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Unique pandanus - Flavour, food and medicine

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Abstract

Pandanus /screw pine has around 600 species of pine family Pandanaceae. All parts of the plant are useful. The leaves of Pandanus are used for thatching and making mats, hats, twine, sails, baskets, and fibre products, especially from pandanus palm (*Pandanus tectorius*) and the common screw pine (*P. utilis*). Leaves of *P. amaryllifolius* are used in Southeast Asian cooking. The fleshy fruits and seeds of *P. utilis* and *P. leram* are edible. Due to the exotic fragrance, *Pandanus odoratissimus* flowers are used for preparing perfumes. Long aerial roots of Pandanus species contains strong fibers, which are used for making ropes and baskets. Pandanus contains phytochemicals like steroids, carbohydrates, phenols, isoflavones, coumestrol, lignans, alkaloids, glycosides, amino acids and vitamins. Significant Pharmacological activities reported by scientists are anti-microbial, anti-diabetic, anti-viral, anti-neoplastic, anti-oxidant, anti-diuretic, analgesic and neuroprotective. We systematically reviewed and compiled information about pharmacognostic, phytochemical, pharmacological and nutritional aspects of Pandanus plant.

Keywords: Pandanus, Pandanus odoratissimus, Pandanus fascicularis, Antioxidant, Anti-Diabetic, Analgesics

Introduction

Pandanus genus has around 600 members and are found from West Africa eastward to Hawaii [1]. The species range from a few feet high to 100-feet tall trees. Pandanus genus is divided into two large subgroups, first used for the fruit and second group used for the seeds. Plants with edible fruit or seeds are usually oily and mainly composed of carbohydrates, proteins and are generally known as “marita”. The major species of pandanus are mentioned in table 7. The species *Pandanus tectorius* which includes *Pandanus leram*, *Pandanus fischerianus* are cultivated for their edible fruit which is mostly red or yellow in colour [2, 3]. The Pandanus species which produces edible seeds is the ‘karuka’ of New Guinea (*Pandanus brosimos* / *Pandanus julianettii*).

There are around 30 to 40 species of Pandanus in India. *Pandanus odoratissimus*, commonly known as kewda, belongs to the family Pandanaceae [4]. It is widely distributed in India over coastal districts of Orissa, Andhra Pradesh, Tamilnadu and to some extent in parts of Uttar Pradesh [5]. Kewda is said to restore health, strength and over all well-being of an individual. Essential oils are extracted from the highly scented male inflorescence of *Pandanus odoratissimus* [6]. As per Ayurveda, it is useful in treating headaches, earaches and rheumatic pains. It is commonly used as breath freshner and is also used for flavouring foods since ancient time.



Pandanus tree



Pandanus Shrub

~ 8 ~

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Pandanus unripe and ripe Fruit

Pandanus Stem

Natural Habitat: Pandanus species mainly grows in forest habitat or near sea shores [7]. Sea level of 66ft is most suitable for its growth, but can grow at elevation upto 1970ft. The plants are found growing along seashores, river banks, ponds, canals and other water bodies [8]. It grows in tropical climate, where it can withstand strong winds and droughty salty sprays. It grows quickly.

Cultivation and Collection: Kewda is mainly cultivated in the Ganjam District of south Orissa in India. The tree flowers after 3 to 4 years of planting. Flowering occurs in rainy season and the flowers are mainly harvested in the early morning. Male plants are valued for their fragrance and other products. The fully matured tree bears 30-40 spades a year and is used for the production of Kewada water, Kewada Attar and Kewada oil. Thousand flowers of kewda yield about 30gm of kewda oil [9].

Climatic conditions for the Cultivation of *Pandanus odoratissimus* are [2, 10]

Light: Pandanus plants flourish in spotted or direct sunlight. In the summer, non-adaptable plants should not be exposed to direct sunlight to prevent scorching. In the winter abundant light will be beneficial for the growth.

