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Neem Tree Extracts Used in Textile Industries

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In Loving Memory of Late Professor Doctor ""Mohamed Refaat Hussein Mahran""

Abstract
Azadirachta indica, also known as the neem tree, is a multipurpose plant that has been utilized for ages in traditional medicine, farming, and even the textile industry. Numerous substances, such as neem oil and neem extract, are produced by the neem tree and have been shown to have insecticidal, antibacterial, and antifungal qualities. Neem extract is especially useful in the textile sector since it can serve as a natural color fixative. This makes it a valuable component in the dyeing process since it can aid in enhancing the colorfastness of textiles. Furthermore, it has been discovered that neem extract possesses anti-bacterial qualities, which may aid in inhibiting the development of bacteria and fungi in textiles and prolonging their longevity.
Neem extract is also being investigated for its potential to replace synthetic chemicals in the textile sector in a sustainable manner. Neem extract may provide a sustainable and natural way to dye and finish textiles as the market for non-toxic, environmentally friendly textile production methods expands. In conclusion, the use of neem extract in the textile industry holds great promise for improving the sustainability and performance of textile production processes. Its natural properties make it an attractive alternative to synthetic chemicals, and its potential to enhance colorfastness and prevent microbial growth makes it a valuable ingredient in textile dyeing and finishing.
Keywords: Neem plant, textile industries, natural fabrics.

1. Introduction

The adaptable Meliaceae family tree known as neem, Azadirachta indica A. Juss, originated in the dry island woods of Myanmar or the forests of Karnataka in South India.[1] When Burma (Myanmar) was a part of India, Roxburgh (1874) stated that it originated there. Its origins in arid parts of Upper Myanmar (Irrawady Valley, upper region of Prome) are described by Brandis (1921) and Jacobs (1961). Its native range encompasses the Shivalik Hills in India.[2, 3]

On the other hand, neem is a massive evergreen tree that can reach heights of 20 meters and girths of 2.5 meters. Neem trees are now present in about 80 countries, with an estimated 91 million of them in the world. The primary distribution regions are in South Asia and Sub-Saharan Africa. The tree is currently found growing on the islands of the South Pacific, the West Indies, Haiti, Surinam, the Dominican Republic, Cuba, Nicaragua, and some parts of Mexico. It was brought to east Africa, the Caribbean islands, Fiji, Mauritius, and other places in the last century. Selected areas of California, Southern Florida, Oklahoma, Arizona (USA), and Queensland (Australia) were exposed to it.[4]

Twenty years has passed since the neem trees were planted at the US Department of Agriculture Experimental Station in Mayaguez, Puerto Rico. When these trees were almost a meter tall, they were transplants from greenhouses. In the late 1980s, work was done in Arizona to use seeds from Northern India to create neem trees that would withstand frost up to -8C.[5]

Neem trees can be found in Bolivia, Ecuador, Venezuela, and Colombia in South America. As part of massive afforestation programs, over 300,000 trees were recently planted in arid areas of northeastern Brazil's Savannah; by 2003, 10 million neem trees are expected to have been planted.[6]

Several million neem trees are thought to be found now along Africa's east coast, stretching from Eritrea and Somalia to Kenya, Tanzania, and on to Mozambique. Neem is extensively found on the

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island of Mauritius as well as in the arid southwest of Madagascar.[7]

More than half a million neem trees have been planted in Queensland, in the northeast of Australia, in recent years. The Australians have great expectations for the use of neem as a non-synthetic insecticide in addition to reforestation and erosion control. The first neem trees were planted in the People's Republic of China in the 1980s on the Hainan peninsula and in the southern region of Guangdong. There are currently about 100,000 trees in different locations of China.[6]

Neem is found in western Asia in the Arabian Peninsula, Mecca, Saudi Arabia, the Euphrates-Tigris Valley in Iraq, and the southern low-lying regions of Iran.[8]

In the past thirty years, neem has gained recognition as a tree with multiple uses, including forestry, medical, agricultural, and domestic applications. [9, 10]

Neem could thrive on deteriorated soil and an environment that was dry, harsh, and hostile, especially in arid regions of the planet. Additionally, it might aid with soil reclamation.[11]

Both humans and cattle might benefit from the shade that the tree offers, and ruminants could feed on the leaves. The wood can be used for agricultural tools, firewood, and furnishings in the home. In addition to being used as a lubricant for agricultural machinery, household lighting, disease prevention, pest control, and soap manufacturing, the seeds can produce oil.[12]

The primary focus of neem material research has been on its identification as a valuable source of plant allelochemicals, particularly for the insecticidal, insect repellant, antifeedant, and growth-regulating qualities of neem kernel extracts, which have garnered global interest. A tetranortriterpenoid called azadirachtin is the main active component. It is still being studied how its molecular mechanisms of action work, however it shows conventional insect growth regulation (IGR) effects on insects in their embryonic stages.[13, 14]

India is arguably the only nation equipped to acquire raw materials in significant quantities. When using neem for other applications, having a high-quality and reasonably priced raw material is crucial. Thus, extreme caution must be used during processing at every stage in order to produce high-quality material The following are some of the numerous beneficial components of neem, both for commercial and medicinal purposes: seeds, which are the most commonly utilized part; leaves; bark; fruits; flowers; and gum.[4]

The neem tree is a multipurpose plant with several possible use for all parts of the plant. Neem is actually used for therapeutic purposes and has a long history in Indian Ayurveda and Unani medicine, which dates back more than 3000 years. This is the oldest known usage of neem. Neem is now widely recognized as a traditional medicinal herb used to treat digestive issues, malaria episodes, skin disorders, bacterial infections, inflammations, diabetic illnesses, and pain relief.[14, 15]

Neem and its allelochemicals have a range of impacts on pests, according to several findings from around the world. To present, over 140 active principles that appear in various tree segments have been found. The most significant elements found are the azadirachtins and tetranortriterpenoids. Numerous methods have been demonstrated for neem to manage major pests (Fig. 1). Because of its unique method of action, particular effects on pests, safety for non-target organisms, biodegradable nature, and ease of obtaining from renewable sources, it has a high level of efficacy and a minimal danger of developing pest resistance. The promise of neem for controlling pests has only become apparent in the last ten years; unlike neurotoxins, it alters the physiology and behavior of pests instead of killing them. Neem's effects, however mild, include growth suppression, mating disruption, chemo-sterilization, feeding and oviposition deterrent, repellency, and more.[5, 8]

