The Green Gold-Neem: A Review

Aastha Vithalkar[1], Keshav Kaiwartya[1] and Yashwant Kumar Patel[2,*]

[1]M.Sc. (FPT) Alumni, Dept of FPT, UTD, Atal Bihari Vajpayee Vishwavidyalaya, Bilaspur, Chhattisgarh, India

[2]Assistant Professor, Dept of FPT, UTD, Atal Bihari Vajpayee Vishwavidyalaya, Bilaspur, Chhattisgarh, India

ABSTRACT

In the Indian subcontinent, the Neem tree (*Azadirachta indica*) has long been referred to as the "miracle tree." It has grown in significance in the current global setting because it provides solutions to the most pressing issues affecting humanity. The US Environmental Protection Agency has given the herb neem (*Azadirachta indica*) the go-ahead to be used on crops used for human consumption since it is thought to be safe to people, animals, birds, beneficial insects, and earthworms. Azadirachtin and other active components in neem seeds have insecticidal qualities that work well against a variety of insects, numerous mites and nematodes, even snails and fungus, and they don't seem to cause pests to develop resistance to them. Neem and its extracts are now found in many allopathic and natural medications. Additionally, neem contraceptives are also offered on the market. Neem extract was shown to have a large blood sugar reducing impact, which is highly helpful against diabetes. Neem extract contains the active ingredients nimbinin and nimbandiol. Dermatitis, eczema, acne, bacterial, fungal infections, and other skin conditions are treated with neem. As a potent antibiotic, it has proven to be effective. Neem has also demonstrated antibacterial, antiviral, and antifungal effects. It treats inflammatory skin disorders and supports a robust immune system. Neem has historically been used to treat ailments that cleanse the blood and skin. Neem not only aids in the treatment of illnesses, but it also boosts our immune, giving us the fortitude to fend against illnesses.

Key-words: Neem, *Azadirachta indica*, Antimicrobial, Herbal Medicine and anti-inflammatory.

INTRODUCTION

Popular fast-growing trees like *Azadirtachta indica* may be found in India, America, and Africa. Neem is known as "arista" in Sanskrit, which signifies flawless, whole, and imperishable. Arishtha is the name of the neem tree in Sanskrit. In India, the tree is regarded as the local medical facility. The US National Academy of Sciences produced a paper in 1992 titled "Neem - A Tree to Solve Global Problems" in which it acknowledged the significance of the neem tree. It is prevalent in parts of West Africa and Southeast Asia, and a few trees have lately been planted in Mexico, the Caribbean, and some central American nations. The neem tree is revered by the people of India. For generations, millions have used neem sprigs to clean their teeth, neem leaf juice to treat skin conditions, neem tea as a tonic, and neem leaves in their beds, books, grain baskets, and closets. Ancient texts like the "Charak-Samhita" and the "Susruta- Samhita" highlight the many advantages of neem. It is frequently called "Indian Lily" or "Margosa," and it is a member of the tribe Melieae, subfamily Meloideae, and family Meliaceae. The neem tree has the greatest potential and is one of the most adaptable and diversified tropical plants. It has more beneficial non-wood products than any other tree species, including leaves, bark, blossoms, fruits, seeds, gum, oil, and neem cake. known for its biological properties, including those that are anti-allergenic, anti-dermonic, anti-feedent, antifungal, anti-inflammatory, antipyorrheic, antiscabic, cardiac, diuretic, insecticide, larvicide, nematicide, and spermicide. Neem has a

wealth of applications as a result of these activities, making it a green gem. Neem has grown in significance in the modern world since it provides solutions to some of humanity's biggest issues. Neem has been permitted for application on food crops by the US Environmental Protection Agency because it is thought to be safe for use by people, animals, birds, beneficial insects, and earthworms. Most tropical nations have neem trees, which are evergreen trees with potential medical use. Azadirachtin, Meliacin, Gedunin, Salanin, Nimbin, Valassin, and many additional derivatives of these biologically active principles have been isolated from various sections of plants. The bitter components of neem seed oil are made of meliacin, which is also present in the seeds. Tignic acid (5-methyl-2-butanoic acid) oversees the oil's characteristic odour. These substances are Triterpenoids, which are marketed as natural goods (limonoids). The active components are easily soluble in organic solvents including hydrophiles, alcohols, ketones, and esters yet are lightly hydrophilic and freely lipophilic. There have been reports of two species of *azadirachta*: *Azadirachta indica* A. Juss, which is indigenous to the Indian subcontinent, and Azadirachta excelsa poop, which is only found in the Philippines and Indonesia. Neem belongs to the same family as mahogany. A fast-growing, small to medium-sized evergreen tree (5 to 20 m tall), *Azadirachta indica* A. Juss (Meliaceae) loses most of its leaves during the dry season before blooming fully. After 3 to 5 years, you can achieve two-thirds of your height. After five years, the first fruit harvest is possible, and after five to seven years, the first timber harvest. The tree can adapt to a wide range of topographical and climatic circumstances. It does well on soil that is dry, rocky, flat, and even contains hard limestone or clay pan. The neem tree needs lots of sunshine and minimal water. Breeding and enhancement of agroforestry and multifunctional species, particularly tree species in the arid zone, have received a lot of attention recently. Neem is especially interesting among these species (*Azadirachta indica* A. Juss). Neem is a versatile plant that may be utilised as a biological pesticide as well as for a variety of medicinal conditions, shade, and the production of wood and fuel. You may extract some plant tissues, such as azarachterin, from leaves, fruits, and more (Khan *et al*., 2004). Both locally and on a big scale, the products are employed in industrial production as well as by farmers and domestic users (Chandramohan *et al*., 2022).

