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RESEARCH ARTICLE

Palmyra Tuber As a Functional Food: Nutritional Value and Potential Health Benefits

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Abstract: The Palmyra palm (Borassus flabellifer) is a highly versatile tree, often celebrated for its extensive economic and cultural significance. In Indian mythology, it is revered as the "Kalpa Vriksha" or wish-fulfilling tree, as nearly every part of it serves a valuable purpose. The palm is predominantly distributed across Tamil Nadu, Telangana, Andhra Pradesh, Odisha, and Bihar. Despite its remarkable potential, it remains underutilized in South India, even though natural seed regeneration contributes to its growing population. The tender fruits, considered a seasonal delicacy, are rarely harvested on a commercial scale. Similarly, ripe fruits are not fully exploited for juice extraction or tuber processing, although the tubers are commonly sold fresh in local markets. Notably, Palmyra tuber flour is an important raw material in the food industry, particularly in the production of starch-based products such as bakery and confectionery items.

Keywords: Palmyra tuber, composition, health benefits, bioactive compounds, value added products.

INTRODUCTION

Palmyra (*Borassus flabellifer* L.), a remarkable tree belonging to the *Arecaceae* family, widely distributed across Asia, particularly in northern and eastern regions of Sri Lanka, southern India and other tropical countries (Thabrew & Jansz, 2004). In India, palmyra is predominantly cultivated in Tamil Nadu, Andhra Pradesh, Bihar, and Odisha. Additionally, it is extensively grown in Kerala, West Bengal and along the western coast of India.

The Asian Palmyra palm (*Borassus flabellifer*), known for its versatility and multiple uses, is especially abundant in Tamil Nadu (Basava Prasad et al., 2022). A lesser-known edible part of the tree is its young shoot, which is commonly consumed in northern and northeastern Sri Lanka, as well as parts of Southeast Asia (Mason & Henry, 1994). This shoot develops from the germinated seed of the palmyra palm, grows downward into the soil over 6-8 months. Before harvest, the shoot typically reaches a height of 12-15 cm (Saravanya & Kavitha, 2017).

The palmyra palm (*Borassus flabellifer* L.) belonging to the Arecaceae family, is cultivated across India. Various parts of the tree, including the roots, leaves, seeds and fruit are utilized for multiple purposes. India is home of approximately 60 million palmyra palms, with the highest number from Tamil Nadu. The tree is widely distributed along both the east and west coasts. Palmyra offers a diverse range of both edible and non-edible products, serving various purposes. However, fresh palmyra tender fruit endosperm (*Nungu*), sap (*Neera*) and tuber flour are highly perishable and susceptible to significant post-harvest losses due to spoilage (Vengaiah et al., 2013).

Among all palmyra products the tuber, a significant edible shoot that grows in loose soil, reaching a height of about 1–1.5 meters from the seed of ripe fruit. It is primarily cultivated in southern India between January and March. The seeds germinate naturally and are also planted by local farmers for commercial sale. Selling palmyra sprouts is a profitable seasonal business, particularly during festivals like Makara Sankranti in Karnataka, Telangana, and Maharashtra, as well as Pongal in Tamil Nadu.

The mature palmyra tuber is brittle and breaks easily, whereas immature tubers are more flexible and contain higher fiber content. As a rich source of starch, the tuber is optimally harvested around 135 days after sowing, with an average weight ranging between 90–110g. Starch is the primary carbohydrate in palmyra tuber flour, characterized by low viscosity and a low gelatinization temperature while exhibiting excellent setting properties, making it suitable for use as a food starch. Unlike some other tuber-based starches, palmyra tuber flour is naturally devoid of bitterness. Its starch granules have a grain size of approximately 40 µm, similar to that of potato starch (Jansz et al., 2002).

The mature tuber is brittle and easily breaks off, serving as a rich source of carbohydrates and fiber. It is commonly consumed by roasting in an open fire after peeling off the outer layer. Additionally, dried and roasted tubers are ground into flour, which is often mixed with wheat flour for baking. This flour is traditionally used to prepare various food items, including *odiyal*, which is consumed as *khool* (a type of porridge), and *puttu*, a steamed dish.

