South Pacific Indigenous Nuts

Proceedings of a workshop 31 October – 4 November 1994
Le Lagon Resort, Port Vila, Vanuatu

Editors: M. L. Stevens, R. M. Bourke and B. R. Evans

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Introduction

Barry Evans*, R. Michael Bourke† and Paul Ferrar‡

A FIVE-DAY workshop on South Pacific indigenous nuts was held in Port Vila, Vanuatu, in October–November 1994. The workshop provided the first opportunity to bring together the growing number of people from a diverse range of disciplines and countries who are associated with the development of indigenous nuts in the region. This publication brings together most of the papers presented at the workshop plus a few additional papers. Twenty-two papers are presented on a wide range of issues associated with the production, processing and marketing of indigenous nuts (Parts I to III). These papers cover primarily the genera *Canarium*, *Barringtonia*, *Terminalia*, *Inocarpus* and *Pandanus*. Workshop discussions are summarised in Part IV as country priorities for research and development, and a compiled bibliography is presented in Part V.

The Traditional Importance of Indigenous Nuts in the South Pacific

Indigenous nuts are an integral part of the complex arboricultural, agricultural and sociobiological systems that have evolved to suit the diverse biophysical conditions of the South Pacific islands. Selection, conservation, cultivation and exchange of superior cultivars over thousands of years by Pacific Islanders has produced a wide range of indigenous nut morphotypes, a unique wealth of ethnobotanical knowledge, and strong cultural and spiritual affinities with the crops. Despite the introduction of exotics and a corresponding change in diets, indigenous nuts remain a seasonally important part of rural people's diet.

Contemporary Interest in Indigenous Nuts

Recent interest in the commercial development of indigenous nuts has developed for a number of diverse but interrelated reasons. South Pacific countries are experiencing rapid growth in population, urbanisation and youth unemployment. Overseas aid is diminishing in real terms and the shift to a cash economy has increased the demand for imported consumer goods. To tackle these problems, governments need to increase revenue from exports and provide rural income-earning opportunities. However, commodity prices and export revenue from established cash crops such as copra and cocoa have steadily decreased over the past 20 years through competition from other crops and increased supply from other countries. Governments are therefore keen to diversify their agricultural production to high-value, low-volume crops with little overseas competition. The introduction of many new exotics has been technically and managerially problematic and there is now a growing awareness of the commercial potential of indigenous species such as nuts. At the same time, governments in western Melanesia have supported a dramatic expansion in industrial logging since the late 1980s to provide short-term revenue. Aside from the controversy and concerns about the sociological and environmental effects of this logging, there is growing domestic and international concern over the effects of logging on the current and future production of non-timber forest products such as many of the indigenous nuts found in the region. This has

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hastened the need to attach an economic value to these products by developing them commercially, both to provide an alternative to logging and to support their conservation.

Commercial Activity

Commercial processing and marketing of *Canarium indicum* and *C. harveyi* (known locally as ngali nut) began in Solomon Islands in 1989. This stimulated commercial development of the same two species (nangai) in Vanuatu in 1991, as well as *Terminalia catappa* (natapoa) and edible *Barringtonia* spp. (navele). This was followed by *Terminalia kaernbachii* (okari) and *Canarium indicum* (galip) in Papua New Guinea in 1993 and 1994 respectively.

In all three Melanesian countries, commercialisation of indigenous nuts is in a very early stage of development, the industries are still very small, and they are being run under diverse managerial arrangements. In PNG, a rural development project in West New Britain funded by Australian aid has built a processing unit and has started to buy and sell nuts locally. In Solomon Islands, development is controlled by government departments and the Commodity Export Marketing Authority in Honiara. And in Vanuatu, commercial development is promoted and run by a private businessman in Port Vila. Each country and managerial model has faced unique problems (and opportunities), but many more are shared and a need exists to exchange information and experiences.

South Pacific Indigenous Nuts Workshop

Early in 1994, the USAID-funded Commercial Agriculture Development (CAD) Project, which had sponsored work on the development of a mechanical cracker for *Canarium*, proposed a regional Pacific workshop on marketing tropical nuts and spices. After discussions with Barry Evans, then a Visitor at the Botany Department at the University of Queensland, CAD agreed to focus the workshop on South Pacific indigenous nuts and expand the scope to include aspects of production and processing. The workshop was organised by Michael Brown (CAD, Apia, Western Samoa), Barry Evans and Mike Bourke (Australian National University, Canberra) with contributions from John Kreag (CAD, Suva) and Paul Ferrar (Australian Centre for International Agricultural Research (ACIAR), Canberra). Funding was provided by USAID, IRETA (the Institute for Research, Extension and Training in Agriculture at the University of the South Pacific, Alafua campus, Western Samoa), ACIAR and AusAID.

The workshop was held in October–November in Port Vila, Vanuatu, and was attended by some 40 people of diverse interests and backgrounds from 10 countries (see list of participants). There was lively discussion throughout the workshop and a number of experienced conference participants commented that this was one of the most enthusiastic gatherings they had attended.

The workshop considered a number of important questions:

- Which species of nuts could be exploited commercially?
- From what sources can they be obtained?
- Would there be any negative consequences from such exploitation, either socially or environmentally?
- What types of commercial product could be obtained from the indigenous nuts?
- Who would be likely to buy the nuts and associated products, and in what forms?
- What processing is needed to harvest, prepare, preserve and pack the products?
- What is the best way to organise production and marketing?

The workshop papers and discussions brought together here address many of these questions, including prehistoric and recent usage of indigenous nuts by villagers, distribution, production, sustainability, processing and marketing. Two papers outline experience outside the region with *Canarium ovatum* (pili nut) in the Philippines and macadamia worldwide. The report is divided into five parts.

Part I: Overview of the Resources

The papers in this part provide an historical, geographical, developmental and resource overview of indigenous nuts in the South Pacific. Barry Evans presents the type and size of the natural

resource available for commercial development in the region, and Doug Yen discusses its historical and biogeographical context. The paper by Mike Bourke and the paper by Annie Walter and Chanel Sam give details of indigenous nuts in Papua New Guinea and Vanuatu respectively. Finally, Barry Evans summarises the problems facing the embryonic industries as a precursor to further discussion and country priorities (see Part IV).

Part II: Developments in the Region

Papers in this part give the experiences of the people and organisations currently involved with the development of South Pacific indigenous nuts. The papers by Pitakia Pelomo and Ted London describe very different approaches to the development of canarium nut in Solomon Islands. Charles Long Wah's paper describes his commercial experience in Vanuatu with a range of nuts. Papers by Max Henderson, David Wissink, Damien Ase, Micael Olsson and Ken Houghton describe projects to develop canarium nut and okari nut in PNG. The latter three authors offer different perspectives of the same okari nut project: producer organisation, non-government organisation (NGO) donor-collaborator and wholesaler-retailer.

All these papers clearly show that development of culturally important, non-timber forest products such as indigenous nuts requires a multidisciplinary approach.

Part III: Aspects of Developing the Resource

This part, which is divided into four sections, looks at the current work to develop techniques for improving the production, processing and marketing of indigenous nuts in the region, and examines the lessons learned from elsewhere in the world in developing similar commodities.

The papers by Will Akus, Noel Roposi and Semion Iputu, in the first section, describe current research and development work at government-run agriculture and forestry stations. All three papers emphasise the lack of systematic research on indigenous nuts and stress the need to look ahead.

In the next section, Mary Maima looks at current processing systems and problems and stresses the need for comprehensive trials. Loren Gautz reports on the design and testing of electric and hand-powered mechanical crackers.

John Kreag and Michael Brown discuss opportunities for marketing in the third section. Kreag recommends management structures and models for producer organisations in the embryonic industry. Brown describes the marketing potential of indigenous nuts in the rapidly growing tourist industry in the South Pacific. Both authors stress the important need for market-driven development of the industry.

Finally, Roberto Coronel's paper describes the Philippine experience with the closely related pili nut, and Andrew McGregor's paper on macadamia nut provides some lessons on another nut tree species that has been commercialised relatively recently.

Part IV: Country Priorities for Research and Development

At the end of the workshop, participants from the South Pacific countries were asked to discuss their priorities for future research and development on nuts and nut industries. The discussions of the production, processing and marketing working groups and the research and development priorities of the country groups are summarised by Paul Ferrar in Part IV. These decisions were made by people based in the Pacific island countries and are designed to steer their own work and guide potential donors.

Part V: Bibliography

A bibliography of indigenous nuts in the South Pacific by Annie Walter, Barry Evans and Mike Bourke and compiled by Patty Hobsbawn constitutes the fifth and final section of this report.

The Future

This publication represents a snapshot of the birth of an industry: an industry based on natural, indigenous, traditional and potentially sustainable forest resources in the South Pacific. The sustainable development of non-timber forest products, such as indigenous nuts, is a comparatively new science. As interest grows in developing similar resources, such as wild fruits and fungi,

for example, it will be important that the lessons learned so far for indigenous nuts not be lost. We hope that this publication will serve as a case study and will guide the future of the industry by recording its history, mistakes and opportunities.

Tapes

Audiotape and videotape recordings of the workshop were made and can be obtained direct from IRETA, University of the South Pacific, Alafua Campus, Apia, Western Samoa.

Part I: Overview of the Resources

Overview of Resource Potential for Indigenous Nut Production in the South Pacific

Barry Evans*

THESE Proceedings are testimony to the current interest in developing indigenous nuts in the South Pacific region. The development of non-timber forest products, such as indigenous nuts, holds the promise of combining monetary income, conservation and sustainable rural development. PNG, Solomon Islands and Vanuatu have already begun commercialisation of some nuts based on existing production from wild and traditionally cultivated trees. And interest in further development of other nuts is high. But what is the capacity of the existing resource? Will it withstand commercialisation? Is it sustainable?

The aim of this paper is to provide background information on the status, potential and current production of indigenous nuts in the South Pacific region. For each genus of nut with significant economic potential, an outline is given of its economic species, economic and marketing characteristics, distribution, seasonality, potential and current production levels, and resource capacity and sustainability. The paper concentrates on canarium nut as it is the focus for most current commercial development. More detailed information from South Pacific countries, including greater detail on some of the taxa, is given in other papers in these Proceedings.

Before going into details of South Pacific indigenous nuts I would like to prescribe a standard terminology for their description. This will help minimise confusion and enhance meaningful comparisons between the papers in these Proceedings and perhaps set standards for the embryonic industry.

Table 1 summarises the suggested standard terminology for indigenous nuts in the South Pacific. The kernel-to-nut (K:N) ratio is the best measure of overall nut-in-shell (NIS) quality. It encompasses NIS and kernel-in-testa (KIT) weight and moisture content and allows meaningful comparison of different batches, cultivars, varieties and species of nuts independent of size. The K:N ratio has a critical effect on the profitability of commercial production by lowering unit kernel purchase costs (Fig. 1) and raising the productivity of cracking NIS (Evans 1991b).

South Pacific Indigenous Nuts

Based on work by myself and others, and to focus attention on economics, I have split the indigenous nuts of the South Pacific into two groups: those with traditional importance and significant commercial potential (group 1; Table 2) and those with traditional importance or possible commercial potential (group 2; Table 3).

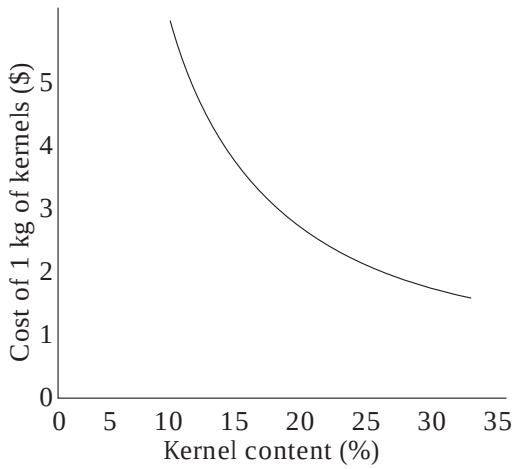

Figure 1. The effect of kernel content on the real purchase cost of kernels-in-testa at a constant nut-in-shell buying price. As kernel content (K:N ratio) increases, the unit cost of kernels decreases

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Table 1. Glossary of nut terminology

Fruit	The outer skin (exocarp) and flesh (mesocarp), the nut-in-shell and the kernel-in-testa
Nut-in-shell (NIS)	The shell (endocarp) and kernel-in-testa.
Kernel-in-testa (KIT)	The edible kernel (seed) and testa.
Testa	The skin surrounding the kernel
K:N ratio	The percentage of nut-in-shell that is kernel-in-testa, sometimes known as the 'kernel content' = weight of dry kernel-in-testa ÷ weight of dry nut-in-shell × 100%
Kernel oil	The oil pressed from the kernel
Kernel cake	The residue after oil extraction

Table 2. South Pacific indigenous nuts with significant commercial potential

Genus	Main species	Abbrev.	Standard common name	Common, pidgin or vernacular name			
				PNG	Solomon Is.	Vanuatu	Fiji
Canarium	*indicum*	CANIND	canarium nut	galip	ngali	nangai	—
	salomonense	CANSAL	canarium nut	—[1]	adoa/bush ngali	—	—
	harveyi	CANHAR	canarium nut	—	Santa Cruz ngali	nangai	kauningai
Barringtonia	*procera*	BARPRO	cut nut	pau	cutnut	navele	
	edulis	BAREDU	cut nut	pau	cutnut	navele	vutu kana
	novae-hiberniae	BARNOV	cut nut	pau	bush/wild cut nut	navele	
Terminalia	*catappa*	TERCAT	sea almond	talis	alite	natapoa	tavole
	kaernbachii	TERKAE	okari	okari	bush alite	—	—
Inocarpus	*fagifer*	INOFAG	Polynesian chestnut	aila	ailali	namambe	ivi
Pandanus	*julianetti*	PANJUL	pandanus nut	karuka	—	—	—
	brosimos	PANBRO	pandanus nut	wild karuka	—	—	—
	dubius	PANDUB	pandanus nut		screw pine	panadanas	fala

— known not to occur

1. Bougainville Island only

Source: Smith (1979, 1985), Henty (1982), French (1986), Henderson and Hancock (1988), Carlos and Dawes (1990), Evans (1991a), Walter, Sam and Mabonlala (1993), Bourke (pers. comm.)

The word potential is emphasised. Although several nuts (particularly in group 1) are being commercially developed, none has yet become an established commodity.

Group 1: Nuts with traditional importance and significant commercial potential

Nuts in this group are discussed in much greater detail in the following sections, but it is worth outlining some of their characteristics here. The group contains 12 species of nuts from five genera (Table 2). For commercial and marketing purposes the 12 species can be condensed into six commodities. These have been given carefully chosen standard common names (by myself and my colleagues Mike Bourke and Annie Walter): canarium nut, cut nut, sea almond, okari nut, Polynesian chestnut and pandanus nut.

None of the nuts in group 1 is botanically classed as a nut (defined as a 'hard, indehiscent, one-seeded fruit'), but all are commonly referred to as nuts. The list notably excludes three candidates: betel nut, the kernel from the *Areca catechu* palm, which is chewed with lime as a mild stimulant in PNG and Solomon Islands; breadfruit (*Artocarpus altilis*), whose segments are often referred to as nuts, but considered here as a
staple; and the ubiquitous coconut (*Cocos nucifera*), which is well covered elsewhere.

Group 2: Nuts with traditional importance or possible commercial potential

The list of nuts shown in Table 3 is not exhaustive. There are probably more than 50 (non-botanical) 'nuts' found in the South Pacific and many regionally important types are missing, but I have tried to cover the important taxa and those with possible commercial potential. Some of the nuts in this group are covered in other papers in these Proceedings. The group includes some nuts, such as candle nut and kauri pine, which are well known in and outside the region, and others, such as lotus nut in PNG, which are of local importance only.

The listing of common, pidgin and common vernacular names is incomplete and I would welcome comments and additions.

Canarium Nut (*Canarium* spp.)

Why *Canarium* nuts?

Before describing *Canarium* in detail it is worth highlighting some of the main reasons why the tree and its nuts are seen as such a strong prospect for commercial development.

- The kernels have a unique delicate taste.
- The NIS has a hard, non-perishable shell, which protects the kernel from verminand pathogens.
- The tree is widely distributed throughout Melanesia.
- The trees have been cultivated for thousands of years in Melanesia and hence are well integrated into existing agricultural systems.
- Cultivation has produced a wide variety of cultivars with inherent pest and disease resistance. This should provide a sound basis for a modern systematic breeding program.
- The trees are multipurpose:
  - —they form part of existing multilayered arboricultural systems
  - —the shells can be used for fuel wood, charcoal and jewellery
  - —the kernel oil can be used for cooking and cosmetics
  - —the oleoresin can be burnt for lighting and incense or used to caulk boats
  - —the mesocarp can be eaten, used as fertiliser or fed to animals.

In fact, the commercial potential of canarium nut was recognised many years ago, but it has taken a inexcusably long time for action to be taken.

Economic species

There are more than 50 species of *Canarium* (Burseraceae), spread from West Africa to Polynesia (Leenhouts 1959). The trees are dioecious, but some cultivated species have become polygamodioecious (male and female flowers on separate trees plus variable ratios of hermaphrodite flowers on both) (Evans 1991a). The geographical centre of their genetic diversity is the Molucca Islands of eastern Indonesia, but their centre of cultivated diversity is undoubtedly western Melanesia. Twenty to 25 species are

Table 3. South Pacific indigenous nuts with traditional or possible commercial potential

Genus	Main species	Abbrev.	Standard common name	Common, pidgin or vernacular name				Comments
				PNG	Solomon Is.	Vanuatu	Fiji	
Agathis	spp.	AGA	kauri pine nut					overexploited as timber crop; regional significance only
Aleurites	*moluccana*	ALEMOL	candle nut			kandel	sikeki	mostly used for oil; can be eaten after cooking
Castanopsis	*acuminatissima*	CASACC	PNG oak					sometimes cooked before eating. PNG only?
Castano-spermum	*australe*	CASAUS	Moreton Bay chestnut			bean tree		must be soaked and cooked before eating
Cycas	spp.	CYC	cycad			namwela		must be soaked for a long time before eating
Elaeocarpus	spp.	ELA			ai enda			some forest spp. eaten
Finschia	*chloroxantha*	FINCHL	finschia nut		akama			close relative of macadamia
Gnetum	*gnemon*	GNEGNE	gnetum nut	tulip	dae/king tree			cultivated in parts
Heritiera	*littoralis*	HERLIT			one one			common on seashore; some records of it being eaten
Neisosperma	*oppositifolia*	NEIOPP						seashore; small kernel
Nelumbo	*nucifera*	NELNUC	lotus nut			—		PNG; freshwater only
Omphalea	*queenslandiae*	OMPQUE			kwalo falake			woody climber; kernel needs processing
Pangium	*edule*	PANEDU	pangi	sis	falaka/ra			berry; important food in parts of PNG

— known not to occur
Source: French (1986), Henderson and Hancock (1988), Evans (1991a), Bourke (pers. comm.)

Table 4. Economic characteristics of edible *Canarium* nuts[1]

Species	NIS wt (g)	KIT wt (g)	K:N ratio (%)	Tree yield (kg NIS)	Tree yield (kg KIT)	Ease of opening NIS	Variation in NIS shape	Taste
C. indicum	12 (5–20)	2 (1–4)	17 (<10–27)	100 (50–300)	16 (5–81)	variable	v. high	?
C. salomonense	5 (4–6)	1 (0.5–1.5)	19 (<15–22)	25 (10–50)[2]	5 (2–11)	easy	low	?
C. harveyi	15 (12–21)	4 (2–6)	24 (20–32)	50 (25–75)	12 (5–25)	easy	medium	?

1. Most data taken from Solomon Islands (Evans 1991a). Figures are averages and (ranges)
2. Tree NIS and KIT yields for *C. salomonense* and *C. harveyi* are estimates only

found in the South Pacific, of which 21 are in PNG (Leenhouts 1959), eight in the Solomon Islands (Evans 1991a) and three or four in Vanuatu (Wheatley 1992). Probably all *Canarium* species produce edible kernels, but many are bitter and small. Commercial interest in the South Pacific is currently focused on three traditionally cultivated species: *C. indicum*, *C. salomonense* and *C. harveyi* (collectively called canarium nut).

C. indicum (Fig. A1) is closely related to three species (in the taxonomic group *vulgare*) that are semicommercialised in other countries: *C. vulgare* (kenari nut) in Indonesia, and *C. ovatum* (pili nut) and *C. luzonicum* (Manila elemi) in the Philippines. Pili and Manila elemi are discussed by Coronel elsewhere in these Proceedings.

C. salomonense and *C. harveyi* are closely related (in the taxonomic group *maluense*). Both species have a number of wild subspecies and varieties, the taxonomy of which is complicated and confused by cultivation. Commercial attention is focused on *C. salomonense* ssp. *salomonense* (Fig. A2) and *C. harveyi* var. *nova-hebridiense* (Fig. A3).

Two other species of *Canarium* are worth noting here. Little is known about the New Guinea natives *C. lamii* and *C. kaniense*, but both have very large NIS and kernels that are reputedly edible. (See the paper by Yen in these Proceedings for details of these last two species.)

Economic and marketing characteristics

The main economic characteristics of canarium nut in the South Pacific are shown in Table 4.

Variation in the morphology of the NIS of *C. indicum* var. *indicum* is very high. This is important commercially as it results in a wide range of K:N ratios, which necessitates the grading of NIS to balance the real cost of purchasing kernels (Fig. 1). Some cultivars found on Choiseul, Solomon Islands, have shells thin enough to break by conventional hand crackers (making them a candidate for Christmas nuts), plus a large kernel, and hence have a correspondingly high K:N ratio. Samples from commercial purchases in West New Britain suggest that the maximum K:N ratio in PNG could be much higher than the 27% recorded in Solomon Islands and Vanuatu (Evans, unpublished). Female flowered trees of *C. indicum* have very high yields; one tree in the Solomon Islands produced more than 300 kg of NIS in one season (Chaplin and Poa 1988).

Variation in the shape and size of the NIS of *C. salomonense* ssp. *salomonense* is very low, making it a good candidate for mechanical cracking. Although the species produces relatively small NIS, the K:N ratio is still quite high.

The NIS of *C. harveyi* var. *nova-hebridiense* is very large and easy to crack. The trees yield much fewer NIS than the other two species, but the very high K:N ratio might result in similar kernel yields.

