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International Journal of Noni Research

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Noni (*Morinda citrifolia L.*) - the Miracle Fruit - A Holistic Review

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Keywords : *Morinda citrifolia,* L. - distribution-Taxonomy-Genetic diversity-nutraceuticals-medicinal uses-propagation -physical chemical and biological properties.

Abstract : Noni, botanically known as *Morinda citrfolia* L, an under utilised, miracle plant with more than 150 nutraceuticals were found growing naturally in all types of lands right from sea coast to interior with out proper care and management are now being cultivated as crop by the farmers of India. While the cultivation is gaining popular ,it is necessary to know the research and development work carried out in India and else where ,and so an attempt is being made to review the available literature and presented here.

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Introduction

Morinda citrifolia, L. popularly known as Indian Noni or Indian mulberry is an ever green small tree bearing flowers and fruits throughout the year. It belongs to family Rubiaceae. It is grown in tropical regions of the world. Morton (1999) reported that the fruits of this tree have a history of use in the pharmacopoeias of Pacific Islands and South East Asia. It is nature's abundance bundled in one fruit. It is the biggest pharmaceutical unit in the universe because it has more than 150 nutraceuticals, several vitamins, minerals, micro and macro nutrients that help the body in various ways from cellular level to organ level. Noni is one of the important traditional folk medicinal plants that has been used for over 2000 years in Polynesia. It has been reported to have a broad range of therapeutic and nutritional value. The ancestors of Polynesians are believed to have brought many plants with them, as they migrated from Southeast Asia about 2000 years ago (Tabrah and Eveleth, 1966; Gerlach, 1996). Of the 12 most common plants they brought, Noni was the second most popular plant used in herbal remedies to treat various common diseases and to maintain overall good health (Krauss, 1993; Gerlach, 1996).

Tribes of Andaman and Nicobar Islands in India, Polynesians and Tahitians in Pacific have used the ripe and unripe fruit as food and medicine. All the

plant parts are used in the treatment of various diseases and disorders. The fruit is important because of its wide range of therapeutic potentials such as anti-bacterial, anti-viral, anti-tumor, anti-helminthes, analgesic, hypertensive, anti-inflammatory and immune enhancing effects. Use of Noni fruit juice from unripe or ripe fruit

is a more recent innovation and is recently accepted in the European Union as a novel food. The roots are being used to synthesize red dye while the leaves, bark, and fruits are used to produce facial creams, soaps, toothpaste, lotions, tea powder and various other products. Abbott (1992) reported that Noni has been used as drink, food, medicine and dye. In the past decade the global popularity of Noni has increased dramatically (Dixon et. al.,1999 and Clatchey, 2002). There are many Noni based products like health products, home care products, ,food products, health support products, fruit drinks, cosmetics like body care, oral line, face line, hand line, feet line etc., (Vigneshwari and Peter, 2007).

Common Names In India

Tamil - Nuna, Manjanathi, Manjanuna, Telugu-Bandamaddi, Maddicettu, Mogali, Molugu ,Malayalam-Kakai palam, Kattapitalavam,Mannanatti, Kanada-Haladipavete, Tagatemara, Hindi- Ach, Awl, Sanskrit-Ach, Paphanah, Achchhuka, Marathi- Aseti, Nagkura, Mundari, Salidaru.

Local names for Morinda citrifolia L

It is known in different names locally as Cheese Fruit, Forbidden Fruit, Headache Tree, Hog Apple, Mona, Mora de la India, Nino, Nona, Nono, Nonu, Nuna, Pain Bush, Pain Killer Tree, Pinuela, Wild Pine, etc. in various parts of the world. It is also called as Indian Mulberry (Mathivanan et. al., 2005).

Distribution of Morinda

The species is generally found from sea level to 400 m above MSL, although it adapts better to coastal regions (Lu¨ berck and Hannes, 2001). Noni is an evergreen tree and is often found growing along lava flows. Bulk of the crop is wild and adapts to hardy environment and soil conditions. It can be found naturally in disturbed forests, alien grass lands, open areas near the shore lines, pastures, coconut plantations, littoral forests, fallow areas and in waste lands (Cambie and Ash, 1994). The genus Morinda is distributed worldwide with 80 species reported so far, predominantly in tropical countries. It occurs in Africa, Australia, Barbados, Cambodia, Caribbean, Cayman Islands, Cuba,

Dominican Republic, El Salvador, Fiji, Florida, French West Indies, Guadeloupe, Guam, Haiti, Hawaii, India, Jamaica, Java, Laos, Malaysia, Marquesas Islands, Philippines, Polynesia, Puerto Rico, Raratonga, Samoa, Seychelles, Solomon Islands, Southeast Asia, St. Croix, Surinam, Tahiti, Thailand, Tonga, Trinidad and Tobago and Vietnam.

In India it is widely grown under natural conditions in Andaman and Nicobar Islands. It is seen throughout the coastal region along fences and road sides due to its wider adaptability to hardy environment. In the main land of India it is found along the coastal areas of Kerala, Karnataka, Tamil Nadu and many other places. Survey of Morinda in south India indicated that 12 different species or varieties of Morinda are distributed throughout Tamil Nadu and Kerala. However, the species M. tinctoria is present abundantly in most parts of Tamil Nadu and in some parts of Kerala. M. citrifolia L. is not recorded in the study area of Tamil Nadu whereas it is profusely distributed in most parts of the Kerala especially coastal region and also in the Mangalore area of Karnataka. Recently an unidentified Morinda species with large and leathery leaves was reported in the Dhandakaranya forest area of Malkanagiri district in Orissa (Singh et. al., 2007).

Plant Description

Morinda citrifolia is a bush or small tree, 3-10 m tall, with abundant wide elliptical leaves (5-17 cm length, 10-40 cm width). The small tubular white flowers are grouped together and inserted on the peduncle. The petioles leave ring-like marks on the stalks and the corolla is greenish white (Morton, 1992; Elkins, 1998; Dixon et. al., 1999; Ross, 2001; Cardon, 2003). The Noni fruit (3-10 cm length, 3-6 cm width) is oval and fleshy with an embossed appearance. It is slightly wrinkly, semi-translucent, and ranges in colour from green to yellow, to almost white at the time of picking. It is covered with small reddish-brown buds containing the seeds. The ripe fruit exhales a strong butyric acid-like rancid smell (Morton, 1992; Dixon et. al., 1999). The pulp is juicy and bitter, light dull yellow or whitish, gelatinous when the fruit is ripe; numerous hard triangular reddish-brown pits are found, each containing four seeds (3-5 mm) (Dittmar, 1993). The fruit can grow in size up to 12 cm or more and has a lumpy surface covered by polygonal-shaped section. The seeds, which are triangular shaped and reddish brown, have an air sac attached at one end, which makes the seeds buoyant. The mature Noni fruit has a foul taste and odour. Noni is identifiable by its straight trunk, large, bright green and elliptical leaves, white tubular flowers and its distinctive, ovoid, "grenade-like" yellow fruit.

Taxonomy of Morinda

Mathivanan et. al., 2005 in their review article made a detailed taxonomy of Morinda. Morinda Citrifolia L. belonging to the family of Rubiaceae has a derivation of the name Morinda: from Latin Morus, Mulberry and indicus, Indian referring to the similarity of the fruit to the Mulberry, Morus indica. The genus Morinda consists more than 80 species, (Johanssen, 1994, McClatchy, 2002).

Vernacular Names of *Morinda citrifolia*

Vernacular Names	Country	References	Year
Morinda citrifolia	-	Linnaeus	1762
Awl tree	India	Simmonds	1854
Indian Mulberry	India	Drury	1873
Togari wood	India	Watt	1908
Ach	India	Benthall	1946
Mona, monii	Tahiti	Smith	1882
Nuna	Southern India	Safford	1905
Head ache tree	St.Croix	Millspaugh	1902
Nonu	Samoa	Safford	1905
Noni	Hawaii	Degener	1945
Nino	Philippines	Safford	1905
Morinda	Australia	Webb	1948

Source: Singh (2007)

Genetic Diversity of *Morinda citrifolia* L.

Important species

Morinda *citrifolia*
Morinda tinctoria
Morinda elliptica
Morinda billarderel
Morinda cendollbei
Morinda deplanchei
Morinda angustifolia
Morinda phyllireoides
Morinda tomentosa
Morinda trimera
Morinda lucida
Morinda bucidifolia
Morinda neocaledonica
Morinda multiflora
Morinda officinalis
Morinda truncata

Morinda glaucescens	*Morinda reticulata*
Morinda rigida	*Morinda decipiens*
Morinda montana	*Morinda kanalensis*
Morinda myrtifolia	*Morinda glomerata*
Morinda grayi	*Morinda collina*
Morinda umbellata	*Morinda tenuifolia*

General description of the genus Morinda

Plant : Woody vines, lianas, shrubs, medium-sized trees or tall canopy trees; raphides present; auxiliary thorns absent. Morinda citrifolia is a small evergreen shrub or tree, usually less than 10 feet height and occasionally rising to 20 feet (Nelson, 2002).

Stipules : Interpetiolar, free at base or interpetiolar, connate at base or sheathing (not splitting on one side), oblong or ligulate, spatulate or bifid, sheathing at base, with two small (non-foliose) lobes each side, persistent.

Leaves : Opposite or whorled, rarely ternate, 3 per node, long or short-petiolate; blades ovate, broadly elliptic, oblong or oblanceolate, chartaceous or stiffly chartaceous; foliar pellucid glands absent; domatia sparse or dense tufts of hairs or absent.

Inflorescence : Axillary or terminal, simple panicle or umbellate heads, not frondose, globose, not subtended by bracts.

Flowers : Bisexual, protandrous. The flower heads grow to become mature fruit, 3 to 4 inches in diameter . The surface is divided into somewhat warty polygonal pitted cells (Camble and Ash, 1994).

Calyx: Tubular, urceolate or hemispheric, extremely reduced, with small lobes or short tubular, caducous; lobes absent (calyx truncate or undulate) or 4 to 7, broadly triangular, minute. Calycophylls absent.

Corolla : Tube, more or less funnel shaped, hypocrateriform or narrowly infundibuliform, actinomorphic, white to cream-white; tube externally glabrous, internally glabrous or pubescent; without a pubescent ring inside; orifice annular thickening absent; lobes 4 to 7, valvate in bud, lanceolate or oblong, margin entire, obtuse or acute at apex.

Stamens : Alternate to the corolla lobes, included, partially exerted (only tips exerted) or exerted just beyond the corolla; anthers narrowly oblong or elongate, round at base, with acuminate extensions at apex, dehiscing by longitudinal slits, dorsifixed near the middle; filaments attached at the middle of the corolla tube, free at base, slender, long, shorter than corolla tube, equal, glabrous.

Style : Exerted just beyond the corolla, terete throughout, not fleshy, capitate, glabrous; lobes absent or 2, ovate, oblong or linear, stigmatic surface located at style apex. Exert.

Ovary : Inferior, 2- or 4- locular, narrowly obovoid; placenta reduced, ovules basally inserted, 1 per locule.

Fruit : Densely clustered globose syncarp, fleshy. The Noni fruit is initially green in colour, turns yellow and the ripened fruit has unpleasant, insipid, foul or fetid odour (Francis, 2003).

Seeds : Vertical, medium-sized, ovoid to obovoid or reniform; wings absent.

Planting Material Production

Noni is relatively easy to propagate from seeds, stem, or rooted cuttings and air layering . The preferred methods of propagation are by seeds and cuttings made from stem verticles (Nelson, 2001). Micro propagation using tissue culture is the other possibility of multiplication of planting material.

Seeds : Seeds are extracted from the fruits and sowing can be done immediately after extraction. Hot and wet conditions are required for maximum germination. Under green house condition or raising seedling in the warmest part of land provide better environment for better seed germination (Singh et. al ., 2007). Seeds after drying in shade for 3 or 4 days can be stored in air-tight containers at room temperature. However, the storage studies are yet to be taken up (Singh et. al., 2007).The treatment with hot water at 40 oC for a period of 24 hours and a treatment with sulphuric acid at 50 % concentration for 5 minutes was able to overcome the seed dormancy (Ponnaiyan and Vezhavendan, 2005). The highest germination of seeds were obtained where the seeds were nicked and then treated Gibberllic acid (GA) at 1000ppm for a period of 24 hours (Ponnaiyan and Vezhavendan, 2005). Seeds treatment with hot water at 40 oC combined into sea weed, (Ascophyllum riodosum) Biozyme and the treatment with sulphuric acid 50% for 5 minute combined with Biozyme were able to break seek dormancy as well as better health and vigour to the germinated seedlings (Muthu and Mathan 2006). Seed germination studies of soaking seeds for 24 hours with Gibberlic Acid (GA) at 800 ppm increased the germination percentage to 91.06% as against mere water treatment (51.4 %). The inter action of seed soaking and treatment by GA 800 ppm increased high percentage of seedlings and number of leaves (Singh and Rai (2005) and Singh et. al., 2007). Pre treatment of seeds with Na HClO3 (5% available chlorine for 30 minutes) increased the germination up to 84%. However, the growth parameters were good in KNO3 (150 ppm)(Sudha and Singh, 2007).

Vegetative Propagation : The importance of vegetative propagation is to get best planting materials with highest genetic quality (Nanda, 1970; Wright, 1975; Hatman and Kester, 1983). Singh and Rai (2005) and Singh et. al., (2007) have suggested the use of growth regulators like Naphthalene Acetic Acid (NAA), Indole Butyric Acid (IBA) for quick and better rooting in vegetative propagation. Vertical and lateral stem cuttings with sap flow at the time of cutting with vigorous growing points are the best suited for vegetative propagation. Vezhavedan and Ponnaiyan (2005) compared different types of cutting viz., tip, semi hard, and hard wood cuttings with different number of nodes (2,3,and 4) and reported that hard wood cuttings with 4 nodes performed better and gives more success percentage and healthy planting materials. It is better to avoid the cuttings without sap flow for vegetative propagation. It is also better to avoid hallow stem cuttings since the percentage of recoverable seedlings are low and take 5 days more than non hallow cutting which took only 15 days and survival was 79.4% (Singh et. al., 2007). In an another study Sudha et. al., (2007) had found that both in hollow and non hollow cuttings, IBA 6000 ppm showed significantly higher rooting values than IBA 2000 ppm. Root initiation and percentage of sprouting were maximum in non-hollow cuttings compared to hollow cuttings.

Root hormones may help to promote the vegetative growth of cutting. Soaking of the cuttings with 4000 ppm Indole Acetic Acid ((IAA) and Naphthalene Acetic Acid (NAA) separately and in combination promoted root and shoot growth and establishment besides increasing percentage of rooting, length and number of roots, length of longest primary root when cutting is dipped in 4000 ppm of Indole Butyric Acid (IBA)(Singh et. al., 2007). The sprouting of cuttings under closed poly house was earlier (15 days) and survival of cuttings was 83.3 % while in covered poly house it was 20 days with 60 % sprouting at 33.5 oC and 80 % RH. Under open conditions with optimum light intensity of 44382 lux and maximum temperature of 31.9 oC, minimum 27.03 oC and RH 77.1%. The growth of vegetative propagated plants under open grew faster and put up 4 branches in 32 days and reached reproductive stage (Singh et. al., 2007).

Micropropagation / Tissue Culture

The varying effect of cytokinin and auxin combinations were studied on Morinda Citrifolia for effective in-vitro induction of shoots from nodal explant and it clearly indicated that irrespective of basal media used (either MS or WP), it is the hormonal combinations which are very vital for the in-vitro response, BAP alone for shoot initiation, kinetin along with BAP for multiple shoot formation. Calli with roots produce shoot(s) in BAP with IBA

medium.(Antony Selvaraj et .al., 2006). Further studies showed that the rooted plants have established well with 95-98.5% survival at green house conditions while hardening. Further better growth with zero per cent mortality was observed at nursery stage (Subramani et. al., 2006). Now micro propagated plants have gone for field test. Presently cell culture study is being carried out (Subramani et. al., 2007).

Plant protection

Noni growing in natural ecosystem did not have much pest problems, but became susceptible to a wide spectrum of insect pests, pathogens and nematodes when domesticated in a monoculture as experienced in Hawaii and other Pacific Island. Further, Noni is likely to become more and more susceptible when the cultivation is intensified to a larger extent. Literature revealed that Morinda citrifolia is infected by a wide range of fungal pathogens such as Phytopthora sp. and Sclerotium rolfisii (black flag and stem, leaf and fruit blights), Guignardia morindae, (leaf spot), Phellinus noxius (brown root rot) and Collectrotrichum sp. (anthraconose). A pathogenic alga, Cephaleuros minimus has been reported to cause leaf spot in Noni. Further, occurrence of mold infection caused by Rhizopus sp. in the post harvested fruits were recorded. Noni is susceptible to several species of root-knot nematodes, like Meloidogyne spp. and is also vulnerable to parasitic plants namely Cuscuta spp. and Cassytha filiformis. Noni is attacked by several insects, such as aphids (Aphis gossipii), scales (Coccus viridis), weevils, leaf miners, whiteflies (Dialuerdes kirkaldyi), caterpillars (Achaea janata), thrips (Heliothrips haemorroidalis) and unidentified eriophid mites. Excess use of nitrogenous fertilizers in Noni cultivation can induce susceptibitily to sap-feeding insects such as aphids, whiteflies and scales (Mathivanan, 2007). He also had suggested that systematic bio control studies should be initiated in the angle utilizing the knowledge on the use of natural enemies, microbial agents, and botanicals for control of various pests on Noni. How ever, there is scope for enhancing the impact potential of bio pesticides through improved formulations and application methods (Sithanantham, 2007).