Table 1: Taxonomy of *Azadirachta indica*

S.No	Kingdom	Kingdom Plantae
	Sub-kingdom	*Tracheobionta*
	Division	*Magnoliophyta*
	Class	*Eudicot*
	Subclass	*Rosidae*
	Order	*Sapindales*
	Family	*Meliaceae*
	Genus	*Azadirachta*

Source: Uzzaman, 2019

ECOLOGY

The neem tree is renowned for withstanding drought. It typically flourishes in regions with sub-humid weather and 400 to 1200 mm of yearly rainfall. It can thrive in areas with annual rainfall below 400 mm, although in certain situations, it is very reliant on groundwater. Neem may grow in a variety of soil types, but it does best in deep, sandy soils that have good drainage. It grows at average annual temperatures between 21 and 32 °C and is a typical tropical or subtropical tree. It can endure temperatures lower than 40 °C. Neem is a plant that thrives in India's plains and in regions that are around 1850 metres above sea level. Neem is cultivated from sea level up to 1500 m altitude in its newly established range. Most soil types, including dry, rocky, shallow soils, lateritic crusts, and extensively leached sands and clays, are tolerable to neem (Schmutterer. 1995). It may thrive on soils with a pH range of 5 to 8.5. However, deep, porous, well-drained soils with a pH of 6 to 6.5 are optimum for growing it to a height of 8 m. It can tolerate slightly alkaline, strongly sodium, carbonate, and bicarbonate-rich soils. It was successfully planted in soils with near-surface calcareous hard pans on both deep, severely eroded, and degraded sites. Seasonally flooded areas, salty sands, salty alluvial soils, flat, poorly drained clays, and dry sands where the seasonal ground water level is below 8 m in depth all have poor neem growth. The growth of neem appears to be constrained in soils deficient in zinc and potassium and is dependent on the availability of soil moisture. The optimum growth occurs on well-drained areas with water tables that fluctuate between around 3 and 5 metres throughout the year (Schmutterer. 1995). Due to the quality of the leaf litter and the somewhat rapid pace of leaf breakdown, neem is a valuable plant for enhancing soil fertility in degraded soil arid regions. Therefore, calcium and pH levels in the top soil beneath 5-year-old neem stocks in Togo's fallow clay Acrisol grew more quickly than those in nearby acacia stands (Schmutterer. 1995). Neem seeds often only last three months since they are short-lived. The pulp should be manually scraped from the seeds, and they should be shade-dried to a moisture level of 15-20% in order to help them live longer.

CHEMICAL CONSTITUENT AND PROPERTIES OF NEEM

Indian medicinal scientists studied the chemical properties of neem in 1919, isolating an acidic component they called "margosic acid" in the oil. However, the separation of three active constituents—nimbin, nimbidin, and nimbinene—in 1942 marked the beginning of significant scientific research. An Indian scientist conducted a thorough analysis of the chemistry of neem's active ingredients in 1963. Neem kernel's chemistry has expanded significantly since it was discovered to be a locust feeding inhibitor. It has been possible to isolate and describe many substances. The major characteristic is that they may all be biogenetically derived from tetracyclic terpenes and have a lot of comparable chemical properties. These bitter components, also known as liminoids (azadirachtin, meliantrol, salanin, etc.), can be found in various plant species (Rutaceae and Simaroubaceae). A famous piece of work on natural product chemistry is the unravelling of very complicated structural characteristics and biogenetic connections. Practically speaking, these substances also display a wide range of biological activity, such as insecticides, antifeedants, and cytotoxic qualities. Levaesmaily produce a multitude of liminoids, as well as the flavonoid quercetin and the ß-sitosterol nimbosterol (nimbin and its derivatives). It is well known that the polyphenolic flavonoid quercetin has antimicrobial and antifungal effects. The chemically varied groups of neem constituents have been grouped into two main categories, Isoprenoids and II Non-Isoprenoids. Glycerides, polysaccharides, sulphurone

compounds, flavonoids and their glycosides, amino acids, aliphatic compounds, etc. are included in the latter category. Sarita and others (2014).

BOTANICAL DESCRIPTION OF *AZADIRACHTA INDICA*

Azadirachta indica is one of the versatile, quickly-growing evergreen trees, yet under certain climatic circumstances, it frequently turns deciduous (Chaguthi *et al*. 2018; Sultana *et al*. 2011). It may reach a diameter of 12 to 18 metres, and its stem can be as wide as 1.8 to 2.4 metres (Quraishi *et al*. 2018; Sultana *et al*. 2011). Neem plant's bark is hard and woody, dark grey and reddish brown in colour, and has numerous longitudinal and oblique furrows as well as sporadic tubercles (Chaguthi *et al*. 2018; Tewari 1993). Imparipinate, compound, opposite, and alternating leaves with leaflets that are 8 cm to 19 cm long (Quraishi *et al*. 2018; Hashmat *et al*. 2012; Subapriya and Nagini 2005). The leaflets have a rounded edge, a lanceolate apex, and an acuminate tip. (Sultana *et al*. 2011). Neem flowers are abundant, fragrant, stunning, and aromatic (Nicoletti and Murugan 2013; Chaguthi *et al*. 2018); they are bisexual in nature and pale yellow and white in colour (Quraishi *et al*. 2018). According to Rahmani *et al*. (2018), the flowering season occurs between March and April (Hashmat *et al*. 2012). Fruits are smooth, tiny, and oblong in shape, and are known as Niboli. They are green in colour while unripe and become yellow to brown with a bitter flavour when they are mature (Quraishi *et al*. 2018). Between June and August, fruits begin to mature (Nicoletti and Murugan 2013). Neem has a lot of ovoid-shaped oil seeds with a diameter of 1 to 2 cm (Chaguthi *et al*. 2018). The axillary inflorescence, imbricate calyx, polypetalous, short cylindrical stigma, and elongated style are characteristics of the neem plant, according to (Quraishi *et al*. 2018; Sultana et al. 2011).

Table 2: Biological Activity and Functions of Neem

S.No	Biological Activity	Function	References
	Anti-fungal	Work against Candida, Microsporum, Trichophyton, Geotrichum, Epidermophyton, Trichosporon etc	Sitara *et al*.,2008; Mahmoud *et al*., 2011
	Anti-bacterial	It inhibits the activity of bacteria such as Salmonella typhi, Staphylococcus aureus, Streptococcus mutants, M. tuberculosis, Vibrio cholerae, M. pyogenes and Klebsiella pneumoniae.	Pandey *et al*., 2014; Aslam *et al*., 2009
	Anti-viral	Treatment of fowl pox, smallpox, chicken pox, Vaccinia virus, warts, moderate inhibition of hepatitis B virus, Chikungunya, herpes virus, and measles virus.	Faccin *et al*., 2012; Tiwari *et al*.,2010
	Insecticidal	Effective against maggots, horn flies, headlice, blowflies and biting flies	Schmutterer *et al*., 1990
	Promotes oral health	Neem twigs are used as toothbrushes averting periodontal diseases and gum inflammations.	Singh & Purohit 2011