When the palmyra seed germinates, it produces a sprout with fleshy, food-preserving flakes, which eventually develops into the edible palmyra tuber (*Tegalu*). The

tuber can be processed by either boiling and drying or drying alone. Before harvest, the shoot typically grows to a height of 12–15 cm.

If the germinated seed is sun-dried without boiling, it is known as *Odiyal* (unboiled tuber). Alternatively, if the sprout is boiled and then dried, it is called *Pulukodiyal* (boiled tuber). The tuber is commonly consumed by roasting it over an open fire after peeling off its outer layer. Both boiled and unboiled tubers can be ground and sieved to produce palmyra flour, known as *Odiyal flour* (from unboiled tubers) or *Pulukodiyal flour* (from boiled tubers).

The effectiveness of any post-harvest food treatment depends on its impact on the nutritional and functional properties of the food (Duvivier et al., 2010). Various processing methods applied to palmyra tubers can influence the physical and functional characteristics of the resulting flour. Currently, tubers are preserved either by sun drying (raw dried tubers) or boiling before drying.

Sun drying, although a common preservation method is time-consuming and cause loss of nutritional properties, resulting in poor quality and limited storage stability. To overcome these drawbacks, boiling followed by drying has been adopted as a heat treatment technique to retain nutritional composition and to extend shelf life by regulating the moisture content of these seasonal products.

PALMYRA TUBER COMPOSITION:

Odiyal made from palmyra tuber flour provides 1,432 kcal of energy per 100g and contains 10.8g of moisture, 3.1g of protein, 77.1g of carbohydrates, and 5.6g of crude fiber (Jansz et al., 2002).

Palmyra tuber flour has a moisture content of 5.19%, while its ash and fat contents (on a dry matter basis) are 2.60% and 0.57%, respectively. Additionally, it contains 3.20% protein, 10.17% fiber, and 69.38% carbohydrates. The caloric value of the flour is 282.19 kcal per 100g.

Nutritional analysis of palmyra roots revealed that they contain 8.54% protein, 23.53% carbohydrates, 7.29% crude fiber and negligible fat. These roots are also high in calories and serve as an important food source, particularly for economically disadvantaged communities. Both the seedlings and fleshy roots are consumed as food. Approximately 100 to 150 drupes are sown in 3–4 layers in loose sandy soils of 0.8/sq.m yielding roughly 100–150 seedlings, sometimes even more. These seedlings are typically removed when they are 2–4 months old. The elongated, club-shaped, starchy, and tender material can be eaten in various forms—baked, roasted, fried, boiled, or processed into flour. To preserve them for future use, the seedlings are boiled and sun-dried. The fleshy roots, harvested around four months are rich in starch but low in fats and proteins. Traditionally, the root is believed to have cooling, restorative, diuretic, and anthelmintic properties. It has been used in folk medicine to treat gonorrhea, while a decoction of the young root, along with juice extracted from the young terminal buds and leaf stalks, has been used to relieve gastritis and hiccups. Additionally, it serves as an antacid for heartburn and is recognized for its anti-periodic properties (Chayanika Sahni et al., 2014).

The roots of the palm tree were found to be high in carbohydrates, with a moderate protein content, making them a valuable protein source. Additionally, the fiber content was substantial. The roots contain very little fat, making them an excellent dietary choice for individuals managing their weight. The energy value of the dried roots was determined to be 118.42 Kcal. The nutritional benefits of *Borassus flabellifer* roots are highlighted in the table (Table 1) (Chayanika Sahni et al., 2014).

