

Noni: The Complete Guide

for Consumers and Growers



**Scot C. Nelson
and
Craig R. Elevitch**

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Publisher: Permanent Agriculture Resources (PAR), PO Box 428, Hōlualoa, Hawai'i 96725, USA;
Tel: 808-324-4427; Fax: 808-324-4129; E-mail: par@agroforestry.net; <<http://www.agroforestry.net>>.

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ISBN 0-9702544-6-6

Library of Congress Control Number: 2006903347

Printed in China through Colorcraft Ltd., Hong Kong

First edition July 2006

Recommended citation: Nelson, S.C., and C.R. Elevitch. 2006. Noni: The Complete Guide for Consumers and Growers. Permanent Agriculture Resources, Holualoa, Hawaii.

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Main cover photo: Many thanks to noni models (left to right) Olivia, Wailana, Shauncey, and Mako for helping out with this photo. PHOTO: C. ELEVITCH **Title page photo: A healthy noni fruit.** PHOTO: S.

NELSON

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PREFACE

In 2003 we collaborated on a publication about noni for the Traditional Tree Initiative, a project to promote the native and traditionally important species of the tropics. Of the 80 species covered by the project, including such popular species as mango, citrus, banana, and coconut, our profile on noni has consistently been the most requested. Due to the popularity of that noni publication, we felt that noni deserved a more extensive treatment, and this book came to be.

Our purpose was to give a well-rounded view of noni, its medicinal and nutritional features, environmental roles, horticulture and management, botany, and historical roles in human societies. People have formed a long and profound relationship with noni for hundreds, if not thousands, of years. We are mindful that much of the traditional knowledge about noni accumulated by Pacific islanders has been lost, or is not available to us. At the same time, scientific noni research is in its fledgling stages, with much work to be done. Recognizing that as individuals and as a society, we are just beginning to learn about noni in both its historical and modern contexts, we have taken a cautious approach to claims of medical efficacy. We hope that this book strikes a balance between time-tested traditional knowledge and modern, fledgling scientific findings.

This book could have had the title “Noni for Everyone,” as it embodies our personal commitment to

sharing knowledge. We believe that noni (and many other plants) will be increasingly recognized for their role in both human and environmental health. The book begins by presenting both historical and modern views of noni’s nutritional and medical aspects and a consumer guide to noni products, which will likely have the most interest to the widest audience. The book then describes the environmental roles of the tree, encouraging people to value and protect native populations. It goes further to show how to propagate, plant, and maintain noni. For those interested in producing their own noni products, insights into processing and a how-to guide to home production are also included. In short, we hope that this book will empower people to be involved with noni at whatever level they choose.

Noni is a beautiful tree that fills many environment roles and provides numerous products for people. While writing this book we were always aware that noni is only one of hundreds of tropical plants with ethnobotanical importance. We encourage you to keep sight of noni as one of an essential cadre of plants for medicine, environmental restoration, and urban landscaping.

Scot C. Nelson
Craig R. Elevitch
Island of Hawai‘i
May 31, 2006

ACKNOWLEDGMENTS

We have numerous people to thank for their input to this book. Helen Russell gave extensive comments and corrections to several chapters, and we are grateful for her input. We thank Julia Rosekrans, Brian Issell, and Jay Ram for reviewing critical chapters and keeping our treatment balanced and accurate. Jacqui Wright contributed her wide knowledge about pests and diseases of noni in the Pacific. Lisa Raymond consulted on the use of noni as a dye plant and generously contributed a photo of her work. Eileen Herring helped with research on noni patents. Barbara Fahs contributed three recipes to the Consumer chapter. Kumu Keala Ching very kindly arranged the cover photo with some of his students as models, who were gracious and patient subjects. Trisha Fernandez and her kids Kama and Makana were fun and willing photo subjects. Photo contributions by Fred Brooks and Mark Bonin are gratefully acknowledged. Alvis Upitis generously provided art direction and photographic guidance. We thank Dale Evans for editorial advice and support.

The authors are deeply appreciative for the information shared over the years by colleagues and friends that has been incorporated in this book. Many thanks to:

The noni farmers of the Pacific for providing access to their farms and sharing information. Keikialoha Kekipi for sharing knowledge of noni and Hawaiian practices. Will McClatchey for sharing his extensive knowledge of noni through the years. Jay Ram and Matt Archibald for sharing a wide range of noni data and information. Michael Harvey and Alan Yoza for sharing production and nutritional information and for providing farm access to study diseases. Edgar Cocker of Rota for noni processing information. Stéphane Ricard for sharing noni nutritional data. Mike Zelko for providing information on noni seed scarification. Zach Gibson for consultation and farm ac-

cess regarding noni processing and pests and diseases. Jim Currie, Jim Hollyer, and Mark Bonin for supporting Scot's noni workshop in Rota. Fred Brooks and Don Vargo for supporting Scot's noni workshop in American Samoa. Singeru Singeo, Flordeliza and Raul Javier, and COM-FSM for supporting Scot's noni research in Pohnpei. The USDA and other entities for providing grant funds for noni workshops and research. Margarita Hopkins and the Hawai'i County Department of Research and Development for funding the 2002 Hawai'i Noni Conference, and all of the speakers and trade show representatives who participated in the conference. Uncle Sim Rodriguez and the Backyard Noni Group for constant support and for helping with the 2002 Hawai'i Noni Conference. Herb Moniz and Roseanna Kanoa for access to their processing facility, hosting a workshop, and sharing production information. Cheryl Jones for research assistance. The Pacific Islands Noni Association for information about quality control in noni processing. Mel Jackson and the Hawai'i Agricultural Research Corporation for collaborating on noni research. The Hawai'i Department of Agriculture for funding noni research. The University of Hawai'i for sponsoring noni information extension, noni medical research, and other noni-related activities.

Finally, we thank the authors of popular noni books, who have raised public awareness about noni. Thanks also to commercial noni producers and retailers for spawning the noni industry worldwide.

Noni: The Complete Guide



Wild noni tree, South Kona,
Hawai'i. PHOTO: C. ELEVITCH

HISTORY, LORE, AND ETHNOBOTANY

The Ring of Fire

The Ring of Fire is an arc of seismic activity stretching from New Zealand along the eastern edge of Asia, north across the Aleutian Islands of Alaska, and south along the coast of North and South America. The Ring of Fire is located along the volcanically active edge of the Pacific Plate where it meets other tectonic plates. The Ring has over 75% of the world's active and dormant volcanoes. The plates are like giant rafts of land mass on the earth's surface which often collide with or slide underneath each other (subduction). This process creates earthquakes, volcanoes, and has led to the formation of many of the Pacific islands.

Noni evolved among the tropical islands in the vicinity of New Guinea. These islands were created by the collision of the Indo-Pacific Plate and the Pacific

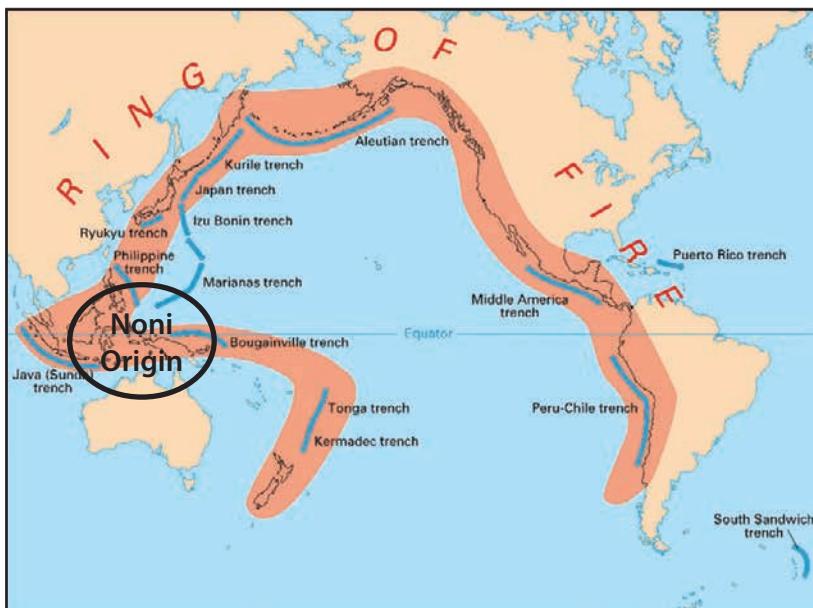
Plate (see map). Noni and volcanism were inseparably linked in this early period, for noni is one of the first and only plants that can readily colonize new lava flows. The area of the world where noni evolved is famous for the spectacular diversity of its flora and fauna. Before contact with humans, noni seeds were probably dispersed among new volcanic islands by ocean currents carrying noni seeds. Huge rafts of floating pumice ejected from violent eruptions have also carried seeds or surviving plant fragments long distances.

Noni and human migration

By about 50,000 years ago, hunter-gatherer societies inhabited noni's geographical epicenter, the region of Northern Australia and New Guinea. It is quite likely that these people encountered and perhaps even used noni, but we have no data about this. Noni probably has been used by humans for at least 5000 years and perhaps much longer.

About 3200–3600 years ago, the migrations of the Lapita cultural complex spread from New Guinea to Fiji, Samoa, and Tonga, which is where Polynesian culture first developed. Samoan and Tongan voyagers settled the Cook Islands, Marquesas, Tahiti-nui, and Tuamotos at least 2300 years ago. Easter Island was discovered by the Polynesians around 1700 years ago or earlier. Hawai'i (about 1600 years ago or earlier) and New Zealand (about 1000 years ago) were some of the last Pacific islands to be colonized by the Polynesians.

Wherever these voyagers went they car-



The Ring of Fire, showing the proposed geographic center of origin for noni (*Morinda citrifolia*). MAP: U.S. GEOLOGICAL SURVEY

ried with them the plants they needed to survive and flourish, reportedly about 70 species in all. Noni was one of these “canoe plants.” Therefore, the history of the spread of noni throughout the Pacific is told by the sequential colonization of new lands by the Polynesians.

Noni reaches Europe

In the 1760s, a sturdy sailing ship returned home to Sweden carrying botanical samples of unknown plants collected from a long and arduous journey to the Pacific Ocean. The cargo was precious and unique: thousands of carefully preserved botanical specimens from the New World. Samples of leaves and flowers had been pressed and dried, and given names during the journey by students of a prominent Swedish botanist, Carl Linnaeus.

Linnaeus popularized a new system for naming, ranking, and classifying organisms that is still in wide use today (with many changes). He sent his students out on trade and exploration journeys to all parts of the world in order to collect plant samples. Linnaeus and his team were the first to collect a large number of interesting and unusual tropical plants in the Pacific and Australia. Upon their return, the plants were described, named, and classified using Linnaeus’ classification system.

The Linné Herbarium at the Swedish Museum of Natural History preserves some of Linnaeus’ original plant specimens, including noni. Linnaeus gave noni the name *Morinda citrifolia*, its universally recognized botanical name.

The modern globalization of noni

Even though the Swedish botanist Linnaeus cataloged noni, it remained a relatively obscure medicinal plant for the next 200 years or more. Noni became well known worldwide in the 1980s, when

Table 1.1. Twenty-seven Polynesian canoe plants and their primary uses (after St. John and Jendrusch).

1. **Sugarcane**, *Saccharum officinarum* (food, medicine, religion)
2. **Bamboo**, *Schizostachyum glaucifolium* (knives, kapa stamps)
3. **Coconut palm**, *Cocos nucifera* (food, cordage)
4. **Giant swamp taro**, *Alocasia macrorrhiza* (famine food)
5. **Taro**, *Colocasia esculenta* (principal food plant)
6. **Ti**, *Cordyline terminalis* (food, medicine)
7. **Polynesian arrowroot**, *Tacca leontopetaloides* (food, medicine)
8. **Yam**, *Dioscorea alata* (food)
9. **Bitter yam**, *Dioscorea bulbifera* (famine food)
10. **Finger-leaf yam**, *Dioscorea pentaphylla* (famine food)
11. **Banana and plantain**, *Musa* species (food, food preparation)
12. **Turmeric**, *Curcuma domestica* (dye, purification)
13. **Wild ginger**, *Zingiber zerumbet* (scenting, medicine)
14. **Kava**, *Piper methysticum* (relaxation, ceremony)
15. **Breadfruit**, *Artocarpus altilis* (food, craft)
16. **Paper mulberry**, *Broussonetia papyrifera* (kapa and clothing)
17. **Polynesian cress**, *Rorippa sarmentosa* (food, medicine)
18. **Fish poison plant**, *Tephrosia purpurea* (fish stupefaction and poisoning)
19. **Candlenut tree**, *Aleurites moluccana* (lighting oil, food, craft)
20. **Beach hibiscus**, *Hibiscus tiliaceus* (fire making, canoes, medicine, fertilizer)
21. **Portia tree**, *Thespesia populnea* (calabashes)
22. **Beauty leaf**, *Calophyllum inophyllum* (calabashes, garlands/leis)
23. **Mountain apple**, *Syzygium malaccense* (food, craft)
24. **Sweet potato**, *Ipomoea batatas* (food, leaf vegetable, starch)
25. **Kou**, *Cordia subcordata* (calabashes)
26. **Noni**, *Morinda citrifolia* (medicine, dye, famine food)
27. **Bottle gourd**, *Lagenaria siceraria* (storage containers, musical instruments)

scattered researchers began looking more closely at noni’s chemical constituents. By 2005, noni’s popularity had reached global proportions. This ancient canoe plant has literally arrived on all shores.

Myths and lore

Most of what we know about noni, its lore and history among societies, derives from the age-old oral traditions of some Polynesian and Melanesian societies in Hawai‘i, Tahiti, Samoa, Tonga, Fiji, and many other island nations scattered throughout the region. Apparently, the plant does not feature very prominently in the legends and mythologies of these peoples, even though it was widely used. More immediately life-sustaining, nutritious foods such as



Example Polynesian canoe plants. Top row: banana; pandanus; breadfruit and coconut for sale in market. Middle row: wild ginger; noni; paper mulberry. Bottom row: sugarcane; candlenut; mountain apple. PHOTOS: C. ELEVITCH

banana and taro have mythologies that are closely linked with human creation accounts. What we do know about noni traditions was collected and recorded mainly by ethnobotanists who interviewed local healers who received the knowledge orally.

Polynesian hero and heroine myths

There are a number of Polynesian stories of heroes and heroines who encountered great famine and survived by eating noni.

Hawaiian mythology—the pig god battles the volcano goddess

There is a tale of the Hawaiian pig god, Kamapua‘a, who taunted Pele the volcano goddess with the following chant.

*I have seen the woman gathering noni,
Scratching noni, Pounding noni.*

According to the legend, this derisive chant referred to Pele’s red eyes (and alluded, apparently, to the fact that noni roots were used to make red dye), and the

taunt was derogatory enough to cause Pele to plunge into battle with the pig god.

Tongan mythology—a god arises from the dead

Most ancient societies have myths about the death and subsequent resurrection of gods who appear in human form. The myths are used as allegory to explain how mortal bodies can be resurrected as immortal spiritual bodies through the process of enlightenment. An old Tongan myth tells of the god Maui being restored to life by having the leaves of noni placed on his body.

Tahitian mythology—the origin of the noni plant

The Tahitians say that the first noni plant was produced from ear wax, because they made a bright yellow dye from the plant.

Noni and “that which is hidden”

All societies throughout history have a tradition of hidden knowledge that is reserved for initiates. The relationship between noni and esoteric knowledge of spiritual and medical matters is exemplified by the Hawaiian culture, in particular by the *kahunas*. A *kahuna* is a highly specialized expert with considerable skill in physical or spiritual diagnosis and pharmacology. *Kahunas* were teachers and caretakers of an ancient body of philosophical, medical, and spiritual knowledge called *huna*, which translates into “that which is hidden.” This is what we call esoteric knowledge, available only to specialized initiates as opposed to knowledge that is available to all. The knowledge about noni and similar plants was very highly regarded and carefully guarded. The Hawaiians considered this knowledge of the healing power to be among their most valued capacities. The Hawaiians used secret chants, prayers, and incantations to augment their expertise with noni.

Traditional uses of noni

The oral tradition

Most of what we know about the ancient and tradi-

tional uses of noni comes from an age-old oral tradition of passing important knowledge from generation to generation, and the handful of ethnobotanists who recorded some of the information through conversations with healers. Knowledge about how to use the plant and what to use it for was held and passed down mainly by the healers. The practice of healing was considered a sacred occupation, and was guarded from common use.

Much of the ancient knowledge may have been lost. Some of what remains is public knowledge, although there is still knowledge about noni and many other plants that remains closely guarded by living caretakers of traditional knowledge.

The plant with many uses

Ancient societies turned to noni and other plants for many of their needs, ranging from the mundane to the life-sustaining to the spiritual. Proof of noni’s status as a critically important plant can be found in the stories of the ancient Polynesians. The Polynesians considered noni to be important enough to intentionally take it to new lands in the Pacific and plant it near their settlements. Here we describe some of the best-known ancient and traditional uses of noni. Many of these applications are still in use among indigenous peoples throughout the tropics.

Here are the essential components of a complete and functioning society that are met to some degree by noni.

- Fire
- Tools
- Weapons
- First aid
- Clothing/fabrics
- Fodder
- Human food
- Curative or advanced medicine
- Spiritual medicine

Marooned!

In a sense, the human race is marooned on a small island in a vast sea of space. The island is called Earth. On this island, we depend on plants for survival. The existence of the human species is made possible by our intelligent use and understanding of the plant kingdom. On a smaller and more literal scale, this is also true for islands in the tropics as well.

Imagine that you are shipwrecked and marooned on a remote, uninhabited island in the Pacific Ocean. In order to survive you will need water, food, first aid, fire, and tools. You are injured, thirsty, hungry, afraid, and desperate.

Hardly able to move, you stretch your arm across the rocky beach and grab onto an odd-looking, lumpy, soft, smelly, yellowish fruit at the base of a tree growing on the beach. You hold

the fruit to your parched lips; the cool liquid seeps from within, quenching your thirst. You notice immediately that the pain of your cracked lips is eased. You eat the whole fruit and fall asleep, wondering briefly if the odd fruit has sedative properties.

You awake feeling refreshed. You drag yourself to the shade of a coastal tree with large, green, glossy leaves, and stinking fruit. You pick up more of the fruits and rub a ripe one on your injured leg; the pain subsides and the wound tingles with healing energy. You notice a fruit with the tooth marks of a rat, and you think of spearing one of the pests with a stick from this strange tree and roasting it over the coals of a fire made from its wood.

After locating a piece of sharp, angular basaltic rock, you lash the stone to a stem of this tree and secure it with strong grasses, making a temporary

axe for construction and self-defense. You use sticks from the plant to dig holes. You find much later that when you grind the seeds of this plant between rocks and apply the mixture to your scalp, the troublesome lice are finally repelled. It occurs to you that this odd plant could well have saved your life.

The plant's leaves and fruits sustain you until the island's vegetation can recover from the effects of the storm that sank your ship and also blew down most of the trees on the island (but not this odd plant). You recognize that the plant (and there are many of them along the coast) can provide for you a renewable supply of many things required for your immediate survival.

This odd plant that saved your life is noni, one of the outstanding multi-purpose plants used by man.



PHOTO: C. ELEVITCH

Noni can be seen as a survival plant for tropical islands.



Traditional Samoan mixed farm filled with useful plants such as coconut, breadfruit, banana, yam, noni, and many others.

Plant survival kit

Canoe plants were life-sustaining plants, fruits, and seeds carried carefully in canoes by Polynesian seafaring explorers and colonizers around the Pacific. For example, the first Hawaiians brought important plants with them when they arrived in Hawai'i 800 years or more ago. Polynesians planted canoe plants such as breadfruit, taro, and banana near their set-

tlements and relied on them for survival. The canoe plants filled many society needs, including food, fiber, medicine, tools, clothing, and fodder. Many of these plants, such as sugarcane and noni, served multiple functions as food and medicine or as tools, shelter or fire. Others, such as kava, were mainly medicine plants or used ceremonially rather than for food.

Fire

Fire is one of man's most basic and universal needs. Tropical societies used noni wood as fuel wood for cooking fires.

Tools

The ability to make tools from materials in the environment enabled many ancient societies to flourish. Every society can use convenient and renewable source of high-quality woods to make tools and to

construct buildings. Noni wood was used to make canoe paddles, digging implements, and other hand tools. Noni wood was also used in fashioning weapons such as for axe handles.

First aid

Preventing sickness and loss of life helps to keep a society strong. Noni leaves and fruits were used as immediate first aid treatments for cuts, bruises, burns, and broken bones. Noni served a dual role of helping to promote healing and to relieve pain.

Clothing/fabrics

Fabrics are essential to societies for clothing and other purposes. Virtually all societies dye their fabrics in some way. Very important red and yellow dyes for tapa cloth were made from noni by many indigenous societies.

Fodder

Most societies utilize animals for food, transportation, or work. Noni fruits and leaves are a good supplement to ruminating animals' diet (pigs, for example).

Human food

Island or seafaring societies in the tropics are faced with destructive hurricanes and tidal waves. These calamitous events can destroy most of the plant life near or on the coastline. Famine often follows such events and until the vegetation can recover, people need something to eat. Noni fruit and leaves filled

this role as a “famine food” plant. It was not particularly delicious or nutritious, but it could sustain life.

Curative or advanced medicine

Societies all over the globe have a long established healing tradition of using noni as one of their most important medicinal plants. The specific medical uses of the plant, what plant parts are used, and how they are used vary among tropical societies. The importance of the plant also varies among societies. Nevertheless, the plant is so widely used for medicine that this may be considered its most important function. As a medicine, healers often mixed noni with other herbs to render medicines. Healers commonly combined herbs in specific amounts and mixtures to affect more complete cures of complex problems. Herbal treatments together with spiritual healing or god supplication activities was probably more common than using herbs such as noni alone.

Tapa

Tapa is a bark cloth made from the paper mulberry tree (*Broussonetia papyrifera*) in many of the Pacific islands. Paper mulberry is native to Eastern Asia and Polynesian seafarers brought it to the Pacific islands on voyages of migration. Noni dyes are often used to color tapa cloth in reds and oranges.

A generic tapa-making process

- Strip bark from tree
- Sun-dry the bark
- Beat bark on wooden anvil with wooden mallet
- Place beaten bark against a dyed, carved wooden block to apply traditional patterns in bands
- Dry the cloth
- Dye the cloth and/or decorate with a brush or design carved in a wooden stamp.

Tapa patterns are beautifully geometric with interesting plant and animal motifs, and are

culturally distinct among island nations. Polynesians use the cloth mainly for clothing. Tapa makes a prized wall decoration also.



Various shades of noni-dyed tapa cloth. PHOTO: C. ELEVITCH, SAMPLES COURTESY L. RAYMOND

Table 1.2. Some traditional uses of noni

Plant part	Preparation	Use
Leaf	Fresh	Wrap and flavor meat for cooking, livestock fodder, silkworm food, topical burns, headaches, fever, ghost medicine
	Tea	Malaria, fever, pain
	Poultice	Tuberculosis, sprains, deep bruising, rheumatism, sciatica, fever, stings from stonefish, bone fractures, dislocations
	Extract	Hypertension, bleeding caused by a bone puncture, stomach ache, fractures, diabetes, loss of appetite, urinary tract ailments, abdominal swelling, hernias, vitamin A deficiency
	Vapor of broken leaves	Sties
Fruit	Unripe	Sores or scabs around or in the mouth, ghost medicine
	Ripe	Famine food, sore throat gargle (mashed), peeling or cracking of the toes and feet (crushed), body or intestinal worms, cuts, wounds, abscesses, mouth and gum infections, toothaches, appetite and brain stimulant, pig food
	Poultice	Boils, carbuncles, tuberculosis, sprains, deep bruising, rheumatism
	Oil	Stomach ulcers
	Extract	Hypertension
Stem	Wood	Canoe parts, paddles, axe and adze handles, digging sticks, firewood, red pigment
	Decoction of bark	Jaundice
	Wood or bark extract	Hypertension
Seed	Oil	Scalp insecticide, insect repellent
Flowers		Sties
Roots	Wood	Carving
	Bark	yellow pigment
	Juice	Badly infected cut
All parts of the plant		Mild laxative

* The information in this table was gathered from a comprehensive review of published ethnobotanical literature about *Morinda citrifolia*.

NUTRITION AND CHEMISTRY

This chapter provides nutrition facts for some popular noni products: 100% fruit juice, fruit powder, and leaf powder. By “nutrition facts” we mean the chemical elements and vitamins commonly found on grocery product nutrition labels and which are commonly of interest to consumers and health care professionals. Many other chemical compounds that are found in noni are also covered. This information is provided as a reference source that health professionals and consumers can use to assess nutritional issues related to noni.

Noni as a nutritional supplement

Most plant-based supplements such as noni are sold as nutritional supplements in order to comply with government labeling regulations, even though many people consume noni for the medicinal benefits they believe it has. It is sold in the U.S. and New Zealand as a nutritional supplement, in the EU as a novel food (recently introduced food), and in Australia as a food. In other words, noni is marketed in many places as a nutritional supplement without making explicit claims of any medicinal value.

The nutrition data presented here are representative for their respective products. Variation in data is expected between different sources of noni products.

Like many other products labeled as nutritional supplements, noni has modest nutritional value. As shown in Table 2.1, noni juice is roughly comparable to apple juice in its nutritional analysis, although it

Table 2.1. Comparison of basic nutritional aspects of noni juice and apple juice.

per 31 g (about 1 fl oz)		
	Noni juice	Apple juice
Calories	4.8 (20.3 kJ)	15 (63.4 kJ)
Calories from fat	0	0
Total fats (g)	<0.1	0.3
Cholesterol (mg)	N/A	N/A
Sodium (mg)	3.3	1
Total carbohydrate (g)	1.0	3.6
Dietary fiber (g)	<0.2	~
Protein (g)	0.13	0.02
Vitamin A (IU)	<3	~
Vitamin C (mg)	10.4	12.9
Calcium (mg)	3	2
Retinol (IU)	<5	~

Noni data provided compliments of the Hawai'i noni industry. The values for apple juice are obtained from Calorie-counter.com.

is somewhat lower in calories. People normally do not consume noni or similar herbal supplements to satisfy their basic dietary requirements (vitamins, minerals, calories, etc.), but rather to provide their bodies with chemistry they think might help ward off or heal infections and diseases.

Noni juice

A complete nutritional analysis of pure noni juice (Table 2.2) reveals that it is a fairly good source of vitamin C and other antioxidants (see this chapter's “Chemical constituents” section). Like some other fruit juices, it is relatively high in potassium (K), as shown in Table 2.3. Potassium is associated with many health benefits, and noni is a good source of the essential mineral potassium. Potassium promotes healthy heart rhythm, muscular contraction, nerve

Table 2.2. Nutritional analysis of 100% Hawaiian noni juice, conducted in May 2005 by an analytical laboratory.

per 100 ml (3.4 oz)	
Dry matter	7.6 g
Water	94.8 g
Fat	<0.1 g
Total protein	0.5 g
Ash	0.4 g
Total dietary fiber	0.6 g
Sucrose	1.3 g
Glucose	1.5 g
Fructose	1.5 g
Carbohydrates	6.0 g
Calories	27 (113 kJ)
Sodium (Na)	9 mg
Potassium (K)	150 mg
Calcium (Ca)	6 mg
Magnesium (Mg)	11 mg
Iron (Fe)	0.4 mg
Phosphorous (P)	10 mg
Chloride (Cl)	62 mg
Vitamin B ₁	0.006 mg
Vitamin B ₂	0.035 mg
Vitamin B ₆	<0.05 mg
Vitamin B ₁₂	70.0 micrograms
Panthenothenic acid	0.169 mg
Niacin	0.194 mg
Biotin	4.07 micrograms
Folic acid	11.4 micrograms
Ascorbic acid	53.2 mg
Vitamin E (total)	0.05 mg
Beta-carotene	<0.0005 mg
Total carotene	0.0035 mg
Acidity	pH 3.43

Data compliments of HawaiiPhytomedicine.com

Table 2.3. Potassium content comparison for various fruit juices.

Per 6 fl oz (177 ml) serving	
	Potassium (mg)
Prune juice	530
Orange juice	354
Tomato juice	400
Noni juice	390–555

Data source: Higdon 2004



Juice is the most popular way to consume noni. Other consumable products include whole fruit powder (including seeds), and seedless fruit powder. PHOTO: C. ELEVITCH

function, energy production, and fluid balance. Insufficient potassium is associated with fatigue, muscle weakness and spasm, and insomnia. According to the Food and Nutrition Board of the Institute of Medicine of the National Academies, adults should consume at least 4.7 grams of potassium per day to lower blood pressure, minimize the effects of salt, and reduce the risk of kidney stones and bone loss. However, most American women 31–50 years old consume less than half of the recommended amount of potassium, and men’s intake is only moderately higher. Incorporation of noni in one’s diet could help correct this deficiency. People with renal problems need to be aware of their potassium intake from all foods and supplements, including noni.

Noni juice is low in protein, calories, and fat, and has no cholesterol. Aged juice is usually very acid-

ic, about as acidic as lemon juice. It provides trace amounts of many elements.

Noni fruit powder

Noni fruit powder is consumed directly or mixed into a beverage. Encapsulated noni fruit powder is widely available and usually sold as a nutritional supplement. One type of noni fruit powder is made from the whole fruit including the seeds, usually by sun-drying (the fresh fruit is sliced and placed on wire mesh to dry in the sun). Another type of noni fruit powder is made from seed-free noni juice or noni pulp, by low-heat dehydration, or freeze drying. The drying ratio of seedless fruit pulp to dried powder is about 26 to 1. For powder made from the whole fruit including the seeds, the ratio is about 9 to 1. This means that seed-free powder is about three times more concentrated than whole fruit powder containing seeds. Based on research at Southern Cross University in Australia, 30 ml (about 1 oz) of pure noni juice was roughly equivalent to 3 grams of whole fruit powder with seeds, and 1 gram of seed-free powder. This has implications for the encapsulated noni market, which to date has not stated the equivalency conversion between juice and powder servings. For noni capsules (whole fruit with seeds) that contain 500 mg, the recommended serving or dosage is six capsules per day. For seed-free capsules, the recommended serving is about two capsules per day. This is based on the industry standard recom-



Noni fruit powder is usually sold in capsules or sometimes in bulk form for reconstituting as juice or for mixing in other products. PHOTO: S. NELSON

Table 2.4. An analysis of selected nutritional aspects of Hawaiian fruit powder.

per 100 grams	
Protein	5.8%
Fat	1.2%
Moisture	9.3%
Ash	10.3%
Carbohydrate	71%
Total dietary fiber	36%
per 1200 milligrams	
Protein	69.6 mg
Fat	15.5 mg
Carbohydrate	843 mg
Total dietary fiber	419 mg
Calories	3
Vitamin A	2.26 IU
Vitamin C	9.81 mg
Niacin	0.048 mg
Thiamin	~
Riboflavin	~
Iron	0.02 mg
Calcium	0.88 mg
Sodium	2.63 mg
Potassium	32.0 mg

Data provided compliments of the Hawai'i noni industry.

mendation of 1 oz (about 30 ml) of pure noni juice per day, although this standard is apparently not based on any published evidence in the scientific literature and should be taken as a guideline only.

In addition to encapsulated forms, fruit powders are used to make reconstituted noni juice products as well as some cosmetics such as bar soap. They are also used to make tea.