Treatment of ailments	Treatment of arthritis, Chagas disease (kissing bugs that transmit the parasites), malaria, fever, pain, burning sensations, ringworm, respiratory disorders, eczema, intestinal helminthiasis, rheumatism and constipation.	Kumar & Navaratnam 2013; Patel *et al*., 2016
Immunostimulant	Activates cell-mediated immune pathways to provoke an enhanced response to subsequent mitogenic or antigenic encounter	Upadhyay *et al*., 1992
Anti-diabetic	Reduces blood sugar level and precludes adrenaline and glucose-induced hyperglycaemia.	Patil *et al*., 2013
Anti-ulcer	Produce highly potent antiulcer activity.29	Riar *et al*., 1991
. Anti-fertility	Avoids pregnancy and could be used as a way of contraception.	Garg *et al*., 1993
. Anti-cancer	Inhibits cell carcinoma in oral mucosa by modulation of glutathione and its metabolizing enzymes	Paul *et al*., 2011
. Anti-oxidant	Eliminates toxins, filter blood, and inhibit damage caused due to free radicals in the body.	Nahak *et al*., 2010

THE USE OF *AZADIRACHTA INDICA* IN THE FOOD INDUSTRY

Neem was first widely used as a potent pesticide and fertiliser for agricultural use (Govindachari, 1992; Nicoletti *et al*., 2012; Chaudhary *et al*., 2017), but in more recent years, it has come to be recognised as a safe and efficient broad-spectrum antimicrobial with uses in the food industry that span from food production and storage to packaging and human consumption. Campylobacter, Lactobacillus, and Carnobacterium spp. are a few of the bacterial species that might impact the quality and safety of meat during processing. All of these potentially pathogenic organisms are resistant to neem cake extract, a waste product from the manufacture of neem seed oil (Del Serrone *et al*., 2015aMoreover, Ravva and Korn (2015) discovered that neem leaf and bark supplements were effective in eradicating Escherichia coli O157:H7 from cultured cow manure; given that this E. coli strain was isolated from an apple juice outbreak of O157:H7, these findings may have widespread applications on farms where crops and orchards are frequently present in close proximity to cattle (Ravva and Korn, 2015). Antibiotic-resistant Vibrio parahaemolyticus can endanger both shrimp and human health when another source of protein is produced for human consumption, especially in shrimp farming A thorough investigation into the potential for neem use in this industry included in vitro and in vivo tests that revealed aqueous neem extract had a MIC against V. parahaemolyticus of 62.5 mg/ml and was capable of significantly increasing shrimp survival by 76% in comparison to the untreated control (Morales-Covarrubias *et al*., 2016). Storage and/or packaging are among the following procedures in the creation of pathogen-free human food. In the past couple of years, many organisations have demonstrated how neem leaf extracts, neem

oil, and other plant-based products may be included into food preservation films made of polyethylene or environmentally friendly materials like seaweed (e.g., turmeric and curcumin) (Ahmed *et al*., 2022). The resultant composite films show improved antifungal and antibacterial activity against C. albicans and a variety of Gram-negative and Gram-positive species, including E. coli, S. aureus, Pseudomonas aeruginosa, and Bacillus subtilis. They also block UV radiation and are shelf-stable (Sunthar *et al*., 2020; Uthaya Kumar *et al*., 2020; Oyekanmi *et al*., 2021; Subbuvel and Kavan, 2021). Furthermore, multiple recent publications that detail the following show that A. indica has the capacity to inhibit the activities of food-spoiling fungi:

1. Neem oil's potential to stop the growth of the fungus Aspergillus carbonarius, which ruins grape products, and to stop some strains of it from producing mycotoxin (Rodrigues *et al*., 2019).
2. Neem leaves' capacity to stop Aspergillus parasiticus from producing aflatoxins when rice, wheat, and maize are kept in long-term storage (Sultana *et al*., 2015).
3. Neem seed extracts' 10% 10% inhibition of Aspergillus flavus and Aspergillus parasiticus growth during maize storage. (An *et al*., 2019)
4. The capacity of various neem seed, bark, and leaf extracts to suppress the development of Aspergillus niger, Fusarium oxyporium, and Pythium spp., three main potato-spoiling fungus, by 72-100% (Ezeonu *et al*., 2019).
5. Neem leaf extract's capacity to detoxify aflatoxin B1 and ochratoxin A in vivo as well as to limit the development of A. niger and A. parasiticus (Hamad *et al*., 2021).
6. Taken together, these studies on food should encourage more research into the usefulness of A. indica-derived products throughout the food industry; these products might serve as a sustainable antimicrobial alternative that could possibly improve food security through improved stable long-term storage and improve human health by getting rid of foodborne pathogens.

COMMERCIAL VALUE OF NEEM

There are many uses for the leaves, flowers, roots, branches, seeds, and trunks of neem plants (Bhowmik *et al*. 2010). Several companies, including those in the pharmaceutical, disinfection, biopesticide, cosmetic, textile, and rubber sectors, have established facilities to utilise various components of neem in the production of various goods (Kumar and Bhat 2008). The first firm to produce toothpaste, hand and body lotion, cream, neem herbal spray, and soap made from neem leaves is Neem Aura. Neem is used in a variety of agricultural, soap, and veterinary products that are produced in India and exported to various Asian and African nations (Yadav *et al*. 2016). Neem wood, which is highly durable, is used to make furniture. Heartwood is used to make structures, cart wheels, agricultural equipment, boats, and other things because it is strong and durable (Kumar and Bhat 2008). Neem leaves and bark are used to make a variety of cosmetics, insecticides, fertilisers, herbicides, medications, and dental care items including toothpaste (Bhowmik *et al*. 2010; Kumar and Bhat 2008). Insects can be deterred from wool and silk clothing that is being conserved by using neem leaves (Bhowmik *et al*. 2010). The gums and tannins found in neem bark are used in the tanning and colouring processes (Bhowmik *et al*. 2010). Numerous insecticides, fungicides, veterinary medications, cosmetics, propellants, soaps, hair oils, shampoos, toothpaste, and other health care items are made from neem oil (Singh 2019). Natural insecticide, soil fertiliser, soil neutralizer, soil moisturiser, and animal feed are all uses for

neem cake (Kumar and Bhat 2008). Toothpaste with a neem base is widely used in Europe and India. Neem seed pulp is used as a high-carbohydrate source in the fermentation sector and for the manufacture of methane gas (Kumar and Bhat 2008). According to (Singh 2019), dental hygiene also uses toothbrushes made from neem tree twigs.