Table 4 deliberately highlights the lack of any measure of taste, a characteristic of critical commercial importance. The Natural Resources Institute in the UK and Conservation International in the USA have carried out some taste tests, but to date there have been no comprehensive taste trials using fresh material from all three species prepared in a standard method. This is essential

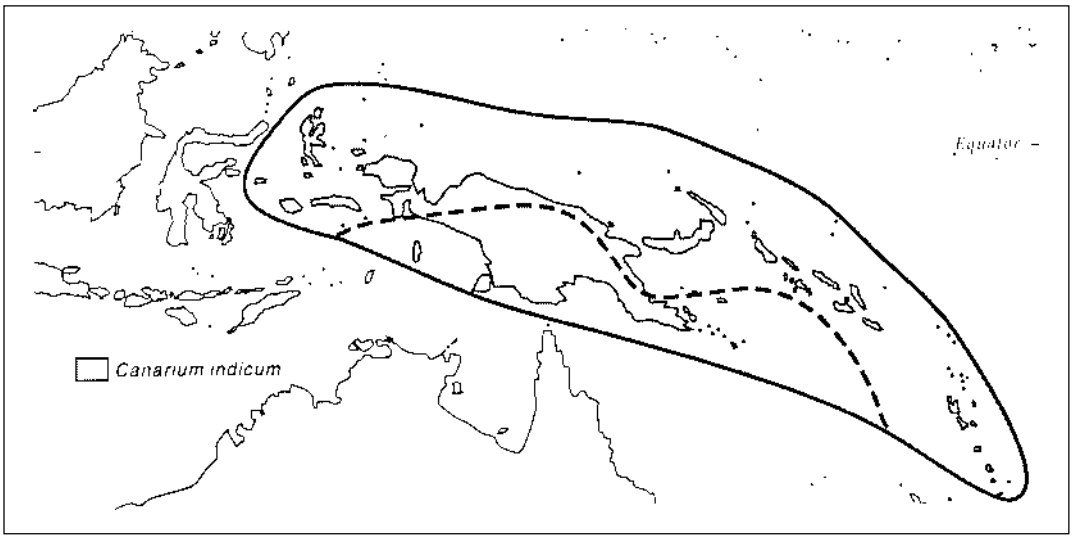

Figure 2. Distribution of *Canarium indicum* (adapted from Leenhouts 1959)

since the high oil content (> 70%) and soft texture of *Canarium* kernels makes them particularly sensitive to processing techniques. I have found people's opinions (especially those of first timers) on the taste of canarium nut to vary and to be sensitive to processing technique. Generally, the kernels of *C. salomonense* are deemed to be sweeter than the other two species and hence a higher price is paid for them in Solomon Islands. *C. harveyi* kernels are considered oily—probably a result of their different fatty acid composition as their total oil content is no higher (Evans 1991b). Like the shape of their NIS, the taste of *C. indicum* kernels differs enormously, from a virtually unpalatable bitter to a soft delicate coconut butter taste.

Distribution

Canarium is found throughout Melanesia as well as Tonga and Samoa, mostly below 500 m, and on all land systems except swamps and mangroves. Generally, smaller fruited species, which are propagated by birds and small animals, grow wild in densities ranging from 0.1 to 2.0 trees per hectare, but the larger fruited species are mainly planted. The large size and number of inland settlements that existed in Melanesia for thousands of years before European contact has led to clumpings of cultivated *Canarium* trees in and around those now abandoned sites. Near-monocrop densities as high as 100 trees per hectare can be found in some areas.

The distribution of *C. indicum* is wide (Fig. 2) and its boundary with *C. vulgare* (its close taxonomic relative) is blurred along its western boundary. Interestingly, it is absent from the Santa Cruz Islands of eastern Solomon Islands, but reappears further south east in Vanuatu. *C. harvey*i also has a wide distribution (Fig. 3), but the cultivated variety nova-hebridiense is confined to a low number of small islands where it is intensively selected. *C. salomonense* is an endemic of the geographic Solomon Islands (Bougainville to Makira), and has been found on a few New Guinea islands as well (Fig. 3).

Seasonality

The phenology of *Canarium* is determined by day length; trees in the lower latitudes of the South Pacific (PNG and western Solomons) flower and fruit earlier than those in the higher latitudes (eastern Solomons and Vanuatu). Fruits of *C. indicum* begin to mature as early as May in West New Britain, PNG (7°S), whereas those in central Vanuatu (17°S) begin to mature around October to December (Fig. 4). *C. harveyi* var. *nova-hebridiense* begins to mature around October to December. *C. salomonense* appears to fruit sightly earlier than *C. indicum* at the same latitude.

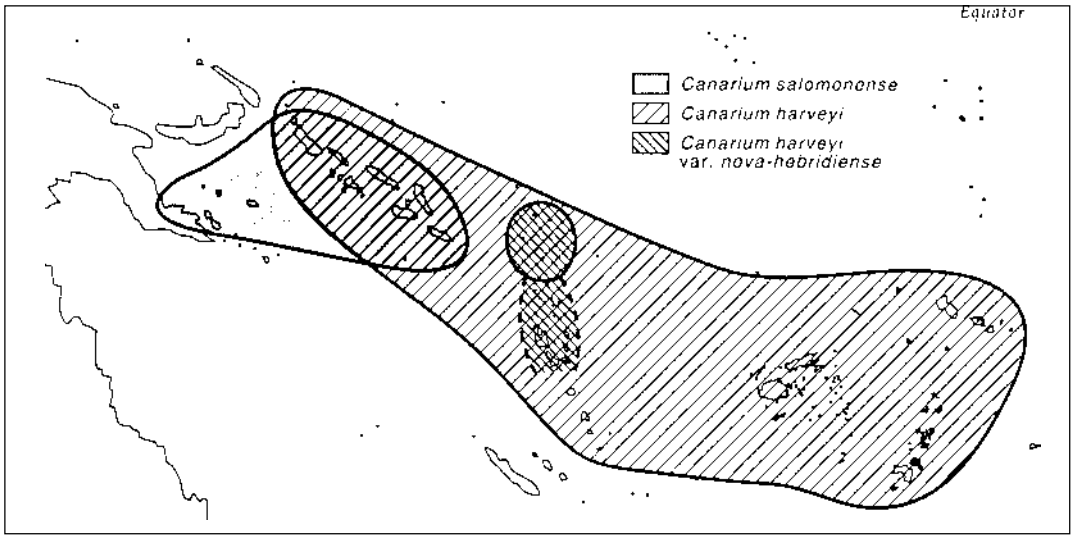

Figure 3. Distribution of *Canarium salomonense*, *C. harveyi* and *C. harveyi* var. *nova-hebridiense* (canarium nut)

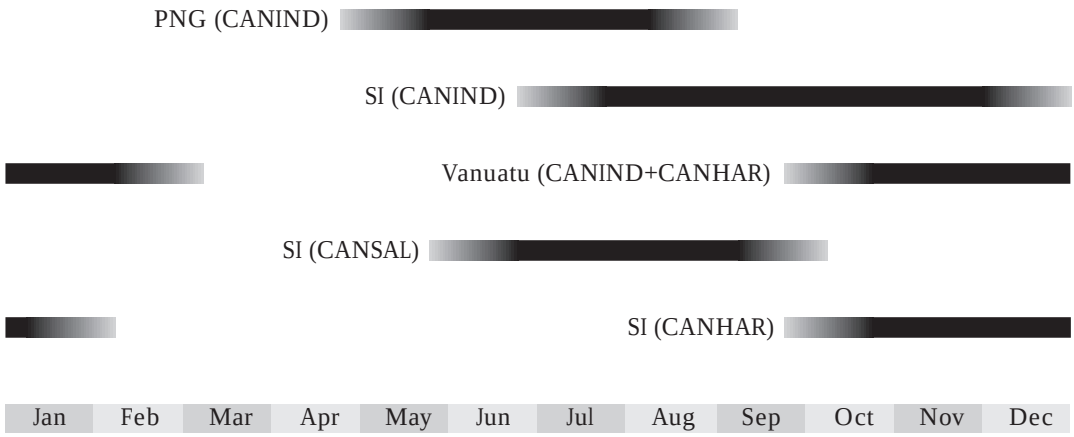

Figure 4. Flowering and fruiting peiods of *Canarium* species in Melanesia. Trees in the lower latitudes (PNG and western Solomons) flower and fruit earlier than those in the higher latitudes (eastern Solomons and Vanuatu)

The flowering period of *Canarium* is very brief—less than two weeks—and is followed by a long gestation of six to nine months.

The extended fruiting season of canarium nut throughout Melanesia means that the region can produce fresh canarium nuts for at least six months a year, with the potential for each country to fill seasonal niches without overtly competing against the others. Allowing for marketing lead times, PNG in particular is well placed to supply the Christmas period, when demand for nuts in Europe and the USA more than doubles.

Production

Total production of canarium nuts in western Melanesia is estimated to be more than 100 000 tonnes of NIS (= 16 000 t KIT @ 16% kernel content) a year from two million trees (Table 5). (Estimates of total production from natural resources are notoriously difficult but nonetheless important for aspiring industries. Canarium nut production is no exception, but the completion of forest resource inventories in Vanuatu and Solomon Islands now gives us a much clearer idea of tree numbers. The figures shown in

Table 5 are the first attempt to estimate the annual production of canarium nut in western Melanesia. In compiling the figures I have always erred to the conservative.) At current farm gate prices this is worth US$25m annually as dried NIS (US $0.20 to $0.37/kg) and a minimum of US$50m (using a conservative price of US$3.00/kg) as value-added processed kernels (cf. current value of macadamia nuts, US$10/kg, Brazil nuts, US$3.70/kg, and cashew nuts, US$5.90/kg). In comparison, total world production of plantation-based macadamia and natural Brazil nut kernels is currently 7000 t and 26 000 t p.a. respectively.

Because of the remoteness of trees, the steep and difficult terrain, low population densities and poor infrastructure in western Melanesia, however, perhaps only 10% of total production is accessible for commercial harvesting. Nevertheless, after these allowances and using conservative figures, total accessible production is estimated to be 1600 t kernels a year, worth nearly US$5m.

These figures are not unrealistic. To put them in perspective, the total accessible annual production from ‘natural’ trees could be produced by a plantation of just 2000 ha of mature *C. indicum* (@10 t NIS/ha, 100 trees/ha and 50 kg of NIS per tree).

Production does not, however, equal supply—especially in imperfect rural Melanesian markets. The supply of canarium nuts, like any other agricultural commodity, will be a function of the normal array of factors, such as price, access to and knowledge of the market, opportunity cost of labour, and less tangible constraints such as the strong cultural values attached to canarium nuts. These latter constraints should not be underestimated.

Current supply

Purchasing of canarium nuts began in Solomon Islands in 1989, in Vanuatu in 1990 and in PNG in 1994. In Solomon Islands, where nuts are bought at eight copra buying centres scattered around the country, supply was more than 200 t of NIS in 1992 (Table 6), but has since declined because the Commodity Export Marketing Authority (CEMA) has ceased buying *C. indicum*. In Vanuatu, where supply has ranged from 2 to

Table 5. Estimated annual production of edible *Canarium* nuts in western Melanesia

Country	Total lowland forest area (million ha)	Area with *Canarium* (million ha)	Average density of edible *Canarium* trees/ha	Total number of edible *Canarium* trees (million trees)	Total NIS production (@50kg /tree/yr) (t)	Total KIT production (@15%) (t)	Current farm gate NIS buying price (US$/kg)	Total revenue (US$m) (at farm gate)	
								NIS	KIT (@$3/kg)
PNG	23.0	6.0[1]	0.2[2]	1.0	48 000	7 200	0.20	9.6	21.6
Solomon Is	2.0	1.8	0.5[3]	0.9	45 000	6 750	0.22	9.9	20.3
Vanuatu	0.4	0.3	1.0[4]	0.3	15 000	2 250	0.37	5.6	6.8
Total	25.4	8.1	1.7	2.2	108 000	16 200		25.1	48.6

All figures rounded to one decimal place 1. North coast of New Guinea, New Britain, New Ireland and Bougainville 2. Evans (1994)
3. Forest inventories found edible *Canarium* densities of 0 to 1.1 (av. 0.76) trees/ha (> 60 cm) (SIG 1992–1994)
4. Sample transect inventories have found densities from 1 to 87 *Canarium* trees/ha (Walter pers. comm.)
Source for total lowland forest area: PNG: IUCN (1991); Vanuatu: Tacconi and Bennett (1993); Solomon Islands: SIG (1992–94); plus Barden (1993)

Table 6. Commercial supply (t of NIS) of edible *Canarium* nuts in western Melanesia

Country	1989	1990	1991	1992	1993	1994
PNG						30.0
Solomon Is.	3.5[1]	2.6[2]	45.8	205.2	7.2[3]	
Vanuatu[4]		2.4	10.6	5.5	15.1	28.8
Total	3.5	5.0	56.3	210.8	22.3	58.8

1. Oct–Dec only
2. July–Dec only
3. Purchasing of nuts stopped
4. Production in Vanuatu bridges calendar year i.e. Oct–Mar
Source: Evans (1991b), Pelomo (1993), Long Wah (pers. comm.), Wissink (pers. comm.)

30 t NIS a year, nuts are bought by a single private business in Port Vila (see the paper by Long Wah in these Proceedings). The situation in PNG is different again. There, an Australian-funded, regional development project started to buy nuts at two to four existing trade stores in the Kandrian and Gloucester Districts of West New Britain. Nevertheless, supply reached 30 tonnes of NIS in the first year of operation. Assuming that CEMA resumes buying all nuts in Solomon Islands, we can expect total supply in the region in 1995 to approach 500 t of NIS— approximately 75 t of KIT.

Resource capacity and sustainability

Existing supply in western Melanesia is less than 5% of estimated total accessible production and less than 1% of estimated total production. Assuming a consumption of 1 kg KIT per person per year, current rural demand for NIS is estimated to be a maximum of 10 000 t of NIS a year. These deliberately cautious estimates (minimising production, maximising demand) still indicate a production surplus of 800 t NIS a year (120 t KIT) from accessible trees in western Melanesia, and 90 000 t NIS (13 500 t KIT) from total production.

The ecological potential for sustainable management of natural products is a function of their botanical characteristics, life strategy, productivity and population structure (Peters 1994). Overall, the potential of *Canarium* is high (Table 7) because of its high yields and easily dispersed fruits. But other factors, such as its low tree density, recalcitrant seed and poorly understood reproductive biology, will require good management practices (for example, selection and research) to ensure sustainability.

Finally, it is worth reiterating that production of canarium nuts in the short to medium term depends on existing stands of wild and semi-cultivated trees in western Melanesia. This area is currently facing an unprecedented logging boom. The effect of the logging on canarium nut (and other non-timber forest products) is unquantified. In most cases, *Canarium* is listed as a protected species, but the trees are still being cut for their premium timber. (An indication of the desperation for raw logs is demonstrated by the fact that in classical timber manuals *Canarium* wood is considered second-rate but, with the world supply of tropical timbers disappearing, *Canarium* now attracts a premium.) Clearly, with a potential value of US$25 per tree per year from kernels alone, it is important that the trees should not be cut for their monetary value alone. One possible benefit from sustainable logging is that access to more remote *Canarium* trees could be improved. Providing, of course, they are left standing.

Cut Nut (*Barringtonia* spp.)

Why cut nut?

- Widely distributed throughout the south west Pacific
- Very common cultivated tree in coastal villages
- Easy to cultivate
- Good ‘nutty’ taste when processed

Table 7. Overall management potential of *Canarium* based upon botanical characteristics

Feature		Potential for sustainable management*
Resource group		resins, fruits, seeds (1)
	Yield/plant	high (2)
Species characteristics:		
	Flowers	small, many (2)
	Fruits	small, many (2)
	Seed germination	intermediate (1)
	Sprouting capability	low (1)
Population structure:		
	Size–class distribution	type I curve (2)
	Tree density/hectare	0–5 adults (0)
	Spatial distribution	clumped (1)
Regeneration guild		primary (2)
Flower and fruit phenology		annual (2)
Reproductive biology:		
	Pollination	biotic, with generalist vector (1)
	Pollinator abundance	unknown (0)
	Seed dispersal	biotic, with generalist vector
	Disperser abundance	common: pigeons, bats etc. (2)
Total points		20 (high ecological potential for sustainable management)

* 0 = low, 1 = medium, 2 = high
Adapted from Peters (1994)

- Long shelf-life after processing
- Comparatively low oil content.

Economic species

Barringtonia belongs to the diverse family Lecythidaceae, which also contains Brazil nut. There are some 40 species around the world, with about 10 species found in the Pacific (Payens 1967). The herbarium-based taxonomy of *Barringtonia* has restricted use in the field, but for now is used to name three species of economic importance: *B. procera, B. edulis* (Fig. A4) and *B. novae-hiberniae* (collectively known as cut nut).

Economic and marketing characteristics

Cut nuts have large inter- and intraspecies variation (Table 8). *B. procera* is more fecund than the other two species. It has generally smaller fruits but a higher K:N ratio, resulting in higher kernel production per tree. The colour of the fruit, endocarp and testa (see Table 1 for glossary of terms) of cut nut is particularly variable, giving 12 distinguishable cultivars in PNG (Jebb 1992), 15 in Solomon Islands (Evans 1991a) and more than 10 in Vanuatu (Walter et al. 1993), but these differences appear to have no correlation with taste. Cut nut has a very high moisture content when fresh, necessitating quick, effective and

Table 8. Economic characteristics of edible *Barringtonia* nuts

Species	Fruit wt (g)	KIT wt (g)	K:N ratio (%)	Est. tree yield (kg fruit)	Est. tree yield (kg KIT)	Ease of opening fruit	Variation in fruit shape
B. procera	61	5.5	9.0	10–50	1–5	easy	medium
B. edulis	99	5.0	4.5	10–50	0.5– 2.5	easy	medium
B. novae-hiberniae	91	3.7	3.9	10–50	0.5– 2.0	easy	medium

Most data taken from Solomon Islands (Evans 1991a)

standardised processing for marketing.

Distribution

Cut nut is cultivated in and around coastal villages, and is frequently found growing semiwild in near-coastal disturbed forest. The larger tree of *B. novae-hiberniae* is also sometimes found growing wild in primary forest. All three species are found in PNG, Solomon Islands and Vanuatu. *B. edulis* extends eastwards to Fiji (Fig. 5) and possibly further.

Seasonality

Cut nut trees fruit irregularly two or three times a year at lower latitudes (PNG and Solomon Islands) and once or twice a year more regularly further south in Vanuatu and Fiji.

Production

It is not possible to accurately assess the number of cut nut trees in the region as their distribution is clumped around villages and they are not recorded in (predominantly timber-based) forest inventories. It would appear that there is not a huge potential surplus from existing trees as demand for their fresh, tasty and nutritious kernels is high. However, the potential to easily increase future production is very high as the trees are easy to propagate (from seed or cuttings), are fast growing, start to fruit early and grow on a wide range of sites.

Current supply

Cut nuts are regularly sold in local markets. The only commercial sale of cut nuts has been in Vanuatu: in 1990, 200 kg, and in 1994, 1200 kg

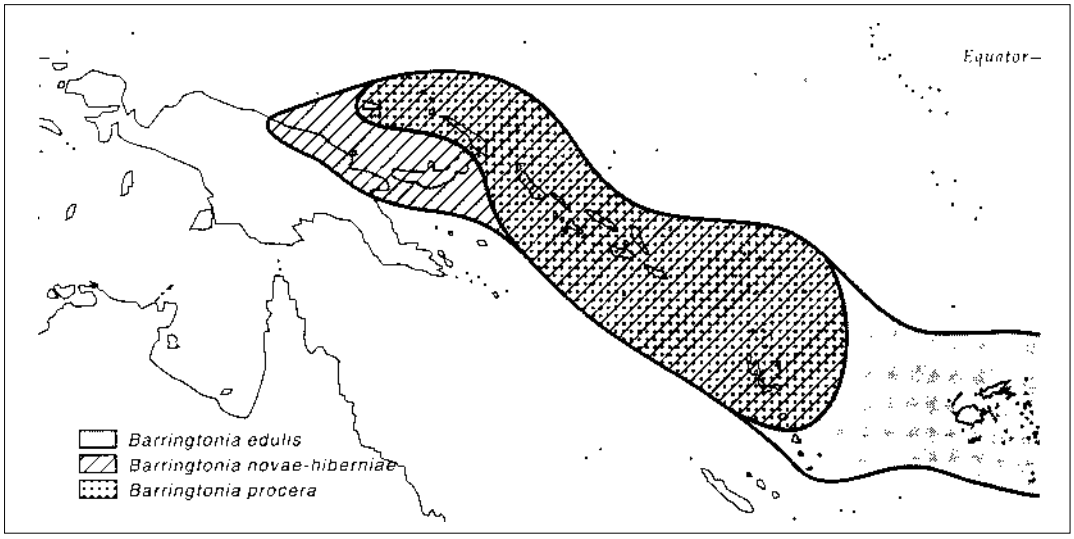

Figure 5. Distribution of cut nut (*Barringtonia procera, B. edulis* and *B. novae-hiberniae*)

KIT, at an approximate farm gate value of US$2000.

Resource capacity and sustainability

Results from Vanuatu suggest that the commercial market demand for processed cut nuts is high. However, current production from village-based trees is unlikely to fully satisfy demand from any expanded marketing operation. And it would be nutritionally counterproductive to divert nuts away from fresh consumption in villages. Any major marketing initiative will, therefore, have to be accompanied by an appropriate agricultural and nutrition extension program aimed at increasing tree numbers and maintaining domestic consumption.

The ecological potential for the sustainable management of cut nut from naturally occurring trees is only low to medium (Table 9), so unsupported commercialisation is not recommended. Given its uncomplicated agronomy, however, it should be relatively easy to increase production and to treat it more as a conventional cash crop than as a naturally occurring, non-timber forest product.

Sea Almond and Okari Nut (*Terminalia* spp.)

Why *Terminalia*?

Interest in *Terminalia* is high because at least one species is very common in the South Pacific and

Table 9. Overall management potential of cut nuts based upon botanical characteristics

Feature		Potential for sustainable management*
Resource group		fruits, seeds (1)
	Yield/plant	medium (1)
Species characteristics:		
	Flowers	few, large (0)
	Fruits	few, large (0)
	Seed germination	high viability (2)
	Sprouting capability	high (2)
Population structure:		
	Size–class distribution	type I curve (2)
	Tree density/hectare	10+ adults (2)
	Spatial distribution	clumped (1)
Regeneration guild		late secondary (1)
Flower and fruit phenology		supra-annual (1)
Reproductive biology:		
	Pollination	biotic, with generalist vector (1)
	Pollinator abundance	intermediate (1)
	Seed dispersal	biotic, with specialist vector (0)
	Disperser abundance	rare: large birds (0)
Total points		15 (low to medium ecological potential for sustainable management)

* 0 = low, 1 = medium, 2 = high
Adapted from Peters (1994)

because of the kernel's delicate flavour. The PNG species produce very large kernels with a taste considered by many to be the best of all indigenous nuts in the region.