Table 1: Nutritional composition of roots of *Borassus flabellifer*

Nutritional Composition	Content
Moisture (g 100 g -1 FW)	62.38
Ash (g 100 g -1 DM)	4.95
Protein (g 100 g -1 DM)	8.54
Fat (g 100 g -1 DM): (Fresh, dried)	0.6
Crude fiber (g 100 g -1 DM)	7.29
Carbohydrates (g 100 g -1 DM)	23.53

According to Sandhiyadevi et al. (2021), Palmyra sprout, also known as Palmyra tuber, is widely cultivated in Tamil Nadu and is recognized for its extensive nutritional properties. It serves as a rich source of essential nutrients, including iron (1.7 mg per 100 g in flour and 0.94 mg per 100 g in sweet), carbohydrates (85.1 g per 100 g in flour and 36.92 g per 100 g in sweet), and calcium (53 mg per 100 g in flour and 41 mg per 100 g in sweet). Additionally, it provides significant energy with 384 Kcal per 100 g in flour and 247 Kcal per 100 g in sweet. The roots of Palmyra can be dried and processed into Odiyal, a hard and chewable snack that is traditionally consumed in various regions.

Palmyra sprout also known as the palmyra tuber an edible product traditionally prepared during the winter season (Krishnan, 2007). It can be consumed in various forms, including boiled, sun-dried and powdered, or incorporated into different food preparations. Palmyra sprouts are an excellent source of carbohydrates, containing 98% fiber and 95% starch (Saravanya & Kavitha, 2017). They also provide essential micronutrients such as calcium, magnesium, and ferrous ions (Mason & Henry, 1994).

Jeyaratnam M. (1986) reported that starch is the primary carbohydrate in palmyra shoot flour with sucrose, glucose and fructose being the major sugars content.

Palmyra seed shoot flour is also rich in essential minerals such as sodium (Na), potassium (K), calcium (Ca), and magnesium (Mg). Additionally, previous studies suggest that it contains other vital minerals and vitamins. Due to its significant fiber content, it has a low glycemic index, making it a suitable dietary option (Jansz et al., 2002; Krishanthy et al., 2008).

Nutritional Benefits of Palmyra Tuber Flour:
Palmyra sprout, also referred to as palmyra tuber, develops from the germinated seed of the *Borassus flabellifer* palm. The hard shell of the germinated seed can be cut open to extract the crunchy kernel, which has a sweet taste similar to that of a water chestnut. It is one of the oldest fiber-rich foods used in traditional South Indian cuisine (Vijayanchali, 2024).

It is a natural source of dietary fiber; it also provides essential minerals such as potassium, iron, copper, phosphorus, and zinc (Vijayanchali, 2024; Sridhar & Bhat, 2022). Palmyra sprout flour is often incorporated into dough to enhance its fiber and protein content (Chakraborty et al., 2023). Rich calcium content plays a vital role in strengthening bones and teeth thus prevent age-related bone disorders like osteoporosis and osteoarthritis. Additionally, its good beta-carotene source, supports in improved vision and overall eye health (Sridhar & Bhat, 2022).

Palmyra sprouts, known as "panam kilangu" in Tamil Nadu, are primarily consumed in their raw form. For centuries, various parts of the palmyra plant have been utilized in traditional medicine, particularly as an anthelmintic and diuretic. The plant is highly versatile, with nearly 800 documented uses, including its potential applications in food and beverages, fiber production, Ayurveda, and medicinal treatments (Arulraj & Augustine, 2008).Medicinally, the young plant is believed to help relieve biliousness, dysentery, and gonorrhea

Traditionally it is used in the management of anxiety, mental confusion, fungal infections, urinary diseases, and dysentery (Kannan et al., 2024). It is also believed to aid in treating venerable diseases, enhancing skin health, and improving beauty (Sivakumar et al., 2024). Additionally, young roots exhibit diuretic and anthelmintic properties, and their decoction is traditionally used to treat respiratory diseases. (Chakraborty et al., 2023; Kannan et al., 2024).

Rich in Dietary Fiber:
Palmyra sprout is an excellent source of dietary fiber, widely recognized for its ability to regulate bowel movements and prevent or relieve constipation. Since fiber is a type of carbohydrate that the body cannot digest or absorb, it plays a crucial role in lowering blood cholesterol and glucose levels while promoting satiety, which helps prevent overeating (Slavin, 2013).

The high fiber content in palmyra sprout offers numerous health benefits, making it especially beneficial for diabetic patients. By slowing down the digestive process and the absorption of carbohydrates, it helps maintain stable blood glucose levels (Weickert & Pfeiffer, 2018). Additionally, fiber supports better digestion, reducing the risk of constipation, indigestion, and other intestinal issues. A healthy digestive system, in turn, helps prevent various other health problems.