BENEFITS OF NEEM:

Antioxidant Activity:

One of the main culprits in the development of several diseases is the free radical or reactive oxygen species. However, one of the crucial steps in the treatment of diseases is the neutralisation of free radical activity. Antioxidants have a role in the activation of anti-oxidative protein that plays a role in the regulation of damage caused by free radicals/receptive oxygen species and stabilize/deactivate free radicals, frequently before they attack targets in biological cells (Nunes *et al*., 2012). Antioxidant activity has been linked to medicinal plants. (Rahmani *et al*., 2015). Natural plant products including seeds, oil, leaves, bark, and roots play a crucial role in preventing diseases since they are a rich source of antioxidants. The antioxidant activity of A. indica leaf and bark concentrates has been investigated, and the results of the investigation have unmistakably demonstrated that leaf and bark extracts/fractions of neem produced in the lower areas have considerable antioxidant characteristics (Ghimeray, *et al*., 2009). Another thorough analysis of the Siamese neem tree's leaves, fruits, flowers, and stem bark extracts was carried out to determine the antioxidant activity, and the findings suggest that the extricates from the leaves, blossoms, and stem bark have significant antioxidant potential (Sithisarn *et al*., 2005).

Anti-cancerous Activity

Around the world, malignant growth is a serious medical problem that has several causes. Changes in molecular and genetic pathways have a role in the development and spread of malignant growth. The allopathic treatment plan is convincing on one hand, but it also shows negative effects on ordinary cells. Previous studies explained that plants and their components have effects that prevent the growth of cancerous cells by altering cell growth, apoptosis, the tumour suppressor gene, and several other molecular pathways (Rahmani, *et al*., 2014). Flavanoids and other compounds found in neem are crucial in preventing the progression of malignant development. Numerous epidemiological studies imply that high flavonoid intake may be associated with a reduced risk of cancer (Marchand, *et al*., 2002).

Anti-Inflammatory Effect of Neem:

It is common to use plants or isolated products of them to treat or serve as anti-inflammatory agents. According to a study, a concentrate of A. indica leaves at a dosage of 200 mg/kg, p. o., significantly reduced inflammation in rats' cotton pellet granulomas (Chattopadhyay *et al*., 1998). Other research findings revealed that although neem leaf extracts significantly reduced inflammation, they were less effective than dexamethasone (Mosaddek *et al*., 2008). Research findings also suggest that nimbidin inhibits the components of neutrophils and macrophages that are related to inflammation (Kaur *et al*., 2004). Previous research showed that bark and leaf concentrations had immune-modulating and anti-inflammatory properties, and that oil seeds have antipyretic and anti-inflammatory properties (Arora *et al*., 2011., Biswas *et al*., 2002). Neem seed oil was tested in experiments on albino rats to determine its ability to reduce pain, and the results showed that it had a significant pain-relieving effect between 1 and 2 mL/kg and a dose-dependent pain-relieving effect

(Kumar *et al*., 2012). Neem seed oil (NSO) was the subject of a second study to determine its anti-inflammatory effects in albino rats with carrageen-induced posterior pawedema. The study's findings showed that NSO showed increased paw edoema inhibition with a dynamic dosage increase from 0.25 mL to 2 mL/kg body weight. At the fourth hour after receiving a carrageen injection, NSO showed the greatest (53.14%) edoema resistance at a dose of 2 mL/kg body weight (Naik *et al*., 2014).

Hepatoprotective Effect:

Therapeutic herbs and their constituents have strong hepatoprotective properties without any hostile entanglements. The effectiveness of azadirachtin-A in preventing carbon tetrachloride (CCl4)-induced liver damage in mice was investigated, and the results of the histology and ultrastructure tests confirmed that pretreatment with the compound significantly reduced hepatocellular damage. The results of the test show that, aside from any side effects, pretreatment with azadirachtin-An at higher dose levels tolerably restore the rat liver to normal (Baligar *et al*., 2014).

Wound Healing Effect:

Various plants and their constituent parts have a fundamental role in the effect of damage recovery. The ability of concentrations of leaves from A. indica and T. cordifolia to repair damage was examined. Results showed that the concentrate of the two plants essentially pushed the damage mending activity in both the extraction and entrance point damage models in Sprague Dawley mice employing the extraction and cut injury models (Barua *et al*.,2010). Additionally, in section point wounds, it was observed that the stiffness of the recovering tissue in the two plants treated group was much higher when compared to the control groups (Of usori *et al*., 2010). Unique findings shown that *Azadirachta indica* leaf concentrates promote damage repair activity through increased provocation response neovascularization (Osunwoke *et al*.,2013). The findings of a study to assess the effectiveness of neem root bark extract (NRE), which is 70% alcoholic, in treating diabetes revealed that 800 mg/kg of neem root bark extract provided demonstrably significant outcomes (Patil, *et al*., 2013). Another study was conducted to investigate the pharmacological hypoglycemic action of *Azadirachta indica* in diabetic rodents. The findings showed that in a glucose tolerance test, neem extract 250 mg/kg indicated glucose levels were fundamentally lower when compared with the control group, and *Azadirachta indica* significantly decreased glucose levels at the fifteenth day in diabetic rodents. (Dholi, *et al*., 2011).

Antibacterial Activity:

A test was done to determine whether homegrown options for endodontic irrigants were antimicrobial sufficient and to distinguish them from sodium hypochlorite, and the results showed that leaf concentrates and grape seed extricates both showed zones of restriction, indicating that they had antimicrobial properties. Additionally, leaf extract demonstrated zones of inhibition that were essentially more striking than those caused by 3% sodium hypochlorite (Ghonmode *et al*., 2013). A delayed result of the analysis suggested that guava and neem extracts have compounds with antibacterial properties that may be significant to control food borne pathogens and deteriorating life forms. The antibacterial development of guava and neem isolates against 21 strains of food borne pathogens was evaluated (Mahfuzul *et al*., 2007).

Antiviral Activity:

The results showed that neem bark (NBE) extract effectively prevented HSV-1 entrance into cells at concentrations ranging from 50 to 100 g/ml (Yerima, *et al*., 2012). Additionally, when the concentrate was pre-incubated with the illness but not with the goal cells, obstructing growth of NBE was seen, suggesting a rapid adversary of HSV-1 feature of the neem bark (Tiwari *et al*., 2010). As suggested by methods for disease inactivation and yield decline, the concentrated leaves of neem (*Azadirachta indica* A. Juss.) (NCL-11) have demonstrated virucidal development against coxsackievirus contamination B-4 that looks at other factors besides interfering with the virus' early replication cycle. (Badam, *et al*., 1999).