Economic species

The genus *Terminalia* (Combretaceae) contains around 250 species, many of which are important for timber. Twenty to thirty species are found in the South Pacific (Coode 1969 and 1978); the greatest diversity is in PNG. Commercial interest is currently centred around *T. catappa* (sea almond, also known as Indian almond) and *T. kaernbachii* (okari nut) (Table 2). *T. impediens* is very similar to *T. kaernbachii* but is much less common in its native PNG. *T. copelandii* is reported to have a good edible kernel (Coode 1978), as is *T. sepicana*.

Economic and marketing characteristics

T. kaernbachii (Fig. A5) are tall trees that can produce more than 100 kg of very large fruits (90–200 g) with a KIT ranging from 5 g to 15 g and a K:N ratio of 5% to 10% (Table 10). Many would consider okari nut to be the best tasting indigenous nut in the Pacific.

T. catappa (Fig. A6) is a shorter, broader tree that can produce more than 50 kg of much smaller fruits (8–20 g) and sweet tasting KIT (0.5–2.0 g) with a similar K:N ratio of 6% to 12% (Table 10). Intense selection of sea almond on certain smaller islands has produced some large-kernelled cultivars with distinctive tastes.

The kernels of sea almond and okari nut contain more than 50% and 60% oil respectively, which consists of mostly palmitic and oleic acids (Morton 1985, Clark et al. 1951).

The fruits and NIS of both species have to be laboriously cut or prised opened with a knife. For long-term storage the kernels must be dried, roasted or frozen immediately after collection owing to their high moisture content. The kernel consists of a delicate and intricately entwined cotyledon (first embryonic leaf), which is prone to break apart unless handled very carefully.

Distribution

The pan-tropical sea almond is very common in all coastal areas of the South Pacific and can be found as far south as 30°S. The trees are mostly self-sown, but on smaller islands are frequently cultivated as part of multistorey tree crop systems. Okari nut is endemic to western and southern New Guinea and is found at 50 to 1100 m (see the paper by Bourke in these Proceedings). The trees have been slowly introduced eastwards and a few specimens can now be found as far east as Makira in Solomon Islands.

Seasonality

Sea almond fruits sporadically throughout the year at lower latitudes, and has heavier crops towards the end of the year at higher latitudes. Okari nut fruits once a year between March and August according to latitude.

Production

No figures are available for either sea almond or okari nut. The total production of sea almond in the region is probably very high given its wide distribution, but it is unclear if a real commercial surplus exists because, except on a very small scale in Vanuatu, it has not been commercially marketed. The trees are easy to propagate, however, so production could be quickly increased. Production of okari nut is very high in regions of PNG but many trees are in remote areas.

Table 10. Economic characteristics of edible *Terminalia* nuts

Species	Fruit wt (g)	KIT wt (g)	K:N ratio (%)	Est. tree yield (kg fruit)	Est. tree yield (kg KIT)	Ease of opening fruit	Variation in fruit shape
T. catappa	8–20	0.5–2	6–12	10–50	0.6–6.0	time-consuming	medium
T. kaernbachii	90–200	5–15	5–10	10–100	0.5–10.0	medium	low

Source: Evans 1991a, Chaplin 1985

Current supply

The only commercial sale of sea almond in the region has been in Vanuatu: in 1994 nearly 100 kg of KIT was bought at a value of US$1000. (Substantial amounts of sea almonds are regularly traded in parts of Asia and SE Asia.)

Okari nut has been commercially sold only from the Managalas Plateau of PNG. In 1994, 1200 kg of KIT was bought from tree owners at a farm gate price of US$1.50/kg and a total retail value of nearly US$10 000 (see papers by Houghton, Ase and Olsson in these Proceedings).

Resource capacity and sustainability

Both *Terminalia* nuts are important local sources of nutrition. They are frequently sold and bartered in local markets and given as presents. The potential capacity of sea almond is very high, but profitability and hence supply could be limited by high processing costs (mostly cracking). Local demand for okari nut is high; with suitable processing techniques, commercial demand could be likewise.

Sea almonds are easily propagated, hardy and fecund and therefore have a high potential for sustainable management (Table 11). Prospects for

Table 11. Overall management potential of edible *Terminalia* based upon botanical characteristics

Feature	Potential for sustainable management*	
	T. catappa	*T. kaernbachii*
Resource group	resins, fruits, seeds (1)	resins, fruits, seeds (1)
Yield/plant	high (2)	high (2)
Species characteristics:		
Flowers	small, many (2)	small, many (2)
Fruits	intermediate (1)	few, large (0)
Seed germination	intermediate (1)	low viability (0)
Sprouting capability	high (2)	low (1)
Population structure:		
Size–class distribution	type I curve (2)	type I curve (2)
Tree density/hectare	0–5 adults (0)	0–5 adults (0)
Spatial distribution	clumped (1)	clumped (1)
Regeneration guild	late secondary (1)	primary (2)
Flower and fruit phenology	annual to supra-annual (1.5)	annual (2)
Reproductive biology:		
Pollination	biotic, with generalist vector (1)	biotic, with generalist vector (1)
Pollinator abundance	common: small insects (2)	intermediate (1)
Seed dispersal	biotic, with generalist vector (1)	biotic, with generalist vector (1)
Disperser abundance	common: pigeons, bats etc. (2)	common: mammals, pigeons, bats etc. (2)
Total points	20.5 (high)	18 (medium to high ecological potential for sustainable management)

* 0 = low, 1 = medium, 2 = high
Adapted from Peters (1994)

okari nut are generally good, but the rudimentary seeds have difficulty sprouting and are a favoured food of animals. Commercial development would therefore require backup with nursery propagation to ensure adequate regeneration.

Polynesian Chestnut (*Inocarpus fagifer*)

Why Polynesian chestnut?

The trees are widely distributed and site-tolerant, and there are a great many cultivars. The kernels, which must be cooked before eating, are declining in importance as a local food, making them potentially available for commercial marketing without anti-nutritional consequences (outside disasters).

Economic species

Inocarpus belongs to the large leguminous 'bean' family Fabaceae. There are various accounts of closely related edible species in the genus *Inocarpus*, but most have been reduced to taxonomic synonyms (for example, *I. fagiferus* and *I. edulis*) and cultivars of *I. fagifer* (Fig. A7).

Economic and marketing characteristics

The fruit is a large (6–10 × 5–10 cm), green-brown, indehiscent pod that contains a single starchy seed (kernel). The seed must be roasted or boiled before eating to remove mild toxins. Once roasted, the taste is rather bland, but the seeds are easily stored and transported, making them a good candidate for commercial marketing—perhaps with flavour enhancements. Trees can produce more than 100 fruits per season (Aburu 1982). Variation in fruit—and to a lesser extent seed size—is high, as there are many cultivars throughout the South Pacific.

Distribution

A native of Malesia, Polynesian chestnut grows naturally and is cultivated in most lowland, wet and seaside parts of the South Pacific (see papers by Bourke and Walter in these Proceedings).

Seasonality

Fruiting is seasonal, around January to May depending on latitude, but some cultivars appear to produce unseasonal crops.

Production

No figures are available. Assumed to be high but decreasing owing to a decline in the importance of the kernels as a local food crop.

Current supply

Polynesian chestnuts are still an important food and barter crop in some areas of the South Pacific, but there is no current commercial marketing of the kernels.

Resource capacity and sustainability

Regional production is assumed to be high, but there might not be existing local surpluses suitable for marketing. There is a potential for commercial production, however, as the kernels are becoming less important as a local food source, and the trees are robust, site-tolerant and easy to propagate, and have a high potential for sustainable management (Table 12).

Pandanus Nut (*Pandanus* spp.)

Why pandanus nut?

There are many endemic species that are easy to propagate true-to-type and that cover a wide range of sites. The nuts form part of existing food systems with a strong production base.

Economic species

Pandanus (Pandanaceae) has about 600 species, many of which are endemics. The taxonomy of the Pacific species remains unresolved, but three current species are of commercial interest: *P. julianettii* (karuka), *P. brosimos* (wild karuka) and *P. dubius* (collectively known as pandanus nut). (The cultivated *P. julianettii* could be a cultivated form of *P. brosimos* (Stone 1992).)

Economic and marketing characteristics

The fruit is a syncarp that can grow up to 30 cm in diameter and 15 kg in weight. It contains 50 or more fibrous segments, each with two to four edible seeds and flesh that can, according to species, be eaten raw or after cooking. After roasting or slow drying the seeds can be preserved for several months. The seeds contain between 10% and 60% oil according to species. Cultivation of karuka has produced many cultivars with

variable tastes that can be reproduced true-to-type from suckers or stem cuttings.

The hardy stems and leaves of most *Pandanus* are used in handicraft, furniture and building materials.

Distribution

The karukas are confined to the higher altitudes (above 1800 m) of New Guinea (see paper by Bourke in these Proceedings), whereas *P. dubius* is found throughout the sandy shorelines of the South Pacific islands.

Seasonality

The karuka fruiting season usually starts at the beginning of the year, but can vary dramatically according to temperature and rainfall (see paper by Bourke in these Proceedings). *P. dubius* fruits sporadically according to latitude, site and stress.

Production

No figures are available. Karuka production is variable. *P. dubius* production is said to have declined in Polynesia.

Current supply

Karuka is an important seasonal food crop in the PNG highlands, where local demand is high.

Table 12. Overall management potential of Polynesian chestnuts based upon botanical characteristics

Feature		Potential for sustainable management*
Resource group		fruits, seeds (1)
	Yield/plant	medium (1)
Species characteristics:		
	Flowers	small, many (2)
	Fruits	intermediate (1)
	Seed germination	high viability (2)
	Sprouting capability	high (2)
Population structure:		
	Size–class distribution	type I curve (2)
	Tree density/hectare	0–5 adults (0)
	Spatial distribution	clumped (1)
Regeneration guild		late secondary (1)
Flower and fruit phenology		annual (2)
Reproductive biology:		
	Pollination	biotic, with generalist vector (1)
	Pollinator abundance	intermediate (1)
	Seed dispersal	biotic, with generalist vector (1)
	Disperser abundance	common: bats (2)
Total points		20 (high ecological potential for sustainable management)

* 0 = low, 1 = medium, 2 = high
Adapted from Peters (1994)

Informal trading takes place but there is no commercial marketing. Similarly, preserved *P. dubius* seeds are also bartered and marketed locally on some smaller Polynesian and Micronesian islands, but no formalised trade exists in the South Pacific.

Resource capacity and sustainability

Total karuka production is evidently high, but observers are quick to point out the nutritional importance of the seasonal crop. It would therefore be wise to complement any commercialisation with increased (nursery?) propagation and planting. Although karuka is known to be site-tolerant, the fragile ecosystem of the New Guinea highlands will necessitate careful site selection and management for any intensification of production (Table 13).

Acknowledgments

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Table 13. Overall management potential of edible *Pandanus* based upon botanical characteristics

Feature		Potential for sustainable management*
Resource group		fruits, seeds, leaves (2)
	Yield/plant	high (1)
Species characteristics:		
	Flowers	unisexual (0)
	Fruits	few, large (0)
	Seed germination	intermediate (1)
	Sprouting capability	high (2)
Population structure:		
	Size–class distribution	type II curve (1)
	Tree density/hectare	5–10 adults (1)
	Spatial distribution	clumped (1)
Regeneration guild		late secondary (1)
Flower and fruit phenology		unpredictable to supra-annual (0.5)
Reproductive biology:		
	Pollination	cultivated and natural (1)
	Pollinator abundance	unknown (0)
	Seed dispersal	man, animals, birds (1)
	Disperser abundance	common! (2)
Total points		14.5 (medium ecological potential for sustainable management)

* 0 = low, 1 = medium, 2 = high
Adapted from Peters (1994)

cific Islanders who have so willingly provided information on indigenous nuts to me over the years.

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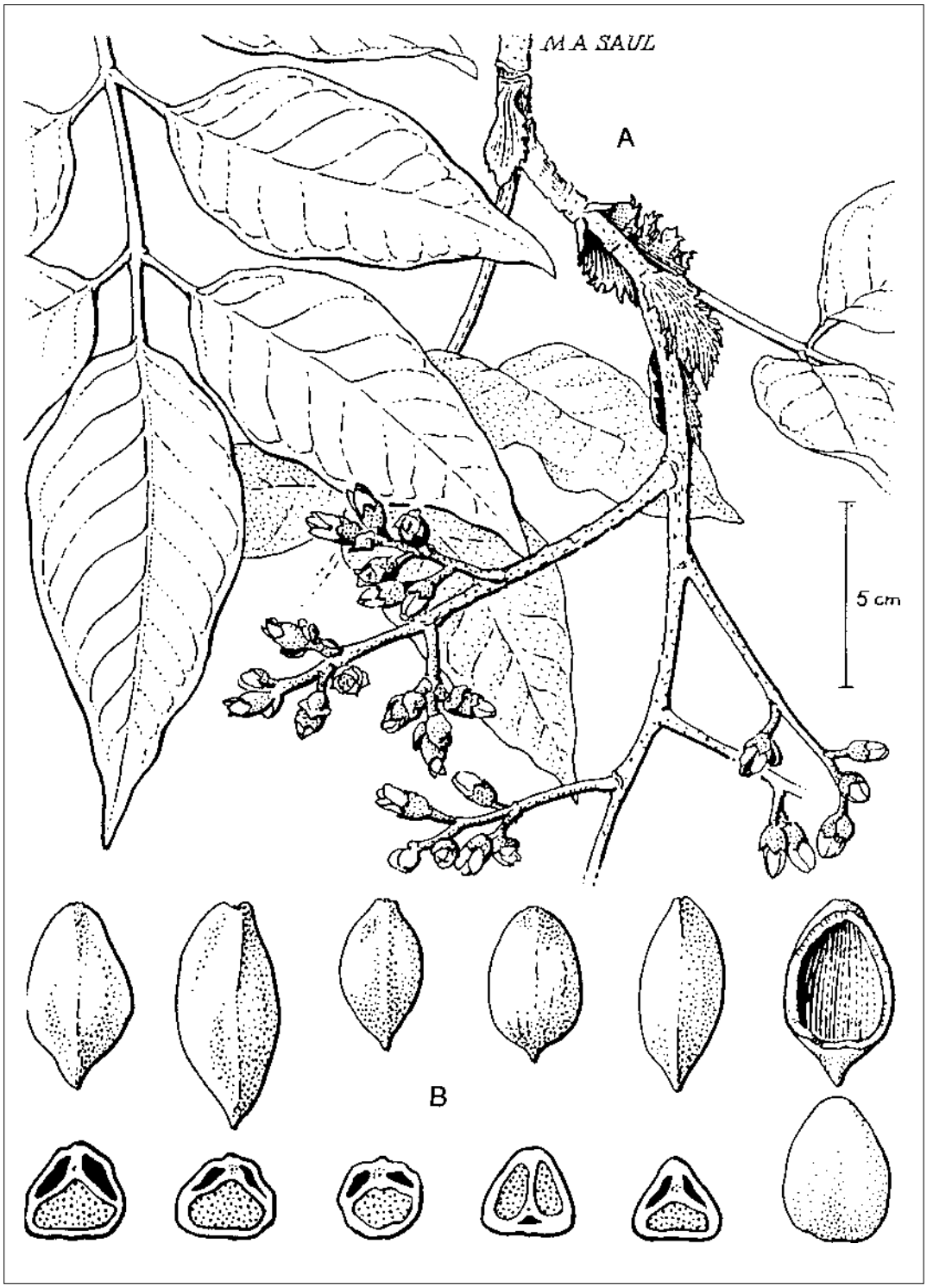

Figure A1. *Canarium indicum* L. var. *indicum*, canarium nut. A: branch with leaves, stipules and inflorescence with flowers (male + hermaphrodite). B: nuts in-shell from different cultivars. (Drawn from composite Solomon Islands material)

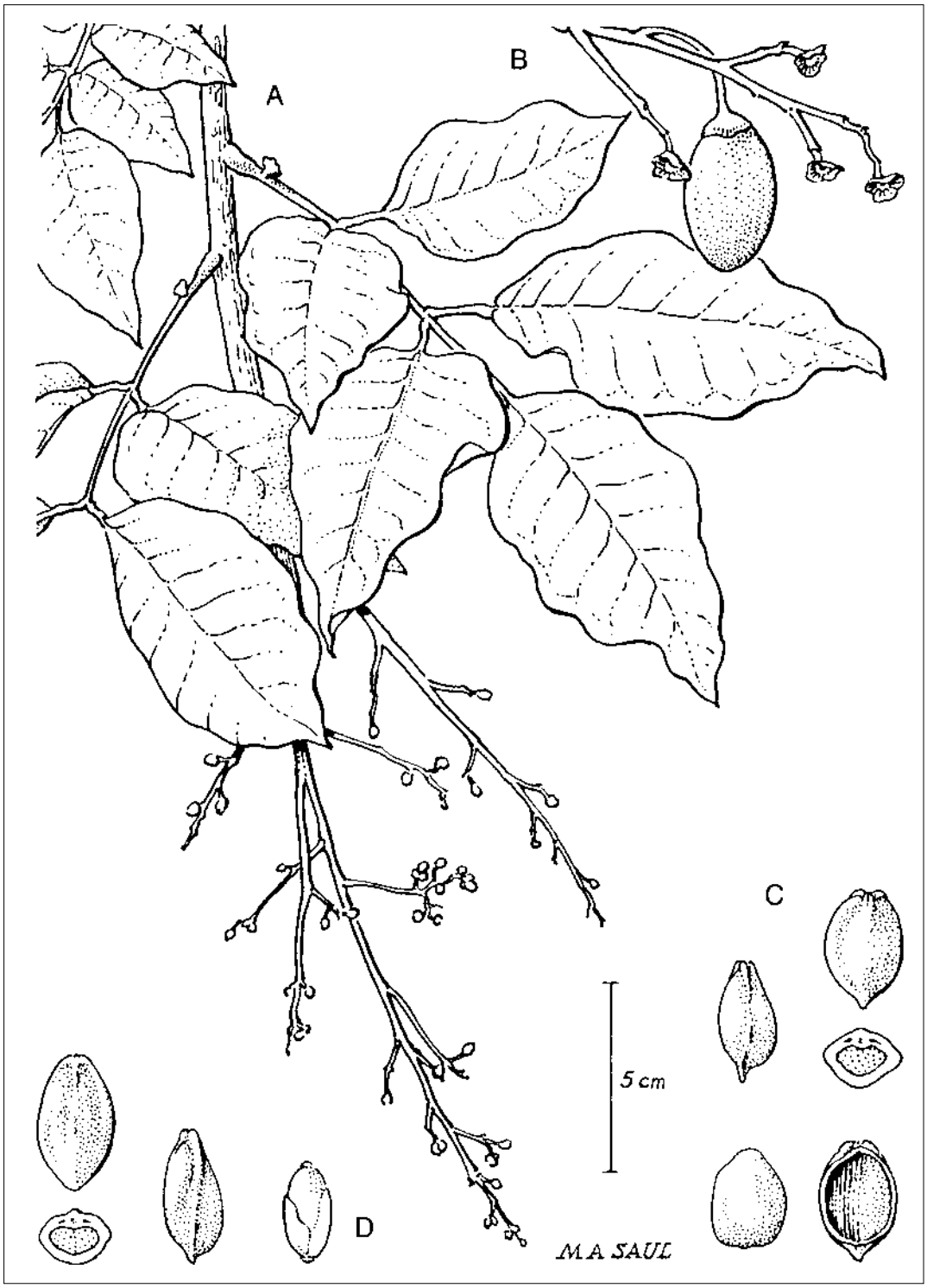

Figure A2. *Canarium salomonense* Burt. ssp. *salomonense*, canarium nut. A: branch with leaves, stipules and inflorescence with flowers (sex unknown). B: inflorescence with fruit. C: nuts-in-shell. D: kernel with testa removed. (Drawn from composite Solomon Islands material)

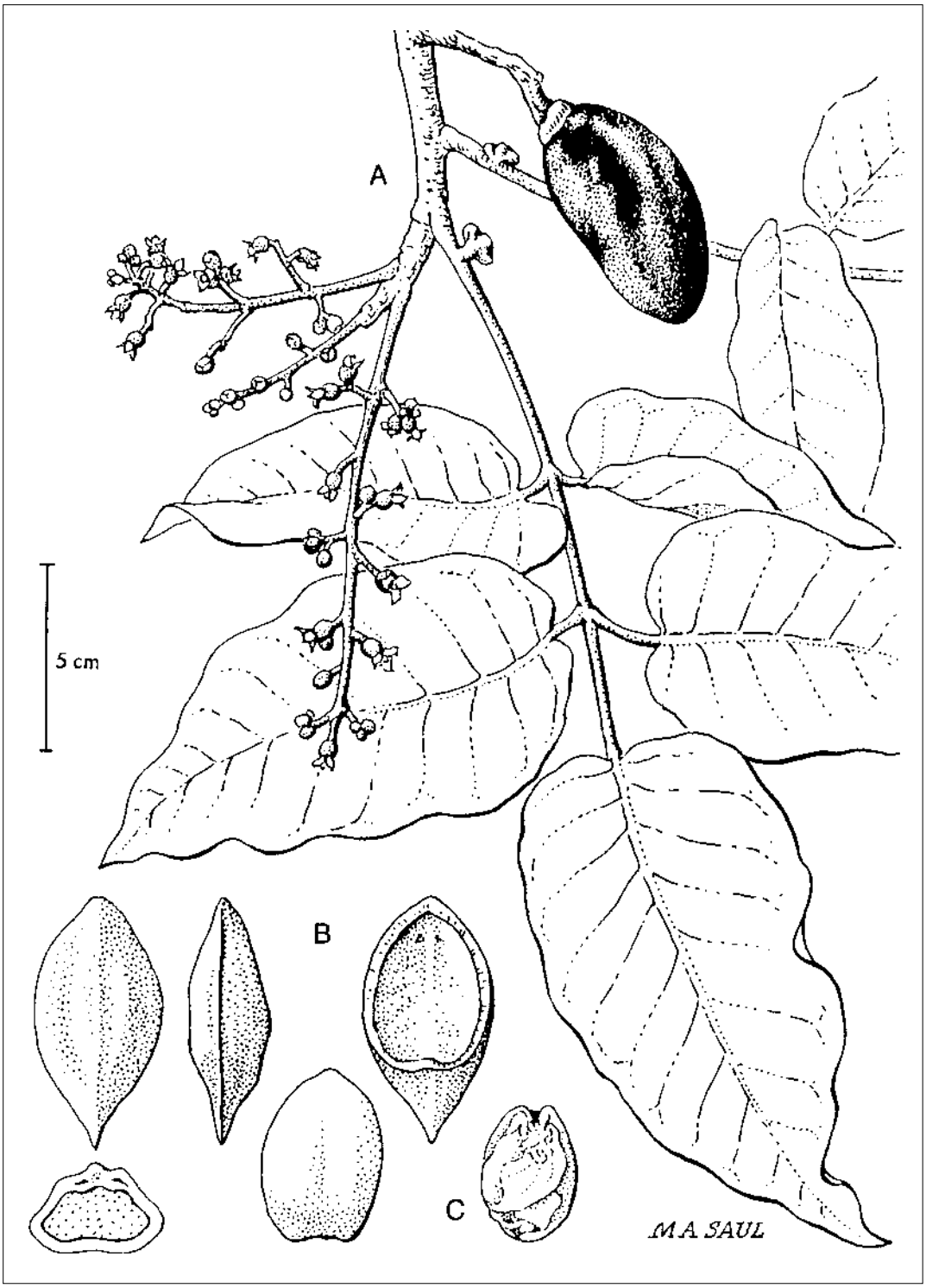

Figure A3. *Canarium harveyi* Seem. var. *nova-hebridiense* Leenh., canarium nut. A: branch with fruit, leaves, stipules and inflorescence with flowers (male + hermaphrodite). B: nuts-in-shell. C: kernel with testa removed. (Drawn from composite Solomon Islands material)

