



Phytochemical and pharmacological aspects of *Araucaria heterophylla*

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ABSTRACT

The object of this article is to present an extensive review of the plant Araucaria heterophylla . Being an evergreen coniferous tree, it is easily found in India and it also known to be grown in countries of southern hemisphere, Australia and Egypt. The common name of the plant is Star pine or Triangle tree. The plant has been known to possess a decent number of chemical groups such as alkaloids, flavonoids, phenols, tannins, carbohydrates, terpenoids which can be identified by performing phytochemical screening of the plant extract. Being an ornamental plant, it is easily available in almost every part of country. Mostly experimental and research work has been carried on its resin and essential oil of the plant. Various activities have also been researched on its leaves and roots extract. The presence of active chemical constituents of the plant are responsible for showing its wide variety of pharmacological activities such as anti-inflammatory, anti-microbial, anti-oxidant, anti-cancer, anti-pyretic, nephroprotective activity. This review covers all the following activities and the research work that has been done on the plant. The vast range of utilization of different parts of plant also shows the positive future perspective for Araucaria heterophylla .

KEYWORDS: *Coniferous; Phytochemical screening; Extract; Pharmacological activities; Ornamental.*

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INTRODUCTION

Araucaria heterophylla is an evergreen coniferous tree which is allied to the family Araucariaceae of genus Araucaria. The tree possesses fast growth rate. It reaches about 50-65 meter of height in a narrow pyramidal or columnar manner hence it appears to be symmetrical. The plant is grown in almost all regions of India. It is also known to be found mainly in countries of southern hemisphere, in the islands of Australia, land of Egypt. Being an evergreen plant, it is also found in every season [1]. It is a sustainable innocuous plant that can be found profusely [2]. The various other names of the plant are Norfolk Pine, Norfolk Island Pine, Triangle tree, Star Pine, House pine, Christmas tree [3]. Modern Pharmacopoeias include about 25% of the drugs obtained from natural sources [4].

Being a natural source, different parts of this plant also possess various pharmacological activities due to the presence of active chemical groups such as carbohydrates, flavonoids, alkaloids tannins, phenols, terpenoids. α -copaene, α -pinene, germacrene-D, g-gurjunene, d-cadinene, sabinene, D-limonene are the active constituents found in the leaves of the plant. The plant had been used since ages as conventional medicine for the treatment of various diseases by both rural and urban population. It is an ornamental plant as well because it can be placed inside the houses for decorative purposes.

Some of the pharmacological activities of this plant are anti-inflammatory, anti-thrombic, anti-oxidant, hepatoprotective, anti-cancer, anti-microbial, nephroprotective, anti-pyretic, anti-fungal, gastroprotective [5].

PLANT PROFILE

Name- *Araucaria heterophylla*

Synonym- Norfolk-island pines, Star pine

Family- Araucariaceae

Class- Pinopsida

Phylum- Tracheophyta

Order- Araucariales
Genus- Araucaria
Division- Pinophyta
Clade- Gymnosperms
Kingdom- Plantae

BOTANICAL DESCRIPTION

Araucaria heterophylla is a long, pyramidal shaped, symmetrically arranged evergreen tree. The tree generally reaches to a height of 50-70 m with its horizontal or slightly oblique branches coming out of main branch. The horizontal branches of the tree are soft covered with small needles like leaves. The tiny needles are generally 1cm long grows symmetrically. The fresh leaves of the tree are bright green in colour which gets darker with time [6].

The trunk of the plant is generally greyish brown in colour. The flowers of this plant are unnoticeable. The cones are oval in shape usually possess length of about 10-12 cm and have 12-14 cm of diameter [7].



Fig. 1 Upper-view of *Araucaria heterophylla*



Fig. 2 Leaf of *Araucaria heterophylla*

Araucaria heterophylla is a monoecious plant i.e., it has both male and female reproductive organ in one individual. The male pollen cones are present on the soft branches whereas female cones are present on the thick branches of the plant while some of them are dioecious as well [3].

An experiment was conducted on propagation of the stem and roots of the plant using auxin. The study showed excellent feasibility on the in-vivo propagation of the plant [8].

CHEMICAL CONSTITUENTS

Araucaria heterophylla contains a wide range of chemical constituents that are responsible for their various pharmacological activities [9].

