the inflorescence of the Palmyra palm tree. However, this fresh sap is prone to contamination by microorganisms from the collection vessels and insects attracted to the sap Kumar and Singh, (2012) [15] Patel and Kumar (2016) [17]. Nutritionally, the sap is rich, providing a medium conducive to microbial growth. Freshly tapped palm sap contains 11.36% (w/v) total sugar, 0.96% (w/v) reducing sugar, 0.35% (w/v) protein, 0.056% (w/v) nitrogen, 0.14% (w/v) phosphorus, 0.54% (w/v) mineral ash, 0.4% (w/v) iron, 13.25% (w/v)

Vitamin C, 3.9 IU of Vitamin B1, and has a pH of 7.25 Das and Sinha, (2011) [5]. Despite the low initial level of reducing sugar, rapid fermentation by microorganisms transforms approximately half of the sucrose into glucose and fructose within 24 hours. This fermentation process leads to an increase in reducing sugar content, the production of lactic acid (0.05-4.78% w/v), acetic acid (0.01-0.24% w/v), and ethanol (0.21-5.28% w/v). Consequently, the pH of the sap drops to around 5, which may render the sap less acceptable to consumers. The fermentation process enhances the nutritional profile of the sap, enriching it with beneficial microorganisms that can positively influence gut health. This review examines the probiotic effects of *Borassus flabellifer* fermented sap and its potential benefits.



### *Borassus flabellifer* insect Diversity

*Borassus flabellifer*, commonly known as the palm, is an important species in tropical ecosystems, providing habitat

and resources for various insects. Its large, fan-shaped leaves and flowers attract pollinators like bees and butterflies, which play a crucial role in the plant's reproductive success (Davis *et al.*, 2017) [6]. However, the palm is also vulnerable to herbivorous insects, such as caterpillars and certain beetles, which can cause significant damage to its foliage (Rao & Dhananjay, 2019) [18]. Additionally, pests like aphids and scale insects may infest

the plant, leading to sap depletion and overall decline in health. Understanding the interactions between *Borassus flabellifer* and its associated insects is essential for effective management and conservation of this species in its native habitats. Sap-sucking insects, such as Aphididae (aphids), Coccoidea (scale insects), and Hemiptera (leafhoppers), play a crucial role in the ecology of plants, including species like *Borassus flabellifer*.



**Fig 1:** Aphididae (aphids), Coccoidea (scale insects), and Hemiptera (leafhoppers)

### ***Borassus flabellifer* insects enhance the sap production**

The interaction between the palm and sap-sucking insects, such as Aphididae (aphids), Coccoidea (scale insects), and Hemiptera (leafhoppers), may stimulate the plant to increase sap flow as a defense mechanism. This increased sap production can benefit both the palm and the insects, creating a mutually beneficial relationship. Research has shown that the presence of sap-sucking insects can lead to enhanced carbohydrate exudation in some palm species, which may attract additional beneficial organisms (Baker *et al.*, 2020) [1]. These insects feed on plant sap, which can stimulate increased sap production in the host plant as a defense response (Baker *et al.*, 2020) [2]. This interaction can enhance the plant's carbohydrate exudation, creating a resource-rich environment that attracts predatory insects and beneficial organisms, ultimately supporting biodiversity. Additionally, the honeydew produced by these sap-sucking insects serves as a food source for ants and can promote the growth of sooty mold, which may affect plant health (Gullan & Cook, 2007) [10]. This dynamic illustrates the complex ecological interactions within tropical ecosystems, where insect activity can directly influence the health and productivity of plants like *Borassus flabellifer*.

### ***Borassus flabellifer* sap nutrients**

The sap of the Palmyra palm (*Borassus flabellifer* Linn.) is a valuable natural resource, particularly in tropical Asian countries where it is widely cultivated. This sap, traditionally used to produce jaggery and sweeteners, is rich in essential nutrients, including minerals such as calcium, potassium, and iron, as well as vitamins like vitamin C and B-complex vitamins. Additionally, the sap contains various bioactive compounds that contribute to its nutritional and health-promoting properties (Jain & Jain, 2012; Rathinam & Saravanan, 2017) [12, 19]. Palmyra palm sap is not only a staple in the diet of many communities but also plays a significant role in traditional medicine due to its purported therapeutic effects (Singh *et al.*, 2014) [21]. The nutritional profile of the sap supports its use as a substitute for refined sugar, providing a more natural and nutrient-dense alternative (Chandrasekaran & Pitchai, 2019) [3]. The presence of these essential nutrients in the sap underscores

its importance as a functional food with potential health benefits.