Soil: It can grow in light to heavy textured soils viz. sands, sandy loams, loams, sand clay loams, clays, saline soils, light-coloured, infertile coralline atoll sands, alkaline sands, thin soil over limestones. Well drained Fertile soil is preferable for raising the plant.

Soil Drainage: Pandanus grows in soils with free or impeded drainage, including seasonally waterlogged soils.

Soil acidity: Pandanus grows in soil with acidic to alkaline pH 6-10

Rainfall: Pandanus can be drought-tolerant, especially when they get a little bit older. Pandanus mainly occurs in area with annual rainfall with 1000-2000 mm with no or short dry conditions.

Temperature: Mean annual temperature required for the growth of Pandanus is 24-28 °C.

Propagation methods of Pandanus [11]

It is propagated mainly from seeds but can also be propagated from branch cuttings. The plant can be cultivated by division of suckers or by off-sets. In branch cutting, shorter laterals including one or more aerial or prop roots of length 30-40cm are chosen. Leaf area is reduced by about 70% by cutting and trimming the leaves. It is preferable to plant the cuttings immediately or shortly after collection.

Division of suckers: Trim the sucker by removing the main

root or stolon (creeping underground stem) up to the fibrous roots. Reduce long, leafy shoots by about half to limit drying out of the sucker after planting and to promote bushy re-growth. Sucker is planted into fertile, free draining soil enriched with organic matter such as well rotted garden compost, manure or leaf mould.

Growth: Growth of the plant varies with the variety, sex and type of planting stock. In seedling plants, there is 4-5 year of juvenile phase followed by 5-12 years of erect trunk growth phase. Flowering commences at about 15 years and continues for 40 to 50 years. The growth rate of stem is from slow to moderate i.e 2-80 cm per year. The plants raised by branch cutting usually grow faster in earlier years i.e 50-80 cm per year and start flowering in 2-6 years, producing 10-40 male flowers per year. The life span of pandanus plant is typically 50-80 years. Sexually mature plant produces about 8-12 fruits per plant every second year. Weight of fruits is about 1 to 1.5 kg per plant².

Harvesting of leaves begins fourth year onwards. Leaves can be harvested every 3 months for the period of 5 - 10 years. Healthy plant yield about 10-90 leaves per year on less fertile sites and 150-300 leaves per year on optimal sites

The fully mature kewda tree produces about 30-40 flower spikes each year. In India flowering season is divided into three different seasons [12]:

- Hot Season (May-June) contribute 30% of the total yield
- Rainy Season (July-September) contribute 60% of the total yield and thus it is the main season.
- Cool Season (October-November) contribute a little about 10% of the total yield.

During these seasons the flowers are harvested for the period of forty days.

Storage: Pandanus leaves can be stored in refrigerator for four days. For longer duration storage leaves are frozen on baking sheet. These frozen leaves can be stored for 6 months.

Flowers of Pandanus are immediately used after harvesting, for extracting oil. This is done to extract the volatile constituent 2-phenyl ethyl-methyl ether responsible for imparting the fragrance. The fragrance is lost after opening of the male inflorescence [13].

Pharmacognosy

Taxonomical classification [13]

Plant name: Pandanus odoratissimus Linn

Kingdom: Plantae-plants

Subkingdom: Tracheobionta

Family: Pandanaceae

Genus: Pandanus

Species: Pandanus odoratissimus

Botanical Description [1, 2]

Flowers: The Pandanus species have large, terminal, pendulous, compound, leafy, raceme, having linear-oblong, pointed white to yellow petals. In the axill of each flower there is thyrus of small and simple recemes of long and pointed anthers.

Fruit: Fruit of pandanus is rich orange coloured, compound, oval shaped, having 6-8 inches diameter, 6-10 inches length and 4-8 pounds in weight. The fruit is composed of numerous wedge shaped drupes. After ripening of the fruit their large

exterior ends get detached from one another and get covered with firm orange coloured skin. The exterior half of the drupes (next to the apex) consists of dry spongy cavities and the lower part next to the core is yellow, made of a rich-yellow coloured pulp.