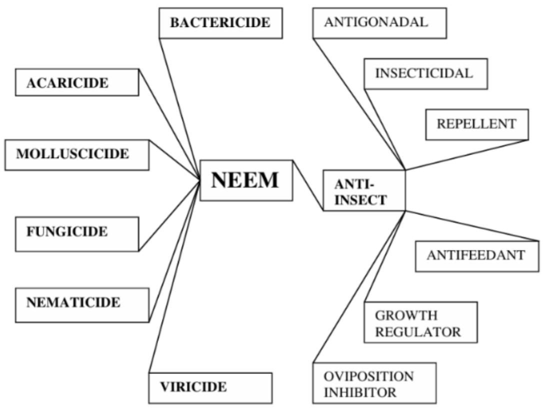

Figure 1: Neem as pesticide

Despite their high selectivity, neem derivatives affect between 400 and 500 different species of insects, including ostracod species, several mite species, and members of the following insect groups: Blattodea, Caelifera, Coleoptera, Dermaptera, Diptera, Ensifera, Hetroptera, Homoptera, Hymenoptera, Isoptera, Lepidoptera, Phasmida, Phthiraptera, Siphonoptera, and Thysanoptera. Moreover, neem preparations function as nematicides against ectoparasite species of Hoplolaimus and Tylenchorhynchus, semiendoparasitic species of Rotylenchus and Pratylenchus nematodes, and endoparasitic species of Melloidogyne and Globodera.[16]

The word "AZADIREX": The combination of insecticidally active substances found in neem seeds is not well-named. Neem extract is a word that is used extremely loosely. Products made from fruit, seeds, or leaves may be referred to as such. It has been utilized in insecticidal, nematipridal, antibacterial, and herbal medicinal products; azadirachtin may or may not be present. However, the term "azadirachtin" only describes one substance, and the active mixture derived from the seeds contains more than this. A class of highly oxidized limonoids are the key ingredients in neem seed extract that contribute to its insecticidal properties. At least 160 triterpene compounds have been identified from one or more neem tree parts, including leaves, bark, twigs, and roots. If there are more, they have not yet been found. Approximately one-third of these have had their biological characteristics investigated. There is now virtually little chance of discovering novel chemicals with insecticidal properties. Here, the name "azadirex" (an extract containing azadirachtin) is proposed in an attempt to avoid vague definitions. This term was coined to describe an extract of neem tree seed kernels that is insecticidally active (however obtained) and contains related biologically active chemicals of the limonoid group of triterpenes, including azadirachtin, which is the main active ingredient. The presence of other inactive limonoids such nimbin and the sometimes active substance salannin in this azadirex derivative is uncertain.

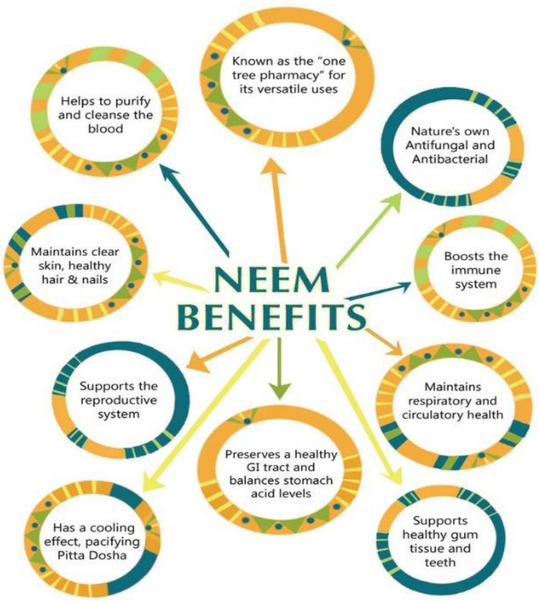

Figure 2: Neem Benefits in all field

2. wet processing of textiles

The textile industry, in general, is primarily involved in the processing, sizing, and desizing of yarn as well as the creation of fabrics and clothing. Globally, the textile sector has grown at an exponential rate in the last few decades.[17]

Textile wet processing is a typical procedure that involves pretreatments, dyeing, printing, and finishing steps.[18-24]

A technique that is growing more and more popular for use with all types of fibers, fabrics, and clothing is textile printing, which is a subset of the textile wet processing industry. At its core, printing is coloring—but with the colors applied to specific regions of the cloth instead of the entire surface. In comparison to plain dyed cloth, the colorful patterns that are produced have more artistic and elegant effects, increasing the cloth's worth. An agent that thickens is used to paste the coloring material inside the design area. The proper color, mark sharpness, levelness, dexterity, and effective dye application are all necessary for a successful print. Which kind of thickener is used determines all these things.[25]

3. Dyeing and Printing

Textiles are given color by the use of dyes and pigments in the dyeing and printing processes. In the past, the solubility of dyes and chemicals was used to distinguish them. Soluble coloring materials or those that could be made soluble in water were referred to as dyes, while insoluble coloring materials were called pigments. with dyeing, an aqueous solution or dispersion of dyes is employed, which gives the textile material a solid shade; with printing, however, dye is applied to the surface in the form of a pattern using a dye/pigment printing paste that has been thickened with a sizing substance. [26-41]The majority of dyes used in commercial textile applications are synthetic, made from aromatic compounds present in coal tar, and have a low biodegradability.[42]

In the textile business, dying is a procedure where the fiber and the dye are bonded together chemically or physically. The act of immersing cloth in a dye solution to cause the fibers to bend color is called dyeing. While chromophore functional groups like azo (-N=N-), carbonyl (-C=O-), nitro (-N=O-), and quinoid in the dyes are responsible for the color, auxochrome functional groups like amine, carboxyl, sulphonate, and hydroxyl are responsible for bending with fiber.[43]

A roller-printing machine is used in the printing process. Crucial reactions that occur throughout this process are comparable to those that occur during death. While dye is administered as a solution during the dying process, it is applied as a thick paste during the printing process to stop the dye from spreading.[44]

Unfixed color, thickening agent, and other printing paste chemicals wash off the fabric into waste water, contributing to the textile industry's heavy pollution of the water supply.**[45, 46]**

Consequently, there is a growing interest in natural materials due to environmental concerns. Natural dyes are thought to be more environmentally friendly than synthetic ones.**[45]** and there have been several conversations around this topic . As a result, there is currently a growing interest in the coloring of textiles using plant-based and other natural dyes**.[45]** This is why natural materials were used in this research's wet methods.

