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Research and Phytochemical Testing of Pacific Yew (Taxol)

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Abstract: *Pacific yew (Taxus brevifolia) is a slow-growing evergreen conifer native to the forests of North America and is widely recognized for its significant medicinal value. The plant gained scientific importance after the discovery of paclitaxel (Taxol), a potent anticancer compound isolated primarily from its bark. Paclitaxel has become one of the most effective chemotherapeutic agents used in the treatment of ovarian, breast, lung, and several other cancers due to its unique mechanism of stabilizing microtubules and inhibiting cell division. This review article highlights the morphology, geographical distribution, phytochemical constituents, and medicinal importance of Pacific yew. Special emphasis is given to the taxane diterpenoids, alkaloids, flavonoids, and other bioactive compounds present in the plant. The article also discusses extraction procedures and phytochemical screening methods used for the identification of important secondary metabolites such as alkaloids, tannins, saponins, and terpenoids. Furthermore, recent advancements in paclitaxel-based nanomedicine and their role in improving drug delivery and therapeutic efficacy are summarized. Overall, Pacific yew represents an important natural resource in pharmaceutical and medicinal research, especially in the development of anticancer therapies.*

Keywords: Pacific Yew, Taxus brevifolia, Paclitaxel, Taxol, Phytochemical Testing, Anticancer Activity, Taxane Diterpenoids, Medicinal Plant, Cancer Therapy, Soxhlet Extraction

I. INTRODUCTION

Pacific yew is a slow growing evergreen plant, conifer that comes from the forests of the North America. It is the part of the Taxaceae family and also grows in the old growth forests that stretch from southern Alaska to British Columbia, northern California, and parts of the Rocky Mountains. [1] Differing from other big conifers found in the area, Pacific Yew is a small to medium-sized tree, which has reddish-brown bark, dark green, flattened needles, and red fruit-like seed covers called arils. [2]The pacific yew tree has historically been identified as an ordinary or average tree growing in the forest and discarded due to deforestation operations. This is because the pacific yew tree became important only when its bark was known to contain paclitaxel, also called Taxol.[3]Taxol is used to treat cancers like ovarian cancer and breast cancer. Cancer survivors use Taxol to ensure that there is no possibility of a relapse. At the moment, however, there are adequate supplies. The demand will increase in future since Taxol may be used for treating different cancers, Alzheimer's disease, and Multiple Sclerosis. [4] Out of the many plants that were screened, the National Cancer Institute chose 35,000. Of all the samples that were collected, the one sample that Barclay collected was one that yielded a compound which is now among the most widely used chemotherapeutic agents for cancer patients. The Pacific Yew tree bark yielded Taxol, a compound isolated from the bark of the tree. This compound was developed commercially in 1977 and tested on patients in 1984. It got approval from the FDA in 1992 and its annual sales by 2000 were A$2.1 million.[5] Paclitaxel authorized by the Food and Drug Administration as an anticancer drug used against

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cancer cells such as ovarian, lung, breast cancer, and Kaposi's sarcoma. The basic function of Taxol is cell death by binding to tubulin and inhibiting the breakdown of microtubules. Taxol can be regarded as a microtubule targeting agent (MTA).[6] The use of Taxol is very crucial in the treatment of cancers because of its distinct mode of action and broad range of activity. Although there are some drawbacks to its use, scientists continue working on improving its efficacy and reducing side effects. [7] The nanomedicines used in current practice are relatively effective in addressing challenges associated with the process of drug development like poor solubility and insufficient circulation times. Paclitaxel is a wide spectrum anti-cancer medicine belonging to the class of the most frequently used chemotherapeutics in cancers of solid types.[8]Up to this point the nanomaterials of paclitaxel have shown their effectiveness when used in clinical practice against ovarian, lung and breast cancer.[9]

