

## Review article

# AN OVERVIEW OF *Pandanus amaryllifolius* Roxb.exLindl. AND ITS POTENTIAL IMPACT ON HEALTH

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### Abstract:

**Background:** Pandan (*Pandanus amaryllifolius* Roxb.ex Lindl.), a plant belonging to Pandanaceae family, mainly native to South-east Asian countries. Pandan leaves are widely used in South East Asia for flavouring various food products such as bakery products, sweets and even home cooking because of its distinct and pleasant aroma. This aroma is due to the presence of the compound 2-acetyl-1-pyrroline (2AP) and is the only species of Pandanus genus with scented leaves. Many studies revealed that Pandan is a rich source of flavonoids and phenolic compounds. Leaves of Pandan can be used for diuretic, cures headache, fever, arthritis etc. It exhibits several bioactivities such as antiviral, antioxidant, antihyperglycemic, anticancer, antimicrobial activities including food preservatives and its industrial applications. **Objective:** This review focuses on an overview of different literatures that includes the effect of crude extract from PA leaves on the management of various diseases, health related problems and combat them and its effect is due to the presences of phenolic compounds, flavonoids, alkaloids, essential oils etc. and this may be useful to the health professionals, scientists and scholars working the field of pharmacology and therapeutics to develop evidence-based alternative medicine to cure different kinds of diseases in man and animals. **Method:** For this review, we conducted searches using both scientific databases e.g., PUBMED, Science Direct, SCI-HUB and Elsevier for scientific studies, as well as, commercial search engines such as google, google patent, google scholar, India Biodiversity portal and we carried out different literatures survey that has been worked on this plant. **Discussion and Conclusion:** In this review article, an attempt has been made to compile the reported literatures of this plant and we have found out that Pandan is use as a source of therapeutic values against various diseases. Extensive studies can be carried out in this plant for further exploration of the necessary and potential benefit for the development of better medicinal products.

**Keywords:** *Pandanus amaryllifolius* Roxb. ex. Lindl., Pandan, 2-acetyl-1-pyrroline(2AP); antiviral, antioxidant, antihyperglycemic, anticancer, antimicrobial, food preservatives, industrial applications.

## Introduction:

The World Health Organization refers to “Good-Health” as a state of physical and mental well-being not altered by any disease or ailment [1]. Globally, medicinal plants have been used as a source of medicine and 80–85% of populations rely on these medicinal plants using the extracts or their active components as traditional medicine to meet their primary health care needs. A number of active components were isolated from medicinal plants for direct use as drugs, or act as a lead compound or pharmacological agents [2]. One of the medicinal plants that has been used traditionally in South-east Asian Countries and is believed to have medicinal values in various disease is Pandan (*Pandanus amaryllifolius* Roxb, ex Lindl.), a member of screw pine belonging to the family *Pandanaceae*, is a tropical herbaceous plant with aromatic scent [3]. It is commonly known as ‘*pandan-wangi*’ or ‘*fragrant screw pine*’ because they resemble the pineapple with the spiral arrangement of long, narrow and strap-shaped green leaves [4]. The genus *Pandanus* from the family *Pandanaceae* comprises approximately 600 species distributed in tropical and sub-tropical regions [5]. Among them only nineteen species of *Pandanus* are recorded in India [6]. This is the only species with *Pandanus* genus having scented leaves due to the presence of the compound 2-acetyl-1-pyrroline (2AP) [7]

It was first described by Scottish botanist William Roxburgh in 1832 and revised by American botanist Benjamin C. Stone in 1978 from the Maluku Islands, Indonesia and the rare presence of male flowers in these specimens may indicate that it is the origin of the species [8;9;10]. It is widely cultivated in the Asian countries such as Thailand, Malaysia, Indonesia, Singapore, Vietnam, New Guinea, Taiwan, Philippines, India where good moisture regimes are present in air and soil [10]. It is a vertical, green plant with fan-shaped sprays of long, narrow, blade-like leaves reaching a maximum height of about 4.5m and woody aerial roots [11]. The stems are slender, about 2-5 cm thick, decumbent, and ascending reaching 1.0-1.6 m tall. The leaves are middle to pale green, somewhat flaccid, more or less glaucous beneath and the apex with a very few prickles less than 1 mm long. The blades are commonly 25-75 cm in length and 2-5 cm in width, rarely with 1–3 small stout prickles on midrib near the base. The flowers are unknown and probably never produced. In its large growth phase, *P. amaryllifolius*

eventually produce erect stem reaching 2.0-4.5 m tall and 15 cm diameter, usually sparsely branched. The leaves are broad and linear with acute apex [7; 8; 9;10;12]. The plant is rare in the wild, female flowers are unknown, male flowers are very rare thus the fruits are unknown [7].