Marimuthu and Nakkeeran (2007) have suggested the use of plant growth promoting rhizobactera (PGPR) viz., Pseudomonos, Azospirillum, Rhizobium, Bacillus and Serratia spp. in the management of pests and diseases of noni.

Nutrient deficiencies and disorders

Noni is reported to display abnormal foliar symptoms for nitrogen, iron, and phosphorous deficiencies. Inter veinal chlorosis, scorching of leaf margins,

leaf curling, purpling and marginal necrosis are some of the distinct deficiency symptoms.

Harvest and Post Harvest Processing

Harvesting Stage

Depending on the post-harvest technology programme adopted, the fruits may be harvested at different stages of development. After harvesting Noni ,the fruit ripens within a week at ambient temperature and also because of its short storage life the fruits cannot be transported to the distant places even with in the country. To over come the problem harvesting fruits with pedicel helped to maintain better quality and market acceptability and highest spoilage of fruits was observed in fruits harvested without pedicel (Fruits with pedicel performed well in terms of keeping quality, ascorbic acid and TSS. Among the accessions, SPG-2 recorded minimum loss of weight (2.90%) followed by Pbay-7 (3.74 %) in 9 days during storage (Singh et al.2007). The evolution of the colour and firmness of fruits left to ripen naturally on the tree is reported in Table 1. Nonetheless, most processors buy Noni harvested at the ''hard white'' stage for juice production, as the fruits become soft too quickly once this stage P. Rethinam et al. Noni (Morinda citrifolia L.) - the Miracle Fruit - a holistic review 8 Intl. J. Noni Res. 2007, 2(1-2) is reached (Nelson, 2001, 2003). The change from stage 4 to stage 5 occurs very quickly (few hours) and the pulp practically liquefies and turns from green to white, as well as develops the characteristic butyric smell. The fruits are individually selected on the tree and harvested by hand. At the ''hard white'' stage, they are well able to withstand being transported in baskets or containers, and exposure of the fruits to light or high temperatures immediately after harvest does not affect their overall quality. Before processing, fruits are ripened at room temperature for a day or more, depending on the end product (tea, juice, pulp, dietetic products, etc. (Nelson, 2003).

Table 1. Evolution of fruit skin colour and firmness in the course of ripening.

Maturity stage	Colour	Firmness
1.	Dark green	Very hard
2.	Green-yellow	Very hard
3.	Pale yellow	Very hard
4.	Pale yellow	Fairly hard
5.	Translucent-grayish	Soft

Table 2. Noni Fruit physical character and recovery

Fruit weight	147.9 g
Length of fruit	9.8 cm
Girth of fruit	5.26 cm
Specific Gravity	1.13g (wt./ vol.)
Recovery of juice	38.95 - 48.50% (range)
Pulp Percentage	44.76 - 46.72
Seed Percentage	3.24 - 4.31

Yield

Morinda citrifolia is a perennial bush and it is possible to find fruits at different stages of maturity on the same plant at the same time. Under favorable conditions, the plant bears fruit about nine months to one year after planting. At this stage, the fruits can be harvested, but they are generally small and the yield per tree is low. Some producers choose not to harvest in the first year, and they prune in order to let the bush grow stronger. In Hawaii, Noni fruits are harvested throughout the year, although there are seasonal patterns in flowering and fruit bearing (meteorological factors, fumigation, and irrigation) (Nelson, 2001, 2003). In India the plants are allowed to grow for two years without any side growth by periodical pruning so as to make the plant sturdy. It is reported that noni plant is capable of giving yield up to 250-300 kg under better cultivation conditions. after 7-8 years of planting. However in the initial stages yield may range from 30-40 kg per plant and the well grown tree will produce an average of 90 - 100 kg per tree. It is also reported that the productivity of the trees will be up to 40-50 years and the harvest can be done more than 6 - 7 times in a year.

In Hawaii, noni plots are usually harvested two or three times per month, although fruit production is lower during winter. With a density of 638 plants per hectare with good soil fertility, drainage, and irrigation and appropriate pest, disease and weed control, along with an appropriate fertilization plan, it is possible to obtain yields of between 7 tonnes/ha/year in the second year after planting to approximately 70 tonnes/ha/year after the fifth year (Nelson, 2001, 2003). With a juice extraction rate of approximately 50% (w/w), one hectare can thus yield around 35 tons of juice. However, many factors may affect these yields, and most producers do not obtain such good results because of diseases or poor agricultural practices (grown wild plants). In Hawaii, an average annual yield of 50 tonnes/ha is generally attained (Nelson, 2001, 2003).

The cost of cultivation per acre under Andaman conditions has been worked out to Rs. 42,425 per ha (Singh et al, 2007). It was observed that five years plantations in Bay Islands gave a gross income of Rs.468,750 /- with a net income of Rs. 200,731/- (Subhash Chand and Singh, 2007).

Chemical Composition of Noni

About 160 phytochemical compounds have been already identified in the noni plant, and the major micronutrients are phenolic compounds, organic acids and alkaloids (Wang and Su, 2001). Of the phenolic compounds, the most important reported are anthraquinones (damnacanthal, morindone, morindin, etc.), and also aucubin, asperuloside, and scopoletin (Wang and Su, 2001). The main organic acids are caproic and caprylic acids (Dittmar, 1993), while the principal reported alkaloid is xeronine (Heinicke, 1985). However, chemical composition differs largely according to the part of the plant. The complete physico-chemical composition of the fruit has not yet been reported and only partial information is available on noni juice (Table 2). The fruit contains 90% of water and the main components of the dry matter appear to be soluble solids, dietary fibers and proteins Table 2. The fruit protein content is surprisingly high, representing 11.3% of the juice dry matter, and the main amino acids are aspartic acid, glutamic acid and isoleucine. Minerals account for 8.4% of the dry matter, and are mainly potassium, sulfur, calcium and phosphorus; traces of selenium have been reported in the juice (Chunhieng, 2003).

Vitamins have been reported in the fruit, mainly ascorbic acid (24-158 mg/ 100 g dry matter) (Morton, 1992; Shovic and Whistler, 2001), and provitamin A (Dixon et al., 1999). Phenolic compounds have been found to be the major group of functional micronutrients in noni juice: damnacanthal, scopoletin, morindone, alizarin, aucubin, nordamnacanthal, rubiadin, rubiadin-1-methyl ether and other anthraquinone glycosides have been identified in Noni (Morton, 1992; Dittmar, 1993; Dixon et al., 1999; Wang and Su, 2001). Damnacanthal is an anthraquinone that has been characterized recently and has some important functional properties (mainly anti-carcinogenic) (Solomon, 1999). Scopoletin is a coumarin that was isolated in 1993 at the University of Hawaii and has been found to have analgesic properties as well as a significant ability to control serotonin levels in the body (Levand and Larson, 1979). Other researchers have shown that scopoletin may also have anti-microbial (Duncan et al., 1998) and anti-hypertensive effects (Solomon, 1999). Different Hawaiian teams (Heinicke, 1985; Solomon, 1999) reported the presence of a novel component, proxeronine, in the noni, it would be the precursor of xeronine, an alkaloid that is claimed to combine with

human proteins, improving their functionality. These authors attribute most of all the beneficial effects of noni to xeronine. Nonetheless, neither the chemical characterization of this alkaloid has been published nor the method used to assess its content. About 51 volatile compounds have been identified in the ripe fruit (Sang et al., 2001), including organic acids (mainly octanoic and hexanoic acids), alcohols (3-methyl-3-buten-1-ol), esters (methyl octanoate, methyl decanoate), ketones (2-heptanone), and lactones [(E)-6-dodeceno-glactone] (Farine et al., 1996).

Table 3. Physico-chemical composition of Noni Juice

Characteristics	Chunhieng (2003)a	Shovic and Whisler (2001)a	European Commission (2002)b
pH value	3.72	-	3.4-3.6
Dry matter	9.8±0.4%	-	10-11%
Total soluble solids (Brix)	8	-	-
Protein content	2.5%	0.4 g/100g	0.2-0.5%
Lipid0.15%	0.30g/100g	0.1-0.2%	
Glucose	11.9±0.2g/l	-	3.0-4.0%
Fructose	8.2±0.2g/l	-	3.0-4.0%
Potassium	3900 mg/l	188 mg/100g	30-150 mg/100g
Sodium	214 mg/l	21 mg/100g	15-40 mg/100g
Magnesium	14 mg/l	14.5 mg/100g	3-12 mg/100g
Calcium	28 mg/l	41.7 mg/100g	20-25 mg/100g
Vitamin C	-	155 mg/100g	3-25 mg/100g

a-Noni Fruit b-Tahitian Noni TM Juice (Commercial noni juice that contain 89% noni juice and 11% common grape and blue berry juice concentrates).

The location of the chemical compounds identified by the different authors are given in the Table 4.

Table 4. Location of chemical compounds in the plant

Location	Chemical constituents	Reference
Flower	2-methyl-4-hydroxy-5,7-dimethoxyanthraquinone 4-O-ß-D-glucopyranosyl	Sang et al.(2002)

	(1 4)-a-L-rhamnopyranoside	
Flower	5,8-dimethyl-apigenin 4'0-O-ß-D-galactopyranoside	Sang et al. (2002), Elkins (1998)
Flower	Aracetin 7-O-ß-D-glucopyranoside	
Fruit	ß-D-glucopyranose pentaacetate	Sang et al. (2002), Elkins (1998)
Fruit	2,6-di-O-(ß-D-glucopyranosyl-1-O-octanoyl-ß-D-glucopyranose	Dittmar (1993)
Fruit	6-O-(ß-D-glucopyranosyl-1-O-octanoyl-ß-D-glucopyranose	Wang et al. (1999)
Fruit	Ascorbic acid	Liu et al. (2001)
Fruit	Asperulosidic acid	Morton (1992), Elkins (1998), Wang et al. (2002), McClatchey, 2002),
Fruit	Asperuloside tetraacetate	Wang et al. (1999), Liu etal. (2001), Cardon, (2003)
Fruit	Caproic acid	Dittmar, (1993)
Fruit	Caprylic acid	Sang et al. (2002), Dittmar, (1993), Elkins (1998), Wang et al. (2002), Levand and Larson, (1979),
Fruit	Ethyl caprylate	Cardon, (2003), Elkins (1998), Wang et al. (2002), Levand and Larson, (1979),
Fruit	Ethyl caproate	Dittmar (1993)
Fruit	Hexanoic acid	Dittmar (1993)
Fruit	cQuercetin 3-O-a-L-rhamnopyranosyl-(1-6)-ß-D-glucopyranoside	Farine et al (1996),

		Sang et al. (2002), Cardon, (2003), Wang and Su (2001).
Heartwood	Physcion 8-O-a-L-arabinopyranosyl-(1-3)-ß-Dgalactopyranosyl-(1-6)-ß -D-galactopyranoside	Wang and Su (2001) Wang et al. (2002).
Leaves	Alanine	Sang et al. (2002), Srivatava and Singh (1993), Cardon, (2003).
Leaves	Quercetin 3-O-a-L-rhamnopyranosyl-(1-6)-ß-D-glucopyranoside	Sang et al. (2002).
Leaves	Serine	Dittmar (1993), Elkins (1998)
Leaves	Threonine	Dittmar (1993), Elkins (1998)
Leaves	Tryptophan	Dittmar (1993), Elkins (1998)
Leaves	Tyrosine	Dittmar (1993), Elkins (1998)
Leaves	Ursolic acid	Sang et al. (2002), Cardon, (2003), Wang et al. (1999).
Leaves	Valine	Dittmar (1993), Elkins (1998), Elkins (1998),
Plant	2-methyl-3,5,6-trihydroxyanthraquinone	Cardon, (2003), Inoue et al. (1981).
Plant	b2-methyl-3,5,6-trihydroxyanthraquinone 6-O-ß-D-xylopyranosyl-(1-6)-ß-D-glucopyranoside	Cardon, (2003), Inoue et al. (1981).
Plant	3-hydroxymorindone	Cardon, (2003), Inoue et al. (1981).
Plant	b3-hydroxymorindone 6-O-ß-D-xylopyranosyl-	Cardon, (2003), Inoue et al. (1981).

	(1-6)-ß-Dglucopyranoside	
Plant	b5,6-dihydorxylucidin 3-O-ß-D-xylopyranosyl-(1-6)-ß-Dglucopyranoside	Cardon, (2003), Inoue et al. (1981).
Plant	5,6-dihydroxylucidin	Wang et al. (2002)
Plant	Aucubin	Elkins (1998), Wang et al. (2002)
Plant	Linoleic acid	Wang et al. (2002)
Plant	Lucidin	Cardon (2003), Inoue et al.(1981), Ross (2001)
Plant	bLucidin 3-O-ß-Dxylopyranosyl-(1-6)-ß-Dglucopyranoside	Cardon (2003), Inoue et al.(1981),
Plant	Scopoletin	Farine et al. (1996), Wang et al. (2002)
Location	Chemical constituents	Reference
Leaves	Arginine	Dittmar (1993)
Leaves	Aspartic acid	Dittmar (1993)
Leaves	ß-sitosterol	Sang et al. (2002), Chunhieng (2003), Elkins (1998), Wang et al. (2002)
Leaves	Citrifolinoside B	Sang et al. (2002)
Leaves	Cysteine	Dittmar (1993), Elkins (1998)
Leaves	Cystine	Dittmar (1993), Elkins (1998)
Leaves	Glutamic acid	Dittmar (1993)
Leaves	Glycine	Dittmar (1993), Elkins (1998)
Leaves	Histidine	Dittmar (1993), Elkins (1998)
Leaves	Isoleucine	Dittmar (1993), Elkins (1998)

Leaves	cKaempferol 3-O-a L-rhamnopyranosyl-(1-6)-ß-D glucopyranoside	Sang et al. (2002)
Leaves	Kaempferol 3-O-ß-D-glucopyranosyl-(1-2)-a-Lrhamnopyranosyl-(1-6)-ß-D-galactopyranoside	Sang et al. (2002)
Leaves	Leucine	Dittmar (1993), Elkins (1998)
Leaves	Methionine	Dittmar (1993), Elkins (1998)
Leaves	Phenylalanine	Dittmar (1993), Elkins (1998)
Leaves	Proline	Dittmar (1993), Elkins (1998)
Leaves	Quercetin 3-O-ß-D-glucopyranoside	Sang et al. (2002)
Root, heartwood, root bark	Morindone	Sang et al. (2002), Inoue et al. (1981), Dittmar (1993), Ross (2001), Cardon (2003), Wang etal. (2002)
Root, heartwood,seeds	Damnacanthal	Sang et al. (2002), Cardon (2003)
Leaves	Quercetin 3-O-ß-D-glucopyranosyl-(1-2)-a-Lrhamnopyranosyl-(1-6)-ß-D-galactopyranoside	Sang et al. (2002)
Root	8-hydroxy-8-methoxy-2-methyl-anthraquinone	Cardon (2003), Solomon (1999)
Root	rubichloric acid	Elkins (1998), Morton (1992)
Root	1,3-dihydroxy-6-methylAnthraquinone	Morton (1992)
Root	Morenone 1	Solomon (1999)

Root	Morenone 2	Solomon (1999)
Root	bRuberythric acid	Cardon (2003)
Root	Rubiadin	Cardon (2003), Elkins (1998), Inoue et al. (1981), Ross (2001)
Root bark	Chlororubin	Dittmar (1993), Elkins (1998)
Root bark	Hexose	Dittmar (1993)
Root bark	Morindadiol	Dittmar (1993)
Root bark	Morindanidrine	Dittmar (1993)
Root bark	Morindine	Cardon (2003), Dittmar (1993), Elkins (1998), Morton (1992)
Root bark	Pentose	Dittmar (1993)
Root bark	Physcion	Solomon (1999)
Root bark	Rubiadin monomethyl ether	Dittmar (1993)
Root bark	Soranjidiol	Dittmar (1993), Elkins (1998), Ross (2001)
Root bark	Trioxymethylanthra quinonemonoethyl ether	Dittmar (1993)
Root, rootbark,fruit	Alizarin	Cardon (2003), Dittmar (1993), Elkins (1998), Ross (2001), Wanget al. (2002)
Seeds	Ricinoleic acid	Solomon (1999)

Source: Blanco et. al., (2006)

General Use of Morinda

The roots, stems, bark, leaves, flowers, and fruits of the Noni, Morinda Citrifolia, L. are all involved in various combinations in almost 40 known and recorded herbal remedies (Bruggnecate, 1992). Additionally, the roots were

used to produce a yellow or red dye for tapa (cloths) and fala (mats). While noni fruit is most famous for its role in Polynesian, Melanesian, and Southeast Asian material medica, there are also numerous ethnobotanical reports of its use as food (Rock, 1913; Wilder, 1934; Brown, 1935; Yuncker, 1943; Turbott, 1949; Stone, 1970; Degener, 1973; Uhe, 1974; Seemann, 1977; Whistler, 1992; Krauss, 1993; Terra, 1996). Some reports have indicated its use was limited to times of famine (Krauss, 1993). This, however, is not correct. The fruit was reported to have been eaten often by Rarotongans, was a favorite ingredient in curries prepared by Burmese, and the Australian Aborigines were known to be very fond of the fruit. Captain James Cook of the British Navy noted in the late 1700's that the fruit was eaten in Tahiti. In 1769, Sydney Parkinson, one of Captain James Cook's crew on the Endeavour, recorded that Tahitians ate noni fruit. This was likely the 1st written description of its use as a food. More than 2 centuries later, in 1943, the U.S. government recognized the fruit as edible (Merrill, 1943). There has thus been ample human experience with eating noni fruit to validate its safety for human consumption), while the fruit was eaten for health and food (Aragones et al., 1997).

