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REVIEW ARTICLE



A review on phytochemistry, traditional uses, and pharmacological potential of *Morinda citrifolia* (Noni)

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ABSTRACT

For centuries, the noni plant (*Morinda citrifolia*) has been a cornerstone of traditional medicine across Southeast Asia and the Pacific Islands, used to treat a vast array of ailments. Today, this tropical fruit has captured global attention, moving from ancient remedies to modern health food stores. This review paper critically evaluates the science behind the hype, exploring noni's rich phytochemical makeup and its promising pharmacological potential. The paper compiles evidence showing that nearly 200 beneficial compounds including anthraquinones, flavonoid, and iridoids have been identified in different parts of the noni plant. These compounds contribute to a broad spectrum of biological activities. Research suggest that noni and its extracts possess anticancer (significant inhibition of breast, lung and colon cancer), anti-microbial (inhibition of *Candida albicans* and *Staphylococcus aureus*), analgesic (162-212% increased pain tolerance in rodents), anti-inflammatory, cardio-protective, and blood-sugar-lowering (hypoglycemic) properties. While the historical use and a growing body of preclinical studies are compelling, the authors conclude that high quality clinical trials are limited. Such research is crucial to confirm its effectiveness, establish proper dosage, and ensure long-term safety. This review concludes that, with the unique combination of historical value, nutritional richness, and diverse therapeutic potential, noni stands as an invaluable resource for the future of nutraceuticals and modern medicine while well designed human trials must establish clinical efficacy, optimal dosage, and sustained safety in humans.

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INTRODUCTION

Morinda citrifolia, commercially known as noni, is a perennial fruit-bearing plant originating in Southeast Asia (Nelson, 2001). It has been assigned a diversity of names called nhaut in Southeast Asia, noni in Hawaii, Nuna or Indian mulberry in India, pain-killer bush or cheese fruit in Caribbean (Chan-Blanco *et al.*, 2006). Noni belongs to the same family as coffee plant called Rubiaceae and subfamily Rubioideae (Lachenmeier *et al.*, 2006). It is greatly adopted to the tropics, up to 800m with mean

annual temperature of 20°- 35°C and annual rainfall of 250 – 4000mm (Nelson, 2006). It is small evergreen shrub up to 6m tall at maturity and is characterized by: straight stem, lanceolate format large leaves, sincarpic, oval and fleshy fruit with hard and rough peel which softens at maturity (Almeida *et al.*, 2019). Nelson (2005) reported its fruit size up to 14 cm in length and 8 cm in diameter producing unpleasant odour during its advanced ripening stage. Moreover, the fruit contains up to 260 seeds (Lin *et al.*, 2014). After planting under favourable conditions, the plant can bear the fruits from about nine months to one year,

wheres *M. citrifolia* plots are usually harvested twice or thrice per month and yields around 35 tons of juice per hectare (Abou Assi et al., 2017).

There are two validated varieties of *M. citrifolia* (*M. citrifolia* var. *Citrifolia* and *M. citrifolia* var. *bracteata*) and one cultivar called *M. citrifolia* cultivar *Potteri*, among which *M. citrifolia* var. *citrifolia* with the greatest health and economic importance is found widely (Pawlus & Kinghorn, 2007). Noni has been used as medicinal plant in South and Southeast Asia, Australia, and the Caribbean since ancient period which has been used to cure diversity of ailments (Pawlus & Kinghorn, 2007). Over 2000 years, Polynesians has used it for two main purposes: First, as a dye for traditional and ceremonial clothes abstracted from the roots and barks, and secondly, entire plant parts been used to treat a variety of infirmity (Wang et al., 2002). In recent years, the use of noni has inclined in North America, Western Europe and elsewhere with its wide availability in health food stores, pharmacies, and grocery stores (Pawlus & Kinghorn, 2010). In 1996, due to its numerous therapeutic effects, *M. citrifolia* juice was presented as a wellness tonic (Kamiya et al., 2009). The plant has revealed antibacterial, antiviral, anti-fungal, anti-tumor, anthelmintic, analgesic, hypotensive, anti-inflammatory, and immune-enhancing activities in pharmacological studies despite their effectiveness has remained unproven (Chan-Blanco et al., 2006). In 2003, European commission certified its juice as a novel food; even though, this certification was limited to the Tahitian fruit juice and not to other products (Potterat & Hamburger, 2007). The roots of these plants are the good sources of anthraquinones, wisely present as aglycones and to some extent, in the form of glycosides as reported by Krishnaiah et al. (2012). Variation in chemical composition among bracteata and citrifolia cultivars, harvesting stage of fruits, processing methods and solvent extraction remarkably affect phytochemical profiles and bioactivity of morinda. Researchers suggest long term systematic clinical trials to warrant systematic reevaluation. This review emphasizes the phytochemical variability and its impact on pre-clinical pharmacology, human studies, reproducibility, and contradiction between traditional claims and latest evidences.