Fiber also contributes to appetite control, reducing the tendency to consume high-carb or high-fat snacks, thereby supporting weight management. Furthermore, studies have shown that a higher intake of dietary fiber is associated with a lower risk of cardiovascular disease and certain types of cancer (Aune et al., 2011).

Rich in Calcium:
Palmyra sprout is rich in calcium, an essential mineral for muscle contraction and the development of strong bones and teeth. Regular consumption of calcium-rich foods like palmyra sprout helps maintain bone density and prevents bone degeneration (Tai et al., 2015). It also plays a crucial role in protecting against age-related bone disorders such as osteoporosis and osteoarthritis, reducing the risk of fractures and joint deterioration (Heaney et al., 2000; Tai et al., 2015). Including palmyra sprout in the diet can contribute to better bone health and overall mobility as one age.

Rich in Iron:
Palmyra sprouts are rich in iron, a crucial mineral necessary for the proper functioning of hemoglobin, the protein responsible for oxygen transport in the blood (Dietary Iron, 2025). Adequate iron intake supports a healthy pregnancy, boosts energy levels, and enhances athletic performance. The iron content in these tubers plays a vital role in maintaining healthy blood circulation, regulating hemoglobin levels, and ensuring optimal oxygen flow throughout the body. Additionally, it helps prevent anemia, making Palmyra sprouts a valuable dietary inclusion for overall well-being (Iron & Anemia, 2025).

Rich in Magnesium:
Palmyra sprout is a rich source of magnesium, an essential mineral that plays a key role in maintaining cardiovascular health. Magnesium helps in regulating blood pressure, ensuring a steady and healthy circulation (Rosanoff et al., 2012). Additionally, it supports the production of cholesterol, helping to maintain a balanced lipid profile, which is crucial for heart health (Di Nicolantonio et al., 2018). Regular consumption of magnesium-rich foods like palmyra sprout can contribute to reduced risk of hypertension, heart disease, and other cardiovascular conditions (Bo & Pisu, 2008).

Rich in Protein:
Palmyra sprout is an excellent source of protein, a fundamental component of every cell in the body.

Proteins play a crucial role in tissue generation and repair, as well as in the production of hormones, enzymes, and other essential bodily substances (Wu, 2016).

These tubers contain a significant amount of protein, which supports growth and ensures the proper functioning of all body systems. Acting as the building blocks of bones and muscles, proteins contribute to overall strength and aid in body repair (Phillips et al., 2016). Unlike carbohydrates and fats, the body does not store protein, meaning it must be obtained regularly through diet (WHO, 2007). The high protein content in palmyra sprouts helps support growth, regulate body functions, and strengthen muscles and bones. Incorporating palmyra sprouts into the diet ensures a steady supply of protein, keeping the body strong and well-maintained.

LOWER IN GLYCEMIC INDEX:

The glycemic index (GI) ranks carbohydrates based on how they impact blood glucose levels. Foods with a low glycemic index are digested, absorbed, and metabolized slowly, leading to a gradual rise in blood sugar and a controlled insulin response. Palmyra sprout is a low-GI food, making it an excellent dietary choice for managing blood glucose levels. Its slow digestion helps:

- Prevent sudden blood sugar spikes
- Enhance insulin sensitivity
- Provide sustained energy
- Support diabetes management

The glycaemic index (GI) is a measure that ranks carbohydrates in foods based on their impact on blood glucose levels. Foods with a low glycaemic index are digested, absorbed, and metabolized slowly, leading to a gradual and lower rise in blood sugar. This slow release helps regulate insulin response, making such foods beneficial for maintaining stable blood glucose levels. Palmyra sprout, with its low glycaemic index, is a suitable dietary option for managing blood sugar effectively. Including palmyra sprouts in the diet can help stabilize blood sugar levels and promote overall metabolic health.