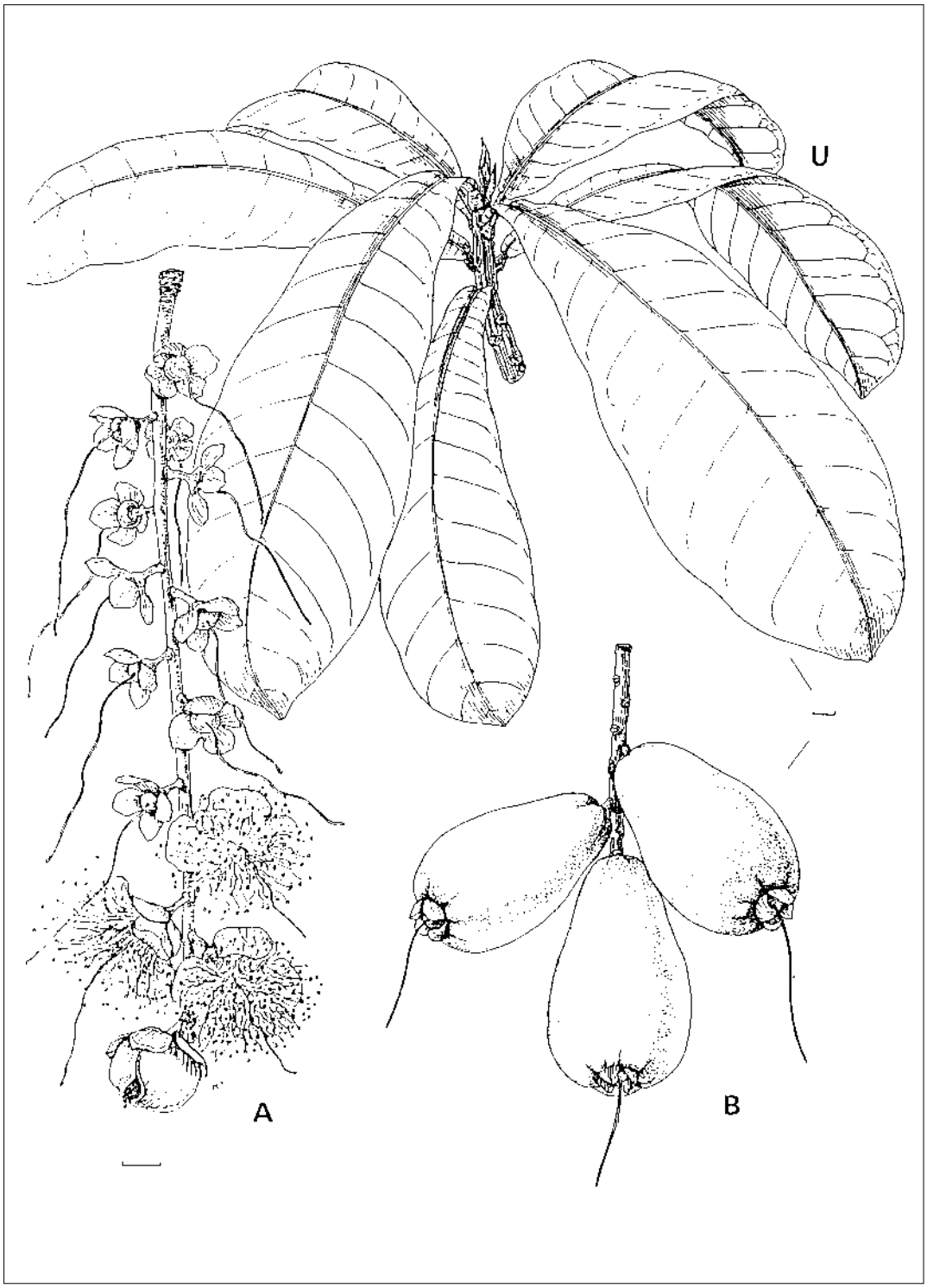

Figure A4. *Barringtonia edulis* (?) (Miers) Seem. ex Solomon Islands, cut nut. A: inflorescence. B: fruit. U: leaves. (By kind permission of Chris Henderson)

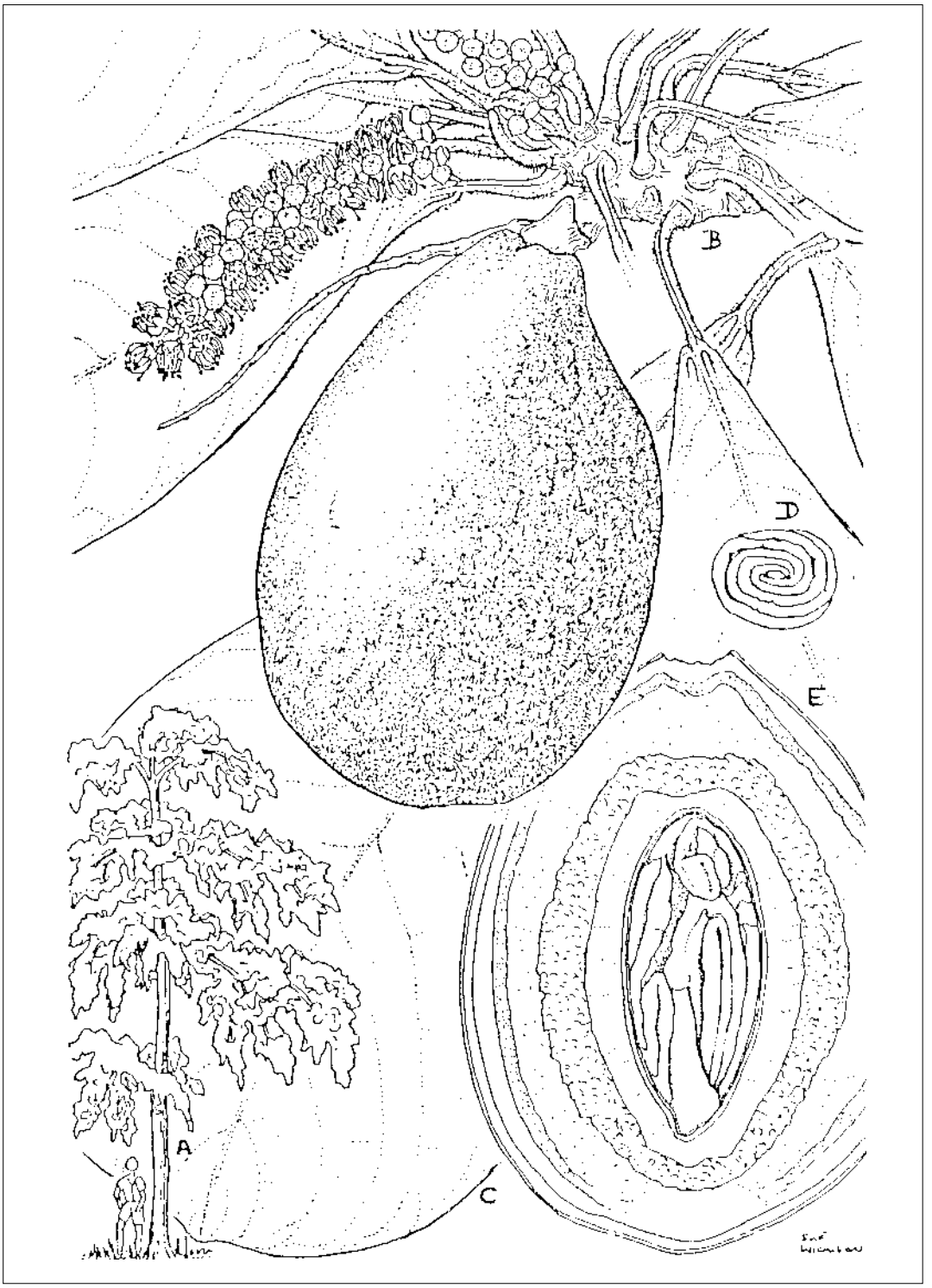

Figure A5. *Terminalia kaernbachii* Warb., okari nut. A: tree. B: flowering branch with fruit. C: leaf. D: cross-section of kernel. E: longitudinal section of fruit. (By kind permission of Graham Chaplin)

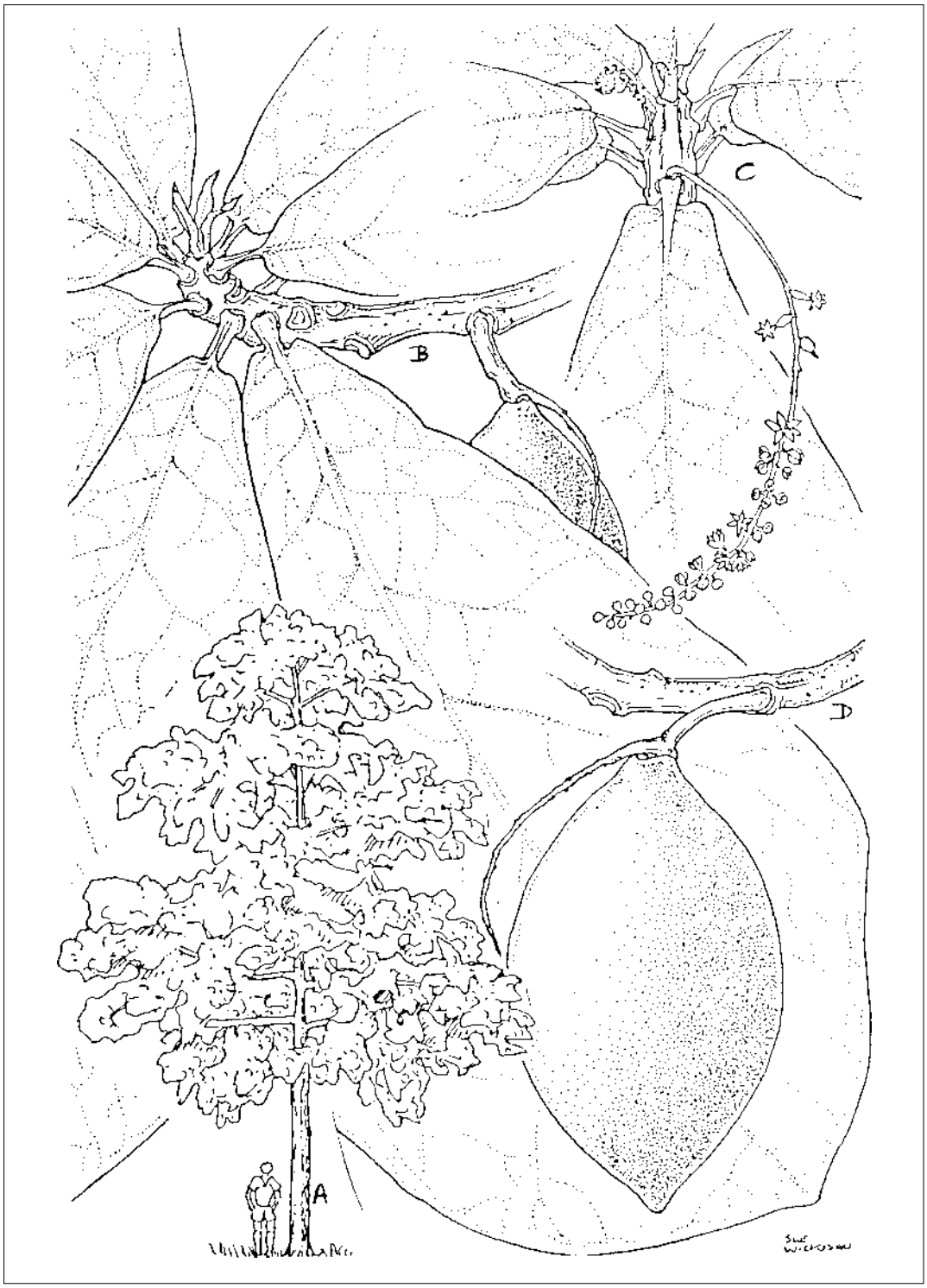

Figure A6. *Terminalia catappa* L., ex Solomon Islands, sea almond. A: tree. B: branch with leaves and fruit. C: branch with inflorescence and flowers (sex unknown). D: fruit. (From Henderson and Hancock 1988)

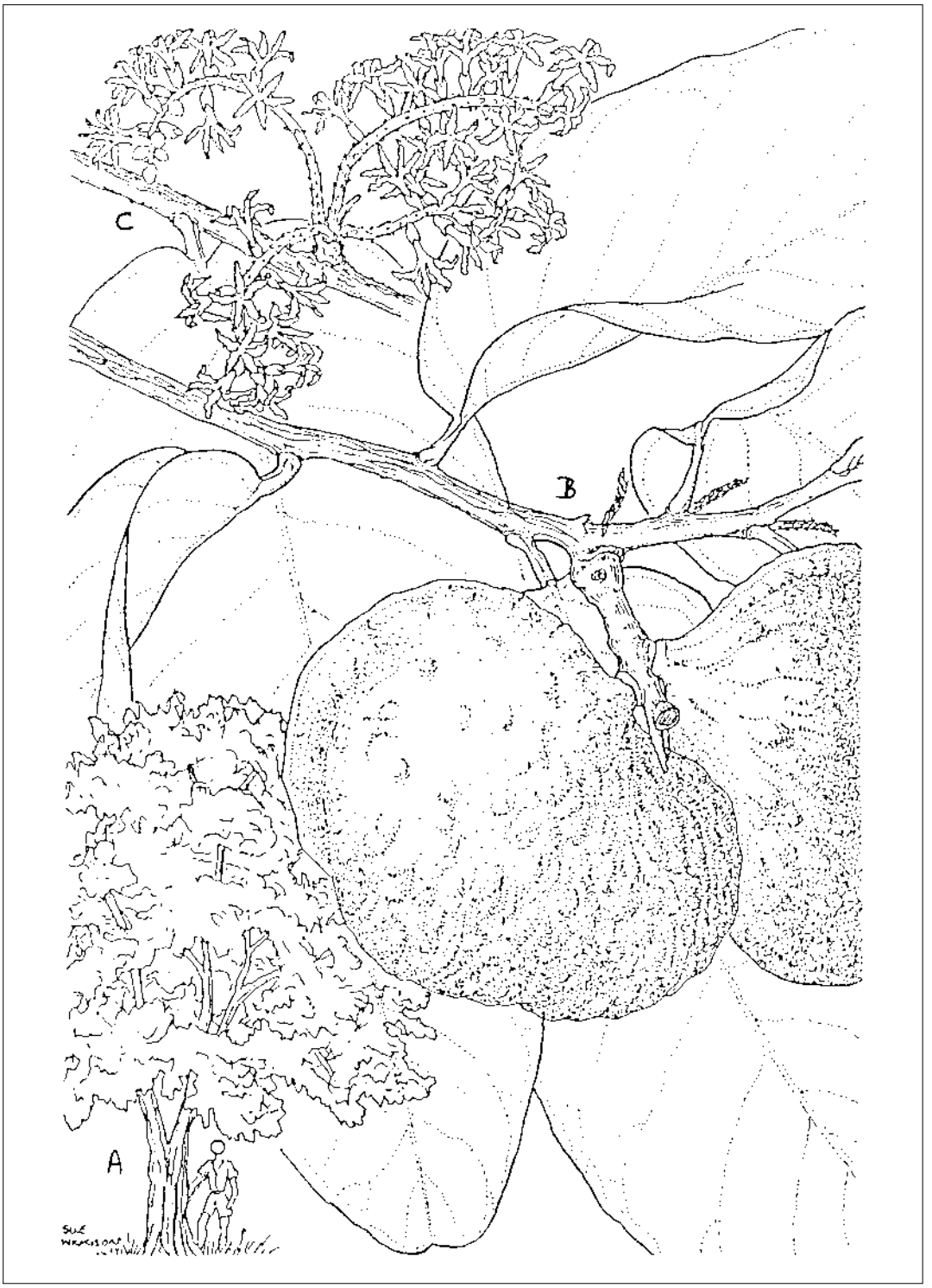

Figure A7. *Inocarpus fagifer* (Park. ex Zoll.) Fosb. ex Solomon Islands, Polynesian chestnut. A: tree. B: branch with fruit. C: inflorescence. (From Henderson and Hancock 1988)

Melanesian Arboriculture: Historical Perspectives with Emphasis on the Genus *Canarium*

Douglas E. Yen*

History of Melanesian Arboriculture

THE literature in ethnobotany, human geography and modern agricultural development of the Pacific has tended to stress the traditional cultivated 'field' crops, the associated animal husbandry and the economic potential of exotic species. In Melanesia, the importance of tree crops in indigenous economies recorded by anthropologists—for example, Hogbin (1938–39) and Oliver (1955)—has only recently received wider attention, despite the fact that among the earliest of accounts of the 16th century Spanish explorers, a quite extensive range of strange fruits and nuts was described from Santa Cruz in Solomon Islands (Yen 1973).

One of the first positive economic development projects focusing on the Pacific, but as exploitation rather than local improvement, was the successful expedition of William Bligh to transfer breadfruit stocks from Tahiti to the West Indies (Oliver 1988) in 1792 after the earlier *Bounty* fiasco, which had the same objective. There are tinges of irony in this story, for the Polynesian breadfruit tree, which was not really the great success envisaged for the West Indies, was a relatively highly selected form of the species. The genetic variability was much greater in the western Pacific (Melanesia) and thus offered a better proposition for adaptation to new environments. New Guinean tree species offered a huge range of alternative products that might have better enlarged the food range in the New World tropics.

I have chosen to introduce this paper with an historical approach, however sketchy, since some of the past events carried issues whose importance is magnified today in the light of political sovereignty and economic change. There is no doubt of the necessity for joining the world economy, and the potential of primary products from indigenous agriculture for export earnings needs to be explored in a way that was unheard of even half a century ago. It hardly needs saying that this contrasts with some former philosophies of development such as taking genetic material out of the Pacific for the possible benefit of other economies: for example, breadfruit, sugar, coconut and sago; and introducing exotic crops of known cash value: for example, cacao, coffee and oil palm. It is reminiscent, however, of the early exploitation of Pacific island copra and the development of what Oliver (1951) called the coconut civilisation, because for nearly a century copra was the only agricultural product whose cash proceeds would allow trade with the dominant European cultures.

It may be said, then, that the potential of Melanesian cultivated plants has only been skimmed while the natural flora embodied in the great timber resources has already been over-exploited. And here lies the danger to the reserves of germplasm of the fruit and nut trees: not only are wild relatives of cultivated species endangered, but also the variation in those species that look like wild natural forest components, but are in fact the signs of arboriculture as part of traditional agricultural systems. Although this paper takes an historical perspective towards *Canarium*, I hope that there is some pertinence to 'future history' of the genus.

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Fruit and Nut Trees of Melanesia

The western Melanesian region is a centre of domestication of tree species with generic origins in Southeast Asia. The endemic speciation of those genera, however, was the result of selection by the early Melanesian cultivators.

The historical domestication of trees for food is found in all Pacific environments, even though most originated in the rainforests of the low montane regions of New Guinea (Yen 1991). This area and the lower northern slopes and valleys of the central ranges are the putative sources of domesticated *Canarium*, *Artocarpus altilis* or breadfruit, and the important fruit trees *Pometia pinnata* and *Burckella obovata*. These latter two and *C. indicum* form a triumvirate of fruit and nut species that heavily influenced the indigenous agricultural systems of coastal, lower altitudinal and small island environments of Melanesia. This is manifest not only in food patterns but in trade and cultural significance.

It is interesting that the one crop that was to dominate the arboricultural element in Pacific agriculture was breadfruit. In northern New Guinea, this species is valued for its seed; two fruit forms are grown, seeded and unseeded (actually sparsely seeded). In Polynesia and Micronesia, however, selection for seedlessness (parthenocarpy) was more intense in the past. This resulted not only in rarity of seeded varieties and thus the eclipse of the seeds as food, but in a total dependence on vegetative reproduction in cultivation.

The adaptation of breadfruit to what is regarded as one of the most marginal environments for agriculture, the coral atolls, was accompanied not only by the development of intensive practices for crops like *Cyrtosperma* and *Colocasia* taro, but by the domestication of the tree *Pandanus odoratissimus* for fruit, nuts, building material and fibre. *Pandanus* is probably the most unsung of agricultural genera in the Pacific. Its adaptability as a genus is remarkable in providing other domesticates from the widest range of environments: the nut pandans of the New Guinea highlands; the fruit pandans of the mid-altitudinal highlands; and, on the small oceanic islands, nuts, fruits, processed food, and leaves and wood for building, mats and, in earlier times, canoe sails.

Bourke (these Proceedings) covers the range of New Guinea nut species in more detail, including the coastal domesticate, *Terminalia kaernbachii*, another species of commercial potential.

The islands of northern New Guinea have had major roles in the adaptation of trees in subsistence systems. Indeed, the process of transdomestication, or the genetic elaboration of early domesticates on transfer to other environments, has as much evidence here as anywhere in the world. We may view the extension of the economic flora of New Guinea to the Santa Cruz Islands of the Solomons as an example. In my field work in the eastern Solomons (Yen 1974), native informants claimed that the nut-bearing tree *Barringtonia procera* arose on Santa Cruz Island. This island and the neighbouring Reef Islands were acknowledged as the sources of the domesticated species on San Cristobal of the central Solomons. The westerly direction of this backflow of the 'new' cultivated species to the remoter Kolombangara in the western Solomons and Karkar, an off-shore island of northern New Guinea, was further attested by informants there. By contrast, the distribution of *Canarium harveyi*, the most important of the Santa Cruz nut species, extended eastward to Tikopia, Anuta, Fiji, Samoa, Tonga and Niue (Leenhouts 1959). The large-fruited forms of *Terminalia catappa* and *Pandanus dubius* appear to be Santa Cruz domesticates of narrowly local distribution.

