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A Comprehensive Study of Use of Plant Leaves in Product Packaging

Rahul Tirpude and Sumer Singh

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Rahul Tirpude [1][0000-0002-9327-5665] and Sumer Singh[2][0000-0001-7868-5888]

[1,2] Department of Design, Indian Institute of Technology Delhi, Delhi, India 110016
Rahul.Balaji.Tirpude@design.iitd.ac.in

Abstract. There has been an extensive use of plastics in the packaging industry. One of the primary concerns with plastic packaging is its disposal. Much of it ends up in landfills, where it can take centuries to decompose fully. Moreover, a considerable amount of plastic waste finds its way into waterways, leading to pollution in oceans, rivers, and other ecosystems. the pollution caused by plastics, particularly microplastics, has significant and far-reaching consequences for marine life, ecosystems, and potentially human health. There are numerous biodegradable and recyclable materials found in our surrounding environment that can serve as sustainable alternatives to traditional plastics. These materials not only help reduce the burden on the environment but also offer various benefits in terms of renewability, compostability, and reduced carbon footprint. The problem is the availability of widely accepted frameworks for the selection of biodegradable materials for use in product packaging purposes. Natural fibers, like jute, hemp, banana, coir, bamboo, and various leaves are comparably eco-friendly and can be used as plastic substitutes. For example, leaves may be used as an excellent packaging option for wrapping different raw and cooked food items. It is a considerably cheap, readily available, renewable, and environmentally friendly material. The use of leaves is not restricted to rural communities, but on several occasions, it gives an esteemed value in urban setups also. The presented re-view paper is an attempt to consolidate the research made in the application of leaves for product packaging.

Keywords: Biodegradable material, leaf, product packaging.

1 Introduction

Packaging plays a vital role in protecting different products against all possible damages such as microbial, chemical, physical and environmental etc. in different stages of transportation, storage, marketing and selling[1]. Packaging catches the attention of consumers and communicates sufficient product information in a short period of time at the point of sale. Packaging consists of two main components; one is Structure Design and other one is Graphic Design. The efficient structural design of packaging protects the products against all possible damages during transportation or storage. Whereas, graphic design offers product details/information to consumer and aesthetically appeals customers to attract their interest towards buying the product. In a

nutshell, In a nutshell, packaging plays a vital role in serving, containment, protection and preservation of various food and non-food products, until finally delivered to the end-consumer. With the urbanization and continuously changing life style, packaging industry has become very prompt and self-sufficient industry to fulfil all demands of every type of consumer. For example, packaging protects products from a safety and quality standpoint. It helps in handling, storage, disposal, transportation and marketing of products. Packaging protects the products from shock or vibration like damage. It acts as chemical barrier for oxygen, moisture and light and protects the package by tracking and tracing through labelling. Packaging provides products' information to customer by its labelling. Packaging provides some convenience features to consumers as well for example product can be visible from outside i.e. transparent packaging, thus making the product aesthetically appealing. Moreover, there are various types of packaging materials available in market which are employed in the packaging of many goods from food to electronics to chemicals to liquid items. Paper, paperboard, plastic, glass, metal are some broad range of packaging materials available in the market. Kraft paper, brown paper, parchment paper, grease proof paper, sulfite paper are some common examples of paper packaging materials. White board, chip board, corrugated fiberboard, solid board are commonly available packaging material in the category of paperboard. Amongst plastics, polypropylene, polyesters, polyoleofins, PVC, PVDC, PS etc. are some generally used packaging materials. Similarly, aluminum, tin plate, steel, laminates are used as metal packaging materials [2].

The packaging industry has earned a dignified place in the commercial world. However, the packaging industry has contributed to almost half the total global waste generated annually." Single-use plastic food packaging, a symbol of throwaway society, makes up the majority of packaging waste, which consists of packaging and packaging components. As per estimation, 79 percent of the plastics generated worldwide end up in the garbage stream. Merely 9% of the world's total plastic garbage gets recovered through recycling. According to a 2018–19 Central Pollution Control Board (CPCB) report, India generated 3.3 million metric tons of plastic garbage annually.