The various species of Araucariaceae family are known to contain essential oil whose composition and concentration changes with respect to region in which they are grown [10].

Some specific plants belonging to the same family have been characterized for a large number of chemical constituents such as terpenes including sesquiterpenes and diterpenes, phenolic compounds like iso-flavonoids, phenylpropanoids [11].

Diterpenes have been separated from the plant, the resin extracted out is known to contain labdane diterpenes which includes 14-diene, labda8(17), 13-epicupressic acid and 13-O-acetyl-13-epi-cupressic acid. The chief active constituents of *A. heterophylla* are α -pinene and phyllocladane which are present in its leaves. Due to the presence of these chemical constituents, plant shows potent anti-inflammatory activity [9].

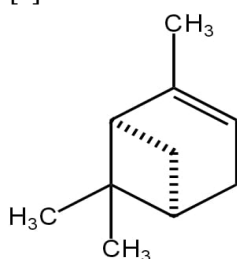


Fig. 3 α -pinene

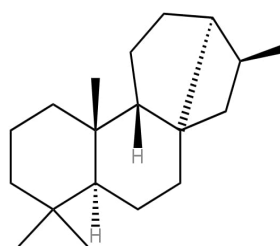


Fig. 4 Phyllocladane

The leaves of the plant are rich in essential oil which contains chemical constituents like diterpenes, flavanols, phenolic acid, polysaccharides. Elshamy and his colleagues worked on the essential oil resin of

Araucaria heterophylla which revealed its potent anti-pyretic and anti-inflammatory activity due to the presence of high amount of terpenoid, mainly monoterpenes [9].

According to Praveen M. and Srikanth T. Vijay et al, the leaves of this plant showed effective bio sorbent efficacy for taking away poisonous hexavalent chromium from water [12]. Some major active chemical constituents are b-caryophyllene, germacrene-D, a-copaene, sabinene, D-limonene [13].

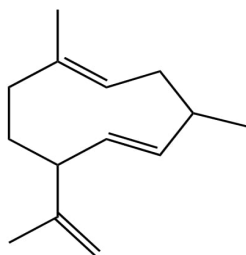


Fig. 5 Germacrene-D

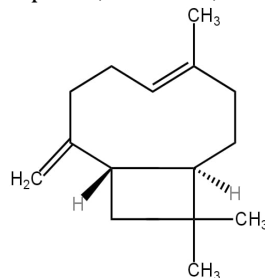


Fig. 6 b-caryophyllene

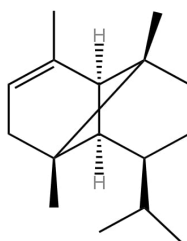


Fig. 7 a-copaene

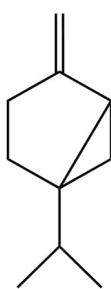


Fig. 8 Sabinene

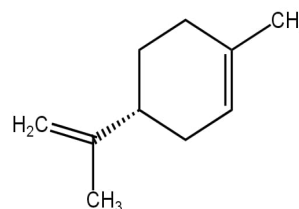


Fig. 9 D-limonene

The aqueous extract of the leaves of plant when put through phytochemical testing showed presence of flavonoids, alkaloids, sterols, saponins, phenols, terpenoids and tannins. It also contains labda-8, beyerene, rimuene as active constituents. It is also known to be rich in bioflavonoids [6]. The mucilage of the plant may contain some amounts of carbohydrate and reducing sugars [14]. The gum obtained from the plant has been known to possess excellent flowing properties in the form of powder which exhibit the traits of carbohydrate and reducing sugars as well [15].

PHARMACOLOGICAL ACTIVITY

Araucaria heterophylla possess a large number of pharmacological activities due to its richness in active chemical constituents such as anti-ulcerogenic, anti-bacterial, antioxidant, anti-cancer activity [16]. Many scientists from all over the world has conducted experiment to evaluate the various pharmacological uses of the plant.