Noni fruit powder can be a source of selenium and manganese and provides some zinc and boron. Analysis of dried fruit reveals mainly carbohydrate (71%) of which about half is dietary fiber (36%). However, a serving (1500 mg) makes up less than 1% of the recommended daily intake of carbohydrates and fiber. Noni fruit powder has very few calories (only 3 per serving) and is a relatively good source of vitamin C.

Noni leaf powder

Leaf powder is used in teas or made into encapsulated nutritional supplements. In Korea the powdered

leaves are mixed with powdered garlic and made into pills referred to as “healthy kidney” pills. Noni leaves are a good source of calcium.

Drug interactions and contraindications

Health care professionals and consumers want to know if a nutritional supplement poses any risk of interference with their existing drug or food therapies. No negative drug interactions or contraindications have been reported for noni. If potassium should be restricted in your diet, please consult a physician about using noni.

Consumption guidelines

There are no scientific studies published that include recommended noni consumption guidelines. The consensus recommendation for noni juice among health practitioners and consumers is 1–2 fl oz (30–60 ml) per day for the average person in good health and up to 6 fl oz (180 ml) or more per day for people with a disease such as cancer. We strongly encourage you to consult with a licensed physician or other qualified health care provider before using noni products.

Equivalency between juice, whole powder, seed-free powder, and fresh fruit is roughly as follows.

1 fl oz (30 ml) juice \approx 3 g whole fruit powder (or six 500 mg capsules) \approx 1 g seed-free powder (or two 500 mg capsules) \approx 2 oz (60 g) fresh fruit, or about two large bites

Regulatory and consumer protection

It is worth noting that the United States Food and Drug Administration (FDA) does not recognize the medicinal applications of noni (or those of many other traditional medicinal plants). Therefore, the product must be sold only as a nutritional supplement without making any health claims. The FDA actively enforces its regulations against companies who make claims about the medicinal applications

of noni in advertising or product information. Noni products sold in EU countries are subject to EU rules and regulations. Noni juice is permitted to be sold in EU countries as a novel food.

Testing

Noni juice and product manufacturers should perform routine analyses of their products to ensure that their pasteurizing process is effective. This helps to protect the noni industry and consumers alike. For example, testing should include assays for harmful bacteria such as *E. coli* and *Salmonella*, as is routinely done for similar products.

Pasteurization

Pasteurization refers to the process of heating a beverage at time of bottling to a sufficient level to kill off most of the bacteria in the juice. One industry standard set for noni pasteurization is 176°F (80°C) for 3 seconds (called “flash pasteurization”). Unless you make your own noni juice while practicing good sanitation as described in the “Making noni products” chapter, you should probably only consume pasteurized noni juice, which should be labelled as such. Non-pasteurized, bottled noni juice that is sold in the U.S. must be labeled “for external use only” or “for pet use only.”

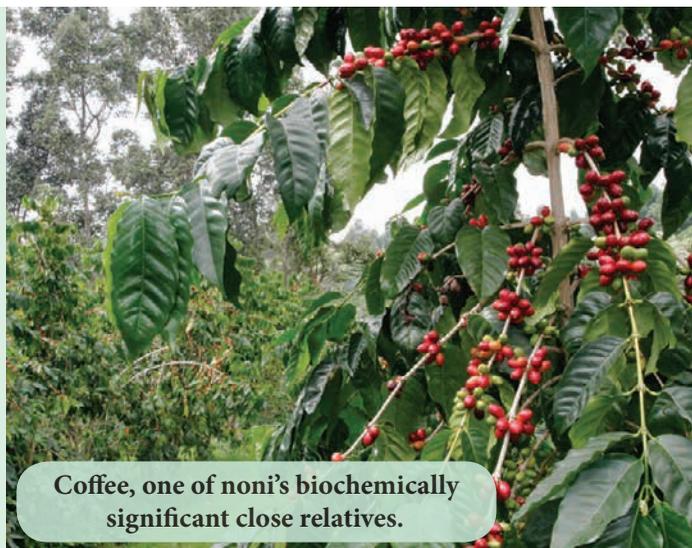
Ethanol

As noni juice is aged it undergoes changes due to chemical reactions induced by living organisms that split complex organic compounds into relatively simple substances. This process may be generally referred to as “fermentation,” which does not necessarily result in the production of ethanol, but may do so, especially in yeast fermentations associated with wines and beers. Noni juice, however, is not like many other fermented fruit juices because there is usually very little, if any, ethanol produced.

Like all fruit juices, noni may contain a small amount of ethanol, usually less than 0.5%. Poorly controlled noni juice fermentations can allow wild yeasts to produce alcohols (e.g., ethanol) in noni juicing vessels, sometimes up to 2%. The Japanese market imposes an excise tax on any noni juice shipment that contains in excess of 1% ethanol. In the United Arab

Noni belongs to the botanical plant family Rubiaceae, also known as the gardenia, coffee, or quinine family. There are many plants in this family which have useful biochemistry:

- coffee (*Coffea* species)—caffeine
- quinine (*Cinchona* species)—quinine, other alkaloids
- gardenia (*Gardenia* species)—yellow dye, essential oil/fragrance
- madder (*Rubia* species)—red dye
- jasmine (*Jasminum* species)—aphrodisiac, calmativ



Emirates (UAE) a maximum level of 0.5% ethanol is allowed (similar to grape juice), and any shipments of noni juice that exceed this limit are rejected. In EU countries there is a recommended limit of 0.3% ethanol, although at present this is only a guideline.

Concentrate-based products such as fruit or juice powders contain no ethanol because it is all vaporized and removed during the drying process if it was there in the first place.

Nutrition summary

Noni is a nutritionally valuable fruit that is probably safe for most people to consume in moderate quantities. Noni juice is similar to apple juice in many basic nutritional values, except that it has fewer calories and is usually more acidic. Noni has good antioxidant levels that are similar to green tea. Potassium levels in noni juice are similar to other juices such as prune, tomato, and orange; people with renal problems should consult their physician regarding potassium intake from such juices.

Chemical constituents

The health benefits of consuming certain fruits and vegetables have been known for centuries. Epidemiological studies of the 20th century clearly demonstrated that eating certain plants or plant-based foods protects against several chronic disease conditions, such as cardiovascular disease and cancer. For

example, people who consume nutrient-rich foods and get enough vitamins and minerals from their diet reduce their risk of common illnesses such as cancer, heart disease, and osteoporosis.

Noni, like all plants, is a living biochemical factory. It produces many biologically active and useful chemical compounds. The list of chemical components found in noni grows longer each year as researchers refine their focus and characterize new molecules. Some of the discoveries have revealed significant medically active compounds. To date, the major groups of chemical constituents of most significance in noni are the complex polysaccharides, anthraquinones, glycosides, and triterpenoids.

Here is a summary description of the most important, interesting, or medically promising chemical constituents that have been discovered in the noni plant, and how they may apply to human health. The descriptions of the chemical constituents are listed in alphabetical order in Table 2.5 below.

Alkaloids

Alkaloids are a group of nitrogen-containing bases which have a pharmacological effect on people or animals. Many of them are drugs, the most well known being caffeine, nicotine, and cocaine. Some alkaloids reported to be found in noni but disputed by others, remain enigmatic and require further research. Xerone is an alkaloid that has been hypothesized to

Table 2.5. Some of the most useful, interesting, or promising chemical constituents of noni. Constituents are identified as specific molecules or compounds and/or as chemical groups.

Chemical group or molecule ¹	Activities, diseases, or applications ²
Anthraquinones <ul style="list-style-type: none"> • damnacanthal • morenone 1 and 2 • several others 	antibacterial, anti-viral, type I collagen synthesis, cholesterol reduction, triglyceride reduction, anti-tumor, analgesic, sedative
Glycosides, Glucosides (flavonol glycosides, iridoid glycosides, lipid glycosides) <ul style="list-style-type: none"> • asperuloside • citrifolinin A and B 	anti-cancer, anti-tumor
Lignans/Neolignans <ul style="list-style-type: none"> • americanin A • morindolin, others 	antioxidant, arteriosclerosis
Polysaccharides	immuno-modulatory, anti-cancer, anti-tumor
Sterols <ul style="list-style-type: none"> • sitosterol 	needed for steroid hormone production
Scopoletin	hypertensive, anti-bacterial and anti-fungal; anti-inflammatory; analgesic; histamine-inhibiting; arthritic conditions; allergies; sleep disorders; migraine headaches; depression; Alzheimer's disease
Triterpenoids <ul style="list-style-type: none"> • ursolic acid 	anti-tumor (skin cancer), hepatoprotective, anti-inflammatory (oral and topical), anti-ulcer, antimicrobial, anti-hyperlipidemic, anti-viral
Other Fatty Acids <ul style="list-style-type: none"> • caproic/caprylic acid • ricinoleic acid 	impart odor to noni "castor oil acid" obtained from castor bean plant is used in soaps and textile finishing
Morindin, Morindone	yellowish dyes
Alizarin	red dye

¹ These are examples only, many other chemical constituents exist.

² Many medical authorities do not currently recognize medical applications for chemistry isolated from or attributed to noni. Applications were determined mainly in laboratory cell cultures or on living mice, and not on humans.

be found in noni, but its existence is questioned by many scientists.

Anthraquinones

Anthraquinones are an important group of phytochemicals found in noni. These are quinines occurring as glycosides in plants (see “Glycosides and glucosides” below). Anthraquinones are often colored and may be useful as dyes, including alizarin, morindin, and morindone. The basic chemical structure of anthraquinones is $C_{14}H_8O_2$. Several potentially very beneficial anthraquinones are found in noni leaves, fruits, cell suspensions, and noni roots. Damnacanthal is one of the most important anthraquinones in noni, and a number of promising new anthraquinones have been discovered recently. Anthraquinones have promise in cancer treatment. The EU regards two anthraquinones present in noni leaves, morindin and rubiadin, as toxic. All noni products are screened for these compounds in the EU. To be safe, noni leaves should be consumed in small quantities or avoided.

Damnacanthal

First found in noni roots, damnacanthal is an orange-yellow solid with chemical formula $C_{16}H_{10}O_5$. Research on damnacanthal derived from noni has demonstrated cancer prevention (inhibition of lung carcinoma in mice), sedative effect in animal studies, and treatment against the malaria parasite.

Glycosides and glucosides

Noni contains a number of useful glycosides that have promise in cancer prevention. A glycoside is any compound that contains a sugar molecule (carbohydrate) that is convertible by hydrolysis into a sugar and a non-sugar component. These molecules are found in noni leaves, cell suspensions, and fruits. Important examples from noni include flavonol and iridoid glycosides, citrifolinoside, asperuloside, and citrifolinin A and B, scopoletin, and anthraquinones. The anti-cancer medical properties of glycosides from noni include free radical scavenging activity and inhibition of UVB-induced Activator Protein-1 activity in cell cultures.

Lignans and neolignans

These comprise a large group of natural products found in plants that are produced by the coupling of two C_6C_3 units. Noni fruits have a number of them. Lignans are very potent antioxidants. They are found in other useful and healthful plant products such as flax seed oil. These potent antioxidants work throughout the human body to scavenge free radicals, which can damage tissue (and are thought to play a role in the pathology of many diseases). The neolignan americanin A found in noni fruits is one of noni's most potent antioxidants. Others such as morindolin are newly discovered and require further study.

Polysaccharides

The unique polysaccharides found in noni appear to boost the mammalian immune system to provide cancer prevention or amelioration. A polysaccharide is a polymer that is made up of many hexose or pentose units. Common polysaccharides in plants include cellulose, pectin, and starches. They are sometimes referred to as long-chain sugars and they are found in ripe noni fruit and noni fruit juice. Noni contains novel as well as common polysaccharides. The novel polysaccharides in noni are sometimes referred to as complex polysaccharides. Interesting or useful polysaccharides in noni include glucuronic acid, galactose, arabinose, rhamnose, glycosides, and a trisaccharide fatty acid ester. There are several others not yet fully characterized or named and considered to be novel or unique to noni and which have potential anti-cancer or immuno-modulatory activity. Based on experiments on mice, these complex polysaccharides are immuno-stimulatory, immuno-modulatory, anti-bacterial, anti-tumor, and anti-cancer.

Sterols

Sterols are a group among the steroids. They are lipids that are resistant to saponification and are found in all animal and vegetal tissues. Sitosterol is a group of sterols that occur in high concentrations in certain plants, such as yam, and are used in the synthesis of steroid hormones.

Scopoletin

Scopoletin ($C_{10}H_8O_4$) has potentially wide medical applications. Scopoletin is a coumarin found in ripe noni fruit and fruit juice. It is known to regulate blood pressure through dilation of the vasculature. Scopoletin is also anti-bacterial, anti-fungal, anti-inflammatory, analgesic, histamine-inhibiting, and useful for arthritic conditions, allergies, sleep disorders, migraine headaches, depression, and Alzheimer's disease. Research at the University of Hawai'i recently confirmed that after ingesting noni, scopoletin levels in the human bloodstream increased measurably. Scopoletin regulates the hormone serotonin, which helps to reduce anxiety and depression. It also has anti-inflammatory activity and can be used to treat bronchial illnesses and asthma. Other sources include passionflower and stevia.

Triterpenoids

Triterpenoids are terpenoids having a C_{30} skeleton. They form a large group of natural substances which includes steroids and consequently sterols.

Ursolic acid

Ursolic acid naturally occurs in a large number of vegetarian foods, medicinal herbs, and plants. Urso-

lic acid has been found to be medicinally active both topically and internally. Its anti-inflammatory, anti-tumor (skin cancer), and antimicrobial properties make it useful in cosmetic applications.

Dyes

Noni was once used extensively to produce yellow and red dyes for tapa cloth. A dye is a colored substance, often obtained from plants, that has an affinity to the substrate to which it is applied. Alizarin is a red dye found in noni root bark and noni heartwood. It is one of the most stable natural pigments. In 1868, a synthetic method for making alizarin was discovered. The ancient Hawaiian and Polynesians used dyes from the noni plant to color tapa cloth, a traditional bark cloth from Polynesia characterized by simple geometric patterns. Morindin and morindone are yellowish-red pigments. The dye is extracted as the glucoside morindin and produces the dye (morindone) upon hydrolysis. Morindin and morindone are found mainly in noni root bark, while morindone is also found in noni heartwood. Like alizarin, morindin and morindone are anthraquinones. These substances are known to be antibacterial.

NONI AND MODERN MEDICINE

Noni is part of a growing health care trend toward integrative medicine. Traditional and sometimes unorthodox healing modalities are now commonly used as an adjunct to modern, rationalistic therapies. We play a more active role in our own health care, through lifestyle modifications, psycho-spiritual healing, self-care, self-medication, and the increasing use of integrated medicine through complementary and alternative therapies.

Some alternative modalities have become so popular that they are finding their way into hospital emergency and recovery rooms. One of the authors, for example, awoke from anesthesia in a hospital recovery room after routine surgery. Standing over him was a very kind nurse holding a pendant and a chain. She started swirling the chain around each *chakra*, and when she got to one of his *chakras* she stopped and said, “this *chakra* is not working right” and proceeded to sweep his aura and use healing touch on him.

Dissatisfied with invasive modern medical procedures and skeptical of pharmaceuticals and their side effects, people are turning to energy healing modalities, prayer, complementary alternative medicine, and vitamin therapy. Many people are also turning to plants and plant products. Exotic botanicals are incorporated into range of preparations referred to as nutraceuticals, herbal or dietary supplements, and health foods. The marketing of such botanicals to a wide group of consumers in the U.S. was set in law by the U.S. Dietary Supplement Act of 1994.

The majority of people in the U.S. and many industrialized countries now seek and receive so-called “alternative” health care therapies and/or use botanicals for specific health reasons. Often botanicals are used to treat insidious lifestyle-related diseases with complex causes that plague modern industrialized societies such as diabetes, cardiovascular disease, arthritis, cancer, and others. These alternative therapies often lie outside the established and accepted medical-pharmaceutical structure. Because alternative therapies pose a potential economic threat to

Consumer responsibility

Although some doctors allow or advocate noni use by their patients, not all doctors agree with that practice. Some doctors object to noni use on the grounds that not enough is known about noni to justify its consumption or application for medical purposes. The same applies for veterinary doctors. If you decide to use noni, pay careful attention to any adverse reactions you may experience. If there is an uncomfortable side effect, discontinue its use.

Even though noni has certain chemistry known to be beneficial to humans, consuming noni products may not have beneficial effects due factors such as dosage, frequency of application, or interaction with body chemistry or other foods or medications.

The extensive ethnobotanical history of successful medicinal use cannot be entirely discounted on the grounds that it is scientifically unproven. Therefore, one may consider using noni at one’s own discretion.

Some published or widely disseminated information about noni may not be accurate or applicable. There exists a range of reliability in information, and personal discernment is necessary.

established health care businesses and the pharmaceutical industry, the controversy around using medicinal plants is complicated by economics and not confined to scientific considerations alone.

The shamanization of modern man

Noni, and many plants like it, now sit between two worlds. One is the ancient world of the shaman, the healer, and the initiated. In the shaman's world, knowledge was passed orally from generation to generation for hundreds and thousands of years. Knowledge was attained through pragmatic methods of trial and error and through communion with the spirit world.

The other is the modern world of the scientist, steeped in a 150-year-old tradition of hypothesis testing and the scientific method. In the scientist's world, knowledge is passed from generation to generation by means of peer-reviewed, scientific research articles in respected scientific journals.

The old world, the world of the shaman, knows that noni is a wonder plant, capable of healing the human body and spirit in many ways. The new world of the scientist remains largely skeptical of noni and its healing powers and is reluctant to embrace the plant until further research demonstrates its efficacy in replicated trials.

Which way should one turn for health care, to the old world or to the new world? The answer appears to be to borrow the best of both worlds and integrate them in complementary ways, i.e., use the wisdom and spirituality of the ancients and add to it the results of scientific research. In essence, each person has become their own 21st century shaman, capable of dealing with their own illnesses on both the spiritual and physical planes armed with the knowledge of the ancients and modern scientific knowledge.

We believe that as this trend continues toward embracing past knowledge and practices and integrating them with modern medical research, that noni is one of the botanicals that will bridge both worlds.

Table 3.1. Known activities of phytochemicals that may result in human health benefits*

Absorbents and sequestrants that bind to and eliminate undesirable constituents in the intestine
Compounds that enhance the absorption and or stability of essential nutrients
Fermentation substrates for beneficial oral, gastric or intestinal bacteria
Substrates for biochemical reactions**
Cofactors of enzymatic reactions**
Inhibitors of enzymatic reactions**
Ligands that agonize or antagonize cell surface or intracellular receptors**
Scavengers of reactive or toxic chemicals**
Selective growth factors for beneficial gastrointestinal bacteria**
Selective inhibitors of deleterious intestinal bacteria**

*based on published research or reported traditional uses of noni

**Known activities of phytochemicals found in noni

The fuss about phytochemicals

There is a palpable buzz in the air about plant phytochemicals and animal or herbal supplements. Everyone seems to know something about the topic and can talk about the benefits or wonders of some botanical supplement. What's this buzz all about? Phytochemicals are plant compounds with proven effects upon human biochemistry and metabolism. Therefore, phytochemicals can potentially impact the state, health, or metabolism of all systems of the human body.

Some of the most popular phytochemicals have major effects on the human metabolism or consciousness and act as relaxants or stimulants. Some of the main phytochemicals/products accepted and used widely by modern medical practices include strychnine, quinine, aloe, antioxidants found in teas, aspirin, digitalis, etc.

The phytochemicals in noni (described in the "Nutrition and chemistry" chapter) are being widely examined for their ability to provide health benefits. Later in this chapter we review recent research and examine its implications for future health care.

Table 3.2. Existing, emerging, and potential human health applications and markets for phytochemicals

Noni contains compounds which have applications in these areas based on published research or traditional use	Noni is not known to contain compounds with applications in these areas
Immune system modulation	Mental acuity
Energy	Altered consciousness, anti-anxiety
Insomnia, sleeplessness	Hormone therapy, replacement
Joint health	Vision
Sprains, athletic injuries	General breast and prostate health
Routine pain relief	Skeletal strength
Inflammation	Body fat reduction
Cancer	Emotional disorders
Skin care	
Hypertension	
Diabetes	
Diuresis (water retention)	
Gut or bowel remedies (constipation, irregularity)	
Blood fat, cholesterol	
Antimicrobial	

Do any of noni's phytochemicals have scientifically proven effects on human health?

This is the difficult and expensive question that is before noni medical researchers. Based on traditional uses and published medical and chemical research for noni, it may have some activities as indicated in Table 3.2.

These activities can be used to devise useful application for noni's phytochemicals, which is exactly what biomedical entrepreneurs, businessmen, and inventors have been doing in recent years.

Based on traditional uses of noni and published medical and chemical research about noni, noni has some usefulness and is now prescribed by some medical doctors for certain applications in the list above.

The noni health craze—based on fact or fiction?

The problem of exaggerated health claims

Now we come to the question of whether the noni

health craze is based on fact or fiction. What and who should you believe? What is real and what is not?

One might be led to think that noni is a cure-all, if one believes all of the stories of noni's ancient traditional uses and modern testimonials. In the U.S., the Food & Drug Administration (U.S. FDA) does not allow noni retailers to make specific claims about human diseases or health conditions that may be treated by, or respond to, the consumption or use of noni products. Exaggerated health claims by merchants who sell noni products damage the credibility of noni in general.

Food safety

Noni is considered by the U.S. government as a safe herb to consume. *Morinda citrifolia* is listed on the U.S. federal GRAS list, i.e., foods that are **Generally Recognized As Safe** to eat. According to a bureaucratic branch of the federal government, noni is "safe" to consume. This is significant, because for years noni was left off the GRAS list.

Also, the U.S. FDA allows noni to be sold as an herbal supplement product and millions now consume it without problems. The safety of noni as a food also traces back to a survival publication produced by the

U.S. War Department and a Harvard botanist during World War II. The survival guide listed all the plants in the Pacific considered safe to eat if a soldier or pilot needed to survive off the land. Noni was included in the list of survival plants, and stated that the leaves and fruits were edible fresh or cooked.

Safety as an herbal supplement

What about the safety of taking noni as an herbal supplement? This is a very difficult question to answer, considering all of the forms of noni present on the market, their sources, processing methods, etc. Essentially, we just don't know. A few unsubstantiated reports have come out of Germany and France recently of a few liver problems potentially associated with noni consumption. The reports appear to be related to a very small number of people who had underlying illnesses and may have been taking medications that cause toxic effects on the liver, so the reports do not clearly help to understand the possible ill effects of noni. Considering the wide use of noni in modern times coupled with long traditions, noni supplements appear to be very safe to consume, at least in moderation.

Questions of noni dose and frequency, however, remain to be answered by medical research, as well as questions about the side effects of consuming noni and the interaction of noni's chemical constituents in people with different physiology and metabolisms, or if there are any harmful chemical constituents in the plant of which we are not yet aware. We do not know how noni interacts with pharmaceutical medications which people take for common chronic conditions. Although there are no published contraindications for taking noni, the authors have received a few personal reports of adverse reactions from consuming fresh noni juice, including some bowel discomfort or irregularity (a laxative effect) and a shortening in the length of the menstrual cycle.

Another issue to be resolved is the health effects of consuming certain anthraquinones, as some are considered to be unhealthy. The authors have reports of the EU expressing concern about these phytochemicals in noni products and may refuse entry to herbal supplements than contain them. The type of anthra-

quinone found in noni depends on the plant organ, so noni products might face problems due to anthraquinones depending on whether the products are made from fruits, roots, or leaves, for example. The positive and encouraging side of noni's anthraquinone chemistry is that in late 2005, two separate research groups discovered new anthraquinones in noni fruit with potential for medical benefits. More research will be required to see if these are safe to consume. Based on noni's long track record and lack of health problems from using it, it seems unlikely that consuming moderate amounts of noni juice from ripe fruits will produce any anthraquinone-related toxicities.

Conclusion

Despite the hype surrounding some noni products, there is a huge body of factual information and data that is continually accumulating. The truth about noni lies somewhere between the positive and negative spins placed on the plant by its proponents and detractors. The most ardent proponents of noni probably indulge in a bit of wishful thinking or have vested interests that tend to obscure or minimize the need for scientific study. The detractors are probably too conservative or have vested interests that are threatened by noni and tend to disregard the centuries of useful applications of noni by traditional healers. Noni may work its way slowly into mainstream western medicine, but this process will take many years of testing and experience. For now, our best advice is to know thyself, educate thyself, and *caveat emptor* ("let the buyer beware").

Noni's place among herbal therapies

Noni's uses in herbal therapies are varied and extensive. Here we examine what is generally believed among herbalists to be the medical activities of noni and the diseases or conditions that it can treat.

Activities, indications, and contraindications

An "activity" is a specific biochemical effect that an herb has on a disease or condition (an "indication"). A "contraindication" means that you should not use an herbal product for a specific disease or condition.

Noni activities* based on traditional medicine and not scientifically proven (source: *CRC Handbook of Medicinal Herbs*)

- *Analgesic*—reduces pain without loss of consciousness
- *Anti-arthritis*—relieves symptoms of arthritis, inflammation of the joints
- *Anti-pyretic*—also called febrifuge; a fever reducer
- *Anti-rheumatic*—relieves any of various conditions characterized by inflammation or pain in muscles, joints, or fibrous tissue (muscular rheumatism)
- *Anti-tumor*—prevents or stops an abnormal benign or malignant new growth of tissue that possesses no physiological function and arises from uncontrolled, usually rapid, cellular proliferation (e.g., cancer, carcinoma, sarcoma)
- *Anti-spasmodic*—prevents or relieves an involuntary and abnormal contraction of muscle or muscle fibers or of a hollow organ (as an artery, the colon, or the esophagus) that consists largely of involuntary muscle fibers.
- *Ascaricide*—killing any of a genus of nematodes.
- *Deobstruent*—removing obstacles; purgative
- *Depurative*—tending to purify or cleanse (i.e., cleansing of the liver, kidney)
- *Diuretic*—tending to increase the excretion of urine
- *Emetic*—an agent that induces vomiting
- *Emmenagogue*—promotes menstruation
- *Emollient*—makes skin soft or supple, soothing to skin or mucous membranes
- *Fungicide*—kills fungi
- *Hypotensive*—lowers blood pressure
- *Laxative*—loosens or relaxes bowels to relieve constipation
- *Litholytic*—an agent that dissolves calculi (stones)
- *Sedative*—calm, moderate, or tranquilize nervousness or excitement
- *Stomachic*—relieves stomach problems such as stomach ache
- *Tonic*—provides boost of energy and sense of well being

*a biomedical effect on a disease or condition

According to the *CRC Handbook of Medicinal Herbs*, noni has a number of documented activities for a wide range of diseases and conditions. Noni has no known contraindications, according to this reference.

Given only this information, is it possible to accurately assess the place of noni among modern herbal remedies? The answer is “probably not,” because several important questions about the activities remain unanswered by modern science. For example:

- For a given activity, how strong is the activity, what is the dose and how should the dosage be administered?
- Which phytochemicals or combinations of phytochemicals are responsible for each activity?
- What are the possible side effects associated with using noni to treat the indications listed above?

Until these questions are answered, which could take many years or even decades of research, noni’s place among herbal medicines will remain nebulous, non-specific, of dubious value, possibly not effective at all, or even deleterious in some ways. The consumer is left with a trial-and-error process to be conducted on an individual, anecdotal level.

How doctors and health practitioners are using noni today

Even without accepted scientific results about noni treatments, noni is increasingly perceived to be useful and safe for use in conjunction with more proven, modern health care therapies. Not only are medical doctors now allowing their patients to take noni supplements, they are actually prescribing it in some cases. In Hawai‘i, cancer specialists are giving it to patients battling a range of cancers. Some of the anecdotal reports coming out of these treatments are impressive. Anecdotal reports of pain relief and symptom improvement are impressive in the areas of cancer and diabetes.

What health-industry entrepreneurs and inventors think about noni’s place among herbal therapies

Despite all of the doubts expressed by mainstream medical science, world business leaders and inventors have their own perspective and are translating that into an aggressive agenda of product and service development. Looking at patent applications pertaining to noni is a good way to see what the entre-

Noni indications based on traditional medicine, a range of popular literature, and some science-based literature. (source: *CRC Handbook of Medicinal Herbs*)

- *Arthrosis*—a degenerative disease of a joint
- *Ascaris*—a family of nematodes (Ascaridae) resembling earthworms in size and superficial appearance, and including one parasitic in the human intestine (*A. lumbricoides*)
- *Asthma*—a chronic lung disorder that is marked by recurring episodes of airway obstruction (as from bronchospasm) manifested by labored breathing accompanied especially by wheezing and coughing and by a sense of constriction in the chest, and that is triggered by hyper-reactivity to various stimuli (as allergens or rapid change in air temperature)
- *Cancer*—a malignant tumor of potentially unlimited growth that expands locally by invasion and systemically by metastasis
- *Cold*—a bodily disorder popularly associated with chilling
- *Colic*—an attack of acute abdominal pain localized in a hollow organ or part (as the small intestine, ureter, or bile duct) and often caused by spasm, obstruction, or twisting
- *Constipation*—abnormally delayed or infrequent passage of dry, hardened feces
- *Cramp*—a painful involuntary spasmodic contraction of a muscle
- *Diabetes*—any of various abnormal conditions characterized by the secretion and excretion of excessive amounts of urine
- *Diarrhea*—abnormally frequent intestinal evacuations with more or less fluid stools
- *Dysentery*—a disease characterized by severe diarrhea with passage of mucus and blood and usually caused by infection
- *Dysuria*—difficult or painful discharge of urine
- *Fever*—a rise of body temperature above the normal
- *Fungus*—any of the kingdom Fungi of saprophytic and parasitic spore-producing eukaryotic typically filamentous organisms formerly classified as plants that lack chlorophyll (molds, rusts, mildews, smuts, mushrooms, and yeasts)
- *Gallstone*—a calculus (as of cholesterol) formed in the gallbladder or biliary passages, also called *biliary calculus*, *cholelith*
- *Gout*—a metabolic disease marked by painful inflammation of the joints, deposits of urates in and around the joints, and usually an excessive amount of uric acid in the blood
- *Headache*—pain in the head, also called *cephalgia*
- *Heart*—a hollow muscular organ of vertebrate animals that by its rhythmic contraction acts as a force pump maintaining the circulation of the blood
- *Hepatosi*s—any noninflammatory functional disorder of the liver
- *High blood pressure*—higher than healthy blood pressure
- *Infection*—the state produced by the establishment of an infective agent in or on a suitable host
- *Insomnia*—prolonged and usually abnormal inability to obtain adequate sleep, called also *agrypnia*
- *Leukorrh*ea—a white, yellowish, or greenish white viscid discharge from the vagina resulting from inflammation or congestion of the uterine or vaginal mucous membrane
- *Mycosis*—infection with or disease caused by a fungus
- *Nervousness*—of or relating to the nerves or originating in or affected by the nerves
- *Neuralgia*—acute paroxysmal pain radiating along the course of one or more nerves usually without demonstrable changes in the nerve structure
- *Pain*—a state of physical, emotional, or mental lack of well-being or physical, emotional, or mental uneasiness that ranges from mild discomfort or dull distress to acute often unbearable agony, may be generalized or localized, and is the consequence of being injured or hurt physically or mentally or of some derangement of or lack of equilibrium in the physical or mental functions (as through disease), and that usually produces a reaction of wanting to avoid, escape, or destroy the causative factor and its effects
- *Rheumatism*—any of various conditions characterized by inflammation or pain in muscles, joints, or fibrous tissue
- *Sapremia*—a toxic state resulting from the presence in the blood of toxic products of putrefactive bacteria and often accompanying gangrene of a part of the body
- *Sore*—causing, characterized by, or affected with pain
- *Sore throat*—painful throat linings
- *Stomach ache*—painful in the stomach
- *Stone*—a calculus
- *Tumor*—an abnormal benign or malignant new growth of tissue that possesses no physiological function and arises from uncontrolled usually rapid cellular proliferation
- *Ulcer*—a break in skin or mucous membrane with loss of surface tissue, disintegration and necrosis of epithelial tissue, and often pus
- *Wound*—a physical injury to the body consisting of a laceration or breaking of the skin or mucous membrane

Definitions of most activities and indications are from the National Institute of Health <<http://www.nlm.nih.gov/medlineplus/medlineplusdictionary.html>>.

preneurial world currently thinks of noni and how inventions derived from noni can generate profitable businesses. The number of applications is an indication of what lies ahead for this plant and for industries spawned by it.