The sweet and delightful flavour of pandan leaves, which is well-known as a source of natural flavouring is commonly used in culinary arts such as food colouring, flavour enhancing and aromatic flavour into the dishes for its fragrant leaves [4]. Its aroma is distinct with a nutty to fresh hay flavour, that resembles to the fragrance found in certain varieties of expensive aromatic rice grown in southeast Asia, such as, Jasmine-Thai rice, Kaorimai- Japan rice, Basmati-India rice and other scented rice like Joha rice-Assam (India) [7]. The aroma is due to the presence of many volatile compounds in the leaves of *P. amaryllifolius*, particularly 2-acetyl-1-pyrroline [13;14;15]. However, the other alkaloids (such as, pandanamine, pandamerilactones) with pyrroline-derived structures are also found in the leaves. [16;17;18;19].

The Geneva-based International Standards Organization (ISO) has included *P.amaryllifolius* in the document 676 that lists 109 herb and spice plant species useful as ingredients in food [20]. Besides its culinary value, pandan leaves are used in the perfume industry and also medicinally as a diuretic, cardio-tonic, anti-diabetic and for skin disease. Tender shoots are directly eaten in the case of severe jaundice [7]. Furthermore, the leaves are used to refresh the body, reduce fever, and relieve indigestion, and are reported to contain various alkaloids and unglycosylated pandanin protein which exhibits antiviral activity [3]. Through this review we aim to highlight the latest work done on the extracts of *Pandanus amaryllifolius* Roxb. ex Lindl., focusing on certain major aspects, such as their importance as antioxidants, and their potential role in mitigating diabetes and cancer, as antibacterial and against tuberculosis disease, as dental anxiety, as food preservatives. Beforehand we will give a brief overview on several of the most relevant bioactive compounds typically found in many extracts, although through our work, we will continue referring to other compounds as it is understandable that both starting materials and extraction processes differ greatly. Furthermore, we emphasize that much of the current work continues to be experimental and as such, there is a section devoted to the toxicity effects,

which should always be considered, encouraging further research to develop better products for human use.

**Synonyms:**<sup>[21]</sup>

*Pandanus hasskarlii* Merr.

*Pandanus latifolius* Hassk.

*Pandanus odoratus* Ridl.

**Taxonomical classification:**<sup>[21]</sup>

Kingdom: Plantae

Phylum: Tracheophyta

Class: Liliopsida

Order: Pandanales

Family: Pandanaceae

Genus: *Pandanus*

Species: *Pandanus amaryllifolius* Roxb.

**Vernacular names:**

Based on the different countries languages it has various vernacular names viz: Rampe (Hindi); Jahapaat (Assamese) ; Ambemohor pat (Marathi) ; Ramba (Tamil); Pandan rampeh or Rampai (Sri Lanka, Java and derive) ; Pandan wangi (Malaysia) ; Toei-hom (Thailand) ; Seuke bangu (Acheh and Sumatra); Pandan mabongo {Phillippines(Luzon)}; Pondak{Moluccas Islands (Ternate)}[8;21;25]

**Traditional use and its medicinal properties :**

Pandan leaves are widely used in South East Asia for flavouring various food products such as bakery products, sweets and even home cooking because of its distinct and pleasant aroma [7;12;26;27;28]. The leaves are used as food flavouring and in traditional medicine in the Philippines, Thailand, and Indonesia [29].In India, *P.amaryllifolius* leaves are traditionally used for cooking common non-aromatic rice to impart a resemblance of the basmati aroma to the cooked rice. It is also used to flavour meat and vegetable products [3]. The dried leaves powder have been widely used in ice cream, yogurt, soup, cake, tea, a type of Malaysian traditional pandan-flavoured rice, and even Malaysian traditional coconut jam called “Kaya” [28; 30]. Juices extracted from the leaves are used as an

essence in cake industry and “Nasi lemak” in Malaysia and “Nasi kuning” in Indonesia; a popular breakfast menu is traditionally prepared by cooking the rice with coconut milk ‘santan’ and Pandan leaf. In India, leaves are sold in local markets traditionally to flavour rice, curries, milk, cakes, puddings and ice-cream. [7; 12; 27; 28]