Seed: The seeds are obovoid, ellipsoid or oblong (6-20 mm) long, red-brown outside and whitish inside.

Trunk: The plant has single, 1 feet high trunk with very large, spreading bush. Large descending carrot-shape pointed roots emerge from the stems and large branches, descending towards the ground. Initially the material of solid wood of trunk is like cabbage stem and as the time passes acquires a woody hardness on the outside.

Root: The root system of plant is dominated by thick spreading roots from the lower part of the trunk (1-1.5 feet). The subterranean root system is concentrated in the surface layers of soil.

Microscopic Characteristics^[14]

Transverse Section of Leaf (Surface View): TS of leaf showed the presence of single layered thin walled epidermal cells on upper and lower side. Covered with unicellular, lignified trichomes that are pointed at one end. Mesophyll forms the bulk and is differentiated into thin walled, large, polyhedral, colorless parenchyma with intercellular spaces and 3 to 4 layered, tightly arranged spongy parenchyma (Chlorenchyma). Calcium oxalate crystals are present in parenchymatous cells of mesophyll. Collateral vascular bundles were seen at regular intervals and have protoxylem followed by metaxylem towards upper epidermis and phloem followed by bundle sheath extension (sclerenchyma) towards lower epidermis. The whole vascular bundle is covered by border parenchyma.

Organoleptic Characteristics

Leaves of *Pandanus odoratissimus* are pale yellow green in color with a characteristic odour. They are about 6-8 feet in length and 2'' width. The leaves have spiral and tristichous phyllotaxy. The apex of the leaves is sharp with spines at the margin. The lamina of the leaves is linear, simple with parallel, palmate and convergent venation with distinct midrib.

Powder microscopy

Coarsely powdered, shade dried leaf of *Pandanus odoratissimus* is light green in colour with characteristic odour and acrid taste. It primarily consists of scalariform and annular xylem vessels, thick walled unicellular trichomes which are lignified, pointed at one end and paracytic stomata with straight walled epidermal cells surrounding it. Prism and acicular needle shaped crystals of calcium oxalate are scattered in Parenchyma.

Leaf Surface Data.

The value of stomatal index of upper epidermis of leaf is 23 and value of stomatal index of lower epidermis is 56.

Nutritional aspects

The fruit of selected edible cultivated varieties (Table 4, 5) having low amounts of calcium oxalate crystals are consumed raw or cooked. The fruit is used to prepare jam and juice. The

flesh of fruit contains Provitamin-A carotenoid^[3, 21]. Thus it has the potential to alleviate vitamin-A deficiency. The food containing carotenoids can protect against diabetes, heart diseases and cancer. Pandanus fruit is also a good source of vitamin C (ascorbic acid), thiamine, riboflavin and niacin (vitaminB3).

Pharmacological effects

In the traditional medicine, Pandanus is used for multifaceted medicinal activities which kindled scientific interest. Many studies are carried out to check the vast pharmacological activities of Pandanus plants. The details of the species wise activities, the part of the plant used, type of extract used and phytoconstituents responsible for it are described in Table-6:

Different products from *Pandanus odoratissimus* and *Pandanus fascicularis*^[12]

Kewra oil (rooh kewra), kewra attar, kewda water are the perfumery and flavouring products obtained from *Pandanus fascicularis* and *Pandanus odoratissimus*. For preparing these products kewra flowers are collected in the early morning using plucking sticks. The collected flowers are subjected to distillation with water, in the distilleries to get the perfumery products.

