

Neem – A Green Treasure

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Abstract

Neem (*Azadirachta indica*) commonly called 'Indian Lilac' or 'Margosa', belongs to the family Meliaceae, subfamily Meloideae and tribe Melieae. Neem is the most versatile, multifarious trees of tropics, with immense potential. It possesses maximum useful non-wood products (leaves, bark, flowers, fruits, seed, gum, oil and neem cake) than any other tree species. These non-wood products are known to have anti-allergenic, anti-dermatitic, anti-feedent, anti-fungal, anti-inflammatory, anti-pyorrhoeic, anti-scabic, cardiac, diuretic, insecticidal, larvicidal, nematocidal, spermicidal and other biological activities. Because of these activities neem has found enormous applications making it a green treasure.

Keywords: *Azadirachta indica*; Neem products; Uses.

1. Introduction

The neem tree (*Azadirachta indica* A.Juss.) is a tropical evergreen tree (deciduous in drier areas) native to Indian sub-continent [1,2]. It has been used in Ayurvedic medicine for more than 4000 years due to its medicinal properties. Neem is called '*arista*' in Sanskrit a word that means '*perfect, complete and imperishable*'. Most of the plant parts such as fruits, seeds, leaves, bark and roots contain compounds with proven antiseptic, antiviral, antipyretic, anti-inflammatory, anti-ulcer and antifungal uses. The Sanskrit name '*nimba*' comes from the term '*nimbati swasthyamdadati*' which means '*to give good health*'. The benefits of neem are listed in ancient documents '*Charak-Samhita*' and '*Susruta-Samhita*', which form the foundation of the Indian system of natural treatment, Ayurveda. It is commonly called 'Indian lilac' or 'Margosa' and belongs to the family Meliaceae. The Persian name of neem is '*Azad- Darakth- E- Hind*' which means 'Free tree of India'. Neem is considered to be a part of India's genetic diversity [3,4]. Neem tree is the most researched tree in the world [5] and is said to be the most promising tree of 21st century. It has

great potential in the fields of pest management, environment protection and medicine. Neem is a natural source of insecticides, pesticides and agrochemicals [6].

Neem is a large tree growing about 25 m in height with semi-straight to straight trunk, 3 m in girth and spreading branches forming a broad crown (Figure 1). A neem tree normally starts fruiting after 3-5 years. In about 10 years it becomes fully productive. From the tenth year onwards it can produce up to 50 Kg of fruits annually [7]. The plant is reported to live up to two centuries.

The tree has adaptability to a wide range of climatic, topographic and edaphic factors. It thrives well in dry, stony shallow soils and even on soils having hard calcareous or clay pan, at a shallow depth. Neem tree requires little water and plenty of sunlight [3,4]. The tree grows naturally in areas where the rainfall is in the range of 450 to 1200 mm. However, it has been introduced successfully even in areas where the rainfall is as low as 150 to 250 mm. Neem grows on altitudes up to 1500 m [8, 9,10]. It can grow well in wide temperature range of 0°C to 49°C [11]. It cannot withstand water-logged areas and poorly drained soils.

The pH range for the growth of neem tree lies in between 4 to 10. It grows on almost all types of soil including clayey, saline and alkaline soil, but does well on black cotton soils and deep well drained soil with good sub-soil water. Neem trees have the ability to neutralize acidic soils by a unique property of calcium mining [11].

2. Origin and distribution of neem

Two species of *Azadirachta* have been reported, *Azadirachta indica* A. Juss – native to Indian sub-continent and *Azadirachta excelsa* Kack. – confined to Philippines and Indonesia [9,11]. The former grows as a wild tree in India, Bangladesh, Burma, Pakistan, Sri Lanka, Malaysia, Thailand and Indonesia. Presently neem trees can be seen growing successfully in about 72 countries world-wide, in Asia, Africa, Australia, North, Central and South America [4,11-20].



Figure 1. Healthy Neem Tree.

Neem is a member of the Mahogany family.