Palmyra tuber flour serves as a valuable raw material in the food industry, particularly for the production of starch and sweeteners (Anonymous, 2015). Starch derived from Palmyra tubers functions as a taste enhancer, binder, filler, thickening agent, and stabilizer, making it an essential component in various food applications. Both raw and cooked Palmyra tubers have been traditionally consumed and utilized as key ingredients in food preparation (Anonymous, 2014). These tubers are harvested at full maturity, typically after four months of growth, and are rich in essential nutrients, phenols, and metal ions, which contribute to their strong antioxidant properties, which help protect the body from oxidative stress and promote overall health and well-being.

Palmyra tuber flour has a low glycemic index, making it particularly beneficial for diabetics as it helps regulate blood sugar levels. Rich in phytochemicals, it plays a significant role in preventing chronic diseases, reducing the risk of age-related disorders, and protecting against cardiovascular illnesses, thereby promoting overall health and well-being. Additionally, it contains Flabelliferin, a naturally occurring bitter compound known for its antibacterial properties, which contribute to immune support and disease prevention.

Palmyra tuber is an affordable and nutrient-rich source of starch, carbohydrates, lipids, essential minerals, and health-promoting bioactive compounds (Bolade & Bello, 2006; Jansz et al., 2002). These nutritional components make it particularly beneficial in managing various diseases, especially diabetes, by supporting overall health and metabolic balance.

Regular consumption of palmyra tuber flour helps increase body strength, reduce hunger, and, when combined with other foods, can play a significant role in reducing malnutrition. Despite its excellent nutritional and therapeutic value, it remains underutilized in everyday diets. However, its high potential for processing into various quality food products presents an opportunity for greater utilization. Each year, nearly 5,000 tons of tubers are used in the production of value-added products (Krishanthy & Mahendran, 2008), highlighting its economic and nutritional significance.

Palmyra sprouts are rich in fiber and contain essential minerals such as potassium, iron, copper, phosphorus, and zinc, making them highly nutritious. They serve as an excellent source of iron, which is crucial for preventing and managing anemia. When consumed alongside other iron-rich foods, Palmyra sprouts can help boost iron levels and support overall blood health. Additionally, they play a vital role in hemoglobin production, as their protein content aids in oxygen transport throughout the body (Rashi M. Khatri et al., 2020).

Palmyra sprouts offer numerous health benefits and are known for their pleasant taste. However, they are seasonally available. These sprouts help reduce body heat, prevent constipation, and aid in weight management due to their high fiber content. Additionally, they promote digestive health, boost immunity, and contribute to stronger bones while also benefiting uterine health. Rich in omega-3 fatty acids, Palmyra sprouts help lower high cholesterol levels, thereby reducing the risk of heart disease. Their antioxidant properties further aid in cancer prevention and overall immune system enhancement.

Palmyra tuber is a rich source of starch and fiber, making it particularly beneficial for managing diabetes and other health conditions. Regular consumption of Palmyra tuber flour helps enhance body strength, reduce hunger, and when combined with other foods, it can effectively combat malnutrition (Mohanadas, 2002).

Palmyra young shoot-based products include tuber starch, Palmosha, biscuits, porridge, and steamed food (pittu) (Balasubramanium et al., 1999). However, the presence of various steroidal saponins, particularly flabelliferin and the antimicrobial flabelliferin FB (Wickramasekara and Jansz, 2003), contributes to the bitter taste and potential toxicity, making the young shoot flour less acceptable for consumption. Additionally, spirosterols are the most dominant aglycones found in shoot flour and Palmyra inflorescence (Theivendirarajah, 1994; Yoshikawa et al., 2007).

Various parts of the palmyra palm are abundant in essential nutrients and phytochemicals that support daily bodily functions. The roots of palmyra contain 8.54% protein and are rich in fiber, while palmyra tuber powder serves as an excellent source of fiber, iron, and phosphorus. These nutrients play a crucial role in red blood cell (RBC) synthesis, bone development, and detoxification of the body (Basava Prasad et al., 2022).

Palmyra tuber flour is highly hygroscopic, meaning it readily absorbs moisture from the surrounding atmosphere, which negatively affects its storage stability and overall quality. Low moisture content is crucial for prolonging shelf life and preventing deteriorative reactions caused by excessive moisture absorption. A higher moisture percentage promotes the growth of microorganisms, particularly fungi (Uchechukwu-Agua et al., 2015). Additionally, during storage, an increase in total soluble solids (TSS) may occur due to the conversion of polysaccharides into soluble sugars and the rise in moisture content, leading to greater solubilization of reducing sugars.