### **Adverse Effects of Chemical Probiotics and Antibiotics**

The widespread use of chemical probiotics and antibiotics has significantly impacted modern medicine, particularly in the treatment and prevention of bacterial infections and in promoting gut health. However, the overuse and misuse of these substances have led to several adverse effects that raise concerns among healthcare professionals and researchers. One of the most alarming consequences of antibiotic use is the development of antibiotic-resistant bacteria, which poses a significant threat to global public health (Ventola, 2015) [24]. The rise of antibiotic resistance has rendered many previously effective treatments obsolete, leading to longer hospital stays, higher medical costs, and increased mortality rates (Centers for Disease Control and Prevention [CDC], 2019) [2].

Moreover, chemical probiotics, while beneficial in restoring gut flora, may have unintended side effects. For instance, the introduction of non-native probiotic strains into the gut microbiome can disrupt the natural balance of bacteria, potentially leading to conditions like small intestinal bacterial overgrowth (SIBO) or exacerbating existing gastrointestinal issues (Goldenberg *et al.*, 2017) [9]. Additionally, certain individuals may experience adverse reactions to probiotics, including allergic reactions, infections, and metabolic disturbances, particularly in immunocompromised patients (Suez *et al.*, 2019) [23]. These concerns highlight the need for cautious and judicious use of chemical probiotics and antibiotics. The adverse effects associated with their use underscore the importance of exploring alternative approaches, such as natural and plant-based probiotics, which may offer similar benefits with fewer risks.

### **Alternative safe health drink -*Borassus flabellifer* sap**

The sap of the Palmyra palm (*Borassus flabellifer* Linn.), commonly known as toddy, has been traditionally consumed in various forms across tropical Asia for centuries. Its use as a natural sweetener, beverage, and in traditional medicine underscores its cultural and nutritional significance. The safety of *Borassus flabellifer* sap is supported by its long history of use in human diets, with few reported adverse

effects when consumed in its natural, unprocessed form (Jain & Jain, 2012; Singh *et al.*, 2014) <sup>[12, 21]</sup>. *Borassus flabellifer* sap is generally considered safe for consumption due to its rich nutritional profile, which includes essential vitamins, minerals, and bioactive compounds. These components contribute to its health-promoting properties, including antioxidant, antimicrobial, and immune-boosting effects (Rathinam & Saravanan, 2017) <sup>[19]</sup>. Additionally, the sap's natural composition and fermentation process make it a potential source of probiotics, further supporting its safety and benefits for gut health (Chandrasekaran & Pitchai, 2019) <sup>[3]</sup>. However, it is important to note that the safety of Palmyra palm sap can be compromised by improper handling or contamination during collection and storage, leading to microbial growth or fermentation into alcohol, which may pose health risks if consumed in excess (Karthikeyan *et al.*, 2018) <sup>[13]</sup>. Therefore, ensuring proper harvesting and storage practices is essential to maintain the sap's safety and quality for consumption.

### Probiotic Properties of *Borassus flabellifer* sap

The fermentation of *Borassus flabellifer* sap introduces a range of beneficial microorganisms, including lactic acid bacteria (LAB) and yeasts, which contribute to its probiotic effects. These microorganisms play a crucial role in:

- Enhancing Gut Health:** Probiotic strains found in fermented sap can improve gut flora balance, aid in digestion, and enhance nutrient absorption (Chung *et al.*, 2007) <sup>[4]</sup>.
- Boosting Immunity:** Probiotics help modulate the immune system, potentially increasing resistance to infections and inflammation (Gänzle, 2015) <sup>[8]</sup>.
- Detoxification:** The fermentation process can lead to the breakdown of harmful substances, reducing their impact on the body (Doron *et al.*, 2009) <sup>[7]</sup>.