Of all the nut species of the eastern Solomons, *Canarium harveyi* has been the subject of extensive applied research that could result in its wider distribution—as a commercial commodity.

The Species of *Canarium*

Of all the food-producing trees of Melanesia, *Canarium*'s almond-like nut probably has the greatest potential for commercialisation. Its complex history has produced more domesticated species as recognised botanical taxa than any other tree genus in the region, providing a range of choice for commercial development. Figure 1 is a distribution map of the major *Canarium* species of the Pacific islands.

Figure 2 contrasts the external seed character-

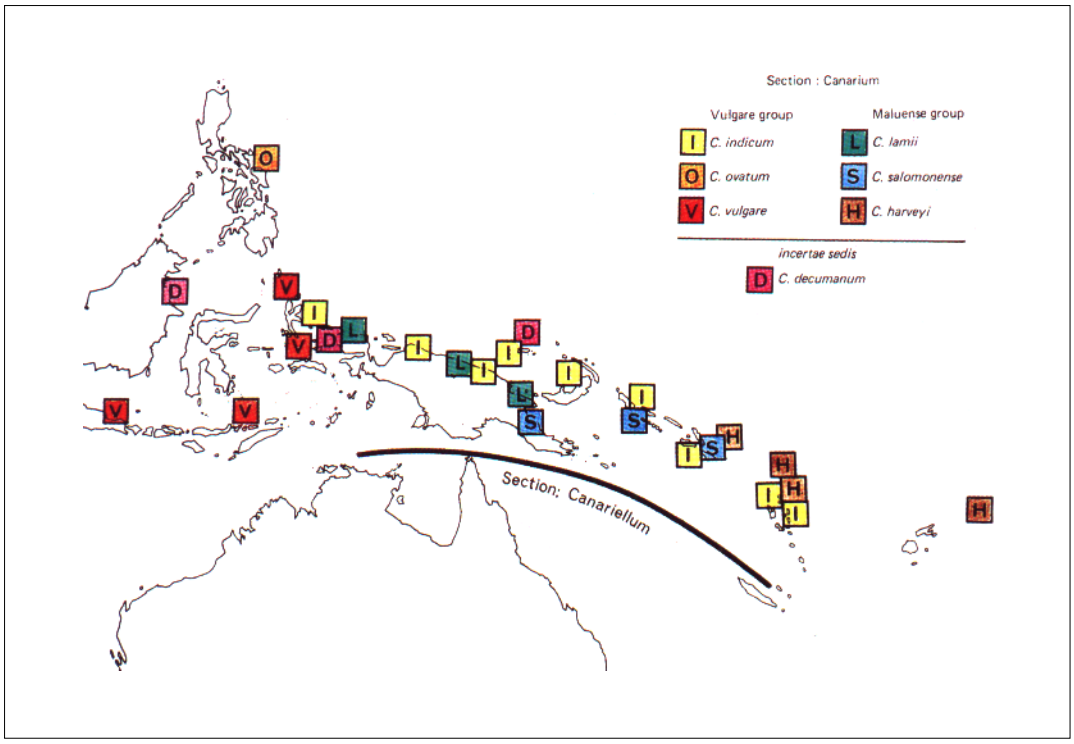

Figure 1. The distribution of domesticated *Canarium* species in the western Pacific islands. O = *C. ovatum*, V = *C. vulgare*, I = *C. indicum*, D = *C. decumanum*, L = *C. lamii*, S = *C. salomonense*, H = *C. harveyi*.

istics of some of the cultivated species. Figure 3 is one of several samples in this paper of X-ray photography that can expose longitudinal- or cross-section internal characteristics of the seed without cutting.

On mainland Southeast Asia, the domesticates *C. album* and *C. pimela* are valued for their fruits, which are processed as dried preserves or fermented as a flavouring in Eastern cuisines. The

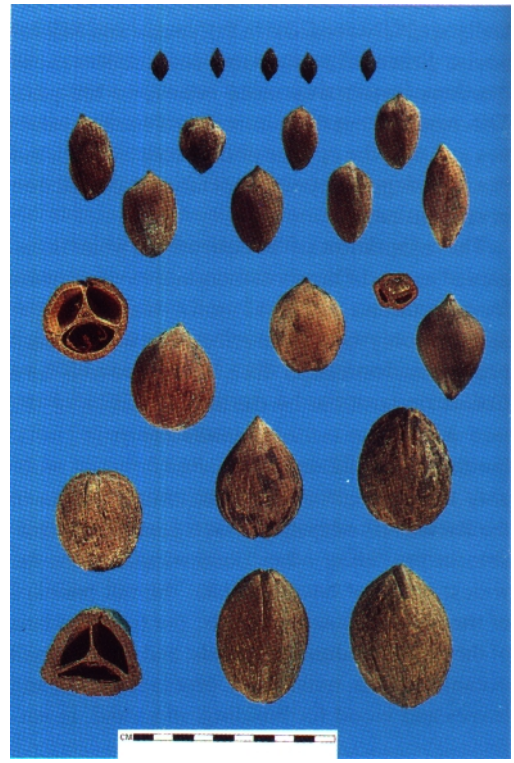

Figure 2. Seeds of some Pacific *Canarium* species. Lower group of four, not pointed = *C. decumanum*, the largest domesticated species; cross-section lower left. Middle group of four, pointed, round cross-section = *C. lamii*. Group of eight = *C. indicum*; representative cross-section below right. Row of small seeds at top: two on left = wild species *C. chinare* from Manus Island; three at right = *C. album*, cultivated in China, purchased as confection in Honolulu.

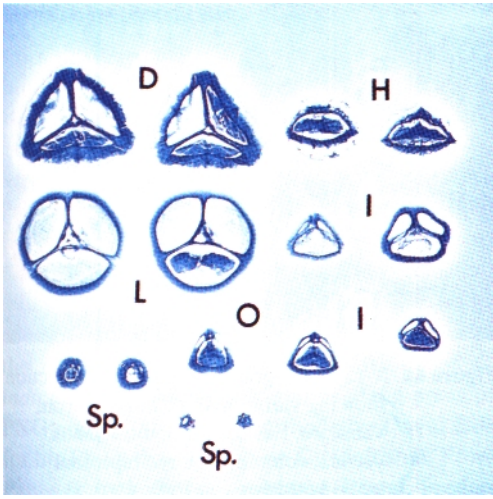

Figure 3. X-ray photograph of some *Canarium* seeds in cross-section. Identifying letters as for Figure 1. Sp (upper pair) = *C. album*; Sp (lower pair) = *C. chinare*.

tiny nuts, extremely difficult to extract, are a decorative flavouring in cake making. Leenhouts (1959 p. 328) opines on taxonomic grounds that the original centre of speciation, and the ultimate origin of the two Asiatic domesticates, may have been in the Celebes and the Moluccas. However 'in more recent [geological] times, the main centre of speciation developed in New Guinea …'

C. ovatum (with *C. luzonicum* of uncertain status as a domesticate) of the Philippines and *C. vulgare* of Indonesia are in the same taxonomic grouping as *C. indicum*. This grouping has the widest range of distribution, stretching from eastern Indonesia to the eastern Solomons. These species appear to be separate domestications from earlier ancestral forms whose pre-agricultural differentiation began in the eastern Indonesian region. Informants on Ambon and Ceram claim that *C. indicum* and the large-fruited form of *Pometia pinnata* are introductions from early contacts with New Guinea. This is feasible in the light of traditional exchange systems in the region.

Of the other New Guinea domesticates, *C. lamii* is restricted in its distribution to the northern coasts, but occurs in village gardens in the Torricelli Range at nearly 1000 m altitude, which is generally the upper limit for the genus. I have been unable to find this species in the northern or eastern islands. *C. salomonense*, with taxonomic affinity to *C. lamii* and to *C. harveyi* of the eastern Solomons, seems limited to the eastern part of New Guinea and the islands to the east.

The most spectacular species in terms of tree (Fig. 4) and nut size (Figs 3 and 4) is *C. decumanum*, whose distribution is enigmatic. Reported by Leenhouts from the Moluccan islands, the Celebes, the Vogelkop Peninsula of New Guinea (Irian Jaya) and Borneo, and recently found on Manus in the Admiralty Islands, its taxonomic status is uncertain. Bridging the gap between the New Guinean domesticated species and those of the Philippines and Indonesia, *C. decumanum*'s distribution probably represents an earlier independent evolution. Either it did not succeed in producing more species, 'or the gap between the present group [*decumanum* group of two species] and other species derived from it became so wide that it is difficult now to recognise the *decumanum*-group as their direct ancestors' (Leenhouts 1959 p. 315). Tentatively, I assign the domestication of this species to the New Guinea region since I have so far not found evidence for its cultivation, at least in the eastern Indonesian islands.

There is considerable variation in size and shape of the nut shells, the edible kernels and the flavour and consistency both between and within species. As with most subsistence crops in Oceania, intra-specific variability is a charac-

Figure 4. A *C. decumanum* tree of some 30 m in height in formerly gardened secondary growth, Manus Island, Papua New Guinea, at about 300 m altitude.

teristic of plantings. *Canarium* and other nut and fruit genera, whether planted in the margins of fields or as village trees, are 'varietally' mixed. Figures 5a, 5b, 6a and 6b illustrate something of such variability in the shell shapes and sizes in *C. indicum* and *C. harveyi*, two species that seem to have commercial potential.

Uses of *Canarium*

As is the case with most economic trees in Melanesia, *Canarium* yields more than food. Timber for construction, canoe building and the manufacture of wooden artefacts require early recognition of trees to conserve for such purposes and early pollarding to maintain trunk straightness. The wood qualities of the different cultivated and wild species are seemingly undiscriminated by modern industry (Pleydell 1970). Answers to questions of wood quality asked of subsistence farmers in the Solomons and New Guinea were unclear. Other products such as the resinous trunk exudates used in caulking of canoes and medicinal uses of leaves and bark need investigation as possible products that might contribute added value in the development of nut industries.

Figure 5a. Variability of seed size and shape of *C. indicum* from Guadalcanal. In horizontal rows, individual trees are represented by three seeds each, except for the middle pair on the third row down.

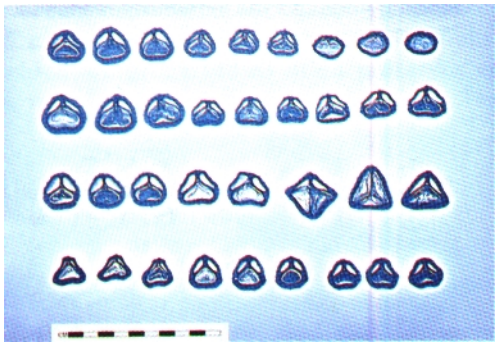

Figure 5b. X-ray photograph in cross-section of the material in Figure 5a, again showing variability. A two-seeded aberrant from the normally single-seeded form is shown third row from top, third from left.

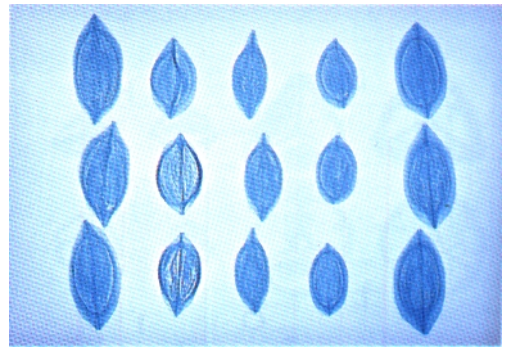

Figure 6a. X-ray photograph in longitudinal section showing variation in *C. harveyi* from Vanikoro, Eastern Solomon Islands. Vertical columns of three represent individual trees.

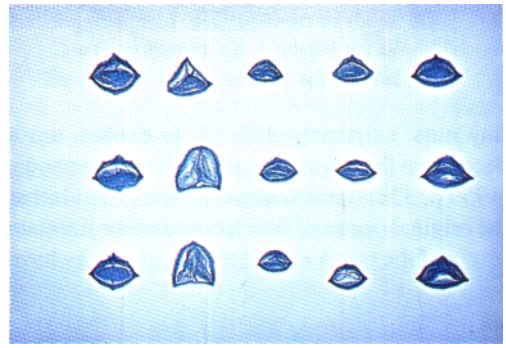

Figure 6b. X-ray photograph of the material in Figure 6a. Seeds from tree yielding predominantly double-seeded fruits are shown in the second vertical column from the left.

The Antiquity of *Canarium*

From its distribution it may be surmised that *C. indicum* is the oldest domesticated species in Melanesia. There are now enough plant remains from archaeology to support that view. The Seraba site in the Sepik–Ramu area of northern Papua New Guinea (PNG) excavated by Paul Gorecki (pers. comm.) yielded one of the best recoveries seen of *Canarium* in quantity and condition, and dated to 14 000 years ago. The range of variation in size of the shells equals that of the collections of extant populations of *C. indicum* from the Wewak and Madang areas of PNG and of the collection made by David Roe for his Ph.D. dissertation on Guadalcanal. From Pamwak rock shelter on Manus Island, Fredericksen et al. (1993) reported *Canarium* without species identification from 11 000 to 12 000 years ago. At Kilu, a site on Buka, North Bougainville, Wickler excavated *Canarium indicum* shells dated to about 9000 years ago (Wickler and Spriggs 1988). Similar finds on the Arawe Islands date to some 6000 years ago (Hayes 1992), and continue through more recent epochs of the group's prehistory. An earlier summary of *Canarium* remains from archaeology (Yen 1991) indicates this for the region as a whole. Thus, unless one were to subscribe to some hypothesis of separate domestications on the New Guinea mainland and the islands of western Melanesia, it is obvious that we are witness, through archaeology, to the role of *Canarium*, and specifically *C. indicum*, in the late Pleistocene transition from hunting–gathering to horticulture in Melanesia. This also implies the transportation from these early dates of forms of the species that were sufficiently highly selected to produce modern descendants whose anatomical characters, in their variation, cannot now be distinguished.

As is the case for many cultivated crops, the presence of wild relatives does not ensure the identification of the crops' progenitors. In the course of my fieldwork, I collected and identified a number of wild species (exemplified in Figures 2, 3 and 7). They had one characteristic in common—their small fruit and nut size, too small to conceive of any combination of parentage producing species with the seed sizes of *C. decumanum*, *C. harveyi*, *C. lamii* or even *C. indicum*. Ironically, in my last field trip in the Vanimo area of PNG, I collected a specimen with a very large, 'winged' pyrene (shell) (Fig. 7). This, dimensionally at least, could have been the type involved in domesticated *Canarium* ancestry. It was identified by Jim Croft of the Department of Forestry Herbarium, Lae, as *C. kaniense*, grouped taxonomically by Leenhouts with *C. indicum*, the Indonesian *C. vulgare* and the Philippine *C. ovatum* and *C. luzonicum*. There is, however, another large-seeded wild species, *C. megacarpum* from western New Guinea (Fig. 7), that could have been ancestral to the domesticates, and was grouped taxonomically by Leenhouts with three cultivated species, the large-seeded *C. lamii* and *C. harveyi*, and the small-seeded *C. salomonense*. The establishment of the ancestry of the cultivated species may not be as remote as some, myself included, had thought, and future application of modern DNA

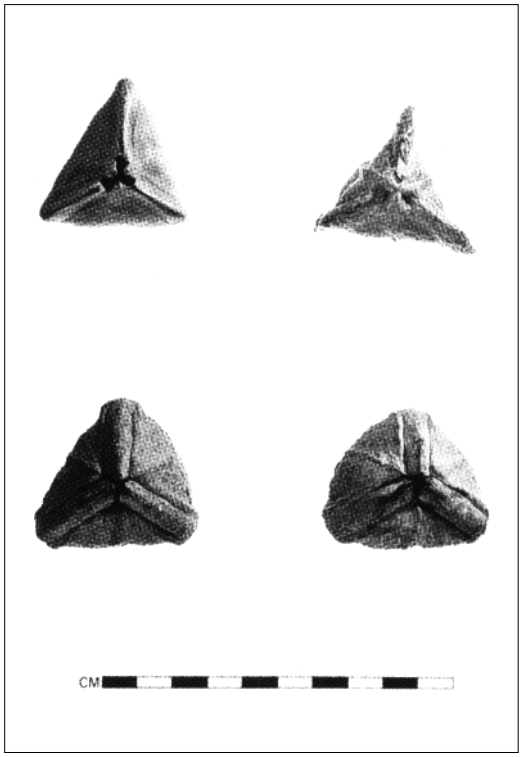

Figure 7. *C. megacarpum* (top left) and *C. kaniense* (top right), both wild species from northern mainland New Guinea, and *C. decumanum* (lower pair)

testing may provide firm genetic evidence for relationships of the wild and the cultivated species.

Intraspecific Variability and Heterogeneity

Variations in seed sizes within most species of domesticated *Canarium* are shown in Figures 3 and 5. Other variations were noted in field collections and were all recognised by the indigenous cultivators. Two trees of *C. harveyi* were pointed out on Vanikoro with virtually red foliage, and probably represented the extreme in variability of the gene for anthocyanin production. Some trees of *C. lamii* in the Markham Valley shared something of the same character. Perhaps more useful for our purpose are two other variants noted, both in *C. harveyi* on Vanikoro. One is seeds that, at maturity, have a natural split of the basal plate of the shell, making kernel extraction very easy. The other is shells bearing some 67% double kernels. The presence of double kernels is sometimes encountered in all species, but its frequency is generally low.

Wherever *Canarium* is grown, it is commonly associated with other fruit and nut trees and with mixed 'varieties' of the species. This is not accidental, for it occurs in all Pacific systems, in all crops. Most indigenous explanations involve the avoidance of singly concentrated harvests, even though first fruits and sufficient harvest for feasts are important. Indigenous cultivators in the eastern Solomons point out the variety of taste and textural qualities of nuts, particularly in *Canarium* and *Barringtonia*, that are encompassed by the mixed stands. Although disease control could be a reason, I have never heard this given for mixed stands. Nevertheless, the widespread practice may represent an unrecognised benefit that should be considered in the commercialisation of crops such as *Canarium*, providing for genetic variability in individual stands. Reserves of variability in the species should be maintained, whether on research stations or indigenous reserves. Such measures cannot be expected to continue without assistance, but these are the kinds of conservation too easily lost in the mercantile objectives of development. Adequate compensation for indigenous conservation of generic stocks may be more economical and effective than the research station alternative. Certainly this is the case for the endemic wild relatives of cultivated *Canarium* species in the Solomon Islands and New Guinea.

Heterogeneity within species is a consideration where commercial development of nut tree cultivation goes beyond the village mode of production, as larger-scale market requirements inevitably demand uniformity of product. Its expression and maintenance are the result of cross-fertilisation. However, monoecious and dioecious reproduction will have considerable bearing on planting practices in larger-scale plantings. Leenhouts' contention that the genus is dioecious has been challenged for the Santa Cruz *C. harveyi*, but accepted for *C. indicum* in the preliminary research of Evans (1991). However, there is some indication from field evidence in New Guinea that monoecious trees of *C. indicum* are the norm in village cultivation. If monoecy is more widespread in the genus, the culling of male trees could be avoided in commercial-scale production, saving time and space.

Conclusions

Research on species variability and breeding systems will become important when commercialisation of indigenous nut species stimulates large-scale production. Elsewhere in these Proceedings, Evans, Pelomo et al. and Akus discuss research in production, marketing, vegetative propagation and wild species conservation.

The potential of *C. indicum* and *C. harveyi* is recognised (as attested by a number of the contributions to these Proceedings), but the other important Melanesian domesticates—the small-seeded but prolific *C. salomonense* and the large-seeded *C. lamii* and *C. decumanum*—have commanded little attention. It is significant to note the comparison with the status of the Philippine species *C. ovatum* (pili nut), in which research on basic aspects of applied biology of the species is ahead of the work in Melanesia (Coronel, these Proceedings). But the languishing condition of the pili nut industry there may reflect the difficulties in market expansion. Any lead could also be lost, however, as nut growers of Hawaii have already expressed interest in obtaining seed

stocks as a diversification of the successful industry founded on the *Macadamia* nut of Australia.

I wish to raise the question of whether these species will follow the pathways of development that began two hundred years ago with Bligh's breadfruit expeditions, and the more successful transfer exploitations of sugar, bananas and *Macadamia* nuts. Just as there is a voluminous literature on crops variously described as 'lost' or 'underexploited,' so is there much now written on intellectual property rights of indigenous peoples. These rights are designed to protect the interests of the descendants of the domesticators and conservators of 'new' crops. Genetic resources (such as the western Pacific nut species) are regarded as part of these rights. Various international agencies have wrestled with this problem, and farmers' rights (contrasting with breeders' rights and plant patenting) have been poorly or confusingly defined. At the core of discussion and dispute is the contention that naturally occurring genes are common property and therefore unqualified for intellectual property protection. Such a statement was made by CGIAR (n.d.) before the International Convention on Biodiversity at the UN Conference in Brazil in 1992. Obviously there needs to be clarification of 'naturally occurring' genes and whether indigenous selection and conservation over centuries and millennia confer rights over genetic materials, such as new and so far undercommercialised crops.

The issues have not escaped the attention of social scientists: Posey (1991), Brush (1993) and Salazar (1994) exemplify concern with the possible injustices of the uses of indigenous genetic sources. International edicts of principle will undoubtedly appear, but with the progress of development of the nut species described in this volume, the Pacific nations where the species were originally domesticated should consider what they can do to at least establish a new primary industry. We should hope that future history does not reflect the past.

Acknowledgments

I wish to thank ACIAR, Canberra, for enabling me to attend the conference and our hosts in Port Vila for their tremendous hospitality. The contributors to the sessions, as well as the discussants, justified the sense of optimism that one felt at the meeting for the future development of Pacific nut crops. The xeroradiography presented in this paper is the work of Wal Ambrose, the photography by Dragi Markovic, both my former colleagues in the Department of Prehistory, Research School of Pacific and Asian Studies (RSPAS), Australian National University.