Based on a survey of noni-related patent activity (Table 3.3), we can make several conclusions about future noni developments.

- Noni research and development is very active. Inventors are attracted by it.
- The inventions span an impressive array of ailments and health issues.
- Even if only a few of the above inventions make their way into the market, the value could be quite high.

Current medical and biochemical research

What kind of research should be done on noni to justify its further or expanded role in mainstream western medicine?

The following is a general sequence of basic research goals.

1. Determine the chemical constituents of the noni plant.
2. Examine effects of noni in disease cell cultures and in animals.
3. Perform human dose studies and look for effects and adverse reactions.
4. Determine effects of noni upon human diseases and symptoms (prevention and cure) in double blind studies.
5. Isolate the demonstrated effects of noni and relate them to specific phytochemicals found in noni.
6. Find ways to purify active ingredients from noni to make pharmaceutical-grade products for their targeted use in intensive therapy.

Table 3.3. Recent U.S. patent applications (as of August 2005). All of these patent applications relate directly to, and often specify within the application, promising chemical constituents of noni.

Topic areas covered by recent noni-related patent applications

Anti-inflammatory constituent of noni
 Type II diabetes treatment
 Antioxidant activities (several)
 Oral care and periodontal disease treatment
 Enhancement of anthraquinone production in cell cultures
 Breast cancer treatment (several)
 Curing hangovers
 Treatment for increasing level of hormones
 Inhibition of metastasis of carcinogenic cells
 Inhibition of estrogen production
 Extraction method for anthraquinone from noni roots
 Aromatase inhibition
 Inhibition of lipoprotein oxidation
 Skin pigment lightening
 Lightening pigment of skin, lip and nails
 Anti-angiogenesis (reduction of blood vessel formation)
 Skin health improvement
 Anti-tumor treatments
 Anti-fungal effects
 Inhibition of mutagenesis
 Osteoarthritis treatment and prevention
 Migraine headache treatment
 Skin disorder treatment
 Liver damage treatment
 Tumor treatments
 Anti-tuberculosis treatment
 Anti-malaria treatment

The status of noni research in the early years of the 21st century

Most of the research done with noni to date has focused on research goals 1 and 2 above; very few studies have even begun to look at goals 3 and 4. A number of scientists from laboratories in Taiwan, the U.S., and elsewhere have been looking for and describing the various chemical constituents of noni in earnest

for the past 10 years or more. Each year, new findings are published and the list of known photochemistry on noni grows. At the same time, researchers in medical labs in Hawai'i and elsewhere are examining the effects of noni on diseases such as cancer in cell cultures and in mice experiments. Finally, there are a handful of researchers engaged in the preliminary work on noni dosage and possible adverse reactions (see the University of Hawai'i cancer study, described below).

Research on the chemical constituents of the noni plant

This has been a very active area of research for a number of years. A search of the literature reveals research articles published from around the world in a wide range of scientific journals. Please refer to the "Nutrition and chemistry" chapter for the focus of the research activities (mainly glycosides and triterpenoids).

Research on the effects of noni in disease cell cultures and in animals

This has been an active area of research by a number of laboratories throughout the world, including Hawai'i. In a landmark published study conducted by the University of Hawai'i, noni shows activity in preventing cancer tumor development in mice. A number of studies show noni's *in vitro* effects against tumor formation in cell culture, and other studies demonstrate the antioxidant scavenging ability of phytochemicals found in noni.

The University of Hawai'i noni-cancer human dose study

Perhaps the most exciting research currently underway with noni is at the University of Hawai'i (UH) Cancer Research Center in Honolulu.

The goals of the Phase I study (first type of human study) which began in 2001 and is funded by the National Institute of Health until July 2006 are to

- determine the maximum tolerated dose of capsules containing 500 mg of freeze-dried noni fruit extract

- define toxicities (side effects) associated with the ingestion of noni
- collect preliminary information on the efficacy of noni in respect to anti-tumor and symptom control properties to help select specific patients for subsequent studies
- identify chemical constituents of the extract that can be used to characterize the bioavailability and pharmacokinetics of noni food supplement.

The researchers are testing the hypothesis that noni at a specified dose regimen provides cancer patients with a sufficient "benefit to toxicity profile" to be useful for cancer patients. Once a dose is selected from this first study, the researchers will move to the next phase with a study to compare the selected dose of noni to a placebo.

In the current study, different doses of the freeze-dried extract of ripe noni fruit in 500 mg capsules are taken by groups of five or more patients. Participants have advanced cancer that will not respond to other treatments. Each group of patients receives a different dose of noni ranging from four to twenty-eight capsules daily. The principal investigator's preliminary report indicates that there is no limiting adverse effect of noni at any dose level and there is improvement in some quality of life measures at certain dose levels when compared to others.

The team is also analyzing the ingredients of noni that get absorbed from the gut into the blood and eliminated in the urine. They are determining which chemicals end up in the bloodstream in measurable amounts. Preliminary results show that the noni phytochemical, scopoletin, ends up in the bloodstream at measurable levels. If scopoletin is found to be an active ingredient of noni it could be used to standardize the potency of the numerous noni products that are available.

Louisiana State University cancer study and "Super Noni"

Researchers at the Louisiana State University (LSU) AgCenter, working with scientists in the LSU School of Veterinary Medicine and the Pennington Biomedical Research Center in Baton Rouge and at the LSU Health Sciences Center in New Orleans, are evaluat-

Key information resources

The PubMed Central system of data retrieval, is the U.S. National Institutes of Health (NIH) free digital archive of biomedical and life sciences journal literature. You can search the PubMed Central online archive by keyword (such as noni, *Morinda*, etc.) to access journal abstracts and even full-text articles. PubMed Central is a rich resource for peer-reviewed literature and a world-class library. The web address is <<http://www.pubmedcentral.nih.gov>>.

For scientific information associated with plant biology, agronomy, pathology, etc., there are excellent online databases associated with agriculture. AGRICOLA (AGRICultural OnLine Access) serves as the catalog and index to the collections of the National Agricultural Library, as well as a primary public source for worldwide access to agricultural information <<http://agricola.nal.usda.gov>>. The BIOSIS

database is a fee-based, comprehensive database for the biological sciences that can be accessed through many university libraries <<http://www.biosis.org>>. Google Scholar is another way to access scientific literature <<http://scholar.google.com>>.

Ethnobotanical literature is often easiest to locate in public and university libraries and through interlibrary loan. Used book sellers abound on the Internet, and many of the rarer ethnobotanical texts can be easily found at reasonable prices online.

Many university cooperative extension services (e.g., in Hawai'i, Australia, Taiwan) offer support services for farmers developing noni products. Even though a university in your area may not be working with noni, most universities have outreach and research services associated with developing new and existing crops. A good place to start is the University of Hawai'i Noni Website <www.ctahr.hawaii.edu/noni>.

ing noni. Scientists at the LSU Health Sciences Center in New Orleans, Stanley S. Scott Cancer Center discovered that noni fruit juice can inhibit angiogenesis (the process by which new blood vessels grow) in a human tissue-based model. They believe that this work can lead to a treatment and prevention of recurrence of all solid tumors, malignant or benign, that rely on angiogenesis to grow and spread. First, they characterized the active fractions of noni juice using a process called column chromatography and identified active ingredients. They think that noni juice contains more than one active compound responsible for antiangiogenic activity, and the active ingredients are in relatively low concentrations. The researchers are now isolating and purifying the active compounds, which will then be characterized using nuclear magnetic resonance and mass spectrometry at the LSU Chemistry Department in Baton Rouge. Once the active compounds are identified, they will be used as chemical markers to standardize what the researchers call "Super Noni" which they believe will be practical for clinical applications and trials designed to test hypotheses about cancer prevention and treatment.

Noni—now and in the future

Modern diseases often have complex causal factors and are associated with a range of interacting risk factors. Treating them is not a simple or straightforward matter in many cases. Effective treatment of diseases such as cancer requires integrated treatment approaches to relieve the symptoms and stop or decrease disease symptoms and progress. Within this context, we believe that noni has a viable place in the future of modern medicine, that is, in the context of an integrated, holistic approach to healing the human organism at all levels, physical, psychological, emotional, and spiritual. Modern medicine is going to have to adapt, because at present it is not equipped to deal with this multifaceted model of human disease. This new (and ancient?) model of disease causation states that disease in the physical body can derive from illness of the emotions, the spirit, the psyche, as well as the physical body. In this new model, disease can occur at many levels, and not just in the physical body. Most modern medicine fails to integrate treatment of disease from this multilevel model of causation.

Although some perceive noni to be a cure-all, we doubt that it will reach this status based on scien-

tific study. More likely, it will be found to be a useful adjunct treatment for some of our most nagging diseases, including cancer, diabetes, and arthritis.

Worldwide markets for noni products are expanding yearly, from a \$400 million industry in 2001 to a projected \$2 billion industry in 2006. Clearly, entrepreneurs are convinced that noni is here to stay, and the consumer evidence appears to support this. Noni as an herb does pose a threat to established pharmaceutical interests, and to some degree, established mainstream medical practitioners. Therefore, it is likely that noni will face lobbying efforts, regulations, and malicious attacks against it in the years ahead as it carves out a viable niche for itself.

CONSUMER GUIDE

The informed shopper: what to look for and what to avoid

The information provided below will help you to make intelligent decisions about the noni juice you buy. Similar considerations apply to other noni products such as fruit powders.

Flavor

Carefully aged noni juice should have a smooth, slightly acidic, and pleasant flavor. Although fresh noni juice (only several days old) may have a disagreeable aroma, strongly objectionable flavors or aromas in carefully aged juice may indicate contamination by unwanted microbes including yeasts, molds, and bacteria. Even though flavor is not the main reason that people choose to use noni juice, most people acquire a taste for it after an initial “getting acquainted” period. If the flavor of well aged, high quality noni juice is too much to handle, there are a number of sweetened and mixed-juice products on the market.

Indication of purity

There should be a clear indication of purity printed on the label. We prefer 100% pure noni juice. Be aware that some manufacturers may label the bottle as “100% juice” even when it has other ingredients added, such as water, sugar, food coloring, or other fruit juices.

Origin

The origin of the juice should be indicated on the bottle, for example, “100% Pure Hawaiian Noni Juice.” This tells where the noni was grown. Noni fruits from some locations may reach higher sugar content and make a sweeter, smoother juice. There is

also some variability in noni plants throughout the world, and this is reflected in the taste of the juice from different areas.

Processing facts

The bottle should indicate how the juice was made, for example, fresh pressed, drip-extracted, or reconstituted from powders or concentrates.

Juice color

The color of the juice is closely linked to juice flavor and other quality parameters. The lighter, younger, yellowish noni juice has more objectionable flavors than darker, older, well aged juice. The younger juice probably has more enzymes and antioxidants because it has been aged a shorter time. Many people think the best-tasting pure juice is amber to reddish, which can resemble wine in flavor and aroma characteristics, being slightly acidic yet fruity. The darker the juice, the more aged and sour it is likely to be, two characteristics some people also prefer.

Juice clarity

The juice should not be cloudy or have suspended or floating particles or masses of any type that do not settle to the bottom of the container. If anything is floating in the juice, do not buy it. There should not be much visible pulp or sediment in the bottle. Pulp occupies space that could be occupied by the more valuable juice. At a retail price of about \$1.00 per fl oz (30 ml), a thick layer of pulp in the bottom of the bottle could be costing you money. However, for home noni juicers, having pulp in the juice is really a matter of choice (some people prefer the effects of noni pulp upon the digestive system for example). Floating pulp or material in the bottle may indicate

that fermentation is still going on or that the bottle had a leak that allowed contaminants to enter.

Nutrition facts

The standard nutrition facts should be clearly displayed on the bottle. There should be no explicit health claims pertaining to diseases or conditions and the product's ability to cure them. Such claims on the bottle may be a sales gimmick and indicate a lack of credibility on the part of the producer and marketer.

Bottle type

Glass bottles are superior to plastic bottles for preserving flavor and quality, but plastic bottles are cheaper and result in a less expensive product. Both clear and colored bottles are fine.

Producer

Research the company making the juice you purchase. Although you may not be able to get answers to all your questions, better companies will be able to give you more product information, as a general rule. Detailed answers to questions are probably more readily available to those who buy wholesale, rather than retail. How long has the company been in business? Is their web site professional? Does the company provide literature or allow you to visit their processing facility? Does the company belong to an industry association that has standards for juice production and regularly inspects its members' facilities? Will the company provide you with a flow chart of their juice production process? Does the company provide its contact information on the bottle? Can you speak to a company representative when you call the company, or do you always get a recorded message? Is the juice sold, repackaged, or reprocessed by a third party who also follows industry standards? It may be difficult to reach someone who knows the answers to these questions, however, it is essential to know the origins of any new product you might buy. Finally, ask friends if they are satisfied with the products they use.



Left: There should not be any floating contaminant material in the bottle, i.e., the juice should be free of particulates such as this high quality commercial juice. **Right:** contaminated homemade juice with masses of floating fungi. Fungi in noni juice may pose a health hazard and produce significant amounts of ethanol. LEFT PHOTO: C. ELEVITCH, INSET PHOTO: S. NELSON

Guarantee

Only buy noni juice that has a money-back guarantee provided by the manufacturer or the retailer. The guarantee may not appear on the label, so make inquiries to find out if a guarantee is offered.

Standardization/consistency of product

Most companies do not standardize their products for any of noni's constituents or presumed active ingredients. Some companies do standardize their juice products for total active polysaccharides. Products that are standardized for acidity, naturally found carbohydrates, etc., are probably superior in quality compared with non-standardized products. Standardized products deliver a reliable and consistent proportion of active ingredients in each serving and are not watered down or variable, and always have the same effects because the levels of active ingredients are guaranteed.

Pasteurization

Noni juice should be pasteurized for consumer protection, especially retail juices that may be in inventory for some time. Commercial juices should be labeled as pasteurized. Unpasteurized juice products

are potentially unhealthy and dangerous to consume because they may contain harmful, living microorganisms such as *E. coli* and *Salmonella*. However, the authors have consumed their own homemade unpasteurized juice for many years without any adverse effects. In fact, unpasteurized noni juice may have microflora that are beneficial to the digestive tract. In other words, it is okay to drink unpasteurized noni juice if you are certain that good hygiene practices have been observed by the producer, as described in the “Making noni products” chapter. Some companies sell unpasteurized, bottled noni juice labelled for “pet use only” or for “external use only.” If you wish to pasteurize your own noni juice, heat the juice in storage bottles to 180°F (82.2°C) for about 30 minutes and then seal the bottles while they are still warm.

Testing

Check to make sure the company tests each product batch for harmful microorganisms such as *E. coli* and *Salmonella* at a certified testing laboratory before they release the product into the market. Contact the company to see if they will provide a copy of their most recent report.

Negative advertising

Examine the advertising associated with a given juice product. Does the advertising single out their juice as the “only” product worth buying, or make negative comments about juice from other geographic locations? Are there scientific claims made without citing credible research journals or publications? Such high-pressure advertising is indicative of a company policy that puts sales over product quality and accuracy of information.

Price

Price is a big issue for many consumers, and noni juice is very expensive. The price range is about US\$0.50–1.00 per fl oz (30 ml) for 100% noni juice sold at retail. The best value on a per volume basis is pure noni juice, because it usually sells for a similar price as noni mixed with other fruit juices. Pure noni juice can be purchased in bulk at wholesale prices on the internet or directly from a production facility. The processor-direct retail price is about US\$25.00 per gallon (US\$6.60/l). Low prices may not indicate a good deal; some companies may dilute their juice products with water in order to undercut their competitors’ prices. Also, the price you pay for juice

What to look for in seeds for propagation

Seeds for propagation should be as fresh as possible. Less than 6 months old is best. We recommend using only seeds from healthy trees with superior qualities such as fruit quantity and quality. Seeds from fruits that have been fermented less than 10 days are fine to use, but we would not recommend seeds left over from long-term processing. Do not use seeds left on the ground from decomposed fruit, as these often have very low viability. When purchasing seed, make sure it is definitely from noni (*Morinda citrifolia* var. *citrifolia*), and not another variety. The price range you can expect to pay for fresh, quality seeds is \$0.03–0.10 per seed, depending where you buy it and the quantity purchased.



Clean, dry seeds ready for propagation. PHOTO: C. ELEVITCH



There are numerous products you can make at home with noni including juice, puree, and fruit leather. PHOTO: C. ELEVITCH

purchased over the Internet may be significantly increased by import taxes in certain countries.

Regulatory

The product should meet all of the regulatory requirements imposed by authorities in your geographic region.

Shelf life

The shelf life of well aged noni juice is about 2 years. A product manufacturing date or expiration date should appear on the container. Refrigeration can extend the shelf life of juice, and if juice is not pasteurized, it should always be refrigerated until used.

Try several juices

Try several juice sources until you are completely satisfied with the quality.

Your own judgment

The effects of noni may be very subtle. You might notice pain relief, a change in consciousness, lower blood pressure, or increased relaxation. Don't expect instant results or give up on it because it did not live up to expectations of immediate results. Give it time. To be safe, watch also for undesirable side effects.

Health practitioner

Consult your health practitioner for product recommendations. Also, ask friends who have used noni for their recommendations.



Fruits can sometimes be found at local markets, or many farmers can provide them on special order. PHOTO: C. ELEVITCH

You get what you pay for

The noni market is very competitive, and some retailers or wholesalers may cut corners in processing, water down, or misrepresent their products in order to lower their price. Remember that price is not always an indication of value or quality.

Cooking with noni

Cooking with noni is easy and when consumed in moderate quantities, thought by many to be safe and healthy. You probably will not find a great number of published noni recipes, because the use of noni in modern western cooking is a fairly recent phenomenon. What follows is an assortment of easy recipes to have fun with.

People who do not care for the taste of noni by itself can use it when preparing naturally sweetened snacks such as fruit leather and healthy treats such as fruit smoothies. Such treats mask the taste of the noni, and everyone can enjoy them.

For others who do not mind the taste, or who may even love it, many more cooking options are available. For example, green fruits can be cooked in curries or the young, tender leaves can be eaten as a leafy vegetable in salads.

Noni leaves also may be used to wrap fish for cooking. This naturally removes the scales from the fish. The sturdy and wide noni leaves also serve well as a disposable plate or platter on which to serve food.

Recipes

Thai red curry noni

In this recipe, fresh vegetables and green noni fruits are simmered in a coconut milk broth with Thai red curry paste.

- 1 tablespoon neutral-tasting cooking oil (vegetable, peanut)
- 1 tablespoon Thai red curry paste
- 1 sweet red bell pepper, cut in strips
- 1 small head broccoli, cut into bite-size pieces
- ¼ head cauliflower, cut into bite-size pieces

- 1 can (14 fl oz [414 ml]) unsweetened coconut milk
- a small handful snow peas
- 1 medium zucchini, cut into julienne strips
- about a handful of prepared bamboo shoots, cut into strips
- 2–3 young, green noni fruits (1 inch [2.5 cm] diameter), cut into thin circular slices
- 1–2 carrots, cut in julienne strips

In a large sauce pan, heat the oil over a medium high heat, add in the Thai red curry paste, and sauté for about 1 minute. The curry spices will become very fragrant. Add noni, broccoli, and cauliflower and mix well to coat with curry paste. Stir-fry for 2 minutes. Add bell pepper and stir-fry for 2 minutes more. Add coconut milk and stir. Bring to a boil and then turn down heat to let simmer for 10 minutes, stirring occasionally. Add zucchini, carrots, and bamboo shoots, and simmer for 5 minutes more. Check vegetables and cook until they are your preferred texture (firm or soft). Serve hot with steamed jasmine rice. Serves 4–6.

Noni leaf salad

Noni leaves have an interesting, somewhat sharp flavor. Use young leaves, about ⅓ or less of their full size. Add a few leaves, cut or broken up, to your favorite mix of salad greens. For extra flavor, sprinkle aged (sour) noni juice all over the salad as a simple dressing, or use one of the more elaborate salad dressings described below. Because of potentially anti-nutritive compounds in the leaves, it is best to use just a few noni leaves together with the other salad ingredients.

Here are some common leafy vegetable greens and other items you can add to your noni salad: arugula (rocket), spinach, endive, chives, lettuce, celery, cabbage, carrots, olives, bell peppers, tomatoes, tofu, etc.

Noni herb vinegar SOURCE: B. FAHS

This is a noni fruit and herb infusion in your favorite vinegar.

1. Chop enough very ripe noni fruit to fill a glass jar $\frac{1}{3}$ – $\frac{1}{2}$ full.
2. Fill the jar with apple cider, Balsamic, or rice wine vinegar. Add your choice of onion, garlic, ginger, turmeric, and other herbs.
3. Cover jar tightly and place in a sunny location for up to a week. One day in the sun is sufficient.
4. Strain through cheesecloth and store in a tightly-sealed glass container in a cool, dark place.

Noni Caesar salad dressing SOURCE: B. FAHS

This recipe uses the noni herb vinegar from the above recipe in a salad dressing.

- 6 tablespoons (90 ml) noni vinegar made with apple cider or Balsamic vinegar
- $\frac{2}{3}$ cup olive oil
- 2–3 large cloves of garlic, pressed or crushed
- Freshly squeezed juice of 1 lemon
- 2 3-minute eggs

Combine the first four ingredients in a jar or cruet. After the eggs have boiled for 3 minutes, run them under cold water, then crack with a knife over your container, allowing the yolk to run into the other liquids. With a teaspoon, scoop out the partly-cooked egg white in small bits and add it to ingredients in the jar. Shake dressing and serve over greens. Sprinkle some authentic Italian Parmigiano-Reggiano



Left: Young noni leaves make a nice addition to a salad and have a flavor reminiscent of endive (should be used fresh to avoid browning in the refrigerator). Right: Young fruits less than 1 in (2.5 cm) in diameter can be sliced thin and used in stir-fry dishes. PHOTOS: C. ELEVTICH

cheese over your salad too! If you make the dressing a few hours ahead of time, the garlic flavor will blend. Refrigerated, it will keep for about a week.

Noni elixir SOURCE: B. FAHS

To make a noni elixir, place noni fruit in a mason jar with cider vinegar. Steep for 4 weeks or longer. Drink the elixir directly or use it in dishes such as salads.

1. Chop noni fruit and put the pieces in a clean mason jar, about $\frac{1}{3}$ full.
2. Add other ingredients, such as cinnamon sticks, cloves, allspice, and fruits such as mango, dried apricots, passion fruit, etc.
3. Cover the ingredients with brandy. For a non-alcoholic elixir, you can use food-grade vegetable glycerin (available from health food stores) and/or cider vinegar instead of brandy.
4. Close the jar tightly and store out of direct sunlight.
5. Shake your elixir every day for 4 weeks. Then strain it and sweeten to taste with molasses, maple syrup, or honey to suit your taste.
6. Bottle your concoction, preferably in dark glass, and store it in a cool, dark place at room temperature. Don't forget to label what's inside! For long-term storage, it's best to refrigerate elixirs.

As an elixir, use two to four full droppers 2–3 times each day. You can include it in a delicious healthful



salad dressing by mixing it with olive oil and other ingredients.

Purple paradise noni fruit smoothie

- 1 cup (240 ml) frozen cherries
- 1 cup (240 ml) frozen mangos
- 1 cup (240 ml) frozen blueberries
- 1 banana
- 3 heaping tablespoons (60 ml) of vanilla yogurt
- ½ cup (120 ml) soy milk (vanilla flavored)
- 3 tablespoons (45 ml) noni juice concentrate

Place ingredients in blender and blend until smooth. Serve immediately. Experiment with in-season fruits for different flavors and colors! Serves: 2–3.

Noni juice ambrosia

The following fruit ambrosia is a tasty way to receive a daily serving of noni juice.

- Fruit slices, crushed fruit, or fruit sections (e.g., bananas, papaya, mango, pineapple, citrus, grapes, strawberries, apples, etc.).
- ¼ cup (60 ml) noni juice, or to taste, i.e., enough to thoroughly soak the fruit slices and leave residual juice in the bottom of the cup.

Mix ingredients together and chill. Serve in cups.

Pineapple-orange-noni frozen treat

Use this recipe to include noni in your kids' diet while they love every bite of it.

- pineapple juice
- orange juice
- noni juice

Mix pineapple and orange juice in equal amounts. Add about 1 oz (30 ml) of noni juice for each 6 oz (180 ml) of the other fruit juices, or to taste. Pour into molds. Freeze and serve frozen. Other fruit juices can be used.

Noni-strawberry fruit leather

This recipe is great for children (and adults will love it too). It is a convenient, light-weight, and easy-to-



Purple paradise fruit smoothie—beautiful and delicious.
PHOTO: S. NELSON

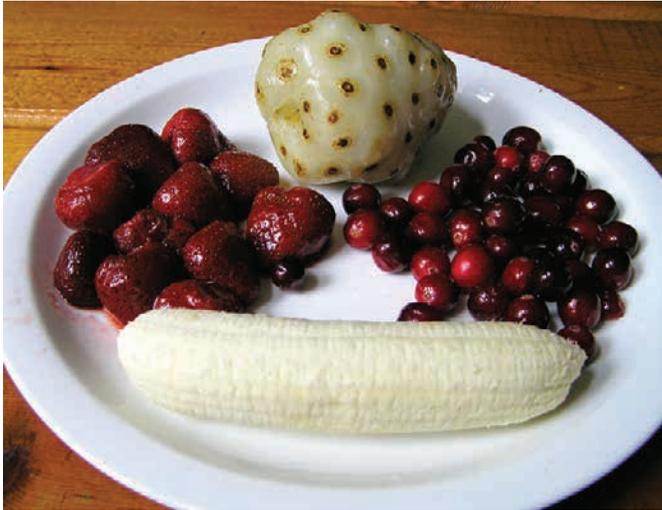
store way to take noni with you while traveling or on camping trips.

- ripe noni fruits
- strawberries

Remove seeds from ripe noni fruit and puree the pulp. Puree an equal amount of strawberry fruit. Mix them together and spread the noni-strawberry puree in thin layers on the screen-type shelves of a ring-style kitchen food dehydrator. Set the temperature to 120°F (49°C) and let the puree dehydrate until it forms leathery sheets. Store sheets in sealed plastic bags or rolled up in jars in a refrigerator until you want to eat them. Other fruits such as blueberry, mango, or apples can be substituted for strawberries.

Noni lime-aid

Noni juice mixes very well with citrus of all types in-



A delicious fruit leather can be made using ripe noni fruit or fruit juice powder mixed with other fruits. Top: Noni, strawberries, cranberries, and banana. Middle: Macerated fruits spread on tray in home drying unit. Bottom: Dried fruit leather ready to eat. PHOTOS: S. NELSON

cluding lemon, lime, tangerine, and grapefruit juice. Squeeze the juice from one lime and add 4–6 oz (120–180 ml) drinking water and 2 oz (60 ml) noni juice. Sweeten with honey if you wish. For an extra treat use coconut water instead of drinking water. The sometimes objectionable taste of noni is well masked by the similarly acidic citrus juice.

Noni sun tea

Dried noni fruit slices can be rehydrated by soaking in water placed in direct sunlight to make a “sun tea.” This is especially convenient for travelers or campers. As soon as a noni fruit ripens and becomes soft, cut the fruit into slices and dry the slices on a screen or rack in sunlight, a food dehydrator, or oven set to 115°F (46°C). Store the dried slices in an airtight container until used. When ready to use, place the slices into a clear glass jar with water, then seal the jar and place it in the sun. After 2–3 days, drain off the now noni-infused water and store it in the refrigerator or drink it. Put enough noni slices to the water to suit your particular taste preferences. Add some lemon juice or lime juice to the tea just before drinking and sweeten with a little honey, if desired. Mix with other natural herbal sun teas for different flavors and additional health benefits. Sun teas may also be made from dried noni leaves instead of dried fruit.

Noni fruit puree

Noni fruit puree is very easy to make and is a delicious treat. It resembles a tart and tangy applesauce and is used in more noni beverage products than any other type of noni fruit extraction, including pure noni juice. Noni puree stores very well and can be used in many ways. After making puree, you can store it frozen indefinitely in plastic freezer bags until you are ready to use it. The authors keep noni fruit puree on hand for making fruit leather roll-ups, smoothies, general cooking and baking, and a ready-to-use treatment to help heal or sooth wounds or burns. Noni fruit puree is perhaps the best way to consume fresh noni without having to deal with seeds. To make noni fruit puree in your kitchen, obtain some fully ripe, soft, translucent noni fruits. Wash the fruits and your hands. Break up the fruits with your hands and place the pieces into a hand-held

kitchen sieve, the kind with wire screen. Using a clean handheld device such as a clean pot-scrubbing brush (reserved for this purpose) or wooden or plastic spoon, press the pulp through the screen into a bowl using a circular motion. The puree has the consistency of apple sauce. Commercial noni puree manufacturers use machines commonly used in other fruit puree industries. If you want, you can clean and use the leftover seeds for planting.

The puree can be dried to a crispy consistency in an oven or food dehydrator and then ground into powder using a coffee grinder or kitchen blender. The powder can then be added to water or other beverages as a good source of nutrition and fiber. The powder is lightweight, stores well if kept dry, and is well suited for use while traveling or camping.

To calculate the equivalency between noni fruit puree and pure noni juice, use the rule of thumb that under normal drip-extraction conditions, pure noni juice represents about 60% of the fruit weight. This means that 50 grams of noni fruit puree is equivalent of about 1 fl oz (30 ml) of pure noni juice.

First aid

Noni reportedly has skin healing properties that make it a good topical first aid plant. The Hawaiians, for example, used noni leaves and fruits applied to the body to set broken bones and to treat skin wounds, burns, and skin problems.

Cut, wound and abrasion, burn, sunburn

A good first aid treatment should ideally be anti-bacterial or anti-microbial, anti-inflammatory, analgesic, and stimulating to the immune system. Noni leaves and fruits have all of these properties. This explains why placing noni fruits or leaves on skin wounds relieves pain, reduces swelling and inflammation, and promotes quick healing with reduced risk of infec-



Top: Noni fruit puree is easy to store in the freezer for use in juice, smoothies, and cooking. PHOTO: S. NELSON Bottom: Dried noni leaves or fruit slices are suitable for travel and can be used to make tea by infusing in water. PHOTO: C. ELEVITCH

tion. Noni is thought to be immuno-modulatory, meaning that it has natural plant chemistry which can modulate and stimulate the human immune system to help ward off infection and disease.