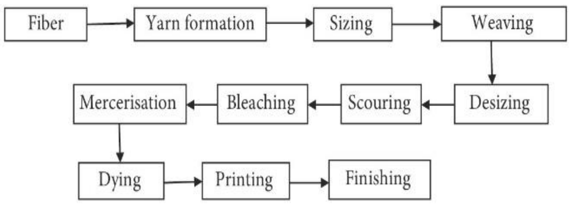

Figure 3: A flow diagram various steps involved in wet processing fiber production.

3.1. Thickeners:

High molecular weight polymers called thickeners are employed to give printing paste its viscosity and flexibility.[47] In every printing process, thickeners are necessary. Their primary function is to secure chemicals, dyes, and other printing aids to the cloth while printing is being done. The chemical and physical characteristics of the thickeners used determine how well the print turns out. They affect or even dictate the print's depth, color brightness, and, in particular, print sharpness and smoothness.[48-69]

3.2. The Thickener's primary characteristics

Thickeners should have distinctive qualities like the following since printing paste needs a thickening to improve its qualities.

- Water soluble, readily manufactured, and has appropriate rheological characteristics.
- Compatible with other ingredients in printing paste and suitable for blending with other thickeners.
- It must to be affordable and accessible.
- Stability in terms of temperature, pressure, and storage during printing
- It shouldn't leave the color on the fabric or preserve it.
- The thickener's affinity for other chemicals and colors should be low.
- The thickening should result in a solid film with good mechanical, elastic, and adhesive qualities as well as non-stick qualities.
- The stability of chemicals during the drying process.
- The thickener ought to yield consistent, high-quality color intensity and brightness.
- It shouldn't leave the color on the fabric or hold it.
- The fabric should be easily removable and soft after washing, with no negative effects on feel.[70]

3.2.1. Classification of Thickeners:

3.2.1.1. Depending on where they came from, thickeners fall into one of three categories (Table 1).[71]

a) Natural thickeners
b) Modified natural thickeners
c) Synthetic thickeners
d) Emulsion thickeners

A synthetic or natural polymer could be used as the thickener. The usage of artificial thickeners in the printing industry has a number of negative environmental implications. However, this effect can be reduced by substituting natural thickeners that are good to the environment with synthetic ones. [72]

The plant kingdom has a vast array of readily available natural thickening sources that are widely distributed.

The ingredients in natural thickening pose no health risks and are neither poisonous nor allergic to humans. For textile printing, the most important need for thickeners is that they must either dissolve in water or absorb it to create a viscous solution. Natural thickeners totally satisfy this need.[25]

3.2.2. Natural Gums as Thickeners in the Process of Fabric Printing :

Natural gums (NGs) have garnered attention recently because of their unique qualities and wide range of uses in the food and pharmaceutical industries as thickening agents, encapsulating agents, binding agents, gelling agents, and coating materials.[73]

Natural gums and their derivatives are hydrocolloids, carbohydrate polymers (polysaccharides), and have the capability to create gel and stabilized emulsions with hydration capacity in water. They are derived from renewable plant and animal sources [74]. They are typically made of monosaccharide units connected by glucosidic linkages, hydrophilic, and have a high molecular weight [75]. Because they are made from food sources, biodegrade naturally, and are inexpensive, nontoxic, and biocompatible, natural gums are a great alternative to synthetic polymers.[76-79]

Table 1: Classification of Thickeners

Thickeners			
Natural	Modified natural	Synthetic	Emulsions
A. Plant exudates 1. Neem gum 2. Arabic gum 3. Cashew gum 4. Guar gum B. Plant Seeds 1. Locust bean gum 2. Tamarind seed gum 3. Guar gum C. Seaweed extracts 1. Alginates D. Starch	A. Starch derivatives 1. British gum 2. Dextrin 3. Carboxymethyl Starch (CMS) B.Cellulose derivatives 1.Carboxymethyl Cellulose (CMC) 2. Methyl cellulose 3.Hydroxyethyl- cellulose	A. Vinyl polymers 1. Polyvinyl Alcohol (PVA) 2. Polyvinylpyrrolidone (PVP) B. Acrylic polymers 1. Polyacrylamide 2. Polyacrylic acid	A. Water-in-Oil (W/O) B. Oil-in-Water (O/W)

Figure 4: Characteristics of natural gums

3.2.2.1. *Classification of Natural Gums:*

Natural gums include Neem gum, albicia gum, almond gum, agar gum, acacia gum, bhara gum, cashew gum, carrageenan, guar gum, ghatti gum, gellan gum, honey locust gum, locust bean gum, okra gum, tamarind gum, and xanthan gum; these gums are found in nature all over the world [78].