Other than plastic, packaging waste contains glass containers (bottles & jars), packaging and containers made of aluminum (can & foils), packaging and containers made of steel (steel barrels), packaging and containers made of paper and paper board, packaging made of wood (crates, chip, boards, planks) etc. The Earth is polluted by packaging garbage. Every form of life on Earth harms humans. Animals, whether on land or in the ocean, are being choked to death by packaging trash pollution. Air pollution is caused by the incineration of packaging trash, which releases methane, vinyl chloride, CFC, hexane, and CO_2. Marine forms are facing life threatening issues with the entanglement and ingestion of packaging waste. Human beings are also suffering from the health issues due to Styrene, benzene, and BPA which have been identified in packaging debris which comes in human body from the consumption of marine forms. The production of miscellaneous packaging products like adhesives, coatings, and inks releases hydrocarbon emissions. When plastic is utilized, harmful chemicals such as phthalates, vinyl chloride, melamine, and bisphenol A are released into the food. According to Today in 2017, bisphenol A is a possible carcinogen that can lead to cardiac problems, insulin resistance, and malignancies of the breast and prostate. It also affects animal

and human fertility, both male and female. Melamine damages the kidneys. Polystyrene is cancer-causing agent and metabolic disruptor as well which adversely affect the thyroid hormone levels. These are also potential carcinogens and vinyl chloride monomer, is also a human carcinogen. Dioxins and furans are emitted from the incineration of plastics which are poisonous and carcinogenic agents. Microplastic pollution occurs in the marine environment as a result of long-lasting, slow-degrading plastic particles with a length of less than 5 mm that accumulate in the ocean and food chain. According to estimates, every day, India produces almost 26,000 tonnes of plastic garbage, with 11 kg of plastic consumed annually by each Indian. This is a very serious condition and therefore an urgent attention for eradication of plastic pollution and reduction of its uncontrolled application is needed [3]

The world is now moving towards sustainability in all aspect. Hence, the time is now ripe for finding alternative to conventionally used packaging material for sustainable future. To reduce the negative impact of the plastic packaging waste on ~~the~~ all forms of life, there must be a highly effective waste management process to improve environmental cleanliness against this packaging pollution. The minimization of packaging material may be one of the simple ways to fight against the packaging pollution. There may be various ways to lessen the amount of packaging trash, such as outlawing single-use plastics, promoting eco-friendly alternatives, increasing social awareness and education, encouraging voluntary cleanups, and switching to reusable or biodegradable packaging materials. Keeping the same point of view, this review paper has been designed where possibility of different ecofriendly and biodegradable natural packaging materials will be discussed which can be used as an alternative to different types of product packaging.

2 Leaves as Suitable Alternative Materials for Product Packaging

Making products from renewable resources as a starting point is now widely acknowledged as a critical component of developing sustainable products. Leaves are an example of a renewable resource. Leaves have been used for a wide range of products, including food packaging, in all over the world. Developed countries con-duct research programmes to develop the packaging which can biodegrade. The "leaf use" method of preserving food has been refined by populations in developing nations through planting, processing, and other techniques. There is a long tradition of using biodegradable packaging. However, due to urbanization and the resulting popu-lation density, a scarcity of this traditional packaging method has emerged. As a result, environmentally unsound friendly packaging technology from developed countries has been introduced, with more negative effects on the environment and human health, such as cooking food in plastic film instead of traditional washed leaves which leads to the migration of toxins from the plastic to the food. The impact of single-use plasticware on our daily lives has led to research for more sustainable alternatives. One such option is the age-old Indian practice of utilizing plant leaves for food wrappers and dining plates. The long-standing tradition in India is significant in terms of culture, religion, medicine, and

socioeconomics. The leaves are picked from the woods by tribal people in India. In many Indian languages, the terms patravali, pat-tal, vistari, vistaraku, and finished, dona refer to the leaf-based plates and cups. The leaf plates are environmentally friendly, biodegradable, suitable for long-term storage, and can easily be disposed of. They are cost-effective and do not need the time-consuming and labor-intensive washing of phosphate-rich soaps and detergents. Nutrient-rich detergents that are discharged into water sources can induce eutrophication, which is a phenomenon where fish die as a result of fast algae growth and anaerobic breakdown that reduces dissolved oxygen [4]. The leaves have a stroking appearance. The leaves have powerful antibacterial and antifungal effects against a variety of fungus and bacteria, shielding us from infections in the air and in our food [5]. They are perfect natural antioxidants due to their excess of polyphenols, which are prone to be leached into food [6]

