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Taxus Species: From Medical Use to Landscape Architecture

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Abstract

Turkey is located in the temperate zone and has vegetation rich in biodiversity compared to many neighboring countries. More than 12,000 plant taxa grow naturally in Turkey, and the number of plant species is close to the number of plant species in Europe. It is one of the important countries in the world with approximately 3,649 endemic taxa and an endemism rate of more than 30%. Yew trees (*Taxus sp.*) are evergreen trees and ornamental plants widely used for landscaping in North America, Europe and other parts of the world. However, all parts of the plant except the fleshy parts of the bright red fruits are poisonous. Taxol is the active compound isolated from the bark of the Pacific yew tree by bioactivity-directed studies of its active extract and has strong anticancer activities3. In this study, biological and biochemical studies of Taxus species and their use in landscaping were evaluated.

Keywords: *Taxus sp*; Phytochemistry; Lanscape

1. Introduction

Medicinal and aromatic plants today; It is used in many areas such as food, cosmetics, paint, textile, medicine, agriculture, indoor and outdoor plants. Yew trees (*Taxus spp.)* are ornamental plants commonly used for landscaping in North America, Europe, and other parts of the world.

2. Botany of *Taxus sp*.

The taxonomy of the yew family is much controversial, but most authorities recognize the following: Japanese yew (*T. cuspidata*), European yew (*T. baccata*), American yew (*T. canadensis*), Hicksii/Anglo-Japanese Yew (*Taxus* × *media*), Pacific or Western yew (*T. brevifolia*) and American or Canadian yew (*T. canadensis*). They are common species associated with poisoning in animals (Tiwary et al. 2005; Wilson et al. 2001). During the Christmas season, *T. canadensis* is frequently used to adorn homes throughout North America (Lee et al. 1998).

The Proto-Germanic word yew (*īwa-) may have initially been a loanword from the Gaulish *ivos. It is referred to as Eibe in German. In Latin, baccata means bearing berries. When the word "yew" was first employed, it seemed to allude to the color brown. Theophrastus was aware of the yew (μίλος), noting its slow growth, evergreen nature, and fondness for cold, shaded mountains (Wikipedia).

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The common yew (*T. baccata*) is a species of yew from the yew family (Taxaceae) that is mostly a tall shrub and sometimes has the appearance of a densely branched, round-topped tree that can grow up to 20 meters tall. In the common yew, the red-brown bark cracks and falls off haphazardly. Young shoots are green in color and very elastic. Needle leaves are 1-2.5 cm long, dark green and shiny on their upper surfaces. The tips of the needle leaves are pointed, and their cross sections are flat. Although at first appearance it resembles the needle leaves of fir, false yew and redwoods, it differs from them by some characteristic features. First, common yew does not have distinct stomatal lines on the undersides of conifers. Again, there are no resin canals in the cross sections of needle leaves, but others do. The Pacific yew tree is often found to be more than 200 years old in its habitat (Hansen et al. 1999).

Taxus spp. received little attention outside of its use as an ornamental plant in North America and Europe. Until the 1980s, *T. brevifolia* and *T. canadensis* were ignored or considered wild forest species without economic value for timber or pulp. This changed with the discovery of the potent anticancer activity of taxane-derived compounds in yew plants in the 1960s and 1970s (DeLong & Prange, 2006). Taxol is isolated from the Pacific yew tree and has attracted great attention in many research fields due to its potent anticancer activities and complex structure. As a result, numerous chemical reactions have been reported to obtain taxol and compilations have been prepared for the synthesis of both taxol and taxane diterpenoids (Kingston et al. 1993).

3. History of Yew trees

Linked to antiquity, yews are associated with both folklore and legend. In pre-Christian times, Druids considered the yew tree sacred, in part because of its longevity. There are species of yew still growing today in Europe that are estimated to be between 2000 and 3000 years old. The yew tree has long been regarded with a mixture of awe and fear, carrying numerous profound meanings in folklore and religion. In times past, it was believed to protect and purify the tombs of the dead and was a symbol of immortality due to its ability to revive, boasting stories of stems sprouting from the staffs of holy men or from beams inside buildings.

Yew timber is extremely strong and durable. In fact, one of the oldest wooden artifacts in the world, a 450,000-year-old spearhead found in Essex, was made from yew wood. Being a hard, close-grained but flexible wood, it was traditionally used to make tool handles, but is perhaps best known as the main material of the formidable and deadly medieval longbow, for which entire fields of yew trees were once carefully cultivated for their production. Today, lumber is still popular for bows, wood turning, carpentry and veneers.