Traditional Food Use

Morinda citrifolia fruit has long history of use as a food in tropical regions throughout the world. Documentation of the consumption of the fruit as a food source precedes the twentieth century. An 1866 publication in London explained that M. citrifolia fruit was consumed as a food in the Fiji islands. Later publications described the use of this fruit throughout the Pacific Islands, Southeast Asia, Australia and India. In Samoa, Noni fruit was common fare and in Burma it was cooked in curries or eaten raw with salt. In 1943, Merrill described M. Citrifolia, L. as an edible plant in a technical manual of edible and poisonous plants of the Pacific Islands, in which the leaves and fruits were used as emergency food. In 1992, Abbott reported that Noni had been used as food, drink, medicine and dye. The tribes i.e., Nicobarese are known to have consumed this fruit raw with salt as well as cooked as vegetable (Singh et. al., 2005).

Medicinal use of Morinda

The Polynesians utilized the whole Noni plant for herbal remedies. The fruit juice is in high demand in alternative medicine for different kinds of illnesses such as arthritis, diabetes, high blood pressure, muscle aches and pains, menstrual difficulties, headaches, heart disease, AIDS, cancers, gastric ulcer, sprains, mental depression, senility, poor digestion, arteriosclerosis, blood

vessel problems, and drug addiction. Scientific evidence of the benefits of the Noni fruit juice is limited but there is some anecdotal evidence for successful treatment of colds and influenza (Solomon, 1999). Allen and London (1873) published one of the earliest articles on the medicinal benefits of Noni in which they reported the ethnobotanical properties of Noni and the use of fruit. Abbott (1985), a former botanical chemist at the University of Hawaii, stated the use of Noni for diabetes, high blood pressure, cancer, and many other illnesses (Abbott, 1985; Dixon et al., 1999). Noni was a traditional remedy used to treat broken bones, deep cuts, bruises, sores and wounds (Bushnell et al., 1950). Morton (1992) gave numerous references for medicinal uses of Noni. In addition, Polynesians are reported to treat breast cancer and eye problems.

The species of Morinda especially M. citrifolia has been reported to have a broad range of health benefits for cancer, infection, arthritis, asthma, hypertension, and pain (Whistler, 1992). The leaves, seeds, bark , fruits and roots of Noni have been used in various topical remedies in South Pacific Islands and South East Asia (Wang et. al., 2002, Fygh-Berman, 2003).

It is reported to have antibacterial, anti fungal, analgesic, hypotensive, anti-inflammatory and immune enhancing effects (Mc Clatchy, 2002; Wang et.al., 2002; Mathivanan et .al., 2005). Murugesh (2007) reported that Noni has a broad range of therapeutic effects such as analgesic, anti-inflammatory, antihypertensive, immune enhancing, anticancer, antibacterial, antiviral, antifungal, antituberculous, antiprotozoal, antioxidant, antistress and also sedative properties, Also Noni is effective in cough, nausea, colic, enlarged spleen, joint disorders such as gout and arthritis, senility, poor digestion, arthrosclerosis and drug addiction. These beneficial effects of Noni are strongly documented and well authenticated by valid scientific literature evidences. Also Noni has a strong cancer preventive effect. The various therapeutic benefits of Noni are due to the enriched phytoconstituents. The high therapeutic profile and safety potential of Noni has made it a popular health enhancer and food supplement world wide.

Phyto chemical Properties of Morinda

A plethora of phyto chemical constituents have been identified and reported different scientific Groups in the leaves, bark, stem, flowers and fruits of the plant. The fruit is a powerful detoxifier which removes toxins from the body, Researchers have discovered more than 150 nutrceuticals in the fruits of Morinda citrfolia, L. (Singh et al., 2007). Potassium content was more (1226 ppm) followed by leaf (1219 ppm).

A number of major compounds have been identified in the Noni plant such as scopoletin, octoanoic acid, potassium, vitamin C, terpenoids, alkaloids,

anthraquinones (such as nordamnacanthal, morindone, rubiadin, andrubiadin-1- methyl ether, anthraquinone glycoside), b-sitosterol, carotene, vitamin A, flavones glycosides linoleic acid, alizarin, amino acids, acubin, L-asperuloside, caproic acid, caprylic acid, ursolic acid, rutin and a putative proxeronine. (Levand and Larson, 1979; Farine et al., 1996; Peerzada et al., 1990; Budhavari et al., 1989; Moorthy and Reddy, 1970; Daulatabad et al., 1989; Balakrishnan et al., 1961; Legal et al., 1994; Singh and Tiwari, 1976; Simonsen, 1920; Heinicke, 1985). The dominant substances in the fruit are fatty acids, while the roots and bark contain anthraquinone. The seed of M. citrifolia contains 16.1% Oil. The main fatty acid components of the oil were linoleic (55%), Oleic (20.5%), Palmitic (12.8%), Ricinoleic (6.8%) and Stearic (4.9%) (Dualatabad et al., 1989; Seidemann, 2002).

A research group led by Chi-Tang Ho at Rutges University in the USA is searching for new novel compounds in the Noni plant. They have successfully identified several new flavonol glycosides, and iridoid glycoside from the Noni leaves, trisaccharide fatty acid ester, rutin and an asperolosidic acid from the fruit. Two novel glycosides and a new unusual iridoid named citrifoliniside have been shown to have inhibiting effect on AP-1 trans activation and cell transformation in the mouse epidermal JB6 cell lines (Wang et al., 1999; Sang et al., 2001a and b; Liu et al., 2001; Wang et al., 2000). Further, 23 different phytochemicals were found in Noni besides, 5 vitamins and 3 minerals (Duke, 1992).

Biological Properties of Noni

Antimicrobial activity

The anti-microbial effect of noni may have been the first observed property: indeed, the fruit contains relatively large amounts of sugars that are not fermented when fruits are stored in closed containers at ambient temperature. This property is used to transport the fruit by boat from the scattered Pacific islands to processing plants without specific treatment. It has been reported that Noni inhibits the growth of certain bacteria, such as Staphylococcus aureus, Pseudomonas aeruginosa, Proteus morgaii, Bacillus subtilis, Escherichia coli, Helicobacter pylori, Salmonella and Shigella (Atkinson, 1956). The same author claims that the anti-microbial effect observed may be due to the presence of phenolic compounds such as acubin, L-asperuloside, alizarin, scopoletin and other anthraquinones. Another study showed that an acetonitrile extract of the dried fruit inhibited the growth of Pseudomonas aeruginosa, Bacillus subtilis, Escherichia coli, and Streptococcus pyrogene (Locher et al., 1995). It has also been found that ethanol and hexane extracts of noni have an antitubercular effect since they inhibit by 89-

95% the growth of Mycobacterium tuberculosis (Saludes et al., 2002). The major components identified in the hexane extract were Ephytol, cycloartenol, stigmasterol, b-sitosterol, campesta-5,7,22-trien-3-b-ol, and the ketosteroids, stigmasta-4-en-3-one and stigmasta-4-22-dien-3-one. Furthermore, they showed that the anti-microbial effect is highly dependent on the stage of ripeness and on processing, being greater when the fruit is ripe, without drying. The anti microbial activity was more pronounced with M.citrfolia than M .pubescens (Mathivanan and Surendran 2006).

Several anthraquinone compounds in Noni roots are all proven antibacterial agents. These compounds have been shown to fight against infectious bacterial strains such as Pseudomonas aeruginosa, Proteus morgaii, Staphylococcus aureus, Bacillus subtilis, Escherichia coli, Salmonella sp. and Shigella sp. (Mohtar et al., 1998; Jayasinghe et al., 2002). These antibacterial elements within Noni are responsible for the treatment of skin infections, colds, fevers, and other bacterial- caused health problems (Atkinson, 1956, Ancolio et al., 2000). Bushnell reported on the antibacterial properties of some plants found in Hawaii, including Noni. He further reported that Noni was traditionally used to treat broken bones, deep cuts, bruises, sores and wounds. Extracts from the ripe noni fruit exhibited antibacterial properties against P. aeruginosa, M. pyrogenes, E. coli, Salmonella typhosa, Salmonella montevideo, Salmonella schottmuelleri, Shigella paradys (Bushnel et al., 1950; Dittmar,1993).

Leach et al. (1988) demonstrated that acetone extracts of M. citrifolia showed antibacterial activity. The wide spread medicinal use of these plants would suggest that they do contain pharmacologically active substance and alternative methods of extraction and screening should be carried out to find the major bioactive components in the plants for the purpose of new drug development. Locher et al. (1995) reported that selected plants including M. citrifolia have a history of use in Polynesian traditional medicine for the treatment of infectious disease. The scopoletin, a health promoter of Noni inhibit the activity of E. coli that is commonly associated with outbreaks resulting in hundreds of serious infection and even death. Noni also helps stomach ulcer through inhibition of the bacterium H. pylori (Umezawa, 1992).

Another species of Morinda namely M. tinctoria have excellent antimicrobial activity against various human and plant pathogenic bacteria, and fungi. The chloroform fruit extract of M. tinctoria exhibited high antimicrobial activity against the human pathogens such as Pseudomonas aeruginosa, Staphylococcus aureus, Escherichia coli and Candida albicans. Further the same extract also significantly inhibited the spore germination and mycelial growth of plant pathogenic fungi viz., R. solani, B. oryzae, F. oxysporum and C. lunata (Surendiran, 2004).

A compound isolated from Noni roots named 1-methoxy-2-formyl-3-hydroxyanthraquinone suppressed the cytopathic effect of HIV infected MT-4 cells, without inhibiting cell growth (Umezawa, 1992).

Noni has been found to kill Mycobacterium tuberculosis. A concentration of extracts from Noni leaves killed 89 of the bacteria in a test tube, almost as effective as a leading anti-TB drug, Rifampicin, which has an inhibition rate of 97% at the same concentration. Although there had been anecdotal reports on the native use of Noni in Polynesia as a medicine against tuberculosis, this is the first report demonstrating the antimycobacterial potential of compounds obtained from the Noni leaf (American Chemical Society, 2000).

Anti tumour and anticancer activities

The anticancer activity from alcohol-precipitate of Noni fruit juice (Noni-ppt) on to lung cancer in c57 B1/6 mice has been presented in the 83 Annual Meeting of American Association for Cancer Research. The noni-ppt significantly increased the life of mice up to 75% with implanted Lewis lung carcinoma as compared with the control mice (Hirazumi et al., 1994). It was concluded that the Noni-ppt seems to suppress tumor growth directly by stimulating the immune system (Hirazumi et al., 1996). Improved survival time and curative effects occurred when Noni-ppt was combined with sub optimal doses of the standard chemotherapeutic agents such as adriamycin (Adria), cisplatin (CDDP), 5- flourouracil (5-FU) and vincristine (VCR), suggesting important clinical application of Noni-ppt as a supplemental agent in cancer treatment (Hirazumi and Furusawa, 1999). These results indicated that the Noni-ppt might enhance the therapeutic effect of anticancer drugs. Therefore, it may be a benefit to cancer patients by enabling them to use lower doses of anticancer drugs to achieve the same or even better results.

Wang et al. (2002) demonstrated that the cytotoxic effect of Tahitian Noni Juice (TNJ) on cultured leukemia cell line at various concentrations. They also observed the synergistic effects of TNJ with known anticancer drugs. At a sub-optimal dose, both prednisolone and TNJ could induce apoptosis. When the dose of prednisolone was fixed, the dose of TNJ increased. Therefore TNJ is able to enhance the efficacy of anticancer drugs such as predinosolone. When a single dose of taxol induced a lower percentage of apoptosis in leukemia cells, TNJ enhanced the rate of apoptosis.

Hiramatsu et al. (1993) reported the effects of over 500 extracts from tropical plants on the K-Ras-NRK cells. Damnacanthal, isolated from Noni roots is an inhibitor of RAS function. The Ras oncogene is believed to be associated with the signal transduction in several human cancers such as

lung, colon, pancreas, and leukemia. Two glycosides extracted from Noni-ppt were effective in inhibiting cell transformation induced by TPA or EGF in the mouse epidermal JB6 cell line. The inhibition was found to be associated with the inhibitory effects of these compounds on AP1 activity. The compounds also blocked the phosphorylation of c-Jun, a substrate of JNKs, suggesting that JNKs are the critical target for the compounds in mediating AP1 activity and cell information (Liu et al., 2001).

Insecticidal Activity

An ethanol extract of the tender Noni leaves induced paralysis and death of the human parasitic nematode worm, Ascaris lumbricoides within a day (Raj, 1975). Noni has been used in the Philippines and Hawaii as an effective insecticide (Morton, 1992; Murdiatia et al., 2000). Noni has been used as an effective insecticide in the Philippines and Hawaii (Rangadhar Satapathy, 2007).

Analgesic activity

Younos et al. (1990) tested the analgesic and sedative effects of the Noni extract and observed a significant dose-related central analgesic activity in the treated mice. The analgesic efficacy of the Noni extract is 75% as strong as morphine with free of side effects. The TNJ was tested for its analgesic properties by the twisted method animal model using mice. Clearly the analgesic effect of TNJ in mice showed a dose-dependent manner. The analgesic effects of each TNJ group are statistically significant compared with that in the control group. Data from this experiment have clearly indicated that the TNJ was able to make the animals tolerate more pain.

Immunological activity

An alcohol extract of Noni fruit at various concentrations inhibited the production of tumor necrosis factor-alpha (TNA-a), which is an endogenous tumor promoter. Therefore, the alcohol extract may inhibit the tumor promoting effect of TNF-a (Hokama, 1993). Hirazumi and Furusawa (1999) found that Noni-ppt contains a polysaccharide-rich substance that inhibited toxic effects in adapted cultures of lung cancer cells, but could activate peritoneal exudate cells to impart profound toxicity when co-cultured with the tumor cells. This suggested the possibility that Noni-ppt may suppress tumor growth throughout the activation of host immune system. Noni-ppt was also capable of stimulating the release of several mediator from murine effector cells, including TNF-a, interleukin-1 beta (IL-1b), IL-10, IL-12, interferon-gamma (IFN-g) and nitric oxide (NO) (Hirazumi and Furusawa, 1999). Hokama (1993) separated ripe

noni fruit juice into 50% aqueous alcohol and precipitated fractions that stimulated the BALB/c thymus cells in the (^{3}H) thymidine analysis. It is suggested that inhibition of Lewis lung tumors in mice, in part, may have been due to the stimulation of the T-cells immune response. Wang et al. (2002) observed that the thymus in animals treated with TNJ was enlarged. The wet weight of the thymus was 1.7 times that of control animals at the seventh day after drinking 10% TNJ in drinking water. The thymus is an important immune organ in the body, which generates T cells, involved in the ageing process and cellular immune functions. TNJ may enhance immune response by stimulating thymus growth, and thus affecting anti-ageing and anticancer activities, and protecting people from other degenerative diseases.

Allergenicity and toxicity

Studies sponsored TNJ Morinda Inc, marker of TNJ were focused to investigate the acute toxicology of TNJ. About 15000 mg/kg was administered via gavage and the animals were observed and no adverse clinical signs were noted. No signs of gross toxicity were seen in the organs after necropsy. Two studies using guinea pigs were performed to assess the allergenic risk of TNJ. Both study designs included an induction phase and a rest period, followed by a challenge with TNJ. Results of this study have revealed that there were no allergic reactions to TNJ (Kaabeer, 2000).

Similarly a 13-week oral toxicity study in rats indicated that the No-Observable-Adverse Effect Level (NOAEL) was above 20 ml of 4 times concentrated TNJ/kg/day. This is equivalent to 80 ml TNJ kg/day. Perceptively, this amount is 8% of the animal's body weight (Sang et al., 2001a and b). The major ingredients in TNJ, Noni fruit, have been safely consumed in other parts of the world for several hundred years (Whistler, 1992; Bruggnecate, 1992; Seemann and Flora, 1866; Dengener, 1973; Rock, 1913; Stone, 1970; Sturtevant, 1919; Terra, 1996; Turbott et al., 1949; he, 1974; Wilder, 1934; Yuncker, 1943). TNJ is demonstrated to be safe for human consumption through extensive chemical, microbiological, and toxicological analysis and evaluation.

Antioxidant activity

In general consuming fruits and vegetables reduces free radicals-induced oxidative damage and the consequent lipid peroxidation and therefore reduce the cancer risk (Wang and Leiher, 1995; Diplock et al., 1998). It is believed that fruits and vegetables are major sources for antioxidants (Weisburer et al., 1997; Nishikimi et al., 1972). Noni is a medicinal plant that helps the

human in different health conditions. It was believed that the Noni fruit juice contained significant level of antioxidants. This has been proved scientifically by the analysis of TNJ. The study was designed to measure how the TNJ scavenged super oxide anion radicals (SAR) and quenched lipid peroxides (LPO) by TNB assay and LMB assay, respectively (Auerbach et al., 1992; Wang and Su, 2001). SAR scavenging activity was examined in vitro by Tettrazolium nitroblue (TNB) assay. The SAR scavenging activity of TNJ was compared to that of three known antioxidants; vitamins C, grape seed powder, and pyncogenol at the daily dose per serving level recommended by US RDA's or manufacturer's recommendations. Under the experimental conditions the SAR scavenging activity of TNJ was shown to be 2.8 times that of vitamin C, 1.4 times that of pyncogenol and 1.1 times that of grape seed powder. Therefore TNJ has a great potential to scavenge reactive oxygen free radicals (Wang and Su, 2001).