3 Diverse Plant Leaves Used in India as Wraps, Plates, and Packing Material

A wide range of plant kingdom families' leaves are used to create food wraps, single leaf covers, stitched dining leaf plates, and food wrapping materials. The current study focuses on the following topics: plant local names, distribution, biological properties, medicinal qualities, leaf applications, cultural and religious significance, and leaf applications.

3.1 Shorearobusta

In Sanskrit, sal means "house," and in other Indian languages, saluva, dammar, and ral indicate "home." It is highly respected by Buddhists, Jains, and Hindus alike. Odisha, West Bengal, Bihar, Jharkhand, Madhya Pradesh, Chhattisgarh, Haryana, Assam, Tripura, Andhra Pradesh, and Himachal Pradesh are among the Indian states where it is accessible. The leaves, which are 10–25 5–15 cm long, are used to heal illnesses in Unani and Ayurvedic medicine.

Fresh leaves are used to serve tiny snacks like boiled lentils (dona), while sun-dried leaves are sewn together to create leaf bowls and plates (khali) using grass stalk sticks or a sewing machine. The leaf plates are used to prepare meals at home as well as at ceremonial events. The leaf cups are often used to distribute panipuri, chaat, and ragda pattice to patrons of roadside cafes as well as prasadam to devotees in temples [Fig. 1(a)]. Sal forests occupy about 30% of India's soil, and they are one of the only sources of income for the country's landless, marginalised, and forest-dependent tribal communities.

Fig. 1. (a) Manually made Cup from the leaves of sal, S. robusta b)the bilobed leaf of addaku, P. vahlii, (c) the hand stitched and(d) machine compressed dining plates made from the leaves of addaku, (g) Machine Compressed dining plates made from the leaves.

The absence of legal restrictions, the all-year-long quantity of leaves, and the presence of a long-standing history of leaf plate production led the locals to embrace this profession as a means of subsistence. This plate is meticulously produced by the tribal community. By use of roads and railroads, machine-pressed plates are transported to the states of Andhra Pradesh, Bihar, West Bengal, Telangana, Madhya Pradesh, Karnataka, Maharashtra, and [7]

3.2 Phaneravahlii

The plants are referred to as addaku, madapaku, and siali in different Indian languages. Several South Asian nations, including China, Vietnam, India, Nepal, Myanmar, Thailand, and Pakistan, are home to it. primarily found in India's many states' woods. Quercetin flavonoids, which have antibacterial, antimicrobial, antioxidant, anti-inflammatory, and anti-diabetic activities, are abundant in the bilobed, 10-46 cm long leaves [Fig. 1(b[8]
In essence, four to five numbers of shade-dried leaves are machine and hand-stitched into circular plates using grass stalk sticks and thread [Fig. 1(c-d)]. These leaf plates are frequently used as meal plates at homes, hotels, marketplaces, weddings, group feasts, and other events when food is served to a significant amount of people [9]. In rural areas, the leaves are often utilized as a packaging substance for meat at tiny hotels and butcher shops, as well as for fried dishes like idli and sweets like *jalebi*. Leaf wrappers with a cone form are used to steam cook millet flour idli. When food is prepared by steaming, the food wraps prolong its shelf life and add to its aroma [10]
Additionally, they are made into bowls and cups to serve liquid meals like ice cream, soup, and dal.
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3.3 Butea monosperma