Chopped leaves are mixed with petals of selected scented flowers to make a “Potapourri” which is arranged during traditional ceremonies in Malaysia stated that *P.amaryllifolius* essence can be a possible substitute to vanilla essence[9]. This species is also used in some traditional medicine such as remedy for toothache, rheumatism [17], diuretic [5], anti-inflammatory and for decreasing glucose concentration or hypoglycemic effect [31;32], ingredients for curing rheumatic and neuropathy, the roots extract are used to cure thyroid problems. In addition, the Taiwanese always use this plant to treat fever [33]. In Thailand, this is a traditional medicine for treating diabetes [34]. Tender shoots are directly eaten in the case of severe jaundice. The oil obtained from the leaf is described as stimulant and antispasmodic and is effective against headaches, rheumatism, and epilepsy and as a cure for sore throats [35]. Traditionally a mixture of Henna (*Lawsonia inermis* L.); *Limau purut* (*Citrus hystrix* DC.); coconut milk; milk and *P. amaryllifolius* leaf is used to clean hair and to provide fragrance. [7;10;36]

Leaves are used in perfume industry and also medicinally important as diuretic, cardio-tonic, anti-diabetic and for skin diseases. Leaves are soaked in coconut oil for several days and the oil is then used for rheumatic problems. Infusion of leaves is taken internally as a sedative in restlessness. In Thailand, this is a traditional medicine for treating diabetes [34]. Studies have established significant repellent activity of *P.amaryllifolius* against American cockroaches (*Periplaneta americana* L.) [37], but similar effects against other species of cockroaches have not yet been looked into. It is said that taxi drivers in Singapore and Malaysia keep bunches of *P. amaryllifolius*) in their taxis to ward off cockroaches. *P. amaryllifolius* has the secondary benefit of adding visual and olfactory pleasure to humans. Traditionally, leaves are used as medicine for women after childbirth in Malaysia and also for hair wash. It is also used for preparing lotion along with ash and vinegar to treat measles, purgative, in the treatment of leprosy, sore throat and as diuretic in Philippines [38]. Hot water extracts of the root

of this plant (reported as *P. odor* Ridl.) show hypoglycaemic activity, and 4-hydroxybenzoic acid has been isolated as the active principle [31;32; 39;40] stated that *P. amaryllifolius* essence can be possible substitute to vanilla essence. [7;10]

### **Methods:**

This review focuses on an overview of the current literature on *Pandanus amaryllifolius* and its extracts, highlighting the importance of the compounds found via several extraction methods and from different parts of the plant. In addition, we also show through, how the different extracts are currently being explored for their potential benefit in human research, much of what is described refers to either animal model or *in-vitro* research. In certain cases, extracts have been used currently used as alternative medicine as well as derived products because natural products are cheaper in price with less side-effects.

For the development of this literature review, we conducted searches using both scientific databases e.g., PUBMED, Science Direct, Sci-hub, Elsevier for scientific studies, as well as, commercial search engines such as google, google patent, google scholar, India biodiversity portal. For current research-based literature we used terms and boolean operators: “*Pandanus amaryllifolius* ” And “Traditional medicine” And/Or “Bioactive compounds of Pandanus ” And “Phytochemical” And/Or “Pharmacological”. For commercial applications we used terms such as “*Pandanus amaryllifolius* industrial applications”.

### **Phytochemistry:**

Over time, research has shown that *Pandanus amaryllifolius* Roxb. is rich in a wide range of compounds, of which several have pharmacological potential. As reported histochemical and preliminary phytochemical screening provides the general idea regarding the presence of primary and secondary metabolites revealed the presence of phytoconstituents such as alkaloids, terpenoids, flavonoids, saponins, anthraquinone glycoside and cardiac glycoside [41]. It is also mentioned that carbohydrate, tannins, flavonoids and saponins are present in the ethanolic extract of *Pandanus amaryllifolius*. A previously conducted study showed that compounds like flavonoids and saponins might be responsible for the antidiabetic activity