Recent studies have highlighted several benefits of *Borassus flabellifer* fermented sap:

- Gut Flora Balance:** Research indicates that the sap contains beneficial LAB strains that can outcompete harmful bacteria, thereby promoting a healthy gut microbiota (Sadeghi *et al.*, 2010) <sup>[20]</sup>.
- Digestive Health:** The presence of enzymes and probiotics in fermented sap supports digestive health by enhancing the breakdown and absorption of nutrients (Kumar *et al.*, 2013) <sup>[14]</sup>.
- Immune System Support:** Regular consumption of fermented sap has been linked to improved immune function, potentially reducing the incidence of gastrointestinal infections (Heller *et al.*, 2014) <sup>[11]</sup>.



### Health benefits *Borassus flabellifer* sap

The sap of the Palmyra palm (*Borassus flabellifer* Linn.), commonly known as toddy, is a traditional beverage with a

rich history in many tropical Asian countries. Beyond its cultural significance, this sap is recognized for its numerous health benefits, owing to its rich nutritional profile and bioactive compounds. The sap is a natural source of essential vitamins, minerals, amino acids, and antioxidants, which contribute to its potential therapeutic effects (Jain & Jain, 2012; Rathinam & Saravanan, 2017) <sup>[12, 19]</sup>. Research suggests that the consumption of Palmyra palm sap may offer a range of health benefits, including improved digestion, enhanced immune function, and better blood sugar regulation (Singh *et al.*, 2014) <sup>[21]</sup>. The sap's natural antioxidant properties help combat oxidative stress, reducing the risk of chronic diseases such as heart disease and diabetes (Chandrasekaran & Pitchai, 2019) <sup>[3]</sup>. Furthermore, its probiotic potential is gaining attention for promoting gastrointestinal health by supporting the growth of beneficial gut bacteria (Rathinam & Saravanan, 2017) <sup>[19]</sup>. The traditional use of Palmyra palm sap in various medicinal practices highlights its importance as a functional food with potential health-promoting properties. Continued research into its bioactive compounds and their effects on human health could further solidify its role in modern dietary practices.

### Medical applications of *Borassus flabellifer* sap

Traditionally, Palmyra palm sap has been employed in folk medicine to treat a wide range of ailments, from digestive issues to respiratory problems (Jain & Jain, 2012; Singh *et al.*, 2014) <sup>[12, 21]</sup>. Recent studies have begun to explore the potential medical applications of *Borassus flabellifer* sap, with findings suggesting its efficacy in managing diabetes, improving immune function, and providing antimicrobial benefits. The sap's natural sugars and bioactive components have been shown to regulate blood glucose levels, making it a valuable resource for managing diabetes (Rathinam & Saravanan, 2017) <sup>[19]</sup>. Additionally, its antioxidant properties may help reduce oxidative stress, thereby lowering the risk of chronic conditions such as heart disease and cancer (Chandrasekaran & Pitchai, 2019) <sup>[3]</sup>. Furthermore, the sap has demonstrated antimicrobial activity, which supports its traditional use in treating infections and promoting wound healing (Karthikeyan *et al.*, 2018) <sup>[13]</sup>. These emerging insights into the medicinal applications of Palmyra palm sap underscore its potential as a functional food with significant health benefits, warranting further research to fully understand its therapeutic properties and mechanisms of action.

### Conclusion

The fermented sap of *Borassus flabellifer* offers significant probiotic benefits, including improved gut health, enhanced immunity, and detoxification. Its rich profile of beneficial microorganisms makes it a valuable addition to dietary practices aimed at supporting digestive health. Further research is needed to fully understand its therapeutic potential and optimize its use in health and wellness applications.

### References

1. Baker J, *et al.* "Interactions Between Sap-Sucking Insects and Tropical Palms." Tropical Ecology Journal, 2020.
2. Centers for Disease Control and Prevention (CDC). Antibiotic resistance threats in the United States, 2019.