Here are some noni first-aid treatments for wounds. These are based on historical Polynesian treatments that may or may not have scientific merit, and these and other treatments in this chapter **should not be used to replace modern professional medical treatment for serious wounds or injuries.**

Crushed noni fruit and sea salt

Crush green noni fruit together with sea salt and place directly on wound and cover with a cloth bandage. This is the ancient Hawaiian method.

Ripe noni fruit pulp

Break open a soft, ripe noni fruit and rub the pulp over the wounded area, leaving pulp on the skin. Allow to air dry. This immediately relieves pain, dries out the wound, and leaves a protective skin of dried pulp to cover the wound. If you keep the area dry, a bandage might not be necessary. Rub ripe noni fruits on your skin for immediate relief and enhanced recovery from sunburn.

Heated leaves on wounds or boils

Pass noni leaves over a flame until soft and apply them to the injured area as a poultice overnight. Apply heated leaves to hip using a bandage or medical tape (duct tape in a pinch) to relieve sciatic pain.

Other first aid applications

Here are some additional reported uses of noni in first aid, especially if you are in remote location where noni grows and/or you are without access to a doctor or pharmacy. Try some, you might be amazed!



Ripe or nearly ripe fruit rubbed on superficial skin wounds, burns, and other problems can help reduce pain and inflammation. PHOTO: C. ELEVITCH



Fruits can be used at various stages of development for first aid, medicine, or food. PHOTO: C. ELEVITCH

Again, these treatments are not a replacement for professional medical care.

Facial and scalp dermatitis

The face and head are exposed to sunlight and as result can dry out and develop painful areas of damaged skin. Noni juice or fruit is especially good for scalp problems developed in sensitive people and seniors. The authors use raw noni juice as a scalp treatment by soaking the scalp with juice, letting it sit for a few minutes, and then rinsing off with fresh water. Also, try mixing noni juice with foot soaks or epsom salts to improve foot health.

Worms, intestinal parasites

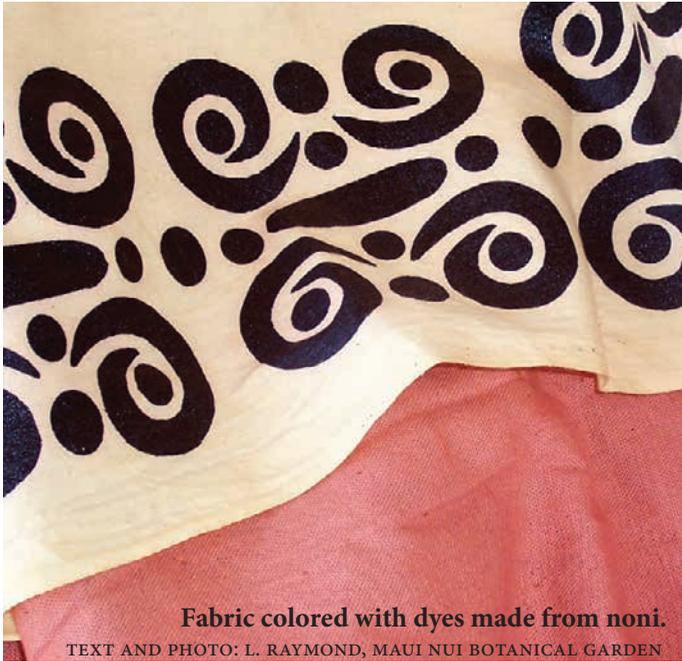
Consume one whole ripe noni fruit including seeds (or ¼ fruit or less for pets) to expel worms. Repeat daily and increase quantity of fruit consumed if needed. This is a folk remedy.

Constipation, irregularity, diarrhea

For constipation and irregularity, drink unpasteurized, organic, “young” noni juice in its active fermentation stage, about 7–10 days old. Drink older, more aged, properly fermented juice for diarrhea.

Insomnia

Drink noni juice. The effect is not strong or overwhelming, but some people claim that it works for them.



Fabric colored with dyes made from noni.

TEXT AND PHOTO: L. RAYMOND, MAUI NUI BOTANICAL GARDEN

Making a red dye from roots

1. Strip off the cambium layer from young, 2–4-year-old noni roots and chop or grind it up. This material is yellow in color and can be mixed with water to make a yellow dye.
2. Separately, grind into powder coral that has been burnt over a fire. Burning the coral changes its chemical composition, turning it to lime.
3. Mix the burnt coral powder and ground noni roots with sea water. This turns red immediately and is used to dye cloth. The alkalinity of the lime creates the red color. A small amount of wood ash added to the solution intensifies the red and keeps it from fading to orange.
4. Apply the red dye to the fabric and let dry.

Arthritis

Wrap joints in warm noni leaves or apply warm noni fruit pulp to affected areas.

Stomach ache

Drink warm noni tea made from leaves.

Mouth infection, sore throat, toothache, tonsillitis

Chew on the fruit which may be young and unripe to completely ripe. Green fruits are probably more effective for this application. Adding sea salt to the fruit is fine, if desired.

Fungal skin problems

Applying ripe or semi-ripe fruit to fungal skin problems such as ringworm (a fungus), fungal rashes, and athlete's foot is said to clear up these problems where even conventional treatments fail.

The noni hunter: where the intrepid tourist can find wild noni

For a general description of noni's habitats, please refer to the "Botany and environment" chapter. When in doubt about specific locations for wild noni plants, you can always look for the general habitats that noni is known to frequent. Local people can often tell you

where noni trees can be found in nearby public areas.

Hawaiian Islands, general information

Wild noni can be easily found growing on all main Hawaiian islands—Hawai'i, O'ahu, Kaua'i, Maui, Moloka'i, and Lāna'i. The plants are accessible off-road to hikers, and there are also many wild roadside plants accessible to motorists.

Island of Hawai'i

Wild, roadside noni plants are abundant along Highways 130, 137, and 132 in East Hawai'i and along Highway 11 in the South and North Kona Districts. Noni also grows in two national parks on the island of Hawai'i, Hawai'i Volcanoes National Park (along Highway 130 [Chain of Craters Road]) and at Pu'uhonua o Honaunau National Historical Park. Hikers can also find abundant noni growing in many gulches and valleys along the Hāmākua coast. On the Kona side of the island, noni can be found growing up to about 2500 ft (760 m) or higher, whereas in East Hawai'i noni can be found growing at elevations of up to 1000 ft (300 m). Noni can also be found growing on or near sandy or rocky beaches on Hawai'i, such as Kehena Beach (a popular clothing-optional beach) on Highway 130 or the Old Kona Airport beach park in Kailua-Kona. If you are not sure what

noni looks like, you can see it growing at several botanical gardens on the island, including the Bishop Museum Amy B. H. Greenwell Ethnobotanical Garden in South Kona on Highway 11. Other specific locations on Hawai'i include Keākea Park (Kohala) and Waipi'o Valley (along jeep road to the first falls).

Island of O'ahu

Many of the lowland valleys and mountainsides on O'ahu that are accessible to hikers have noni growing along trails. For example, noni plants are very abundant along trails and roads of Waimea Valley. Other specific sites include Ewa coral plain; Waimea River (lower part); Waiānae Mountains; Mākua; Kalanui Valley; and Kahana Bay. Plants can be seen at Bishop

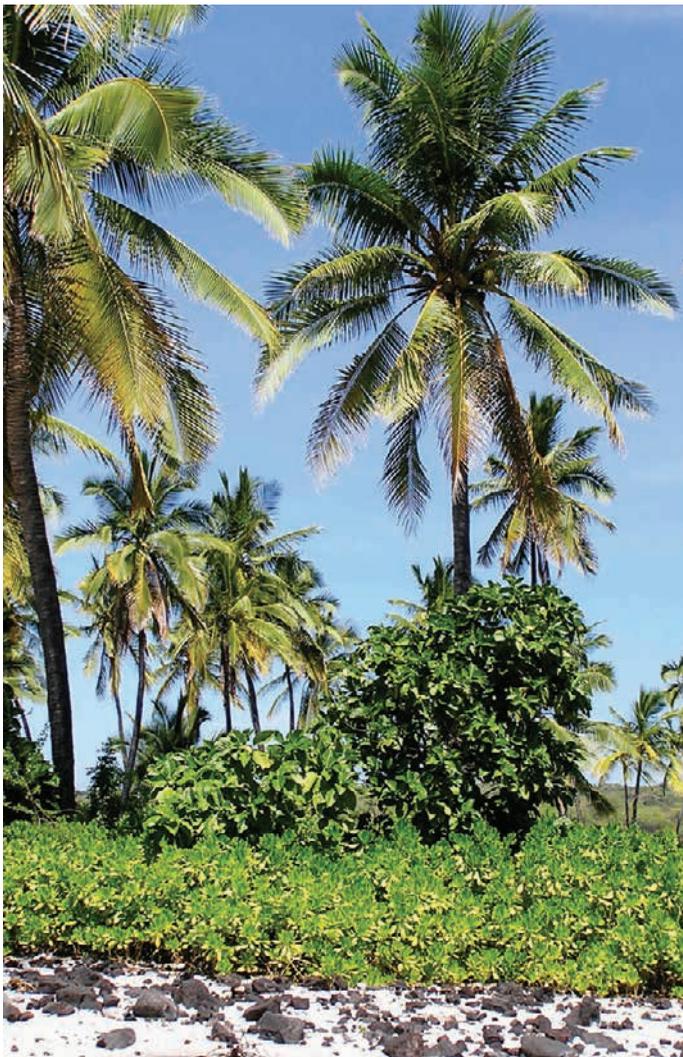
Museum; Lyon Arboretum; University of Hawai'i Mānoa campus; ; Mānoa Theatre, Mānoa.

Island of Kaua'i

Plants can be found growing on Kālepa Ridge; Hoary Head Mountains, Kīpū; Wainiha Valley; Lumahai; and Hidden Valley.

Island of Maui

A large population of noni plants can be found in the Hana District and the famous "road to Hana" on the highway west of Seven Pools Park. Noni can also be seen at Maui Nui Botanical Garden.



Noni trees can be seen in many areas throughout the Pacific. **Left:** Growing along beach at Pu'uhonua o Honaunau National Historical Park, South Kona, Hawai'i. PHOTO: S. NELSON **Right:** Trees growing in landscaping at scenic outlook, Keauhou, Kona, Hawai'i. PHOTO: C. ELEVITCH



Left: Tree on edge of Apia Bay, Samoa. Right: Many areas have lots of wild noni to see such as here in Waipi'o Valley, Hawai'i. PHOTOS: C. ELEVITCH

Picking courtesy

In Hawai'i there are customary rules for picking flowers or fruits from wild plants along public roads. It is acceptable to collect lei flowers or fruit such as noni along public roads in moderate quantities for personal use (not for commercial use). Every country has different accepted rules, so be sure to check with local people or the tourist office in each country you visit before picking. The following guidelines apply in Hawai'i.

- pick only for personal use in modest quantities up to 10 lb (4.5 kg) per occasion
- leave some part-white fruit on the tree that will ripen in 1–2 weeks time for the next person
- noni trees are very brittle and branches break easily, so twist off fruit gently and avoid forcefully bending down branches to pick fruit
- do not climb noni trees to reach fruit as you could break off large branches
- never pick from private homegardens or farms without permission
- only pick with permission from a park ranger within county, state, or federal parks
- gathering litter whenever harvesting is a good way to give back to the community



Both small and large branches snap off very easily, so it is important to be careful when picking fruit. It is best to twist off fruit rather than pulling. PHOTO: C. ELEVITCH

Island of Moloka'i

The valleys and coastline of the eastern part of Moloka'i island contain the most wild noni plants. Specific site locations include the peninsula west of Wailua Valley; Mapulehu Valley, near mouth; Hälawa; and Keöpuka Loa.

Island of Lāna'i

Specific site locations for wild noni include Löpā and the Löpā coast.

Other Pacific islands

Elsewhere in the Pacific, noni grows in the wild, on farms, and in public areas—ask the locals where to find it. Talking with local people is also a good way to find out how they use noni in different regions. Noni is being introduced as a commercial crop to new areas in the Pacific where you may be able to locate producers.

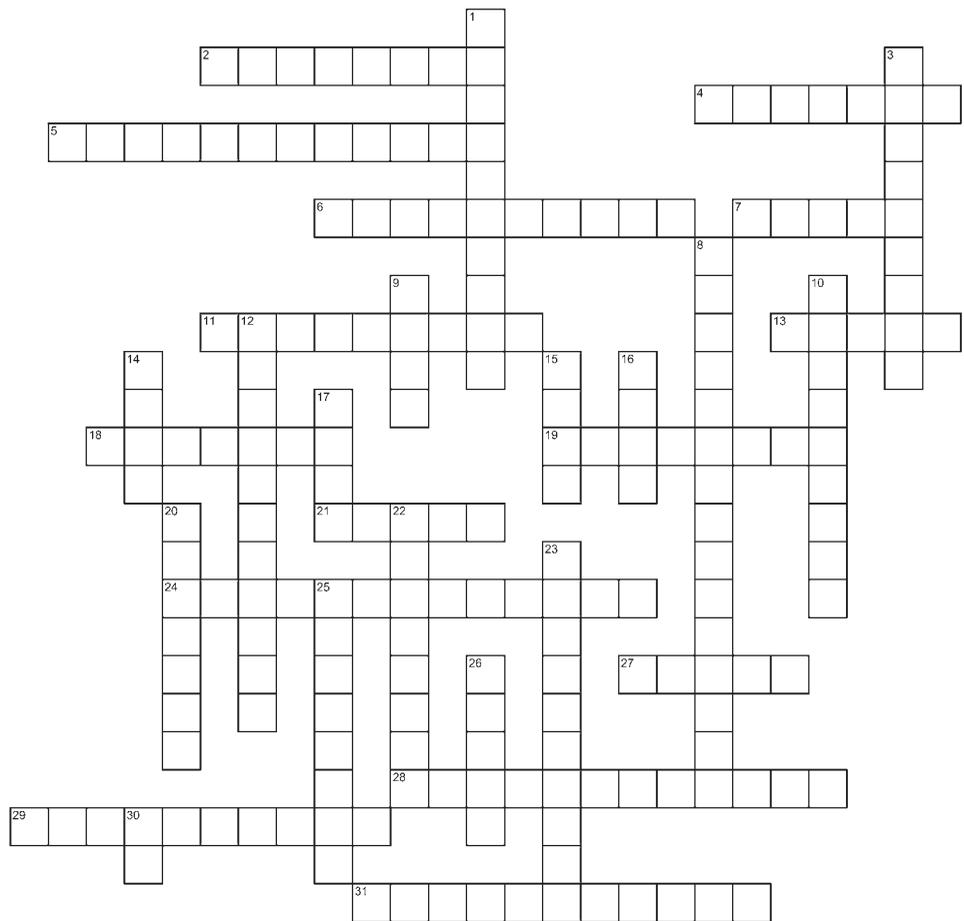
Test your noni knowledge with this crossword puzzle! All the answers are found in this book, and the puzzle solution is given on page 104.

ACROSS

- 2 Plant family to which noni belongs
- 4 Variegated cultivar of noni
- 5 Conversion of sugars in juice to organic acids and CO₂
- 6 Species name for noni
- 7 What noni seeds do in water
- 11 Serious root-infecting pests of noni
- 13 Noni plant part used to make reddish dyes
- 18 Genus name for noni
- 19 Swedish botanist who gave noni its Latin name
- 21 Color of 6-week-old noni juice
- 24 Property of noni that suppresses the growing of certain fungi and bacteria
- 27 Color of ripe noni fruits
- 28 Sustainable and traditional method of cultivating noni with other plant species in Pacific islands
- 29 Chemical in noni juice used to treat hypertension
- 31 Carried noni throughout the Pacific during travels

DOWN

- 1 A regional vernacular name for noni that indicates one of its healing properties
- 3 Variety of noni with conspicuous bracts
- 8 Chemicals in noni linked with tumor suppression
- 9 Painful joint condition alleviated by noni consumption
- 10 Elemental nutrient found in noni in relatively large quantities
- 12 The study of plant uses in a traditional society
- 14 Objectionable attribute of noni fruits
- 15 Noni plants tolerate this compound found in sea water
- 16 Most commonly used vernacular name for *Morinda citrifolia*
- 17 Noni is one of the first plants able to colonize this type of land



- 20 Do this to a noni seed to improve germination
- 22 Type of microbes commonly involved in the fermentation of noni juice
- 23 Arc of seismic activity in the Pacific
- 25 Dye found in noni plant
- 26 A cooked food dish that can include green noni fruits
- 30 A measure of noni juice acidity

BOTANY AND ENVIRONMENT

The genus *Morinda*

Noni belongs to a large plant group (genus) called *Morinda*. *Morinda* species comprise a useful and widely distributed group of tropical trees, shrubs, and vines. There are about 80 *Morinda* species, most originating from Borneo, New Guinea, Northern Australia, and New Caledonia. At least 20 species have significant economic and traditional value as

a source of medicine, food, dyes, or wood. Several species, including noni, have buoyant seeds that can float in salt water for months and still remain viable upon landing on a remote coast. These *Morinda* species became essential components of many tropical coastal and forest ecosystems as well as serving important functions in a number of ancient indigenous societies.

Table 5.1. Some useful *Morinda* species.

Scientific name(s)	Example vernacular names	Some traditional uses
<i>M. citrifolia</i>	noni (Hawai'i, Marquesas, trade name)	medicinal*: anti-tumor, hypertension, many others food: famine food; fruits cooked in curries; leaves used to wrap and serve food; leaves eaten in salads other: red and yellow dyes
<i>M. coreia</i> (syn. <i>M. tinctoria</i>) (syn. <i>M. tomentosa</i>) (syn. <i>M. aspera</i>)	<i>al, aal, ack</i> (India)	medicinal: diarrhea, dysentery, cholera (vomiting) food: unripe fruits used in curries; leaves fed to livestock other: morindone/morindin dyes from root bark
<i>M. lucida</i>	brimstone tree (Africa)	medicinal: astringent, purgative, emetic, diuretic (hemorrhoids, dysentery, jaundice) food: bitter tasting roots used to flavor alcoholic beverages and food other: wood used in construction; roots (yellow) and bark (red) used for dyes; leaves used for scouring or cleaning
<i>M. officinalis</i>	<i>ba-ji-tan</i> (China)	medicinal: analgesic, anti-bacterial, anti-rheumatic, astringent (urinary, genitals), anti-depressant, aphrodisiac, androgenic, hypotensive, musculoskeletal restorative (arthritis, fatigue, musculoskeletal atrophy, impotence)
<i>M. parvifolia</i>	<i>hong-zhu-teng</i> (China)	medicinal: antitumor, antilekemic (relief of pulmonary symptoms)
<i>M. panamaensis</i>	<i>yema de heuvo</i> (Colombia)	other: wood used in construction, especially railroad ties in Central and South America
<i>M. royoc</i> (syn. <i>M. yucatanensis</i>)	<i>hoyoc</i> (Guatemala)	medicinal: aphrodisiac, purgative, laxative, stomachic, emmenagogue (digestion, liver, jaundice, warts) other: roots make yellow dye
<i>M. umbellata</i>	<i>noona kai</i> (India)	medicinal: dysentery, intestinal worms, dropsy; purgative food: ripe fruit eaten, green fruits used in curries other: stems used as ropes; roots produce dye

* Medicinal terms refer to conditions and diseases (e.g., dysentery) or treatment (e.g., purgative).

Botany

Noni is a small evergreen tree or shrub approximately 10–33 ft (3–10 m) in height at maturity and 6 in (15 cm) or more in stem diameter. The plant sometimes supports itself on other plants as a woody climber (liana). There is significant variation in the species for overall plant form (see “Varieties” below), fruit size, leaf size and shape, palatability, odor of ripe fruit, and number of seeds per fruit.

Noni is known worldwide by dozens, if not hundreds, of vernacular names, including Indian mulberry

(English), *fromager* and *murier indien* (French), and *mora de la India* (Spanish) (see “List of vernacular names: below for an extensive list of worldwide names). The most widely used vernacular name, and the name used commercially, is the Hawaiian and Marquesan name noni.

Varieties

Botanists recognize three distinct varieties of *M. citrifolia* with differing leaf and fruit morphologies.

Morinda citrifolia var. *citrifolia* (“noni”) is the only

General botanical description

Flowers are perfect, with about 75–90 in ovoid to globose heads. Peduncles 0.4–1.2 in (10–30 mm) long; calyx a truncated rim. Corolla white, 5-lobed, the tube greenish white, 0.28–0.35 in (7–9 mm) long, the lobes oblong-deltate, approximately 0.28 in (7 mm) long. Stamens 5, scarcely exerted; style about 0.7 in (15 mm) long.

Leaves are opposite, pinnately veined, and glossy. Blades membranous, elliptic to elliptic-ovate, 8–18 in (20–45 cm) long, 3.5–10 in (7–25 cm) wide, glabrous. Petioles stout, 0.6–0.8 in (1.5–2 cm) long. Stipules connate or distinct, 0.4–0.5 in (1–1.2 cm) long, the apex entire or 2–3 lobed.

Twigs are light green and four-angled.

Fruit (technically known as a syncarp) is yellowish white; fleshy, 2–4 in (5–10 cm) long, about 1.2–1.6 in (3–4 cm) in diameter, soft and fetid when ripe.

Seeds are brown or reddish-brown, oblong-triangular, about 0.25 in (6 mm) long and have a conspicuous air chamber and a durable, water-repellent, fibrous seed coat.

Sapwood is soft and yellow-brown. The bark is relatively smooth to slightly rough, and colored gray or light brown.

Noni has a rooting habit similar to that of citrus and coffee, with an extensive lateral root system and a deep taproot. New stems and foliage may sprout easily from exposed lateral roots.



Clockwise from top left: Flowers, leaf and fruit, stem cross section, fruit cross section, seeds (wet on left, and dry on right), and cut trunk. PHOTOS TOP ROW AND BOTTOM LEFT: C. ELEVITCH, PHOTOS BOTTOM ROW MIDDLE AND RIGHT: S. NELSON

The botanical name for the genus *Morinda* was derived from the two Latin words *morus*, mulberry, and *indicus*, Indian, in reference to the similarity of noni fruit to that of true mulberry (*Morus alba*). The species name *citrifolia* indicates the resemblance of the plant foliage to that of some citrus species.

variety used globally as a nutritional supplement and is the variety covered in this book. It is the most important variety, having greatest cultural, economic, and medicinal value. It also probably has the widest distribution among the three varieties. This variety is itself morphologically diverse, with no clear sub-populations bearing unique characteristics. For example, there exist large-fruited (e.g., the Hawaiian noni) and small-fruited types (e.g., the Micronesian *lada*) and narrow-leaf and rounded-leaf types. The large-fruited types such as the Hawaiian tend to have more rounded (ovate) leaves, and small-fruited types tend to have narrower and more elliptical leaves.

Morinda citrifolia var. *bracteata* is a small-fruited variety with conspicuous bracts that look like petals attached to the base of the fruits. Although the fruits are quite different from noni's fruits, the leaves of var. *bracteata* are very similar to var. *citrifolia*'s in size and shape. It is found naturally in Indonesia and other regions between the Indian and Pacific Oceans and is cultivated in some locations.

Morinda citrifolia cv. 'Potteri' is an ornamental, smaller-fruited, narrow-leafed type with green-and-white leaf variegation. It is found throughout the Pacific.

Reproductive biology of noni

Noni produces flowers and fruits throughout the year. Unripe fruits are light green. Ripe fruits are whitish-yellow and have a distinct, disagreeable odor when ripe. When harvested at this "hard white" stage, fruits turn soft and translucent yellow within a few days. There exists no published information on pollination and fruit set for noni, or on the time required from initial flowering to maturation and ripening of fruits. In Hawai'i flowers on individual noni fruits



Top: *Morinda citrifolia* var. *citrifolia* (noni) is the variety of greatest importance and widest distribution. Middle: *Morinda citrifolia* var. *bracteata* is a small-fruited variety with conspicuous bracts (petal-like structures on bottom of fruits). Bottom: *Morinda citrifolia* cultivar 'Potteri' is an ornamental type with green and white leaf variegation distributed throughout the Pacific. PHOTOS: S. NELSON

Invasiveness warning

Noni is naturalized outside its native range in many locations throughout the Pacific and the tropics. Although not considered invasive to the degree that it threatens ecosystems, noni is recognized for its ability to persist, disperse, and colonize new areas. This may take place with or without biological dispersal

agents such as humans, rodents, and birds. For example, noni seeds float for long periods of time in ocean water or streams and rivers and can remain viable for months during their journey until they land on a suitable substrate. Noni is considered to be a weed in some locations (e.g., in some agroforestry or diversified farming settings in Micronesia).

Avoid planting noni near archaeological sites and try to eradicate it from these sites where possible; noni plants are very difficult to kill once established, and may be virtually impossible to eradicate without causing site damage. Also, noni plants can sucker from the roots under certain circumstances, spreading by vegetative means rather than by seed.



Left: Bullet-ridden tower in Yap colonized by noni (on top) and other species. PHOTO: S. NELSON **Top right:** Root suckers growing up to a few feet from plants can pose a maintenance problem in landscapes. PHOTO: S. NELSON **Bottom right:** Noni produces a large number of seeds that are spread by birds and rodents and natural elements such as wind and rainwater. Some of the seeds find their way to niches where they can sprout and grow into trees. PHOTO: C. ELEVITCH

are produced over a span of many weeks as fruits expand in size.

Wild habitats

Noni is a common component of primary forests or shrub vegetation, including on small atolls and basaltic lava flows. It can be found in disturbed forests, dry to mesic forests, grasslands, open areas near the shoreline, pastures, coconut plantations, around villages, littoral forest, fallow, and waste areas.

Beginning about 2000 years ago, native seafaring Polynesian peoples carried noni with them throughout the Indo-Pacific region. By the late 1500s, Europeans began to explore and colonize the Pacific. For example, by the late 1500s the Spanish had colonized the Philippines and reached several islands in Micronesia. By the 17th and 18th centuries, explorers, merchants, and privateers from Holland, France, and England began to explore and chart the Pacific. Since that time, people have spread the plant throughout the tropics, both intentionally and unintentionally with the help of rats, birds, bats, and pigs.

Today, noni is distributed pantropically, roughly between latitudes 19° N and S. The Indo-Pacific distribution includes Indonesia, Australia, Southeast Asia, Eastern Polynesia (e.g., Hawai'i, the Line Islands, Marquesas, Society Islands, Australs, Tuamotus, Pitcairn, and Cook islands), Melanesia (e.g., Fiji, Vanuatu, New Guinea, New Caledonia, and the Solomon Islands), Western Polynesia (e.g., Samoa, Tonga, Niue, 'Uvea/Futuna, Rotuma, and Tuvalu), and Micronesia (e.g., Pohnpei, Guam, Chuuk, Palau, the Marshall Islands, and the Northern Marianas). Noni has also become naturalized on the open shores of Central and South America (from Mexico to Panama, Venezuela, and Surinam) and on many islands of the West Indies, the Bahamas, Bermuda, the Florida Keys, and parts of Africa. The list of worldwide vernacular names for noni below reveals its current geopolitical distribution.

Environments, climates, soils, latitudes

Noni is noted for its adaptability to an extremely

Summary of climatic conditions

Elevation range 3,3–2600 ft (1–800 m), depending on latitude and environment

Mean annual rainfall 10–160 in (250–4000 mm)

Rainfall pattern Wide variation

Dry season duration (consecutive months with less than 1.6 in [40 mm] rainfall) At least 3–4 months depending on age, size of tree, temperature, relative humidity, and soils

Mean annual temperature 68–95°F (20–35°C)

Mean maximum temperature of hottest month 90–100°F (32–38°C)

Mean minimum temperature of coldest month 40–64°F (5–18°C)

Minimum temperature tolerated 54°F (12°C)

wide range of environmental tolerances. It grows from elevations near sea level up to about 2600 ft (800 m) above sea level, depending on latitude and environment. Noni prefers temperatures of 68–95°F (20–35°C), and can tolerate a minimum temperature of about 40°F (5°C). It is most commonly found in relatively dry to mesic sites or lowland areas in close proximity to shorelines, or as an important forest understory species in low-elevation tropical island forests and rainforests.

Soils

Noni tolerates and thrives in an unusually wide range of soils and environments. It has a remarkable ability to survive in harsh environments such as those found on coral atolls or basaltic lava flows. It can also be found in solution pits or brackish tide pools near the coast, in limestone soils or outcroppings, on coral atolls, as a colonizing species of basaltic lava flows, as well as in native forests. It can grow in a wide range of drainage conditions including seasonal waterlogging but prefers free, well drained soils. It tolerates a wide range of acidity levels, from acidic to alkaline. Noni also tolerates shallow, saline, sodic, and infertile soils. It is often most competitive where many other plants cannot grow. Noni grows very well on

Table 5.2 List of vernacular names for *Morinda citrifolia* by geopolitical location.

Location	Vernacular name(s)
Africa	bumbo, bungbo
Australia	awl tree, canary wood, cheese fruit, great morinda, Indian mulberry, Leichhardt's tree, morinda
Barbados	wild pine
Barbados	forbidden fruit
Cambodia	nhor prey, nhor thom
Cayman Islands	hog apple, mulberry
China	ba ji tian
Chuuk	nen, nopur
Cook Islands	gogu atoni, nano, nenu, nonu atoni
Cuba	mora de la india
Dominican Republic	baga, buneula, coca, feuille froide, heuvo de reuma, nigua, pain killer, pina de puerco, pineula
El Salvador	rubarbo caribe
Fiji	kura
Florida (USA)	Indian mulberry, limburger tree
French West Ind.	bilimbi, pomme macaque, rubarbe caraibe
Guadeloupe	rubarbe caraibe, rubarbo caribe
Guam	Indian mulberry, lada, ladda
Haiti	boi douleur, douleur, feuille douleur, fromagier
Hawai'i	dye tree, Indian mulberry, large-leaved morinda, noni
India	ach, awl tree, Indian mulberry, mulberry, togari wood
Indonesia	nony, nuna, pacel
Jamaica	hog apple
Java	awl tree, Indian mulberry
Kiribati	non
Kosrae	i
Laos	nho
Malaya	awl tree, bengkudu, bengkudu daun besar, bengkudu laki-laki, great morinda, mengkudu, mengkudu besar, mengudi besar
Malaysia	nona
Marshall Islands	nen, nin
Niue	gogu atoni, nano, nenu, nonu atoni
N. Marianas	lada
"Pacific world"	bankudu
Palau	kesengel, lel, ngel
Philippines	bangkoro, bankoro, nino
Pohnpei	weipwul
Polynesia	awl tree, noni
Puerto Rico	gardenia hedionda, indian mulberry, pain killer
Rarotonga	nono
Rotuma	ura
Samoa	gogu atoni, nano, nenu, nono, nonu, nonu atoni
Seychelles	mirier de java
Singapore	hai ba ji, luo ling, wu ning
Solomon Islands	urati
St. Croix	headache tree, pain killer
St. Thomas/Virgin Islands	pain killer
Surinam	mengkoedoe, morinda
Taiwan	luo ling
Tahiti	mona, monii, nono
Tamil	munja pavattay
Telugu	maddhi chettu, molagha
Tobago, Trinidad	pain bush
Tonga	gogu atoni, nano, nenu, nonu, nonu atoni
Vietnam	grand morinda, nhau, nhau lon, nhau nui
Yap	mangalweg

rocky soils but may not compete well with grasses or other weeds in deep, silty soils.