Anti-inflammatory activity:

Araucaria heterophylla contains a chemical constituent known as a-pinene which is a terpenoid and responsible to show its action against inflammation. So, the presence of this constituent makes the plant a potent natural source for treatment of inflammation and topic for research as well. According to Gupta Nilesh et al, many plants have been tested which may possess anti-inflammatory activity that can also suppress rheumatic pain. So, various research has been conducted to find out the same for this plant [17]. Experiment on the essential oil of the resin of ecospecies found in Egypt of *Araucaria heterophylla* had been conducted. This species of plant is known to contain 39 compounds. The nano-emulsion was prepared from the essential oil of plant by suitable method. Adult Wistar albino rats were used to carry out the animal testing. To carry out the anti-inflammatory activity, carrageenan induced rat hind paw oedema procedure was utilized. The outcome of the result was positive. The prepared nano emulsion showed efficient anti-inflammatory activity in rats. Hence it shows that the plant contains various chemicals which are effective for medical uses [13].

Another study conducted on the anti-inflammatory activity of 3 species of *Araucaria* involving *A. heterophylla*. The scientist worked on the possible effect of species of plant against COVID-19. Their study involved anti-inflammatory action due to the fact that inflammation plays an essential role in the pathogenesis of SARS-CoV-2. So, the anti-inflammatory drugs are used as effective treatment for COVID-19 patients [18].

The anti-inflammatory activity of the oleoresin gum obtained from the trunks of *Araucaria heterophylla* was evaluated. From the resin of the plant, 2 major labdanes 13-epi-cupressic acid and acetyl-13-epi-cupressic acid were obtained from which 7 new derivatives were prepared. Dexamethasone was utilized as the standard drug for evaluation of the activity. By detecting the extent of COX-2 and b-actin in RAW 264.7 cells, the activity was studied. The study performed concluded that the diterpenes present in the resin of the plant in the form of labdanes has both in-vitro and in-vivo anti-inflammatory activity [19].

Toothache:

An ethno-pharmacological review showed the research done on various species of genes of *Araucaria* including *A. Araucana*, *A. angustifolia*, *A. bidwillii*, *A. heterophylla*, *A. cunninghamii*.

The utilization of herbal traditional plants has been known since ancient time to relieve dental problems mainly toothache [20]. It was concluded that out of all the species, the aerial part of *A. heterophylla* has been used for alleviate toothache [21].

Anti-microbial activity:

The plant is also known to possess the most promising anti-microbial activity which was studied by many scientists till now and still under research.

According to Hemeg A. Hassan, Moussa M. Ihab et al, various herbal plants possess antimicrobial activity due to their capability of giving secondary metabolites of relatively complicated structures [22].

The alcoholic extract of the leaves of *Araucaria heterophylla* was tested against both gram-positive and gram-negative bacteria using agar cup plate method which showed effective anti-microbial outcome. The plant extract may show activity against various types of bacteria such as *Staphylococcus aureus*, *Proteus vulgaris* and *Escherichia coli* exhibiting different inhibition zone. The research conducted concluded the presence of certain chemical constituents which can inhibit or prevent the growth of bacteria [23].

The invitro evaluation of anti-microbial properties of the plant was also studied using cup-plate agar method against four different types of bacterial and fungal strains- *Staphylococcus aureus*, *Candida albicans*, *Aspergillus niger*, *Pseudomonas aeruginosa*. The plant extract showed effective inhibition zone and proved to be a potent natural source for anti-microbial activity [24].

The gum of this plant was also utilized for the preparation of unloaded or drug loaded nanocarriers from the polysaccharides by using Tri sodium tri meta phosphate (STMP) chelator against *Bacillus Sp.* The preparation carried out by using water and ethanol as solvent. The prepared nanocarriers showed effective anti-microbial activity against the bacteria [25].

The methanolic extract of the leaves of *A. heterophylla* was also tested to evaluate its anti-microbial activity against bacteria such as *Escherichia coli* and *Salmonella typhi* by the process of disk diffusion. The research conducted showed potent inhibition zone to the growth of bacteria that concluded the plant to have effective anti-microbial activity [26].

Another research was conducted on extracted and characterized gum isolated from the plant. The gum was obtained from the bark exudates of the plant and after its purification, it was subjected to various phytochemical evaluation. Then, the gum of the plant was evaluated for the microbial contamination using pour plate method against certain bacteria and fungi. The experiment conducted showed excellent results against both bacteria and fungi [27].

Anti-oxidant activity:

Being rich in active chemical constituents, *A. heterophylla* has been known to possess potent scavenging of free radicals.

A study was conducted on the gum extract of the plant which was subjected to the process of solvent extraction to obtain polysaccharides. The extracted polysaccharides were tested for anti-oxidant activity and found to be potentially effective [28].