It goes by several Indian names, including flame of the jungle, moduga, palasa, and palash. It is a deciduous, frost- and drought-resistant tree that grows well in the poor soils of wastelands, grasslands, and open fields during the dry seasons. Southeast Asian

nations that have it include Vietnam, Malaysia, Indonesia, Sri Lanka, India, Bangladesh, Nepal, Myanmar, Thailand, Cambodia, and Vietnam.In certain Indian states, it is also accessible. India's richest states are Jharkhand, Andhra Pradesh, Telangana, West Bengal, Maharashtra, Kerala, and Punjab.It is a sacred tree to Buddhists and Hindus, with pinnate, trifoliate, and 10–15 cm tall branches [Fig. 1(e)] [11]. Considering its therapeutic qualities, Ayurveda frequently uses parts of the tree, including the leaves, stem, bark, fruits, gum, and seeds. Throughout the states of Odisha, Maharashtra, Andhra Pradesh, and Telangana, people frequently serve food and meals to one another during rural feasts, offer naivedyam to various gods, and distribute prasadam to deities during festivals and religious ceremonies using plates (vistari) and cups (dona) made of dried leaves.

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Consuming food offered on moduga leaves is believed to offer protection against cancer, skin conditions, and liver illness [12]. In addition, the leaves are used to stack the sides of a bamboo stick for grilling the tribe's cholesterol-free chicken meal, bongu chicken. Not to mention, the leathery, nutrient-rich leaves are great buffalo feed.The tree is known to improve soil fertility by increasing soil organic carbon levels and hastening the breakdown of nutrient-rich leaf litter. Pruned trees are suitable for lac cultivation because they are a primary host tree for the lac insect (Lacciferlacca). As a result, leaf plucking is carried out in a way that is both environmentally sustainable and does not affect the forest [13].

3.4 Butea monosperma

In Indian languages, it is called adakka, vakka, adike, puga, supari, pakku, kamugu, and gua. In English, it is called areca palm, areca nut palm, and beetle nut palm. It is a medium-sized, single-trunked tropical palm with an erect, slender stalk that is unbranched, and it is a member of the Aracaceae family. It can be found in several countries in South Asia. The leaves are 1.5–2 meters long, palmate, and elongated.

The leaf sheaths envelop the stem, creating a protective covering around it. The sheaths have an oblong shape, with dimensions varying between 65 and 111 cm in length, 23 to 33 cm in breadth, and 2.5 to 5.25 mm in thickness [Fig. 2(a)]. The sheaths have a low calorific value and a high tensile strength because they are composed of fiber, cellulose, hemicelluloses, lignin, and pectin.

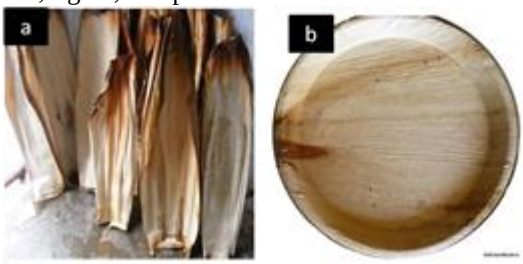

Fig. 2.(a) The leaf sheath of vakka, A. catechu (b) the machine compressed dining plate made from the leaf sheath of vakka.

While the dry sheaths are used as firewood, farmers add the wet sheaths to cow fodder. Typically, trees are planted without the use of pesticides or fertilizers in hilly regions. Disposable plates and cups are made from leaf sheaths, which are widely available in Kerala, Tamil Nadu, and Assam [Fig. 2(b)]. Dense sheaths that fall naturally are gathered, cleaned, bathed in hot water, and then hot compressed to make plates and cups. They are of superior quality, strong, dense, and heat-tolerant than other leaf plates.

They are naturally compostable and biodegradable, and they have no smell. They are also leak-proof, resistant to the refrigerator, microwave, and oven. Regarding food safety, they can be used numerous times for dry food and once for moist food. Liquids, both hot and cold, are frequently stored in leaf cups and plates due to their shape stiffness and resistance to heat. In addition, they are durable, have a wood-like look because of the attractive and natural texture of the plate, and may be used for outdoor activities like picnics.