Materials: (Neem plant extracts)

Azadirachta indica gum: Also referred to as neem, Azadirachta indica is a modern-day miracle tree that is evergreen. Because of its many uses, Indians have utilized it for a variety of purposes since the beginning of time. It has cytotoxic, anti-inflammatory, antiviral, antibacterial, and anticarcinogenic qualities. Neem contains the following phytochemical components: gallic acid, epicatechin, catechin, margolone, azadirachtin, nimbidin, nimbin, and nimbolide. Azadirachtin, the main active ingredient, functions as a potent antibacterial.[25]

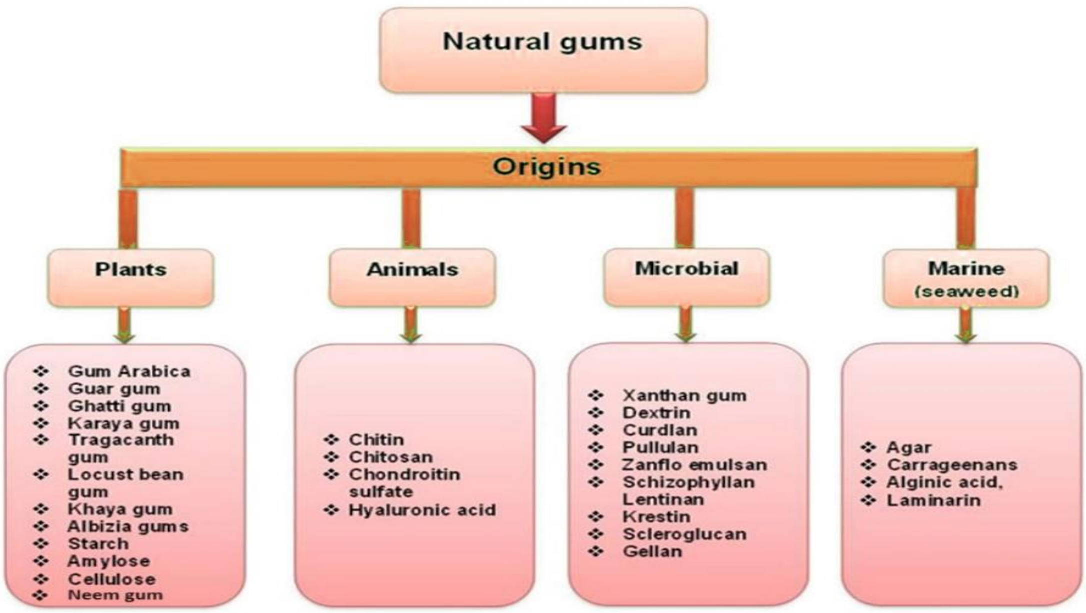

Figure 5: Classifications of different types of natural gums

Table2: Source and chemical composition of some plant-based natural gums

Types of gum	Source	Chemical constituents	References
Neem gum	Azadirachta indica	Mannose ,glucosamine, arabinose,galactose, fucose, xylose,glucose, acylgucosaminyl-asparaginyl bond	[80]
Gum arabic (gumsudani, acaciagum,Arabicgum, gumacacia,acacia, Senegalgum,Indiangum	Acaciasenegal/ seyal tree	D-galactose,Larabinose,L-rhamnose,D-glucuronic acid,and4-O-methyl-D glucuronicacid,1–3-linked β-D-galactopyranosyl, (1–6) linkedβ-D-glucopyranosyl	[81]
Cashew gum	Anacardium occidentale	Galactose,arabinose, rhamnose,glucose, glucuronicacid,andother sugarresidues,gumyields L-arabinose,L-rhamnose, D-galactose,andglucuronic acid,(1!3)-linkedβ–D galactopyranosylunits interspersedwithβ-(1!6) linkages	[82]
Guar gum	Cympopsis tetragonoloba (guar bean)	Galactomannan,mannose, (1!4)-linkedβ-D mannopyranosylunitswith (1!6)-linkedα-D galactopyranosyl	[83]

4. Neem gum

typically exudes from neem trees as a result of natural or man-made damage. Neem bark has deodorizing and antimicrobial properties. Owing to a variety of internal processes, neem bark releases a noticeable, strong, brown-colored gum material that dissolves in cold water and has a mild flavor. The gum is a product that is multipurpose.

The gum exudates from the stem of the Azadirachta indica tree are composed of a blend of polysaccharides and proteins. Azadirachta indica gum is known to include D-glucose, D-glucoronic acid, L-arabinose, L-fucose, mannose, xylose, rhamnose, D-glucosamine, aldobiuronic acid, serine, threonine, and aspartic acid. Furthermore, it has organic fatty acids in it.[84, 85]

4.1. Extraction of gum

After being collected from the damaged site's trees, the gum was powdered to the required size, shade dried, and then sieved [86]. After adding 10 g of dried gum powder to 250 cm3 of distilled water, the mixture was agitated for 6–8 hours at room temperature. The mixture is put through a centrifuge. The resulting clear solution, referred to as supernatant, is abundant in dissolved gum. However, there was still gum in the residue, so it was cleaned with water and the washings were added to the supernatant.

There were four more iterations of this procedure. After that, the supernatant was brought up to 500 cm3 and continuously stirred while being treated with twice as much acetone (1000 cm3). After being precipitated, the material was dried at 50–60°C and cleaned with distilled water.

4.2. Dyes of Neem plant

Globally, consumers are becoming more interested in consuming natural fiber that has been colored with natural dyes as they become more aware of the organic worth of eco-friendly products. Since prehistoric times, natural dyes have been used primarily for coloring natural textiles like cotton, silk, and wool.[87] The development of a fabric with antimicrobial qualities and biocides is a significant task for the defense against harmful microorganisms. The majority of contemporary antimicrobial finished fabrics were created with synthetic materials. Recently, recommendations for environmentally friendly items have increased.[88]

Dyes are organic chemical substances that have the ability to absorb light to produce the phenomena of color. These materials have strong colors and are kept in substances by mechanical retention, physical absorption, and the creation of covalent chemical bonds or complexes with metals or salts. The colorant with substantivity for a substrate—whether it be intrinsic or brought about by reactants—is called a dye.[89] An endless range of materials, including fabrics, paper, wood, varnishes, leather, ink, fur, food, cosmetics, medications, and more, can be colored with dyes. In general, dyes can be divided into two categories: natural dyes taken from natural sources and synthetic colors made from chemical substances or by chemical processes. All dyes obtained from natural sources, including plants, insects, and minerals, are referred to as natural dyes.[90]

Natural dyes have gained popularity recently for use in textile coloring. Several plants have been used to extract natural colors with antibacterial qualities for the textile industry [91]. When dyeing any textile substrate, it is crucial to extract the color component from natural sources in order to assess the dying properties and optimize the color yield [92].

5. Neem leaves

The neem plant, Azadirachta indica, is a member of the Meliaceae family. Neem leaf's primary components include minerals, calcium, phosphorus, vitamin C, carotene, protein (7.1%), and carbs (22.9%).