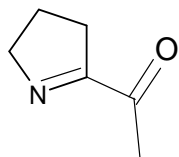
[42]. Recently Nurul AMZ with his co-workers conducted an analysis involving ethanol-water leaf extracts by using either soaking method or microwave-assisted extraction (MAE) that revealed the presence of phenolic compounds and flavonoids and possess antioxidant activity. [43]

Pandan leaf extract contains the free amino acids and reducing sugars such as glutamic acid, proline, glucose, and fructose as possible precursors to ACPY (2-acetyl-1-pyrroline) and might play significant role in the aroma ACPY formation. The major volatile compound in heated pandan and unheated pandan are 3-methyl-2(5H)-furanone followed by ACPY and 3-Methyl-2(5H)-furanone respectively. They also found that ACPY is the only compound that possessed pandan aroma characteristic by using GCO (gas chromatography-olfactometry) analysis [44]. The presence of 2AP(2-Acetyl-1-Pyrroline) was also determined using GCMS by using ethanol as the solvent to extract 2AP from Pandan leaves and the higher 2AP peak arises from ethanol chromatogram [45]. Additionally 30 aroma components also have been found of which the main ones are hexanal, 2-hexenal, 3-methyl pyridine, 2-penten-1-ol, nonanal, benzaldehyde and linalool [46;47]. In the study, Ali G suggested that pandan extracts showed good potential of bioactive compounds such as catechin, gallic acid, kaempferol and naringin. Pandan leaves contains Gallic acid, catechin, caffeic acid, myricetin, luteolin, and quercetin [4]

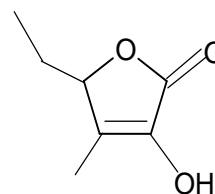
It is also reported that Pandanin, (mannose-binding protein) appears to be present in the saline leaf extract in minute amount elicits antiviral activity. Pandan leaves contain certain alkaloids like Norpandamarilactonine-A,-B, Pandamarilactam 3 $\alpha$ ,-3 $\gamma$ , Pandamarilactone-1, Pandamarilactonine A,-B,-C, Pandamarine, Pandanamine [48]. The other alkaloids (such as, pandanamine, pandamerilactones) with pyrroline-derived structures are also found in the leaves. [3]

As mentioned by Chiabchalard A [49], its in-depth phytochemical analysis has confirmed the presence of several compounds such as essential oils, tocopherols, tocotrienols, alkaloid, fatty acids, esters non-specific lipid transfer protein, carotenoids and flavonoids that act as a natural antioxidant and antidiabetic agents. PA leaf extract demonstrated higher antioxidant activity than that of root extract. The major flavonoid in plant is quercetin, which belongs to a flavonol class that could inhibit  $\alpha$ -glucosidase enzyme by

acting as a noncompetitive inhibitor[49;50]. Strobel P *et.al.* ; Bazuine *et.al.*, found that six flavonoid compounds; apigenin, luteolin, kaempferol, quercetin, genistein, and fisetin could inhibit glucose uptake in mouse fat cells. [51;52]



**Fig (i) ACPY (2-acetyl-1-pyrroline) furanone**



**Fig (ii) 3-methyl-2(5H)-**

### **Pharmacological properties of *Pandanus amaryllifolius* Roxb.:**

**Antidiabetic activity:** Diabetes or the lack of control over glucose concentration in the blood is rapidly rising as one of the major chronic degenerative disorders. World Health Organization projected that diabetes will be the 7th leading cause of death in 2030. As the disease progresses, it becomes a lifelong burden (physical and economical) over the patient, therefore lower cost treatments become necessary. Among the various methods and pharmacotherapies being developed, the use of *Pandanus amaryllifolius* extracts has steadily grown in interest since these herbs are cheaper and have fewer side effects as compared to synthetic drugs. According to several studies, Pandan leaves are seem to be used in the treatment of diabetes traditionally. Pandan leaf extract contained several compounds such as essential oils, tocopherols, tocotrienols, alkaloid, fatty acids, esters, non-specific lipid transfer protein, carotenoids, flavonoids and phenolic compounds that act as a natural antioxidant and antidiabetic agents. Chiabchalard A *et.al.*, found that PA extracts could inhibit  $\alpha$ -glucosidase enzyme and induce insulin production in rat pancreatic cell (RINm5F) in dose-dependent manner ( $P < 0.05$ )[49]. Sasidharan and co-workers also found that combination of ethanolic extract of *Carica papaya* and *Pandanus amaryfollius* leaf could reduce blood sugar levels in streptozotocin-induced diabetic mice [42]. Similar results were obtained in a study conducted by Peungvicha *et al.* using only *Pandanus odoratus* Ridl. root aqueous extract on normal rats, however, the antihyperglycemic mechanism remained