Antifungal Activity:

The effectiveness of various neem leaf concentrates against the seed-borne parasites Aspergillus and Rhizopus was investigated. The results confirmed that both alcoholic and water extracts effectively inhibited and regulated the development of both infectious species. Additionally, neem leaf alcohol concentration was the finest.

Immuno-Stimulant Activity

According to a study, 4% infusion of neem leaves in fresh water at a rate of 50 ml L-1 may be used as a potential natural growth promoter and immune stimulant that improves body composition, weight gain, FCR feed conversion ratio, gross return, lower mortality, and antibody titer against infectious bursal disease (IBD). Neem is one of the most effective agents for inducing both specific (cell-mediated immunity and cellular immunity) and nonspecific (cytotoxic and phagocytic activity of macrophages) immune responses. (Dholi *et al*., 2011; Mohammed *et al*., 2007).

Dentistry:

An experiment was conducted to see if neem mouthwash was effective in combating gingivitis, and the results confirmed that A. indica mouthwash is just as effective in reducing periodontal records as chlorhexidine (Chatterjee *et al*., 2011). The findings of a second research to evaluate the antibacterial capabilities of natural neem concentrates against three bacterial strains responsible for dental caries showed that oil ether and chloroform removal revealed strong antimicrobial effect against S. mutans. Streptococcus salivarius was effectively eliminated by chloroform, while the third strain of Fusobacterium nucleatum was extremely sensitive to both ethanol and water treatment (Lekshmi *et al*., 2012). Prior finding affirmed that dried chewing sticks of neem indicated most extreme antibacterial action against S. mutans when contrasted with S. salivarius, S. mitis, and S. sanguis (Chava, *et al*., 2012).

Dried Neem leaves for urinary stones:

Dry *Azadirachta indica* leaves are burned in an earthen pot to create kshara, or ash. Water and ash are thoroughly combined, then let to remain motionless for 24 hours. After removing impurities from the water, the sediment is utilised as kshara. Urinary stones can be removed by drinking a kshara of neem leaves every morning with warm water. (Kalaivani *et al*., 2009).

THE FUTURE ASPECTS

Medicines

In various regions of the world, herbal remedies are utilised to cure a variety of disorders. The neem tree, which plays a significant role in various herbal remedies, is referenced in several ancient literature on

medicine. It is regarded by traditional Indian medical experts as the best remedy available. Because of Neem's amazing qualities, its bark, leaves, blossoms, seeds, and fruit pulp have been and are still used to cure a variety of illnesses and complaints, including leprosy, diabetes, ulcers, skin conditions, constipation, and more. In order to create new antibiotics, scientists from the industrialised world are actively researching the Neem tree and its qualities (Debjit Bhowmik *et al.*, 2010).

Cosmetics

Dry *Azadirachta indica* leaves are burned in an earthen pot to create kshara, or ash. Water and ash are thoroughly combined, then let to remain motionless for 24 hours. After removing impurities from the water, the sediment is utilised as kshara. Urinary stones can be removed by drinking a kshara of neem leaves every morning with warm water.

Agricultural

The majority of scientists have concentrated their study on agriculture in order to examine the advantages of neem for crop development. Neem oil, Neem cake, leaves, and other Neem tree components are now widely employed in the agriculture industry around the world as a result of their discoveries. Its primary applications in agriculture are foliar pesticide, soil amendment, food storage insecticide, fertiliser efficiency enhancer, and soil amendment.

Food Storage

Infestations of worms, beetles, and other pests cause a significant portion of the produced food in all tropical regions to spoil during storage. People don't want to apply chemical pesticides on grains that are being kept, especially when it comes to food that is being saved for their own use. Neem oil has long given farmers a powerful defence against these insects. With no degradation or loss of flavour, a very thin coating of neem oil can shield stored food crops from all forms of pests for up to 20 months. Although this is done on a small scale, using fresh neem leaves for the proper preservation of food grain at home (Debjit Bhowmik *et al.*, 2010).

Soil Amendment

Neem cake, or the leftover substance known as cake after the oil is extracted from the seed kernels, has been utilised for millennia as a successful soil supplement throughout the Indian subcontinent. Farmers in this area have discovered through experience that incorporating Neem cake into the soil results in bigger, healthier plants with little to no insect or disease issues. Various investigations were also carried out by various specialists to determine why plants thrived in soil that had been combined with Neem cake. Their findings showed that neem cake is richer in nutrients that are accessible to plants than manures; it also eliminated harmful nematodes, encouraged a big population of earth worms, helped maintain the availability of nitrogen to plants in the soil, and offered notable insect protection. Farmers in that area are aware that nematodes in the soil may be used to eradicate a significant plant pest. Nematodes pose a serious threat to plants. Nematodes suck fluid from plant roots to the point that the roots are unable to provide the plant with enough nutrition. After that, despite having enough food, water, and care, the plants appear ill, fail to thrive, and may finally perish. By encouraging earthworm activity in the soil, which facilitates easier and more effective nutrient and

water absorption by plants, the use of neem cake in the soil also aids in maintaining soil's looseness. Neem cake first shields plants from insects and pests, enabling them to build a powerful defence against these pest attacks second, the neem components that are absorbed via soil strengthen these built-in defence mechanisms thanks to their shown nutritional, antifungal, and insect repellent qualities.

Poverty

The world's natural resources and economic resources are being severely depleted by the explosive rise of the human population today. There would be no chance of lifting everyone out of poverty in the developing nations unless the uncontrollable pace of population increase in the world was slowed down. The failure of birth control programmes is further hampered by the lack of affordable contraceptive technologies that do not traumatise individuals or offend their aesthetic, cultural, or religious sensibilities. Recent research, however, suggests that certain Neem compounds could work as readily available, inexpensive contraceptives. Neem's effectiveness as a contraceptive was recently confirmed by a controlled study conducted in the Indian army. In a recent report, the International Food Policy Research Institute, based in Washington, predicted that by 2020, the world would be even more unfair than it is now, with food surpluses in the industrialised world and ongoing instability and food shortages in the south, particularly in African nations. The Neem tree now holds a very high level of relevance in the eyes of the US Academy of Sciences. The "Tree of the 21st Century," according to the United Nations, is the neem tree (Debjit Bhowmik *et al.*, 2010).