Additionally, the extract's chemical makeup includes amino acids that resemble cystine, fatty acids like dodecanoic, tetradecanoic, and elcosanic, as well as glutamic acid, tyrosine, aspartic acid, alanine, praline, and glutamine.

Neem has many therapeutic and germicidal qualities and is non-toxic and biocompatible with humans.[93] Many human ailments, including those with anti-inflammatory, anxiolytic, anti-androgenic, anti-stress, humoral and cell-mediated immune stimulant, anti-hyperglycemic, liver-stimulant, antiviral, antiulcer, antifungal, and anti-malarial properties, have been linked to the majority of the plant's parts, including fruits, seeds, leaves, bark, and roots [94].

Figure 6: Melia Azadirachta L. Bark (Neem Leaves)

The biochemical system needs certain relatively critical minerals, which are present in neem leaves. demonstrated that flavonoids, saponins, steroids, alkaloids, amino acids, and tannins were detected positively in the biochemical screening of the crude neem leaf extracts [95, 96].

Neem's biocompatibility with human PDL fibroblasts has been demonstrated by its proven effectiveness in treating periodontal disorders.

6. Neem Bark

Neem, or Azadirachta indica, is a tree in the Meliaceae family of mahogany. It is present across Myanmar's arid region. It is well known as a forest crop with a variety of applications, such as the production of oil tannins, insecticides, organic manures, fuel wood, and medicinal goods.

6.1. Phytochemical Investigation of Neem Bark:

The primary chemicals that are present or absent in bark were investigated using the preliminary phytochemical tests. The methods and procedures outlined in the textbook "A Guide to Modern Techniques of Plant Analysis" were followed while testing for alkaloids, polyphenol, flavonoids, glycosides, phenolics, saponins, lipophilics, and tannin.[97]

In addition, neem bark has anti-inflammatory, antihyperglycemic, antiulcer, antidiabetic, antioxidant, antimalarial, antibacterial, antimutagenic, anticarcinogenic, and anticancer properties.

The active coloring component tannin, which is used for tanning and dyeing, is what gives neem bark its brown color. The OH groups in the tannin have a strong binding with the fabric's functional locations.[98, 99]

Figure 7: Melia Azadirachta L. Bark (Neem Bark)

7. Conclusion

Natural goods has focused a lot of attention on green chemistry. It is function has increased the effectiveness of colorant extraction from plant material, as well as the dyeing behavior of natural dyes (neem bark and leaves) and printing by using a natural extract as a thickener, such neem gum. This is why the neem plant has an effective role in the textile industry

8. Fund

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9. Conflict of interest

The authors have no conflict of interest

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11. References

[1]. J.S. Gamble, A manual of indian timbers, Рипол Классик1881.

[2]. J.F. Duthie, Flora of the upper gangetic plain and of the adjacent siwalik and sub-himalayan tracts. 3 vols, Govt. of India, Central Publication Branch, Calcutta, India 1922 (1903).

[3]. A.S. Bagri, N. Singh, G.K. Dhingra, P. Tiwari, A catalogue of the higher plants of the adhwani temperate forest and its fringe areas (western himalaya, india), (2022).

[4]. H.S. Puri, Neem: The divine tree azadirachta indica, (1999).

[5]. H. Schmutterer, K.R.S. Ascher, H. Rembold, Natural pesticides from the neem tree (azadirachta indica a. Juss), German Agency for Technical Cooperation.

[6]. P. Foerster, Mission report on a fact-finding study on neem in people’s republic of china, GTZ/UNIDO (1998).

[7]. P. Freter, G. Moser, Status report on global neem usage, Deutsche Gesellschaft fr Technische Zusammenarbeit (GTZ) Eschborn (2000).

[8]. H. Schmutterer, The neem tree, azadirachta indica a. Juss. And other meliaceous plants: Source of unique natural products for integrated pest management, medicine, industry and other purposes, (1995).

[9]. O. Koul, M.B. Isman, C.M. Ketkar, Properties and uses of neem, azadirachta indica, Canadian Journal of Botany 68(1) (1990) 1-11.

[10]. O. Koul, Neem research and development: Present and future scenario, Supplement to Cultivation and Utilization of Medicinal Plants, PID, CSIR, New Delhi (1996) 583-611.

[11]. T. Sastry, Plants for reclamation of wastelands, (1990).

[12]. B.L. Axtell, R.M. Fairman, Minor oil crops. Part i-edible oils. Part ii-non-edible oils. Part iii-essential oils, 1992.

[13]. A.J. Mordue, A. Blackwell, Azadirachtin: An update, Journal of insect physiology 39(11) (1993) 903-924.

[14]. O. Koul, Mode of azadirachtin action, Neem. New Age International Publishers Ltd., New Delhi (1996) 160-170.

[15]. N. Khanna, M. Goswami, P. Sen, A. Ray, Antinociceptive action of azadirachta indica (neem) in mice: Possible mechanisms involved, Indian Journal of Experimental Biology 33(11) (1995) 848-850.

[16]. T. Musabyimana, R. Saxena, Efficacy of neem seed derivatives against nematodes affecting banana, Phytoparasitica 27 (1999) 43-49.

[17]. T. Gulzar, T. Farooq, S. Kiran, I. Ahmad, A. Hameed, Green chemistry in the wet processing of textiles, The impact and prospects of green chemistry for textile technology, Elsevier2019, pp. 1-20.

[18]. T.L. Vigo, Textile processing and properties: Preparation, dyeing, finishing and performance, Elsevier2013.

[19]. E. El-Sayed, E. Abd El-Aziz, H. Othman, A.G. Hassabo, Azo dyes: Synthesis, classification and utilisation in textile industry, Egy. J. Chem. (2024) -.

[20]. N. Khalid, H. Othman, A.G. Hassabo, Manufacturing and usage of lyocell fabric, Egy. J. Chem. (2024) -.

[21]. F. Saad, M. Mosaad, H. Othman, A.G. Hassabo, Polymers and polymerization mechanisms for textile industry, Egy. J. Chem. (2024) -.

[22]. S. Shaker, H. Ghazal, A.G. Hassabo, Synthesis of carbon dots and their functional impact on natural and synthetic fabrics, Egy. J. Chem. (2024) -.