3.5 *Musa paradisiaca*(Banana)

The banana plant is referred to as kadali, arati, and ke-la in several Indian languages.Australia, China, and India are the world's top banana producers. It is referred to as kalpataru, a plant of all virtues, because each of its constituent parts has more than one use. The leaves have a diameter of 2.7 0.6 m and are broad, flexible, and water-resistant [Fig. 3(a)]. An Indian practice that dates back many years is serving food or a meal on a banana leaf. Serving food on banana leaves is a safe, customary, and fortunate practice during holidays, family get-togethers, weddings, cultural feasts, and religious events. Banana leaves are frequently used as eating plates due to their high content of polyphenols, which serve as antioxidants and promote healthy digestion by releasing nutrients like potassium and vitamin C when food is heated. The endless leaves have a distinct flavor and scent, are free of detergent residue, and are waterproof and leakproof after serving the steaming dish. Moreover, animals and buffalos love to eat the biodegradable leaves that are thrown out.

Meals served on banana leaves are typically eaten with the hands whilst seated on the floor at vindubhojanam and sadhya, which are presented at weddings as well as other festive and ritual moments. Certain eateries throughout Tamil Nadu & Karnataka require their meals to be served on banana leaves.Maharashtrians consume food on banana leaves during the Ganesh Chaturthi celebration. Because naivedyam is offered to multiple gods and goddesses on banana leaves, the rite is referred to be holy [Fig. 3(b)]. The wide, flexible leaves come in different sizes and make great decorations for tables and plate liners. They are easy to cut.

Fig. 3(a)The leaf of banana, M. paradisiaca,(b)naivedyam offered to god Ganesha on banana leaf during the festival of Ganesh Chaturthi and (c) lunch boxes were not popular/affordable, people used to use burned banana leaves to wrap the lunch (d) The utilization of banana leaf blade as a non-adherent surface for spreading the batter of gaare before oil frying.

Pothichoru, a Japanese takeaway dish that features multiple dishes wrapped in blanched leaves of bananas for later consumption, is one instance of how the leaves are used to wrap cooked food, such as rice, because they act as a foil to retain the moisture and flavor of the food. In the days before lunch boxes, it was usual in Kerala to carry pothichoru to offices, colleges, and schools. Banana leaf is also used in certain Keralan eateries to serve parotta with chicken or mutton curries.

Salads, roasted pulses, fried lentils, and savory foods are all consumed in leaf cones. The leaves can also be used to wrap meats that are baked, roasted, steamed, or grilled. This adds flavor and protects the contents from direct heat. They are used as wrappers for elayada, a popular delectable dish from Kerala that is steam-fried. In West Bengal, the leaves are used while steaming and grilling macher paturi, which is a boneless fish enveloped in a banana leaf and marinated with spices. They are also used as fresh, organic saucepans for producing Mangalorean catholic food thathbakri, and as a cover for roasting rice panki, a savory dish from Gujarat. Before oil-frying, the leaves are utilized as a non-adherent layer to distribute the gaare batter. [Fig. 3(c)]. The dried leaves are used to carry food, and the cups fashioned of them are used to serve liquid meals. In the southern states of India, the production of banana leaves for use as dinner plates has become a commercial enterprise due to planned operations and coordinated marketing networks. It is anticipated that the leaf business will generate almost Rs 100 crore in income annually.Due to its ecological, traditional, cultural, and religious significance as well as the year-round demand for the leaves, the plant's ability to stabilize the fruit trade market, its suitability for greenhouse, wetland, and highland production systems, and its potential to help many marginal farming families, its popularity has grown.

3.6 Nelumbo nucifera

In Indian languages, the lotus plant is called by several names like tamara, kamal, padma, and pankaja. It is revered in Buddhist and Hindu religions as a sacred lily. This herb is found in Russia, New Guinea, Australia, China, Japan, Vietnam, India, and Sri Lanka. Its distribution in India spans the country's middle, northern, and southern regions. The lotus flower is both India's and Vietnam's national flower. The peltate, round leaves, which vary in diameter from 20 to 90 cm, are employed as floating or flying blades in water features like rivers, lakes, even water gardens. [Figure 4(a)]. The development of a thick, waxy cuticle covering on the leaf is the cause of ultra-hydrophobicity, commonly referred to as the lotus leaf effect. This property may be investigated for hydrophobic packing or packaging applications needing water resistance.