Anti-inflammatory activity

Evidences are indicating that COX-2 inhibitors may be involved in breast, colon, and lung cancer development (Yau et al., 2002; Takahashi et al., 2002; Langman et al., 2000). Research on anti-inflammatory has shown that the selectivity of COX- 2 inhibition of TNJ is comparable with that of Celebrex. The discovery of the selective COX-2 inhibition of TNJ is very significant since TNJ is a natural fruit juice without side effects this is the first scientific evidence for a strong anti- inflammatory activity in TNJ, which may also be one of the mechanisms of cancer prevention (Zhang et al., 1994). The anti-inflammatory activity was observed in an acute liver injury model in female SD rats induced by CCl4. A decrease in inflammatory foci and lymphocyte surrounding central vein areas were observed at 6 h post CCl4 administration in animals pre treated with 10% TNJ for twelve days in drinking water compared with CCl4 without TNJ (Wang et al., 2001).

Research from this clinical trials indicated that cigarette-smoke is not only involved in cancer but also involved in pulmonary, heart and other degenerative diseases. However, drinking TNJ was beneficial for the prevention of heart, lung, and brain diseases as well as delaying the ageing processing, and maintaining overall good health.

Wound healing activity

It is well established that the Morinda leaf and fruit extracts are effective in healing the wounds. Surendiran (2004) studied the wound healing property of M. tinctoria using the animal model. The application of chloroform fruit extract of M. tinctoria topically on the excision wound surface of two different

doses accelerated the wound healing process by decreasing the surface area of the wound. The fruit extracts of M. tinctoria at 20 mg/ml significantly healed the wound in rats within 15 days where complete healing was observed against 60% in untreated control. On day 3, all the treated animals exhibited considerable increase in the percentage of wound contraction as compared to control. The wound contraction was significantly increased in the subsequent days due to treatment of fruit extract at 10 and 20 mg/ml as compared to control.

Anti Lithiatic Effect

Noni, *Morinda citrifolia* ,L has the anti Lithiatic effect on Ethylene Glycol induced Lithiasis in male albino rats.This observation provided the basis for considering Noni for inhibiting stone formation induced by ethylene glycol, (Murugesh and Christina2007).

Anti fungal activity

The observational study of the anti fungal activity of Morinda Citrifolia,L. fruit extract of Fusarium semitectrum had indicated the inhibitory activity for Morinda extract and it is equivalent to that of commercial available anti fungal agents,(Murugesh and Kannan, 2007).

Epilogue

The review presented here, is not a complete one, but by and large one could see that more to be done on germplasm assemblage, breeding, varietal / hybrid development, developing manurial and water management need to develop technologies for water / mixed / multiple cropping and integrated farming system. The prevalence of pest and disease and developing suitable bio management need to be given a fillip. Harvesting and post harvesting technique, reducing the post. Harvest lossess need attention. Being a new crop taken up for cultivation by farmers many technological gaps need to be filled up.

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Micropropagation of *Morinda citrifolia L.*

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Keywords : *Morinda* sp, Nodal explant, multiple shoots, Rhizogenic calli

Abstract : The varying effect of Cytokinin and Auxin combinations on *Morinda citrifolia* L. for effective in – vitro induction of shoots from nodal explants was studied by using both WP and MS basal media. BAP alone with 2 mg/l concentration was found effective in both the basal media, to initiate auxillary shoot induction. Further BAP along with 1mg/l Kinetin combination gave 4-5 multiple shoots from a single node within a period of two weeks. Further by using leaf ex–plants, callus was induced. Actively growing yellowish callus was induced by using 2 mg /l-2,4-D. Further the initiated calli were sub-cultured in MS basal media containing 0.5 mg/l NAA to produce rhizogenic calli with lots of roots at periphery. These calli mass with roots in BAP and KN media combination, became organogenic and resulted in producing shoot (s).

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Introduction

Morinda citrifolia L. commercially known as Noni, grows widely throughout Asia and Pacific, is one of the most significant sources of traditional medicines among Pacifiic Islands Societies. (Clatchey, 2002; Nelson, 2001). The botanical name for the genus was derived from two Latin word Morus, mulberry and indicus, Indian, in reference to the similarity of the fruit of Noni to that of true mulberry (*Morus alba*), belongs to the family Rubiaceae (Morton, 1992).

Noni is relatively easy to propogate from seeds, stem or root cuttings and air layering. The preferred methods of propagation are by seeds and by cuttings made from stem verticals (Nelson, 2001). Till date, not much work on *in vitro* propagation by using tissue culture techniques were carried out in this plant. Preliminary studies on *in vitro* propagation of *Morinda citrifolia L.* was attempted at this center for the past one year. Both the nodal ex-plants and rhizogenic calli have given shoot(s) in both the WP and MS media with the combination of Cytokinin and Auxin.

Materials and Methods

Plant Material

Seeds of *Morinda citrifolia L.* brought from the Western Ghats, India were sown in the gardens of Health India Laboratories, Sholinganallur. Two leaf

stage plants were brought to Tissue Culture Laboratory and used for explant collection. Apical regions and nodal explants were used. Young leaves were used for callus initiation.

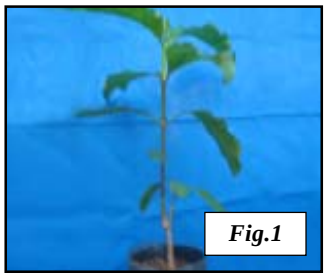


Fig.1

Fig.2

Sterilization details

a. Nodal explant

The nodal explants were collected from 6-8 months old seedlings. Top 3 nodes were taken for tissue culture purpose by leaving the basal single node in the mother plant. Due to the removal of upper axillary buds, the axillary region sprouts very efficiently by producing two axillary sprouts in vivo within 8-10 days.

b. Procedure

Top 3 nodes were taken and then washed with sterile water and kept in 1: 2 (Sodium hypochlorite : Sterile water) with constant stirring for 30 minutes. The ex-plants were washed 3-4 times with sterile water, then treated with 0.1% mercuric chloride for 5 minutes and rinsed with sterile water before inoculation.

c. Leaf ex–plant

The above sterilization treatment was given for leaf ex plant also to initiate callus.

Media details

Following basal media with various combinations of Cytokinin and Auxin were tried in our in-vitro studies. The results are shown in Table 1, 2 & 3.

Table 1. Various combinations of media for in-vitro Multiplication

Media	BAP (mg/I)	KN (mg/I)	IBA (mg/I)
MS	2.0	-	-
	4.0	-	-
	1.0	1.0	-
	2.0	0.75	2.0
	1.0	0.25	-

Media	BAP (mg/I)	KN (mg/I)	IBA (mg/I)
WP	2.0	-	-
	4.0	-	-
	2.0	1.0	-
	2.0	-	2.0
	2.0	0.5	-

Table 2. : Various media combinations for callus initiation and regeneration from Leaf Explants

Media	2,4-D (mg/I)	NAA	IAA	IBA	BAP	KN
MS	2.0	-	-	-	-	-
	-	0.5	0.1	-	-	0.5
	4.0	-	0.5	4.0	1.0	-
	-	-	1.0	2.0	3.0	1.0
	-	-	-	1.0	4.0	-
Media	2,4-D (mg/I)	NAA	IAA	IBA	BAP	KN
WP	2.0	-	-	-	-	
	-	-	0.5	-	-	-
	-	-	-	-	2..5	1.0
	-	-	0.1	-	2.0	-
	-	1.0	1.0	-	3.0	-
			-			
			-			

Table 3. : Various media combinations for in-vitro rooting

Media	IBA (mg/I)	IAA (mg/I)	NAA (mg/I)
MS	1.0	0.1	0.1
	2.0	0.3	0.3
	4.0	0.5	0.5
WP	1.0	0.1	0.1
	2.0	0.3	0.3
	4.0	0.5	0.5

Result and discussion

Shoot initiation

Both Ms and WP media were used along with various combinations of Cytokinins and Auxin. Axillary bud sprouting were observed in both the basal media with 2.0 mg/l BAP alone. (Fig 3 & 4)

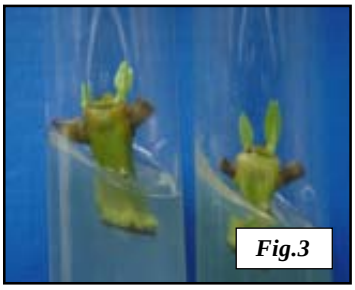


Fig.3

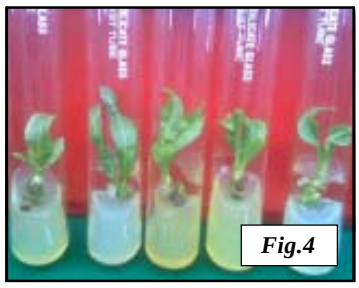


Fig.4

Multiplication in-vitro

After four weeks of axillary bud sprouting, initiated young shoots with the nodal region were transferred to multiplication media. BAP 4.0 mg/l, along with IAA 0.5 mg/l have produced 3-5 multiple shoots within 4-6 weeks after subculture (Fig 5). Both MS basal and WP were found equally good enough for culture multiplication. Culture were allowed to grow at $26\pm2^{\circ}$ C temperature and humidity at 55 ± 10%, photoperiod 16 hrs light and 8 hrs dark and light intensity of 2000 lux.

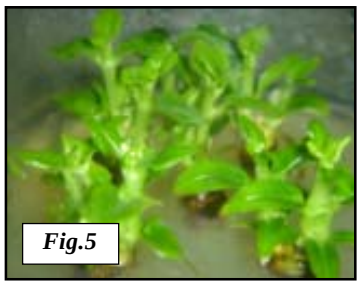
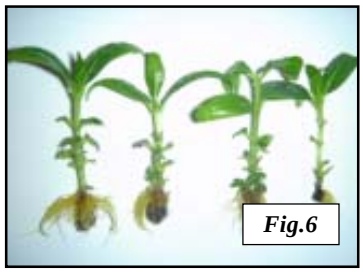


Fig.5

In-vitro rooting

Out of MS and WP basal media used, MS basal with 1.0 mg /l IBA and 0.5 mg /l NAA have produced enough roots in vitro (Fig.6). 4 to 6 cm long shoots were removed separately from the multi culture and inoculated in the rooting media. MS media with 1.0 mg /l IBA and 0.5 mg /1 NAA were used in the rooting media. Individual plants with roots were transferred to green house for hardening.

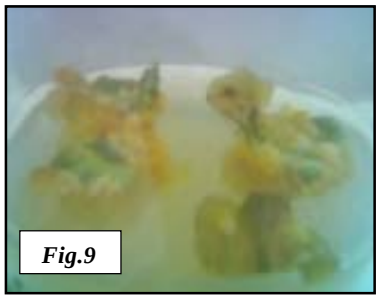


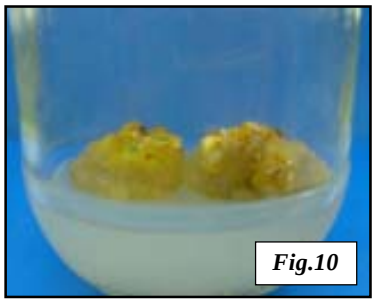
Hardening at green house

Well rooted plants were transferred to pro trays (98 cavities) containing coco-peat (Fig. 7). After hardening for 5-6 weeks, young plantlets were transferred to nursery stage (Fig.8). Green house temperature was maintained at 32 ± 4 ^{0} C and humidity 60 ± 20%.

Callus Initiation

Amount of 2 mg/1 2, 4 –D in both MS and WP media were found to be ideal for callus initiation (Fig. 9). Calli were further maintained in media containing 2 mg /1 2,4-D (Fig.10).





Callus regeneration

a. Callus from MS/WP media were further sub-cultured on media (MS/WP) containing 4 mg BAP, 0.5 mg/l kinetin that resulted in formation of single shoot in 25 days (Fig. 11).

Fig.11

b. Further the rhizogenic calli when subcultured on media with 2.0 mg/ l BAP, 1 mg/l kinetin and 0.1 mg /l IAA resulted in multiple shoot formation. (Fig 12).

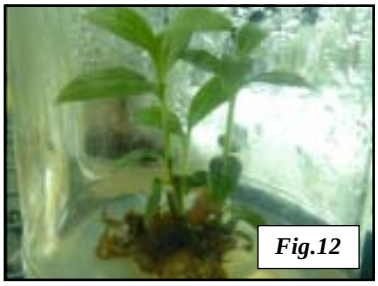


Fig.12

Conclusion

The idea of this whole study is to standardize the viable commercial protocol for mass multiplication of elite clones of *Morinda citrifolia L.* in future for our corporate farming.

The preliminary studies clearly indicate that irrespective of the basal media used (either MS or WP), it is the hormonal combination that are very vital for the in-vitro response. BAP alone for shoot initiation, BAP along with IAA for multiple shoot formation and IBA along with NAA have given good rooting in-vitro. Rooted plants have established well with 95-98 % survival at green house conditions while hardening. Further better growth with zero percent mortality was observed at nursery stage. Calli with roots produce shoot (s) in BAP and KN. Further studies are to be carried in commercial multiplication of micro propagation its cost of production and field performance for large scale cultivation.

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Morinda citrifolia L. – An evergreen plant for diversification in commercial horticulture

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Keywords : Morinda citrifolia, CARI, Port blair, phendogical traits, propagation, Tsumani, Physico-chemical properties, economics.

Abstract : *Morinda citrifolia L.* var. citrifolia, the commonly called Noni in India and also known as the Indian Mulberry is one of the important plants of Rubiaceae family. Noni's broad proliferation gives testimony to its value to traditional cultures. In Andaman and Nicobar Islands, it is widely found throughout the coastal region and also along the fences and the roadsides due to its wide adaptability to hardy environmental and soil conditions. The whole plant ie. leaf, stem, root and fruits is known to be of commercial importance. The tribes of these islands are known to consume this fruit in raw form with common salt as well as cooked vegetables. After Tsunami disaster, it has been found that Morinda is the only plant of commercial value, which is surviving in affected lands turned wastelands due to sea water intrusion. Studies at CARI, Portblair, were initiated to evaluate the full potential of this plant. It has been found that this plant can be used for rehabilitating the livelihood of farmers affected by Tsunami. It survives in sea water inundated saline soils and in all kinds of soil in Andaman and Nicobar Islands. This plant can also come up under 50 percent shade and therefore can be grown as intercrop. The canopy coverage provides very good cover to soil resulting in reduction in soil and runoff losses. The annual yield of Morinda fruits per tree initially is 10 kg /tree in the third year by harvesting 5-8 times in a year and it increases to 100 kg/ year after 6 years.

With fruit juice being used for manufacturing health enhancer, its cultivation assumes source of regular income and employment security. In addition, *Morinda* juice can be used as poultry feed supplement for immunity enhancement. Its leaves can also be used as mulch material. This paper presents a summary of the initial results of this study.

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Introduction

Indian Noni plant (*Morinda citrifolia L.*) belongs to the family *Rubiaceae.* It is commercially known as Noni, and also known as Indian Mulberry, Cheese fruit, Yellow fruit, Pain killer, Nono etc.. It is a large shrub or a dwarf

tree and native to South East Asia but has extensively spread throughout India and the Pacific Islands extending up to the Hawaiian Islands. It is known that Polynesians first took it from its homeland in Southern Asia. In Andaman and Nicobar Islands, *Morinda* is widely found growing in the coastal belts, rocky shores along fences, roadsides as well as in the wastelands of the islands. Two main varieties ie. *Morinda citrifolia L.* var. *citrifolia* and *Morinda citrifolia L.* var. *bracteata* are available in plenty in A& N islands. They are locally known as Lorang, Burma phal, Pongee phal, Suraogi etc. by the tribals of Andaman and Nicobar Island. (Singh, *et. al.,* 2005). Today, Noni grows in most regions of South Pacific, India, the Caribbeans, South America and the West Indies. Noni's broad proliferation gives testimony to its value to traditional cultures. Historically, it was known as the "queen" of all canoe plants. In Malaysia, it is known as Mengkudu. In South East Asia, it is known as Nhau. In the islands of the South Pacific particularly in Samoa and Tonga, the plant is known as Nonu. It is called, Noni in Raratonga and Tahiti, and Noni in the Marquesas Islands and Hawaii. In Australia, it is known as fromager, murier indien (French), Indian mulberry (English), nonu (Tahiti), nen, nin (Marshall islands, Chuuk) etc.. (Morton, 1992, Francis, 2003). The tropical humid climate is very much suitable for cultivation of *Morinda citrifolia L.* (Singh, *et. al.*, 2005).

Though it has greater demand hitherto, so far no efforts have been made for its domestication which is possible by standardizing the propagation techniques.

Importance and nature of plant

It is a potential under utilized fruit, which is being currently identified and popularized after the devastating Tsunami that struck on 26, December 2005. The *Morinda* tree attains a height of about 3-10 m. Plant forms have variation in fruit size, its morphology, odour of ripe fruit and number of fruits. Flower is white in colour, leaves are dark green, and fruits are greenish yellow, fleshy, fetid and soft when ripe. Seeds are brown in color, conical to oblong in shape, has the ability to retain viability for a month if left in water. The wood is yellowish in color. The prime quality of the *Morinda* tree is its medicinal value and its nature to withstand any type of climatic conditions and environmental conditions and its competitiveness to grow on all types of soils like, loamy sand to very rocky soils. The species *citrifolia* is the best known to tolerate salty soils and salt spray. It is intermediate in shade tolerance and grows under the canopy of forests as well as in the open. *Morinda* grows naturally on the edges of mangroves, shorelines and on the landward side of beach and road sides as strand

vegetation. The fruits may also be fed to pig livestock and poultry. *Morinda* is propagated either from seed or stem cuttings. The phenological traits of *Morinda citrifolia L.,* is given in Table. 1.