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Edible Indigenous Nuts in Papua New Guinea

R. Michael Bourke*

THERE are more than 40 indigenous plant species with an edible kernel in Papua New Guinea (PNG). These are listed, together with an assessment of their significance in the agricultural systems and villagers' diets, in Table 1. Eleven of these are classed here as very significant, significant or important in village agriculture. The remainder are classed as minor or very minor and are commonly self-sown. This paper is concerned with six species that, it is judged, have potential for commercial development. The main criterion for selecting these species is acceptance of the nut by people from outside the area where it was traditionally grown. The six species are cut nut (pao) (*Barringtonia procera*), galip (*Canarium indicum*), karuka (*Pandanus julianettii*), okari nut (*Terminalia kaernbachii*), Polynesian chestnut (aila) (*Inocarpus fagifer*) and sea almond (talis, Java almond) (*Terminalia catappa*). All six species, particularly galip, karuka and okari nut, are marketed locally and are sometimes sent to more distant markets within PNG. New commercial ventures are currently being established for roasted galip nut in East and West New Britain, and for fresh okari nuts from the Managalas Plateau in Northern Province.

Agricultural environments in PNG

People live and practise agriculture in a wide range of environments in PNG. These cover an altitude range from sea level to 2800 m (and up to 3100 m for wild karuka nuts); a rainfall range of 1000 to 8000 mm a year; from climates with no dry months to those with an average of seven dry months a year; and landforms that include raised coral reefs, coastal plains, mountains and hills, colluvial fans and highland valleys. Nut-bearing species and other tree crops are grown in all inhabited environments, but there are three in which they are particularly important for villagers' food supply.

The first of these environments is the high altitude zone (1800–2400 m) and the very high altitude zone (2400–3000 m), where karuka and wild karuka nuts respectively are very important. Villagers living in these zones commonly trade karuka nuts with those living in the main highland valleys between 1400 and 1800 m. The second environment where tree crops are particularly important is the highland fringe (600–1200 m) on the New Guinea mainland. Here the staple foods include combinations of sago, bananas and root crops (previously mainly taro but now sweet potato, *Xanthosoma* taro and cassava). These are supplemented by marita pandanus fruit (*Pandanus conoideus*), breadfruit seed (but not flesh), tulip (*Gnetum gnemon*) leaves and seed and sometimes castanopsis nuts (*Castanopsis acuminatissima*) and sis nuts (*Pangium edule*). In the southern part of the New Guinea mainland, okari nuts are often very important as well.

The third environment in which tree crops, including nut-bearing species, are particularly important is small islands. These include those off the north coasts of New Guinea and New Britain, those east of New Ireland, the Mussau Islands (Lepofsky 1992; Kirch 1989) and the islands of Milne Bay Province (MBP). The species composition varies between locations, but the dependence on fruit and nut trees is often marked (Kirch 1989 p. 226; Yen 1974). For example, on Karkar Island the following were very important food sources (at least until earlier this century): coconut, galip nut, breadfruit (flesh and seed), Polynesian chestnut, sea almond, *Pouteria*

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Table 1. Edible indigenous nuts in Papua New Guinea. Significance refers to significance in village agriculture or villagers' diet

Botanical name	Common name	Significance
Aleurites moluccana	Candle nut	minor
Artocarpus altilis	Breadfruit	very significant
Barringtonia edulis		minor
Barringtonia novae-hiberniae		minor
Barringtonia procera	Cut nut (pao)	significant
Buchanania sp.		very minor
Canarium acutifolium		very minor
Canarium decumannum		minor
Canarium indicum	Galip	very significant
Canarium kaniense		very minor
Canarium lamii		very minor
Canarium salomonense		very minor
Canarium vitiense		very minor
Castanopsis acuminatissima		important
Cocos nucifera	Coconut	very significant
Elaeocarpus fagifer		minor
Elaeocarpus polydactylus		very minor
Elaeocarpus pullenis		very minor
Elaeocarpus womersleyi		very minor
Finschia chloroxantha	Finschia	minor
Finschia ferruginiflora		very minor
Gnetum gnemon	Tulip	minor
Heritiera littoralis		very minor
Inocarpus fagifer	Polynesian chestnut	important
Nelumbo nucifera	Lotus	very minor
Nypa fruticans	Nipa	minor
Omphalea gageana		minor
Pandanus antaresensis	Wild karuka	minor
Pandanus brosimos	Wild karuka	significant
Pandanus iwen	Wild karuka	very minor
Pandanus julianettii	Karuka	very significant
Pandanus limbatus	Wild karuka	very minor
Pandanus odoratissima		very minor
Pangium edule	Sis	important
Parartocarpus venenosa		very minor
Scleropyrum aurantiacum		very minor
Semecarpus (?) *cassuvium*		very minor
Sloanea tieghemii		very minor
Sterculia schumanniana		very minor
Terminalia catappa	Sea almond (talis)	important
Terminalia copelandii		very minor
Terminalia impediens	Okari	minor
Terminalia kaernbachii	Okari	significant
Terminalia megalocarpa	Dausia	minor

maclayana fruit and mon fruit (*Dracontomelon dao*) (Allen et al. 1994, p. 50). Villagers on Karkar say that arable agriculture has become more important since the adoption of steel tools some 70 years ago and that fruits and nuts are now less important in their diet. People on the nearby islands of Boisa and Manam previously exported galip nuts to the mainland in exchange for sago (Allen et al. 1994, pp. 45–48).

In the islands of MBP, fruit and nut tree species are very commonly grown, but they have become less important in peoples' diets since the incorporation of sweet potato and cassava into the agricultural system during this century. Important species in these islands include coconut, breadfruit (flesh and seed), Polynesian chestnut, sea almond, the traditional and introduced mango (*Mangifera minor* and *M. indica*), golden apple (*Spondias cytherea*), *Pangium edule* nuts, bukabuk fruit (*Burckella obovata*), Malay apple (*Syzygium malaccense*), several *Flacourtia* fruit species and dausia nuts (*Terminalia megalocarpa*) (Hide et al. 1994). A similar decline in the significance of fruit and nut tree crops has occurred in the Mussau Islands (Lepofsky 1992, p. 208).

Focus of paper and data sources

The focus for the six species discussed here is on their distribution within PNG, their significance in agricultural systems, the environments in which the species are grown and the year-to-year production pattern. The distribution of many nut species in PNG was previously surprisingly restricted; that is, some species were grown in certain regions, but not in other regions with a similar environment. Over the past 30 years, some of these species, including okari nut and cut nut, have been grown more widely within PNG. Other species, such as karuka, were already widespread in the environment in which they can grow.

Information on species distribution is based on several sources: my observations throughout most parts of PNG (the small islands off New Ireland, Manus and Bougainville are the only significant gap here); recordings made as part of the project 'Agricultural Systems of Papua New Guinea' and being published as a series of working papers, for example Allen et al. (1994) and Hide et al. (1994); and some published sources including Aburu (1982), Coode (1978), French (1986), Henty (1982), Hyndman (1984), Jebb (1992) and Lepofsky (1992). Information on species distribution within PNG is still incomplete.

Where available, information is provided on the physical environment in which each species is grown. Aspects considered are altitude (temperature), rainfall, habitat and drainage. Soil type is not mentioned further because it has minimal influence on a species' distribution. Soil fertility and drainage undoubtedly influence the rate of crop growth and productivity, but information on this relationship does not exist. Of these physical factors, altitude (temperature) has the greatest influence on a species' distribution. Differences in altitude as small as 200 m (1°C) may have a considerable influence on plant distribution. Data on crop altitudinal range are from Bourke (in preparation). The altitudinal ranges given here are mean figures for the usual range; standard deviations for these figures and extreme values are given by Bourke (in preparation). Information on production patterns is from a number of sources collated in Bourke et al. (1996). These include three to four years of yield records for experimental plots of galip and okari nut at Keravat in New Britain; market surveys and observations on harvesting of karuka nuts by a network of people at six highland locations over six to ten years; statements by villagers recorded by me; and a literature review for many locations throughout PNG.

In PNG, seasonal changes in temperature are small and variable from one year to another. Seasonal temperature differences are negligible nearer the equator, and greater further from it. However, even at 10° S in MBP, mean minimum monthly temperature varies by only 2°C between the coolest and warmest months. Seasonal rainfall changes may be small or great in PNG; they usually vary from one year to another; and the seasonal pattern is sometimes reversed over short distances. For example, the wettest months on the north coast of New Britain are December to March, but on the south coast the wettest months are June to September. Seasonal changes in day length are small near the equator but increase to

about one hour at 9° S; they are constant from one year to another (McAlpine et al. 1983). These contrasts in environmental seasonality within PNG allow some preliminary analysis to be made on environmental triggers to the flowering of tree crops.

Six Significant Species

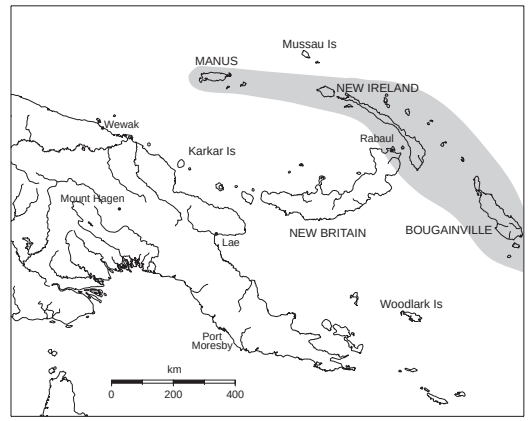
Cut nut (*Barringtonia procera*)

This species has a remarkably limited distribution within PNG. It is commonly grown and eaten on Bougainville Island, New Ireland and the Gazelle Peninsula of New Britain (but not elsewhere in New Britain) (Fig. 1). Jebb (1992) has reported this species near Madang on the New Guinea mainland, although all trees that I have seen on the mainland are recent introductions. Since 1960 it has been planted at locations on the north coast of New Guinea and elsewhere in PNG. The limited distribution in PNG supports Jebb's (1992, pp. 177–178) suggestion that this species is a recent introduction to the Bismarck Archipelago (New Britain and New Ireland) and that it originated in the Solomon Islands. Other edible *Barringtonia* species (*B. edulis* and *B. novae-hiberniae*) are more widely distributed on the mainland and other islands, but both are of only minor importance as food in PNG.

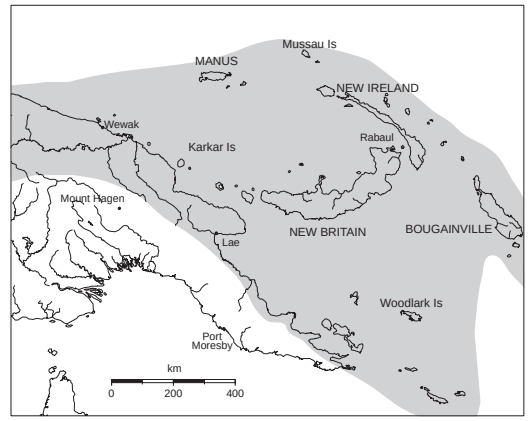
Cut nut is grown from sea level to 500 m altitude, near the coast and in inland locations. These locations have a rainfall range from 2000 to over 4000 mm a year. Trees are generally planted near villages, often in open sites. No longitudinal data on production patterns have been collected and observations reported by different observers are conflicting. Production appears to be intermittent throughout the year and non-seasonal, but more information is required to confirm this. In the Bismarck Archipelago, cut nut is eaten by outsiders, including expatriates. This acceptance suggests that it has good prospects for commercial development.

Galip (*Canarium indicum*)

Galip is widely distributed in lowland areas on the northern side of New Guinea and in all island groups (Fig. 1). It is most important on



Cut nut (*Barringtonia procera*)



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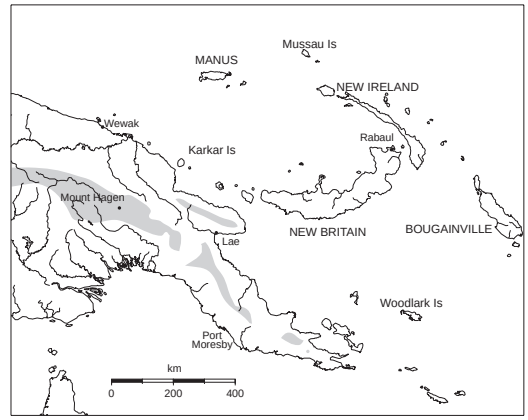


Karuka (*Pandanus julianettii*)

Figure 1. Geographical distribution of *Barringtonia procera, Canarium indicum* and *Pandanus julianettii* within Papua New Guinea

Bougainville, New Britain, New Ireland, the Mussau Islands, islands off the New Guinea north coast (such as Karkar, Manam and Vokeo), and in certain lowland locations on the northern side of the mainland. It is likely that it was a more important food before the widespread adoption of sweet potato, *Xanthosoma* taro and cassava, but it is still important in many locations. Puddings made from galip nut, coconut, taro or sago were made on Bougainville Island. Galip grows near villages, in woody regrowth after cultivation and in mature forest. Trees are usually dispersed and not grown in groves. Self-sown seedlings are protected and trees are planted, often being selected for desirable characteristics. Many trees in forest locations are self-sown. Galip grows from sea level to 700 m altitude and in locations with a wide range in rainfall (2000–6000 mm/year). It occurs on both well drained and poorly drained sites in forested locations, but is uncommon in grasslands.

The start of the producing period for galip is fairly constant from year to year for any location, and production typically lasts for about three months (Fig. 3). The production pattern in adjacent locations is independent of the rainfall seasonality. This suggests that flowering is initiated by changes in day length rather than seasonal changes in temperature or rainfall. The start of the producing period depends on latitude. At 3° to 4° S, it starts in about April. The producing period starts progressively later at higher latitudes so that at 10° S it starts in about September. This relationship is illustrated in Figure 4, using data from 11 locations in PNG and Solomon Islands. The relationship appears to hold at locations further south outside PNG; for example, on Efate Island in Vanuatu at 17°30′ S, production starts in October (A. Walter, pers. comm.).

Casual observations and anecdotal evidence, such as reports of soft-shelled cultivars (Aburu 1982, p. 104), suggest that there is considerable genetic variation within the species in PNG. Galip is popular among outsiders, including expatriates, where it is sold in major urban markets such as Rabaul and Madang. Prospects for commercial development are judged to be excellent.

Karuka (*Pandanus julianettii*)

Karuka is very widely planted in a narrow altitudinal band in the highlands in the central cordillera of New Guinea and on the Huon Peninsula (Fig. 1). This species is always planted. A closely related nut-bearing species (*P. brosimos*) grows at higher altitudes (2400–3100 m) and is distributed by animals, not people. Karuka nuts are an important part of highlanders' diets during the producing period. They provide one of the few high protein plant foods in this region (Rose 1982). During the harvest, entire households and their domestic pigs may migrate from the main highland valleys up to higher altitude locations. Tree counts in two villages indicate means of 176 and 12 trees per household (Bourke 1988, p. 30). However, these villagers' land extends just into the altitudinal zones where karuka grows and much higher tree numbers are likely at higher altitude locations.

The cultivated species grows at between 1800 and 2600 m and in locations with a mean rainfall from 2000 to 5000 mm a year. It grows well on poorly drained sites, for example, near streams and drainage depressions, but it can also be grown on better drained sites. It is grown as individual trees and in large groves in primary forest and in woody regrowth and cane grass areas originating from human activity (Stone 1982). It does poorly in open sites and short grasslands. A preliminary study by Rose (1982) indicated some genetic differences between cultivars.

Production is irregular in the western part of the highlands where rainfall seasonality is slight or absent. This is illustrated by the data from Wabag, Mendi, Tari and Oksapmin in Figure 5. In the eastern part of the region (Kainantu and Goroka data), where the rainfall is seasonally distributed, production approximates to an annual seasonal pattern; but there is still large year-to-year variation in the harvest size. In any year, the producing period also varies between locations (Fig. 5). After periods of soil moisture stress or drought, such as occurred in 1979 and 1982, the producing periods coincide at all or most locations. The biggest harvests follow major droughts, such as those of 1941, 1965, 1972 and 1982.

Karuka nuts are very popular among the highlanders and, to a lesser degree, among outsiders. Unlike galip and some of the other lowland nut

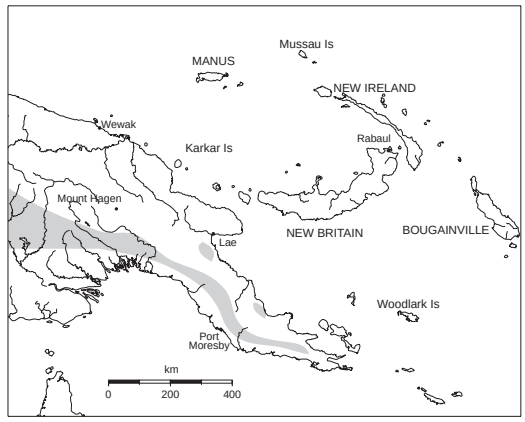
species, most of the available nuts are harvested and consumed. This suggests that commercialisation could harm the quality of tree owners' diets. This aspect requires further investigation before karuka is developed for commercial production. This reservation aside, karuka has considerable potential as a commercial nut within PNG in the 1800–2600 m altitudinal zone, and possibly in other environments that experience seasonal temperature differences.

Okari nut (*Terminalia kaernbachii*)

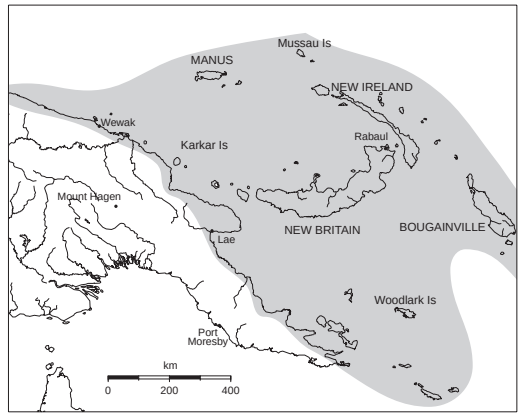
Okari nut has a limited distribution within PNG. It is very common in inland lowland locations on the south side of the central cordillera from the Irian Jaya border in the west to Mt Dayman in the east (Fig. 2). It also occurs in a few inland locations on the northern side of the main ranges; for example, on the Managalas Plateau in Northern Province and in the Menyamya–Bulolo area south of the Markham Valley in Morobe Province. It grows in West New Britain between the Aria River and Cape Gloucester, where villagers say that it is a precontact species. On the northern side of the central cordillera, the closely related nut-bearing *T. impediens* occurs, but it is not as common as *T. kaernbachii* is on the southern side.

Okari nut does poorly near the ocean and grows best in inland lowland and intermediate altitude locations up to an altitude of 1100 m. This may be because salt air has a negative influence on growth, but it is more likely to reflect a positive response to the greater diurnal temperature variation that occurs away from the moderating influence of the ocean. Locations where trees are very numerous and okari nuts are important in villagers' diets include the Kiunga–Nigerum region, the Great Papuan Plateau and the Managalas Plateau. It is more common on flat and gently sloping land than on slopes. It appears to tolerate poor drainage and grows at locations with a wide range in rainfall (2000–7000 mm a year). It is less common in lowland locations in Western Province where the rainfall exceeds 7000 mm a year, suggesting that production may be adversely affected by these extreme conditions.

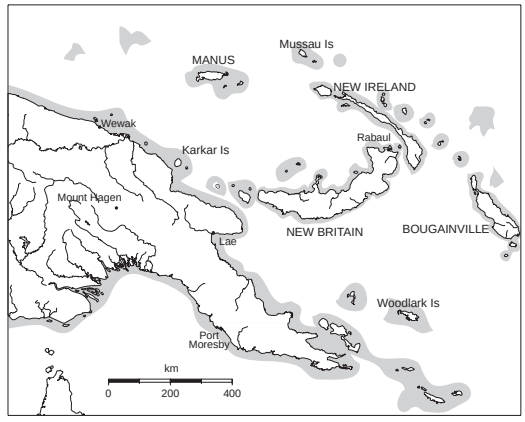
The producing period is quite regular from year to year (Fig. 3) and is independent of rainfall seasonality. As for galip, there is a close



Okari (*Terminalia kaernbachii*)



Polynesian chestnut (*Inocarpus fagifer*)



Sea almond (*Terminalia catappa*)

Figure 2. Geographical distribution of *Terminalia kaernbachii*, *Inocarpus fagifer* and *Terminalia catappa* within Papua New Guinea

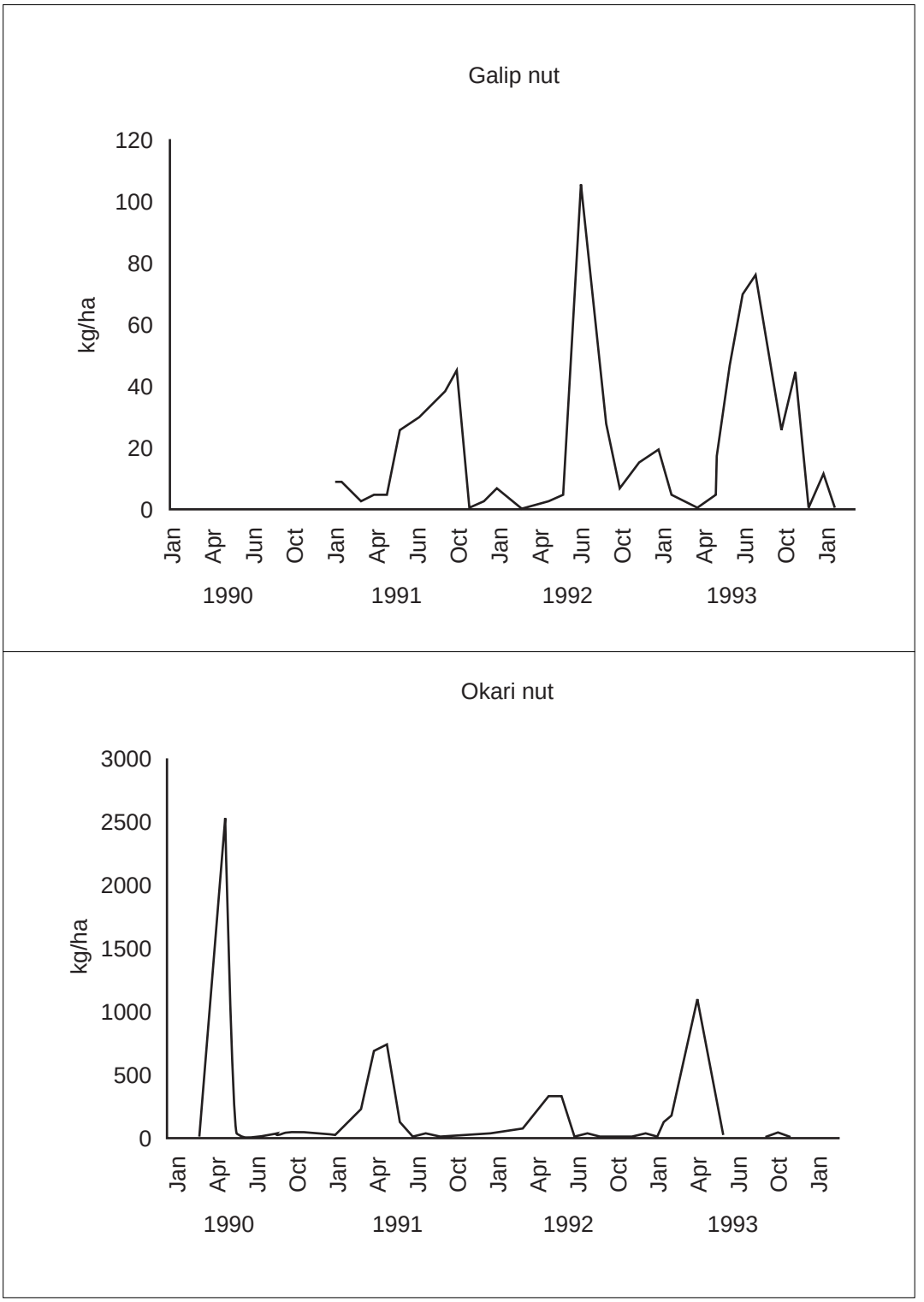


Figure 3. Production (kg/ha) of galip and okari at the Lowlands Agricultural Experiment Station, Keravat, January 1990 to March 1993 (Source: S. Woodhouse, pers. comm.)