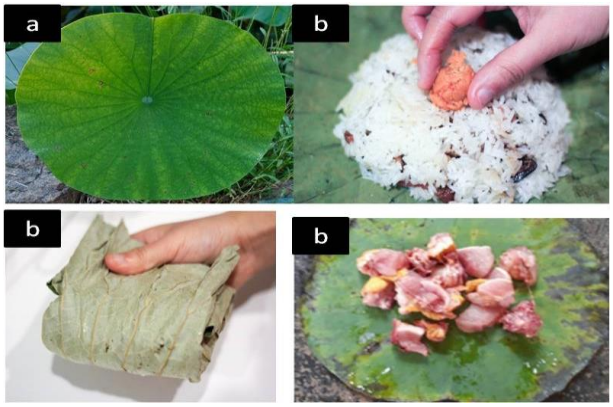

Fig. 4.(a) The leaf of lotus, *N. nucifera*, (b) the application of lotus leaf for packing of food & meat,

Because it is hydrophobic, water-proof, and self-cleaning, the leaf is considered a symbol of sanctity and purity during Karma Sanyasa Yoga, according to explanation in Bhagavad Gita Chapter 5.
Lotus leaves have several therapeutic properties, including antidiabetic, antifungal, and antibacterial properties. The leaves are used to wrap food ingredients during steam cooking, and the subsequent infusion resulting from the leaf contents lends the dish a unique flavor, earthy aroma, and taste Both fresh as well as dried lotus leaves can be used to make Naivedyam offerings to the gods. The leaves are utilized for packaging meat, sweets, and flowers, as well as to wrap prepared dishes [Fig. 4(b)]. (Mishra, 2014) The leaf powder prevents oxidation when prepared food is chilled for storage [14].

3.7 Terminalia catappa

Terminalia catappa is known as Indian almonds, which is a tropical fruit of medium size. It is also known in Indian languages as badam. The size of the leaf15–25 cm

long Fig. 4(c)]. It is also used as medicinal antibacterial, antifungal, antiviral, antioxidant, and antidiabetic.

Fig. 4.(c) the leaves of Indian badam, *T. catappa,* (d) the hand stitched dining plate made from the leaves of Indian badam,

Hand-stitched fresh leaves are used to serve food on bowls. Figure 4(d) In the past, rural women who were seeking for additional earnings often made dishes out of badam leaves. Eating from these plates protects against kidney, liver, and also throat issues because the leaves stand for nutrients. Additionally, they serve as coverings for food when steam-cooking badam leaf kudubu, an Udupi cuisine specialty from Karnataka.

3.8 Borassus flabellifer

Indian languages have several names for the palmyra palm, including thati, toddy, tala, tad, and numerous others. In addition to the tropical parts of Africa, it is widely grown in many south Asian nations. Among other Indian states, it is also created in Andhra Pradesh, Telangana, Tamil Nadu, and Maharashtra.The top of the tree is covered in a great number of stiff, fan-shaped leaves that are about 3 meters long and 1 to 1.5 meters wide. The leaves have been divided into lance-shaped sections that are folded along the midvein. [Fig 5(a)]. The palmyra palm has a variety of medicinal properties, including The leaves consist of phenolics, flavonoids, glycosides, tannins, proteins, steroids, triterpenoids, carbohydrates, and lipids, which have antibacterial, antifungal, and antioxidant activities.[Figure 5(b)]. In addition to being used for fuel and chingfibre, the leaves are utilized to produce country um-brellas, fans, hats, cushions, boxes, and pots. Ancient Indian texts were written on leaves of the tala patra plant. Ropes, belts, and links are made from the fiber extracted from the leaves. To package and transport meat, a solitary young leaf is folded into a circle and fastened with leaf fiber. The same packaging is used for mun-jelu, a jelly endosperm made from the seeds of unripened fruit, and burra gunju, sweet seeded kernel, white in colour obtained from the toddy tree's

developing seeds.The sensitive folded leaf is also used to make Kallu, a fermented drink of sweet sap from the newly emerged flowering of the toddy tree.