Botanical description

The genus name of *Morinda citrifolia* L. is derived from two Latin words *morus* (meaning mulberry) and *indicus* (meaning Indian), as the fruit shares similarities with that of true mulberry (*Morus alba*). The species name 'citrifolia' indicates that the foliage of *Morinda* resembles some citrus species. This plant belongs to the family Rubiaceae and subfamily Rubioideae.

Form: Perennial shrubs or small trees with variation in fruit size, morphology of foliage, palatability of fruit, odor of ripe fruit, seeds count per fruit and overall plant form.

Size of plant: Plant typically heights from 3 to 10 meters at mature stage.

Flowers: *Morinda citrifolia* typically has small, white, perfect and

tubular flowers with head like clusters at the tips of branches and leaf axils. The flowers are fragrant and appear year round.

Fruits: Fruit is multiple fruit with fused drupes. Each drupes contain four seeds which gets developed after 9 to 12 months of plantation. Fleshy fruits of length 5-10 cm and 3-4 cm diameter, soft when ripened are found.

Leaves: Leaves are opposite, 20-45 cm long, 7-25 cm wide.

Distribution

Morinda species are all regional endemics and *Morinda citrifolia* is the only species with a pantropical distribution. Large-fruited *Morinda citrifolia* var. *citrifolia* is widely distributed through natural dispersal of seeds by oceanic floating. The analyses support Micronesian origin of *M. citrifolia* and also suggests that large fruited *M. citrifolia* var. *citrifolia* might have been present in Pacific prior to the arrival of Micronesian and Polynesian ancestors (Razafimandimbison et al., 2010). The prevailing perspective suggests that this plant, originally native to Southeast Asia, was spread to the Pacific islands and other tropical regions through human activity and/or ocean currents (Morton, 1992). The plant is highly adaptable, thriving in diverse habitats such as low-elevation lava flows, rocky coasts, salty tide pools, open grasslands, lowlands, gulches, and cliffs (Nelson, 2006).

Chemical constituents

Approximately 200 phytochemicals have been already identified from the different parts as stem, ark, trunk, fruit and seeds of the noni plant, including anthraquinones, flavonoids, polysaccharides, glycosides, iridoids, lignans, and triterpenoids (Figures 1 and 2) reported by a number of researchers (Pawlus et al., 2005; Singh, 2012; Abou Assi et al., 2017). The principal micronutrient recorded are phenolic compound, organic acids, and alkaloids; of the recorded phenolic compounds, anthraquinones (such as damnacanthal, morindone, morindin), aucubin, asperuloside, and scopoletin are the most important (Wang & Su, 2001). Dittmar (1993) reported the crucial organic acids recorded are caproic and caprylic acids also supported xeronine is the principal alkaloid recorded. According to the part of the plant, the availability of chemical composition varies greatly; the fruit composed of 90% water and the major constituent of dry matter seem to be soluble solids, dietary fibres and proteins (Chanblanco et al., 2006). Chunhieng (2003) reported the fruit protein content is amazingly high, consisting 11.3% of the juice dry matter, and the major amino acids are aspartic acid, glutamic acid and isoleucine; also, 8.4% of the dry matter account for minerals with mainly potassium, sulfur, calcium and phosphorus. Vitamins, primarily ascorbic acid (24- 158mg/100g dry matter) has been reported in the fruit (Morton, 1992). In 1993, Scopoletin, a coumarin which has significant ability to control serotonin levels in the body together with analgesic properties was isolated at the University of Hawaii (Levand & Larson, 1979). Different Hawaiian teams (Heinicke, 1985) reported the presence of a novel component, proxeronine which might be the precursor of



Figure 1. Noni plant, its trunk, stages of flower, fruit and seeds (Sources: *Plant medica*).