The leaves extract of the plant was also studied for its anti-oxidant activity. The extract was found to be rich in phenols and phenolic compound are good electron donors which can change ferric ion (Fe^{3+}) to ferrous (Fe^{2+}). It showed activity by deconstructing the chain reaction and donating hydrogen atom. Hence, it indicates the effective anti-oxidant activity of the plant [24].

The methanolic extract of the leaves of plant was also utilized to analyse about its anti-oxidant activity. The DPPH (2,2-Diphenyl-1-picrylhydrazyl) standard test was applied for the evaluation and the plant extract was found to be capable of inhibiting the formation of DPPH free radicals. The inhibition showed the potent anti-oxidant activity of the plant [25].

The anti-oxidant activity of the gum of *Araucaria heterophylla* was screened depending upon time and concentration. Different doses of different concentration were prepared along with disparate incubation time. The research conducted concluded that with the increase in concentration as well as incubation time, the activity increased its efficacy. The anti-oxidant activity of the plant was reported due to the presence of various chemical constituents such as diterpene, phenylpropanoid, phenolics [29].

The *in-vitro* anti-oxidant activity of the leaves of plant *Araucaria heterophylla* was conducted by carrying out extraction using suitable solvent. The extract was studied for total anti-oxidant activity of different concentration. The result came out to be positive which showed potent anti-oxidant activity.

DPPH scavenging activity was studied by extracting leaves of the plant with various solvents such as ethanol, methanol, n-hexane. DPPH along with ascorbic acid was utilized as control group to perform the activity. The extract of ethanol and methanol showed potent DPPH scavenging activity, so as with extract of n-hexane also showed that with an increase in the concentration of extract of ethanol and methanol, the activity also increased. The extract of n-hexane was found to be independent of the concentration as it showed same effect in all concentration [30].

The anti-oxidant activity of the resin of the plant *A. heterophylla* was evaluated. The essential oil of the resin was obtained by the microwave assisted extraction technique. It was then tested for its capability of decreasing the free-radicals DPPH (2,2-Diphenyl-1-picrylhydrazyl) and ABTS (2,2-azino-bis-3-ethylbenzothiazoline-6-sulphonic acid). The result showed potent anti-oxidant activity of the essential oil of plant. The study conducted concluded the increase in the concentration of essential oil also increased its scavenging activity. The various chemical constituent was found to be responsible for the potent activity in essential oil of plant such as a-pinene, b-pinene, b-caryophyllene, germacrene-D [31].

Anti-pyretic activity:

Various studies have been conducted on *Araucaria heterophylla* to know about its ability to release fever as it contains various chemical constituents responsible for anti-pyretic activity.

For many years all over the world, plants, their different parts, extracts have been utilized for medicinal purposes known as “phytotherapy”. Various herbal drug sources have been used as anti-pyretic medication since ancient times [32].

Research was conducted on resin which was obtained from the essential oil of the plant. Brewer’s yeast test was used to test the activity. Brewer’s yeast suspension can easily induce fever in rats. When the prepared resin was given to test the activity, the decrease in temperature was observed in rats when compared with drugs like Paracetamol and normal saline. Decrease in their temperature showed that the plant possesses potent anti-pyretic activity as well [13].

Anti-cancer activity:

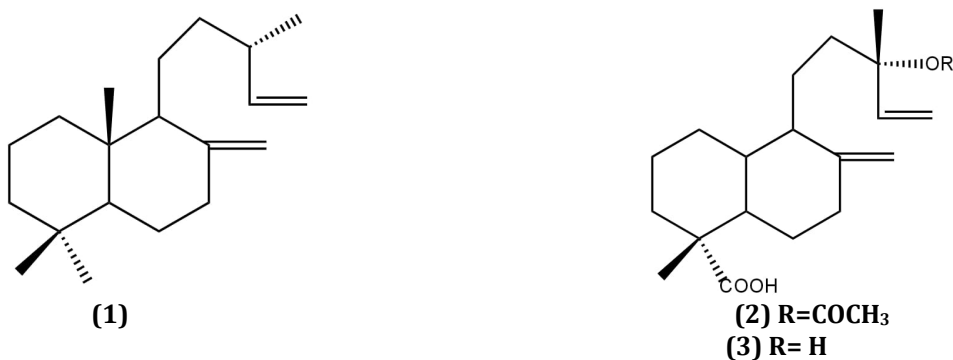
Anti-cancer activity of the plant was studied using extracts of different solvents. The plant is known to treat various types of cancer of different organs due its potent anti-cancer activity and presence of active chemical constituents.