Fig. 5.(a) The leaves of thati, *B. flabellifer*, (b) hand oven leaf basket of made from thati is used for storing star gooseberry fruits and (c) packing of toddy jaggery in leaf baskets of thati

In the Chittur area of Andhra Pradesh, roadside eateries steam-cook marinated chicken in pots using the tender leaf that has been folded and sealed in a circle. Farmers frequently utilize the leaf for a meal plate when there aren't any other huge leaves available for usage in the fields. The solitary veins in the leaves are frequently utilized to carry and anchor fish as well as skewer meat. Sugarcane, toddy jaggery, as well as mangoes, coconuts, groceries, flowers, and wooden children's toys, are packaged in toddy leaf baskets [Fig 5(c)]. Circular leaf stands are used to protect and balance circular hot utensils like pots and [15]

3.9 Artocarpus heterophyllus

It goes by several names in different Indian languages, including panasa, chakka, phanas, and others. The moderate to large-sized, evergreen jackfruit is primarily found in the Western Ghats of India and other countries in South Asia. It is abundantly distributed throughout India's states. The leaves have an elliptical form, are leathery, 4–25 cm long, and have an acute tip [Fig. 6(a)]. They are used as a treatment for a number of illnesses. It functions as an antimicrobial, antifungal, and antibacterial medical characteristic. [Fig. 6(c)] These are single-use, disposable plates made from freshly sewn leaves. Eating from plates made from jackfruit leaves enhances digestion and balances the body's pitta dosha. The leaves are also used as a covering for hand-woven baskets for the purpose of steam cooking panasabuttalu, Andhra pottikkalu, kottekkalu, idli, kottekadubu, and kumbilappam in the states of Karnataka, Goa, Kera-la, Andhra Pradesh, and Maharashtra [Fig. 6(d-e)]; and in its various forms of as a covering layer for baked goods. In Kerala, leaf cones known as plavilakori are also utilized as spoons for drinking kanji, a soup made from rice starch [Fig. 6(b)] [16].

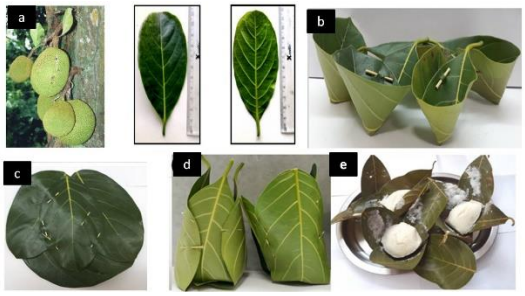

Fig. 6.(a) Leaves Artocarpus heterophyllus, (b) the cones, plavilakori made with the jackfruit leaves are used as spoons for drinking kanji, (c) the hand stitched dining plate made from the leaves of jackfruit, (d) the hand woven jackfruit leaf baskets, panasabuttalu and (e) the steam cooked Andhra pottikkalu in leaf baskets.

3.10 Ficus bengalensis

In Indian languages, the banyan tree is referred to by numerous names, such as vata, bar, and others. It is considered a frightening flower in India, where temples and shrines are frequently built beneath it. It is regarded as timeless and exemplary of eternal life, serenity, and harmony due to its unique immortality.In indigenous medical systems like Ayurveda, Siddha, Unani, and homoeopathy, various plant sections like bark, fruits, aerial branches, vegetative bubs, leaves, prop roots, and latex are commonly used in the prevention and treatment of various ailments. [Fig. 7a]] Robust, leathery, whole, elliptic to ovate, measuring 10–20 x 8–20 cm, with a blunt tip, stalked, having reticular pinnately veined leaves.