Yew tree has been preferred by people for making bows for thousands of years. Yew was also preferred for other hardwood containers, and the species is now protected in many European countries. Despite its popularity, the number of studies on yew is still small. Yew wood is unusually homogeneous and fine-grained and has a high tensile strength to fracture. Additionally, yew has a high specific bending strength and a low specific elastic modulus. For this reason, bows made from yew wood have qualitative features such as smooth tensile and easy springback (Bjurhager et al. 2013). The longbow made of yew wood became famous because the English victory in the Hundred Years' War (1337-1453) between the English and the French depended on the efficiency of the English archers and their weapons.

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4. Phytochemistry of *Taxus sp*.

All parts of the plant except the bright red berries (arillus) are poisonous; The seed inside the fruit is also poisonous. Yews contain at least 10 taxine alkaloids, with taxine A and taxine B most commonly recognized as cardiotoxins. Taxine B is the most potent of the taxine alkaloids. Japanese yew (*T. cuspidata*) and English yew (*T. baccata*) contain the highest amounts, and Pacific yew (*T. brevifolia*) the least, of taxine alkaloids (Wilson et al. 2001), this results in a low toxicity for *T. brevifolia* and a high toxicity for *T. baccata*. Yew plants have seasonal variations in their taxine concentrations, with winter seeing the greatest concentrations and summer seeing the lowest (Cope et al. 2005).

The chemistry of yew has gained significant interest in recent years due to its taxane diterpenoids and some non-alkaloid taxoids (Gu et al., 1991). Among the phenolic components of yew, the butanoid glucoside rhododendrin also showed hepatoprotective activity (Parmar et al., 1991). Five taxane-derived compounds such as taxol, 10-deacetylbaccatin -III, 2-deacetoxytaxanin J, brevifoliol, 13-decinnamoyl taxanin were isolated from Himalayan *T. Baccata* leaves by Das and his colleagues (Das et al., 1998). Additionally, compounds with a flavonoid structure have been isolated from the yew tree (Krauze-Baranowska, 2004).

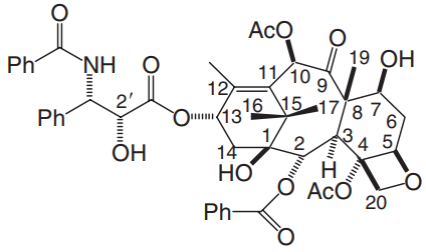

Figure 1. Chemical structure of Taxol

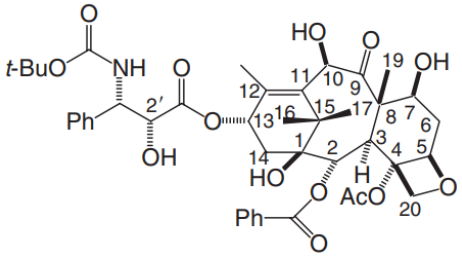

Figure 2. Chemical structure of Taxotere

Taxol® was first isolated by Wall and Wani in 1971. Taxol was approved by the FDA for the treatment of advanced ovarian cancer and breast cancer in December 1992 and April 1994, respectively. Taxotere® was approved by the FDA for the treatment of breast cancer in May 1996 (Ojima et al. 1997). Thanks to its unique mechanism of action and potent antitumor activity, much scientific research has been conducted on taxol in the fields of pharmacology, chemistry and medicine in the last two decades (Cheng et al. 2000).

Taxol is an antimitotic agent. Unlike other plant-derived anti-microtubule agents such as colchicine, podophyllotoxin and Vinca alkaloids, which inhibit microtubule formation, it promotes tubulin assembly and inhibits microtubule disassembly (Manfredi & Horwitz, 1984). Taxol can also induce tumor necrosis factor and interleukin-1 expression in macrophages,

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stimulate MAP-2 kinase activity, and increase tyrosine phosphorylation. All these effects may affect the antitumor activity of Taxol. In addition to their role in mitosis, microtubules have many functions in the regulation of cellular processes. Therefore, Taxol can be used in other therapeutic areas other than cancer chemotherapy.

Taxus leaves are used to treat nervousness, hysteria, epilepsy and as a lithontriptic. Tincture prepared from young shoots has long been used for headaches, dizziness, weakness, low pulse and diarrhea. The aqueous extract of its leaves has shown that it has a depressant and tranquilizing effect on the central nervous system in mice (Ambasta, 1994). Yew extracts have hormonal activity in insects and mammals.