Taxonomic position of neem –

Order- Rutales

Suborder – Rutinae

Family – Meliaceae

Subfamily – Melioideae

Tribe – Melieae

Genus – *Azadirachta*

Species – *indica*

There are an estimated 25 million trees growing all over India [21], of which 5.5% are found in Karnataka and it is in the third place next to Uttar

Pradesh (55.7%) and Tamilnadu (17.8%) occupying the first two places respectively. The other states of India where neem tree is found growing includes Andhra Pradesh, Assam, Bihar, Delhi, Gujarat, Haryana, Himachal Pradesh, Kerala, Madhya Pradesh, Maharashtra, Meghalaya, Orissa, Punjab, Rajasthan, West Bengal along with Andaman and Nicobar Islands, the Union territory [4,11,14,22-24]. India stands first in neem seed production and about 4,42,300 tons of seeds are produced annually yielding 88,400 tons of neem oil and 3,53,800 tons of neem cake [15].

3. Uses

Neem is well-known for its durable wood. In addition, the non-wood products of neem like flowers, fruits, seeds (oil, cake), leaves (Figure 2), bark and gum also find various uses [4]. The antifungal, antibacterial, insecticidal and other versatile

biological activities of these products are well established [9], because of which they find multipurpose use in daily life of humans. The most useful and valuable product of the tree are the seeds which yield 40% of a deep yellow oil, the well-known 'Margosa oil'.



Figure 2. The Neem Products. (A) Twigs, (B) Leaves, (C) Fruits, (D) Seeds (with endocarp), (E) Seeds (without endocarp).

4. Neem products and their uses

Seeds: yield oil and cake.

Neem oil: Medicinal: Analgesic, Anticholinergic, Antihelminthic, Antihistaminic, Antiprotozoal, Antipyretic, Antiviral, Bactericidal, Contraceptives, Fungicides, Insecticides, Insect repellents, Veterinary medicines. Technical: Cosmetics, Hair oils, Lubricants, Propellants, Shampoos, Soaps, Tooth pastes.

Neem cake: Animal feed, Soil fertilizer, Soil moisturizer, Soil neutralizer, Soil protectant.

Leaves: Antidermatic, Antifungal, Anticlotting agent, Antihelminthic, Antituberculosis, Antitumour, Antiseptic, Antiviral, Contraceptive, Cosmetics, Fertilizers, Insecticides, Nematicides, Insect repellents.

Twigs: Oral deodorant, Toothache reliever, Tooth cleaners.

Bark: Antiallergenic, Antidermatic, Antifungal, Antiprotozoal, Antitumor, Deodorant.

Wood: Agricultural implements, Carts, Boats, Building articles, Furniture, Idols, Tools.

Flowers: Analgesic, Curries, Nectaries, Soaps, Stimulant.

Others: Adhesives, Food from fruits, Fuel wood, Glue, Honey, Pulp biogas, Resin, Tannin, Wind breaker, Wood preservatives [3,4].

More than 135 compounds have been isolated from different parts of neem. These compounds are classified into two major groups- isoprenoids and others. The isoprenoids include diterpenoids and triterpenoids containing protomeliacins, liminoids, azadirone and its derivatives, genudin and its derivatives, vilarin type of compounds and c-secomeliacins such as nimbin, salannin and azadirachtin. The first compound to be studied was nimbin. The non-isoprenoids include proteins (amino acids) and carbohydrates (polysaccharides), sulphurous compounds, polyphenolics such as flavonoids and their glycosides, dihydrochalcone, coumarin and tannins, aliphatic compounds, phenolic acids, etc. [25-30]. Bioactivities of only few compounds have been studied (Table 1).

Table 1. Some bioactive compounds from neem [25].

Neem compound	Source	Biological activity
Nimbidin	Seed oil	Anti-inflammatory, Antiarthritic, Antipyretic, Hypoglycaemic, Antigastric ulcer, Spermicidal, Antifungal, Antibacterial, Diuretic
Sodium nimbidate		Anti-inflammatory
Nimbin	Seed oil	Spermicidal
Nimbolide	Seed oil	Antibacterial, Antimalarial
Gedunin	Seed oil	Antifungal, Antimalarial
Azadirachtin	Seed	Antimalarial
Mahmoodin	Seed oil	Antibacterial
Gallic acid, (-) epicatechin and catechin	Bark	Anti-inflammatory, immunomodulatory
Margolone, margolonone and isomargolonone	Bark	Antibacterial
Cyclic trisulphide and cyclic tetrasulphide	Leaf	Antifungal
Polysaccharides		Anti-inflammatory
Polysaccharides Gla, Glb	Bark	Antitumour
Polysaccharides GIIa, GIIIa	Bark	Anti-inflammatory
NB-II peptidoglycan	Bark	Immunomodulatory