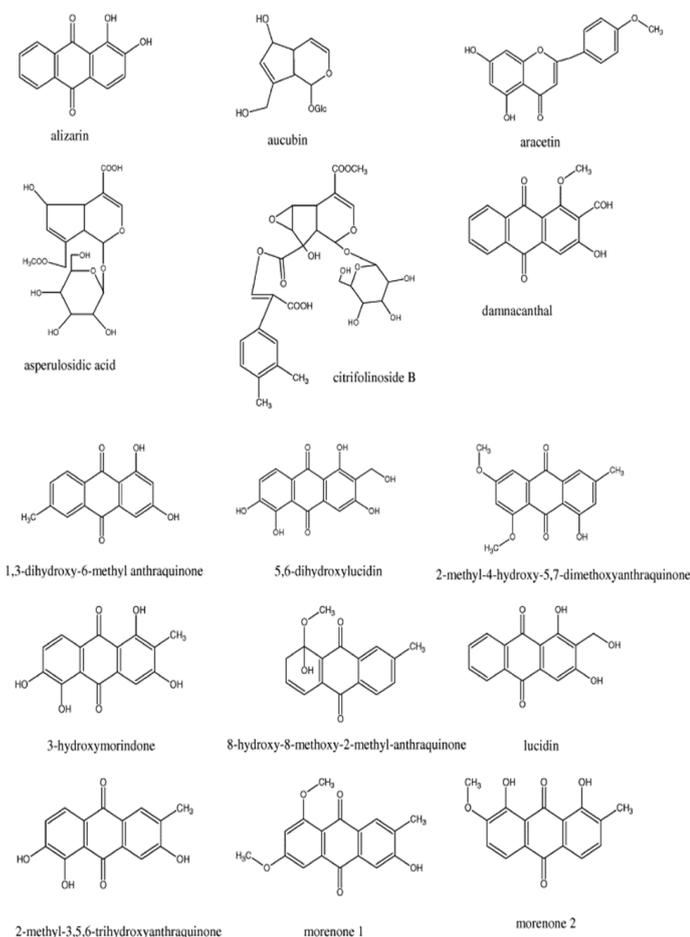


Figure 2. Chemical constituents of *Morinda citrifolia* L. (Source: *Abou Assi et al., 2017*).

xeronine: an alkaloid combined with human protein to improve their functionality. Around 51 volatile compounds were recognized in the ripe fruit (*Sang et al., 2001*) which includes organic acids (primarily octanoic and hexanoic acids), esters (methyl octanoate, methyl decanoate), alcohols (3- methyl-3-buten-1-ol), ketones (2- heptanone), and lactones [(E)- 6- dodeceno- γ -lactone] (*Farine et al., 1996*).

Major components

Noni plants contribute numerous major components such as octanoic acid, scopoletin, vitamin C, anthraquinones (such as rubiadin, morindone, anthraquinone glycoside), potassium, terpenoids, Vitamin A, linoleic acid, rutin, caprylic acid, and putative proxeronine.

Pharmacological activity of Noni

Anticancer activity

A study of Noni and its bioactive elements show positive anti-cancer results among various cancer types. For breast cancer, Tahitian Noni Juice (TNJ) decreased tumor size and weight in mice and intensified the potency of doxorubicin in Ehrlich ascites tumor models. TNJ further reduced tumor multiplication and increased survival rates in Sprague-Dawley rats. In lung and colon cancer, six identified and two new compounds from Noni remarkably inhibited cell proliferation. Noni and Berries reveal preventive and healing effects in esophageal cancer models of rats. Noni-ppt (a polysaccharide fraction) promote the impact of chemotherapy drugs like cisplatin and doxorubicin while minimizing tumor angiogenesis (*Ali et al., 2016*).