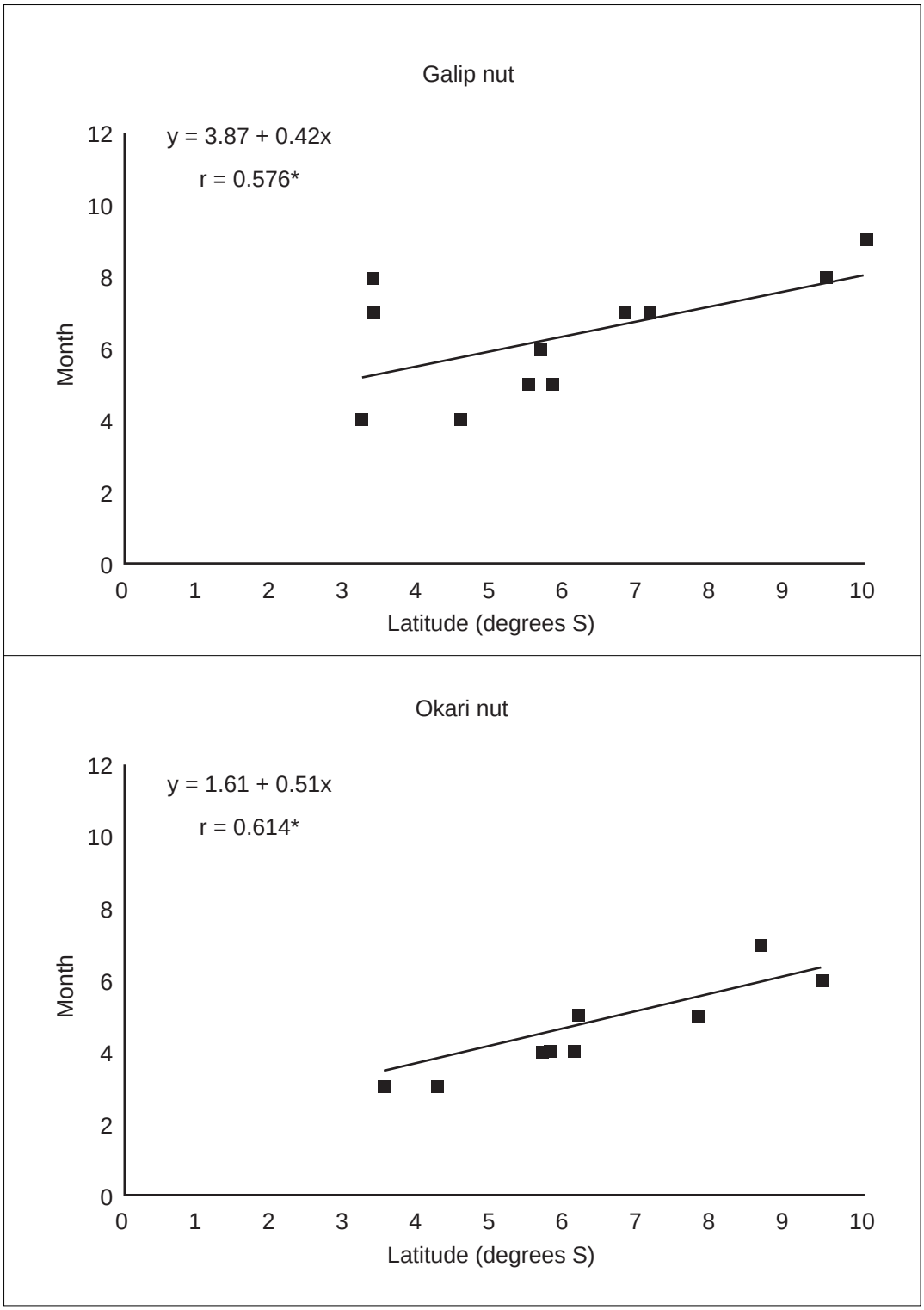


Figure 4. Start of the harvesting season (month) of galip and okari nuts at various locations in Papua New Guinea versus latitude (Source: Bourke et al. 1996)

relationship between the start of the producing period and latitude. For example, production starts in March or April at 3°–4° S and in June or July at 8°–9° S (Fig. 4). This suggests that flowering is initiated by seasonal changes in day length rather than by temperature or rainfall. Trees at Keravat in New Britain, grown from seed from the Northern Province, show large variation in nut and kernel characteristics (Aburu 1982, p. 126).

Okari nuts are popular in Port Moresby and other urban centres in the producing region. Given the extensive stands in many locations in southern New Guinea, it is likely that only a proportion of the available nuts is consumed by local villagers each year. Hence prospects for commercial development from existing trees are very good. Okari nut is now being grown at locations in PNG distant from its traditional distribution and there are good prospects for extending cultivation to other inland lowland and intermediate altitude locations.

Polynesian chestnut (*Inocarpus fagifer*)

Polynesian chestnut is widely distributed in the lowlands on the northern side of New Guinea and on all island groups (Fig. 2). On the New Guinea mainland it is usually only of minor significance; it is more important in the Bismarck Archipelago; and it is most important on the islands and mainland of Milne Bay Province. In the MBP islands, it is an important dietary component during the harvesting season, although it was probably more important before the adoption of sweet potato and cassava. It grows from sea level to 500 m altitude in coastal and near-coastal locations, usually near villages or in woody regrowth. It also grows in the foothills on the New Guinea mainland, possibly at higher altitudes.

In MBP three researchers reported the producing season from 17 locations as about November to February, but statements by villagers and researchers about the producing period for other islands in PNG are not consistent. It is possible that production is not strictly seasonal, but further data are required to test this.

The nut is not popular with people from outside the islands where it is commonly grown. Prospects for commercial development are only moderate.

Sea almond (*Terminalia catappa*)

Sea almond is widespread in most coastal regions of the New Guinea mainland and islands (Fig. 2). It is usually confined to beach areas and village sites near the beach, but it occasionally grows at up to 400 m altitude. Most trees are self-sown. In most of PNG, nuts are eaten occasionally by children or not at all. However, it is more important in the islands of MBP where both children and adults eat the nuts. One island, Iwa in the Marshall Bennett Group, is renowned for its soft-shelled nuts. They are preserved there by smoking and exported to nearby islands such as Woodlark. Unfortunately, population pressure on Iwa is intense, with a population density of more than 300 people per km^2, and fruit and nut trees are being cleared for arable subsistence agriculture.

The producing period occurs some time between November and March, with December to February the most commonly reported period. The limited available data suggest that the period is fairly constant from year to year. Prospects for commercial development are reasonably good, particularly if cultivars with soft shells and large kernels are selected.

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Steve Woodhouse provided unpublished data on galip and okari nut; numerous observers reported on karuka production. Patricia Hobsbawn assisted with preparation of this paper. Jean Bourke and Geoff Humphreys commented on an earlier draft. Their assistance is acknowledged with thanks.

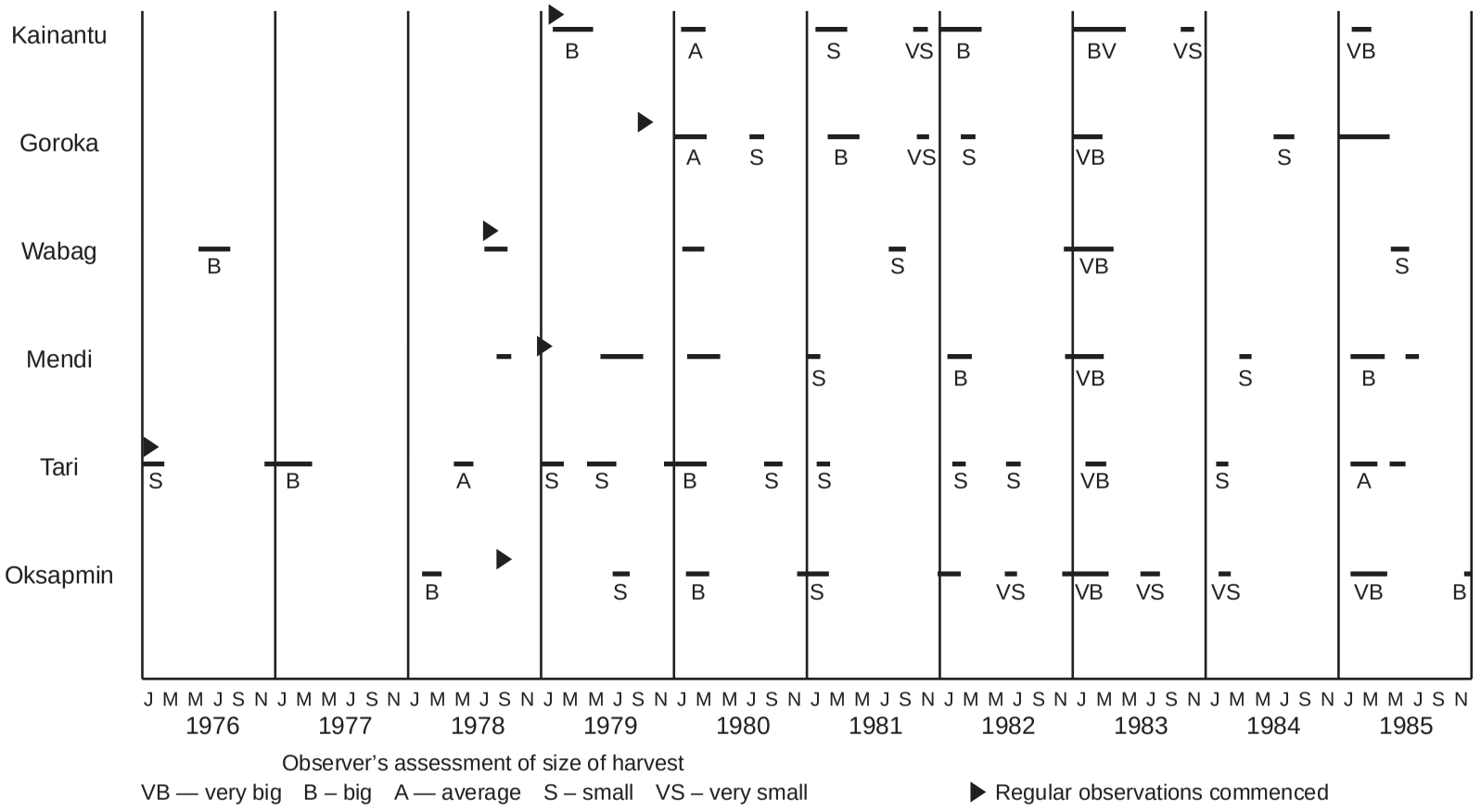

Figure 5. Harvesting periods of karuka nut pandanus at six highland locations, 1976 to 1985. (Source: Bourke et al. 1996)

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Indigenous Nut Trees in Vanuatu: Ethnobotany and Variability

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ARBORICULTURE is known to have been one of the major components of subsistence agriculture in island Melanesia (Kirch 1989; Yen 1974), and fruits and nuts are a major part of this. Vanuatu has one of the largest gene pools of oceanic fruit and nut species: many have been grown and eaten since prehistoric times.

Twenty-one nut tree species have been identified in Vanuatu (Table 1), excluding palm trees, shrubs, lianas and breadfruit (which is used mainly for its pulp and only very occasionally for its nuts in Vanuatu).

Many indigenous nut species in Vanuatu have a wide geographical distribution on all oceanic islands from Indo-Malesia towards the Marquises. Some are known to have been introduced by aborigines into the central Pacific, and others have been distributed by sea currents. Among these widely distributed species are *Adenanthera pavonina*, *Aleurites moluccana*, *Cordia subcordata*, *Neisosperma oppositifolia*, *Inocarpus fagifer* and *Terminalia catappa*. A few edible species, namely *Barringtonia*, *Canarium* and *Finschia chloroxantha*, have a narrower distribution and do not occur east of Vanuatu and Fiji.

Only seven species in Vanuatu are commonly cultivated around villages or gardens, or are protected and tended. These are *Barringtonia edulis*, *B. novae-hiberniae*, *B. procera*, *Canarium harveyi*, *C. indicum*, *Inocarpus fagifer* and *Terminalia catappa.* They all play an important part in the diet and all show wide variability within and between species. This paper focuses on these seven species because they represent potential economic resources for Vanuatu.

Besides these species, there are minor nuts that are occasionally eaten, mostly by children or in famine time. They may be tended by local communities for another use, such as cordage, basketry, rattles, house construction or light. This paper briefly reviews these minor species as well.

From 1991 to 1994 ORSTOM (the French Institute of Scientific Research for Development in Cooperation) studied indigenous fruit and nuts in Vanuatu for the Vanuatu Department of Agriculture. Information collected will allow future development of the species and the simultaneous conservation of the environment .

All the results presented here were collected during a two-year survey of 20 areas in Vanuatu. A list of vernacular names for practically all the kinds (morphotypes) of *Barringtonia*, *Canarium*, *Inocarpus* and *Terminalia* present in each area was established first with the local community, then trees were found. A total of 346 trees was tagged.

The figures given do not represent the real genetic diversity or even the true numbers of botanical varieties. They give the number of morphotypes recognised in a given area by the local people. The names of the morphotypes in each area are either a real local name or a descriptive one (for example, green fruit, small fruit). Names tend to be consistent in an area for the most common morphotypes but not for the rarest ones.

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Table 1. Nut tree species in Vanuatu.

Species	Origin	Status	Main use	Food
Adenanthera pavonina L.	Ia	W	beads	not eaten
Aleurites moluccana (L.) Willdenow	In	T	light	toxic if > 2–3 eaten
Barringtonia edulis (Miers) Seemann	N	C; T	food	regular
Barringtonia novae-hiberniae Lauterbach	N	C; T	food	regular
Barringtonia procera (Miers) Knuth	N	C	food	regular
Canarium harveyi Seemann	N	C; T	food	regular
Canarium indicum L.	N	C; T	food	regular
Canarium vitiense Gray	N	W	timber	children?
Castanospermum australe Cunn. et Frazer ex Hook.	In	W	timber	toxic
Cordia subcordata Lamarck	N	W	carving; posts	famine; children
Elaeocarpus chelonimorphus Gillespie	N	W		occasional
Finschia chloroxantha Diels	N	T	food	occasional
Gnetum gnemon L.	Ia	T	food	occasional
Inocarpus fagifer (Park. ex Zoll.) Fosberg	N	C; T	food	regular
Neisosperma oppositifolium (Lamk.) Fosberg et Sachet	N	W	post	famine; children
Pandanus dubius Sprengler	N	W; T	basketry	occasional
Pandanus tectorius Parkinson	N	C	basketry	occasional; children
Pangium edule Reinwardt	In	T	rattle	toxic; famine
Sterculia vitiensis Seemann	N	T	food	regular
Terminalia catappa L.	N	T; C	food; shade	regular
Terminalia samoensis Rechinger	N	W		children

N: native
Ia: aboriginally introduced
In: aboriginally introduced or native
W: wild
T: tended
C: cultivated

Barringtonia spp.

Family: Lecythidaceae
French name: La velle (vellier)
English name: Cut nut

Three *Barringtonia* species occur in Vanuatu: *B. edulis*, *B. novae-hiberniae* and *B. procera*. *B. procera* seems to be more abundant on the north-west islands; *B. novae-hiberniae* is restricted to the north, being particularly abundant on the islands of Emae, Epi and Ambrym; *B. edulis*, present throughout the islands, becomes the main or only species in the southern part of Vanuatu (Table 2).

Table 2. Geographical distribution of *Barringtonia* in Vanuatu. Numbers indicate percentage proportion of each of the three species present. Islands or groups are listed from top to bottom in approximately their north to south distribution.

Island or group	*B. procera*	*B. edulis*	*B. novae-hiberniae*
Torres	42	43	15
Banks	54	46	0
Maewo and Pentecost	31	43	26
Malo and Malakula	63	32	5
Ambrym	29	6	65
Epi and Emae	8	21	71
Efate and Nguna	26	65	9
Tanna	0	100	0

1	Calyx entire, fruits pedunculate	*B. novae-hiberniae*
1*	Calyx splitting into 2–4 lobes, fruits sessile or pedunculate	2
2	Petiole 0–1 cm, fruits sessile	*B. procera*
2*	Petiole greater than 1 cm, fruits pedunculate or sessile, buds and flowers not very congested	*B. edulis*

Figure 1. Key to the edible species of *Barringtonia* used in Vanuatu (adapted from Jebb 1992)

Taxonomy and description

The first revision of the genus (using herbarium specimens) was done by Payens (1967). The last revision of edible barringtonias was done by Jebb (1992), who reviewed those of PNG (using herbarium specimens and field observations). The key determination given by Jebb is based on the size of the apical pore of the buds, on the way the calyx splits and on the fruit attachment (sessile or pedunculate).

We have encountered some difficulties in using Jebb's key, in which all the *Barringtonia* fruits except those belonging to *B. novae-hiberniae* are sessile. We have observed that Vanuatu *B. edulis* fruits can be sessile or pedunculate. So the key used for determination of Vanuatu *Barringtonia* is a modification of Jebb's key (Fig. 1).

It was possible to classify 155 of 170 tagged trees. *B. procera* is easy to identify. The tree has few branches, long, densely clustered, sessile leaves, minutely open calyx pore in bud, which clearly splits into two or three lobes, and octagonal fruits. Typical *B. edulis* trees have a larger crown, less clustered leaves with a short petiole (more than 1 cm), leaves narrowing at the base (inferior third), more or less open calyx pore in bud, which splits into three or four lobes, and ovoid pedunculate or sessile fruits. Typical *B. novae-hiberniae* trees have a large crown, smaller flat leaves, long petiole, large open calyx pore in bud, which does not split into lobes, and round pedunculate fruit.

Each morphological character may vary within each of the species, and 15 trees could not be classified. Some look obviously like hybrids of *B. edulis* and *B. novae-hiberniae*, but others remain indeterminate. *B. edulis* on Tanna looked more homogeneous than in the other islands: the fruits are ovoid, parallel-sided and pedunculate.

The main characteristics of each species are given in Table 3. In Vanuatu, *B. novae-hiberniae* fruits are rounder than in Solomon Islands, and *B. procera* fruits are longer. The length of *B. edulis* decreases from PNG to Tanna. The bigger kernels are found among *B. procera*, the smallest among *B. novae-hiberniae*.

Within each species it is possible to distinguish some groups of morphotypes according to fruit shape, size and colour. Edible barringtonias, especially *B. edulis*, are the most variable nut trees in Vanuatu. Generally the seedlings are not exactly the same as the mother tree.

Table 3. Main characteristics of edible species of *Barringtonia* in Vanuatu (figures in parentheses from the Solomons for comparison, Evans 1991).

		B. edulis		*B. procera*		*B. novae-hiberniae*	
		Vanuatu	Solomons	Vanuatu	Solomons	Vanuatu	Solomons
Fruit	length (mm)	78(150)	86(106)	77(130)	65(70)	65(90)	86(99)
	width (mm)	51(60)	44(47)	44(61)	43(48)	53(67)	42(50)
	circum. (mm)		145(160)		142(160)		134(170)
Kernel	length (mm)	37(50)	44(54)	38(60)	35(40)	32(50)	45(55)
	width (mm)	22(30)	23(25)	24(38)	23(30)	21(35)	20(25)
	circum. (mm)		78(80)		70(76)		50(50)

Intra-species variability in fruit shape

B. procera is divided into two groups:

- cylindrical fruits, equal to or longer than 80mm. These occur in the north of Vanuatu (Torres, Banks)
- ovoid fruits shorter than 80 mm, present from the Solomons to Vanuatu.

B. edulis is divided into two groups:

- long sessile fruits, equal to or longer than 90mm. They often have a very long but poorly productive inflorescence, up to 1 m long
- ovoid fruits, usually but not always pedunculate. These are the more common.

B. novae-hiberniae is homogeneous, with ovoid or spherical fruits.

Intra-species variability in fruit colour

Eleven 'forms' can be distinguished on fruit colour across the three species. Each 'form' can occur in more than one species. Table 4 shows a clear predominance of an entirely green form (VVBB). *B. procera* is the only species to have a form with a red endocarp. (This character is exceptional in *B. edulis* and not present in *B. novae-hiberniae*). *B. novae-hiberniae* is the only species to have a form with a red mesocarp while all the other structures are green. Apart from the red endocarp of *B. procera*, the colours of the fruit parts seem more likely to be related to parentage than to species.

Some forms of interest are:

- a dwarf tree of *B. procera*
- fruits with a thin pericarp, easy to open, in each species
- cultivars of *B. edulis* and *B. novae-hiberniae* with dark red leaves, very beautiful as ornamentals
- a cultivar of *B. procera* that bears fruit at less than four years
- some cultivars of *B. procera* and *B. edulis* that can be propagated by cuttings
- cultivars in each species with a huge kernel.

Table 4. Forms of *Barringtonia* spp. according to the colours of the fruits.

Colour	*B. edulis*	*B. procera*	*B. novae-hiberniae*	Total
RRBB	5	0	5	10
RRRR	0	1	0	1
RVBB	18	0	9	28
RVBR	1	2	0	3
RVRB	5	2	0	7
RVRR	0	6	0	6
VRBB	1	0	0	1
VVBB	17	14	12	43
VVBR	0	2	0	2
VVRB	0	0	3	3
VVRR	1	10	0	11
Total	48	37	29	115

Numbers are of specimens observed per species.
V = green (vert)
R = red (rouge)
B = white (blanc)
First letter = colour of epidermis
Second letter = colour of exocarp
Third letter = colour of mesocarp
Fourth letter = colour of endocarp

Growth and development

A survey of barringtonias was conducted during 1993 and 1994 to determine when the species flower and fruit. The results are not easy to interpret and are subject to bias, but they show the main features of flowering and fruiting.