Table 1 : Phenological traits of *Morinda citrifolia L.*

Phenological Traits	Mean
Plant height (cm)	44.50
Number of side shoots	6-8
Number of flowers per bunich	27-35
Petal size (cm)	2.0
Flower stalk length (cm)	0.8
Anther size (cm)	0.9
Main shoot length (cm)	42.50
Side shoot length (cm)	24.38
Days taken to bud formation	30-45
Days taken to flower anthesis	15-20
Flower duration (days)	5-7 days
Maturity of fruits (days)	20
Number of seeds per fruit	130 –160
Seed weight (g)	0.03-0.034

Methodology

The present investigation was carried out in Bay islands by a team of scientists of Central Agriculture Research Institute (CARI), Port Blair to conduct the extensive survey in Bay Island to explore the extent and coverage of area by the *Morinda*. Global Positioning System (GPS) was used to locate the existence of plant locations. The plant specimens, seeds and fruits were collected by the team. Accordingly, different parts of Bay Island were surveyed. The methods of propagation and multiplication were tested at CARI, research farm. The fruits were collected from the mother trees and their physico chemical properties were evaluated. The different growth regulator and growth enhancer agents were tried to see their effect on the growth of the plants. The analysis of fruit nutrients was also carried out. The economics of *Morinda* cultivation was also worked out taking into consideration the buying price offered by processor.

Methods of propagation adopted

Morinda citrifolia L. is naturalized in almost all parts of the islands, as it grows in dry to wet lands and in sea level of about 500m elevation. The production of large number of saplings from the limited elite pedigree tree could be possible within a short period and could meet growing demand by the farmers. The true pedigree plants thus produced in the country can be used for propagation either through seed or stem cuttings.

Propagation through seed

Ripened and soft *Morinda* fruits were chosen for seed collection and the seeds were separated from fibrous, clinging fruit flesh in running water. The fruit were split into pieces by hand and then the seeds were separated from the flesh using a strong spray of water or strainer.

After cleaning, the seeds are spread in a clean newspaper and dried in shade or indoors for 3-4 days. The seeds should be stored in airtight container at room temperature. However, viability studies are to be carried out.

Morinda seeds can be planted immediately after extraction from the fruit. *Morinda* seeds require hot, wet condition for maximum percentage of germination. For this, warmest spot in the nursery or greenhouse must be chosen for maximum germination. If germinated outside, partial sun is preferable to full sun to prevent drying of the medium. *Morinda* seeds can be germinated in seedling flats or trays or sown directly in light medium containers that can retain water and remains aerated. Artificial growth media are favored compared to field soil for germinating the *Morinda* seedlings generally as the field soil contains pathogens which can cause plant diseases. Deeper seedlings flats are favored to shallow flats, because seedlings with longer taproots are produced. Seedlings with deep, well established tap roots tend to withstand better transplanting shock and establish much quicker. Seeds germinated in flats, should be transplanted into growing containers within a few weeks of germination. The larger and deeper the pots, more vigorous and larger the seedlings growth will occur. Fortunately, *Morinda* seedlings are grown in pots in open sunlight for a minimum of 9-12 months before they are transplanted to the field. If Noni plants are transplanted too young then they can be susceptible to weed competition, mechanical damage and slug attack. Seedlings and young plants grown from cuttings can be given fertilizer once in a month. Young plants respond well to applications of dilute, liquid foliar fertilizers. *Morinda* is salt tolerant and fertilizer burn is uncommon under normal conditions.

Table 2: Effect of seed soaking on percent seed germination in *Morinda citrifolia L.* in different concentrations of GA at different duration germination.

Duration	Seed Germination Percentage						
	C0	C1	C2	C3	C4	C5	Average
D1	53.30	60.00	73.30	86.60	86.60	77.30	72.80
D2	57.30	61.30	76.60	100.00	90.60	86.60	78.73
D3	58.60	61.30	77.30	86.60	86.60	75.30	74.60
Average	56.40	60.90	65.70	91.06	87.90	80.40	

CD (5%) C= 1.526 D = 2.158 C XD = 3.293

D- Duration of soaking (12,24 & 36 hours)

C- Concentration [400,600,800, 1000, 1200 ppm & Control (water)]

It is evident from Table 2 that under different concentrations of GA, seed germination percentage varies and 24 hours soaking of seeds exhibited highest rate of germination (79%).

Propagation through stem cuttings

Cultivation of *Morinda* plants from vertical and lateral stem cuttings lessens the time taken to obtain plants that are ready for transplanting. Under proper conditions for *Morinda* cultivation, the cuttings from branches and stem will sprout more readily. It depends on the selection of stem cuttings from the vigorous growing plants. While cutting the plant for propagation, the fresh sap will flow from the cut ends, if the sap flows readily, cuttings can be made from the collected materials. But in some cases if the sap does not flow readily or there is no sap to ooze, then the cut materials must be discarded. Usually sap flow signifies that it is an actively growing plant with high energy. Root hormones if required must be applied for proper vegetative growth. The plant needs full sunlight and regular fertilizer applications.

The goal of vegetative propagation is to get the best planting material with the highest genetic quality (Nanda,1970; Wright, 1975; Hatman and Kester, 1983). Since, auxins like Naphthalene Acetic Acid (NAA) and Indole Butyric Acid, (IBA) are reported to show quick and better rooting in vegetative propagation of many fruit crops viz., guava, grapes, ber, custard apple, (Dhua, *et. al.,* 1982; Shanmugavelu, 1987; Singh and Singh, 1973 and 1989), it may be used for *Morinda* as growth regulator.

Agrotechniques

As the *Morinda* plants are quite susceptible to root knot nematode, the site selection should be done carefully in order to avoid those places. It should contain proper aerated soil with adequate drainage facilities and adequate light. Although it grows in varied agro climatic and soil conditions it does not grow well where winds are strong. The proper spacing for *Morinda* plants is 4 x 4 m. Plants of less than three years of age should be pruned after their first production of fruit. Pruning usually reduces the outbreak of pests and diseases. *Morinda* plants require only limited application of fertilizers. A fertilizer application of 10-20-20 kg NPK/ ha will be sufficient. *Morinda* plants need moderate irrigation but once they are established fully, they can withstand drought. Over watering can result in root knot nematode and root rot (Nelson, 2005). *Morinda* fruits can be harvested when they change their colour infestation from green to yellowish green. Usually these stages of fruits are suitable for shipping. For self use or local purpose, fruits can be harvested when ripe so that the juice can be squeezed easily from it. Fruits should be harvested 3 years after planting at any stage of development depending on the proposed processing method. Mostly producers prefer green fruits, where as, the processors prefer mature yellowish green fruit for processing. Noni fruits do not bruise or damage easily and need not be refrigerated.

Results and discussion

The survey results revealed that due to its hardiness or versatile nature it is found growing near road side (Location – 11° 37'03.08"; 92° 42' 30.2"), near sewage drain (11° 40'6.3"; 92° 44' 15.9"), under shaded conditions (11° 40'13.5; 92° 43'56.2"), in hill top (11° 35'50.7'; 92° 43'56.2"), near sea shore (11° 35'37.6"; 92° 36'38.1"), in sea water inundated lands (11° 36'42.6"; 92° 40'47.3"), in jungle areas (11° 40' 27.8"; 92° 43' 36"38"), and in various other locations like Ross Island, which was erstwhile capital of Port Blair during the reign of British, where *Morinda* tree was found to be growing even in tree trunks, in old damaged buildings, in symbiotic association with *Ficus* plants etc.

Effect of gibberlic acid as growth regulator

Various seed germination studies were undertaken by this institute and the results revealed that GA at 800 ppm followed by 1000 and 1200 ppm induced significantly higher percentage of germination (91.06, 87.9 and 80.4% respectively) against water treatment (56.4%). Results further elucidated

that soaking for 24 hours gave the best results on germination (78.75%). Interaction results revealed that overall maximum germination (100%) was recorded from the seeds soaked for 24 hours at 800 ppm. Seed treated by GA significantly increased the height of seedlings (19.23 cm) and number of leaves per seedlings (13.10). Every increase in concentrations of GA increased the height of seedlings and number of leaves, significantly. The interaction resulting in maximum number of leaves / seedlings (13.59 cm) was noted in 1200 ppm, GA for 36 hours (Table 3). These findings are in agreement with those reported by Babu and Lavania (1985) for lemon.

Table 3 : Effect of different levels of growth regulators on root formation in the cuttings of *Morinda citrifolia L.*

Treatments	Rooting (%)	No. of primary Roots	Length of the primary roots (cm)	Diameter of the thickest root (cm)
IBA				
2000 ppm	66.87	13.27	11.58	0.09
4000 ppm	93.12	18.25	17.55	0.50
6000 ppm	75.00	13.88	14.14	0.06
NAA				
2000 ppm	64.37	15.32	14.48	0.07
4000 ppm	73.13	17.22	16.96	0.03
6000 ppm	73.75	12.76	15.21	0.04
IBA + NAA				
2000 ppm	65.62	13.34	13.41	0.03
4000 ppm	76.62	14.94	15.57	0.03
6000 ppm	69.37	14.14	15.02	0.03
Control	33.12	10.08	11.44	0.02
C.D. at 5%	3.68	1.15	1.41	NS

Hulling of seed coat of *Morinda* or scarification of the tough seed coat reduced the time required for germination (15 days) with 56% germination. Seed germination studies of *Morinda* sp. after plastering of beds with cow dung had 80-85% germination within 20-25 days. Seed germination studies of *Morinda sp*. after covering of beds with polythene sheet showed

that within 17-18 days, 66.43% germination at maximum and minimum temperature of 30.29 & 25.84 ^{0}C & 80.55 % RH, occurred.

Viability studies in *Morinda citrifolia L.* revealed that germination percentage was higher (50%) during the month of May 2005 within 30 days of sowing (temp. 27.81 – 32.88 ^{0}C; 70% RH) followed by higher germination (30%) during the month of June 2005 within 37 days of sowing (temp. 27.14, 31.68 ^{0}C; 75% RH). Only 10% germination was recorded during the month of December with maximum of 50 days taken for germination (temperature 25. 81 – 29.79 ^{0}C; 72.92% RH). Seeds were found not to be viable during the months of January, February, March and April with 0 percent germination. Gibberllic acid has been reported to improve seed germination and seedling growth in many crops (Abdalla, *et. al.,* 1978, Singh, *et. al.,* 1979 and Chakrawar, 1981.

Effect of IBA on growth of *Morinda citrifolia L.*

Various studies were undertaken and the results of the study revealed that the cuttings treated with growth regulators viz., 2000, 4000 and 6000 ppm of IBA and NAA separately and in combinations promoted root and shoot growth establishment. Percentage of rooting, number of primary roots, length of longest primary root and length of basal portion of cuttings showing roots were significantly higher than control, when the cuttings were dipped in 4000 ppm IBA. This trend was confirmed with the work reported by Cameron and Rook, (1974), Nanda, (1970) and Banker, (1989). However, high level of auxins associated with comparatively reduced root growth would have retarded the carbohydrate metabolisation and caused nutritional imbalance as suggested by Spiegel, (1954) and Nanda, *et. al.,* (1974). The performance of soft wood cuttings with respect to the percentage of rooting, number of primary roots, percentage of secondary rooting and callus production was significantly superior over semi hard wood cuttings.

Growth performance under polyhouse

The sprouting of cuttings under closed polyhouse and covered polyhouse revealed that under closed polyhouse the germination was noticed earlier (15 days) compared to covered polyhouse (20 days) with 60% (temp. 33.5^{0}C and 29.08^{0}C and 76.53% RH) of sprouting and 83.33 % of cuttings survived in closed polyhouse whereas only 50% (30.29^{0}C and 25.48^{0}C and 80.55 % RH) of sprouting and 80% of cuttings survived in top covered polyhouse with IBA (6000 ppm). The studies revealed that the plants were found to be luxuriantly growing under open condition with optimum light

intensity of 44382 lux, maximum temperature (31.93^{0}C), minimum temperature (27.03^{0}C) and RH (77.1%) and also under shaded condition. The vegetative growth of plants were superior under open condition in terms of plant height (58.50 cm) with 4 branches and of reproductive growth with bud initiation on 32 days after planting and fruit production on 42 days after planting whereas the plants grown under shaded condition revealed to be having a height of 54.50 cm with 2 branches/plant.

Effect of cow dung on sprouting of cuttings

Within 13 days, 60% sprouting was observed after application of cow dung whereas in control the sprouting took about 15 days with 30% sprouting.

Effect of hollow and non hollow cuttings on sprouting

The findings of the study revealed that the sprouting initiated within15 days in case of non - hollow cuttings and 20 days in case of hollow cuttings. About 50% sprouting was noticed in case of non - hollow cuttings and about 40% sprouting in case of hollow cuttings. Maximum (79.44%) plants were able to survive in case of non - hollow cuttings whereas in case of hollow cuttings the survival percentage was 62.78%.

Phytochemical properties

a) Nutrient composition

The chemistry of Noni was investigated extensively by various scientific groups. A plethora of phytochemical constituents have been identified in the leaves, bark, stem, flowers and fruits of the plant. Noni fruit specifically is a rich source of phytochemical constituents, which demonstrate bioactivity.

The fruit of *Morinda citrifolia L.* is a powerful detoxifier. It removes the toxins from cells of our body. It builds and strengthens every cell of our body to stay healthy. Researchers have discovered more than 150 neutraceuticals in the fruit of *Morinda citrifolia L.* Noni fruits appear to stimulate the production of T-cells, macrophages and thymocytes, thereby enhancing immune function. And in animal studies, Noni fruit extended the lives of mice with cancer.

Various experimental studies were carried in the laboratory and the results revealed that in *Morinda citrifolia L.*, Potassium, content was maximum in fruits (1226 ppm) followed by leaf (1219 ppm) while it was in very little in wood and bark. But in leaves, the calcium and magnesium contents were

found to be higher, 5462 and 570.60 ppm, respectively followed by 534.34 ppm of calcium in bark and 58.89 ppm in fruits. Magnesium content was found to be next higher in case of fruits (196.64 ppm) and lower in wood (44.67ppm). While comparing the other micronutrients, Iron content was higher in wood (378.54 ppm), followed by 146.67 ppm in bark and was the lowest in leaf (4.47 ppm). Higher content of Copper was found in fruit (27.44 ppm) and the lowest in leaf (2.23ppm).

In case of *Morinda trimera*, the Calcium content was higher (515.44 ppm) in leaves followed by iron (88.88 ppm), magnesium (64.96 ppm) and lead was maximum (825 ppm) followed by calcium (504.33 ppm), magnesium (52.09ppm), Iron (44.91 ppm) and the least content of copper (14.44 ppm) respectively (Table 4).

Table 4 : Nutrient composition in leaves (ppm)

Species	K	Ca	Mg	Fe	Cu
Morinda citrifolia	1226	58.89	196.64	42.44	27.44
Morinda trimera	825	504.33	52.09	44.91	14.44

Comparison of nutrients in leaves (*Morinda citrifolia L.*) irrigated with normal water and sea water revealed that the Calcium content was invariably higher (5462 ppm) in leaves of normal water irrigated plants than in leaves of sea water irrigated plants (539.17 ppm). Magnesium content was higher (570.60 ppm) in leaves of normal water than ppm in sea water leaves (50.23). Invariably higher content (185.09 ppm) of Iron was recorded in sea water leaves and the lowest content (4.47 ppm) in leaves of normal water. Copper was higher (4.62 ppm) in sea water leaves and only about 2.23 ppm in normal water leaves.

Comparison of nutrient content in leaves of *Morinda citrifolia L.* irrigated with sea water (100% , 75%, 50%, 25% and normal water (control) revealed that among the nutrients analyzed (Ca, Mg, Fe and Cu), calcium content was comparatively higher in all treatments than other nutrients. Higher content of calcium was recorded in 75% sea water (539.17 ppm), followed by 100% sea water (536.67 ppm) and lowest content in 50% sea water (484.47 ppm). Magnesium content was comparatively higher in 50% sea water (50.74 ppm) and similar trend was observed in 25% (50.72 ppm), 75% (50.23 ppm) and 100% sea water (49.82 ppm).

Iron content was higher in 50% sea water (271.14 ppm) followed by 75% (185. 09 ppm), 100% (182.44 ppm) and of the lowest in 25% sea water (83.58 ppm). Copper content was invariably lower among all the nutrients, with high content in 25% sea water (7.55 ppm), followed by similar trend

of 4.62, 4.50 and 4.39 ppm in 75%, 50% and 100% sea water irrigation treatments, respectively.

Table 5 : Nutrient content in different parts of *Morinda citrifolia L.*

Parts of the Plant	K	Ca	Mg	Fe	Cu
		(ppm)			
Leaf	1219	5462	570.60	4.47	2.23
Wood	Trace	270.02	44.67	378.54	6.22
Bark	Trace	534.34	47.93	146.67	5.46
Fruit	1226	58.89	196.64	42.44	27.44

Comparison of nutrients in leaves (*Morinda citrifolia L.*) irrigated with normal water and sea water revealed that the calcium content was invariably higher (5462 ppm) in leaves of normal water than in leaves of sea water (539.17ppm). Magnesium content was higher (570.60 ppm) in leaves of normal water than about 50.23 ppm in sea water leaves. Invariably higher content (185.09 ppm) of Iron was recorded in sea water leaves and the lowest content (4.47 ppm) in leaves of normal water. Low content of copper was found and it was higher (4.62 ppm) in sea water leaves and only about 2.23 ppm in normal water leaves. (Table 5).

Soil analysis

Nutrient analysis in soils collected near mother tree of *Morinda citrifolia L.* (Table 6) showed that potassium content was invariably higher (151.10 ppm) in Sippighat soil followed by Wandoor soil (112.30 ppm) and lowest in farmers field located at Memio. Similar trend was observed in sodium content which was invariably higher in Sippighat soil (113.10 ppm) and the lowest in Phoenix Bay and Co-operative Bank (26.0 ppm).