NEEM PATENTS:

Up to 2013, 65 patent applications for goods produced from the neem tree had been submitted to the EPO, of which 22 had been approved, 28 had been declared "dead," and 15 were still undergoing review. Concerning one of the active components, azadirachtin, these include claims for insecticides, fungicidal properties, extraction techniques, storage-stable formulations, contraceptives, and medicinal purposes. Even while several Indian businesses have asserted patents on the neem, global enterprises, such as the American pharmaceutical company Rohm and Haas and the agrochemical behemoth W.R. Grace, outnumber them two to one. It's vital to understand that the Neem patents do not cover any genetically modified products, and neither the tree itself nor any of its components have been protected by a patent (Tinghui *et al*., 2001).

CONCLUSION

Both the leaves and the roots of neem are beneficial for blood cleansing and circulation. Neem has become popular in contemporary medicine due to its extensive usage in Ayurveda, Unani, and homoeopathic treatments. Neem produces a wide range of chemically varied and structurally complex physiologically active chemicals. From various neem plant components, more than 140 distinct chemicals have been discovered. Traditionally, the neem tree's leaves, blossoms, seeds, fruits, roots, and bark have all been used to cure fever, inflammation, infections, skin conditions, and dental issues. The immunomodulatory, anti-inflammatory, antihyperglycemic, antiulcer, antimalarial, antifungal, antibacterial, antiviral, antioxidant, antimutagenic, and anticarcinogenic activities of neem leaf and its components have been proven. Neem offers humans several benefits, such as shade, clean air, health, and general well-being, in addition to being a fantastic illness treatment. It's crucial that people are made aware of neem's benefits. Few plants on this planet stand out for their astounding flexibility among all those that have served humans well. The Neem tree is one of the most significant of them. Although there is just early scientific evidence that has to be confirmed, neem is

considered to be particularly successful in the treatment of scabies and is advised for people who are sensitive to permethrin, a well-known pesticide that may be irritating. Additionally, the scabies mite has not yet developed a resistance to neem, making it particularly helpful in situations where the condition persists.

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REFERENCES

1. A. H. Rahmani and S. M. Aly, "*Nigella sativa* and its active constituents thymoquinone shows pivotal role in the diseases prevention and treatment," *Asian Journal of Pharmaceutical and Clinical Research*, vol. 8, no. 1, pp. 48–53, 2015.
2. A. H. Rahmani, M. A. Alzohairy, M. A. Khan, and S. M. Aly, "Therapeutic implications of black seed and its constituent thymoquinone in the prevention of cancer through inactivation and activation of molecular pathways," *Evidence-Based Complementary and Alternative Medicine*, vol. 2014, Article ID 724658, 13 pages, 2014.
3. A. K. Ghimeray, C. W. Jin, B. K. Ghimire, and D. H. Cho, "Antioxidant activity and quantitative estimation of azadirachtin and nimbin in *Azadirachta indica* A. Juss grown in foothills of Nepal," *African Journal of Biotechnology*, vol. 8, no. 13, pp. 3084–3091, 2009.
4. A. Osunwoke Emeka, J. Olotu Emamoke, A. Allison Theodore, and C. Onyekwere Julius, "The wound healing effects of aqueous leave extracts of azadirachta indica on wistar rats," *Journal of Natural Science and Research*, vol. 3, no. 6, 2013.
5. A. S. M. Mosaddek and M. M. U. Rashid, "A comparative study of the anti-inflammatory effect of aqueous extract of neem leaf and dexamethasone," *Bangladesh Journal of Pharmacology*, vol. 3, no. 1, pp. 44–47, 2008.
6. Ahmed, W., Azmat, R., Khojah, E., Ahmed, R., Qayyum, A., Shah, A. N.(2022). The Development of a Green Innovative Bioactive Film for Industrial Application as a New Emerging Technology to Protect the Quality of Fruits. Molecules 27 (2), 486. doi:10.3390/molecules27020486.
7. An, A., Je, A., Cb, U., and Mn, I. (2019). Identification and Control of Specific Aflatoxin-Producing Fungi in Stored Maize Seeds in Awka Using Azadirachta indica (Neem) and garcinia Kola Seeds. Pak J. Pharm. Sci. 32 (4), 1679–1686.
8. Aslam F, Rehman KU, Asghar M, Antibacterial activity of various phytoconstituents of neem. Pak J Agri Sci 2009;46(3):209-213.
9. C. C. Barua, A. Talukdar, A. G. Barua, A. Chakraborty, R. K. Sarma, and R. S. Bora, "Evaluation of the wound healing activity of methanolic extract of *Azadirachta Indica* (Neem) and Tinospora cordifolia (Guduchi) in rats," *Pharmacology online*,vol. 1, pp. 70–77, 2010.
10. Chaguthi P., Mittal A., Singh S., Baghel D.S. (2018). An overview on therapeutic potential of Azadirachta indica. https://www.researchgate. net/profile/