The palmyra tuber serves as a physiological energy reserve, accounting for 32-35% of its fresh weight. Starch is the primary nutrient found in tubers and root crops (Chandra Surya Rao et al., 2020). Palmyra tuber flour, with a fiber content exceeding 3%, is considered a good dietary fiber source. However, fiber content gradually decreases during storage, likely due to the softening of fibrous tissue and the bioconversion of carbohydrates and cellulose into protein, as reported by Enwere (1998).

Bioactive content in palmyra tuber flour:

Starch is the primary carbohydrate found in palmyra tuber flour. It has low viscosity and a low gelatinization temperature, yet it exhibits good settling properties, making it suitable for use as a food starch. Unlike some other starch sources, palmyra tuber flour starch is naturally devoid of bitterness. Additionally, it has a grain size of 40 µm, which is comparable to potato starch.

Palmyra tuber is a cost-effective source of starch, carbohydrates, lipids, essential minerals, and health-promoting bioactive compounds (Bolade and Bello, 2006; Jansz et al., 2002). These nutritional components make it particularly beneficial for managing diseases, especially diabetes. Regular consumption of palmyra tuber flour not only enhances body strength and suppresses hunger but also, when combined with other foods, plays a vital role in reducing malnutrition.

Various parts of the palmyra plant have been traditionally used for their medicinal properties, including antihelminthic and diuretic effects. The fruit pulp of *B. flabellifer* is a key ingredient in traditional dishes, while its sap has been utilized as a natural sweetener for diabetic patients. Phytochemical studies have identified the presence of spirostane-type steroid saponins and steroidal glycosides, which contain the bitter compound flabelliferrins. Additionally, the young roots possess diuretic and anthelmintic properties, and their decoction is commonly used in the treatment of respiratory ailments.

Thamizharasan et al. (2020) studied the anti-diabetic properties of *Borassus flabellifer*, highlighting its significant in vitro anti-diabetic activity. The research findings indicate that extracts from *Borassus flabellifer* Linn, along with isolated compounds such as tyrosol and glucosyl (6-1)-glycerol, exhibited notable anti-diabetic effects, suggesting their potential use in diabetes management.

Palmyra sprouts are plant-based foods that are naturally low in fat and cholesterol-free, making them highly beneficial for diabetic health by reducing the risk of heart-related complications. In addition to their low-fat content, they offer several other health benefits. The presence of Omega-3 fatty acids helps in preventing cardiovascular diseases and reducing obesity risk. Furthermore, regular consumption of palmyra sprouts can enhance insulin response in diabetics, contributing to better blood sugar control.

Value added products of palmyra tuber

Although Palmyra tuber flour is not widely consumed, its exceptional nutritional and therapeutic value makes it highly suitable for processing into various quality products. Approximately 5,000 tons of tubers are utilized annually for value-added product production (Jansz et al., 2002). The effectiveness of post-harvest food treatments depends on their impact on the nutritional and functional properties of the food (Krishanthy and Mahendran, 2008). Various processing methods can influence the physical and functional properties of palmyra tuber flour. Traditionally, these tubers are preserved either by sun-drying (raw dried tubers) or boiling. While sun-drying is a widely used preservation

method, it is time-consuming and leads to nutrient loss, resulting in poor quality and storage stability. To retain nutritional composition and extend shelf life, boiling and drying heat treatments have been adopted, ensuring controlled moisture content in these seasonal products.

Palmyra tuber is a nutritious edible shoot that grows in loose soil from the seed of a ripe fruit. It is commonly cooked over an open fire after peeling off its outer layer and is consumed by many. Additionally, roasted and dried tubers are ground into flour, which is often blended with wheat flour for baking. This versatile flour is traditionally used to prepare various food items, including odiyal, a hard, chewy product, as well as porridge (khool) and a steamed dish (pittu). Odiyal made from palmyra tuber flour provides 1,423 kcal of energy per 100g and contains 10.8g of moisture, 3.1g of protein, 77.1g of carbohydrates, and 5.6g of crude fiber *(*Bolade and Bello, 2006*)*.