- **Kewra attar:** The outer green spinuloses pathes and the pointed tips of the spathe of the flowers are removed and then 1000 flowers are added in 60 litres of water and heated. The generated steam along with the vapour of kewda oil is made to pass through the sandalwood oil kept in the receiver. The sandalwood oil is maintained at lower temperature. The kewra aroma is gradually absorbed in the sandalwood oil to produce kewda attar. Kewra attar is the mixture of 3-5% of kewda oil in the sandalwood oil.
- **Kewra oil:** The essential oil from kewda flower is obtained by hydro-distillation and the technique involves repeated distillation of flowers. In this technique the receiver vessel does not contain base oil. About 30 g of pure oil can be extracted from 1,000 flowers. The oil is commonly known as kewra rooh.
- **Kewda Jal:** Kewda water is prepared by distilling the flowers with water in the similar manner and collecting the distillate in an empty receiver vessel. Distillation of 1000 flowers yields about 10-18 l of kewda water. Kewra water contains about 0.02% of kewra oil^[13].

Uses^[15, 16]

Uses of leaves

- *Pandanus amaryllifolius* is well-known as the only *Pandanus* with scented leaves. The sweet smell of freshly harvested leaves is similar to the fragrant rice of variety Basmati (India), Jasmine (Thai) and Kaorimai (Japan). Leaves of *Pandanus amaryllifolius* are used in Southeast Asian countries to provide special aroma to rice, curry etc. In case of desserts it is used for making pandoma cake. It is also used as a supplement to chocolate.
- In *India*, after soaking the leaves in coconut oil, the oil is employed for rheumatic troubles. The juice of leaves and inflorescence is used to treat chest pains, reduce fevers, and inflammation from arthritis in humans as well as in animals.
- Leaves of *Pandanus amaryllifolius* are used as natural colourant due to presence of high chlorophyll content.

- Infusions of the leaves are used internally and externally as a sedative against restlessness.
- Chewing the leaf of *Pandanus odoratissimus* maintains oral health and stops bleeding gums.
- The leaves are also used to ease stomach cramps and spasms, and are given to women recovering after childbirth.
- Extracts of the leaves can be added to bath water for skin problems and relief from sunburn.
- The fibers of Pandanus leaves are also useful for making high quality handmade paper, in making hats and various types of baskets.

Uses of flowers

- In India (mainly Orissa) and Sri Lanka the flavourings and perfumes 'kewda attar', 'kewda water' and 'kewda oil/ rooh kewda' are prepared from the male inflorescence of *Pandanus odoratissimus*. The characteristic aroma of kewda oil is due to 2-phenylethyl methyl ether, which constitutes 66-85% of the total constituents.
- The most important use of kewda attar is in tobacco preparations, but it also serves to flavour betel-quid and to scent clothes, bouquets, lotions, cosmetics, soaps, hair oils and incense sticks. Pan Masala and Gutka is the largest consumer of Indian attars. The purpose is to mask the unpleasant odour of tobacco by imparting fragrance to the preparation which is well accepted by masses.
- Kewda attar and kewda water are both used for flavouring food, sweets, such as kheer, custard, petha, Ras-malai, barfi, gajarhalwa, pulao, biryani etc. It was the preferred flavor relished by the royal families since ages.
- In Indonesia also the male inflorescence is used to scent clothes, in the preparation of fragrant oils and in ceremonies.

Use of roots

- Long aerial roots of many Pandanus species (*Pandanus tectorius*, *Pandanus amaryllifolius*, *Pandanus dubius* etc.) contain very strong fibers, which are mostly used for making ropes and baskets.
- The root of *Pandanus amaryllifolius* boiled in milk can cure female sterility and can prevent a miscarriage.
- The root is used traditionally to treat STD's, namely, syphilis.

Strange Facts

- *Pandanus odoratissimus* is used as living fences, coastal windbreaks, and it is planted for soil stabilization and as an ornamental plant.
- *Pandanus amaryllifolius* is used as environmental friendly pest management tool to keep out cockroaches.

- Pandanus flowers are offered to lord Ganesha during 21 pushpa pooja.
- Pandanus flowers are also employed in pooja of Lord Shiva in the month of Shravan/july
- Snakes cohabit near Pandanus plants due to their fragrance.