Analgesic activity

A recent study showed that those rats who consumed commercial noni juice (10% and 20%) had greater pain tolerance (162% and 212%) compared with placebo group. The research was done to understand the analgesic properties of noni juice in rats (*Wang et al., 2002*). With writhing and hotplate tests, a French team conducted experiment in 1990 to study the analgesic and sedative impacts of noni on mice. Around 1600mg/kg noni root extract reveals crucial analgesic activity in animals and it further proved to be non-toxic (*Younos et al., 1990*).

Cardiovascular protection

Noni exhibits cardio protective and neuroprotective properties, initially contributed to its antioxidant activity. Research specify that noni bring out vigorously suppress LDL oxidation (methanol and ethyl acetate extract: 88%, and 96%), thereby potentially reducing atherosclerosis progression (*Kamiya et al., 2004*). In cerebral ischemia models, noni juice diminished neuronal injury by balancing post-ischemic glucose metabolism, Recommending a therapeutic role in stroke precaution (*Muto et al., 2010*). While encouraging, human trials were validated to authenticate these preclinical results.

Osteoarthritis protection

Inflammatory joint disease, such as osteoarthritis, results over 20% of the US population (*Akihisa et al., 2007*) heading to swelling, pain, and cartilage degradation arbitrate by matrix metalloproteinases (MMPs) (*Nagase & Kashiwagi, 2003*). Non-steroidal anti-inflammatory drugs (NSAIDs), which is standard treatment slow down cyclooxygenase enzymes (COX- 1 and 2) to repress prostaglandin synthesis (*Vane & Botting, 1998*). Even with their efficacy, NSAIDs are linked with remarkable adverse effects like

Table 1. A known compound with their roles in fruit, leaf and root of *M. citrifolia*.

Plant part	Compound	Chemical classification	Uses/Roles	Reference
Fruit	Octanoic (caprylic) acid	Fatty acid	Antifungal	Elkins (1998), Dittmar (1993)
	Hexanoic acid		Antifungal, Antioxidant	Wang et al. (1999, 2002),
	Caproic acid	Antifungal	Dittmar (1993)	
	Niacin	Flavonoids	Nutritional	Palwas et al.(2007)
	Quercetin		Anti-inflammatory, Lipoxygenase inhibitor	Sang et al. (2001)
	Damnacanthal	Anthraquinones	Anti-cancer	Ali et al. (2016) & (Chan-blanco et al., 2006)
	Vitamin C, E	Vitamins	Antioxidant, Nutritional	Natheer et al. (2012)
	Asperulosidic acid	Iridoid	Antibacterial	Wang et al. (2002)
Leaf	Americanin A	Lignan	Larvicidal, antioxidant	Chan-Blanco et al. (2006)
	Leucine	Amino acid	A source of essential and conditional amino acids	Elkins (1998) and Sang et al. (2001)
	Quercetin-3-O- β -D-glucopyranoside Quercetin-3-O-a-L-rhamnopyranosyl-(1-6)- β -D-glucopyranoside	Flavonoids	Antifungal, Antimicrobial	Sang et al. (2001) and Chan- Blanco et al. (2006)
Roots	Quercetin	Flavonoids	Antioxidant, anti-dyslipidemic	Mohd Zin et al. (2007) and Mandukhail et al. (2010)
	8-hydroxy-8-methoxy-2-methyl-anthraquinone, rubiadin	Anthraquinone	Anti-viral	Elkins (1998)
	Morenone 1, 2	Anthraquinones	Anti-cancer	Elkins (1998)
	Damnacanthal		Anti-carcinogenic	Nualsanit et al. (2012)
	Alizarin	Coumarin derivative	Antibacterial	Dittmar (1993)
Scopoletin 1,3-dihydroxy-6-methyl Anthraquinone			Pirmohamed et al.(2004) Morton (1992)	
Flower	2-methyl-4-hydroxy-5,7-dimethoxyanthraquinone-4-O- β -D-glucopyranosyl-(1-4)-a-L-rhamnopyranoside	Anthraquinone	Antimicrobial	Sang et al. (2002)
	Aracetin-7-O- β -D-glucopyranoside	Flavonoids	Antioxidant	Sang et al. (2002)