unclear[31;32]. Also the *Pandanus amaryllifolius* (PA) leaf water extract has the ability to reverse the metabolic syndrome symptoms, including obesity, hypertension, dyslipidaemia and hyperglycaemia in an established male Wistar rat model induced by 20% fructose in drinking water [53].

### **Antioxidant activity:**

Many studies previously reported that Pandan leaves and roots contain bioactive compounds such as phenolic compounds, flavonoids that act as antioxidant capable of scavenging free superoxide radicals, having anti-aging properties as well as reducing the risk of cancer. In the study Jimtaisong A and his co-authors, found that Propylene glycol extract of Pandan leaf exhibited higher DPPH activity and total phenolic content than the ethanol extract while the Pandan leaf demonstrated higher antioxidant activity than the root [47]. Thus, pandan leaf extract is a potential suitable natural antioxidant, which can serve as an alternative to synthetic antioxidants used in topical emulsion the plant extract showed significantly. Ali G *et.al.*, 2013 [4] explored the antioxidant activity of *Pandanus amaryllifolius* leaves from 3 different locations of Malaysia viz. Bachok; Klang; Pontian. In their study they identified 5 Flavonoids: catechin, naringin, kaempferol, rutin, epicatechin and 3 phenolic acids including gallic acid, cinnamic acid and ferulic acid in pandan extracts. The samples collected from the North (Bachok) exhibited the highest TP (Total phenolic), TF (Total flavonoid), antioxidant and anticancer activity while those from the Southern portion (Pontian) appeared to have the lowest content of TP, TF and antioxidant activity. It has been further reported that the ethanol extract of the leaves cultivated in Malaysia exhibited excellent heat-stable antioxidant property [54].Thatsanasuwan N *et.al.*, 2015 found that the highest antioxidant activity was observed at the particular percentage of ethanol concentration of *P. amaryllifolius* leaf extract.[55]

According to many studies conventional extraction methods are reported to have their limitations. The conventional extraction techniques such as Soxhlet, solid–liquid extraction (SLE), or liquid–liquid extraction (LLE) have certain drawbacks like they often require long extraction time and produce low extraction yield of bioactive compounds [56]. It is also reported that the properties or quality of the extracted compounds are damaged during the conventional extraction. Thus, Zaki NAM *et.al.*,[57] found out the other

techniques of extraction which includes microwave-assisted extraction (MAE) resulted in higher yield of leaf extract of TPC compared to conventional soaking extraction(CSE), higher extraction yield and phenolic richness as compared to the soaking method. From the study, we can conclude that *P.amaryllifolius* possess antioxidant property

**Anticancer activity:** Studies on medicinal plants and phytochemicals have been carried out over the past several decades in order to determine their anti-cancerous activity. Several studies have suggested that flavonoids such as catechin and rutin are able to control cancer cell growth in the human body [1;4].Pandanus leaves produces catechin, naringin, kaempferol, rutin, epicatechin which are well known for their anticancerous properties[4].In the study Chong HZ *et.al.*, they found out that Stigmasterols as one component of *P. amaryllifolius* extracts may have contributed to the induction of the p53mediated apoptosis pathways in MDA-MB-231 cells.[58]

**Antiviral activity:** Antiviral agents are those substances other than virus or virus containing vaccine or specific antibody which can produce either a protective or therapeutic effect to the clear detectable advantage of the virus infected host[59]. Ooi LSM *et.al.*, 2004 estimated that Pandanin(a lectin isolated from the saline extract of the leaves of *P.amaryllifolius*) also possesses antiviral activities against human viruses, herpes simplex virus type-1 (HSV-1) and influenza virus (H1N1).[3]

**Antibacterial Activity:** In the study, Laluces HMC *et.al.*,2015[60], they found out that Pandamarilactonine-A is the most active isolated alkaloids from the leaves of *Pandanus amaryllifolius* against *Pseudomonas aeruginosa*. Again re-investigation on the leaves of *P. amaryllifolius* had isolated the piperidine (1 and 2) and pyrrolidine (3 and 4) type alkaloids and these alkaloids can act as antibacterial agents against three organisms *Staphylococcus aureus* ATCC 25923, *Escherichia coli* ATCC 25922 and *Pseudomonas aeruginosa* ATCC 27853.