Tolerances

Wild noni plants growing in arid conditions can spend their entire lives in conditions of perpetual drought. Mature noni trees in cultivation can easily withstand drought for 6 months or more. The plant grows well in full sun, although it can grow in a wide range of light intensities, from full sun to 80% shade. It can regenerate after fire by sprouting new foliage from roots or stems. Noni withstands and even thrives in brackish tide pools. It can also tolerate flooded conditions for long periods of time. It is very salt-resistant and tolerant of ocean salt spray. Noni is tolerant of extreme salinity in general and is thought to benefit nutritionally from the minerals contained in seawater. Noni can grow in windswept locations such as coastal areas exposed to trade winds. However, yields and overall plant growth of noni in such conditions are diminished and therefore windy areas are not advised for commercial production.

Favored habitats

Since the early days of the indigenous Pacific island voyagers, noni has become naturalized on most Pacific islands. It thrives in wet to moderately wet conditions, from sea level to about 1500 ft (460 m) elevation. It is quite happy near the coast, in open lowlands and grasslands, in gulches, as an early colonizing plant species in recent lava flows, in disturbed forests of the dryer areas, such as the lowland forests in which screw pine (*Pandanus tectorius*) and kukui nut (*Aleurites moluccana*) trees grow.

Lava flows Noni is one of the first dicotyledonous plants to colonize low-elevation lava flows and rocky coasts in the tropics. Often such lava flows are 20 ft (6 m) thick, and have very low water-holding capacity. Even so, noni can get established in cracks in the lava, and will grow well for many decades. Noni is a common lowland roadside plant in Hawai'i, often occurring along the highways that cut through lava fields.

Tide pools Noni belongs to a group of tropical, coastal plants that can tolerate and even thrive in



Left: Noni can colonize the very harsh conditions of new lava flows, such as here in Hawai‘i. Right top and bottom: A noni tree grows in a brackish inland tide pool near sea level in the ‘Opihikao area of the island of Hawai‘i. The salty, brackish water level at this location rises and subsides each day, according to the tides. PHOTOS: S. NELSON

salty tide pools. Noni plants are extremely salt tolerant. The ancient Hawaiians reportedly fertilized their noni plants with sea salt scattered around the bases of plants.

Forests Noni trees are common forest understory plants in disturbed and native forests near the coastlines of islands in the tropics. For example noni, pandanus, and coconuts are common companions in coastline forests.

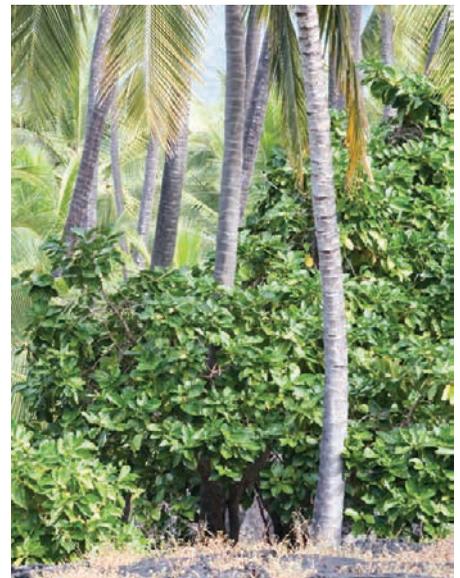
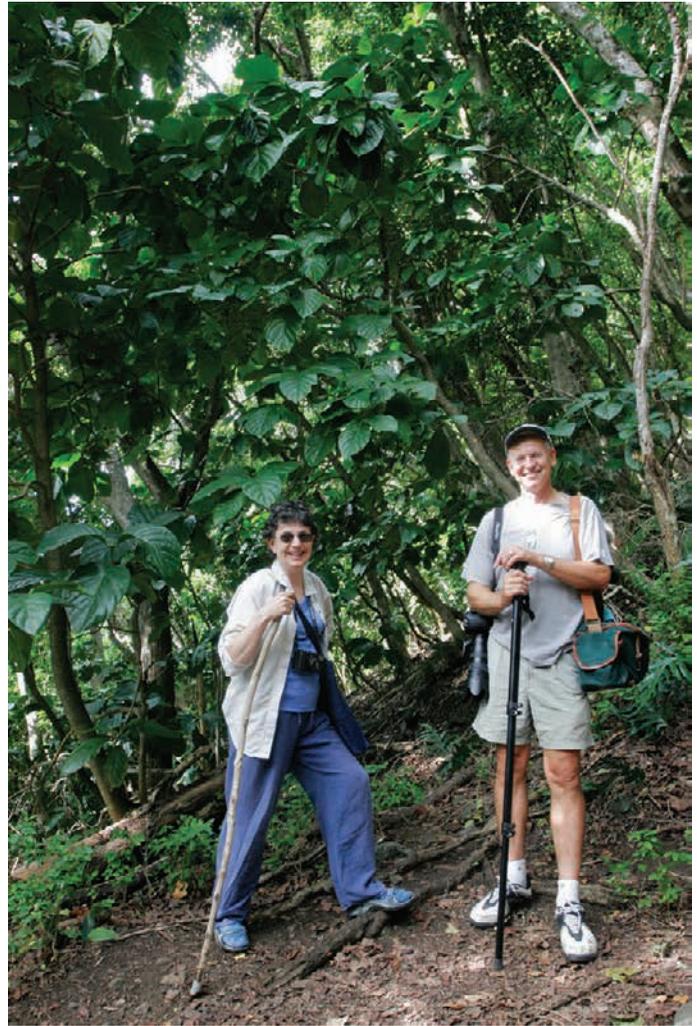
Gulches and cliffs Because noni can thrive on marginal soils and rocky locations, it is often found clinging to the cliff faces of steep gullies and gulches. Noni is also a common river or stream gulch plant.

Coastline and beach habitats Noni can be found

growing right out of beach sand within meters of the ocean throughout the tropics. The sand can either be quartz sand, coral sand, or basaltic sand or rock (black sand).

Raised coral and limestone beds and outcroppings Noni can be found growing in raised coral beds and coral outcroppings near the ocean. In some cases, entire tropical islands may have formed as the result of the geological uplifting of coral beds.

Dryland ecosystems Some ecosystems in the tropics are quite arid and receive little rainfall. Noni can thrive in these areas.



Clockwise from top left: Adjacent to shoreline at Apia Bay, Samoa. Under Java plum and mango trees, Waipi'o Valley. Under coconut palms Pu'uuhonua o Honaunau, Hawai'i. Under pandanus and coconut Upolu, Samoa. PHOTOS: C. ELEVITCH
Growing on cliff Puna, Hawai'i. Coastal growth in Rota. PHOTOS: S. NELSON

PROPAGATION

General propagation tips

In this section we provide general recommendations about starting noni plants from seeds and stem cuttings. The next section covers specific details about the most popular ways to make new noni plants.

Growth media

Noni is very robust and will grow in most commonly available growth media; it will even grow well hydroponically without any solid growth medium at all. In the nursery, either naturally-occurring or commercial growth media may be used. It is usually not difficult to identify a local source of relatively inexpensive material. Noni prefers a light, moisture-retaining, slightly acidic to slightly alkaline, well drained medium that may be high in organic matter derived from compost or peat. Media should be completely free of weeds and root-knot nematodes. Potentially nematode-infested media should be avoided or treated with heat (at least 122°F [50°C] for 20 minutes) prior to using. Natural or local forest soils mixed with sand, volcanic cinders and/or composted organic matter are excellent for noni seedling production. Commercial potting media containing peat and perlite (expanded mineral ash) for example, work well especially for starting noni seeds and for growing plants in nurseries. Vermiculite (expanded mineral mica) is very good for rooting noni cuttings.

Growing area

The best growing area for noni should have plenty of direct sunlight, be well ventilated but protected from strong winds and rain (such as a cold-frame with translucent plastic sheeting for the roof). Although partial shade is okay, direct sunlight warms up the seedling trays or pots and speeds up germination. If

you use a shaded area to grow noni plants, set up an area in full sun to sun-harden the seedlings for a few weeks before outplanting.

Temperature

Generally speaking, the warmer it is, the better noni will grow. Noni does not germinate or grow well below about 50–55°F (10–12°C). Seeds germinate best where it is very warm, about 90–100°F (32–38°C).

Pots and seedbeds

Growth media may be placed into pots, seedling trays, or made into seedbeds. Noni plants grow faster and produce longer, straighter taproots in deeper pots (at least 6 in [15 cm] deep) rather than in shallow pots or in seedling trays. Place mulch (e.g., cinder, sawdust, leaf litter, or sand) over the seeds or in seedbeds as needed for weed control and moisture retention.

Growing containers

Certain pots or container designs can prevent the root system of plants from circling around inside the container, which can cause the outer roots to choke off the main taproot later in life. The pots work either by air-pruning roots at the bottom and/or sides of the pot, by physical barriers which disrupt circular root growth, or by chemical treatment of the inner wall of the pot that stops roots from growing longer upon contact. Such pots are also designed to inhibit the taproot from hitting the bottom of the pot, then growing back up to the top of the pot, a condition called “J-root.”

Benches

Grow noni seedlings on raised benches where possible; this will reduce (but not eliminate) pest problems caused by slugs, caterpillars, and nematodes.

Seed description

The buoyant noni seed is brownish-colored with a bulbous, ovoid air chamber and a flattened, bi-layered tapering paddle. Seeds are about 3/16–3/8 inch (4–9 mm) long. The seed coat is comprised of layers of extremely tough cellulose fibers. The tiny embryo (flattened, oily, light-colored and about 1/8 inch [3 mm] long) is located inside the seed coat between the air chamber and the tip of the tapered paddle. Noni fruits can contain up to about 260 seeds each. When air-dried, a noni seed is very light, weighing only about a quarter of a gram. It takes 22 lb (10 kg) of fruit to obtain about 10,000 or 9 oz (250 g) air-dried seeds. PHOTO: S. NELSON



Water

Fresh catchment rainwater is probably best, but chlorinated municipal water is fine for irrigating noni. Noni is salt-tolerant and hardy, so you can even use brackish water or household graywater for seedling irrigation. Consult local health regulations for storage and use of graywater.

Seed collection

Gather very ripe fruits for seed collection; it will be easier to separate the seeds from the pulp and seeds will be fully mature. Ripe fruits collected from the ground are appropriate for seed collection as they should not be used for consumption due to the risk of contamination with potentially pathogenic fungi and bacteria, especially those associated with rodents and birds. Mature fruit collected from the tree is also fine, although you will have to wait for the fruit to ripen fully and turn soft before extracting the seeds. Seeds can also be extracted from fruit pulp remaining after juice extraction, although such pulp should not be older than about 2 weeks. Each fruit has about 150–200 seeds. It is best to collect fruits from plants that have desirable qualities such as vigor, large and abundant fruit, and good form.

Seed processing

Applying a strong spray of water and press and rub the fully ripe noni fruits against a screen or colander which has holes slightly smaller than the seeds. The soft, fibrous, fleshy pulp will slowly be removed from

the seeds as the seed-bearing pulp is rubbed against the screen and the water carries the pulp fragments away. Using this method, it may take 15 minutes to completely remove the pulp from a few fruits. Seeds may be used right way or air-dried for a few days and stored in glass bottles with silica gel desiccant for up to 6 months.

Seed pretreatment (scarification)

Although not required, noni seeds germinate much faster when the seed coat is nicked or abraded enough to create an opening that allows water to contact the embryo inside, a process called “scarification.” Scarified seeds germinate in 3–6 weeks. Otherwise, it can take months for the tough seed coat to break down enough to allow water to reach the embryo, which is necessary for germination. Two scarification methods for noni are described later in this chapter.

Selection of vegetative material

Collect cuttings from vigorous, disease-free noni plants. Cuttings made from upright-growing stems tend to make plants with better form than cuttings made from lateral (horizontal) branches.

How to start plants

The most common ways to start new noni plants are to

- gather and transplant wild (volunteer) noni seedlings

- grow plants from seed
- propagate plants from cuttings.

Each method has some pros and cons, which are listed below. Other propagation methods include air-layering and tissue culture, which are not covered here.

1. Transplanting wild or volunteer noni seedlings

How to do it Dig or pull out young noni seedlings you find growing naturally. Recover as much taproot as possible. You must harvest the seedlings when they are very young, up to about 8 inches (20 cm) in height. Larger seedlings become very well rooted and are very difficult to pull or dig up without extensive damage to the root system. Inspect the roots carefully for pest or disease symptoms before using the plants; reject nematode-infected plants with galled roots. Transplant them to nursery pots or to the field during the rainy season.

Pros If appropriately-sized wild seedlings are available, this is the fastest way to produce new noni seedlings, which means savings in time and money.

Cons This can be a very high-risk practice where root-knot nematodes or other soil-borne pests are present on wild seedlings. Also, if the root system is damaged when pulling up the seedlings, this may produce weaker plants as compared with nursery-grown seedlings. A strong taproot may be essential for drawing up deep water for the plant. However, even without the taproot, plants can still be high yielding in areas with abundant soil moisture.

2. Growing noni plants from seed

Sowing seeds without scarifying them first

You can plant seeds without scarifying them first. You can even mash up ripe fruit and plant the seed and pulp mixture, or throw ripe fruits into cracks and crevices where some seeds may germinate and



Top: Volunteer seedlings under a noni tree. Bottom: One of the seedlings from the top photo pulled up and ready to transplant. PHOTOS: C. ELEVITCH

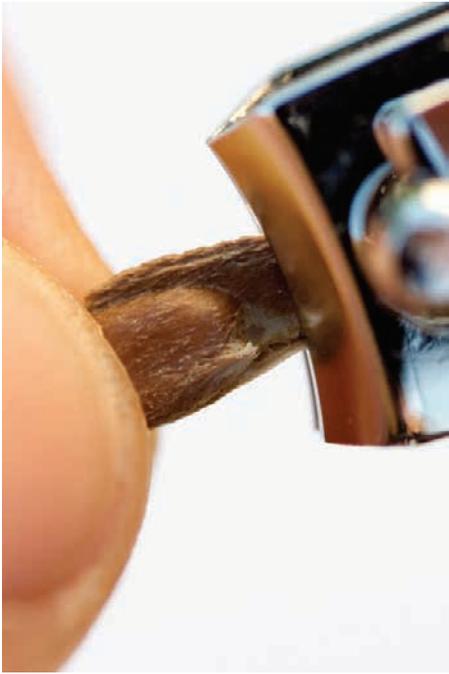
survive. However, because unscarified seeds can take many months to germinate, these methods are not recommended.

Sowing seeds with scarification

Nicking or abrading the outer seed coat allows water to enter the seed. This process ensures uniform germination in a relatively short period of time, within a few weeks. You can start with either fresh, ripe fruit or with clean, dry seeds.

- **Bulk-scarifying seeds in blender**

How to do it Place two very ripe noni fruits or a handful of dry seeds in a kitchen blender. Press the



Top row: Nicking the flat end of seed allows water to enter and thereby speeds germination. Bottom left: Seedlings at four-leaf stage, ready to be pricked out and transplanted. Bottom right: Twelve-week-old seedling. TOP PHOTOS: C. ELEVITCH, BOTTOM PHOTOS: S. NELSON

“pulse” button briefly for about ten short bursts. This will break up the fruit and nick (scarify) some of the seeds. Scatter the pulp and seeds into a planting bed or pot and cover with a layer of media. Irrigate daily.

Pros Can use fresh fruit without the labor of extracting the seeds; easiest way to scarify noni seeds.

Cons Some seed embryos are destroyed by the blender blades which results in a reduced germination percentage.

- **Scarifying using a fingernail clipper**

This is a good method for people who plant noni often and like to store seed. Noni seeds can be collect-

ed, processed, and stored for up to 6 months before they are planted.

How to do it Separate the seeds from the fruit pulp as described above. Air-dry the seeds on a screen in a shaded location for several days. Store the seeds in glass bottles at room temperature in a dark place. When you are ready to use the seeds, scarify them individually as follows. Use an ordinary fingernail clipper to clip off the tip of the flat “paddle end” of the noni seed (the end opposite the bulbous air chamber). This is where the growing tip of the root emerges. Clip off about 1/16 inch (1.5–2 mm) and do not clip too much off, which might damage the embryo. It is usually not necessary to sterilize the clipper used during scarification. Some growers prefer to soak the seeds in warm water for several days before clipping, although this may be unnecessary. Plant the seeds as described previously. The authors prefer to plant the seeds in large numbers in large, deep pots about ¼–½ inch (0.6–1.2 cm) deep. When the new seedling taproots reach the bottom of the pot, they are ready to transplant to individual pots or containers such as the popular 1 gallon (4 l) black plastic grow bags.

Pros This method gives the most rapid and uniform germination.

Cons Labor-intensive to scarify seeds by hand; stored seeds lose viability over time and should be planted within about 6 months of harvest.

3. Growing noni plants from cuttings and root suckers.

This is a rapid way to obtain a large number of noni plants in a relatively short amount of time. Individual plants with favorable qualities such as vigor, productivity, and fruit size can be cloned using this method.

Growing noni from stem cuttings

How to do it The roots will sprout from woody stem tissue, so use cuttings that have some woody tissue (some brown bark, not all green). Vertical branches make superior plants compared with

cuttings from lateral or horizontal branches. Make 6–8-inch (15–30-cm) cuttings about from vertical branches with a diameter of ½–1 inch (1.2–2.5 cm) at the base. The best cuttings have about half woody and half green-succulent stem tissue. Trim off most of the leaves, leaving only 2–3 small leaves at the top. Insert the bottom end of the cutting into inert, absorbent media such as volcanic cinder or vermiculite and water the cuttings frequently. Make sure the media is in close contact with the stem. Warm temperatures promote fastest rooting, which can occur in just a few weeks without using any rooting hormones.

Pros This is a rapid way to make a lot of plants that are ready for transplanting long before plants from seed would be ready; you can make many clonal plants from superior trees; it does not harm the mother plant, as branches re-grow quickly.

Cons Plants from cuttings have no taproot and are inherently weaker than seedlings; if lateral branch cuttings are used they may have a prostrate growth habit initially; plants from cuttings may be less wind tolerant, although in deep, well drained soils they will develop an extensive lateral root system.

Growing noni from sprouted root cuttings

Noni has the ability to regenerate from root shoots or



Left: Cutting placed in vermiculite medium for rooting. Right: Root system of a cutting. PHOTOS: S. NELSON



Left: Symptoms of root-knot nematode—plants that exhibit such symptoms in the nursery should be discarded and never planted in the field. Right: Plants grown from a lateral (horizontal) cutting will have a prostrate growth habit initially.

PHOTOS: S. NELSON

suckers, producing small, sparse thickets or groves. These sprouts can be dug up and planted.

How to do it Use a pair of shears to cut out the root sucker from the mother plant's root system. Carefully dig out the roots emerging from the sucker. Transfer the cutting to a pot full of soil or media. Water daily.

Pros As with stem cuttings, superior trees can be cloned with root suckers; suckers may need to be removed anyway to prevent overcrowding.

Cons Can be labor intensive to dig or cut out sprouted roots; root sprouts can carry root pathogens such as root-knot nematodes; plants may not develop a taproot, just as with stem cuttings.

Seedling care and outplanting

Monitor seedlings for pests and treat any outbreaks accordingly (see "Pest and diseases"). Pests that typically only occur in the nursery include aphids, whiteflies, thrips, and scales. Seedlings in the nursery should be fertilized heavily with a balanced fertilizer containing micronutrients. Seedlings also respond well to foliar applications of liquid fertilizers formulated for the purpose. Inoculating the potting

medium with commercial mycorrhizae fungi will encourage a symbiosis between the plant and the fungi which can benefit the plant for life. When inoculating with mycorrhizae, you should only use mild organic fertilizers so as not to harm the fungi. When the stems of the young plants become woody they are ready for outplanting, provided they have been hardened-off in the sun at least 6 weeks beforehand. Noni seedlings may be planted out after they are 8–12 weeks old and 4–6 inches (10–15 cm) tall, but these young plants require more care in the field initially and are much more vulnerable to the environment and pest attack than older seedlings. Seedlings grown in full sun in ½–1 gallon (2–4 l) pots for at least 24–36 weeks are preferred for outplanting, because they establish rapidly. Plants that are a year old may be optimum for some areas. Even 2–3-year-old seedlings may be outplanted. For older seedlings, loosen the root system gently by hand after removing the plant from the container to reduce the chance that spiraling roots that could strangle the plant later in life.

GROWTH AND MANAGEMENT

Site selection

Site requirements

Noni generally grows between latitudes 19° N and S, usually within a few miles of the coastline, and no higher in altitude than about 2500 ft (760 m) at 19° latitude and up to about 4000 ft (1200 m) at the equator. Noni's lower temperature range is probably USDA Zone 11 (above 40°F [4.5°C]). If you are outside this geographic range, then you may need to locate or create a warmer microclimate in order to grow noni. A south, southwest, or western exposure is best in the northern hemisphere (north, northwest, or western exposure in the southern hemisphere). A hothouse may be the only option in cooler climates. Select a site in full or partial sun with well drained, well aerated soil. Rocky soils are excellent. Rich, well drained, volcanic soils are also very good for noni cultivation.

Environment

The best places to cultivate noni are near areas where the plant already grows wild. Ideally, for high yields the site should receive moderate rainfall distributed more or less evenly throughout the year, about 20–60 in (500–1500 mm) annually. At higher-rainfall locations such as Hilo, Hawai'i, where the annual rainfall reaches 160 in/yr (4000 mm/yr), noni fruits tend to be more watery (less sweet) and ripen more slowly and unevenly, but plants are high yielding. Sunnier, drier locations tend to yield sweeter fruits that ripen more rapidly and evenly. Because noni can grow quite well in certain areas that are considered marginal lands for other crops, adequate sites for growing noni may be relatively available and inexpensive to lease or purchase.

Avoidable problems

Avoid heavy soils, compacted areas, and flood-prone sites. Avoid sites where other nematode-susceptible crops (such as papaya) grew recently, due to noni's high susceptibility to root-knot nematodes. These root parasites can build up to potential harmful levels and remain in soils for many months, even after a previous nematode-susceptible crop was removed. Avoid locations where aggressive, large grasses dominate the land; noni may not compete well with these grasses and controlling them is likely to be very labor intensive and expensive.

Pre-planting and planting

Land preparation

In rocky locations, some growers disturb or plow the subsoil layers ("rip") the land before grading the land to prepare a flat or gently sloping field. The subsoil plowing opens up the subsoil for noni roots to penetrate and improves drainage and aeration. Remember that removing existing vegetation leads to greatly diminished mycorrhizal flora, erosion, and possibly increased risks of pathogens infecting noni's root system. If feasible, leave enough of the native vegetation to keep the ground shaded, and gradually remove it, if desired, as the noni trees grow larger.

Pre-plant soil sampling

If possible, sample the soil for nutrients and plant-parasitic nematodes of the genus *Meloidogyne* and submit it to a diagnostic laboratory for counting and identification of species. You can take corrective action to deter nematodes (e.g., mulches, composts, chicken manure, chemical nematicides) if you have



Land may be cleared for efficient farm operations, but the trade-off is increased susceptibility to pests and diseases. PHOTO: S. NELSON

high populations of root-knot nematodes. Perform a soil test for extractable nutrients using a commercial testing lab or a university service before planting; add lime or amend the soil or planting holes with compost or fertilizer as determined by the test results.

Planting holes

Prepare a hole about the size of the plant container or a little larger, and transplant carefully. The top lateral root emerging from the noni stem should be at the level of the soil surface after you put the plant into the ground and fill in the hole. Do not put any untreated soils into the hole, they may carry parasitic nematodes. If you import soil that is possibly nematode infested to your farm (if your field is very rocky, for example), you must heat the soil to at least 122°F (50°C) for at least 20 minutes or treat it with an approved nematicide to kill off the nematodes.

Seedling quality

You should ensure that container-grown plants are in good health and hardened off in the sun for at least a few weeks before outplanting. This ensures that the plants will be able to adjust to the shock of transplanting and possibly unfavorable weather

conditions as they become established. Container seedlings that have been in pots for over 6 months can have become root-bound, with the outer roots encircling the main taproot, or a taproot that has hit the bottom of the container and begun growing upward (called J-root). If root circling or J-root has occurred, trim the roots with a sharp, clean clippers before planting, or the tree can suffer from self-strangulation of the root system and/or poor root structure later in life.

Irrigation setup

The need to irrigate young seedlings may arise in some locations. Irrigate manually or use an automated system. Lay out irrigation lines before planting. Plan ahead for some flexibility in moving the lines; it is wise to move the lines away from the plant stems after a few months to avoid waterlogging and stem rot. Moving irrigation emitters to the edge of the canopy drip line or farther away from the stem stimulates lateral root growth. Do not use drip emitters in rocky soils; instead, use sprinkle emitters. Water moderately and make young plants “reach” for their water by growing their roots toward the source.



In exposed areas, noni trees benefit greatly when protected by windbreaks. This is a windbreak of ironwood (*Casuarina* sp.) in Hāmākua, Hawai‘i. PHOTO: S. NELSON

Windbreaks

Wind is one of the most important factors in site selection for a noni. Even though noni can survive in exposed, windy places, plants should be protected from high winds to achieve best growth. Avoid planting on windy, exposed hilltops and in areas directly exposed to prevailing winds in excess of 20 miles per hour (33 kph). High winds may stunt noni plants and damage the leaves. Young noni transplants do not grow well where winds are strong. Rows of trees planted as windbreaks can be planted to protect young noni plants. Such trees include eucalyptus, ironwood (*Casuarina* species), or coral tree (*Erythrina* species). Windbreak rows are often planted 150 ft (46 m) apart. Avoid using root-knot nematode-susceptible trees as windbreaks. The seeds from some of these trees, such as gunpowder tree (*Melochia umbellata*), can easily be blown into a noni field where they sprout and host root-knot nematodes.

Variety selection

Most people grow *Morinda citrifolia* var. *citrifolia*, the variety known commercially as noni. Some grow the ornamental cultivar ‘Potteri’ for its attractive green and white leaves. ‘Potteri’ is a nice plant for landscapes because it is appreciated for its beauty as well as for nutrition and phytomedicine.

Plant spacing

The distance between noni plants in a field can be very important. The spacing choice is critical for harvesting operations and to achieve the best plant growth. Growers harvest noni fruits by hand and need enough space between each plant to move around and gather fruit, and enough space to drive a truck or tractor between rows. If you place noni plants too close together, you may not be able to move easily between plants, plants compete with each other, and yields are depressed. Higher planting densities (closer plant spacing) result in crowding and usually increased pest or disease problems. When planted too close, trees will eventually have to be pruned back, which will waste fruit capacity and diminish production until the plants recover.

A good interplant spacing for noni is from 10–15 ft by



Young noni plants in their first year. Spacing is chosen individually for each farm based on anticipated needs for access by machinery and allowable costs for pruning and other maintenance. PHOTO: S. NELSON

10–15 ft (3–4.5 m by 3–4.5 m). At 12 x 12 ft (3.5 x 3.5 m) spacing there are 290 trees per acre (716 trees/ha). A minimum of 15 x 15 ft (4.5 x 4.5 m) spacing is best where growing conditions are good for noni (areas where noni grows well naturally) and at 20 x 20 ft (6 x 6 m) spacing you may be spared from having to prune the plants back after 6 years to maintain access for field operations.

Management

Pruning

Noni is not self-pruning, that is, it does not shed lower branches as the tree gets older. The lowest, lateral branches tend to droop over onto the ground and many farmers or homeowners prune these lower branches away for easier weed control and improved plant appearance and fruit quality (fruits touching the ground on lower branches are subject to more insect and rat attacks and microbial contamination from the soil). Because noni trees can reach a height of approximately 20 ft (6 m), growers may wish to prune the vertical branches of mature plants to keep plants low and bushy for ease of fruit harvest. You may prune virtually any woody stem, even to a short stump, and the tree will regrow. Young noni plants less than 3 years old may be pruned back after or during their first production of fruit. In the following years, the pruned plants become very bushy.



Left: Noni branches between rows after pruning. Rows of trees that are closely spaced require regular pruning for ease of access and to increase air circulation to minimize fungal pathogens. Right: Even pruned down to a stump, trees will regrow vigorously. PHOTOS: S. NELSON

Pruning is an effective means of improving air flow in the canopy, which can reduce the severity of pest and disease outbreaks and make it easier to control them because sprays are better able to penetrate more sparse foliage.

Nutrition and fertilizer

Organic fertilizers

Use of organic fertilizers can have many advantages over soluble, chemical fertilizers. First, organic fertilizers such as green manure and compost build soil organic matter and increase water retention, and nutrient exchange capacity. Second, organic matter feeds the complex soil microlife, which is intimately connected to noni's ability to thrive in nutrient-poor soils and to withstand drought. Third, a fertilization program which includes organic fertilizer as well as

other organic farming methods can lead to organic certification and higher market value for your crop.

Effective organic fertilizers for noni cultivation include K-mag, "7-7-7" (an organic, balanced fertilizer that comes in granular form), composted chicken manure, and macadamia nut husks. Some locations benefit from yearly applications of lime, about 1 lb (450 gm) per plant. Other good sources of organic or natural fertilizers available in the tropics include seaweed, crushed coral, rock dust, guano, manure, compost, and compost tea.

Soluble fertilizers

Noni, being a salt-tolerant plant, tolerates high levels of fertilizer salts in the root zone without damage or burning. The amount of nutrients and frequency of fertilizer applications required by noni depend on

the soil and rainfall. Research is needed to develop the best fertilizer regimes for noni production in various regions of the tropics where noni is grown. Noni trees growing in forests usually appear healthy without the benefit of any artificial fertilizers. This suggests that noni may require only small amounts of fertilizer to grow well. In general, however, if intensive fruit production is desired in an agricultural setting, a fertilizer program is recommended. Remember, though, that there are negative effects from over-fertilization, including increased pest populations and damage, and possibly reduced plant health. Also, heavy use of soluble fertilizers encourages rampant weed growth and makes weed control more costly. One can fertilize by adding organic matter in addition to rapidly soluble chemical fertilizers to foster healthy soil microflora and achieve a more balanced, healthy, and diverse agroecosystem.

The strategy for feeding noni is similar to that for other fruit crops such as citrus or coffee: young plants are encouraged to grow, whereas older plants are encouraged to produce fruit. You can encourage young, non-fruiting noni plants to produce lush vegetative growth with balanced fertilizers such as 14-14-14 or 16-16-16. Feed mature or flowering/fruiting noni plants with high-phosphorous fertilizers such as 10-20-20 to stimulate maximum flowering and fruit production. It is probably safer to give young seedlings and transplants controlled-release formulations, while older, mature plants can better handle fast-release formulations. Fertilizer should be applied away from the trunk of the tree at the “drip line” of the plant, the peripheral area where water drips from the canopy edge.

In very wet environments, fertilize noni more frequently and using smaller amounts of fertilizer on each occasion than you would in a drier location. In high-rainfall areas, young plants up to a year old can be given ¼ to ½ lb (225–450 gm) per month of balanced fertilizer (14-14-14), and more mature plants can be given up to 1 lb (450 gm) per month.