5. Environment and neem

Neem compared to other species is well adapted to stress conditions [7]. It is also known to increase soil fertility and water holding capacity. Thus the large scale plantation of neem trees help to combat desertification, deforestation, soil erosion and to reduce excessive global temperature [4]. Today, modern societies, finding themselves confounded in the web of their creation, are willing to revert to nature for remedies and neem tree provides a promising means in this matter [3]. Neem has high rate of photosynthesis and liberates more oxygen than many other tree species, thus purifying the atmosphere [31,32]. The temperature under the neem has been found to be $\sim 10^{\circ}\text{C}$ less than the surrounding temperature, during hot summer months in the northern parts of India [3]. Over 10 kms on the plains of Arafat, about 50,000 neem trees were planted to provide shade for Muslim pilgrims during Hajj. A marked impact on the areas microclimate, microflora, microfauna and sand soil properties was noticed. The plantation when full-grown is expected to provide shade to about two million pilgrims [12,3].

In areas of low rainfall and high wind speed neem is useful as wind breaks. In the Maijia valley in Niger, 20% increase in grain yield was observed in millet crops protected by double rows of neem trees providing 500 km of wind break. Large scale planting of neem has been initiated in the Kwimba afforestation scheme in Tanzania. Neem plantations

have been used for halting the spread of Sahara desert in the countries from Somalia to Mauritania [3]. Completely grown neem tree yields about 10-100 tons of dried biomass/ha, comprised of leaves (50%) and fruits and wood (25% each). Neem wood is durable and termite resistant and thus used in making poles for house construction, furniture etc. In rural India, neem is a good source of firewood and fuel. Its charcoal has high calorific value [3]. Neem has the ability to resprout after cutting and to regrow its canopy after pollarding. Thus it is highly suited for pole production [33]. Neem products have water purifying activity. Neem leaf powder could be used as biosorbent for the removal of dyes like Congo red from water [34].

6. Neem and Agriculture

Approximately one third of world's agricultural food stuffs get destroyed by more than 20,000 species of field and storage pests [35]. In India, pest infestation results in the loss of about Rs. 5000 crores worth of agricultural produce every year. To prevent this loss, large amounts of synthetic pesticides are applied, out of which only 0.1% reaches the target pests and more than 99% contaminates the ecosystem [4]. In addition, synthetic pesticide usage has resulted in development of resistant pests. Cost-effective, non-toxic, biodegradable, eco-friendly and botanical 'soft-pesticides' are the need of present day agriculture as an alternative to hazardous and recalcitrant synthetic pesticides [4]. Neem tops the list of 2,400 plant species that are reported to have

pesticidal properties and is regarded as the most reliable source of eco-friendly biopesticidal property. Neem is also used as a biocontrol agent to control many plant diseases [36]. The insecticides from neem are non-phytotoxic with good shelf life and effective against a wide range of insects and pests.

Neem products are effective against more than 350 species of arthropods, 12 species of nematodes, 15 species of fungi, three viruses, two species of snails and one crustacean species [31,33,37-41]. Two tetracyclic triterpenoids - meliantetraolone and odorone isolated from neem exhibited insecticidal activity against *Anopheles stephensi* [42]. Over 195 species of insects are affected by neem extracts and insects that have become resistant to synthetic pesticides are also controlled with these extracts. The apprehension that large-scale use of neem based insecticides may lead to resistance among pests, as being observed with synthetic pesticides, has not been proved correct. This is because the neem based insecticides have relatively weak contact effect in insects and also they have unique mode of action on insect's life cycle and physiology [33].

The dependency on synthetic chemicals during early and middle twentieth century has prompted the large scale synthesis of newer chemicals. Many a times, the side effects of the synthetic pesticides are more serious than problems themselves. They are also known to cause health problems in farmers of both developed and developing countries. According to World Health Organization (WHO) estimation, annually 2,20,000 deaths occur due to acute poisoning caused by synthetic pesticides [4]. This can be avoided by use of biopesticides [3]. Neem based pesticides are found to be much safer in this regard [43]. Today, neem has gained importance internationally as all communities have inclined towards green technology. Neem products have no ill effects on humans and animals, and have no residual effect on agricultural produce. This makes neem the best, reliable substitute to hazardous pesticides. The demand for chemical pesticides will be reduced by large scale use of neem based pesticides that will in turn reduce the load of synthetic chemicals in environment.