The soils of Sippighat are also rich in Calcium (8409.36 ppm) and the lowest (818.11 ppm) in farmer's field. Magnesium content was higher (953.10 ppm) in soil series of Wandoor and lowest in farmers field (818.11 ppm). Among the other micronutrients, iron content was invariably higher (89.06 ppm) in Wandoor series of soil and lower (10.81 ppm) in Phoenix Bay series of soil. Manganese seems to be higher followed by iron content, and it was higher (82.88 ppm) in Sippighat series of soil and lower in Memio series (3.12 ppm). Higher content (2.21 ppm) of Copper was found in Garacharma series of soil and least (0.08 ppm) in Phoenix Bay series of soil.

Zinc content was higher (17.82 ppm) in Wandoor series of soil and least (0.15 ppm) in Memio series of soil.

Table 6 : Nutrient content in soils collected near mother tree of *Morinda citrifolia L. from different locations*

Accessions	K	Na	Ca	Mg	Fe	Cu	Mn	Zn
				(ppm)				
GHC -1	98.00	55.30	6198.05	924.54	42.99	2.21	43.04	0.24
SPGH -2	151.10	113.10	8409.36	899.82	18.48	0.30	82.88	0.59
MEM - 3	52.20	24.80	5238.10	835.54	19.47	0.19	3.12	0.15
WAND -4	112.30	102.10	5158.25	953.10	89.06	0.79	77.04	17.82
PBAY -5	50.80	26.00	5288.93	858.94	10.81	0.08	15.95	0.17
CPB -6	56.30	26.00	4483.25	830.25	17.73	2.06	27.28	1.03
FMF 7	15.70	28.00	1924.59	818.11	63.55	1.48	34.88	1.04

Physicochemical properties of fruits

The physico chemical characteristics revealed that the average weight of *Morinda citrifolia L.* fruits was 147.9 g with 9.8 cm length and 5.26 cm girth and 1.13 g specific gravity (wt. volume). The recovery of the juice ranged from 38.95 to 48.50%, with pulp percentage and seed ranging between 44.76 to 46.72% and 3.24 – 4.31 %. The TSS of 8.40 brix and acidity of 0.14% was recorded. The ascorbic acid (mg /100 g) content of the fruit was 139.09 mg /100 g at ripe stage.

Physico chemical analysis of ripe fruits of *Morinda trimera* revealed that the average fruit weight was approximately 24.60 gm with Juice recovery of 41.60 % and TSS content of fruits was about 5.0 brix, 0.08% Acidity and Vitamin C content varies from 87.13 – 125.00 mg /100 g. (Table 7)

Table 7 : Comparison of physiochemical characters of *Morinda sp*.

Species	Fruit wt. (g)	Juice %	TSS (Brix)	Acidity (%)	Vit.C (mg/100 g)
Morinda citrifolia	150-250	38.95-60.25	8.40	0.14	125.00 –139.09
Morinda trimera	15-24	30-41.60	5.00	0.08	87.13-125.00

Salinity tolerance

Noni is a highly salt tolerant tree that thrives in wet and dry conditions. There is a membrane enclosing a gel like substance around each seed enabling flotation, and the seed coating, being very hard and watertight, can delay sprouting for many months. The flower is self pollinating; so only one seed needs to sprout for a successful population to possibly emerge, these are positive traits for sea or air dispersion and colonization in any harsh conditions, from salt flats to lava flows. Influence of seawater inundation on vegetative growth of *Morinda sp*. after one year of planting indicates that the plants reached maximum height of 88.80 cm with 6-8 branches with first bud initiation 62 days after planting and fruit setting on 75 days after planting. An average yield of 1.10 kg fruits per plant was obtained. The soil pH was recorded to be varying from 6.18 to 8.28, EC from 0.18 to 14.25 and the pH of water was recorded to be varying from 6.98 to 8.32 and that of EC from 0.26 to 21.28.

Irrigation with 75% sea water revealed luxuriant growth of *Morinda citrifolia L.* in respect of plant height (72.0 cm), stem girth (0.7 cm), number of leaves (52), in which EC was 13.26 dsm –1 and pH of 7.31 followed by 100 percent sea water which recorded plant height (70.0 cm), stem girth (0.7 cm), no. of leaves (49) and the EC was 17.79 dsm –1 and pH of 7.63 whereas in control (normal water irrigation) the plants reached a height of 51.5 cm, stem girth of 0.5 cm and number of leaves was 51.5 in which the EC was 2.5 dsm – 1 and pH of 7.67. First bud initiation was recorded in 100% sea water within 361 days from the date of planting followed by 366 days in 75% sea water and in control was observed on 410th days after planting.

Gas exchange parameters

Measurement of gas exchange parameters revealed that photosynthetic active radiation (1459 µmol/sq m /s), photosynthesis rate (27.8 µmol/sq m/s), stomatal conductance (75.54 µmol/mol), transpiration rate (2.48 million mol/sq m/s) and internal Co2 (654.04 k Pa) were recorded from plants growing under wasteland and plants growing under sea inundated and recorded photosynthetic active radiation (731.6 µmol/sq m/s), photosynthesis rate (26.70 µmol/sq m/s), transpiration rate (0.70 µmol/sq m/s), and internal CO2 (769.80 kPa).

In sodium chloride (Nacl) irrigation experiment, the results revealed that rate of photosynthesis was maximum (7.90 µmol/sq m/s) in plants irrigated with 19.25 g Nacl/4 litre water whereas PAR was high (115.90 µmol/sq m/s) in plants irrigated with 26.25 Nacl / 4 litre water, rate of transpiration, stomatal conductance and internal CO_2 were recorded to be high (1.30 µmol/sq m /s, 79.80 µmol/mol and 771.80 kPa) in plants irrigated with normal water (control).

In sea water irrigation treatment, the plants irrigated with 50% sea water recorded maximum rate of photosynthesis (87.30 µmol/sq m/s), PAR (6.00 µmol/sq m/s), rate of transpiration (0.60 µmol /sq m/s) and stomatal conductance (32.90 µmol/mol) whereas the internal CO_2 content was recorded to be high (757.90 kPa) in plants irrigated with 100% sea water.

Storage behavior of fruits

The storage behavior and the physiological loss in weight of fruits exhibited significant variation with respect to number of days stored. With the advancement of days in storage, the percentage reduction of fruits gradually increased over number of days stored. It was observed that shelf life of fruits lasted up to 5-7 days in open conditions at room temperature of 25 – 30 ^{0}C and Relative humidity of 70-75%. The mature fruits tend to change its color from greenish yellow to creamy yellow from third day onwards whereas ripe fruits of yellowish green color turn to white on fifth day. Regarding weight of mature fruits, 12 –15 g of loss in weight was found and about 16-18 g of loss in weight of ripe fruits was observed.

Economics of *Morinda* cultivation

Noni plants start flowering 8-10 months after planting. But it is suggested to remove all the flowers up to 1.5 to 2 years. This operation ensures better growth and bushy plant. Flowering and fruiting continues throughout the year. Commercial harvest starts from 20 to 24 months onwards. It yields 10 kg/plant after 24 months. It is reported that Noni plant is capable of giving yield up to 250 - 300 kg/tree under better cultivation condition after 7-8 years. Yield range may be 30 - 40 kg/plant in the initial stage. A well grown tree will produce an average of 90-100 kg / tree. It is reported that the productivity of the trees is up to 40-50 years. The harvesting can be done more than 6 to 7 times in a year.

Table 8 : Economics of *Morinda* cultivation

S.No.	Particulars	Cost of Cultivation / acre (Rs.)
1.	Land Preparation (Cutting of grasses)	500.00
2.	Digging of pits (340 pits x Rs. 10/-)	3400.00
3.	Plant cost (340 x Rs. 10/-)	3400.00
4.	Gap filling	170.00
5.	Filling of pits and planting (6 man days x Rs. 100/-)	600.00

6.	Manuring and Bio-fertilizers	5400.00
7.	Weeding and Hoeing (2x 5 man days x Rs.100/-)	1000.00
8.	Irrigation	1000.00
9.	Plant Protection	500.00
10.	Training and Pruning	500.00
11.	Miscellaneous	500.00
	Total Expenditure	**Rs. 16,970/-**

The BCR was worked out to be 14.5% without considering the opportunity cost. Whereas it was 9.7% with consideration of opportunity cost. This indicates *Morinda* cultivation is highly economical.

This fruit tree is highly economical, if farmer cultivates it at the large scale. The assured marketing also required. Based on CARI studies above results were obtained, which suggests the suitability and economic viability of this tree in A & N Islands. The economics of *Morinda* cultivation is given in Table. 8.

Registration of germplasm

Morinda citrifolia L. has been registered for its salinity resistance and nutrient rich indigenous species with national identity no. – I.C. 524021 and INGR No. – 05028 by the NBPGR, New Delhi.

Conclusion

Initial studies have revealed that Noni can be grown in all types of challenged resource conditions. The package of practices are simple and do not involve any intensive labor and monetary expenditure. The plantation of this crop has potential of restoring livelihood of the farmers affected by tsunami. However, lot of work needs to be done on phyto chemical properties of this fruit, detailed package of practices for its cultivation as intercrop and alley crop, and its other uses.

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Chemical and biological properties *of Morinda* spp.

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Keywords : Hepatoprotective, *M. citrifolia, M. pubscens*

Abstract : The present study was aimed to investigate various chemical and biological properties of *M. citrifolia* and *M. pubescens*. Chemical analyses of the fruit have revealed that most of the essential elements were present in higher amount in the fruits of *M. citrifolia* compared to *M. pubescens.* Manganese was present in high quantity in *M. pubescens,* whereas Calcium, Potassium, Phosphorus and Magnesium were found almost at par in both the fruits. The reducing sugars and lipids were present in high levels in the fruits of *M. citrifolia* whereas, the total soluble sugars, starch and crude fibers were high in *M. pubescens*. The natural antioxidant content was high in the fruit extracts of *M. pubescens* compared to *M. citrifolia*. The fruit extracts of M. citrifolia and *M. pubescens* effectively inhibited wide range of human and plant pathogens. The antimicrobial activity was more pronounced with *M. citrifolia* than *M. pubescens*. Further, the fruit extracts significantly inhibited the respiration rate in human and fungal pathogens. Both the fruit extracts showed excellent hepatoprotective effect against D-galactosamine intoxicated experimental rats. The fruit extracts of *M. citrifolia* and *M. pubescens* have also shown effective antidiabetic activity in alloxan induced experimental rats. This activity was more pronounced with *M. pubescens* than *M. citrifolia.*

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Introduction

The genus *Morinda* is distributed worldwide (Wang et al., 2002) and the presence of as many as 80 different species has already been reported (Smith, 1988). *Morinda citrifolia*, a small tree, grows predominantly along the tropical coasts and is extensively being used in folk medicine. Its antibacterial, antiviral, antifungal, antitumor, antidiabetes, analgesic, anti-inflammatory, immune enhancing activities have already been reported (Wang et al., 2002; Mathivanan *et. al.,* 2005; 2006; Surendiran *et al.,* 2006). Another related species, *Morinda pubescens* grows predominantly in vacant agricultural land and some of its medicinal properties were documented in the ancient literature. However, no scientific research has been carried out in our country on these two *Morinda* species and hence, the present study is focused to explore the potentials of *M.*

citrifolia and *M. pubesens*. The chemical and biological properties of both the *Morinda* species were investigated and reported in this article.

Materials and Methods

Chemical properties

Preparation of plant extracts of *Morinda*.

The fruits of *M. citrifolia* were collected from the trees located in the coastal area of Seruthala in Kerala and *M. pubescens* fruits were obtained from the tree in the Botany Field Research Laboratory, University of Madras, Madhuravoyal, Chennai, Tamil Nadu. They were washed with tap water and rinsed with distilled water and air dried for 1 h. The fruits were ground to powder using pestle and mortar and stored at -20°C until use. For preparation of plant extracts, five different solvents *viz.,* petroleum ether, ethyl acetate, chloroform, ethanol and water were mixed separately with the fruit powder at 2:1 ratio (w/v) and kept over night in shaken condition. These extracts were filtered through Whatman No.1 filter paper and dried *in vacuuo* and used for further studies.

Protein estimation

The protein content in the fruit extracts of *M. citrifolia* and *M. pubescens* was estimated by the standard dye binding method of Bradford (1976) using the following two different extraction procedures.

1. Standard aqueous extraction
2. Extraction using antioxidant

The sugar, starch, lipid and crude fiber content in the fruits of *M. citrifolia* and *M. pubescens* was analyzed using standard methods.

Elements

The essential elements *viz*., Potassium, Calcium, Magnesium, Nitrogen, Phosphorus, Copper, Manganese, Zinc and Iron were estimated using Flame photometer, UV-Vis Spectrophotometer and Atomic Absorption Spectrophotometer (AAS).

Antioxidative activity

The lipid peroxidation levels in the fruit extracts of *M. citrifolia* and *M. pubescens* were estimated by FTC (and Namiki,1981) and TBA (, 1959; Kikuzaki and Nakatani, 1993) methods.

Ferric thiocyanate (FTC) method

The fruit samples of 4mg in 99.5% ethanol were mixed with 2.51% Linoleic acid in 99.5% ethanol (4.1 ml), 0.05 M phosphate buffer, pH 7.0 (8 ml) and

distilled water (3.9 ml), and kept in screw cap containers under dark conditions at 40^{o}. To 0.1 ml of this solution, 9.7 ml of 75% ethanol and 0.1 ml of 30% ammonium thiocyanate were added. After 3 min, 0.1 ml of ferrous chloride in 3.5% HCl was added to the reaction mixture and the absorbance of the red color was measured at 500 nm every 24 h, until one day after absorbance of the control reached maximum. The control and standard were subjected to the same procedure as the sample except for the control, where there was no addition of sample, and for the standard 4 mg of sample were replaced with 4 mg of a-tocopherol or BHT.

Thiobarbituric acid (TBA) test

The same samples as prepared for the FTC method were used in TBA test. To 1 ml of sample solution, 2 ml each of 20% aqueous trichloroacetic acid and aqueous thiobarbituric acid were added. This mixture was then incubated in a boiling water bath for 10 min. After cooling, it was centrifuged at 3000 rpm for 20 min and the absorbance of supernatant was measured at 532 nm. Antioxidative activity was recorded based on absorbance on the final day.

Antimicrobial activity

The antimicrobial activity of *Morinda* spp. was studied using disc diffusion method for bacterial pathogens. In the case of phytopathogenic fungi, the fresh and dry weights were estimated.

Determination of minimum inhibitory concentration (MIC)

Among different solvent extracts, the chloroform fruit extract was used to determine the minimum inhibitory concentration (MIC) against different human and plant pathogens by broth dilution assay of Hammer et al. (1996) with some modifications. The nutrient broth (NB) and potato dextrose broth (PDB) were used instead of heart infusion agar and Mueller Hinton Broth (MHB) with chloroform fruit extract at the concentrations of 10–1000 mg/ml. The pathogens were inoculated separately and the flasks were incubated at 28 ± 2°C under shaken condition. The growth of human pathogens and mycelial weight of the plant pathogens were measured after 24 h and 5 days, respectively. Based on the growth, the MIC for each pathogen was determined.

Effect of fruit extracts of *Morinda spp*. on respiration

The effect of fruit extract of *Morinda* spp. on respiration in different test organisms was determined using dark type polarographic oxygen probe. About 5 ml of distilled water was placed in the sample chamber and temperature controlled water circulator was used in the sample chamber to maintain 30°C. The oxygen probe was inserted into the chamber without any air bubble between the probe tip and the water surface. Magnetic stirrer was turned on

and analog/digital meter reading was set to 100% and then the stability of the meter reading was observed. Later the stirring was stopped and the distilled water and the probe were removed from the sample chamber. Then 5 ml of sample solution with the test organism was placed in the sample camber and the probe was inserted into the chamber. The meter reading was set to 100% and the sample was stirred. The fall in the meter reading was observed. The difference in the initial and final reading was calculated which denote the consumption of oxygen by the test organism.

Hepatoprotective effect of *Morinda spp.*

The fruit extract at the dose of 50-300 mg/kg/day was given up to 21 days before induction with D-gal by oral route. The acute hepatotoxicity was induced in rats by oral administration of D-gal at a dose of 200 mg/kg body weight. After 18-24 h, the serum enzymes, lipid peroxidation and protein concentration in the liver were estimated.

Antidiabetic activity of *M. citrifolia* and *M. pubescens*

The hypoglycemic effect of alcoholic extracts of *M. citrifolia M. pubescens* and also their effects on tissue, lipid peroxidation and antioxidants were investigated in both normal and alloxan induced diabetic rats.

Results and Discussion

Chemical properties of *Morinda spp.*

Protein

The protein content was high in *M. citrifolia* fruit extracts obtained by two different extraction methods than the fruit extracts of *M. pubescens*. It ranged from 8.0 mg/g fresh weight (gfw) to 9.3 mg/gfw in *M. citrifolia* as against 5.3 mg/gfw to 7.0 mg/gfw in *M. pubescens* (Table 1).

Table 1. Protein content in the fruit extracts of *Morinda spp.*

Extraction method	Protein content (mg/gfw)	
	M. citrifolia	M. pubescens
Standard aqueous extraction	8.0	5.3
Extraction using antioxidant	9.3	7.0

Sugar, starch, lipid and crude fiber

The reducing sugars and lipids were present in high quantity in the fruits of *M. citrifolia* whereas, high amount of total soluble sugars, starch and crude fiber was estimated in the fruits of *M. pubescens* (Table 2).