11. Chandramohan K.*, Ajithkumar A., Jagath Ratchagan R., Manikandan M., Manojkanna V. K. and Nepolean R. A Review on Azadirachta Indica (Neem) And Neem Herbal Cream *World Journal Of Pharmaceutical Research* Vol 11, Issue 13, 2022. 2055-2063.
12. Chaudhary, S., Kanwar, R. K., Sehgal, A., Cahill, D. M., Barrow, C. J., Sehgal, R. (2017). Progress on Azadirachta indica Based Biopesticides in Replacing Synthetic Toxic Pesticides. Front. Plant Sci. 8, 610. doi:10.3389/fpls.2017.00610.
13. D. A. Of usori, B. A. Falana, A. E. Ofusori, T. A. Abayomi, S. A. Ajayi, andG. B. Ojo, "Gastro protective effect of aqueous extract of neem *Azadirachta indica* on induced gastric lesion in rats," *International Journal of Biological and Medical Research*, vol. 1, p. 219–222, 2010.
14. Debjit Bhowmik, Chiranjib, Jitender Yadav, K. K. Tripathi, K. P. Sampath Kumar Herbal Remedies of *Azadirachta indica* and its Medicinal Application *J. Chem. Pharm. Res.*, 2010, 2(1): 62-72.
15. Del Serrone, P., Failla, S., and Nicoletti, M. (2015a). Natural Control of Bacteria Affecting Meat Quality by a Neem (Azadirachta indica A. Juss) Cake Extract. Nat. Prod. Res. 29 (10), 985–987. doi:10.1080/14786419.2014.964708.
16. Dholi SK, Raparla R, Mankala SK. Invivo antidiabetic evaluation of neem leaf extract in alloxan induced rats. Journal of Applied Pharmaceutical Science 2011;1(4):100-105.
17. Ezeonu, C.S, Tatah,V. S., Imo,C.,Mamma,E.,Mayel,M. H.,Kukoyi,A. J., .. (2019). Inhibitory Effect of Aqueous and Ethanolic Extracts of Neem Parts on Fungal Rot Disease of Solanum tuberosum. Pak J. Biol. Sci. 22 (5), 206–213. doi:10.3923/pjbs. 2019.206.213.
18. Faccin-Galhardi LC, Yamamoto KA, Ray S, .. The vitro antiviral property of Azadirachta indica polysaccharides for poliovirus. J Ethnopharmacol 2012;142(1):86-90.
19. G. Kaur,M. Sarwar Alam, andM. Athar, "Nimbidin suppresses functions of macrophages and neutrophils: relevance to its anti-inflammatory mechanisms," *Physiotherapy Research*, vol. 18, no. 5, pp. 419–424, 2004.
20. Garg GP, Nigam SK, Ogle CW. The gastric antiulcer effects of the leaves of the neem tree. Planta Med 1993;59(3):215-217.
21. Govindachari, T. R. (1992). Chemical and Biological Investigations on Azadirachta indica (The Neem Tree). Curr. Sci. 63 (3), 117–122.
22. Hamad, G. M., Mohdaly, A. A. A., El-Nogoumy, B. A., Ramadan, M. F., Hassan, S. A., and Zeitoun, A. M. (2021). Detoxification of Aflatoxin B1 and Ochratoxin A Using Salvia farinacea and Azadirachta indica Water Extract and Application in Meat Products. Appl. Biochem. Biotechnol. 193 (10), 3098–3120. doi:10.1007/s12010-021- 03581-1.
23. Hashmat I., Azad, H., Ahmed A. (2012). Neem (Azadirachta indica A. Juss)-A nature's drugstore: an overview. *Int Res J Biol Sci* 1: 76-9.
24. K. Biswas, I. Chattopadhyay, R. K. Banerjee, and U. Bandyopadhyay, "Biological activities and medicinal properties of Neem (*Azadirachta indica*)," *Current Science*, vol. 82, no. 11, pp. 1336– 1345, 2002.
25. Kalaivani T, Meignanam E, Premkumar N. Studies on hepato protective properties of leaf extracts of *Azadirachta indica*A. Juss (*Meliaceae*). *Ethnobotanical Leaflets.* 2009; 13: 165–70.

26. Kumar Singh R. Bhat S.S., Girlish K. (2008). Ethnomedicinal properties of Azadirachta indica. Neem-A Green Treasure. *Electron J Biol* 4: 102-111.
27. Kumar VS, Navaratnam V. Neem (Azadirachta indica): prehistory to contemporary medicinal uses to humankind. Asian Pac J Trop Biomed 2013;3(7):505-514.
28. L. Le Marchand, "Cancer preventive effects of flavonoids—a review," *Biomedicine and Pharmacotherapy*, vol. 56, no. 6, pp. 296–301, 2002.
29. M. R. Naik, A. Bhattacharya, R. Behera, D. Agrawal, S. Dehury, and S. Kumar, "Study of anti-inflammatory effect of neem seed oil (*Azadirachta indica*) on infected albino rats," *Journal of Health Research and Reviews*, vol. 1, no. 3, pp. 66–69, 2014.
30. Mahmoud DA, Hassanein NM, Youssef KA. Antifungal activity of different neem leaf extracts and the nimonol against some important human pathogens. Braz J Microbiol 2011;42(3):1007-1016.
31. Mohammed A, Tanko Y, Okasha MA,Effects of aqueous leaves extract of Ocimum gratissimum on blood glucose levels of streptozotocin induced diabetic Wistar rats. Afr J Biotechnol 2007;6(8):2087-2090.
32. Morales-Covarrubias, M. S., García-Aguilar, N., Bolan-Mejía, M. D., and Puello-Cruz, A. C. (2016). Evaluation of Medicinal Plants and Colloidal Silver Efficiency against Vibrio Parahaemolyticus Infection in Litopenaeus Vannamei Cultured at Low Salinity. Dis. Aquat. Organ 122 (1), 57–65. doi:10.3354/dao03060.
33. N. Arora, A. Koul, and M. P. Bansal, "Chemo preventive activity of *Azadirachta indica* on two-stage skin carcinogenesis in murine model," *Physiotherapy Research*, vol. 25, no. 3, pp. 408– 416, 2011.
34. N. S. Baligar, R. H. Aladakatti, M. Ahmed, and M. B. Hiremath, "Hepatoprotective activity of the neem-based constituent azadirachtin-A in carbon tetrachloride intoxicated Wistar rats," *Canadian Journal of Physiology and Pharmacology*, vol. 92, no. 4, pp. 267– 277, 2014.
35. Nahak G, Sahu RK. Antioxidant activity in bark and roots of neem (Azadirachta indica) and Mahaneem (Melia azedarach). Continental J Pharmaceutical Sciences 2010;1(4):28-34.
36. Nicoletti M., Murugan K. (2013). Neem the tree of 21st century. *Pharmacology Online* 3: 115-121.
37. Nicoletti, M., Maccioni,O., Coccioletti, T.,Mariani, S., andVitali, F. (2012). "Neem Tree (Azadirachta indica A. Juss) as Source of Bioinsectides," in Insecticides – Advances In Integrated Pest Management. IntechOpen). doi:10.5772/28786.
38. Oyekanmi, A. A., Kumar,U. S.U., H. P. S.,A.K., Olaiya,N.G., Amirul,A.A., Rahman, A. A.(2021). Functional Properties of Antimicrobial Neem Leaves Extract Based Macroalgae Biofilms for Potential Use as Active Dry Packaging Applications. Polymers 13 (10), 1664. doi:10.3390/polym13101664.
39. P. Sithisarn, R. Supabphol, and W. Gritsanapan, "Antioxidant activity of Siamese neem tree (VP 1209)," *Journal of Ethno pharmacology*, vol. 99, no. 1, pp. 109–112, 2005.
40. P. X. Nunes, S. F. Silva, R. J. Guedes, and S. Almeida, "Biological oxidations and antioxidant activity of natural products," in *Phytochemicals as Nutraceuticals—Global Approaches to Their Role in Nutrition and Health*, InTech, 2012.
41. Pandey G, Verma KK, Singh M. Evaluation of phytochemical, antibacterial and free radical scavenging properties of Azadirachta indica (Neem) leaves. Int J Pharm Pharm Sci 2014;6(2):444-447.