5. Toxicity of *Taxus sp*.

Even though yew intoxication is rather prevalent, not much study has been done on the poisonous processes of Taxine B, the alkaloid that causes yew toxicity. Taxine B is the most potent of molecules among the 21 taxine alkaloids identified in *Taxus* species and regarded as have great toxic effects on the heart (Andersen 2009). Electrocardiogram (ECG) reports from Yew-impaired persons show a prolonged QRS length, a lack of the P wave, and an increased atrioventricular conduction time. Currently, it is believed that taxines increase cytoplasmic calcium by blocking sodium and calcium channels in the heart cell membrane. For this reason, it is believed that taxes impede the heart's depolarizing conduction mechanism in a dose-dependent way (Wilson et al. 2001). Unaffected by the autonomic nervous system, the diminished cardiac depolarization causes bradycardia, arrhythmia, and diastolic heart failure. Before bradycardia develops, there is initially a period of ventricular tachycardia, and it has been noted that the structure of the taxine molecule is similar to that of digitalis (Yersin et al. 1987). The cardiac effects of taxines are linked to symptoms and post-mortem findings, including as shock, congestion, and hypotension.

The Latin name of the yew tree, 'Taxus', always evokes the word toxic with a bright red 'X', but the word refers to the highly toxic 'taxane alkaloids' found in the needles and bark. But even this frightening fact cannot be held against the magnificent yew tree. In the words of Paracelsus, who expressed the classical toxicology maxim, “Everything is poison, and there is nothing without poison; The dose alone makes it, so nothing is poison.” These alkaloids have been discovered to play a very important role in modern medicine and have been developed as anti-cancer drugs. They are used in the chemotherapy drug Taxotere® (docetaxel), which has proven effective in fighting lung and prostate cancer and advanced cases of breast cancer (Barnes, 2021).

6. Landscape use of *Taxus sp*.

Approximately 190 ornamental yew species have been identified to date (Cope, 1998). Yews became the most popular narrow-leafed evergreen ornamental plants in North America in the second half of the 20th century and remained popular into the 21st century (Cochran, 1999). The beautiful, glossy, dark, evergreen leaves, ranging from low-profile, compact and dense species to taller columnar and pyramidal forms, and the diverse physical forms of commercially available cultivars have played an indispensable role in establishing the popular landscape of the yew tree (DeLong & Prange, 2006; Itokawa & Lee, 2003).

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Yew has needle-like, dark green leaves on horizontal branches and fleshy, cup-shaped, bright red autumn berries on female plants. The dark green leaves of this slow-growing, evergreen conifer provide the perfect background for shrub and herbaceous borders. Broadly conical in shape, it is tolerant of dry shade, calcareous and acidic soils, and urban pollution. Yew also makes a gorgeous, formal hedge. *T. baccata* L. taxon, which is frequently preferred in landscape architecture application studies, is known to cause deaths. Although this taxon looks aesthetically pleasing with its fruit beauty, all parts of the fruit except the fleshy part are poisonous. Especially excessive consumption of fruit seeds results in death (Çorbacı, 2021).

Yews are considered by many to be one of the best groups of evergreen shrubs for landscape plantings. They are attacked by relatively few insects and disease pests and look attractive as they provide dark green color throughout the year. Its leaves are needle-like, their surfaces are shiny, and they have narrow, linear-shaped and flat leaves. Yew plants are male or female, and the fleshy, red berry-like seed cones (grains) are produced by the female. Because of the toxicity of yew seeds, people have generally preferred to use male plants in their landscapes. Male plants do not produce seeds, but their leaves contain the taxine alkaloid and should be avoided. The difference between male and female plants can be understood from the flower buds. Male flowers are spherical and arise from leaf axils in clusters along the undersides of branches. On the other hand, female buds are smaller, stalked and pointed (Trinklein, 2020).

Yews are slow-growing evergreen conifers. There are several varieties of Taxus species, of which *T. capitata* is a tall, upright whorish form that can reach heights of 7 to 10 metres. It is widely planted as an upright type. *T. standishii* is an interesting female variety of English yew. In its columnar growth habit, it has colorful, yellow leaves that retain their color well throughout the year. *T. fastigata* is a graceful, columnar Irish yew variety with striking vertical interest.