**Antitubercular activity:** Results in the study by Bungihan ME [61], they revealed the presence of a wide array of endophytic fungi associated with the leaves of *P. amaryllifolius*, secrete different secondary metabolites that have antibacterial and antitubercular activities i.e against the acid-fast bacteria *G. terrae* and also against *M. tuberculosis*.

**Dental anxiety:** Anxiety is one type of emotional disorders that can cause a major problem and frequently experienced by patients who will undergo examinations and dental treatment, particularly pediatric patients, causing children delaying and refusing to undergo dental treatment. Few methods can be done to reduce the anxiety level, both pharmacological and non-pharmacological, including the use of aromatherapy and music therapy. It is reported in one of the study by Pradopo S, 2017 that Pandan leaves are one of the plants commonly used as an aromatherapy ingredient in Indonesia due to their distinctive aroma and contain alkaloids, flavonoids, and tannins that produce sedative effects, overcoming pain and anxiety, and reducing anxiety. In their study, they found out that Pandan leaves aromatherapy and relaxation music can reduce the anxiety level of the pediatric patients undergoing dental treatment[62].

**As food preservative:** Food poisoning or foodborne disease is still a serious concern. The use of harmful synthetic chemical preservatives are still widely found in society. Aini R *et.al.*, highlighted pandan leaves (*Pandanus amaryllifolius* Roxb) as safe natural preservatives which are often used as a natural food coloring and flavor concentrates, along with anti-bacterial and antifungal properties. Since the pandan leaves extract contain bioactive compounds and extract of 15% concentration were able to decrease Total Plate Count with no microbial contamination in the Putu Ayu samples. We can conclude that this plant can be used as food preservative[63].

**Industrial application:** *P.amaryllifolius* acts as a natural fragrance agent due to the presence of the major compound 2-acetyl-1-pyrroline (2AP). An interesting application is the use of plant extracts as pesticide i.e Aromatherapy products .In the study, Jafar *et.al* produced three sub-products: Pandan Aroma Refresher Spray, Pandan Potpourri and Pandan Room Aroma. From the results they found that after two months of using Pandan Aromatherapy products, the number of rats approaching the premises has decreased and the presence of rats decreased[64].

## **Discussion and Conclusion:**

*Pandanus amaryllifolius* Roxb., commonly known as pandan, is often used to give a refreshing, fragrant flavour to south-east Asian dishes. The major compound contributing to the flavour characteristic Pandan is 2-acetyl-1-

pyrroline (2AP). Besides its culinary value, pandan leaves are used in the perfume industry and also medicinally as a diuretic, cardio-tonic, anticancer, anxiety, food preservative properties. Furthermore, the leaves are used to refresh the body, reduce fever, and relieve indigestion and are reported to contain various alkaloids and unglycosylated pandamin protein which exhibits antiviral activity against human viruses, herpes simplex virus type-1 and influenza virus. Pandan leaves contain several bioactive compounds carotenoids, flavonoids like catechin, naringin, kaempferol, rutin, epicatechin, myricetin, luteolin, quercetin and phenolic acids including gallic acid, cinnamic acid, ferulic acid, caffeic acid that acts as antioxidant and antidiabetic activity. Pandan leaves contain certain alkaloids like Norpandamarilactonine-A,-B, Pandamarilactone-1, Pandamarilactonine A,-B,-C, Pandamarine, Pandanamine. Pandamarilactonine-A is the most active isolated alkaloids from the the leaves of *Pandanus amaryllifolius* against bacteria *Pseudomonas aeruginosa* [17;18;19;65;66]. This plant also contains tannin, essential oils, tocopherols, tocotrienols etc. In certain cases, extracts have been currently used as alternative medicine as well as derived products as natural products are cheaper in price with less side-effects. Extensive studies can be carried out in this plant for further exploration of the necessary and potential benefit for the development of better medicinal products

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List of figures(s)

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Figure (ii) 3-methyl-2(5H)-furanone