Foliar feeding

Noni plants of all ages respond well to sprays of foliar fertilizers. Noni flower and fruit production is very responsive to sprays of high-phosphorous foliar fertilizers (e.g., 10-45-10) and products (e.g., seaweed emulsions) containing nitrogen and minor elements such as iron (iron chelate).

In dry environments, consider applying foliar sprays of fertilizer products, or delivering fertilizer through an irrigation system. A simple home method is to spray compost teas on noni leaves. Make a compost

Compost tea

Compost tea is made by steeping compost in water. The tea serves as a foliar fertilizer or as a soil nutrient and microbial drench. Producing compost tea is an art as much as a science. This is a large topic area—refer to the many excellent available publication on this subject for detailed methods.

Types of compost tea include

Fresh—steep healthy compost in water for a brief time and apply the liquid to plant leaves or soil.

Fermented with aeration—compost is fermented in water infused with a constant stream of air bubbles to promote oxygen-loving aerobic bacteria and fungi. This type of compost tea smells good (not stinky like anaerobic tea), and is very beneficial for soil organisms and as a foliar spray.

Fermented without aeration (do not use)—When left in a container for several days without aeration, anaerobic bacteria and fungi chemically alter the mixture into a stinky brew. Some microorganisms in this smelly tea may produce alcohol as a by-product, which can be highly damaging to plant tissues even in small quantities. Therefore tea fermented without aeration (or that smells bad) should never be used.

tea by steeping composted plant material and manures in a container with water (see “Compost tea” text box).

Irrigation

Noni thrives with moderate irrigation and can survive extended periods of drought once it is established and mature. When plants are less than 2–3 years old

and conditions are dry, irrigate once or more a week, applying up to 10 gal (38 l) per plant; for older plants, irrigate less frequently. Over-watering can accelerate damage from root-knot nematodes, cause root rot, encourage parasitic fungi, cause stem rot in heavy and poorly aerated soils, and leach fertilizer nutrients beyond the root zone. Each month or so, move your irrigation emitters further away from the noni stem; do not leave the emitters close to the stem for

many months, or the plants may suffer from over-watering.

Harvesting and yields

Time to first harvest

Noni plants can begin to bear fruit 9–12 months after planting. Fruits can be harvested at this early stage, although they are generally small and few. Some

Mulch

Mulch is a layer of decaying organic matter on the ground. Mulch occurs naturally in all forests; it is a nutrient rich, moisture absorbent bed of decaying forest leaves, twigs and branches, teeming with fungal, microbial and insect life. Natural mulch serves as a “nutrient bank,” storing the nutrients contained in organic matter and slowly making these nutrients available to plants. All forms of plant life from the ground layer to shrubs and trees grow, shed organic matter, and die and decay, in a complex cycle of nutrients.

Agriculture with mulch in the tropics promotes plant health and vigor. Mulching improves nutrient and

water retention in the soil, encourages favorable soil microbial activity and worms, and suppresses weed growth. When properly implemented, mulching can significantly improve the well being of plants and reduce maintenance as compared to bare soil culture. Mulched plants have better vigor and, consequently have improved resistance to pests and diseases.

Mulch forms a necessary link in nutrient cycling that is vital in tropical soils. When mulch is absent for whatever reason, the living soil is robbed of its natural nutrient stores, becomes leached, and often dries up on the surface. When the soil is left bare, it heats up in the sun and many desirable soil organisms such as ben-

eficial mycorrhizae fungi can no longer survive. This deprives crop plants of associations with soil microorganisms that play an essential role in their ability to thrive. You might say that mulch is a natural blanket that nurtures and protects the soil, and in turn, plants.

You can mulch around noni trees using organic matter that you have on hand as long as it is weed-seed free and will not sprout into new plants when laid on the ground (such as tall, thick-stemmed grasses, succulents, etc.). Fast-growing trees growing near the noni crop can be pruned regularly, with the pruned branches applied as mulch.

AFTER ELEVITCH AND WILKINSON 1998



Left: Mulch, such as this shredded landscape trimmings, helps improve soil health by keeping it cool and moist. The mulch should not contact the stems. Keāhole, Kona, Hawai‘i. PHOTO: S. NELSON **Right:** Grown in the understory of other crops, the soil is also kept cool and moist by natural leaf litter and shade. ‘Upolu, Samoa. PHOTO: C. ELEVITCH

farmers choose to forgo harvest during the first and second years in favor of pruning back the branches instead. Early pruning makes plants bushier and keeps them shorter than they would be without pruning, which can be advantageous for harvesting. Noni fruits mature year-round and the plants flower continually in their natural geographic range. There are seasonal trends in the amount of flowering and fruit production that may be influenced by weather (temperature, sunshine), fertilization regime, and irrigation. For example, fruit production tends to diminish somewhat during the winter months in Hawai'i, which falls within noni's northernmost range. Growers usually harvest a given noni field two or three times per month. Family farms usually harvest on weekends. Backyard growers with a large single tree can pick a few fruits almost any time they wish for home use, and usually have an excess of fruits that fall to the ground.

Estimated yields

Table 7.1 shows estimates for the potential yield of noni trees in cultivation. Many factors may diminish yields such as unfavorable weather, soil condition, and pests and diseases. Nonetheless, the following estimates are achievable with good farm management and optimal growing conditions.

At Year 5 a farmer can expect to harvest approximately 69,600 lb of fruit per acre per year (78,100 kg/ha/

Table 7.1. Realistic estimates based on excellent farm management practices and growing conditions. Actual yields will vary.

Month	Expected fruit yield per plant per month*
0–9	Seedlings grown in nursery, no fruit production
9	Transplant into field, no fruit production
12–24 (Year 1)	2 lb or 580 lb/acre (1 kg or 650 kg/ha)
24–36 (Year 2)	4 lb or 1160 lb/acre (2 kg or 1300 kg/ha)
36–48 (Year 3)	8 lb or 2320 lb/acre (4 kg or 2600 kg/ha)
48–60 (Year 4)	15 lb or 4350 lb/acre (7 kg or 4900 kg/ha)
60–72 (Year 5)	20 lb or 5800 lb/acre (9 kg or 6500 kg/ha)

* Yield assumptions: 290 trees per acre (716 trees/ha); good soil fertility and drainage; good water supply; adequate disease, pest, and weed control; adequate fertilizer additions (e.g., ample compost, organic matter, or inorganic fertilizer)

yr), yielding about 35,000 lb/ac/yr (39,300 kg/ha/yr) of juice at an extraction efficiency of approximately 50% by weight, although 60% is possible. The juice weighs about 9 lb per gallon (1.1 kg/l), so an acre of well managed noni can produce approximately 3,800 gallons of juice per year (35,700 l/ha/yr). Currently, the wholesale juice price (i.e., farm price for bulk quantities) is US\$6.00–12.00 per gallon (US\$1.60–3.20/l).

For mature trees or farms older than 5 years old, yields of up to 500 lb (230 kg) of fruit per plant per year may be realized. However, many factors can im-



Left: Noni fruits in various stages of development, from young green to nearly “hard white.” Noni fruits may be picked at any stage of development, depending on the intended product or processing operation. PHOTO: C. ELEVITCH Right: Recently harvested green fruits for powder production delivered to processing facility in bins. PHOTO: S. NELSON



Left: A simple harvesting tool, a hook lashed to a pole. Right: Picking fruits from tall trees. PHOTOS: C. ELEVITCH

pinge on these numbers. Most farmers do not realize the attainable yields due to pest and diseases or poor agronomic practices. On average, one might expect the average farmer to realize yields up to 50,000 lb/acre/yr (56,000 kg/ha/yr), although it is often significantly less.

Harvesting methods

Noni fruits can be picked at any stage of development, depending on the intended processing method. Some producers prefer green fruits for ease of slicing in certain drying operations, whereas other processors prefer the hard white noni fruits for processing. Most noni juice processors prefer or only accept the hard white stage of fruit development for noni juice production, because the fruits ripen quickly once that stage of development is reached.

Noni fruits are harvested by hand directly or with a simple picking tool. They are placed in baskets or bags or placed in bins for transport to the processing facility. Noni fruits do not bruise or damage easily, and usually no special padded containers or other precautions are needed to prevent fruit damage. Furthermore, exposure of noni fruits to direct sunlight or to warm temperatures immediately after harvest rarely causes problems, so refrigeration is not necessary if the fruit is processed within hours. Do not place bags of noni fruits on the ground or they will become infested with souring beetles and other insects.

Fruits should be washed and air-dried at the processing facility before they ripen fully and turn soft. For juice production, the noni fruits are held at ambient or room temperature for up to several days to ripen

before they are processed. However, if ripe fruits are allowed to sit for an extended period, they begin attract fruit flies, rats, and other insects or pests. For processing of noni fruits for powders or precuts (slicing) for tea, fruits may be processed immediately, even before they fully ripen. Unripe fruits are easier to process with some types of chopping and drying equipment.

Integrated mixed planting

The benefits of interplanting may include fewer disease and pest problems. However, negative plant pest and disease interactions are also possible with some interplanting systems.

Some interplanting systems include:

- Traditional subsistence farming intercropping with breadfruit, kava, papaya, mango, coconut, cordage plants, banana, timber species, coastal shrubs, and grasses.
- Modern commercial intercropping with papaya and coconut and kava.

Noni can also thrive in forest understory settings and can benefit from the composting organic matter and mulch provided by associated plant species (benefits include improved nutrition, weed suppression, soil structure, and soil moisture retention).

The following are some examples of how to integrate noni with other farm activities.

Boundary markers

Noni can be used for boundary markers due to its persistence and ability to survive harsh conditions and extended periods of drought.

Animal fodder

The fruits and leaves are useful as animal feed or fodder (pets and livestock).



Top and middle: Noni integrated with numerous other crops including banana, cacao, pineapple, taro, etc. 'Upolu, Samoa. PHOTOS: C. ELEVITCH
Author Scot Nelson observes noni growing underneath a row of ironwood trees (*Casuarina* sp.) on the island of Rota. PHOTO: M. BONIN

Woodlot

Noni is very compatible with lowland forest or woodlot plant species throughout the Pacific. Noni itself is not managed for wood production.

Native animal/bird food

Ripe fruits are a natural source of food for birds, rodents, and insects.

Bee forage

The noni flower nectaries are very attractive to honeybees, and you can see them foraging on noni plants nearly all daylight hours

Coastal protection

Noni is tenacious enough help to stabilize lands in harsh or unstable coastal environments.

Beneficial insects

Noni attracts many species of beneficial insects including spiders, lady beetles, and praying mantises as well as insect predators such as chameleons, anoles, geckos, and lizards.

Urban and community forestry

Noni is an attractive shrub that grows well in homegardens and tropical landscapes, but only where the smelly fruits do not become a nuisance. Noni trees produce mature fruits year-round, so fruits are always available for home use. Noni may be a good plant for difficult or waste areas in your landscape, as it thrives in poor, rocky soils. It has lush, dark green foliage even under harsh conditions and is a very hardy roadside plant throughout the Pacific. Noni is easy to care for, responds well to severe pruning, and does not require much fertilizer or water.

Size in an urban environment

The size of a noni tree in an urban environ-

ment depends upon soil qualities, spacing, pruning, and tree age. Plants growing in full sun and without competition from other plants can reach a height of about 20 ft (6 m) or more with a canopy spread of 8–12 ft (2.4–3.6 m) diameter. Crowded or shaded noni plants tend to be less vigorous and become stunted. Large plants that are not pruned back periodically produce fruit that cannot easily be reached by hand, which usually results in many fallen, smelly fruits on the ground that attract insects, rats, pigs, and birds.



A tree that is at least 80 years old in homegarden. Kona, Hawai'i. PHOTO: C. ELEVITCH

Rate of growth in a landscape

Young noni plants grow relatively slowly in a landscape, about 1–2 ft (30–60 cm) per year in height, depending on environment. Upon reaching maturity, noni plants grow much more slowly in height, acquiring a denser canopy. Plants from cutting tend to become established more rapidly than plants from seed, but also tend to remain more prostrate and do not grow as tall as seedlings.

Root system

Noni has a deep taproot and an extensive surface-feeding root system. The tree may not compete well in a landscape with plants that have aggressive, surface-feeding roots such as large grasses that are not controlled. Botanists do not consider noni to have an invasive root system, although once a noni plant is established in a landscape it is very difficult to kill and new noni plants can sprout from exposed roots (root suckers). Volunteer plants growing in cracks in cement, asphalt, or other undesirable locations should be uprooted as early as possible.

Environmental requirements

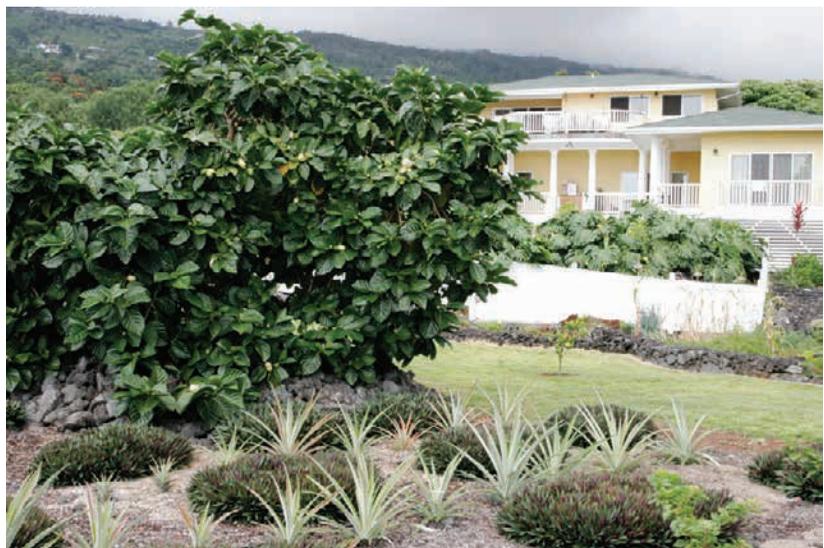
Noni grows very well in full sun to 80% shade. Noni has no special or unusual water or soil requirements. It tolerates a wide range of soil conditions including both acidic to alkaline, saturated to dry, and well drained to compacted soils.

Life span

A noni plant, without significant pest or disease attack or other stresses, may live for at least 80 years in a landscape, and probably much longer.

Varieties favored for use in homegardens or public areas

The variegated noni, *M. citrifolia* cv. ‘Potteri’, is a popular landscaping type of noni due to its beauti-



Top: Noni can make a nice hedge along boundaries or for privacy. PHOTO: S. NELSON **Bottom:** Growing far from the house, the odor of fallen fruit is not a problem. PHOTO: C. ELEVITCH

ful leaves. Variegated noni is also a medicinal plant, although fruit yields tend to be lower than the large-fruited noni type and fruits are relatively small. One may prefer to cultivate seedlings grown from seeds that were collected from trees with desirable qualities (e.g., large fruit).

Use as living fence, hedge, or visual/noise barrier

Noni plants can have a very dense canopy and be useful as hedge plants or living fences. The plants can thrive where other plants have difficulty growing. Noni can withstand heavy pruning although

more frequent, light pruning can be used to ensure adequate foliage always remains to serve hedge functions.

Noni as a house plant

Some people in temperate zones grow noni in large pots that are kept outside during summer months, and inside during cooler weather.

Maintenance requirements

Noni is a low-maintenance landscape plant. It responds well to mulching as long as the mulch is kept away from direct contact with stem. Noni can be pruned or thinned to virtually any extent without damaging the plant. Plants cut back to a stump



Fallen fruit is the biggest nuisance of noni in urban environments. PHOTO: C. ELEVITCH

often grow back even bushier. They usually require no fertilizer, but do respond well to periodic applications of organic or inorganic, balanced fertilizers. Extra phosphorous may be applied to simulate flowering and fruit production. Typical balanced fertilizers used include 13-13-13 and 16-16-16. To stimulate flowering and fruit production use 10-20-10 if a soil test indicates that phosphorous levels are low. If noni leaves are turning yellow, they could be fertilized with about 0.5–1 lb (225–450 g) of fertilizer per plant, depending on age. The plants also respond very well to foliar fertilizers. Because noni plants are salt-tolerant, it is very unusual for their roots systems to be burned by excess fertilizer.

Nuisance and hazard

The fruits have a strong, unpleasant aroma which is considered by some to be a nuisance. The foul odor of noni fruits is considered by many to be a significant detriment to using noni in a landscape. Sprouting of exposed noni roots can result in encroachment by noni on the urban landscape. Lateral roots of noni plants in landscapes should be covered by at least 4 inches (10 cm) of mulch or cinders to avoid suckering. Fruits drop occurs year round. People could slip on ripe fruits along footpaths and sidewalks. Noni trees do not topple easily during high winds, although branches can break, especially when heavy with fruit. Climbing noni trees should only be done with great caution, as branches can suddenly crack off.

Common urban pest problems

Insect pest and plant disease problems of noni are usually less common and severe in mixed plantings in urban environments. The types of problems encountered depend on the environment in which noni is grown. In wetter locations, for example, fungal leaf spots and blights might occur. In drier locations, insect infestations may become established. The most common pest problem for noni in the urban landscape is perhaps root-knot nematodes, the small plant parasitic roundworms that cause conspicuous galls and swellings on roots that severely weaken the plant. Root-knot nematodes are best controlled by avoiding them, i.e., by starting with nematode-free seedlings and by planting the seedlings in a nematode-free location. If nematodes are present, their effects can be minimized by adding compost around plants or other forms of organic matter to the soil and by the use of foliar fertilizers. Noni plants in the urban landscape may also become infested with ants and sap-feeding insects such as scales, aphids, whiteflies, and mealybugs. These sap-feeding insects may be controlled with regular sprays of soapy water or a mixture of soap, water, and vegetable oil. For more information, see the “Pest and disease” chapter.

MAKING NONI PRODUCTS

Beverages

Noni beverages are made from various fruit preparations, including pure fruit juice, whole fruit powder, fruit puree, and fruit juice concentrate. Here we describe these main types of noni juice products with brief descriptions of how they are made. Later in this chapter we provide more detailed information about home and commercial juicing.

Pure juice

These products use 100% pure noni juice, and contain no additives such as water or sugar. The juice is gathered either by the traditional drip-extraction method and/or by pressing the juice from the pulp using special equipment. The juices also vary in their length of aging (fermenting) in the tanks.

Drip-extracted vs. fresh-pressed juice

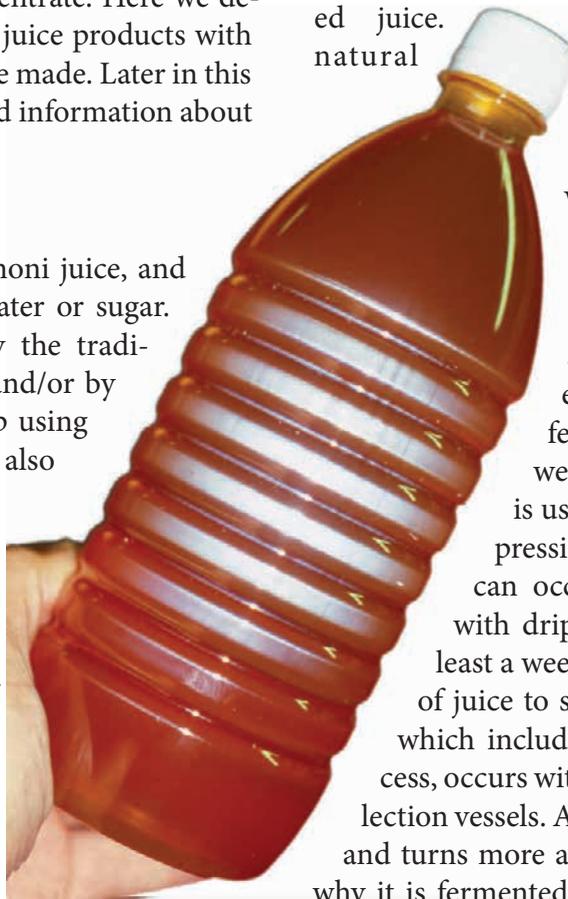
Drip extraction is a natural process where juice gradually seeps out of ripe fruits. This is the typical home method for noni juicing. Fruits are placed in a covered glass jar, and the juice seeps out of the fruits over time and is drained off periodically for drinking. Commercial processors in the Pacific use a similar method on a much larger scale (using large tanks). During drip-extraction, the juice undergoes some natural fermentation. Alternatively, the juice from ripe noni fruits can be pressed from the pulp using a hydraulic juice press or wine press without waiting for the juice to naturally drip from the fruit. Pressing takes

much less time than waiting for drip extraction to take place. Pressing the juice directly from ripe fruits yields a lighter colored juice that is higher in sugars and lower in acidity as compared with drip-extracted juice. Pressed juice does not undergo natural aging or fermentation.

Fermented vs. non-fermented juice

When noni juice is drip extracted, the juice is allowed to seep out of the fruit, a process which takes time (weeks) and results in some fermentation. During drip extraction, noni juice is usually fermented anywhere from 2 to 8 weeks, whereas fresh-pressed juice is usually not fermented because the pressing is done before fermentation can occur. Some fermentation occurs with drip-extraction, because it takes at least a week or two for significant amounts of juice to seep out of the fruits. The aging, which includes a bacterial fermentation process, occurs within the drip-extraction juice collection vessels. As aging occurs, the juice darkens and turns more acidic (see “Noni juice: how and why it is fermented” below). Juice that is aged less than 10 days is lighter in color and higher in sugars than juice that is fermented longer periods.

Non-fermented juice is usually pressed within a week of harvesting the fruit. In order to avoid fermentation, pressed juice must be immediately refrigerated, frozen, or pasteurized.



Juice blends

Juice blends include mixing noni juice with other juice ingredients such as other fruit juices, sugar, and water.

Drinks from whole fruit powders

Whole, ripe noni fruits are sun dried, sliced, ground, and powdered. The powder is mixed with water and other ingredients to manufacture reconstituted noni drinks.

Drinks from fruit puree

Seeds are removed from whole, ripe noni fruits, and the pulp is pureed. The puree is mixed with water

and other ingredients (fruit juices) to manufacture reconstituted noni drinks. Most of the commercial noni juice marketed worldwide is made this way.

Drinks from juice concentrate

Noni fruit juice is vacuum-evaporated to make noni juice concentrate, which ranges from 3:1 up to about 10:1 concentration. The noni juice concentrate is mixed with water and/or other ingredients (e.g., fruit juices) to produce a range of beverage products. The noni juice concentrate can also be sprayed onto an edible powder such as corn starch to produce “juice powder.”

Table 8.1. Comparison of noni juice products

Product	Advantages	Disadvantages
100% noni juice drip extracted/fermented	<ul style="list-style-type: none">• easy to do industrially and at home• inexpensive, traditional method• time tested• no hurry• smooth taste but acidic• strong noni serving per ounce	<ul style="list-style-type: none">• can be unreliable and unsanitary• may introduce unwanted organisms• lower sugar content• sour taste, especially in darker fermentations
100% noni juice fresh-pressed	<ul style="list-style-type: none">• improved juice recovery• avoids fermentation, leaves highest sugars• less oxidation/change of chemistry• strong noni serving per ounce	<ul style="list-style-type: none">• labor intensive• costly pressing equipment required• more unpleasant taste and odor
Noni juice blends	<ul style="list-style-type: none">• improved flavor• may add other beneficial fruits	<ul style="list-style-type: none">• weaker noni serving per ounce
Drinks from noni powders	<ul style="list-style-type: none">• less expensive to ship	<ul style="list-style-type: none">• sediment• stale or off flavors• seed flavors may be introduced
Drinks from noni puree	<ul style="list-style-type: none">• uses whole fruit pulp• avoids fermentation, leaves highest sugars• avoids possible contaminants from aging• consistent product• widely available to consumers• common industry practice	<ul style="list-style-type: none">• higher shipping costs because the pulp is included with juice• high sediment
Drinks from noni concentrate	<ul style="list-style-type: none">• mixes well with water and juices• good flavor• strongest noni serving per ounce• low sediment	<ul style="list-style-type: none">• somewhat unnatural flavor (not like noni juice)



Left: Fermented 100% noni juices (dark-colored juice is aged about 2 months; light-colored juice is aged about 2 weeks). **Top right:** Noni juice powder (left jar), whole fruit powder (middle jar), and dried fruit segments (right jar). **Bottom right:** Tablets of leaf powder and garlic marketed as “healthy kidney” supplement in South Korea. PHOTOS: S. NELSON

Teas

Noni leaves and fruits are dried for use in brewing tea.

Wholesale products

Companies who wish to market noni juice or create noni juice products can purchase bulk wholesale noni ingredients. These bulk products include noni fruit powder, leaf powder, juice powder, and juice.

Non-juice products

Other nutritional supplements found in health foods stores and drug stores usually consist of either en-

capsulated noni fruit powder, juice powder, or leaf powder.

Cosmetics

A range of cosmetics including soap, hand cream, and shampoo are manufactured using noni leaf or fruit powder, juice, and juice concentrate.

Food products

Noni fruit leather, a tasty snack, is made by drying noni fruit puree in a commercial food dehydrator.

Juice: how and why it is fermented

In general, fermentation is any of a group of chemi-

cal reactions or processes in which an agent causes an organic substance or compounds to split or break down into simpler substances or less complex molecules. It is essentially a process of natural digestion. The most common agents are microbes, yeasts, and bacteria. Fermentation can occur naturally through wild yeasts and bacteria, or it can be controlled by eliminating wild or unwanted microbes from the fermentation process and adding desired microbial cultures. Fermented noni juice products are an important part of a growing worldwide noni industry for dietary supplements and herbal remedies.

A common type of fermentation process occurs in the production of vinegars. Here, acidifying bacteria convert sugars into organic acids (such as acetic acid or lactic acid). As this type of fermentation nears completion, the finished products become more and more acidic. The resulting liquids, such as apple vinegar, approach pH levels (about 3.5) that are similar to the natural level of acidity found in lemons. This explains why sweet-tasting fruits such as apples can produce a sour-tasting product such as apple vinegar. The fermentation of noni juice is presumably accomplished by acidifying bacteria, because fully aged juice changes in pH from about 5.5 to about 3.5 and very little or no alcohol is usually produced.

Noni juice fermentation and production have not been standardized as have similar processes such as vinegar production. The microbes responsible for the fermentation have not been identified, at least in published literature, although several bacterial species that are associated with fermented noni juice have been identified that are known to have the ability to ferment the sugars found in noni.

There are many different fungi and bacteria which are naturally associated with noni fruits in their natural habitat. There are also many species of fungi and bacteria that are found in association with humans and processing facilities. Any or all of these fungi and bacteria can find their way into the juicing process and affect the quality and flavor of the finished products. This means that noni juice could become contaminated with inappropriate or harmful microbial species resulting in inconsistent and poor quality products. Scientists have not yet identified best

microbes responsible for the best noni juice fermentation, nor have they determined their effects upon juice quality.

Noni fruits are exposed to possible contamination throughout the process, including from containers, equipment, open air, animals, and humans. Ideally, safe handling protocols are followed, which include washing of fruits and frequent sanitation and sterilization of the processing facility and equipment. The best producers frequently test their products for the presence of harmful or unwanted microbes such as *E. coli*, *Salmonella*, and toxins produced by some fungi. Most commercial producers also pasteurize their products to enhance their safety for consumption.

Because producers lack certain information needed to control the noni aging and fermentation process, there is considerable variability in flavor, color, and pH of finished juice products. This also explains why aged noni juice from different parts of the world can vary drastically in flavor and quality; the species of bacteria and fungi involved are not the same in all locations. One future goal of noni research should be to standardize the fermentation process to ensure more consistency and safety of the products. Similar to the beer, wine, and vinegar industries, this would mean that the best bacterial species are used to create a rapid fermentation with desirable characteristics.

If the process of noni fermentation is not understood or controlled very well, then why is noni juice even fermented at all?

- It's the easiest way to process noni fruits for juice, and has been done for centuries.
- Fruits are very perishable and within a day or two after harvest, they can turn soft and mushy and begin fermenting immediately.
- Fermentation is a natural process that is difficult to stop once fruits turn soft and juice begins to seep from them.
- There is a growing market preference in some segments for aged juice.
- Flavor and aroma are improved in aged juice as compared with fresh juice. The taste is smoother and much less objectionable.
- Shelf life is extended. If the fermentation process

is allowed to proceed until all of the sugars are expended and the pH reaches about 3.5, the juice can be stored at room temperature almost indefinitely in a sealed container.

- It is a very simple and convenient method for the home juicer.
- Pasteurization may not be necessary, an advantage for the home juicer.
- Some biologically active compounds in noni are not affected by fermentation. The complex polysaccharides associated with modulation of the immune system, for example, remain at similar levels throughout fermentation, making the aged and fermented juice virtually equivalent to freshly extracted juice in this regard.

Commercial-scale production of 100% noni juice

Noni juice and juice products are produced mainly in very simple facilities with closed juice collection vessels. Here is a brief description the juicing process and how the facilities operate.

1. Ripe noni fruits arrive at the juicing facility. Noni fruits are picked at the “hard white stage” (fully mature but not soft and ripe) and transported to the juicing facility within 24 hours because the fruit can turn soft very quickly.

Noni fruits at the hard white stage are resistant to superficial damage and bruising during shipping and handling, that is, they require no special handling. Noni fruits at this stage of development will ripen



Left: Collecting noni fruits, ‘Upolu, Samoa. PHOTO: C. ELEVITCH



Top right: Weighing collected fruits. PHOTO: S. NELSON **Bottom right: Mechanical fruit washer.** PHOTO: S. NELSON



Top left: Drying fruits after washing. PHOTO: C. ELEVITCH **Top right: A juice collection and fermentation vessel, approximately half full of noni fruits and juice. PHOTO: S. NELSON** **Bottom: Another type of juice collection and fermentation vessel. After 2 months of fermentation, juice is drained through the spigot at the bottom of the collection vessels, pasteurized, and bottled. PHOTO: C. ELEVITCH**

overnight or in a few days at room temperature and can be processed for juice immediately thereafter.

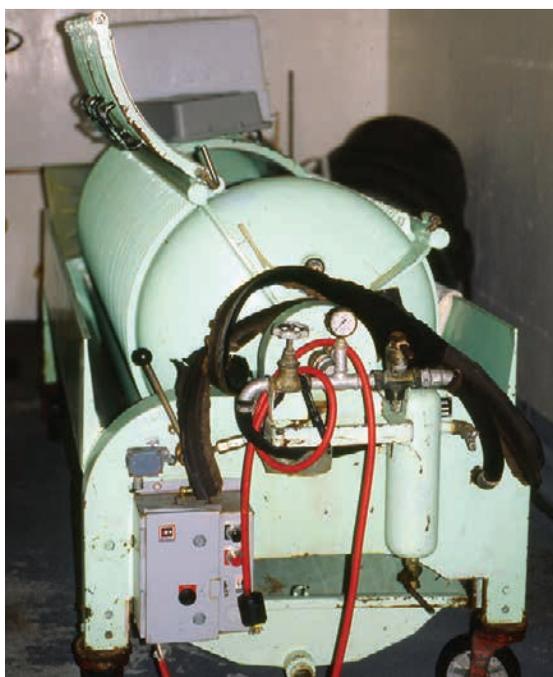
2. Washing and air-drying fruits. Noni fruits must be washed before juicing and sorted. Poor-quality fruits are discarded, including green, insect-infested, moldy, and rat or bird-damaged fruits. Washing is done automatically or by hand. After washing freshly picked noni fruits are allowed to air-dry on raised tables away from pests before they are processed for juice. Air-drying of fruits is a mold-control practice that should be done after washing and before placing the whole noni fruits into juice collection vessels. Some producers use a dilute hydrogen peroxide solution to clean the fruits.