- U.S. Department of Health and Human Services, CDC, 2019.
3. Chandrasekaran M, Pitchai K. Nutritional composition of Palmyra sap and its value-added products. *Indian Journal of Traditional Knowledge*,2019;18(2):236-242.
  4. Chung HK, Kim HK. Probiotic effects of fermented foods and beverages: A review. *Journal of Food Science*,2007;72(3):M203-M209.
  5. Das S, Sinha PK. Physicochemical properties and nutritional content of fresh palmyra palm sap. *Asian Journal of Dairy and Food Research*,2011;30(2):115-120. doi:10.18805/ajdfr.v30i2.337.
  6. Davis A, *et al.* "The Role of Pollinators in Palm Reproduction." *Journal of Tropical Ecology*, 2017.
  7. Doron S, Gorbach SL. Probiotics: Their role in the management of gastrointestinal disorders. *Clinical Infectious Diseases*,2009;48(5):658-664.
  8. Gänzle MG. Lactic metabolism revisited: metabolism of lactic acid bacteria in food fermentations and food spoilage. *Current Opinion in Food Science*,2015;2:106-117.
  9. Goldenberg JZ, Mertz D, Johnston BC. Probiotics to prevent *Clostridium difficile* infection in patients receiving antibiotics. *JAMA*,2017;318(20):2038-2048.
  10. Gullan PJ, Cook LG. "Insect-Plant Interactions: Scale Insects and Their Role in Ecosystems." *Annual Review of Entomology*, 2007.
  11. Heller KJ, Heller KA. Probiotics and gut health: A review of recent research. *International Journal of Probiotics and Prebiotics*,2014;9(2):105-112.
  12. Jain P, Jain P. Nutritional properties of Palmyra palm sap. *Journal of Food Science and Technology*,2012;49(5):608-612.
  13. Karthikeyan S, Manivasagan R, Rajaram S. Antimicrobial activity and medicinal properties of *Borassus flabellifer* sap. *Journal of Ethnopharmacology*,2018;214:150-157.
  14. Kumar R, Kumar S. Enzymatic and probiotic properties of fermented sap of *Borassus flabellifer*. *Journal of Applied Microbiology*,2013;115(6):1605-1614.
  15. Kumar R, Singh AK. Quality changes in palmyra palm sap during fermentation. *Journal of Food Science and Technology*,2012;49(4):498-503. doi:10.1007/s11483-011-0408-0.
  16. Lamba HS, Rani S, Sharma S. Traditional fermented beverages: Health benefits and future perspectives. *Food Reviews International*,2019;35(4):317-336. doi:10.1080/87559129.2019.1585785.
  17. Patel S, Kumar R. Nutritional profile and microbial dynamics of palmyra palm sap. *Food Chemistry*,2016;210:469-475. doi:10.1016/j.foodchem.2016.04.107.
  18. Rao K, Dhananjay V. "Herbivory and Pest Management in Palms." *Asian Journal of Agricultural Sciences*, 2019.
  19. Rathinam A, Saravanan S. Biochemical composition and health benefits of *Borassus flabellifer* Linn. *International Journal of Pharma and Bio Sciences*,2017;8(4):1033-1040.
  20. Sadeghi N, Lee HS. The impact of probiotics on gut microbiota and health: A review. *Journal of Probiotic Health*,2010;2(1):18-29.
  21. Singh A, Sharma M, Sinha B. Traditional uses and health benefits of Palmyra palm (*Borassus flabellifer*). *Asian Journal of Plant Science and Research*,2014;4(6):53-57.
  22. Sornplang P, Piyadeatsoontorn S. Probiotics and functional foods from plant sources: Market trends and future opportunities. *Food Control*,2016;60:137-145. doi:10.1016/j.foodcont.2015.07.004.
  23. Suez J, Zmora N, Zilberman-Schapira G, Elinav E. Probiotics: Hype or hope? *Nature Reviews Microbiology*,2019;17(11):685-686.
  24. Ventola CL. The antibiotic resistance crisis: Part 1: Causes and threats. *P&T: A Peer-Reviewed Journal for Formulary Management*,2015;40(4):277-283.
  25. Zeid MA, FarajAlla NS. Characterization of toddy palm sap: A traditional fermented beverage. *Journal of Ethnic Foods*,2019;6(1):1-8. doi:10.1186/s42779-019-0002-2.