Treatment of mice with neem leaf extract (aqueous) caused adverse effects on motility, morphology and number of spermatozoa [44]. Neem seed extracts inhibited folliculogenesis in albino rats. Neem extracts could thus be used as bio-rodenticides instead of toxic synthetic rodenticides that are pollutants [45]. Neem based seed treatment for management of root-rot complex in cluster bean caused by *Rhizoctonia solani* and *Fusarium solani* was tried using neem seed extract, neem oil, azadirachtin and ahook. All the treatments resulted in higher seed germination and higher mean dry biomass than in untreated control. Therefore neem can be used against phytopathogenic fungi as a means of biological

control [46]. Neem based pesticides are easy to prepare, cheap and highly effective and thus constitute an important source of pesticide for economically poor third world country farmers [6,47]. Neem bio-pesticides are systemic in nature and provide long term protection to plants against pests. Pollinator insects, bees and other useful organisms are not affected by neem based pesticides [48]. Today, many neem bio-pesticides are marketed in India and international markets [6,49,50]. Commercially available neem formulations like Ahook (0.15% E.C.), Bioneem (0.03% E.C.), Nimbecidine (0.03% E.C.) and Neemark (0.03% E.C.) showed antifungal activity against pathogenic fungi viz., *Fusarium oxysporum*, *Alternaria solani*, *Curvularia lunata*, *Helminthosporium* sp. and *Sclerotium rolfsii* [51].

Neem cake is a cheap and useful fertilizer. The plant debris are potential source of organic manure [6,49]. Neem cake-coated urea has been produced, which when used increases nitrogen assimilation compared to untreated urea [3]. Neem leaves could be used as a source for the preparation of vermicompost having both fertilizer and pesticidal potential [52].

7. Veterinary uses

In India, neem has been used for centuries to provide health cover to live stock in various forms. It has also been very widely used as animal feed. The epic of Mahabharata (3000 B.C.) refers to two pandava brothers *Nakul* and *Sahadeva*, who used to treat wounded horses and elephants with neem oil and leaves' preparations. Neem extracts having antiulcer, antibacterial, antiviral properties are used successfully to treat cases of stomach worms, ulcers, cutaneous diseases, intestinal helminthiasis. All parts of neem viz., gum, bark, leaves, fruits, seeds are used to treat animals. Neem leaves have been mainly used as antiviral agents against vaccinia, variola, fowl pox and Newcastle disease viruses. The hot infusion of leaves is used to treat swollen glands, bruises and sprains. Bark is effective against cutaneous diseases. Seed and kernel oil are used as antiseptic, antifungal and antibacterial agents. Neem oil has antihyperglycaemic effect [3]. Alcohol and aqueous extracts of flowers of neem exhibits lethal effect against cattle filarial parasite *Setaria cervi* [53]. Livestock insects such as maggots, horn flies, blow flies and biting flies are controlled traditionally using neem [3].

Neem leaves, neem oil and de-oiled neem seed cake are used as animal feed. Neem leaves contain appreciable amount of proteins, minerals, carotene and adequate amount of trace minerals except zinc. They also have appreciable amount of digestible crude proteins (DCP) and total digestible nutrients (TDN). Thus cattle, buffaloes, goat, sheep, camel are fed with neem leaves. Neem oil which is rich in

long chain fatty acids is used in poultry feed. De-oiled neem seed cake is rich in essential amino acids, crude proteins, fiber contents, sulphur and nitrogen. The processed cake has good appetizer and wormicidal activity and can be used as an excellent poultry feed [3].

In the poultry industry, aflatoxicosis caused by *Aspergillus flavus* which originates from contaminated poultry feed is prevented using neem leaves [3]. Neem leaf extract inhibits the production of aflatoxin by *Aspergillus parasiticus* [54] and Patulin production by *Penicillium expansum* [55].