3. Fermentation and drip extraction. Ripe noni fruits are placed into a juice collection vessel for 10–60 days for juice collection and fermentation. During this time, the noni juice separates (drips) gradually from the pulp. The juice collection and fermentation vessels should be made of glass, stainless steel, or food-grade plastic. Vessels are designed to prevent outside air from entering, but allow fermentation gases to escape. The noni juice collects inside the containers and ferments as it gradually seeps from

the fruits. The juice appearance is initially amber or golden and gradually darkens with age. After the collection and fermentation process is complete, the juice is drained from spigots at the base of containers and filtered. Contact between the juice and fresh air is minimized throughout the process.

4. The noni juice product is decanted, filtered, tested, and bottled. After 10–60 days, much or most of the noni juice separates naturally from the fruit pulp and may be drained from the container and processed. The recovery of juice by this traditional method is approximately 40–50% of the original fruit weight. This method yields about 40–50 lb (18–23 kg) or about 4.5–5.0 gal (17–19 l) of juice from 100 lb (45 kg) of fruit. Fermented juice aged for 8 weeks is a dark brown liquid which is similar in appearance and texture to soy sauce. The pH is low (approximately 3.1–3.5), lending a characteristically sour taste to aged noni juice.

After all of the noni juice is drained from the collection and fermentation vessel, the residual pulp may be pressed to express the remaining juice fluids. The leftover pulp and seeds may be discarded, or they may be dehydrated and used in other noni products.



Left: A hydraulic fruit press for making fresh-squeezed noni juice. Ripe fruits are loaded into the press through the top door and juice is pressed from the pulp and bottled immediately. PHOTO: S. NELSON **Right:** A press for squeezing juice from fermented pulp. Wrapped in special cloth, the pulp is placed into large trays, and the juice is squeezed out by a plate pushed by a hydraulic piston. PHOTO: C. ELEVITCH

Simple home juice production

Using freshly picked mature fruit, you can make a traditional noni juice at home using simple kitchen materials.

Materials list

1–2 gal (4–8 l) mason jar or large see-thru container with large, sealable opening

1–2 gal (4–8 l) whole noni fruits at the hard white stage

large cheesecloth or wire mesh strainer (optional)

Collecting fruit

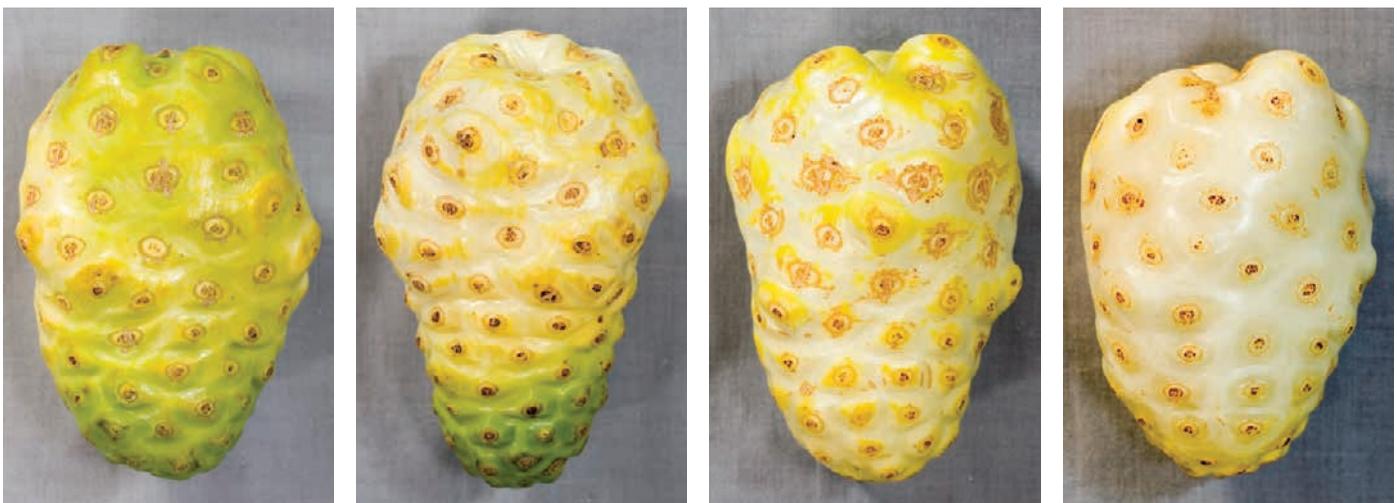
Pick mature fruits directly from the tree. Fruits are mature when they have turned completely whitish-yellow, although it is fine to pick some fruit that still has a bit of light green color on the end. The fruits should still be hard. At cooler times of the year or in certain locations (high elevations and latitudes), it may be difficult to find completely white fruit on trees, because the sunshine and warmth needed to ripen the fruits fully is lacking. It is best not to pick any fruit with bird or rodent damage or to pick up any fruit that has fallen to the ground, as such fruits can introduce unwanted organisms into the juice. Collect enough mature noni fruit to fill your container about $\frac{3}{4}$ full.



Fruit at the hard white stage, perfect for picking. PHOTO: C. ELEVITCH

Fruit preparation

At home, wash the fruit with mild soapy water to remove unwanted bacteria and fungi that maybe on the fruit. Air-dry fruits or pat-dry with a clean towel, and put them in plastic bags to ripen. During the ripening process the mature fruits turn from hard, whitish-yellow to very soft grayish-white and slightly translucent. Unlike many other fruits, noni must ripen fully before it will fully release its juice. In other words, only ripe, soft, and mushy fruits will yield optimal quantities of juice.



Left to right: Too green, and will not ripen; A green tip, most of the fruit will ripen, but the green part will make juice more bitter; A hard, white fruit perfect for picking; A soft, yellowing, translucent fruit one day after picking. PHOTOS: C. ELEVITCH



Top left: After washing the fruits and air-drying, place them in a clear plastic bag for ripening. Top right: As fruits ripen, they soften and begin releasing juice. Bottom left: Place ripe fruits in a container for fermenting. Bottom right: After 7 days, the fruits will be mostly covered in their own juice, and the fermentation is in full swing. PHOTOS: C. ELEVITCH



Rapid bubbling and some surface foam is normal, especially at warmer temperatures or when the container is placed in direct sunlight. PHOTOS: C. ELEVITCH

Fermentation

Check the fruits daily, as some fruits will begin ripening and releasing their juices rapidly, often within hours at room temperature. As fruits ripen, move them from the ripening bag to the container. It's best for the juice extraction to place fruits into the jar whole or broken into no more than 2–3 pieces. Do not put hard fruits into the jar, as these could affect the taste unfavorably. Fermentation, indicated by bubbles forming in the juice collecting between the fruits, begins in earnest after 2–3 days at normal room temperature. After adding fruits to the jar, close the lid loosely so that gases will bleed out, but no outside air will enter the jar as long as the fermentation is active. Stop adding fruits to the container when it is $\frac{3}{4}$ full. This allows for expansion of the contents due to bubbles forming in and around the fruit, and some foaming that may take place at the surface. After a week at 75–80°F (24–27°C), most of the major fermentation gases will be blown off, although fermentation and off-gassing continue at a slower rate for another few weeks.

The fruit can be fermented at room temperature, or in the sun. If the container is kept outside or in sunlight, the amount of bubbling increases greatly, indi-

cating that the fermentation is strongly affected by temperature as the sunlight heats up the juice. Once the bubbling ceases at daytime temperatures, the fermentation has run its course. This can take up to 8 weeks.

Fermentation length

The juice can be used from the first day forward; the duration of fermentation is a matter of personal preference. The taste, color, and, potentially, medicinal properties, change with age. The first 2 days, the taste is strong and unappealing for most people. It becomes sweeter for the next week or two. People who prefer a sweet-tasting juice should decant the juice and refrigerate it after 10–14 days. The sooner the fermentation is stopped, the more sugars will remain. For a deeper color, and smoother, slightly sour taste, fermentation should go on for 6–8 weeks. At the end of the fermentation, the taste becomes more acid and sour tasting with decreasing sweetness and darkening color. Fully fermented juice can be stored at room temperature for years because of the acidifying process that takes place during fermentation, assuming offending organisms are kept out of the fermentation process. For a very sour juice, let it age

for 6–8 weeks, then turn the jar upside down and let it drip drop by drop into another container. The process of dripping through the air seems to increase the sourness substantially.

Decanting the juice

Fermentation can be suspended at any time before 8 weeks by pouring off the juice and refrigerating it. After 8 weeks, the fermentation is usually complete. When ready, decant the liquid into a storage container. Much of the juice will remain inside the fruit, so repeat the decanting process daily over 3–5 days to allow juice to separate from the pulp and drain off. The fruit pulp can be pressed through a strainer or cheesecloth to remove the remaining juice. Some pulpy sediment will fall to the bottom of the storage container. Sediment is not a problem for the home user, although commercial processors remove the sediment before bottling. If the pulpy sediment is unwanted, the juice can be decanted once more after overnight refrigeration.

Tips for the home noni juicer

Hygiene

Strive for a clean, nearly sterile environment in the juicing area. Tools and containers may be sterilized using hot water or simple soaps and disinfectants. Personal hygiene is another important consideration.

Fruit selection

Use mature fruit that is all white or has a small amount of green at the tip, not green fruit. Do not use bird or rodent-eaten, or fallen fruit.

Container

Avoid using plastic containers for juice collection or storage (e.g., plastic garbage cans) that are not food-grade plastics, as they may release undesirable chemicals into the juice. As fermentation occurs, gaseous carbon dioxide is created and released into the fermentation vessel, building up pressure inside. The tiny gas bubbles can be observed steadily rising through the juice as it actively ferments. The pressure that builds up is enough to blow corks off of bottles, or swell and even explode thin plastic bottles. A con-



Use only food-grade plastic containers, or containers made of an inert material such as glass. PHOTO: C. ELEVITCH



Contaminants and air can lead to mold growing on the fruits during fermentation, which ruins the whole batch (it should be discarded). PHOTO: S. NELSON

tainer that can be loosely sealed is recommended so that fermentation gases building inside can escape without letting outside air to enter. Juice that is not pasteurized can blow out or seep through the bottle caps during transit or upon arrival.

Oxygen and air

Prevent air from entering the juice collection vessel as much as possible. Air in the container will favor the growth of yeasts and other fungi, which may lead to toxic by-products and some alcohol production. Oxygen causes unwanted oxidation of noni juice.

Juice color and aging

The juice color will be darkened by green fruits or aging the juice for a longer period of time. The minimum time required for a batch of noni juice to ferment completely is 8 weeks, depending on temperature. However, if contaminants do not enter the vessel, the juice may be aged without any problems for 9 months or more.

Sunlight

You can try fermenting the container in the sun. Sunlight warms the contents, causing a vigorous fermentation. Juice fermented in the sun tends to have a reddish color and rich flavor.

Acidity

Obtain an inexpensive set of pH papers (also called litmus strips) to monitor the acidity of your juice. Fully fermented noni juice should have a pH of 3.5 or less. If the pH of the juice exceeds 3.5, there is a higher probability that it may be contaminated with undesirable organisms, and the higher the pH, the higher probability of contamination.

Quality control

If juice appears cloudy or has an unusual or foul flavor or high pH, it is probably contaminated and should be discarded. If mold forms on the fruit before or during fermentation (as evidenced by “fuzzy” growth on the fruit that is exposed to the air), the entire batch should be discarded.

Filtering of sediment

Juice may be filtered and clarified using cheesecloth



Juice fermented in the sun takes on a reddish color and tends to have a complex flavor. PHOTO: C. ELEVITCH

or other strainer that is safe for food use. Filters or strainers should be sterilized in boiling water before they are used.

Labeling

It is a good idea for home noni juicers to label jars before storing in order to keep track of different batches and in case some of the juice is given away to friends. The following basic information should be included: what kind of juice it is (noni juice), the date it was decanted, how long it was aged, and who made the juice. Other notes many include the source of the noni fruit, pH test results, and whether the juice was aged in the sun or not. If you plan to sell the juice as a retail product, which would normally require following a set of health regulations, nutritional data and other governmentally required information must be included on the label. It is best not to

PH TESTING

What is pH? pH is a measure of the acidity and alkalinity of a solution, the concentration of hydrogen ions (H^+) in a solution. The measure pH is a number on a scale in which 7 represents neutral acidity, lower numbers indicate increasing acidity, and higher numbers indicate increasing alkalinity. Each unit on the pH scale represents a tenfold change in acidity or alkalinity. For example, a solution with pH 4 is ten times more acidic than a solution with pH 5.

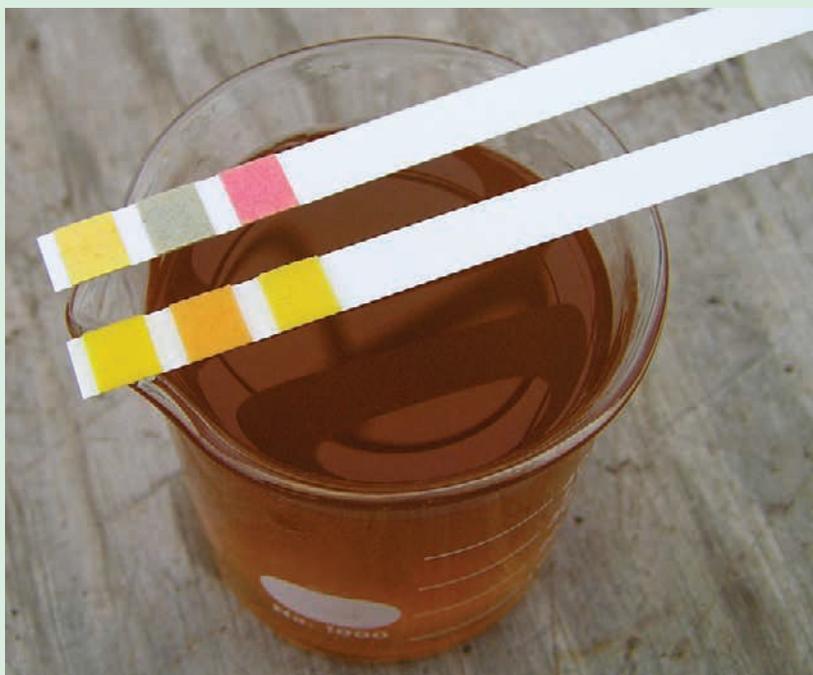
Why does pH matter? pH is important to noni juice production because the desired fermentation process lowers the pH of the juice from an initial value of about 4.8–5 down to as low as 3.1 at completion. The juice becomes more acidic with aging, and pH is a measure of how “finished” a batch of juice is. As the juice becomes more acidic, it tastes more sour as the sugars are converted to organic acids. Therefore, if you want to control how sour your juice is you can do so by testing the pH and stopping the process at your desired sourness by decanting the liquid and storing it in the refrigerator or pasteurizing it. If the juice becomes too acidic for your taste, you can adjust the pH 1 or 2 units higher by stirring in baking soda (sodium bicarbonate). First, add the baking soda to a small sample of juice to see how much baking soda you will need to add to the entire batch.

pH for quality control It is a good idea for home juicers to test the pH (acidity) of their juices as a quality control measure. If the pH of your juice has not decreased to a level of about 4.5 or less by the 3rd week of active, bubbling fermentation at room temperature, there may be an unwanted fermentation process taking place. Often the problem is that the fermentation has become dominated by unwanted yeasts or other fungi rather than the desired kinds of bacteria. A yeast fermentation may also be associated with unusually high cloudiness in the juice or alcohol production. A cloudy batch with a pH above 4.5 after 3 weeks should probably be discarded.

How to measure pH Testing is cheap and

simple using litmus paper (pH strips). You can get more precise pH values by using a battery-powered, hand-held, or tabletop electronic pH testing meter. Although there are a number of pH test papers available from manufacturers and retailers, they vary in quality. The ideal test paper for noni juice testing has these qualities: universal range pH 1–14 and sensitivity of 0.1 pH unit. A package of 100 quality test strips usually costs about \$20–25. A test strip has several colored patches which you can compare with a simple master chart after immersing the strips in the noni juice. Make testing even more economical by cutting the strips lengthwise into 2–4 narrow strips, making each pack of 100 strips able to test 200–400 noni juice samples. Protect the strips from air and humidity in an airtight glass or hard plastic container when not in use.

Keeping records By tasting your juice each time you perform a pH test, you may gradually become experienced enough to know the approximate acidity of your juice by taste alone. Keep records of your observations to track problems and solutions. This way, you will be able to correlate abnormal visual characteristics of the juice (it might be overly cloudy, for example) with pH and taste tests.



Tri-colored pH testing strips, before testing juice (above) and after testing (below). The colors after testing are compared with a master color chart to determine the pH value. PHOTO: S. NELSON

place health claims on the label; if you do, the claims should probably be accompanied by a disclaimer such as, “These statements have not been evaluated by the [insert name of governing authority here, e.g., U.S. Food and Drug Administration]. This product is not intended to diagnose, treat, cure, or prevent any disease.”

Storage

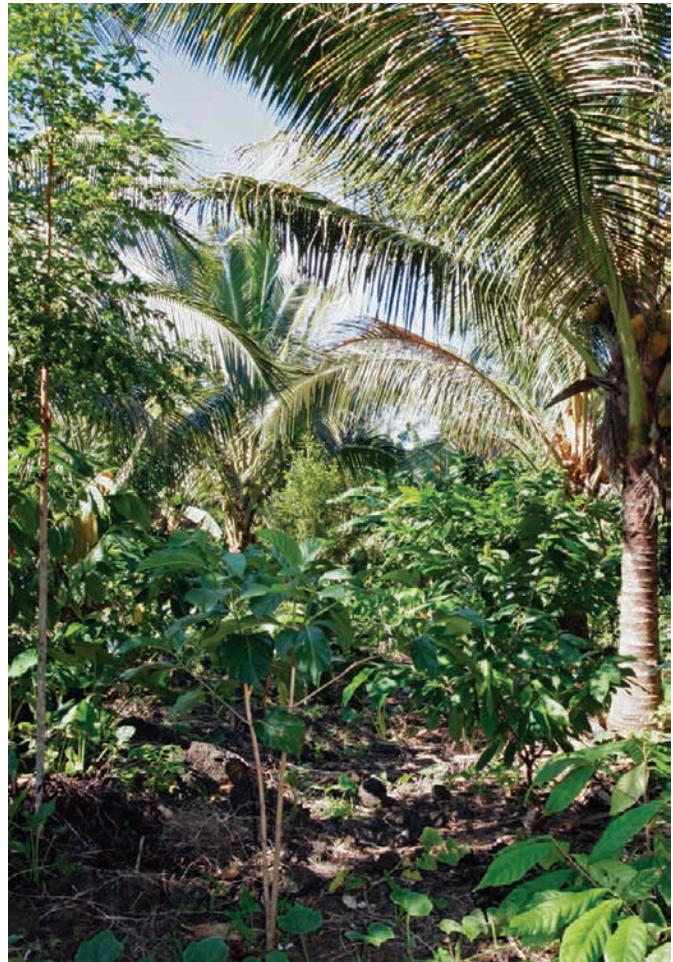
Fresh-squeezed noni juice should be refrigerated. Aged, fermented noni juice at about pH 3.1–3.5 can be stored at room temperature in a sealed container for 1–2 years or even longer without spoiling.

PESTS AND DISEASES

Noni is susceptible to attack by a range of pests and disease-causing pathogens. The extent of the damage caused by these insects and diseases depends on the type of insect or pathogen, how noni is grown (monoculture vs. polyculture), what stage of development the plant is attacked, and the environmental conditions. Where grown in a diverse, forested natural ecosystem, noni usually suffers only slightly from insect pest or disease problems. Where noni is grown in a modern, monocultural farming system, it is more susceptible to attack and damage by many pests and diseases with greater intensity than in mixed plantings or natural ecosystems. In addition, noni grown in monocultures on lands previously used for fruit or vegetable crops often is exposed to pests and pathogens that may not be abundant or even present in forest or natural ecosystems.

Fortunately for noni growers, there are no known diseases of noni caused by plant-pathogenic bacteria, viruses (aside from one report of Tobacco Mosaic Virus infecting noni in Fiji), viroids, or phytoplasmas, which are destructive to some other crops. Currently the principal noni pathogens are fungi (or fungus-like organisms such as *Phytophthora*) and nematodes. Although fungi cause the most common diseases of noni, fortunately at present there are no fungal rusts or powdery mildews of noni, plant diseases that are considered to be among the world's most devastating throughout agricultural history.

This chapter describes the most commonly encountered noni insect pests and diseases in the Pacific. Insect pests listed in the chapter were identified by the authors or by the University of Hawai'i Agricultural Diagnostic Service Center. Fungi, nematodes, and other pests were identified by the authors based on morphological characteristics. It should be noted



Noni grown within mixed cropping systems is much less susceptible to pests and diseases. PHOTO: C. ELEVITCH

that much more research is needed to prove which organisms are the underlying cause of specific symptoms. Most of the presumed causal agents listed here are in a strict sense only associated with the disease symptoms, and are not yet demonstrated by peer-reviewed research to be the causes. The table at the end of this chapter summarizes the pest and disease problems.

Pests in monocultures

There were no notable pests and diseases of noni reported until people moved noni from its natural habitats into large, single-species plantations (monocultures). This exposed noni to new diseases not found in natural settings and created large noni populations that allowed epidemics and new pathogen strains to develop.

General pest and disease categories

Insect pests

Noni is susceptible to attack and damage by a range of insects, including aphids, scales, weevils, leaf miners, whiteflies, caterpillars, thrips, and mites. Overuse of fertilizer can attract heavy infestations of mites and sap-feeding insects (e.g., aphids, whiteflies, scales) that cause a buildup of sooty mold on noni leaves. Stress from lack of nutrients or root problems may also lead to infestations of whiteflies or scales, which at times seem to be attracted to such plants. Insect damage may be more severe in relatively dry or low-rainfall locations or in full-sun plantings such as broadscale monocultures. Of the insect pests, whiteflies and scales are perhaps the most destructive, but usually only where noni is planted in large plantations. They can be controlled with sprays of insecticidal soaps and oils. In some locations, leaf miners periodically cause severe damage to noni leaves.

Pathogens and biotic diseases

In damp, high-rainfall, or flooded areas, noni is prone to certain diseases caused by fungi or fungus-like organisms such as leaf spots (*Colletotrichum* sp., *Colletotrichum gloeosporioides*, *Cephaleuros* spp., *Guignardia morindae* and others), stem blight (*Athelia rolfsii*), and leaf and fruit blights (*Phytophthora* spp.). The fungal leaf spot diseases, such as leaf spot caused by the fungus *Guignardia morindae*, are usually relatively minor in severity but can be a major nuisance, causing extensive defolia-

tion in some locations or where noni is planted in large monocultures in wet environments. The effects of these diseases can be minimized by sanitation (picking up or removing severely diseased leaves) or by periodic application of approved fungicides. Some foliar diseases caused by fungi (i.e., fungal leaf spots, or “black flag disease” presumably caused by the fungus-like *Phytophthora* sp.) may significantly inhibit leaf growth and fruit development.

The most common and severe of all pest problems for noni is root knot disease caused by one or more species of root-knot nematodes (*Meloidogyne* spp.). These soil-dwelling, root-parasitic roundworms are very destructive to noni and must be kept out of the nursery. Root knot disease can cause noni farm failure and has done so in several locations in Hawai'i. Because these nematodes are found throughout the world, they are expected to be a problem for noni wherever it is grown—the leaves get a distinctive yellow mottling pattern as an early sign of the disease, then leaves and branches gradually die back as root galls enlarge and crack open, and soil-line stem cankers form, often leading to tree death.

Nutritional deficiencies and abiotic diseases

Noni can display a range of abnormal foliar symptoms due to deficiencies in fertility elements (e.g., nitrogen, iron, and phosphorous). Deficiencies in iron



Root knot disease, caused by a soil-dwelling, microscopic, parasitic roundworm, is one of the most severe noni pests. Infected plants yellow, and gradually decline. PHOTO: S. NELSON

Basic soap-oil treatment

Instructions for treating soft-bodied insects such as aphids, soft-bodied scales, whiteflies, and mealybugs (for 4 gallon [16 l] spray tank).

Soap-oil stock mixture Mix 4 oz (120 ml) mild dishwashing liquid in ½ gallon (2 l) of vegetable oil. Store until ready to use.

When ready to use Shake stock solution well; mix 11 oz (330 ml) of soap-oil stock solution in 4 gallons (15 l) of tap water. Mix well before spraying.

Use Spray in morning or evening to achieve direct contact with insect bodies and reduce the risk of causing sunburned foliage. Because soaps and oils can sometimes damage the leaves and stems of sensitive plants, test the mixture on a few leaves and then wait 2 days before treating the other plants. Spray as often as needed, but usually twice monthly is sufficient.

or other minor elements are expressed as yellowing along or between the leaf veins (interveinal chlorosis) or scorching of leaf margins. Deficiencies in phosphorous are expressed as leaf curling, purpling, and marginal necrosis. A deficiency of nitrogen results in general foliar yellowing and plant stunting. Symptom development and expression for nutrient deficiencies on noni depend on the setting (natural vs. agricultural), overall plant stress factors (water, disease, root health, and fertilizer practices), and overall demand for nutrition and/or production (low to high). For example, regarding root health, where root-knot nematodes infest noni root systems, interveinal yellowing (chlorosis) of leaves is common.

Host to crop pests/pathogens

Several significant pests and pathogens of general agricultural concern are also problematic for noni (e.g., ants, sap-feeding insects, and root-knot nematodes). These pests have wide host ranges and may initiate or cause significant damage to some crops (e.g., vegetables). Because noni attracts ants, some sap-feeding insects such as aphids may be a concern for certain vegetable intercropping designs with

noni. Farm management plans should take into consideration the common pests and diseases that may attack the components of an interplanted system. Issues regarding pesticide spray drift and potential contamination of products and phytotoxicity must also be considered.

Diagnosis and control

Many of the following pests and diseases were not previously reported for noni before surveys were conducted by co-author Scot Nelson beginning in 1998 in Hawai'i and Micronesia. There is still much research to be done on these pests and diseases to determine their presence and severity in different locations. When using chemical treatments, label instructions should always be followed. Also, when considering the use of pesticides, it is prudent to take account of possible disruptions in the life cycles of beneficial insects, fungi, and other organisms resulting from the treatment. In fact, heavy and repeated use of pesticides may eliminate populations of beneficial insects altogether.

Alphabetical list of noni pests and diseases

Algal leaf spot

Damage potential Locally severe in many Pacific islands

Pathogen The disease is caused by species of plant-parasitic algae of the genus *Cephaleuros* (*C. minimus* and *C. virescens*). *Cephaleuros* species are the only plant parasitic algae known.

Symptoms Leaf spots (about 0.4–0.8 [1–2 cm] diameter), characterized by a light brown color and surrounded by a conspicuous, diffuse, yellow halos. The pathogen, *Cephaleuros minimus*, enters the leaf through the upper surface and forms a filamentous thallus above the epidermis which moves intercellularly to the lower leaf surface. Sporangia and setae break through the lower epidermis and can usually be seen with a hand lens due to their bright orange color. The effect of these symptoms may be minor;

the disease is not fatal but some premature defoliation may occur.

Distribution These algae probably exist throughout the tropics. The disease has been reported from American Samoa (*C. minimus*) and the Cook Islands (*C. virescens*). It is reported to be the one of the most common leaf spot diseases of noni in American Samoa.

Factors effecting disease Algal leaf spot is favored by very wet, warm and humid weather and is most common where noni is growing in low-light conditions as an understory plant that is shaded by other species that are susceptible to the algae, such as avocado. Spores are dispersed by primarily splashing rain and by wind-driven rain.

Control

- Sanitation (removal of severely diseased leaves from the plant; removal and destruction of fallen infected leaves).
- Moisture and humidity management (good drainage, weed control, adequate plant spacing, pruning, minimized leaf wetness and overhead irrigation).
- Grow noni in full sun; prune overhanging plants.

Anthracnose

Damage potential Potentially significant

Pathogen Noni anthracnose is caused in many Pacific islands by the fungus *Glomerella cingulata/Colletotrichum gloeosporioides*. *Glomerella* is the sexual stage of the fungus.

Symptoms This is one of the most common leaf spot diseases of noni in the Pacific. Large expanding leaf spots with dark to tan centers and diffuse irregular margins develop. Expansion of individual lesions results in their “target spot” appearance, i.e., concentric rings become visible in the lesions as the lesions grow each day. Lesions may coalesce to form large, blighted areas on leaves, often at leaf margins. Infected leaves may abscise (drop) prematurely. Symptoms are often most severe within dense noni canopies and/or on the lower leaves. Fruits and stems are not susceptible to infection.

Distribution This disease may become established



Symptoms of algal leaf spot. PHOTO: F. BROOKS

wherever noni is grown in areas that receive frequent or high rainfall. The pathogen (*Colletotrichum*) has a very wide host range (can infect many species of plants) and therefore enjoys a pantropical distribution.

Epidemiology Noni anthracnose is favored by warm, wet weather, and high relative humidity. The fungal spores are dispersed primarily by wind and splashing rainwater.

Control

- Sanitation (removal of severely diseased leaves for the plant; removal and destruction of fallen infected leaves).
- Moisture and humidity management (good drainage, weed control, adequate plant spacing, pruning, minimized leaf wetness and overhead irrigation).
- Protective spray applications of approved fungicides.
- Avoid spreading the pathogen on hands and tools during harvesting operations.

Ants

Damage potential Potentially significant, indirect damage, because ants tend to and protect sap-feed-

ing insects such as whiteflies, aphids, mealybugs, and scales. However, although ants feed on noni fruit and flower nectarines, they cause no significant damage to noni plants.

Damage Where sap-feeding insects have reached damaging levels, ants are usually abundant. Ants disrupt the ecological balance by fending off the natural enemies of these sap-feeding insect pests.

Distribution Ants have a wide distribution.

Impacts Where ants cannot be controlled, some sap-feeding insects can cause plant stunting and poor growth.

Control Backyard growers and professional farmers can control ants with boric acid bait mixtures placed near the base of noni plants.

Aphids

Damage potential Usually minor

Pest Aphids, the melon aphid (*Aphis gossypii*) and the brown citrus aphid (*Toxoptera citricida*). Aphids are most often associated with and tended by one of several ant species.

Damage Aphids are sap-feeding insects that cause stunting and slow growth of noni plants and leaf curling and deformity if aphid populations are large. The sugary waste product that is excreted from aphid abdomens provides a substrate for the growth of a fungus that causes “sooty mold”. If ants and aphids can be controlled, the sooty mold usually disappears after a short time.



Left: Anthracnose symptoms on leaves. Right: Ants tending aphids (small black dots). PHOTOS: S. NELSON

Simple control for most ants that affect noni

Make a boric acid-sugar bait by mixing 3 cups (850 ml) of tap water, 1 cup (280 ml) of sugar and 3 teaspoons of boric acid. Place this bait in a small plastic container or similar bait station that is sheltered from the rain and evaporation.