[23]. M. Zaied, E. Abd El-Aziz, H. Ghazal, H. Othman, A.G. Hassabo, Construction of intelligent bio-pcm matrix for cotton fabrics to improve thermal comfortability and human protection, Egy. J. Chem. (2024) -.

[24]. N. Zakaria, A. Shahin, H. Othman, A.G. Hassabo, Enhancing the properties of textile fabrics using plasma technology, Egy. J. Chem. (2024) -.

[25]. S.F. Harlapur, N. Airani, S.S. Gobbi, Natural gums as thickeners in the process of cotton fabric printing, J. Fash. Technol. Text. Eng 8 (2020) 186-188.

[26]. D.M. Hamdy, H.A. Othman, A.G. Hassabo, Various natural dyes using plant palette in coloration of natural fabrics, J. Text. Color. Polym. Sci. 18(2) (2021) 121-141.

[27]. A. Mendrek, H. Keul, C. Popesccu, A.G. Hassabo, M. Pricop, M. Moeller, G. Knuebel, A. Ferencz, Hair coloration using functionalised polyethyleneimine/dye complex, J. Text. Color. Polym. Sci. 19(1) (2022) 39-49

[28]. M. Mohamed, M. Abd El-AAty, S. Moawaed, A. Hashad, E. Abdel-Aziz, H. Othman, A.G. Hassabo, Smart textiles via photochromic and thermochromic colorant, J. Text. Color. Polym. Sci. 19(2) (2022) 235-243.

[29]. E. Abd El-Aziz, A. abdelraouff, S.S. El-Desoky, G.A. El-Bahrawy, H.A. Ezat, R. Abd El-Rahman, A.G. Hassabo, Psychological color and texture in marketing and textile printing design, J. Text. Color. Polym. Sci. 20(2) (2023) 265-275.

[30]. A.L. Mohamed, T.A. Khattab, A.G. Hassabo, Color-tunable encapsulated perylene-labeled

silica fluorescent hybrid nanoparticles, Results in Chemistry 5 (2023) 100769.
[31]. A.L. Mohamed, S. Shaarawy, N. Elshemy, A. Hebeish, A.G. Hassabo, Treatment of cotton fabrics using polyamines for improved coloration with natural dyes extracted from plant and insect sources, Egy. J. Chem. 66(3) (2023) 1-19.
[32]. E. Abd El-Aziz, H.A. Ezat, R. Abd El-Rahman, A. abdelraouff, S.S. El-Desoky, G.A. El-Bahrawy, A.G. Hassabo, Improve the quality of coloring performance of silk fabric, J. Text. Color. Polym. Sci. 21(1) (2024) 11-22.
[33]. Z.A. Awad, M.A. Eida, H.S. Soliman, M.A. Alkaramani, I.G. Elbadwy, A.G. Hassabo, The psychological effect of choosing colors in advertisements on stimulating human interaction, J. Text. Color. Polym. Sci. (2024) -.
[34]. D.M. Elhawary, T.M. Maghraby, A.E. Elhag, R.M. Romeh, A.G. Hassabo, The psychology of color in psychotherapy in psychiatric rehabilitation hospitals, J. Text. Color. Polym. Sci. (2024) -.
[35]. H.I. Elhefnawy, M.A. Saada, S.T. Abdelkareem, Y.A. Elemam, R.A. Subaih, A.G. Hassabo, Color theory and semiotics: Exploring the relationship between visual semiotics and color, J. Text. Color. Polym. Sci. (2024) -.
[36]. A.G. Hassabo, N.A. Abd El-Salam, N.A. Mohamed, N.Z. Gouda, N. Khaleed, S. Shaker, H. Othman, Alternatives binder in printing using colored pigments on cotton fabrics, J. Text. Color. Polym. Sci. 21(1) (2024) 121-130.
[37]. T.M. Maghraby, A.E. Elhag, R.M. Romeh, D.M. Elhawary, A.G. Hassabo, The psychology of color and its effect on branding, J. Text. Color. Polym. Sci. (2024) -.
[38]. R.M. Romeh, D.M. Elhawary, T.M. Maghraby, A.E. Elhag, A.G. Hassabo, Psychology of the color of advertising in marketing and consumer psychology, J. Text. Color. Polym. Sci. (2024) -.
[39]. M.M. shamiea, A.S. Elkhayat, F.K. El-Shafey, E.L. Mohamed, A.M. Fouad, A.G. Hassabo, The psychological impact of color on the recipient through fixed advertising, J. Text. Color. Polym. Sci. (2024) -.
[40]. H.S. Soliman, M.A. Alkaramani, I.G. Elbadwy, Z.A. Awad, M.A. Eida, A.G. Hassabo, The importance of color in marketing and customer behavior, J. Text. Color. Polym. Sci. (2024) -.
[41]. A.G. Hassabo, M. Bakr, M. Zayed, H.A. Othman, Review on some fabric pretreatment via plasma to improve their printability using various types of colorants and dyes, Materials International (Accept 2022).
[42]. S.S. Muthu, Textiles and clothing sustainability: Sustainable textile chemical processes, Springer2016.
[43]. C.-Z. Liang, S.-P. Sun, F.-Y. Li, Y.-K. Ong, T.-S. Chung, Treatment of highly concentrated wastewater containing multiple synthetic dyes by a combined process of coagulation/flocculation and nanofiltration, Journal of Membrane Science 469 (2014) 306-315.
[44]. T. Adane, A.T. Adugna, E. Alemayehu, Textile industry effluent treatment techniques, J. Chem. 2021 (2021) 1-14.
[45]. A. Hebeish, A.A. Ragheb, S.H. Nassar, E.E. Allam, J.I. Abd El–Thalouth, Eco-friendly technology for textile printing using innovative self printing paste, Egypt. J. Chem. 54(6) (2011) 663-678.
[46]. R. Dayal, P.C. Dobhal, Natural dyes from some indian plants, Colourage 48(8) (2001) 33-38.
[47]. N.A. Ibrahim, M.H. Abo-Shosha, E.A.M.R. El-Zairy, E.M. El-Zairy, New thickening agents for reactive printing of cellulosic fabrics, Journal of applied polymer science 101(6) (2006) 4430-4439.
[48]. M.D. Teli, V. Shanbag, P.R. Kulkarni, R.S. Singhal, Amaranthus paniculates (rajgeera) starch as thickener in the printing of textiles, Carbohydrate polymers 31(3) (1996) 119-122.
[49]. M.H. Abo-Shosha, F.A. Nassar, K. Haggag, Z. El-Sayed, A.G. Hassabo, Utilization of some fatty acid/peg condensates as emulsifiers in kerosene paste pigment printing, RJTA 13(1) (2009) 65-77.
[50]. N.S. Elshemy, A.G. Hassabo, Z.M. Mahmoud, K. Haggag, Novel synthesis of nano-emulsion butyl methacrylate/acrylic acid via micro-emulsion polymerization and ultrasonic waves, JTATM 10(1) (2016) 1-16.
[51]. S.A. Ebrahim, A.G. Hassabo, H. Othman, Natural thickener in textile printing (a mini review), J. Text. Color. Polym. Sci. 18(1) (2021) 55-64.
[52]. G.A. El-Sayed, H. Othman, A.G. Hassabo, An overview on the eco-friendly printing of jute fabrics using natural dyes, J. Text. Color. Polym. Sci. 18(2) (2021) 239-245.
[53]. D.M. Hamdy, A.G. Hassabo, H. Othman, Recent use of natural thickeners in the printing process, J. Text. Color. Polym. Sci. 18(2) (2021) 75-81.
[54]. M.M. Ragab, A.G. Hassabo, H. Othman, Synthetic thickeners in textile printing, J. Text. Color. Polym. Sci. 18(1) (2021) 65-74.
[55]. F. Saad, A.G. Hassabo, H.A. Othman, M.M. Mosaad, A.L. Mohamed, Improving the performance of flax seed gum using metal oxides for using as a thickening agent in printing paste of different textile fabrics, Egy. J. Chem. 64(9) (2021) 4937 - 4954.
[56]. F. Saad, A.L. Mohamed, M. Mosaad, H.A. Othman, A.G. Hassabo, Enhancing the rheological properties of aloe vera polysaccharide gel for use as an eco-friendly thickening agent in textile printing paste, Carbo. Polym. Technol. App. 2 (2021) 100132.
[57]. S.A. Ebrahim, H.A. Othman, M.M. Mosaad, A.G. Hassabo, A valuable observation on pectin as an eco-friendly material for valuable utilisation in textile industry, Egy. J. Chem. 65(4) (2022) 555 – 568.
[58]. A. Hashad, S. Moawaed, M. Abd El-AAty, H. Othman, M. Mohamed, E. Abdel-Aziz, A.G. Hassabo, An overview of carpets printing using inkjet technique, J. Text. Color. Polym. Sci. 19(2) (2022) 223-234.
[59]. A.G. Hassabo, M. Abd El-Aty, H.A. Othman, A critique on synthetic thickeners in textile printing, J. Text. Color. Polym. Sci. 19(1) (2022) 99-109.
[60]. F. Saad, A. Hassabo, H. Othman, M.M. Mosaad, A.L. Mohamed, A valuable observation on thickeners for valuable utilisation in the printing