Sankaralingam et al. (1999) reported the development of various value-added products derived from palmyra tubers, including dehydrated tubers, tuber flour, and rava (sooji). Traditional sweets and snacks such as palmyra tuber laddu, tuber-soya laddu, kesari, payasam (kheer), idli (steamed buns), uppuma (savory tiffin), porridge, pakora (crunchy snack), Thavan peda, Thavan halva, fruit squash, ready-to-serve juice, fruit leather, nungu candy, nungu peda, nungu sharbat (refreshing drink), neera khova (condensed milk sweet), neera pongal (sweetened rice mix), and neera payasam have also been formulated. The Department of Post-Harvest Technology at Tamil Nadu Agricultural University has further expanded the variety of palmyra-based products, including tender fruit RTS beverages, jam, jelly, candy, preserve, peda, ice cream, as well as tuber flour-based idli, rotti, paniyaram, uppuma, murukku, pakoda, laddu, kesari, payasam, porridge, bread, cookies, and vermicelli.

Tamil Nadu is a pioneer in the palm products industry in India, housing 5.10 crores out of the estimated 8.59 crores of palmyra palms in the country. The state's potential for expansion in this sector is immense, with opportunities to boost foreign exchange through the export of palmyra-based products.

Reshma and Annie Abraham (2023) conducted a study on the phytochemical profiling, antioxidant properties, and characterization of aqueous Extract of palmyra sprout. Their findings highlighted that palmyra sprout is highly nutritious and rich in calories. The free radical scavenging activity, total phenolic content (TPC), and total flavonoid content (TFC) analysis confirmed its potential as a valuable source of antioxidants. The Fourier Transform Infrared Spectroscopy (FTIR) analysis revealed the presence of various functional groups, indicating the existence of carbohydrates, glycogen, amino acids, and amides. Additionally, Liquid Chromatography-Mass Spectrometry (LC-MS) analysis detected biologically significant compounds with antioxidant, anti-inflammatory, hepatoprotective, and anti-cancer properties. Based on these findings, the aqueous extract of palmyra sprout can serve as a natural antioxidant, presenting a promising alternative to synthetic antioxidants and enhancing its value as a nutritious food.

Sumithra and Subaratinam (2021) developed cookies enriched with palmyra sprout powder, incorporating 30% of palmyra sprout powder into the formulation. The taste and overall acceptability of these cookies were found to be highly satisfactory. Nutritional analysis of the cookies made with green gram flour and palmyra sprout powder showed that they contained 18.66 g of carbohydrates, 30.02 g of protein, and 4.03 g of fiber, making them a nutrient-rich and wholesome snack option.

Farzana Movafihka Fathima et al. (2024) developed a palmyra sprout (200g) and pearl millet (20g) laddu, which serves as a nutrient-dense solution for addressing anemia. The combination of palmyra sprout and pearl millet enhances the iron content and overall nutritional value, making it an effective dietary supplement for improving iron levels and combating anemia.

Rashi M. Khatri et al. (2020) conducted a study comparing the crude fiber content of palmyra sprout flour (5.08%) with that of regular whole wheat flour (0.52%), highlighting its superior fiber content. The study also explored the development of muffins using palmyra (Borassus flabellifer) sprout flour, revealing that incorporating 50% palmyra sprout flour significantly enhances the nutritional quality of the muffins. The findings indicate that a 50:50 ratio of wheat flour and palmyra sprout flour is suitable for muffin preparation, offering a fiber-rich, nutrient-dense alternative to conventional muffins.

Ramani et al. (2022) developed protein- and fiber-enriched noodles by incorporating wheat flour (20%), squid (5%), palmyra sprouts (22%), arrowroot flour (10%), red rice flour (38%), and guar gum (5%). The resulting squid noodles exhibited an appealing color, smooth texture, and good surface quality. Additionally, the noodles demonstrated an extended shelf life of three months. The study highlighted a notable increase in protein and fiber content, making these noodles a nutrient-rich alternative to traditional varieties.