42. Patel SM, Venkata KCN, Bhattacharyya P,.Potential of Neem (Azadirachta indica L.) for prevention and treatment of oncologic diseases. Semin Cancer Biol 2016;40-41:100-115.
43. Patil P, Patil S, Mane A, Antidiabetic activity of alcoholic extract of neem (Azadirachta indica) root bark. National Journal of Physiology, Pharmacy and Pharmacology 2013;3(2):142-146.
44. Paul R, Prasad M, Sah NK. Anticancer biology of Azadirachta indica L (neem): a mini review. Cancer Biol Ther 2011;12(6):467-476.
45. Quraishi H.A., Islam N., Iqbal A., Bhat S.A., Ahmed J., Ashraf S.S., Khan Q.A. (2018). Therapeutical and medicinal properties of Neem (Azadirachta indica) in context of Unani system of medicine: A review study. *J Drug Deliv Ther* 8: 394-399. http://jddtonline.info/index.php/ jddt/article/view/2141.
46. R. R. Chattopadhyay, "Possible biochemical mode of anti-inflammatory action of *Azadirachta indica* A. Juss. in rats," *Indian Journal of Experimental Biology*, vol. 36, no. 4, pp. 418– 420, 1998.
47. Ravva, S. V., and Korn, A. (2015). Effect of Neem (Azadirachta indica) on the Survival of Escherichia coli O157:H7 in Dairy Manure. Int. J. Environ. Res. Public Health 12 (7), 7794–7803. doi:10.3390/ijerph120707794.
48. Riar SS, Devakumar C, Sawhney RC, Antifertility activity of volatile fraction of Neem oil. Contraception 1991; 44(3): 319–326.
49. Rodrigues,M. P., Astoreca,A. L., Oliveira,Á.A., Salvato, L. A., Biscoto,G. L., Keller, L. A. M.(2019). In Vitro Activity of Neem (Azadirachta indica) Oil on Growth and Ochratoxin A Production by Aspergillus carbonarius Isolates. Toxins (Basel) 11 (10). doi:10.3390/toxins11100579.
50. S. Kumar, D. Agrawal, J. Patnaik, and S. Patnaik, "Analgesic effect of neem (*Azadirachta indica*) seed oil on albino rats," *International Journal of Pharma and Bio Sciences*, vol. 3, no. 2, pp. P222–P225, 2012.
51. Sarita Khatkar, Priyanka Dhiman, Sachin, Neelam Malik, Anurag Khatkar, Neelam Redhu Biological and Medicinal Properties Of Azadirachta Indica: A Review *International Journal of Pharma Professional Research* April 2014, Volume-5, Issue-2.
52. Sarmiento W. C., Maramba C. C., Gonzales M. L. M. An *in vitro* study on the antibacterial effect of neem (*Azadirachta indica*) leaf extracts on methicillin- sensitive and methicillin-resistant *Staphylococcus aureus*. PIDSP Journal, 2011; 12(1): 40–45.
53. Schmutterer H. Properties and potential of natural pesticides from the neem tree, Azadirachta indica Ann Rev Entomol 1990;35:271-297.
54. Singh A, Purohit B. Tooth brushing, oil pulling and tissue regeneration: a review of holistic approaches to oral health. J Ayurveda Integr Med 2011;2(2):64-68.
55. Sitara U, Niaz I, Naseem J. Antifungal effect of essential oils on in vitro growth of pathogenic fungi. Pak J Bot 2008;40(1):409-414.
56. Subapriya R., Nagini S. (2005). Medicinal properties of neem leaves: a review. *Curr Med Chem Anti-Cancer Agents* 5: 149-156. https://www.ingentaconnect.com/content/ben/ cmcaca/2005/00000005/00000002/art00006.
57. Subbuvel, M., and Kavan, P. (2022). Preparation and Characterization of Polylactic Acid/fenugreek Essential Oil/curcumin Composite Films for Food Packaging Applications. Int. J. Biol. Macromol. 194, 470–483. doi: 10.1016/j.ijbiomac.2021. 11.090.

58. Sultana, B., Naseer, R., and Nigam, P. (2015). Utilization of Agro-Wastes to Inhibit Aflatoxins Synthesis by Aspergillus parasiticus: A Biotreatment of Three Cereals for Safe Long-Term Storage. Bioresour. Technol. 197, 443–450. doi:10.1016/j. biortech.2015.08.113.
59. Sunthar, T. P. M., Marin, E., Boschetto, F., Zanocco, M., Sunahara, H., Ramful, R. (2020). Antibacterial and Antifungal Properties of Composite Polyethylene Materials Reinforced with Neem and Turmeric. Antibiot. (Basel) 9 (12). doi:10.3390/antibiotics9120857.
60. Tewari D.N. (1993). Genetic Improvement of Neem: Strategies for the Future. *Winrock Internat Institute Agricult Develop Project* 29-34.
61. Tinghui X, Wegener M. World Distribution and Trade in Neem Products with Reference to their Potential in China. Contributed paper to AARES 2011 conference of Australian Agricultural and Resource Economics Society. Adelaide; 2001; 1–15.
62. Tiwari V, Darmani NA, Yue BY, . In vitro antiviral activity of neem (Azardirachta indica L.) bark extract against herpes simplex virus type-1 infection. Phytother Res 2010;24(8):1132-1140.
63. Upadhyay SN, Dhawan S, Garg S. Immunomodulatory effects of neem (Azadirachta indica) oil. Int J immunopharmacol 1992;14(7):1187- 1193.
64. Uthaya Kumar, U. S., Abdulmadjid, S. N., Olaiya, N. G., Amirul, A. A., Rizal, S., Rahman, A. A., (2020). Extracted Compounds from Neem Leaves as Antimicrobial Agent on the Physico-Chemical Properties of Seaweed-Based Biopolymer Films. Polym. (Basel) 12 (5). doi:10.3390/polym12051119.
65. Uzzaman S. (2020). Pharmacological activities of neem (Azadirachta indica): A review. *Int J Pharmacogn Life Sci* 1: 38-41. https://www. pharmacognosyjournal.com/article/8/1-1-16-389.pdf.
66. Yadav D.K., Bharitkar Y.P., Chatterjee K., Ghosh M., Mondal N.B., Swarnakar S. (2016). Importance of neem leaf: An insight into its role in combating diseases. http://nopr.niscair.res.in/ handle/123456789/36892.