of different textile fabrics, Egy. J. Chem. 65(4) (2022) 431 – 448.
[61]. F. Saad, M.M. Mosaad, H.A. Othman, A.L. Mohamed, A.G. Hassabo, Enhancing the opacity of the modified natural thickening agent with different metal oxides for covering dark dyed fabrics, Fibers and Polymers [EMID:4f46efe6ab478977] (2022).
[62]. S.A. Ebrahim, H.A. Othman, M.M. Mosaad, A.G. Hassabo, Eco-friendly natural thickener (pectin) extracted from fruit peels for valuable utilization in textile printing as a thickening agent, Textiles 3(1) (2023) 26-49.
[63]. A.G. Hassabo, N.A. Abd El-Salam, N.A. Mohamed, N.Z. Gouda, H. Othman, Potential application of natural gums suitable as thickeners in textile printing, J. Text. Color. Polym. Sci. 20(1) (2023) 57-65.
[64]. A.G. Hassabo, N.Z. Gouda, N.A. Abd El-Salam, N.A. Mohamed, H. Othman, Psyllium seeds, sage seeds, rocket seeds as a sources of galactomannan gum, J. Text. Color. Polym. Sci. 20(1) (2023) 67-75.
[65]. A.G. Hassabo, N.A. Mohamed, N.A. Abd El-Salam, N.Z. Gouda, H. Othman, Application of modified xanthan as thickener in the printing of natural and synthetic fabrics, J. Text. Color. Polym. Sci. 20(1) (2023) 41-56.
[66]. A.G. Hassabo, N. Khaleed, S. Shaker, N.A. Abd El-Salam, N.A. Mohamed, N.Z. Gouda, H. Othman, Impact of various treatments on printing wool techniques, J. Text. Color. Polym. Sci. 21(1) (2024) 75-86.
[67]. H. Othman, H.A. Ezat, S.S. Moawaed, R. Abd El-Rahman, A. abdelraouff, S.S. El-Desoky, G.A. El-Bahrawy, A.G. Hassabo, Various printing techniques of silk fabric to enhancing its performance properties, J. Text. Color. Polym. Sci. 21(1) (2024) 23-32.
[68]. H. Othman, N. Gamal, A. Sediek, F. Saad, B.M. Hegazy, H.M. Elmorsy, A.G. Hassabo, Printing techniques of silk fabric, J. Text. Color. Polym. Sci. 21(1) (2024) 1-10.
[69]. H. Othman, H.A. Ezat, S.S. Moawaed, R. Abd El-Rahman, A. abdelraouff, S.S. El-Desoky, G.A. El-Bahrawy, A.G. Hassabo, Various printing techniques of silk fabric to enhancing its performance properties, J. Text. Color. Polym. Sci. (Accept 2023) -.
[70]. W. Clarke, L.W.C. Miles, Synthetic thickening agents for textile printing, Review of Progress in Coloration and Related Topics 13(1) (1983) 27-31.
[71]. M. Abdelrahman, S. Wahab, H. Mashaly, D. Maamoun, T.A. Khattab, Review in textile printing technology, Egyptian Journal of Chemistry 63(9) (2020) 3465-3479.
[72]. S. Yadav, G. Gaba, Mango kernel starch-a natural thickener for screen printing on silk with kachnar bark dye, Global Journal for Research Analysis 5(9) (2016) 159-161.
[73]. P.D. Choudhary, H.A. Pawar, Recently investigated natural gums and mucilages as pharmaceutical excipients: An overview, Journal of pharmaceutics 2014 (2014).
[74]. H.E. Tahir, Z. Xiaobo, G.K. Mahunu, M. Arslan, M. Abdalhai, L. Zhihua, Recent developments in gum edible coating applications for fruits and vegetables preservation: A review, Carbohydrate polymers 224 (2019) 115141.
[75]. S. Srivastava, D.P. Ray, Natural gum resources in india and their commercial importance, International Journal of Bioresource Science 2(2) (2015) 151-155.
[76]. T.R. Bhardwaj, M. Kanwar, R. Lal, A. Gupta, Natural gums and modified natural gums as sustained-release carriers, Drug development and industrial pharmacy 26(10) (2000) 1025-1038.
[77]. S. Goswami, S. Naik, Natural gums and its pharmaceutical application, Journal of Scientific and Innovative Research 3(1) (2014) 112-121.
[78]. S. Lankalapalli, D. Sandhala, A review on natural gums and their use as pharmaceutical excipients, International Journal of Pharmaceutical Sciences and Research 10(12) (2019) 5274-5283.
[79]. R. Mohammadinejad, A. Kumar, M. Ranjbar-Mohammadi, M. Ashrafizadeh, S.S. Han, G. Khang, Z. Roveimiab, Recent advances in natural gum-based biomaterials for tissue engineering and regenerative medicine: A review, Polymers 12(1) (2020) 176.
[80]. A.B. Gangurde, S.S. Malode, R.S. Bhambar, Preliminary evaluation of neem gum as tablet binder, Indian Journal of Pharmaceutical Education and Research 42(4) (2008) 344-347.
[81]. A.d.l.C. Pech-Canul, D. Ortega, A. García-Triana, N. González-Silva, R.L. Solis-Oviedo, A brief review of edible coating materials for the microencapsulation of probiotics, Coatings 10(3) (2020) 197.
[82]. R. da Silveira Nogueira Lima, J. Rabelo Lima, C. Ribeiro de Salis, R. de Azevedo Moreira, Cashew-tree (anacardium occidentale l.) exudate gum: A novel bioligand tool, Biotechnology and Applied Biochemistry 35(1) (2002) 45-53.
[83]. D. Mudgil, S. Barak, B.S. Khatkar, Guar gum: Processing, properties and food applications—a review, Journal of food science and technology 51 (2014) 409-418.
[84]. D.M.W. Anderson, A. Hendrie, The proteinaceous, gum polysaccharide from azadirachta indica a. Juss, Carbohydrate research 20(2) (1971) 259-268.
[85]. S. Mukherjee, H.C. Srivastava, The structure of neem gum, Journal of the American Chemical Society 77(2) (1955) 422-423.
[86]. U. Farooq, K.P. Sharma, R. Malviya, Extraction and characterization of almond (prunus sulcis) gum as pharmaceutical excipient, American-Eurasian J Agric & Environ Sci 14 (2014) 269-274.
[87]. I. Dumitrescu, P.S. Vankar, J. Srivastava, A.N.A.M. Mocioiu, O.G. Iordache, Dyeing of cotton, silk and wool with bixa orellana in the presence of enzymes, Industrial Texting 63(6) (2012) 1-7.
[88]. D.S. Morais, R.M. Guedes, M.A. Lopes, Antimicrobial approaches for textiles: From research to market, Materials 9(6) (2016) 498.