Morphological Characteristic of Pacific Yew

The pacific yew belongs to the Brevifolia species and the Taxaceae family, and its genus is Taxus.Pacific yew is an evergreen tree with needle-shaped leaves which retain their color all-year round. The needles are short, soft and have a spiral arrangement along the stem. The upper side of the needles is yellow-green in color while the underside is light green in color, having sharp-pointed tips. In the summer season, male yew trees bear minute yellow cones, which act as pollens, while female yew trees grow solitary seeds covered partially by red arils. The bark of the tree is thin and scaly with various shades, namely dark and purplish-brown on the outer layer and reddish purple on the inner layer.[10] Pacific yew can survive in a wide range of climates, from fairly dry areas to very wet coastal forests. In drier subhumid regions, where annual rainfall averages only about 470 mm the tree is usually found near rivers and streams or on the lower parts of cool, north-facing slopes where moisture is more available. Interestingly, some of the largest Pacific yew trees are found in these sheltered environments. One remarkable example grows along the banks of Hells Canyon in Idaho, where annual rainfall is estimated at about 500 mmthis tree measures 84.5 cm in diameter and stands 8.5 meters tall. On the Queen Charlotte Islands, Pacific yew is commonly found along the edges of coastal inlets. Overall, however, the species is most abundant in humid and extremely wet environments receiving between 1,400 and 4,000 mm of rainfall each year.[11] For example, the largest yew tree in Oxbow Regional Park grows at the park's highest point, about 210 meters above the surrounding landscape, overlooking the Sandy River far below. This area receives around 1,450 mm of rainfall each year, creating commending conditions for the tree. Pacific yew can grow across a broad elevation range, from sea level in coastal forests to as high as 2,440 metersin the Sierra Nevada. Depending on the region, its growing season may last anywhere from 60 to 300 days, and it can tolerate annual minimum temperatures ranging from about −15°C to −12°C (5°F to 10°F).[12] The Pacific Yew prefers to grow in deep, moist, fertile, and nutrient-filled rocky soils. The Pacific Yew is ideally grown in moisture-filled temperate rainforests found in the pacific northwest region, and some common soil types found there include very nutritious, moderately nutritious, and poorly developed soils, which are scientifically called Ultisols, Alfisols, and Inceptisols.[13]

Geographical distribution

The Pacific Yew is present all over the western coastline of North America. It occurs from Southern Alaska, where it is present on islands such as Annette Island and Prince of Wales Island, its distribution extends from the southern coastal areas of British Columbia to Vancouver Island and the Haida Gwaii Islands along with the Olympic Peninsula. The trees are not commonly seen in the coastal mountain ranges of Southern Washington and Northern Oregon around the Umpqua River, and also in the Southern Marin and San Mateo counties.[14]

Chemical constituents

Pacific yew contains more than 100 chemical substances and most of them belong to the group of taxane diterpenoids. Some of the principal chemical substances that constitute pacific yew are paclitaxel Taxol, baccatin III, taxine A, and taxine B and various compounds like flavonoids, lignans, steroids, and glycosides. These substances are known both

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for their toxic and medicinal uses. Out of the listed substances, paclitaxel assumes particular importance because it is used for treating cancer. This characteristic gives pacific yew its importance in medicinal studies.[15]

Paclitaxel (Taxol) - an active diterpenoid substance used widely as an anticancer agent against breast, ovarian, and lung cancer. It is commonly extracted from the bark.[16]

Taxines (Taxine A & Taxine B) - highly poisonous alkaloids that contribute to the toxic effects of the plant. Taxine A comprises 30%, while Taxine B comprises about 2% of the total amount of the alkaloid constituents.[17]

Taxane diterpenoids – a big family of structurally similar diterpenoids; at least 100 different taxa of these compounds have been detected in various types of Taxus.[18]

Baccatin III – a key taxane precursor which plays a vital role in the synthesis of paclitaxel; it occurs in higher concentrations compared to paclitaxel.[19]

According to scientific investigations, there is considerable interspecific differences in the percentage composition of the bioactive compounds, and somehow some species contain larger quantities of these compounds than others. This can be due to genetic, epigenetic, and environmental factors. More than 3000 diterpene alkaloids have been isolated from the leaves and barks of pacific yew plants over the years of investigation. There are more than 500 flavonoids that have been isolated in these investigations along with many other compounds such as flavanols, dihydro-flavones, chalcones, and flavnols glycosides, among others like lignans, volatile compounds such as alcohols, alkanes, organic acid, and terpenes.[20]

Material and Methodology

Extraction process

Collection of bark, needle or wood of the plant is the first step to make the process successful. Most often, the bark of pacific yew contains maximum quantity of Paclitaxel. Then clean the material and remove any dirt or contamination in it. Next, the plant material is dried through air drying or using an oven dryer.