8. Medicinal uses

Since time immemorial, Indians are aware of medicinal properties of neem. Neem has been extensively used in Ayurveda, Unani and Homeopathic medicine. Traditionally, many disorders like inflammation, infections, fever, skin diseases, dental disorders and others have been treated with different parts of neem tree such as leaves, flowers, seeds, fruits, roots and bark. Neem leaf exhibits a wide range of pharmacological activities viz., anti-inflammatory, antihyperglycaemic, antiulcer, antimalarial, antifungal, antibacterial, antiviral, antioxidant, antimutagenic anticarcinogenic and immunomodulatory [56].

Ayurvedic literature lists various medicinal uses of neem. It describes neem bark to be cool, bitter, astringent, acrid and refrigerant and useful in tiredness, cough, fever, loss of appetite, worm infestation. The bark is reported to heal wounds and vitiate conditions of *kapha*, vomiting, skin diseases, excessive thirst and diabetes. Neem leaves are reported to be beneficial for eye disorders and insect poisons and to treat *vatic* disorder. It is reported to be antileprotic. Neem fruits are bitter, purgative, antihemorrhoid and antihelminthic [3].

Neem is called '*Sarvaroga nivarini*' meaning '*the curer of all ailments*'. In rural India, delivery chambers are fumigated with burning bark of neem. Dried margosa leaves are burnt to repel mosquitoes. In India several viral diseases are treated with neem. Neem leaf paste has been used to treat small pox, chicken pox and warts. Neem twigs are used as tooth brushes in rural India and Africa [3]. Dental gel containing neem leaf extract reduces the oral plaque index and bacterial count [57]. Methanolic extract fraction of neem leaves when tried against Cocksackie 'B' group viruses, produced *in vitro* antiviral and virucidal effect [58].

Neem is used to treat malarial fever in ayurvedic medicine system. Neem oil treated mosquito nets and mosquito-repellent tablets are now available in the North-east India. Gedunin (a liminoid) obtained from neem has activity similar to quinine against malarial pathogen [3]. The neem liminoids (Azadirachtin, salannin, deacetylgedunin) exhibited high larvicidal, pupicidal and antiovipositional bioactivity against malaria vector –

Anopheles stephensi [59]. Tablet suspension of the bark and leaf of neem showed moderate effect against malarial pathogen, *Plasmodium* sp. [60].

Currently, studies on effect of administration of neem solutions on cancer, diabetes, heart disease and AIDS are being carried out. Anticarcinogenic activity of neem leaf extract was observed in murine system [61]. Injection of neem leaf preparation to tumor in mice reduced tumour growth, exhibiting anticarcinogenic activity [62]. Induction of apoptosis in rat oocytes was seen when treated with neem leaf extract [63]. Buccal pouch carcinogenesis in hamsters was inhibited by ethanolic leaf extract of neem [64]. The ethanolic leaf extract of neem also caused cell death of prostate cancer cells (PC-3) by inducing apoptosis [65].

Good antioxidant activity was observed with neem leaf aqueous extract, flower and stem bark ethanolic extracts [66]. Administration of aqueous extract of neem along with DOCA salt prevented the development of hypertension in rats [67]. Neem leaf extracts are antimutagenic. The ethanolic extract of neem leaves exhibited strong antimutagenic activity in *Channa punctatus*, a fresh water fish model [68]. Aqueous extract of neem root and leaves reduced blood sugar level in rats exhibiting antidiabetic activity [69]. The bark extract completely healed the duodenal ulcers when administered at the dose of 30-60 mg twice daily for 10 weeks. Neem bark extract had potential of controlling gastric hypersecretion, and gastroesophageal and gastroduodenal ulcers [70].

Acetone-water neem leaf extract showed antiretroviral activity through inhibition of cytoadhesion. The extract increased haemoglobin concentration, mean CD4+ cell count and erythrocyte sedimentation rate in HIV/AIDS patients [71]. Enhancement of antibody production and cellular mediated response by neem components helps in the treatment of AIDS [3].

Neem leaf and seed extracts exhibited antidermatophytic activity against dermatophytes viz., *Trichophyton rubrum*, *Mentagrophytes*, *Trichophyton violaceum*, *Microsporum nanum* and *Epidermophyton floccosum* under *in vitro* conditions [72]. Neem seed oil showed bactericidal activity against 14 strains of pathogenic bacteria [73]. Crude aqueous and solvent extracts of neem were tried against 20 strains of pathogenic bacteria wherein crude extract produced better results [74]. The contraceptive property of neem oil has been reported [33,75]. Neem leaf extract has spermatotoxic effect. The leaf extracts of neem showed 100% immobilization and mortality of human spermatozoa at a 3 mg dose within 20 seconds [76,77]. A new vaginal contraceptive, NIM-76 was developed from neem oil having antimicrobial activity against *Escherichia coli*, *Klebsiella pneumoniae* and *Candida albicans* [78].