[89]. A. Pal, Chemical investigation on selected indigenous plants for natural dyes and dyeing characteristics, (2017).

[90]. D.R. Gupta, Substitute of harda as mordant–, A study textile dyer and printer 23(10) (1990) 21-23.

[91]. M. Kumaresan, P.N. Palanisamy, P.E. Kumar, Dyeing of cotton fabric with eco-friendly natural dyes using single mordants: Comparison of fastness properties and colour strength, Universal Journal of Environmental Research & Technology 2(4) (2012).

[92]. M. Yusuf, M. Shabbir, F. Mohammad, Natural colorants: Historical, processing and sustainable prospects, Natural products and bioprospecting 7 (2017) 123-145.

[93]. U. Francine, U. Jeannette, R.J. Pierre, Assessment of antibacterial activity of neem plant (azadirachta indica) on staphylococcus aureus and escherichia coli, J Med Plants Stud 3(4) (2015) 85-91.

[94]. N. Wali, S. Dhavan, S. Garg, S.N. Upadhyay, Anti-inflammatory effect of neem leaf extract.

[95]. A.A. Abd El Aty, G.T. El-Bassyouni, N.A. Abdel-Zaher, O.W. Guirguis, Experimental study on antimicrobial activity of silk fabric treated with natural dye extract from neem (azadirachta indica) leaves, Fibers and Polymers 19 (2018) 1880-1886.

[96]. M. Shareef, M.S. Akhtar, Neem (azadirachta indica) and its potential for safeguarding health, prevention and treatment of diseases, Matrix Science Medica 2(1) (2018) 04-08.

[97]. S. Win, K.T. Ni, Study on extraction and application of natural dye from neem bark (melia azadirachta l.), Dagon Univ. Res. J 11 (2020) 263-269.

[98]. S. Susmitha, K.K. Vidyamol, P. Ranganayaki, R. Vijayaragavan, Phytochemical extraction and antimicrobial properties of azadirachta indica (neem), Global journal of pharmacology 7(3) (2013) 316-320.

[99]. R. Al Akeel, A. Mateen, K. Janardhan, V.C. Gupta, Analysis of anti-bacterial and anti oxidative activity of azadirachta indica bark using various solvents extracts, Saudi journal of biological sciences 24(1) (2017) 11-14.

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