The aqueous extract of the leaves of *Araucaria heterophylla* was utilized to obtain the silver nanoparticles. Silver nanoparticles can be made by adding aqueous silver nitrate to the plant’s extract. The nanoparticles are the pharmaceutical formulation having size ranges from 1-100 nanometres which facilitates the easy administration of the prepared drug. The silver nitrate nanoparticles prepared were known to exhibit potent activity against cancer mainly breast cancer cell line [33].

Another study was conducted for *in-vitro* anti-cancer activity by utilizing extract of the plant using different solvents. The activity was tested for mainly four types of cancer- Hepatocellular, mammary gland breast cancer, epithelioid, prostate cancer. The result of the research conducted showed potent anti-cancer activity of the plant extract proving it to be useful to treat various types of cancer [24].

Curcumin is an active chemical constituent produced by plants of *Curcuma longa* species. It is known to possess numerous biological activities including anti-cancer as well. So, research was conducted by synthesizing curcumin loaded nanocarriers from the polysaccharides obtained from the gum extract of *Araucaria heterophylla*. The formulation was tested against the disease and it was found to possess excellent anti-cancer activity [28].

The resin obtained from the stem of plant *Araucaria heterophylla* was evaluated for its cytotoxic activity. Sulphorhodamine B assay was performed to carry out the activity against colon and breast cancer cell lines. Abdel-Sattar Essam and his colleagues were able to isolate 3 chemical constituents which were resulted out to possess effective cytotoxic activity.



The first and the second compound known to possess strong effective cytotoxic activity in counter to both colon and breast cancer cell line where as the third compound showed little weak activity against breast cancer cell line [34].

The invitro cytotoxic activity had been evaluated of the gum isolated from the plant after its extraction and characterization utilizing MTT assay on human embryonic kidney cell which showed no induced cytotoxic activity which indicated the non-toxic nature of the plant which can be used as pharmaceutical excipient for preparations of various dosage forms [27].

Nephroprotective activity:

Araucaria heterophylla is known is possess various chemical compounds which shows nephroprotective activity. Hence the research was conducted to test the retention of salt sodium and water in adult albino Wistar rats. Another plant called *Pinus strobus* along with *Araucaria heterophylla* was used to obtain the extract to test the activity. Gentamicin was used to induce nephrotoxicity, and hence the study concluded that the combination of both plant extracts was able to release more salt in the urine, thus indicating potent nephroprotective activity [6].

Gastro-protective activity:

Araucaria heterophylla is known to possess active chemical constituents in its essential oil which shows effective gastro-protective activity. About 10% of the world population has been suffering from different types of ulcers such as peptic, gastric ulcer [35].

The research was conducted by Ali E. Dalia et al on the resin essential oil obtained from the bark of plant which shows potent gastro-protective activity [36].

Another anti-ulcer activity of the resin had been screened obtained from the stem part of the plant *Araucaria heterophylla* Salisb. The resin was collected by the process of extraction using solvent chloroform and methanol. They used Sprange Dawely rats to study the ulcerogenic effect and ranitidine was utilized as the standard drug. The glandular part of the stomach of rats was observed for lesions. Both long and petechial lesions were observed and the sum total of ulcers index was calculated. The research conducted showed potent activity of plant against ulcers [34].

Anti-helicobacter pylori activity:

Helicobacter pylori can cover up to 50% of the world's population to cause infection in which about 80% of the people do not show symptoms resulting in putting life on a dangerous stake [37].

To overcome this, *Araucaria heterophylla* was chosen to conduct research in order to discover its herbal solution.

The essential oil of the bark of the plant *Araucaria heterophylla* have been known to show good activity against Helicobacter pylori. A study was conducted which showed effective results against Helicobacter pylori in-vitro. Micro-well dilution method was used to study the activity on a reference strain of H. pylori. The extract was able to reduce the peptic ulcer in rats proving it to be a potent natural source to exhibit activity against such bacteria [36].