Table 2. Sugar, lipid and crude fiber content in the fruits of *M. citrifolia* *M. pubescens*

Content	*M. citrifolia*	*M. pubescens*
Reducing Sugar (mg/g)	0.6	0.2
Total soluble sugar (mg/g)	1.4	2.0
Starch (mg/g)	1.1	2.2
Lipid or Oil (%)	3.3	2.0
Crude Fiber (%)	40.0	62.0

Table 3. Content of elements in the fruits of *Morinda* spp.

Element	*M. citrifolia*	*M. pubescens*
Nitrogen (%)	5.0	3.6
Phosphorus (%)	0.25	0.18
Potassium (%)	2.5	2.3
Magnesium (%)	0.3	0.2
Zinc (ppm)	125	99
Iron (ppm)	1722	744
Copper (ppm)	3317	2376
Manganese (ppm)	46	87
Calcium (ppm)	3.0	2.9

Elements

Most of the elements are present in high amount in the fruits of *M. citrifolia* than in *M. pubescens*. However, Mn was present in high quantity in *M. pubescens* and Ca, K, P and Mg content was almost on par in both the fruits (Table 3).

Antioxidative activity

The chloroform fruit extracts of *M. citrifolia* and *M. pubescens* showed an excellent antioxidant activity compared to ethyl acetate and methanol fruit extracts (Figs. 1-6). The antioxidative activity was more pronounced in the fruit extracts of *M. pubescens* (Mp) compared to *M. citrifolia* (Mc).

Table 4. MIC of fruit extracts of *M. citrifolia* and *M. pubescens* on human and plant pathogens

Pathogen	*M. citrifolia*	*M. pubescens*
	MIC (mg/ml)	
Escherichia coli	50	200
Candida albicans	150	200
Pseudomonas aeruginosa	200	400
Staphyllococcus aureus	200	150
Bipolaris oryzae	200	300
Curvularia lunata	300	350
Rhizoctonia solani	250	600
Macrophomina phaseolina	300	600
Phytophthora infestans	200	650
Fusarium oxysporum	300	700

Biological properties

Antimicrobial activity

The MIC of the chroloform fruit extract of *M. citrifolia* was estimated between 50 and 300 mg/ml against different pathogens. However, it was determined as 150 to 700 mg/ml for *M. pubescens* (Table 4).

Effect of fruit extracts of *M. citrifolia* and *M. pubescens* on respiration in fungal pathogens

The rate of respiration in fungal pathogens was greatly reduced due to treatment of fruit extracts of *M. citrifolia* and *M. pubescens* as compared to untreated control. The respiration rate ranged from 61.3 to 94.5 Mol./h/min and 58.2 – 127.3 Mol./h/min, respectively due to treatment of *M. citrifolia* and *M. pubescens* as against 97.8 – 250.2 in control (Table 5).

Hepatoprotective effect of *Morinda spp.*

The rats supplemented with fruit extract showed considerable improvement in the fucose content, ample prevention in the depletion of uric acid, ceruloplasmin and glutathione (GSH). They also showed considerable alteration in iron and elevation of lipid peroxides as compared to D-gal intoxicated animals (Table 6 & 7). The histopathological studies have revealed that the *Morinda* spp. fruit

extract provided considerable protection to the liver cell membrane against toxic metabolites formed due to D-gal administration. The protective effect was more pronounced in *M. citrifolia* than *M. pubescens.*

Antidiabetic activity of *M. citrifolia* and *M. pubescens*

i) Body weight of the animal

Significant weight loss was observed in diabetic rats as compared to non-diabetic control animals. The treatment of *Morinda* alcoholic extracts significantly improved the animal weight as compared to diabetic animals (Table 8).

ii) Hepatic markers

The blood glucose level was significantly increased in alloxan administered diabetic rats as compared to the non-diabetic control rats (Table 9). Administration of alcoholic extracts of *M. citrifolia* and *M. pubescens* significantly decreased the blood glucose level as compared to diabetic control animals. There was considerable increase in the blood bilirubin level in the diabetic rats administrated with alcoholic extracts of both the species compared to diabetic control rats. Also there was a considerable alteration in SGPT, SGOT and ALP levels of liver tissue in diabetic rats compared to control and diabetic rats administrated with alcoholic extracts of *M. citrifolia*and *M. pubescens*. The total protein, albumin and globulin in blood serum were considerably altered in diabetic rats compared to drug control and diabetic rats administrated with alcoholic extract of *M. citrifolia* and *M. pubescens*(Table 9).

Table 5. Rate of respiration in fungal pathogens

Pathogen	Rate of respiration (Mol./h/min)		
	Control	*M. citrifolia*	*M. pubescens*
Bipolaris oryzae	97.8	61.3	58.2
Fusarium udum	134.4	72.3	89.2
Curvularia lunata	200.2	82.4	127.3
Phytophthora infestans	250.2	94.5	92.1
Macrophomina phaseolina	124.3	71.2	82.2

Table 6. Hepatoprotective activity of *M. citrifolia*

Parameter	Group I (Control)	Group II (D-gal)	Group III (*M. citrifolia*)	Group IV (D-gal+*M. citrifolia*)
Protein	7.19	4.21	9.92	8.48
Fucose	35.29	21.21	32.12	29.12
Ceruloplasmin	32.39	21.19	38.25	29.96
Iron	95.92	117.21	121.32	102.12
Uric acid	4.95	3.12	4.01	4.11
GSH	8.39	2.95	8.03	9.12
LPO	2.15	3.86	1.95	2.39
Vitamin E	3.12	1.39	3.03	3.54
CAT	49.27	21.01	42.10	39.21
SOD	5.12	3.17	6.01	4.92

Units: g/dl for serum and mg/g for tissue protein; Units/mg protein for ceruloplasmin; mg/g wet liver for iron; mg/dl for uric acid lipid peroxides; n mol of thiobarbituric acid reactants/mg of tissue.

Table 7. Hepatoprotective effect of M. pubescens

Parameter	Group I (Control)	Group II (D-gal)	Group III (*M. pubescens*)	Group IV (D-gal+*M. pubescens*)
Protein	9.81	3.18	12.4	8.49
Fucose	31.2	25.2	30.2	28. 2
Ceruloplasmin	28.25	16.16	30.60	23.96
Iron	115.10	177.17	119.13	129.12
Uric acid	3.65	2.63	3.06	3.25
GSH	7.45	3.45	6.95	6.15
LPO	1.28	2.56	1.25	1.45

Units: g/dl for serum and mg/g for tissue protein; Units/mg protein for ceruloplasmin; ug/g wet liver for iron; mg/dl for uric acid lipid peroxides; n mol of thiobarbituric acid reactants/mg of tissue.

Table 8. Effect of alcoholic extracts of *M. citrifolia* and *M. pubescens*on body weight in rats.

Days	Body weight (g)					
	Group I (Control)	Group II (Alloxan)	Group III (Fruit extracts)		Group IV (Alloxan + Fruit extracts)	
			Mc	Mp	Mc	Mp
0	120	110	140	120	110	120
5	130	90	135	145	120	120
10	130	110	130	135	115	120
15	140	85	150	160	135	130
20	135	80	145	460	130	130
25	140	85	150	155	135	125
30	145	85	155	170	130	125
35	140	85	160	165	135	120

Mc: *M. citrifolia*; Mp: *M. pubescens*

Table 9. Effect of alcoholic extracts of *M. citrifolia* and *M. pubescens*on hepatic markers.

Parameter	Group I (Control)	Group II (Alloxan)	Group III (Fruit extracts)		Group IV (Alloxan+Fruit extracts)	
			Mc	Mp	Mc	Mp
Sugar	93	256	118	109	168	151
Bilirubin	1.43	0.5	1.58	1.59	2.26	1.31
SGPT	43	94	34	53	42	43
SGOT	134	192	176	158	182	181
ALP	212	825	515	182	279	629
Total protein	7.2	5.7	6.7	7.8	8.4	7.4
Albumin	4.1	1.9	4.4	4.8	4.8	3.9
Globulin	3.1	4.8	3.9	3.4	5.2	4.4

Mc: *M. citrifolia*; Mp: *M. pubescens*

Units: mg/dl for sugar and bilirubin; IU/L for SGPT, SGOT and ALP; g/dl for total protein, albumin and globulin.

Table 10. Effect of alcoholic extracts of *M. citrifolia* *M. pubescens* on antioxidants activity in rats

Parameter	Group I (Control)	Group II (Alloxan)	Group III (Fruit extracts)		Group IV (Alloxan + Fruit extracts)	
			Mc	Mp	Mc	Mp
LPO	3.21	5.94	3.41	2.98	4.12	3.82
GST	28.12	12.22	25.2	27.12	24.12	22.31
GSH	25.56	15.21	28.1	24.21	17.1	19.2
SOD	7.44	3.21	6.81	7.21	6.12	5.97
CAT	74.12	38.23	68.12	63.41	61.21	64.41

Units: n mol MDA formed/mg protein for LPO; n mol/g wet tissue for GST and GSH

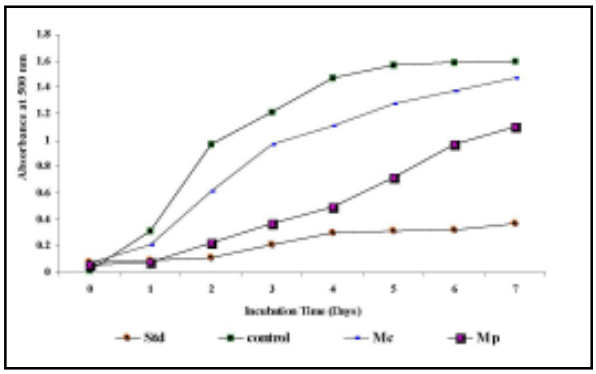

Fig. 1. Antioxidative activity of methanol fruit extracts of *Morinda* spp. (FTC)

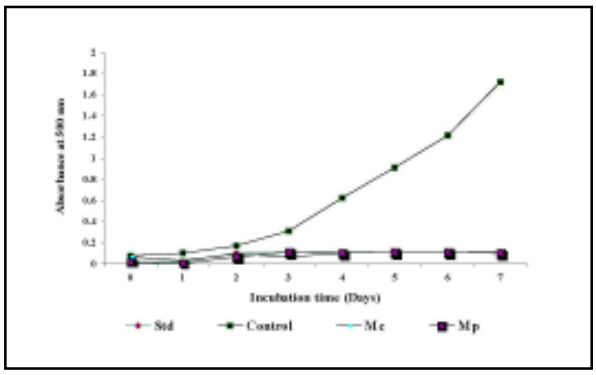

Fig. 2. Antioxidative activity of ethyl acetate fruit extracts of *Morinda* spp. (FTC)

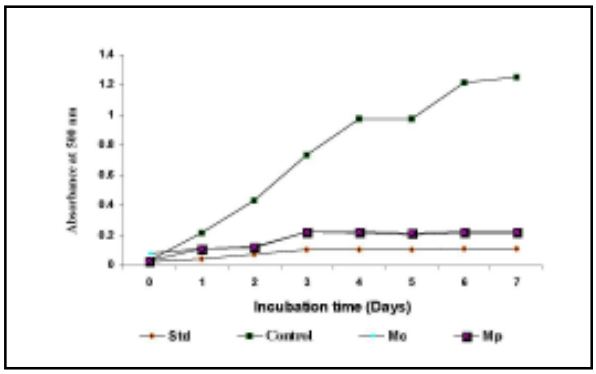

Fig. 3. Antioxidative activity of chloroform fruit extracts of *Morinda* spp. (FTC)

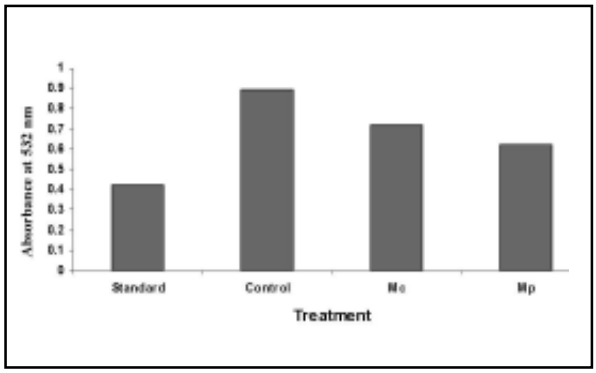

Fig. 4. Antioxidative activity of methanol fruit extracts of *Morinda* spp. (TBA)

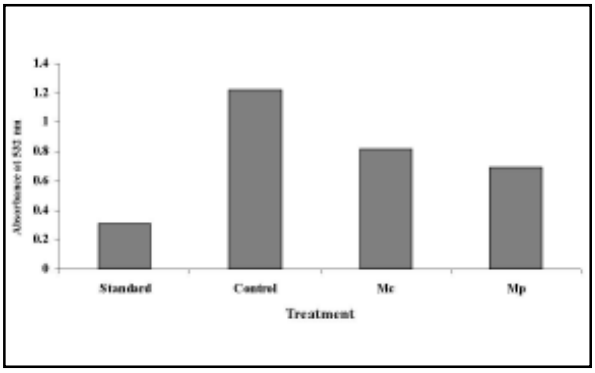

Fig. 2. Antioxidative activity of ethyl acetate fruit extracts of *Morinda* spp. (TBA)

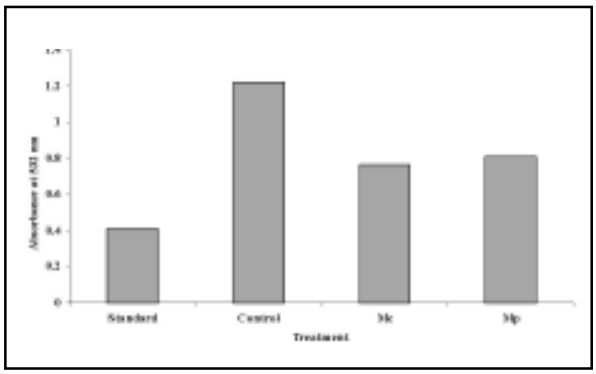

Fig. 3. Antioxidative activity of chloroform fruit extracts of *Morinda* spp. (TBA)

iii) Antioxidant activity

There was significant elevation of lipid peroxidation and significant reduction of reduced glutathione (GSH), glutathione-S-transferase (GST), superoxide dismutase (SOD), catalase (CAT) in the liver and kidney of diabetic rats as compared with non-diabetic control rats. Administration of alcoholic extracts of *M. citrifolia* and *M. pubescens* decreased the levels of lipid peroxidation and elevated the levels of GSH, GST, SOD and CAT in liver and kidney of diabetic rats as compared with the non-diabetic control rats (Table 10).

The findings of the present investigation clearly showed the nutritive value, antimicrobial activity and therapeutic potential of the *Morinda* spp. These results assume significance as there was no work carried out in India on *Morinda* spp. and it is the first report on *M. pubescens* although its wound healing activity has already been reported from our lab (Mathivanan et al., 2006). It is worthwhile to take up further research on different aspects of *Morinda* spp. because it will shed more light on the nutritive and therapeutic values of these species.

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Peptide and Mineral profile of *Morinda citrifolia* fruits and leaves

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Keywords : Peptide profile, leaves, fruits *M.citrifolia*

Abstract : *Morinda citrifolia* (noni) has a long history related to medical uses in Southeast Asian countries. Today, noni grows in the majority of the southern Pacific areas, in India, the Caribbean, South America and the West Indies. In order to obtain better understanding of the medicinal characteristics of the noni fruits and leaves, the peptide profile and the mineral compositions of the raw juice extracted from *M. citrifolia* fruits and leaves were determined. *Morinda citrifolia* fruit and leaves were subjected to dry ashing for the preparation of acid-mineral extract for micronutrients and macronutrients analysis by atomic absorption spectrophotometer. For analysis of peptide profile the water extraction of the *M.citrifloia* fruits and leaves were done and the extract was used for HPLC analysis. The peptide profile of the *Morinda citrifoilia* fruits and leaves were studied by using high performance liquid chromatography (HPLC). The concentration of micro and macro mineral of *M.citrifolia* leaves was found to be more than fruits. The HPLC analysis of the peptide profile of the *M.citrifolia* revealed the following peptide in various concentration such as Gly-Tyr, val-Tyr-Val, Meth-Enkaphalin and Leu-Enkaphalin. Overall, the peptide concentration of the leaf extract was found to be more than the fruit extract. High level of peptide Val-Tyr-Val was found in leaf extract (15.856 ppm) while in fruit the peptide Leu-enkephalin was maximum (3.697 ppm). The peptide analysis of the *M.citrifolia* may be useful in studying various alkaloids present in the fruits and leaves and will be of use in studying the effect of Morinda extract in immune system regulation.

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Introduction

Andaman & Nicobar Islands have a vast variety and diversity in tropical underutilized fruits. Their plant parts have a close association with local beliefs and rituals and are used in health care needs in rich ethnic life of people. The interesting fact is that the tribes i.e., Nicobari tribes of these islands have very long association with noni plant, as they have been using different parts as medicine for different purposes. They consume its fruits raw with salt as well as cooked vegetables (Singh et al., 2005).

Morinda citrifolia, commonly known as noni, is a shrub or small tree belongs to a family Rubiaceae, is a native to Southeast Asia and Australia but has been extensively spread by man throughout India and into the Pacific islands. In Andaman & Nicoabri islands, it is commonly known as Lovany, Burmaphal, Pongee phal and Surangi by the tribals (Singh et. el., 2005).