Fig. 7.(a) The leaves of banyan, *F. bengalensis*, (b) the hand stitched dining plate made from the leaves of banyan, (c) the leaves of aswatha, *F. religiosa*, (d) the hand stitched dining plate made from the leaves of aswatha,

The leaves have a variety of medicinal properties, including antioxidants, antibacterial properties, and so on [Fig. 7(b)]. Disposable plates and food wraps are made from the leaves. It is also a host tree for the lac moth [12]

3.11 Ficus religiosa

Indian languages also refer to Ficus religiosa by the names aswatha, bodhi, bo, peepal, and raavi. In addition to giving humans and other creatures shade, the tree provides habitat for birds and insects. Because Gautama Buddha attained enlightenment (Buddha) while meditating beneath the bloom, Buddhists revere this sacred fig.
It is seen as a representation of happiness, wealth, harmony, enlightenment, immortality, and good fortune. Plant components like roots, bark, latex, leaves, fruits, and seeds have differing degrees of therapeutic usefulness. The leaves have a cordate shape with prolonged tapering ends (drip tip), are shiny, thin, leathery, reticulately vented, and scaled to a length of around 10–17–8–12 cm [Fig. 6(c)].A variety of amino acids, sugars, sterols, tannic acid, triterpenes, hydrocarbons, and fatty alcohols are among the many compounds found in the high protein content leaves. They have been used in traditional medicine to treat wounds, diabetes, hematuria, vomiting, toothache, diarrhea, migraine, gastric, ophthalmic, and skin conditions. Leaves are associated with several health benefits, including anti-inflammatory, antivenin, analgesic, antioxidant, wound healing, antibacterial, antifungal, and laxative effects [Fig. 6(d)] To serve food, the leaves are manually sewed onto the plates. The components in the plates made up of leaves combat jaundice, stimulate red blood cells, and guard against throat infections ([12]

4 Conclusion

Renewable, biodegradable, non-toxic, abundant in antioxidants, and having religious, medical, and socioeconomic value in Indian culture are just a few of the many benefits that biodegradable materials have over plastic. It is clear that there is a lot of room for innovation when it comes to raw material quality, product range, design enhancement, manufacturing process, and marketing when using leaves as packaging materials. Leaves have some characteristic features such as these don't contain any toxin, dyes or irritants, these are flexible which allow easy folding without breaking and these possess strong water proofing quality. It is very certain that not all leaves serve as suitable packaging material for wrapping and carrying purpose. Hence it is urgent requirement to assess different design parameter of leaves so that the standardization of suitable ~~leave~~ leaf can be recommended to be used for industrial designer to develop package design.

5 Future Scope

Leaf-based packaging seems like a smart move. It not only offers an eco-friendly solution but also enhances the overall aesthetic appeal, especially for upscale establishments like luxury goods stores, high-end restaurants, and exclusive food shops. Customers are becoming increasingly conscious of environmental impact, so providing packaging that aligns with their values can be a significant selling point. Plus, it adds a unique and

natural touch to the presentation of products, which could further elevate the perceived value of the items being packaged.

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6. They are perfect natural antioxidants due to their excess of polyphenols, which are prone to be leached into food (Somayaji and Hegde 2016).
7. machine-pressed plates are transported to the states of Andhra Pradesh, Bihar, West Bengal, Telangana, Madhya Pradesh, Karnataka, Maharashtra, and Gujarat (Dash 2015; Singh 2018; Vasundhara, 2018).
8. Quercetin flavonoids, which have antibacterial, antimicrobial, antioxidant, anti-inflammatory, and anti-diabetic activities, are abundant in the bilobed, 10-46 cm long leaves [Fig. 1(b)] (Chouhan and Saklani, 2013).
9. These leaf plates are frequently used as meal plates at homes, hotels, marketplaces, weddings, group feasts, and other events when food is served to a significant amount of people (Chouhan and Saklani 2013).
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11. , West Bengal, Maharashtra, Kerala, and Punjab.It is a sacred tree to Buddhists and Hindus, with pinnate, trifoliate, and 10–15 cm tall branches [Fig. 1(e)] (Prasad and colleagues, 2006).
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15. Circular leaf stands are used to protect and balance circular hot utensils like pots and pans (Jamkhande et al. 2016)
16. In Kerala, leaf cones known as plavilakori are also utilized as spoons for drinking kanji, a soup made from rice starch [Fig. 6(b)] (Today 2017; Sidhu 2012).