Table 1: Indian and International Names

Indian State	Common name
Assam	Keteki, Ketakiphul
West Bengal	Ketaky, Ketaki, Keori, Keya
Gujrat	Kewoda
Urdu	Keora
Kannada	Tale hoovu, Kedige
Malyallam	Kaitha, Kaida, Thala
Marathi	Kewada, Kenda, Keura
Oriya	Kia
Sanskrit	Ketaka
Telgu	Mogil, Mogheli
Country Name	Common Name
Norwegian	Skrupalme
Spanish	Pandan, Pandano
Sweedish	Skruvpalm
Burmesisch	Tsattapu
Danish	Skruepalme
Dutch	Schroefpalm, Pandan
English	Umbrella tree, Screw pine, Screw tree
Estonian	Lõhnav pandan
Finnish	Kairapalmu
French	Pandanus
German	Schraubenbaum, Schraubenpalme
Hungarian	Panpung víz, Pandánusz víz (pandanus water)
Italian	Pandano
Portugese	Pandano
Oriya	Kia
Norwegian	Skrupalme

Phytochemistry ^[17]

Table 2: Phytochemical extracts

S. No.	Parameter	Determined value in %w/w
1.	Extractive values	
	Alcohol soluble extractive values	10.00
	Water soluble extractive values	21.00
2.	Moisture content	07.80
3.	Ash Value	
	Total ash	8.7166
	Acid Insoluble Ash	8.3050
	Water soluble ash	3.6950
	Sulphated Ash	8.000

a. Extractive values b. Moisture content c. Ash values of *Pandanus odoratissimus* leaves

Table 3: Chemical Constituents ^[18-21]

Plant part	Type	Constituent Name
Roots	Steroids	α -spinasterol, stigmast-7-en-3 β -ol, α -spinasterolcaproate, stigmast-4-en-6 β -ol-3-one.
Roots	Phenols	Vanillin, 2(E)-3-(3'-methoxy-4-hydroxyphenyl)-prop-2enal 4-hydroxy-3-(2',3'-dihydroxy-3'-methylbutyl)-benzoic acid methyl ester
Roots	Benzofuran	3-hydroxy-2-isopropenyldihydrobenzofuran-5-carboxylic acid methyl ester
Roots	Lignans	Eudesmin, kobusin, Pinoresinol, Epipinoresinol 4'-O-methyleudesmin, 3,4-bis(4-hydroxy-3-methoxy-benzyl)-tetrahydrofuran
Rhizomes	Flavone	Physcion, Cirsilineol, n-triacontanol, β -sitosterol Camphosterol, Daucosterol and Palmitic acid
Leaves	Alkaloids	Pandanamine and Pandamerilactones
Fruit	Vitamins	Vitamin C (ascorbic acid), Thiamine, Riboflavin, Niacin and vitamin B-3

Table 4: The 100g fruit flesh of pandanus contains [3, 20, 21]

Energy	228 kilocalories
Water	80 g
Carbohydrates	17 g
β-Carotene	19-19,000 µg
Vitamin-C	5 mg
Protein	1.3 g
Fat	0.7mg
Fiber	3.5 g
Calcium	134 mg
Phosphorous	108 mg

Table 5: Nutritional facts of oven dried seeds of Karuka (*Pandanus brosimos*) per 100g²