There are three main species of yew used in landscaping: English yew (*T. baccata*), Japanese yew (*T. cuspidata*), and hybrid yew (*Taxus*×*media*). In the nursery and landscaping trade, these yews are almost always represented by cultivars (straight species are rarely found). Varieties range from perennial small trees to short shrubs. Yews need well-drained soil. Poorly drained soil, such as clay soil or lowland soil, is not suitable for yews. Yew trees are plants that do not require maintenance and are suitable for shady and sunny places. They are resistant to almost any exposure. It is a very cold-hardy plant when dormant, tolerating temperatures down to about -25°C. However, in spring, fresh young shoots may be damaged by frosts. Plants are dioecious, but they sometimes change gender, and monoecious trees are sometimes found. If fruit and seeds are required, male and female trees must be grown. The fruit is produced mainly on the lower parts of one-year-old branches. It is a very long-lived tree, growing slowly and usually taking about 20 years to reach a height of 4.5 meters. Young plants occasionally grow 30 cm per year, but this soon decreases and after 100 years there is almost no increase in height. A very ornamental tree, it has many named varieties. It is very resistant to honey fungus. The bark is very soft and if the bark is removed by constant friction, such as when children climb the tree, the branches or even the entire tree may die. Plants produce very few fibrous roots and should be planted in their final position while they are still small. The fruit is highly appreciated by thrushes. All or part of this plant is poisonous, with inconspicuous flowers or blooms. They require full sun to shaded locations, while in moderate to dry and acidic areas, well-drained soil is an absolute necessity. Yews require adequate moisture but will not tolerate standing water or areas that tend to remain wet for long periods in rainy weather, such as areas near gutter downpipes. Yew trees are easy to establish due to the compact nature of their root systems, even when larger nursery stock is planted. They grow best in slightly acidic soil, but have a fairly

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wide pH tolerance. Can be used as Espalier, Firewood, Fence, Screen, Standard, Superior fence. It is a very easy plant to grow, extremely tolerant of cold and heat, sunny and shady positions, wet and dry soils, exposure and all pH values. While it can be pruned at any time throughout the year, early spring pruning before new shoots develop is preferred. Midsummer pruning should be avoided because the new growth produced does not have time to harden sufficiently and often dies by the following winter. The result is a brown, unattractive appearance until new growth appears in spring. More browning or yellowing of leaves usually indicates root problems caused by excessive amounts of water or poor soil conditions (Trinklein, 2020).

The yew tree especially when sheared, presents a very formal appearance due to its dark green, symmetrical solid canopy. Because they are extremely toxic to humans, badgers should not be planted around playgrounds or other areas (Köylü, 2015). Yew trees are frequently used in landscape architecture, especially in planting designs, as solitary, screening, directional, border and emphasis elements. Yews are also used to perform artistic displays in gardens. Because of its dense texture, the yew tree is dark green and evergreen all year round, making it the perfect backdrop for displaying light-colored works, such as the sculptures in front of them. It is a suitable material for creating living sculptures due to its small or needle-like dense leaves and its evergreen woody structure. Additionally, since Yew has very good pruning qualities, it can be used for topiary art, where it is trimmed into various figures such as animals or waves. Thus, the yew tree both forms the basis for the works and is used as an element of art in itself.

Yew (*T. baccata* (Lindl.)) is a coniferous ornamental plant widely used in park landscapes. It is a very slow growing tree and reaches maturity in 70 years (Asif et al., 2016). Yew is also widespread in natural forest biogeocenoses of Russia, especially in the North-West Caucasus. To date, this species belongs to protected plants with a decreasing status (Kopyltsov & Gneush, 2021). *T. baccata* is stress tolerant, slow growing and maturing, long lived (over 1000 years), shade tolerant and full sun tolerant. It can grow in a wide range of soils and produces strong wood that is resistant to decay (Thomas & Polwart, 2003).

7. Conclusions

In summary, the Yew tree has been widely used by people in religion, literature, pharmacy and natural sciences from ancient times to the present due to its hard, durable and flexible structure and extraordinary longevity. In addition, it has become an important part of other fields, especially garden design and landscape architecture. Its prunability and dense evergreen texture make it a suitable material for the formation of geometric patterns in formal gardens throughout history. Today, it is considered a special plant in landscape designs because it is effective in outdoor landscaping and in displaying artistic objects or creating artistic elements on its own.

In addition to specifying the organs and poisonous substances of poisonous plants such as yew that cause poisoning, such plants should be recognized and known among the public. When including plant materials in landscape planning and application studies, plants such as yew which negatively affect human health due to taxine substances in their structures, should be thoroughly researched and their usage areas should be paid attention to. Particular care should be taken not to use it in children's playgrounds. The main task in this regard falls to botanists and landscape architects. It is important that sellers in nurseries provide plant buyers with information about plants that pose a danger to human health.

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