The plant material is powdered.

Now comes the extraction process.

Take a fixed amount, say 20-25g.

Put the powdered material in cellulose thimble and put the thimble in the Soxhlet apparatus. Add solvent to the round-bottomed flask, say 200-500 ml in case of 20-50g powder. Heat the solvent gently to make it undergo reflux and its vapor goes into the condenser. The solvent thus condensed falls on the powder in the Soxhlet chamber. This cycle keeps on repeating for 2-12 hours.

After the completion of extraction process, solvent is evaporated leaving crude dark green extract behind.

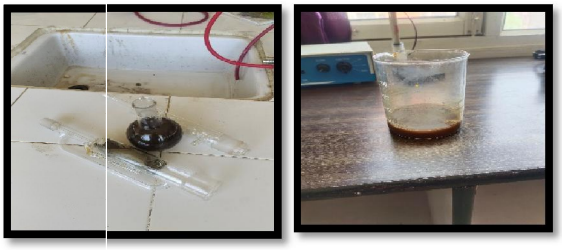

Fig 5.1:Extraction and Extract of Pacific yew

Phytochemical Testing

Tests for Alkaloids

Dragendorff's Test

Take 2ml of extract in test tube.

Few drops of Dragendorff's reagent added

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Observation:
Formation of orange or reddish-brown precipitate indicates presence of alkaloids.

Fig 5.2: Detection of Alkaloid testing

Test for Tannins
Ferric chloride Test
Add few drops of ferric chloride into solution.
Observation:
Solution changes into blue-black colour indicates presence of Tannins.

Fig 5.3: Detection of Tannins testing

Test for Saponins
Foam Testing
Add 2 ml of extract in test tube and 3 to 5ml of distilled water. Now shake the mixture for 30 to 60 seconds.
Observation:
Formation of stable foam indicates presence of saponins.

Fig 5.4: Detection of Saponins testing

Test for Terpenoids
Salkowski Test
Add extract with chloroform.
Add concentrated sulfuric acid.
Observation:
Formation of reddish-brown interface indicates presence of terpenoids.

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Fig 5.5: Detection of Terpenoids testing

pH Testing

Ph Testing procedure to be done to find whether the plant extract is acidic, neutral or alkaline in nature.

Steps using pH paper

Dip pH paper into extract solution and leave for 1 or 2 seconds. Compare the colour with standard table and note the pH value.

Observation:

The extract from pacific yew is acidic in nature having pH of 4.5 -6.

Fig 5.6: Detection of pH testing

II. CONCLUSION

We can state that pacific yew is one of the very useful medicinal plants because of the presence of its anti-cancer nature, or we may state that the presence of Taxol makes the Pacific yew very important. Due to recent scientific study related to pacific yew, the use of this plant as a medicinal plant and for cancer treatment became more important. This plant consists of various types of chemical compounds like taxanes, alkaloids, flavonoids, and diterpenoids.

Moreover, the Pacific Yew has very distinct and unique characteristics of ecology and morphology that make it possible to grow in various climates and climatic zones as well as in various types of soil across North America. There are so many methods or techniques for isolating the active compounds of the plant and performing experiments on them using various phytochemical analyses. The discovery of Taxol and the creation of nanomedicines that act on a specific organ have made the pacific yew more important in medicine.

In the end, we can say that the pacific yew is indeed an example of how a natural plant may contribute to better medicine and treatment of such diseases like lung and breast cancer.

Declaration of interest

The author declares that there is no conflict of interest related to this project work.

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