Distribution Melon aphids and citrus aphids are widely distributed throughout the tropics. Aphid population outbreaks are usually favored in warm, dry locations or during warm, dry periods of the year.

Impact Aphids have the most negative impact on the growth of noni seedlings in nurseries.

Control

- Biological control. In some environments, aphids are controlled effectively by natural enemies (e.g., lady beetles, aphid lions) and parasitic fungi.
- Spray applications of approved insecticidal soaps and oils.
- Ant control. If ants are controlled effectively, aphid populations generally decline.
- Hand removal and destruction of severely infested leaves and stems.
- Weed control or elimination of alternate hosts for aphids.

Beetles (postharvest)

Damage potential Can be a significant postharvest pest of ripe noni fruits.

Pest Souring beetles (*Lasiodactylus tibialis*)

Damage Beetles attack and consume ripe fruit on ground, causing them to disintegrate.

Host range Souring beetles attack a wide range of fruit crops, sometimes attacking fruits that are still on the plant.

Distribution Souring beetles have a worldwide distribution.

Impacts Where ripe fruits are picked from the ground, beetles can be introduced into the container of noni fruit, affecting juice quality.

Control

- Avoid harvesting fallen noni fruits.
- Do not place bags of harvested noni fruits on the ground.

Black flag disease

Damage potential Potentially very significant. Noni black flag is a major threat to noni farms in areas where the disease it occurs.

Pathogen Noni black flag is presumably caused by an unidentified *Phytophthora* sp. We do not yet know the host range of this putative pathogen.

Symptoms Foliar symptoms of noni black flag include black leaf spots and leaf blight; brown to black stem blight; brown to black soft rot of fruits; fruit mummification; severe defoliation (hanging, diseased leaves are referred to “black flags”); blackened leaf veins; death of stems; plant death. Roots and woody portion of the plant are not normally infected.

Impact Large yield losses and even plant death are possible.

Distribution Noni black flag was first discovered in 2000 in the Puna district on the island of Hawai‘i. The disease is not known to exist elsewhere.

Epidemiology Noni black flag is favored by frequent rains, high winds, warm weather and high relative humidity. Spores are dispersed by splashing rain and

wind. Severe symptoms can develop within 5 days after infection.

Control

- Learn to recognize black flag disease symptoms and inspect noni plants regularly during and after periods of extended rainfall.



Symptoms of black flag disease on leaves and fruit. This is a potentially major disease in areas where it occurs. PHOTO:

S. NELSON

- Promptly prune, remove and destroy symptomatic foliage and fruits to reduce pathogen inoculum levels and to minimize the likelihood of disease spread.
- Remove fallen or pruned branches, stems, leaves, and fruits. Do not allow them to accumulate beneath noni trees.
- Promote air circulation within the noni canopy to ensure rapid drying of leaves and fruits. This can be accomplished by selecting wider plant spacing during farm establishment, and by pruning back verticals to open up the canopy to increased air movement.
- Reduce relative humidity within the noni canopy. Prune back overhanging trees. Ensure good soil drainage. Control weeds around the noni plants. These measures will ensure rapid drying of leaves and fruits after rainfall, reduce water congestions in plant tissues, and minimize the infective potential of the pathogen.
- Avoid introducing diseased noni plants or fruits into high-rainfall areas where the disease has not been reported. Start new noni farms with disease-free plants.
- The disease can be controlled very well with fo-

liar sprays of phosphorous acid-containing fertilizers or fungicides.

Croton caterpillar

Damage potential Primarily in greenhouses

Pest Croton caterpillar (*Achaea janata*)

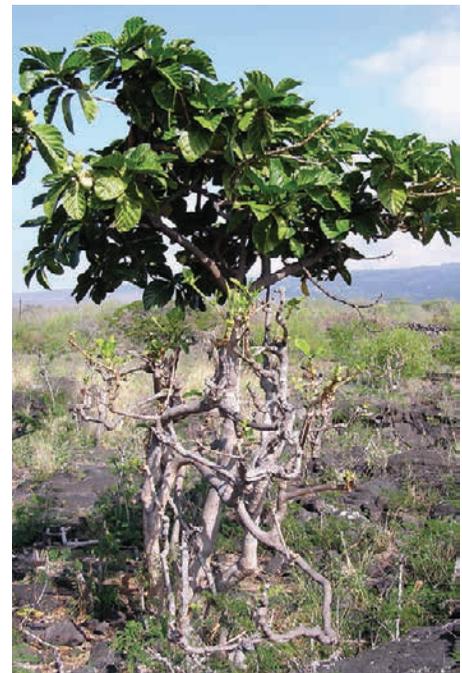
Damage Croton caterpillars feed on leaves of noni seedlings. The caterpillars can consume most of the foliage, leaving large gaping holes in the leaves with just the veins and petioles remaining.

Distribution This moth is widespread throughout the tropical and subtropical Pacific, Australia, and the Orient and has a wide host range.

Host range The croton caterpillar feeds on many different species of plants. Castor bean and croton are preferred hosts. Occasional hosts include banana, cabbage, Chinese cabbage, crown of thorns, *Ficus*, macadamia, mustard, poinsettia, rose, sugarcane and tomato as well as some legumes, teas, *Brassica* species, and noni.

Control

- Biological control (natural enemies), including birds and parasitic wasps.
- Grow seedlings on elevated benches and increase



Left: Souring beetle, a postharvest fruit pest. Middle: Croton caterpillar, primarily a nursery pest. Right: Grazing injury sustained on lower branches that are within reach of cattle. PHOTOS: S. NELSON

plant spacing in nurseries to eliminate hiding places for the caterpillars.

- Use of insecticides (pyrethroid insecticides, *Bacillus thuringiensis*).
- Hand picking and destroying caterpillars.

Fruit cracking

Damage potential Usually minor

Pathogen None; the abnormal condition is probably not caused by a pathogen or pest. The cracking is presumably caused by or related to drastic or abrupt changes in humidity during fruit maturation and ripening.

Symptoms Large, dry cracks in fruit surface.

Distribution Unknown.

Control There is no known control measure where noni is grown outdoors.

Mealybugs

Damage potential Usually minor

Pest The pest is an unidentified species of mealybug with a pink color.

Damage Young fruits and flowers are susceptible to feeding injury.

Distribution Unknown. If this is the so-called pink mealybug, it is widely distributed.

Host range Unknown.

Control Soap-oil sprays.

Grazing injury

Damage potential Severe where livestock are grazing.

Pest Grazing animals such as cattle or horses.

Damage Grazers may feed on all green noni foliage that they can reach.

Distribution Pastures.

Impact Grazing injury can prevent young noni seedlings from becoming established and reduce the fruit yield and overall plant size and vigor.

Control Consider fencing off noni areas to protect them from grazing animals.

Leaf miner

Damage potential Moderate, found in Kosrae, Federated States of Micronesia

Pest The pest is an unidentified species of leaf miner.

Damage The feeding by leaf miners results in pale green, irregular tunnels within the leaf tissue, leading to a necrosis and premature defoliation.

Distribution Damage from leaf miners was observed by co-author Scot Nelson on the island of Kosrae in the Federated States of Micronesia in 2003.

Host range Unknown.

Control Undetermined; probably there exist parasitic wasps to help control this pest.

Mites

Damage potential Potentially severe in greenhouses; significant damage in the field is rare

Pests Broad mites (*Polyphagotarsonemus latus*) and eriophyid mites (unidentified species)

Damage Broad mite damage can be severe in greenhouses, especially on *Morinda citrifolia* var. *bracteata*. These pests cause leaf distortion, yellowing, curling and a leathery-looking appearance. Feeding by eriophyid mites causes the leaves to curl and wrinkle, leading to a bronze scorching and necrosis of leaf margins. Entire leaves may be discolored and defoliate prematurely.

Distribution Broad mites are ubiquitous throughout the world. The distribution of the eriophyid mite is unknown at present.

Host range Broad mites have a wide host range and can cause similar leaf symptoms on citrus and coffee. The host range of eriophyid mites is unknown.

Control

- Foliar applications of sulfur dusts or sprays.
- Manual detachment and removal of heavily infested leaves.
- Canopy management (thinning).
- Weed control (removes potential alternate hosts for the mites).



Left: Typical leaf curl symptoms of eriophyid mite feeding. Right: Parasitic plant *Cassytha filiformis* (the yellowish strands on right side) shades and chokes the tree and saps nutrients. PHOTOS: S. NELSON

- Avoidance (avoid introducing infested plants into your nursery).

Premature or uneven ripening

Damage potential Usually minor

Disorder Premature or uneven ripening

Symptoms The main symptom of this condition is the early or uneven ripening of a section of a noni fruit. The remainder of the fruit ripens much later. This condition is associated with knobby or misshapen noni fruits.

Cause The cause this condition is unknown. It is not known if the condition is genetically transmitted through seeds. However, it is often associated with drastic fluctuations in the weather at some locations that may cause hormonal changes in green fruits, leading to growth abnormalities. Overly knobby fruits are sometimes associated with high levels of phosphorous fertilizer.

Impact Affected fruits are not preferred by processors and may not be marketable. They are okay for home juicing, however.

Control

- Consider reducing levels of phosphorous fertilizer.
- When starting a noni farm from seedlings, select noni fruit with desirable shape and size characteristics as a seed source.

Parasitic seed plants

Noni is susceptible to infection by some coastline parasitic weeds, including dodder (*Cuscuta* spp.) and *Cassytha filiformis*.

Damage potential Potentially significant

Damage *Cassytha* and dodder (*Cuscuta*) are parasitic vines that draw nutrients from foliage. Parasitism by these plants causes reduced photosynthesis and plant vigor, and can cause plant stunting and plant death.

Distribution *Cassytha filiformis* is found throughout Hawai'i, Micronesia, and probably the entire Pacific. Dodders occur in Hawai'i, Micronesia and are widespread throughout the tropics.

Hosts *Cassytha* and *Cuscuta* have wide host ranges, including at least fifteen plant species. *Cassytha* attacks plants in coastal and low-lying habitats.

Control

- Manual removal of vines as soon as possible; repeat as needed.
- Avoid moving this weed to new locations

Rhizopus rot

Damage potential Can be a significant postharvest fruit decay problem

Pathogen The fungi *Rhizopus stolonifer*, other *Rhizopus* spp., and other fruit mold fungi can cause similar damage.

Symptoms Fungal-covered rot of fruits

Impact If these fungi get into noni juicing containers, mold can develop, ruining the juice. Some fungi can produce mycotoxins and/or cause disease to those who consume it.

Distribution These fungi are very widely distributed, probably worldwide. They have a very wide host range and are able to cause postharvest decay diseases of a great number of crops.

Epidemiology The disease spreads by aerial dispersal of fungal spores between fruits. Infection is favored by wet conditions and wounded fruits.

Control:

- Pick fruits at the correct stage (hard white) and wash them with soap and water promptly and dry them.
- Avoid picking up fruits from the ground.
- Keep a clean harvest or juicing facility; sterilize equipment after use.
- Avoid wounding fruits after harvest.
- Other postharvest control measures used for other crops would probably work for noni as well.
- Exclude air from the juicing container if possible, or cover fruits with liquid inside the container.

Rodents and birds

Damage potential Usually minor, but transmission of human pathogens is possible.

Pest any of several species of rats and mice and birds.

Damage Rodents and birds usually feed on fallen fruits or on ripening fruits on trees.

Distribution Rodents and birds are found wherever noni is grown.

Host range Rodents and birds feed on a wide range of plants.

Control

- Reduce rodent population (using, e.g., traps, rodents, cats, dogs).
- Do not allow fruits to fall to the ground, or pick them up the same day they fall (rodents are nocturnal). Do not use fruits picked from the ground

or fruits with signs of rodent feeding (the typical rodent teeth marks).

Root knot disease

Damage potential Potentially significant

Pathogen Noni root knot disease is caused by a group of plant parasitic nematodes, *Meloidogyne* spp., known as the root-knot nematodes. These nematodes have wide host ranges and are able to infect many plant species. They can survive for long periods in soils, even in the absence of host plants. Once established in a field, root-knot nematodes are virtually impossible to eradicate. The nematodes live in the soil and attack young noni roots. Their feeding and reproductive activities cause the noni roots to swell, develop galls, and to crack open. After roots have cracked open, other opportunistic organisms (fungi, bacteria) can enter the noni roots and cause rotting.

Symptoms Leaves are golden yellow; plants are stunted or weak in appearance; root systems are stunted and sometimes rotten; roots galled, knotty, swollen, distorted, cracked and rotten; bark along base of stem may split open, leading to stem girdling by opportunistic fungi and bacteria; plant death is rare but can occur; low yields; sparse foliage.

Impact Noni root knot can depress noni yields significantly, even killing trees in some situations. Replanting costs may be high in severe infestations and some fields may have to be abandoned.

Distribution Root-knot nematodes are distributed worldwide.

Epidemiology Disease often begins when seeds or cuttings are planted in nematode infested soil or when using naturally infected seedlings pulled from the ground and replanted. Nematodes are spread in contaminated soils, media, on tools and shoes and in water runoff.

Control

- Start noni seedlings in soilless media or only heat-treated soil (at least 122°F [50°C] for 20 minutes).
- Composts and chicken manure applied around



Root knot disease. Top row: Golden yellow leaves and stunted growth are symptoms of root knot disease. Bottom row: Root knot symptoms on older roots (left) and on a nursery seedling (right) include root galling and cracking. Nursery seedlings infected with root-knot nematodes will never recover and should be discarded. PHOTOS: S. NELSON

- the root zone help to lower nematode populations.
- Use of foliar fertilizers in severe infestations will help plants to tolerate high nematode populations and severe infections.

- Avoid introducing nematode-infected plants to a new field.
- If plants are obtained from a nursery, inspect root systems for galling before purchase.
- Never purchase or plant a nematode-infected noni plant.

- Avoid planting noni where it does not grow naturally and avoid fields where other crops have been planted.
- Rocky soils are best for noni cultivation.
- Avoid overly close spacing of plant to minimize root-to-root contact. Plant seedlings on 16–20 ft (5–6 m) centers where nematodes are a problem.
- Proper use of irrigation, fertilizer, and composts can help minimize damage caused by root-knot nematodes.

Scale insects

Damage potential Potentially significant

Pest The green scale (*Coccus viridis*). Scale insects are most often associated with and tended by one of several ant species.

Damage Scales are sap-feeding insects that cause stunting and slow growth of noni plants and leaf curling and deformity if scale populations are large. They tend to feed along primary veins on the underside of noni leaves. The sugary waste product that is excreted from their abdomens provides a substrate for the growth of a fungus that causes “sooty mold”. If ants and scales can be controlled, the sooty mold usually disappears after a short time.

Distribution Scale insects are widely distributed throughout the world. Scale population outbreaks are favored at warm, dry locations or during warm, dry periods of the year.

Impact Scales have the most negative impacts on the growth of noni seedlings in nurseries.

Control

- Biological control. In some environments, scales are controlled effectively by natural enemies and parasitic fungi.
- Spray applications of approved insecticidal soaps and oils.
- If ants are controlled effectively, aphid populations generally decline.
- Hand removal and destruction of severely infested leaves and stems.
- Weed control or elimination of alternate hosts for scales.



Symptom of shot hole. PHOTO: S. NELSON

Shot hole

Damage potential Usually a minor disease

Pathogen Shot hole, perhaps the most common leaf spot disease of noni, is caused by the fungus *Guignardia morinda/Phyllosticta morindae*. *Guignardia* is the sexual stage of the life cycle.

Symptoms Initial spots are tiny, maroon-colored specks on leaves and bracts. Specks develop into lesions (2–10 mm diameter) with bleached or tan centers and maroon margins, often surrounded by or accompanied by yellowing of leaf tissue around lesions. As the lesions mature the centers drop out, leaving the typical “shot hole” appearance. Infected leaves may abscise (drop) prematurely. Stems and fruits display no symptoms.

Distribution This disease is likely to become established wherever noni is grown in areas that receive high or frequent rainfall. Noni shot hole is common in noni plant nurseries, where plant crowding is common and overhead irrigation is used.

Epidemiology Noni shot hole is favored by warm, wet, windy weather and high relative humidity. The fungal spores are dispersed by wind and by splashing rainwater.

Control

- Sanitation (removal of severely diseased leaves for the plant; removal and destruction of fallen infected leaves).
- Moisture and humidity management (ensure

good drainage, control weeds, adequate plant spacing, pruning, minimize leaf wetness and reduce overhead irrigation).

- Protective spray applications of approved fungicides.
- Avoid spreading the pathogen on hands and tools during harvesting operations.

Slugs and snails

Damage potential Usually minor. Slugs and snails are not usually a field concern for noni, but can develop into a severe problem in greenhouses and in some field settings.

Pest Any of a number of species of slugs or snails.

Damage Holes in leaves.

Distribution Worldwide.

Impact Can retard the growth of small plants.

Control

- Manual destruction of slugs and snails.
- Baits.
- Biological control (e.g., ducks).

Sooty mold and scale

Damage potential Can be significant, because a large amount of sooty mold means a large population of sap-feeding insects is present.

Organism Sooty mold is caused by ubiquitous, airborne fungi that land on the noni leaves and use the sugary exudates produced by sap-feeding insects as a food source. Thus, the presence of high populations of sap-feeding insects such as aphids and scales is necessary for the formation of sooty mold.

Symptoms/Signs Sooty mold consists of a black, powdery growth, usually on the upper surface of noni leaves. The black growth is not pathogenic (it does not penetrate leaf tissues) and exists as a thin layer that can be scraped away with one's finger or washed off with soapy water.

Distribution The sooty mold fungus is probably distributed worldwide.

Damage potential Sooty mold on leaf surfaces can block sunlight from reaching the leaves, reducing



Sooty mold grows on sugary residues and indicates the presence of sap-feeding insects such as aphids or scales.
PHOTO: S. NELSON

photosynthesis and plant vigor. The sap-feeding insects associated with sooty mold cause more damage to noni plants than the sooty mold.

Control

To control sooty mold, one must control the sap-feeding insects (scales, aphids) that infest the noni plant. Often, the control of these sap-feeding insects can be greatly improved by controlling the ant species that tend them and use the honeydew as a food source. Sooty mold may in some cases be washed off noni leaves with a strong spray of soapy water.

Stem canker

Damage potential Usually minor

Pathogen The cause noni stem canker is unknown, although the disease is associated with an unidenti-



Stem canker. PHOTO: S. NELSON

fied species of fungi, including *Nectria haematococca* in Fiji.

Symptoms Noni stem canker is characterized by a progressive rot of stem at the interface between woody and green stem tissues. Stem may be girdled and collapse, leading to plant death. Stem lesions are irregular in shape with roughened, dark borders and an overall corky appearance.

Distribution This disease is limited to high rainfall areas where noni is grown.

Impact Some plants may recover from this disease with proper management.

Epidemiology Noni stem canker is favored by warm, wet weather.

Control

- In nurseries, rogue or prune severely infected plants. If pruning, sever the diseased stem at least 1 inch (2.5 cm) below the stem canker.
- Humidity management through plant spacing and pruning, weed control, good drainage, etc.
- Minimize stem wounding in nurseries.
- Protective or therapeutic applications of approved fungicides.

Sunburn

Damage potential Usually minor

Symptoms The initial symptom of noni sunburn is bleaching of leaves within a few days after exposing shade-grown plants to full and direct sunlight. As

the bleached tissues die, leaves become bronzed or brown.

Cause Sudden exposure of shade-grown noni seedlings to full and direct sunlight.

Control

- Gradually acclimatize shade-grown seedlings to full sunlight.

Thrips

Damage potential Moderate, primarily in greenhouses; not a usually field problem.

Pest Thrips, the greenhouse thrips (*Heliothrips haemorrhoidalis*).

Damage Thrips feed on noni leaves. Injured tissue takes on a silvery or bleached appearance and eventually turns a bleached and then dark brown color.



Seedling sunburn is caused by moving shade-grown seedlings from shade to full sun too quickly. PHOTO: S. NELSON

Large lesions may develop on leaves, with bleached centers and irregular margins. Feeding on leaf tips may result in wilting and curling. Severely affected leaves may defoliate prematurely. Yellow, chlorotic areas may surround or be associated with visible lesions. The undersides of affected leaves also may have large necrotic areas and silvery bleached regions that are spotted with small black fecal specks.

Distribution Significant damage to noni from thrips is usually found only where noni seedlings are grown in shade houses or greenhouses.

Impact Thrips are not a significant problem for noni in outdoor, field plantings. Thrips have the most negative impacts on the growth of noni seedlings in nurseries in covered shade house or greenhouses.

Control

- Leaf pruning. Detach and remove severely diseased leaves and destroy them.
- Spray applications of approved insecticides. At this time, no insecticides are registered for use on noni that are effective for thrips management.
- Move affected noni plants to an outdoor location. The thrips populations will then decline due to the presence of their natural enemies and a less conducive and protected environment.
- Weed control, and/or elimination of any alternate hosts for thrips.

Whitefly, Kirkaldy (*Dialeurodes kirkaldyi*)

Damage potential Potentially significant

Description Adults are very small, gnat-like with a light orange body. The wings are yellowish, and antennae are seven-segmented. The immature stage is flat, elliptical in shape, yellowish green in color with a longitudinal brown median area. Three nymphal stages and one pupal stage occur in the life cycle.

Damage Leaf discoloration (dulling, browning, yellowing, necrosis); leaf distortion (curling, crinkling, stunting); slow and poor plant growth; premature defoliation.

Distribution This insect occurs throughout the tropics.

Host range Favored hosts include noni and *Jasmi-*

num spp. This pest is also recorded from *Citrus sinensis*, coffee, *Beaumontia grandiflora*, *Allamanda nerriifolia*, and other host plants in 17 genera and ten plant families.

Control

- Foliar applications of insecticidal soaps and oils.
- Manual detachment and removal of heavily infested leaves.
- Canopy management (thinning).
- Weed control (removes potential alternate hosts).
- Avoidance (avoid introducing infested plants into your nursery or farm).

Natural enemies *Encarsia protransvena* is a parasitoid of the Kirkaldy whitefly.

Whitefly, spiraling (*Aleurodicus dispersus*)

Damage potential Potentially significant

Description Adults are similar in appearance to many other whiteflies. They are white and quite small (1/12–1/8 inch [2–3 mm] in length) and coated with a fine, dust-like waxy secretion. Males and females are winged and resemble tiny moths. Mature pupae bear copious amounts of a white cottony secretion (sometimes fluffy, sometimes waxy).

Damage Two types of damage to noni may be caused by the spiraling whitefly: direct damage from feeding and indirect damage from the accumulation of sooty mold and the white flocculent material on leaves (blocking photosynthesis). Sooty mold is a black, non-parasitic fungus that accumulates and grows on the sweet honeydew (a waste product) produced by the whiteflies during their feeding on noni plant sap.

Distribution The spiraling whitefly is native to Central America and the Caribbean region. It is widespread throughout the Pacific and tropics, and is most abundant in coastal areas and elevations below 1000 ft (300 m).

Host range The spiraling whitefly has a relatively wide host range, having been recorded on 38 genera of plants and more than 100 plant species. The pest attacks many vegetable, ornamental, fruit and shade



Symptoms of whitefly damage on the upper leaf surface (left) and lower leaf surface (right). PHOTOS: S. NELSON

tree crops. Specific plants that are attacked include cherimoya, atemoya, sugar apple, avocado, kava, banana, bird-of-paradise, breadfruit, citrus, coconut, eggplant, guava, beauty leaf, Indian banyan, macadamia, mango, palm, paperbark, papaya, pepper, pikake, plumeria, poinsettia, rose, sea grape, ti, and tropical almond.

Control

- Foliar applications of insecticidal soaps and oils.
- Manual detachment and removal of heavily infested leaves.
- Canopy management (thinning).
- Weed control (removes potential alternate hosts).
- Avoidance (avoid introducing infested plants into your nursery or farm).

Natural enemies Several natural enemies of this whitefly exist depending on location.

Yeasts

Damage potential can be a significant postharvest fruit decay problem leading to problems with juice quality.

Pathogen/organism Any of a number of species of yeasts (which are fungi).

Symptoms Yeast covered rot of fruits

Impact If these fungi get into noni juicing containers, they can develop, ruining the juice. Yeasts can

produce alcohol and off flavors in noni juice, which can cause the juice to be rejected by the buyer.

Distribution Yeasts are ubiquitous. They have a very wide host range and are able to cause postharvest decay diseases of a great number of crops.

Epidemiology Yeasts are spread by splashing water and wind and by humans. Infection is favored by wet conditions and wounded fruits and sometimes by the presence of air in the juicing container.

Control

- Pick fruits at the correct stage (hard white) and wash them with soap and water promptly and dry them.
- Avoid picking up fruits from the ground.
- Keep a clean harvest or juicing facility; sterilize equipment after use.
- Avoid wounding fruits after harvest.
- Other postharvest control measures used for other crops would probably work for noni as well.
- Exclude air from the juicing container if possible, or cover fruits with liquid inside the container.

Beneficial organisms

There are many lady beetle species associated with noni. Lady beetles feed on aphids and other soft-bodied insects. Aphid lions and spiders also prey upon some noni pests. Bees help to pollinate noni flowers, producing fertile seeds. Tiny, parasitic wasps attack

and kill leaf miners and other insects. Entomopathogenic fungi are biological control fungi which can parasitize and kill some soft-bodied insect species. For example, the fungus *Verticillium lecanii* occurs naturally in the tropics and is an effective pathogen of some whiteflies. Growers should be aware that

insecticides can reduce the population of beneficial insects and fungicides can reduce populations of beneficial fungi. Excessive or unnecessary use of these pesticides can lead to more harm than good by eliminating the beneficial organisms.



Clockwise from top left: Bees are ever-present pollinators of noni; Lady beetles eat aphids, and the ants that protect the aphids cannot fight off the lady beetle adults; Green anoles eat insects in the noni canopy; These green scale insects (*Coccus viridis*) have been killed by a naturally occurring fungus, *Verticillium lecanii*. PHOTOS: S. NELSON, C. ELEVITCH (TOP LEFT)

Pest and disease summary

Pest or disease	Classification & scientific name of causal agent	Plant organs attacked (•) and/or symptomatic (-)						
		Roots	Woody stem	Green stem	Peti-oles	Leaves	Fruits	Flowers
Algal leaf spot	Algae (<i>Cephaleuros minimus</i>)					•		
Anthracnose	Fungus (<i>Colletotrichum gloeosporioides</i> / <i>Glomerella cingulata</i>)					•		
Aphids	Insect (citrus aphid [<i>Toxoptera citricida</i>] and melon aphid [<i>Aphis gossypii</i>])				•	•		
Beetles	Insect (sourcing beetles, <i>Lasiodactylus tibialis</i>)						•	
Black flag	Fungus-like organism (<i>Phytophthora</i> sp.)			•	•	•	•	•
Caterpillar	Insect (croton caterpillar <i>Achaea janata</i>)					•		
Fruit crack-ing	Abiotic physiological disorder						•	
Grazing injury	Mammal (ruminant) Cattle, horses			•	•	•	•	•
Leaf miner	Insect (unidentified species)					•		
Mites	Insect (broad mites [<i>Polyphagotarsonemus latus</i>], eriophyid mites [<i>unidentified species</i>])					•		
Mealybugs	Insect (unidentified species)					•	•	
Nutrient def.	Abiotic disease; not caused by living organism.					- chlorosis		
Parasitic weeds	Plants <i>Cassytha filiformis</i> , <i>Cuscuta</i> sp. (dodder)		•	•	•	•	•	
Premature or uneven ripening	Abiotic physiological disorders						•	
Rhizopus rot	Fungus (<i>Rhizopus</i> spp.)						•	
Rodents and birds	Mammals, birds (several species)						•	
Root knot	Nematode (<i>Meloidogyne</i> spp., the root-knot nematodes)	•	- cracking			- yellowing		
Scale	Insect (green scale, <i>Coccus viridis</i>)			•	•	•	•	
Shot hole	Fungus (<i>Guignardia citricarpa</i>)					•		
Slugs & Snails	Mollusks (several species)					•		
Sooty mold	Fungus (several species)			•	•	•	•	
Stem rot	Fungus (<i>Athelia rolfsii</i>)		•			- yellowing		
Tafia gata	Fungus (unidentified species)					•		
Thrips	Insect (greenhouse thrips, <i>Heliethrips haemorrhoidalis</i>)					•		
Whiteflies	Insect (Kirkaldy whitefly [<i>Dialeurodes kirkaldyi</i>], spiraling whitefly [<i>Aleurodicus dispersus</i>])					•		
Yeasts	Fungus (<i>many species</i>)							•

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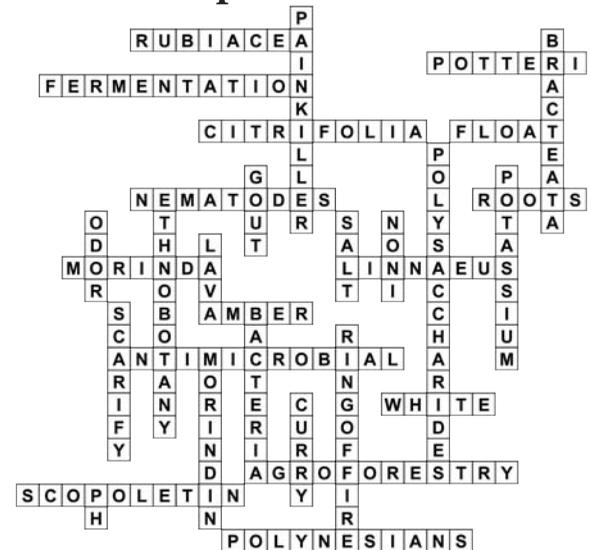
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Crossword puzzle solution



“*Noni: The Complete Guide* is clearly written, accessible, and informative. This book belongs in the personal libraries of individuals interested in consuming and/or growing noni.”

—Dr. Nina L. Etkin, Department of Anthropology, Pacific Center for Infectious Diseases—
Medical School, and Associate Editor, *Pharmaceutical Biology*, University of Hawai‘i

“The information is well researched and up-to-date. This book is an essential reference for those involved in noni cultivation, health care professionals, and consumers who want to learn more about noni.”

—Helen Russell, President, Pacific Island Noni Association (PINA)
and Director, Tree of Health Pty Ltd

This book shows you

- how to get the best value in noni products
- what you need to know to make noni-related nutrition decisions
- how to make your own noni juice
- the recent discoveries about noni chemistry
- the history and origins of noni in the Pacific
- where and how to grow noni trees
- about prevention and control of horticultural pests and diseases
- where to find noni trees when traveling in the Pacific
- recipes that incorporate noni
- noni first aid tips
- how to have fun with noni!



Scot C. Nelson, PhD works in Hawai‘i as a university botanist and plant pathologist, where he is involved in noni research and education. He began his work with noni in 1998 and since then has conducted several noni workshops in the Pacific, authored a number of horticultural and botanical reference articles about noni, and produced the popular Noni Website. Scot has served

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Craig R. Elevitch is an agroforestry specialist based in Hawai‘i with 16 years experience in design, management, and education in agroforestry. His work focuses on multipurpose trees that have economic, environmental, and cultural significance. Craig is editor of *Traditional Trees of Pacific Islands: Their Culture, Environment, and Use* (2006), *The Overstory Book: Cultivating Connections with Trees* (2004), and co-author of *Growing Koa: A Hawaiian Legacy Tree* (2003).



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