Over the last decade, a growing number of people have become interested in the medicinal uses of noni juice, made from the fruit of the Indian mulberry *(Morinda citrifolia)* of the South Pacific Islands of Tahiti, and more recently from Hawaii. *Morinda citrifolia* has been used in folk remedies by Polynesians for over 2000 years, and is reported to have a broad range of therapeutic effects, including antibacterial, antiviral, antifungal, antitumor, antihelminthic, analgesic, hypotensive, anti-inflammatory, and immune enhancing effects (Singh et.al., 1984, Whistler, 1985). It has attained significant economic importance worldwide in recent years through a variety of health and cosmetic products made from leaves and fruits. These include fruit juice as well as powders made from the fruit or leaves. However, scientific evidence or the research findings are limited.The history of published medical research on noni phytochemicals numbers only around a total of 120 reports which began appearing in the 1950s. Just since 2000, about 105 publications on noni have been published in medical literature, defining a relatively young research field. Nearly all noni research is at a preliminary stage, still in the laboratory as in vitro or basic animal experiments. Despite the large market for juice products and research developments, the nutrient and phytochemical profiles of noni have not been extensively studied.

Morinda citrifolia has been documented to contain a mixture of anthraquinones, organic acids, xeronine, several vitamins (such as beta-carotene, niacin, riboflavin, thiamine), some minerals, iron and calcium (Duke, 1992, Levand & Larson , 1979, Moorthy & Reddy, 1970).The potassium content is similar to that in tomato juice and orange juice. Some of the beneficial constituents of Noni include various terpene compounds, caproic and caprylic acids, vitamin C and alkaloids. However, Noni is most famous for the presence of an alkaloid proxeronine, which is believed to be a precursor to xeronine (Heinicke, 1985).

In order to obtain better understanding of the medicinal characteristics of the noni fruits and leaves, the biochemical profile and the mineral compositions of the fruits and leaves of the *M.citrifolia* is very important. The present study was conducted to study the biochemical profile and the mineral profile of the fruit and leaf of *M. citrifolia* plants present in different locality of these islands. The extent and pattern of mineral deficiencies/imbalances in plants vary in different agro-climatic condition as available mineral content in the green

vegetation depend on physical and chemical property of soil, soil erosion, cropping pattern, fertilizer/chemical application, species and genetic difference of plant, stage of maturity, presence of other mineral, etc. (McDowell et al., 1993). Studies on soil-plant relationship in respect of minerals are important and to understand the mineral uptake and the contents of the fruits and leaves the soil from the respective areas were also collected for micro and macro mineral analysis.

Materials & Methods

An extensive survey was made in South Andaman and as per the location of the tree various accessions were given and soil samples were collected by using maun cover (7 cm & 60 cm length) auger. The soil samples were air dried, powdered with wooden mallet and sieved through a 2 mm sieve. The sieved samples (< 2 mm) were analyzed for potassium (K), sodium (Na), calcium (Ca), magnesium (Mg), iron (Fe), copper (Cu), manganese (Mn) and zinc (Zn) content as suggested by Page et al., (1982).

The fruit qualitative parameters were determined by the method as described by Ranganna (1986). The TSS of the samples was estimated by hand refractometer. The fruit size and general appearance were estimated by metroglyph method and mature fruits of different accessions were washed and pulp was taken out with the help of knife and dried in an air circulatory tray drier at 60 ^{0}C for 48 h. Dried pieces were cooled and powdered in a heavy duty grinder. For analysis, the powder was sieved using a 60 mesh sieve and packed in 200 gauge high density polythene bags (Chavan et al., 1995). The quantitative estimation of minerals in fruits and leaves were carried out by using an atomic absorption spectrophotometer. The dry ashing method was followed for estimation of micro and macro minerals immature dried leaves (Jones et al., 1969).

Peptide profile by HPLC : Raw juice extracted from M. citrifolia fruits and leaves were prepared for estimation of the peptide profile. The peptide profile of the Morinda citrifoilia fruits and leaves water extract were studied by using high performance liquid chromatography (HPLC). The water extract of M.citrifolia fruits and leaves were prepared and filtered through 0.45 u membrane filter. The extract was run through HPLC column C-18 with mobile phase water and acetonitrinle in 0.1% trifluoroacetic acid (TFA) in gradient condition. The flow rate of the column was adjusted at 1 ml/min. The standard peptide mixtures were run through the column. The eluent A of mobile phase was a 0.1% by weight aqueous solution of trifluoroacetic acid (TFA) and eluent B was acetonitrile containing 0.1% by weight TFA. A fifty minute linear gradient from 0 to 30% B was run at a flow rate of 1 ml/min.

Mobile phase :

A – Water with 0.1 % TFA
B – Acetonitrile with 0.1 %TFA

Detector : UV- 210 nm
Column : Luna 5 u C-18 (2) (4.6X 250 mm)

Gradient :

Time (min)	B %
0.01	2
30	30
30.1	2
50	2

Results & Discussion

Physico-chemical properties of fruits

The total soluble solids (TSS) of the fruit were higher in JGH-5 followed by HD-6 while minimum was in accession SPG-2. Maximum ascorbic acid content was recorded in HD-6, followed by PBAY-7 (Table 1). The ascorbic acid ranged among all the accessions from 92.30 to 139.87 mg/100g. The fruit weight and juice was recorded maximum in HD-6 followed by PBAY-7 while minimum fruit weight was recorded in SPG-2. The minimum juice % was recorded in JGH-5. In overall quality of the fruit HD-6 was found to be the best among the various accessions. In the present study the various qualitative parameters are different from each other; this might be attributed to tropical humid and unique climatic conditions of Andaman & Nicobar Islands.

Minerals in fruits and leaves

As indicated in table 2 leaf and fruit powder of all the accessions was found quite rich in minerals like K, Ca, Mg, Fe, Cu and Mn. Maximum K was found in MEM-3 as 1182 ppm and minimum in SPG-2 (101 ppm) while on an average the potassium content was higher in leaf as 1390 ppm where as 935.9 ppm was recorded in fruit. Calcium, magnesium and iron content were recorded highest in HD-6 accession, and minimum calcium and iron was recorded in accession FF-8 while magnesium was lowest found in WAND-4. The copper and manganese content ranged from 2.13 to 28.5 ppm and 3.98-4.75 ppm respectively. However, the maximum copper content was recorded in WAND-4 as 28.58 ppm while minimum in SPG-2 as 2.13 ppm. In all accession the copper was at higher side in fruits (18.65 ppm) whereas in leaf it was recorded minimum as 6.7 ppm. However, manganese was higher in leaf as 23.4 ppm while in fruits it was just recorded as 4.21 ppm.

Peptide profile of leaf and fruits

The water extract of fruit and leaves were run in HPLC; C-18 column to study the peptide profile. The following di-peptide, tri-peptdie and pentapeptide profile were obtained such as Ly-Tyr, val-Tyr-Val, Meth-Enkaphalin, Leu- Enkaphalin and Angiotensin. The concentration of each peptide is presented in table 3. High level of tri-peptide Val-Tyr-Val was found in leaf extract (15.856 ppm). In the fruit the level of pentapeptide Leu-Enkepahlin (3.697 ppm) was found to be more. An enkephalin is a pentapeptide ending with either leucine ("leu") (Tyr-Gly-Gly-Phe-Leu) or methionine ("met") (Tyr-Gly-Gly-Phe-Met). Both are a product of the proenkephalin gene.Meth-Enkaphalin is an endogenous opiod neurotransmitter, neuromodulator, also enhances antibody response and immune system function and also function as growth factor (Beck et.al., 2001). Enkephalins play many roles in regulating pain.The peptide analysis of the *M.citrifolia* may be useful in studying various alkaloids present in the fruits and leaves and will be of use in studying the effect of Morinda extract in immune system regulation. Overall, the peptide concentration of the leaf extract was found to be more than the fruit extract except the Ly-Tyr which is more in fruit than in leaf.

Physico-chemical properties of soil

The physico-chemical properties of the soils revealed that the soils are of acidic in nature with pH varied from 4.6-6.1. The average organic carbon content of all the soils was recorded to be greater than 0.75 while the soil moisture varied from 18-23%. The mineral profile of the soil in general is reported to be more than the normal level in almost all the soil. Except the concentration of sodium and zinc the level of all other mineral were found to be in normal range (Table 4). The level of Zn was very low in all the soils except the soil of accession WAND-4(17.82 ppm) which was recorded to be very high. Very high level of mineral such as Ca, Mg and Fe was detected in almost all the soil. The maximum level of K was detected in soil of accession SPG-2 (151.1 ppm) while the lowest level was detected in soil of accession PBAY-7 (29.50 ppm). Overall, the level of all the micro and macro mineral profile of the soil was normal except for few minerals such as Na and Zn.

Nutrient analyses for a major brand of noni juice (Tahitian Noni Juice™, TNJ) were published in 2002 by the Scientific Committee on Food of the European Commission on Health and Consumer Protection (ECHCP). The report suggest that the whole fruit powder has excellent level of carbohydrates and dietary fiber, protein (12% DRI), low in fat (4% DRI).The macro nutrients is present in sparse amount. The pulp of the fruit is reported to contain high level of Vit.C, niacin (Vit. B3), Fe while K, Vit.A, Ca and Na present in moderate amount. In

the present study, the similar trend of micro and macro nutrients was obtained. The high level of ascorbic acid was obtained in almost all the accession. The average value was recorded as 113 mg /100g. Varieties in nutrient composition in leaf and fruit from one accession to another might be attributed to tropical hot and humid climatic condition prevailing in Andaman & Nicobar islands.

Table1: Comparison of Ascorbic acid content, TSS and Juice percentage of *Morinda citrifolia* fruits collected from different accessions (in ppm)

Accession	Fruit wt. (g)	Ascorbic acid (mg/100g)	TSS (^{o}brix)	Juice %
GAH-1	78.44	111.80	8.0	38.66
SPG-2	70.35	92.30	6.0	32.46
MEM-3	115.70	106.60	8.6	33.11
WAND-4		97.93	7.0	38.14
JGH-5	127.55	107.47	9.0	29.92
HD-6	163.99	139.87	8.7	60.25
PBAY-7	134.50	132.60	7.0	38.29

Table 2: Nutrient analysis in *Morinda citrifolia* fruits collected from different accessions (in ppm)

Accession	K	Ca	Mg	Fe	Cu	Mn
GAH-1	1174	52.14	167.53	29.13	27.13	4.15
SPG-2	101	45.73	162.54	20.98	2.13	4.08
MEM-3	1182	50.75	168.58	30.51	22.45	4.05
WAND-4	968	45.51	162.04	25.51	28.58	4.18
JGH-5	1175	46.25	165.00	25.19	25.20	4.06
HD-6	1226	58.89	196.64	42.44	2.44	4.75
PBAY-7	1158	48.51	185.13	35.41	25.42	4.09
FF-8	1048	42.25	171.54	29.53	22.41	3.98
Fruit Avg.	935.9	49.12	173.77	30.21	18.65	4.21
Leaf Avg.	1390	60.08	533	44	6.7	23.4

Table 3 : Peptide profile of the *Morinda citrifolia* fruit and leaf (in ppm)

Extract	Ly-Tyr	Val-Tyr-Val	Meth-Enkepahlin	Leu-enkephalin
Morinda fruit	1.04	0.114	0.865	3.697
Morinda leaf	0.705	15.856	4.135	1.307

Table 4: Major and micronutrient analysis in soil samples collected from different accessions of *Morinda citrifolia* growing areas (in ppm)

Accession	K	Na	Ca	Mg	Fe	Cu	Mn	Zn
GAH-1	98.00	55.30	6198.05	924.54	42.99	2.21	43.04	0.24
SPG-2	151.10	113.10	8409.36	899.82	18.48	0.30	82.88	0.59
MEM-3	52.20	24.80	5238.10	835.54	19.47	0.19	3.12	0.15
WAND-4	112.30	102.10	5158.25	953.10	89.06	2.61	77.04	17.82
JGH-5	72.00	48.10	3388.11	922.15	24.84	3.86	56.13	1.28
HD-6	66.30	49.30	6238.30	913.04	40.98	2.13	62.30	0.98
PBAY-7	29.50	23.50	9096.99	830.35	10.54	2.87	54.85	2.36
FF-8	55.70	28.00	1924.59	818.11	63.55	1.48	34.88	1.04
Avg.	81.77	58.08	5667.333	886.78	40.951	1.97	50.024	4.24
Range	29.5-151.1	23.5-113.1	1924.59-9096.99	818.11-953.1	10.54-89.06	0.19-3.86	3.12-82.88	0.15-17.82

World Noni Research Foundation

With the mission of educating the people, the World Noni Research Foundation, a non-profit organisation dedicates itself to love and care for *Morinda citrifolia.,* through research and development. Learning from the wisdom of the simple people, WNRF aims at working with everyone to conserve and improve Noni towards sustainable human and ecological health. It will share the Noni's past glory, ethnobotany, history, science, benefits and its multiple uses with all. The INRF also serves as a facilitatory body for all Noni farmers, industries and consumers to establish a sustainable Noni economy network. The WNRF collectively represents the interests of all people in the Noni research and industry. It is an independent body and committed to exclusive Noni research and development. The WNRF website, journals and news letters are established to provide a non-biased forum for the researchers, consumers and industries to publicise their research findings and experiences with *Morinda* species.

WNRF believes that this synergistic effort of scientists and people of 'Noni Solidarity' would empower millions of ordinary masses to find their dignity and economic freedom, more naturally. This will lead to the realization of our vision "Healthy people, Healthy nation" in India and rest of the world.

Our Programmes Focus on

- Conserving the *Morinda* species in India and rest of the world from its degradation.
- Organising "Noni Biodiversity Action Network" (NBAN) to save endangered (Red listed) *Morinda* species in the above regions.
- Developing Bioinformatics database on *Morinda* species existing in India and rest of the world and record all Indigenous Technical Knowledge about it.
- Supporting the research and development programmes on discovering the multiple potential of *Morinda* species in fields like pharmaceutical, nutraceutical, cosmetology, dye, agriculture, etc.
- Sharing the cutting edge action-programmes and research findings with researchers, farmers, consumers, food industry leaders, health - drug industry leaders, students and masses.
- Connecting the *Morinda* species researchers in India and rest of the world.
- Promoting the Indian Noni for health regenerative systems and processes through clinical studies & biotechnological research.
- Developing "Noni Villages" for Noni based socio-economic development of people at the grass-root level.
- Monitoring and encouraging quality *Morinda* products in the Market.
- Regenerating the glory of Indian Noni

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INSTRUCTIONS FOR AUTHORS

AIMS AND SCOPE

International Journal of Noni Research (IJNR) publishes original research and review articles on all aspects on Noni (*Morinda citrifolia* L.) and other species of *Morinda*. All submissions will be reviewed by the editorial board or by external references. The journal covers: diversity, cultivation, phytochemistry and clinical research, etc. related to Noni.

Three categories of paper will be considered for publication in IJNR.

1) Reviews
2) Full-length papers
3) Short communications.

SUBMISSION OF MANUSCRIPT (HARD AND SOFT COPY)

Authors are advised to submit their manuscripts along with a covering letter to the Editor, International Journal of Noni Research, 64, Third Cross Street, Second Main Road, Gandhi Nagar, Adyar, Chennai – 600 020.

E-MAIL SUBMISSION

Authors are encouraged to submit their manuscripts via e-mail as attachment file to the E-mail ID : mail@worldnoni.com (A cover letter to be sent with the manuscript).

PREPARATION OF MANUSCRIPT

Two typed copies of manuscripts using MS Word should be submitted. They should be typed on one side of the paper only, double-spaced with 1.2" margins in all the sides. All pages should be numbered.

All the accepted articles will be subjected to editorial revision. A singed statement from all the authors should be accompanied with the manuscript saying that

1. the content of the article has not been published in whole or in part elsewhere
2. the article is not currently being considered for publication elsewhere
3. all necessary ethical safeguards have been met regarding patient and animal experimentation, etc.

FULL-LENGTH PAPERS

There is no page restriction on overall length of article. It should be divided into

1) Abstract (100- 200 words) followed by up to six keywords
2) Introduction
3) Materials and Methods
4) Results
5) Discussion
6) Acknowledgements
7) References

Results and Discussion may be combined. Title page should be prepared in a separate sheet, which should provide the title of paper, name(s) of the author(s), name(s) and address of the institution(s) where the work has been carried out and details of the corresponding author with telephone and fax numbers and e-mail ID.

SHORT COMMUNICATIONS

It should be up to 10 double-spaced manuscript pages with a short summary of 50 words. Short communications should not be divided in to different headings. However, headings can be used for Acknowledgements and References. Figures and Tables should be restricted to a maximum of 2 each. All other style should be as for Full-length papers.

FIGURES AND TABLES

Figures, figure legends and tables should be typed on a separate sheet and numbered consecutively in Arabic numerals. Photographs should be sharp with glossy prints. Micrographs, etc. should include a bar marker to provide an internal measure of scale or magnification should be mentioned in each microscopic photograph.

REFERENCES

References in the text should be cited as follows

Single author: Surendiran (2004) or (Surendiran, 2004)

Two authors: Surendiran and Mathivanan (2005) or (Surendiran and Mathivanan, 2005)

Three or more authors: Mathivanan et al. (2006) or (Mathivanan et al., 2006)

Where two or more than two references are quoted consecutively in the text, chronological order should be followed. If the references are within a year, alphabetical must be followed. Where references are made to papers by the same author(s) in the same year, it should be followed by a, b, c, etc.

References must be listed alphabetically by the name of the authors at the end of the manuscript. The following style must be followed to cite the references

Journal articles

Abbott, I.A. 1985. The geographic origin of the plants most commonly used for medicine by Hawaiians. Journal of Ethnopharmacology 14: 213–22.

Surendiran, G. and Mathivanan, N. 2006. Antifungal activity of *Morinda citrifolia* and *Morinda pubescens*. International Journal of Noni Research 2: 18-23.

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Books or monographs

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