Water	6-10 g
Protein	8.5-14 g
Fat	0.7-35 g
Fibre	5-12 g

Table 6

Pharmacological Activity	Plant Extract	Plant Part and species	Phytoconstituent present in extract
Anti-convulsant [22]	Ethanol extract	Leaves of pandanus odoratissimus	Glycosides, Flavanoids, Alkaloids
Anti-oxidative [23-25]	Ethanol extract	Leaves of Pandanus amaryllifolius	Phenols, Flavanoids and tannins.
Anti-viral ²⁶	Saline extract	Leaves of Pandanus amaryllifolius	Lectin, a mannose binding protein.
Anti-diabetic [27-29]	Ethanol extract	Leaves of <i>Pandanus amaryllifolius</i>	Flavanoids and tannins
Anti-inflammatory [30, 31]	Aqueous and ethanolic extract Chloroform extract	Prop roots of <i>P. fascicularis</i> Leaves of <i>Pandanus fascicularis</i>	Flavanoids, Glycosides and Alkaloids. Steroids, Terpenoids, Flavonoids Saponins and tannins.
Neuroprotective Activity [32]	Ethanol Extract	Leaves and root of <i>Pandanus odoratissimus</i>	Glycosides, Flavanoids and alkaloids.
Analgesic Activity [31, 33, 34]	Aqueous/ethanolic Extract Chloroform extract	<i>Roots of Pandanus fascicularis</i>	Glycosides, flavonoids and alkaloids. steroids, terpenoids, flavonoids, saponins and tannins.
Antitumour Activity [35]	Methanol and aqueous extract	Dried Roots and Leaves of <i>Pandanus odoratissimus</i>	Stigmasterols
Nocturnal Enuresis [36]	Methanolic extract	Leaves of <i>Pandanus odoratissimus</i>	Polyphenols
Anti-microbial [36-38]	Methanolic extract	Leaves of <i>Pandanus odoratissimus</i>	Alkaloids and Flavonoids
Anti-diuretic activity [36]	Aqueous and ethanolic extract	Prop roots of <i>Pandanus fascicularis</i>	Alkaloids, glycosides and flavonoids.
CNS Depressant activity [39]	Methanol extract	Leaves of Pandanus odoratissimus	Saponins and flavonoids
Hepatoprotective Activity [40]	Ethanol extract	Roots of Pandanus odoratissimus	Alkaloids, Flavonoids and Glycosides

Table 7: Availability of Pandanus in different countries and their botanical names

Country name	Botanical name	Edible/Non Edible
Australia	<i>Pandanus spiralis</i>	Edible fruit
Bangladesh	<i>Pandanus amaryllifolius</i>	Edible leaves
Brazil	<i>Pandanus utilis</i>	Edible fruit
India	<i>Pandanus odoratissimus</i>	Non edible flower
Indonesia	<i>Pandanus conoideus</i>	Edible fruit
Malaysia	<i>Pandanus furcatus</i>	Edible fruit
Nepal	<i>Pandanus furcatus</i>	Edible fruit
Phillipines	<i>Pandanus tectorius</i>	Edible leaves and fruit
Srilanka	<i>Pandanus tectorius</i>	Edible leaves and fruit
Thailand	<i>Pandanus biplicatus</i>	Non edible
Nicobar island	<i>Pandanus leram</i>	Edible fruit
Africa	<i>Pandanus candelabrum</i>	Edible seeds, fruit and leaves
Madagascar	<i>Pandanus pygmaeus</i>	Non edible
New Guinea	<i>Pandanus julianettii</i>	Edible seeds

Table 8: Botanical Description of Plant

Fruit type	Tropical
Edible part	Fruit, Seeds (<i>P.tectorious</i> , <i>P.dubius</i>)
Shape of fruit	Oval
Spa-dices per tree	20-30
Texture	Rough
Taste	Pineapple taste

Conclusion

The research on pandanus plants reveals its huge biological potential. The plant has multifaceted medicinal properties like anti-convulsant, anti-oxidant, anti-viral, anti-diabetic, anti-inflammatory, neuroprotective, analgesic, anti-neoplastic, anti-microbial, anti-diuretic and CNS depressant etc. It is used to treat nocturnal enuresis. In Ayurveda, the oil yielded from the pandanus plant is used to treat headaches, earache and rheumatic pains. The plant contains lignans, is of lavones, phenolic compounds, steroids, saponins, terpenoids, glycosides, tannins, flavonoids in the extract. On the basis of biological activities of *Pandanus odoratissimus* studied in animals, further clinical trials and product development are

needed to establish the biological activities in human beings. Identifying the chemical constituents responsible for specific activities is essential for further development.

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