Aldose reductase and butyryl choline esterase enzyme inhibition:

The research was conducted on *Araucaria heterophylla* to find out the study on certain enzymes. The oleogum resin of the plant was collected and subjected to isolation of essential oil by the process of hydro distillation.

The oil was tested for the inhibition of aldose reductase enzyme, BUCHE enzyme and COX-II enzyme separately and showed effective results. The research conducted concluded the chances that the essential oil of *Araucaria heterophylla* can be used for treatment of diabetic cataract and Alzheimer's disease as well as for future research possibilities [38].

Allelopathic activity:

The phytotoxicity activity of the essential oil of the plant *Araucaria heterophylla* was evaluated by conducting an experiment using the weeds *C. murale* and *S. oleraceus*. The essential oil of different concentration was tested on the ripened seeds of the chosen weeds. The study conducted showed the potent inhibition of seed germination, seedling shoot growth and seedling root growth [28].

Toxoplasmicidal activity:

Toxoplasmosis is a disease generally caused by protozoa *Toxoplasma gondii* (T. plasma). Various synthetic drugs used in treatment have been known to show finite efficacy against the protozoa. This pushed to conducted various researches so that herbal medication can be prepared for its treatment and control.

Araucaria heterophylla plant came into notice due to being rich in diterpenes. The resin of the plant contains various other chemical constituents along with diterpenes which was collected from the stem of the plant. The invitro Toxoplasmicidal activity was tested against *T. gondii* for *Araucaria heterophylla* resin (AHR) and 13-epi-cupressic acid (CUP). Cotrimoxazole was utilized as standard drug to perform the research. The result was found to be excellent against *T. gondii* for both AHR and CUP which showed the future perspectives for development of new therapeutic medicines for toxoplasmosis [39].

Pesticidal effect:

An experiment was performed to know about the pesticidal efficacy of extracts of plants *Araucaria heterophylla* and *Commiphora molmol* against certain pests. Various types of pests were collected and subjected to the process of extraction for extracting out the oil-resin of the plant by using suitable solvent such as methanol and hexane. The pesticidal efficacy was tested against four ectoparasites- *R. annulatus*, *H. dromedarii*, *He. Eurysternus* and *Hi. Maculate*. The results obtained showed outstanding novel pesticidal efficacy of both plant extracts. Methanol extract of the plants was found to be friendly to environment and cheap pest control [40].

PHARMACEUTICAL APPLICATION**Utilization as tablet binder:**

An experiment was performed in which gum obtained from the trunk part of *Araucaria heterophylla* was isolated and purified. It was then tested to know if it can work as tablet binder. Binders are the excipients used for the preparation of tablets to bind API's together. Acelofenac was used as the model drug. The tablets were prepared by using different concentration of gum in different batches. The prepared tablet batches were then subjected for testing comprising of bulk density, tapped density, hausner's ratio, angle of repose, weight variation, hardness, friability. The study concluded that the increase in the concentration of gum in the tablet marks an increase in its dissolution as well as disintegration time. Hence, the above study conducted showed that the gum obtained from the plant can be efficiently used as a natural binder in the preparation of tablets. The above study opens distinct ways for usage of the gum of *Araucaria heterophylla* and can be used for various other future perspectives [41].

CONCLUSION

Araucaria heterophylla is a coniferous plant which can grow to a decent height and also to a certain height that it can be placed indoors as well as an ornamental plant. It known to be rich in active chemical constituents which can be assured by performing phytochemical screening. The presence of decent number of chemical constituents in the plant are responsible for various pharmacological activities such as anti-inflammatory, anti-oxidant anti-microbial, anti-pyretic, anti-cancer, nephroprotective, cytotoxic, allelopathic activity. Diverse parts of the plant such as stem, leaves, gum, roots, trunk acquire these wide varieties of pharmacological activities. It opens various plans to utilize the plant and its extracts as active pharmaceutical ingredient for preparation of herbal medicinal drugs. Not only in the human diseases but this plant also shows pesticidal efficacy for various plants against distinct types of pests which shows that it can be used for the preparation of novel pesticidal products. The gum of the plant shows huge number of pharmacological effects. Along with this, it can also be used as an excipient for manufacturing of tablets as a binder. The gum of the plant shows excellent binding capacity. From API's to excipients, *Araucaria heterophylla* plant possesses a wide range of qualities which makes it useful for mankind in the upcoming time.

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