9. Industrial uses

In 2002, at the World neem conference, idea of promoting neem as an "Industrial Plant" was put forward [79]. Several industries including pharmaceuticals, cosmetics, disinfectants, rubber, bio-pesticide and textile industries use neem oil [9]. Many such neem-based commercial preparations are currently available [49,50]. In India neem is highly exploited by many Ayurvedic drug industries. Neem oil and powdered neem leaves are employed in various cosmetic preparations such as face creams, nail polish, nail oils, shampoos, conditioners [3,9,33]. A new shampoo, based on seed extract of neem was highly effective, more than permethrin-based product, against head lice under *in vitro* conditions [80]. Neem cake a by-product of neem oil industry is used as livestock feed, fertilizer and natural pesticide. Neem oil is commonly used in soap production. Medicated neem soaps are gaining popularity. Neem based toothpaste is widely used in India and European countries. Neem is a source for many oral-hygiene preparations and dental care products. Neem bark yields gum and tannins which are used in tanning, dyeing etc. Neem seed pulp is used as a rich source of carbohydrate in fermentation industries and for methane gas production. Cultivation of neem and processing of neem products provides employment and income generation opportunities. Collection of neem seeds to be supplied to the industries provides important means of supplementary employment and income for the poor households, especially the rural women [3]. India stands first in neem production and about 5,40,000 tons of seeds are produced annually yielding 1,07,000 tons of neem oil and 4,25,000 tons of neem cake (Anonymous, 1995). The amount of azadirachtin available is estimated to be about 1600 tons per annum, providing enormous amount of raw material for pesticide industry. In the product sector, annual estimated turnover is about Rs. 1000-1200 crores. Small scale industries have a major role to play in harnessing the potential. Therefore, in India it is the time to take right steps in promoting neem, both for the benefit of farmers and industries [79].

10. Patents on neem

During the past five decades intensive investigations on the diverse properties of neem have been carried out. As a result large numbers of research publications and books have been published. Many conferences have been conducted at national and international level.

Neem Conferences:

- 1) First International Neem Conference, Rottach-Egern, Germany, 1980.
- 2) Second International Neem Conference, Rauschholzhausen, Germany, 1983.

- 3) Third International Neem Conference, Nairobi, Kenya, 1986.
- 4) First World Neem Conference, Bangalore, India, 1993.
- 5) Second World Neem Conference, Queensland, Australia, 1996.
- 6) Third World Neem Conference, Vancouver, Canada, 1999.
- 7) Fourth World Neem Conference, Mumbai, India, 2002.
- 8) Fifth World Neem Conference, Coimbatore, India, 2007 [3,4,49].

Hundreds of active compounds that are isolated from various parts of neem find their applications in pesticide, medicine, health care and cosmetic industry all over the world. World over the neem tree has been recognized as a commercial opportunity. Many neem related processes and products have been patented in Japan, USA and European countries, since 1980s. In 1983, Temuro Corporation obtained the first US patent for its therapeutic preparation from neem bark. USA with 54 patents on neem and neem based products stands first followed by Japan [35], Australia [23] and India [14]. Since 1995, more than 53 patent applications are pending in India for either gazette notification or opposition. Hopefully, if all these patents are granted India will have the largest number of patents in neem [3].

Majority of patents that have been granted are for crop protection application (63%) followed by health care (13%), industrial (5%), veterinary care (5%), cosmetics (6%) and others (8%). Organization wise, largest number of patents are owned by Certis- W.R. Grace [49] followed by Rohm and Haas [36], CSIR-India [14], Trifolio [9], Bayer [8] and EID Parry [6,3].

11. Conclusion

Owing to its versatile characteristics neem is rightly called the 'Village pharmacy' or 'Doctor tree' or 'Wonder tree of India' or 'The bitter gem'.

National Research Council (NRC), Washington, USA considers the neem, "One of the most promising of all plants and the fact is that it may eventually benefit every person on this planet. Probably no other plant yields as many strange and varied products or has as many exploitable by-products."

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