hepatic, renal toxicity (Pirmohamed et al., 2004) and also it does not prevent cartilage breakdown. Some of the plant-based alternatives have gained attention such as ginger (*Zingiber officinale*) (Grzanna et al., 2005), devil's claw (*Harpagophytum procumbens*) (Brien et al., 2006), Cat's claw (*Uncaria tomentosa*) (Hardin, 2007) and more. Among all these, Noni fruit was most common in history of South pacific region for traditional medicine (Dixon et al., 1999).

Antimicrobial and antiseptic activity

In an in vitro assay, *Escherichia coli*, *Candida albicans*, and *Staphylococcus aureus* were tested for the fruit of Tahitian *M. citrifolia* in Methanol partitioned with n-butanol extract. *Candida albicans* was the most sensitive to the antimicrobial activity of *M. citrifolia*, while *Staphylococcus aureus* was the least sensitive (Wahyuningsih et al., 2020). Among the in vitro antibacterial activity of ethanol, methanol and ethyl acetate extracts, methanol extracts showed maximum potential to inhibit all the tested microorganisms. While, all of the three extracts showed potential to inhibit microorganisms so tested (Natheer et al., 2012).

Hypoglycemic activity

Morinda citrifolia possesses α -glucosidase inhibition ability. Ethanol extract of *Morinda citrifolia* at the dosage of 300mg/kg

restored normal blood glucose, glycated haemoglobin, blood urea and blood creatinine in rats (Mahadeva et al., 2009). Noni juice might have shown effect to lower blood glucose either by promoting secretion of insulin or by boosting insulin receptor sensitivity like biguanides and glitazones. (Nayak et al., 2011).

Conclusion

Morinda citrifolia (Noni) is much more than just a tropical plant with extraordinary properties in medicinal, nutritional, and therapeutic values. It's a reservoir of bioactive components like anthraquinones, flavonoids, iridoids, coumarins, and organic acids. These constituents contain a wide range of pharmacological activities, including anticancer, antimicrobial, anti-inflammatory, analgesic, cardio-protective, and hypoglycemic effects. Traditionally, Noni was used widely in Southeast Asia and the Pacific Islands, and it has now gained global recognition both as a natural remedy and as a functional food ingredient. The fruit, leaf, and roots of these plants are rich in nutrients, amino acids, and vitamins that boosts human health and well-being of overall existence. Though preclinical researches support its therapeutic benefits, more standardized clinical studies are needed for humans to confirm human effectiveness, dosag-

es, and long-term safety. Noni exhibits extreme adaptive capacity with its natural environment, along with an abundant number of phytochemicals, rising industrial importance, and pharmacological attention, which makes it an invaluable resource in pharmaceutical and nutraceutical endeavors in modern medicine for clinical value and extensive contemporary study. While, the ethnobotanical and modern pharmacological data confirms the diverse therapeutic potential of *Morinda citrifolia*, its transition from traditional remedy and popular nutraceutical to evidence backed phytomedicine is limited. Future advances demand rigorous standardization of extracts, detailed clinical trials and long term safety studies.

DECLARATIONS

Author contribution statement: Conceptualization: A.S and K.S.; Software and validation: P.G, S.B and A.D.; Formal analysis and investigation: A.S and K.S.; Writing original draft preparation: A.S, S.S and S.B.; Data correction: A.D, P.G and S.B.; Writing-review and editing: A.S, K.S and S.S.; Supervision: K.S and A.S.; Funding acquisition: A.S, K.S, A.D, S.S P.G. and S.B. Specially K.S contributed to the conceptualization and methodology of this study also played key role in whole process. All authors have read and agreed to the published version of the manuscript.

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