Devi and Sharmila (2019) highlighted that palmyra offers a diverse range of both edible and non-edible products with significant commercial potential. The plant is valued for its medicinal properties, including diuretic and anthelmintic benefits. Their study emphasized the importance of preserving bioactive compounds such as β-carotene, vitamin C, phenols, flavonoids, and antioxidants during the drying process, as minimal damage to these nutrients enhances the

functional and pasting properties of the derived flours. This preservation is crucial for value-added food applications, particularly in thickening agents used in various food products.

Devi and Sharmila (2019) developed a nutrient-rich product, nutriball, by incorporating 25% palmyra tuber powder with 75% composite flour consisting of ragi, bajra, and jowar. Their study found this formulation to be highly suitable, enhancing the nutritional value of the product while maintaining good taste and acceptability.

Piratheepan et al. (2017) successfully developed a supplementary food, Palmyra Nutrimix, using locally available ingredients. The formulation included 14.8% cowpea, 14.8% chickpea, 9.2% sesame, 9.2% soybean, 9.2% green gram, 20.3% palmyra tuber flour, 19.4% sugar, and 3% whole milk powder. The preparation process was simple, and the final product was highly accepted based on sensory evaluations.

Nutritional analysis of Palmyra Nutrimix

- Energy: 468.37 kcal/100g
- Protein: 15.66%
- Fat: 10.08%
- Fiber: 4.75%
- Carbohydrate: 61.15%

The total phenolic content (61.0 ± 2.0 mg gallic acid equivalent/100g) highlighted the functional properties of the product. Additionally, the glycemic index (GI) values were 64.00 ± 1.90 with sugar and 50.50 ± 1.26 without sugar, indicating that the sugar-free version is suitable for diabetic individuals due to its low GI value.

Sathya et al. (2022) evaluated dietary fiber-rich palmyra tuber flour noodles for their potential in enhancing bowel movement. The study highlighted that the high fiber content of Palmyra tuber flour contributes to improved digestion and gut health, making it a functional ingredient for promoting better gastrointestinal function. The findings suggest that incorporating Palmyra tuber flour in noodles could be beneficial for individuals seeking dietary fiber-enriched food options.

Osmotic dehydration of palmyra tuber pieces involves an osmosis process, where an optimal time of 5 to 6 hours is required to achieve maximum weight loss (water removal) and solid gain. The ideal combination for effective dehydration was determined to be 60% sugar syrup solution, 4 mm tuber thickness, and a 1:6 sample-to-sugar syrup ratio. To reduce bitterness, cold extraction of tuber flour was used, and bakery products such as cakes, cookies, and noodles were successfully developed with 75% tuber flour. These bakery items, optimized for cookies and bread, are fiber-rich and beneficial for health (Jansz et al., 2002).

The optimization of the process for cake, cookies, and noodles using palmyra tuber flour was studied by (Vengaiah et al., 2017). The study found that up to 50% of refined wheat flour could be substituted with Palmyra tuber flour without compromising product quality. Additionally, bitterness was effectively removed using the cold extraction process, making the tuber flour more suitable for bakery and noodle production.

CONCLUSION:

Palmyra (*Borassus flabellifer*) is a remarkable plant that serves as both a traditional food source and a nutritionally rich natural resource providing essential nutrients such as carbohydrates, fiber, protein, healthy fats, vitamins, and minerals, all of which make it a valuable part of the human diet. Beyond its basic nutrition, palmyra offers a variety of health benefits. Its potential antioxidants and minerals supports the immune system, helps protect against oxidative stress, strengthens bones, and promotes overall well-being. For centuries, it has also been valued in traditional medicine and cultural practices, highlighting its dual role as both a food and a therapeutic plant. Ways, palmyra is a multifaceted resource of nutritional, medicinal, cultural, and ecological. With more scientific research and validation, its potential applications in health, nutrition, and functional foods will continue to grow, ensuring that this age-old plant remains relevant in modern approaches to wellness.

Conflict of interest

The authors declare that there is no conflict of interest in publication of this paper.

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