In a given area, the trees of any one species do not all flower and fruit at exactly the same time. The continual selection of the cultivars has progressively extended the length of flowering and fruiting or has started to synchronise it. *B. procera* trees show some synchronicity in flowering and fruiting and generally bear fruit twice a year in Vanuatu. The trees have few inflorescences but all of them are loaded with fruits. The fruits of *B. novae-hiberniae* ripen throughout the year without showing any synchronous pattern.

B. edulis flowers and fruits twice a year. This seems to depend on latitude: there is a two to three month delay from north to south. Some cultivars have a very long inflorescence that bears barely three or four fruits because the fragile flowers drop before fruit set.

The three species are very tolerant to cyclones and are the first trees to flower after a cyclone has struck. The flowers are pollinated by bees, wind and maybe some other insects. Trees are

attacked by the rose-beetle, which can rapidly destroy them.

Propagation and planting of edible barringtonias

Barringtonia novae-hiberniae is relatively shade-tolerant and can be found in the forest. It grows spontaneously, needs little care and bears many times a year. Its relatively small inflorescences are loaded with fruit. It is rarely pruned. *B. edulis* can also grow spontaneously but it is more often cultivated. *B. procera* is mainly a cultivated tree, not shade-tolerant and needing more care. It is often pruned.

The edible barringtonias have been cultivated for centuries in Vanuatu. The trees, especially *B. procera*, are small and fit easily within the village. Usually every family plants some *Barringtonia* trees near its house to provide nuts for the children. Other trees are planted along pathways, inside coconut plantations or near gardens. The villagers plant a mature fruit or, sometimes, transplant a young seedling.

Vanuatu people love to gather a full collection of *Barringtonia* cultivars in one place, generally in the village. So diversity is encouraged and protected. In most areas, a single term covers the three edible species. Then a second name is added to the first one in order to distinguish the different cultivars.

Uses

Traditionally the nuts are eaten fresh, but can also be boiled or roasted on the fire. Nuts can be seen in the markets. In Gaua, the nuts are preserved by smoking. The tree also has medicinal uses.

Conclusion

The botany of all the edible barringtonias has to be reviewed using information for all of Melanesia, as Evans (1991) has pointed out. *B. edulis* is the most abundant nut tree in Vanuatu and one of the most variable. Between a typical *B. procera* and a typical *B. novae-hiberniae*, all the morphological intermediates can be found. The research priorities for this species, apart from a taxonomic review, are a study of the floral biology and a study of the yield per tree in each species. The bigger fruits are found within *B. procera* and the inflorescence of this species is loaded with fruits. However, the inflorescences are not numerous and it is not clear which species is, in fact, the most productive.

The three species look to be good candidates for development, mainly because the trees are very abundant, are small enough not to occupy a lot of space and tolerate cyclones well. They are also the favourite nuts of the Vanuatu people.

Canarium spp.

Family: Burseraceae
French name: La nangaille (nangailler)
English name: Canarium nut

There are two main species of edible *Canarium* in Vanuatu: *Canarium indicum* L. and *C. harveyi* Seemann, which has two botanical varieties, *C. harveyi* var. *harveyi* and *C. harveyi* var. *nova-hebridiense*. Some intermediates between the two can be found and we believe that the taxonomy of *C. harveyi* varieties has to be reviewed.

C. indicum is present in all the islands from Torres group to Efate. It is rare in Erromango and in north Tanna and absent in south Tanna. *C. harveyi* is less common, but is still abundant in the Banks–Torres group (mainly var. *nova-hebridiense*), in Erromango (var. *harveyi*) and in Emae, Tongoa and Shepherds (with a lot of intermediate forms between var. *harveyi* and var. *nova-hebridiense*).

Taxonomy and description

The botanical review of the genus was completed by Leenhouts (1955, 1959). The determination of the species is based upon stipule and fruit morphology.

C. indicum has a big leafy stipule arising from the junction between branchlet and petiole, four or more pairs of leaflets and the nut-in-shell showing three developed locules in transverse section. *C. harveyi* has an auriculate small stipule arising directly from the petiole (at 1 cm from the junction of petiole with branchlet), fewer than four pairs of leaflets and a nut-in-shell showing one developed locule and two virtual ones in transverse section.

In the field it was quite easy to distinguish the two species. It was more difficult, however, to determine botanical varieties of *C. harveyi*.

Table 5. Main characteristics of edible *Canarium* in Vanuatu (figures in parentheses from the Solomons for comparison, Evans 1991)

		C. indicum		*C. harveyi*	
		Vanuatu	Solomons	Vanuatu	Solomons
Fruit	length (mm)	54(80)	56(75)	49(60)	66(90)
	width (mm)	37(46)	36(45)	33(42)	40(52)
	circumference (mm)		113(150)		112(40)
Nuts-in-shell	length (mm)	39(49)	47(62)	42(54)	61(80)
	width (mm)	26(34)	27(35)	29(38)	33(40)
	thickness (mm)	23(30)		21(27)	
	circumference (mm)	81(115)	82(110)	81(99)	84(110)
Kernel	length (mm)	31(45)	35(45)	29(37)	42(55)
	width (mm)	19(25)	18(23)	20(25)	25(30)
	circumference (mm)		46(60)		60(72)
K:N ratio		19(22)	16(27)	21(24)	24(32)
Shape	broad	45%	20%	42%	4%
	elongated	3 trees	20%	0%	36%

Among the 99 tagged and described trees there are 63 *C. indicum* and 36 *C. harveyi*. The main morphological characters of both species in Vanuatu are given in Table 5.

Intra-species variability

Many specimens of *C. harveyi* were difficult to classify into varieties. We could not observe accurate morphological differences in vegetative organs. The main differences occurred in the morphology of nut-in-shell. Following the nut-in-shell shape we have identified two varieties (var. *nova-hebridiense* and var. *harveyi*). The specimens of *C. harveyi* found in Shepherds, however, are less typical and could not be assigned to either of these varieties. It is probable that these varieties do not really exist and that a full collection of *C. harveyi* samples would show a modal distribution. The intense cultivation of *C. harveyi* in Solomon Islands, Santa Cruz and north Vanuatu has certainly created big fruits and nuts-in-shell whose morphology differs slightly from the more triangular and small wild forms of south Vanuatu (Erromango) and Fiji.

The cultivars of *C. indicum* found in Vanuatu usually have broader nuts-in-shell than the ones found in the Solomons (Evans 1991): 45% of nuts in Vanuatu and 20% in the Solomons are broad. In fact, following the classification of Evans (1991), only three Vanuatu morphotypes can be said to be elongated, and half remain unclassified.

This is not to say, however, that *C. indicum* in Vanuatu is homogeneous. The continuous cultivation of *Canarium* in Vanuatu has created many cultivars. We are currently studying statistically the *C. indicum* nut-in-shell, trying to sort out a formula that can reveal some groups of cultivars. The first results, however, from more than a thousand nuts from different trees and measuring length, width, thickness and circumference, have shown a normal and modal distribution of the nuts. Different morphotypes do occur within the species, however, and the good ones would be reproduced only by asexual reproduction.

The nuts of *C. indicum* are often very variable within a single tree. We have also noticed, in both species, up to 12% sterile nuts. This percentage reaches 34% after cyclone stress.

Some cultivars are of interest:

- In Vanuatu, *C. indicum* fruits are bigger than *C. harveyi* fruits, but the nut-in-shell of *C. harveyi* is larger and its kernel to nut (K:N) ratio is higher.
- Some *C. indicum* trees have a big kernel and

high K:N ratio. The best ones occur on the southwest coast of Malakula, where the people cultivate *C. indicum* intensively and have selected as many as 20 different cultivars. There are good *C. harveyi* trees in Banks and trees of both species are numerous and of good quality in Maewo.

- The shell of *C. harveyi* is usually more easy to open than the shell of *C. indicum*, but 11 cultivars of both species have an easy-to-open shell, which splits easily in two parts.
- A *C. indicum* cultivar on Maewo produces fruits continuously throughout the year.
- Some *C. indicum* cultivars on Malakula (South West Bay) are very productive, bearing inflorescences with up to 40 fruits.
- A *C. indicum* cultivar on Emae has yellow fruits and yellowish leaves.
- A *C. indicum* cultivar on Maewo has deep yellow and white kernels mixed in the same shell (two nuts in one shell).
- A *C. harveyi* cultivar on Maewo has a three-seeded nut.

Growth and development

In Vanuatu both *Canarium* species are polygamo-dioecious. Every tree bears hermaphrodite flowers and male flowers or hermaphrodite flowers and female flowers. The proportion of hermaphrodite flowers and unisexual flowers varies considerably from one tree to another (in a given season). We do not know whether this proportion varies from season to season. The productivity in a given season varies considerably from one tree to another, ranging from numerous inflorescences loaded with up to 40 fruits to poor inflorescences with two to six fruits. Unproductive male trees are very rare in Vanuatu: we found only one or two during our survey.

Both species fruit between October and January; there is a peak in November. A mini-season may occur around May–June, particularly for *C. harveyi*.

Propagation and planting of *Canarium*

The two species are widely cultivated and grow near villages, along pathways and near gardens. Because of the trees' large corona, they are not usually planted directly in the village. They also grow in forest, either spontaneously or in old settlement areas.

Canarium has been cultivated in Vanuatu for many years, as *Barringtonia* has been. The two *Canarium* species are always called by a single name, which 83 times out of 90 is a form of the Proto-Vanuatu word *ngai*. The same word is also found in some languages of the Solomons, Fiji and Samoa.

Canarium trees are propagated by fruit-bats, which eat the flesh, and sometimes by birds, which swallow the small fruits whole. It is possible that propagation by birds was more frequent in ancient times, when the fruit was smaller than today's cultivated fruit. The men transplant young seedlings or plant a mature dry nut-in-shell or a mature fruit in a small hole. Trees are transplanted near the villages for their edible kernels. Many trees are left in the forest to be used for their wood. Usually those trees have small fruits.

Uses

Canarium nuts are an important food of Vanuatu communities. They are eaten fresh or roasted. They are oily and are often sprinkled on tuber pudding, especially *C. harveyi*, which is the oiliest. In the Banks group they are smoked and then kept for many months on baskets hung over the fire. They are sold at market. The wood is used for artefacts and canoe building.

Conclusion

The taxonomy of *C. harveyi* has to be reviewed. A precise floral biology survey and agronomical research are needed. Canarium nuts, particularly *C. indicum*, remain the best candidate for development: there is a big population of trees in Vanuatu and many nuts are not used because production is higher than consumption.

Inocarpus fagifer (Parkinson ex Zollinger) Fosberg

Family: Fabaceae
French name: La châtaigne de Tahiti (châtaignier de Tahiti)
English name: Polynesian chestnut

Inocarpus fagifer is a well known species in the

Pacific. Its distribution ranges from Indo-Malesia to east Polynesia. The species is rare in Java and becomes abundant in the Moluccas and the eastern islands of Indonesia. It is found throughout Vanuatu but seems to be more abundant in the southern part.

Taxonomy and description

It is a medium tree of around 10 m high in Vanuatu but higher when it is not pruned. The trees are usually strong and prolific. The fruit is a large, flat pod, variable in shape and colour, pedunculate and about $9 \times 7 \times 4$ cm. It contains an edible seed of 7×5 cm that must be cooked before being eaten.

Intra-species variability

The species is highly variable in fruit size (5–13 cm long by 3–13 cm wide), shape, colour and taste. Each community recognises an average of six (up to 18) different cultivars, all named specifically, and many unnamed cultivars. In fact, the variability of the fruit is so high that it is difficult to find two identical trees.

However, within this diversity, we have been able to sort out four particular groups of cultivars:

- those with a quadrangular, asymmetrical fruit (these are the most common)
- those with a hooked or crescent-shaped fruit
- those with an orange-red fruit
- those with a pale yellow, small round fruit.

The first two are present on all the islands. The last one occurs only on Ambae, Ambrym, Santo and Tanna.

Some other cultivars have very big fruits (> 10 cm) or very small ones (< 6 cm).

Growth and development

Fruiting occurs between January and April. Some trees bear fruit out of season.

Propagation and planting

Today Polynesian chestnut trees are planted near villages, usually in small groves of useful trees, near gardens or in coconut plantations. The trees are very vigorous and shade-tolerant. Germinated seedlings are plentiful but are usually not allowed to grow in order to keep the area clear around the trees and to make the gathering easier. Propagation is done by planting a mature pod or by transplanting a young seedling.

Although the cultivation of Polynesian chestnut is common today, all the villagers claim that it has declined.

Uses

Polynesian chestnuts are eaten boiled, after they have been taken out of their pods, or roasted directly in the pod. They used to be dried or were preserved in huge pits. They are also sprinkled on tuber pudding. They are an essential food in February and March when yams are in short supply. The taste is reminiscent of chestnuts and varies from one cultivar to another.

Terminalia catappa L.

Family: Combretaceae
French name: La badame (badamier)
English name: Sea almond

Terminalia catappa is the only edible species of the genus in Vanuatu, apart from *T. samoensis*, which is edible but too small to be attractive to consumers.

Taxonomy and description

The taxonomy of *Terminalia* has been given by Exell (1954), Van Royen (1964), Coode (1969 and 1973), Smith (1981) and more recently Evans (1991).

In Vanuatu it is a medium tree to 15 m with characteristic horizontal branching. The fruits are flattened or globulous, yellow, brownish or bright red at maturity, $42–90 \times 30–64$ mm. They bear an elongated, small edible nut (up to 47 mm long on cultivated trees; up to 32 mm long on wild trees) in a hard shell.

Varieties

The variability of the species is very high, according to fruit size, shape and colour, but the villagers in any given area do not differentiate more than three or four cultivars.

There are two groups of morphotypes. The first one, often wild or spontaneous, grows near the shore. The trees have smaller leaves, less clustered toward the top of the branches, and smaller, ovoid, bright red fruits. They bear fruit throughout the year.

The second one, often cultivated, grows near villages at up to 400 m altitude. The trees have bigger fruits, which can be brownish yellow or brownish red, with a glossy skin or a spotted rough skin, and flattened or subglobose, broad or more elongated, round or hooked.

Usually the cultivated trees, which can also belong to the first group, have bigger fruits than the wild ones, but the variability of fruit size is greater among the wild ones. The kernel is always bigger in the cultivated forms.

In both groups, morphotypes with a thin shell that is easy to open can be found.

In the Solomons, *Terminalia catappa* fruits seem to be bigger and less variable than in Vanuatu.

Growth and development

Flowering and fruiting occur throughout the year, but the flowering and fruiting of cultivated trees seem to be more synchronous. Flowering peaks around October to January and is followed by fruiting around March to June.

Propagation and planting

In the coastal areas, where the sea almond tree is abundant, the villagers do not really cultivate the species. They usually allow the big fruited trees to mature and often destroy the others. In the villages away from the shores, where the species is less abundant, the villagers protect the trees and transplant the young seedlings or plant mature fruits of good cultivars found near the coast.

On the whole, *Terminalia* is not really a cultivated tree but rather a tended one.

Uses

The sea almonds are eaten fresh. They are rarely roasted or sprinkled on tuber pudding. They are often sold at market. They are a very popular nut, regularly eaten in Vanuatu.

The species has many other uses. It is a good timber and, traditionally, the wood was used in canoe building and artefacts; leaves and bark were used in traditional medicine.

Adenanthera pavonina L.

Family: Fabaceae
French name: La cardinale (cardinalier)
English name: Coral pea

The seeds of this species are eaten in Indonesia and the central Pacific, but not in Vanuatu. Nielsen (1983) recognises two varieties within the species (var. *pavonina* and var. *microsperma*). It is possible that one of them is edible but the other is not. Which variety is present in Vanuatu is unclear.

Aleurites moluccana (L.) Willd.

Family: Euphorbiaceae
French name: La noix de Bancoul (bancoulier)
English name: Candlenut

In Vanuatu the species is not frequent but is present in all islands. It is a wild tree, 10 to 15 m high, with ovate or trilobate leaves (10–20 cm) and many small white flowers in panicles. The fruit is globose, 3 to 6 cm long, with one or two oily seeds. When eaten raw and in quantity the seeds produce nausea and vomiting, although two or three nuts can be eaten without ill effect. There are in fact two varieties: one moderately poisonous, present in Vanuatu, and a non-poisonous one, introduced from the Solomons. There are few trees of this second variety in Vanuatu.

The nuts contain oil that can be used as cosmetic and for varnish and paint. Traditionally the nuts were threaded on a small twig and will produce light while burning. In Vanuatu, the species may be developed for its oil, but the trees are not numerous.

Castanospermum australe Cunn. A.

Family: Fabaceae
English name: Moreton Bay chestnut

The species, indigenous to northern Australia, has probably been introduced in Vanuatu. The seeds are usually poisonous without proper preparation and are never eaten in Vanuatu. However, one community in north Efate occasionally used to eat the roasted nuts, with some ill effect (vomiting). It is essentially a hardwood timber with no obvious economical potential.

Cordia subcordata Lamarck

Family: Boraginaceae
English name: Sea trumpet

Small tree, up to 15 m high, bark peeling in rectangular flakes. Simple leaves, oval or slightly cordate, light green, 6–8 × 9–16 cm, four to six pairs of veins, long and thin petiole (4–8 cm). Orange flowers, 2–4 cm. Fruit initially green (2–3.5 cm) with a sharp apex, then light yellow and brown when maturing. The fruit is very hard with 1–2(4) tiny edible seeds.

The children like to cut the fruit and to eat these little seeds. In famine time the adults may rely on them. The species is used mainly for its wood and was an important cultural plant of the ancient Oceanians. Today, the tree population has considerably decreased and the remaining trees are tended for shade.

Elaeocarpus chelonimorphus Gillespie

Family: Elaeocarpaceae

Present on some islands with deep forest, the species is not frequent. In Vanuatu it is a medium tree (10–20 m high) with a straight bole. The leaves are elliptic, variable in size (8.7–13.5 × 3.2–6 cm), glossy above. Small greenish flowers (1 cm length). Fruit yellow 2–3.8 × 1–2 cm with a long peduncle (5 cm). The seeds are occasionally eaten raw. The species has no obvious economic potential.

Finschia chloroxantha Diels

Family: Proteaceae
French name: Le chrysocarpe (chrysocarpier)
English name: Finschia

This handsome forest tree occurs in PNG, the Solomons, Vanuatu, the Aru Islands and Palau. In Vanuatu it is a medium-size tree (up to 20 m) with simple lanceolate leaves, 8–25 × 2–7 cm, bright yellow pendulous inflorescence (20–30 cm long), bright yellow or orange mature fruit, round and slightly flattened (3 × 2 cm). The hard endocarp contains one or two edible and delicious nuts, circular and flattened.

The tree has been observed in Banks, Maewo, Malo, Pentecôte, Malakula, Ambrym, Tongoa, Emae, Paama, Erromango, Tanna and Aneityum. It is infrequent but tended, rarely transplanted or planted. Its pendulous long yellow inflorescence and its bright yellow or orange fruits are easily distinguishable in the forest.

The nuts are eaten raw or roasted.

The tree could represent a good candidate for future development as both an ornamental and a nut tree, but numbers would have to be increased. The species also occurs in Papua New Guinea and Solomon Islands, where it seems to be more abundant.

Neisosperma oppositifolium (Lamarck) Fosberg et Sachet

Family: Apocynaceae
English name: Twin apple

The species is widely distributed by sea currents from the Seychelles to Sri Lanka and from the Andaman Islands to Tahiti. In Vanuatu, it is a small tree, 10 m high. The leaves are clustered 3 or 4 in a circle, obovate, narrowing around the inferior third of the leaf. The leaf is dark green and shiny, with many parallel side veins. The latex is abundant. The flowers are clustered on dense panicles. Fruits ovoid, flattened, hanging in pairs, with an oval nut and two very flat seeds inside.

It is a wild tree found near the shore, never tended or planted. The very flat seeds are eaten by children or in time of famine. The leaves are burned to produce an ash used to poison fish. The wood is of little use.

Pangium edule Reinwardt

Family: Flacourtiaceae

Present from Southeast Asia to Vanuatu, through Indonesia, New Guinea and the Solomons; also in Micronesia. It is a high tree, up to 30 m in Vanuatu, buttressed. Simple leaves, large, 18–22 × 16–17 cm, oval or cordate, shiny green, with four pairs of lateral veins, lobate on sapling; long petiole (14–15 cm), flowers dioecious, greenish white. Fruit pyriform, ovoid, large, up to 15 cm long, with a rough brown skin, creamy flesh and enclosing many hard seeds, flattened, 2–5 cm long, with a thick aril.

The seeds are edible after a long preparation including long soaking in water and roasting. It

is a well known famine food in Vanuatu. But the seeds are used mainly as rattles and the tree is often cultivated for this purpose. The wood is rarely used, being of a poor quality.

Sterculia tannaensis Guillaumin

Family: Sterculiaceae

Endemic species of Fiji and Vanuatu. Big tree up to 30 m with a long and straight bole. Large palmate leaves, with seven to nine sessile leaflets, oblanceolate, 10–16 × 3–6 cm each; small yellow flowers on terminal panicle, 20 cm long. The large fruit, 8–10 cm in diameter, is a kind of green capsule becoming brownish yellow at maturity. Around the fruit runs a circular groove that splits at maturity. The black seeds (1–2 cm long) are borne along the margins of this capsule.

The tree has been observed in Maewo, Malakula, Malo, Pentecôte, Santo, Tongoa, Efate, Erromango, Tanna and Aneityum. It is a cultivated tree, moderately abundant.

The seeds, roasted before eating, are edible and frequently consumed in season. The tree also occurs in Fiji. It has no economical potential now, being not numerous enough, but it may be a good nut tree for the future.

Conclusions

Three kind of nuts can be commercialised now in Vanuatu: *Canarium* spp., *Barringtonia* spp. and *Terminalia catappa*. Agronomic studies should be undertaken as soon as possible, simultaneously with commercialisation and marketing. The trees of these species are numerous and the overproduction allows sale of the surplus. All three are popular and important nuts in Vanuatu.

Two other species should be kept in mind for further development: *Inocarpus fagifer*, which can be made into jam, paste or other commercial form, and *Finshia chloroxantha*, which would have to be propagated for its nuts.

The nutritional composition of these species has been studied in the laboratory at the University of the South Pacific with financial support from ACIAR.

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What We Don't Know about Indigenous Nuts in Melanesia

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THE aim of this paper is to highlight the most important and fundamental gaps in the scientific knowledge of indigenous nuts in Melanesia and to show how this lack of information is affecting their commercial development. The paper is not a wish list of research and development projects. Rather, it attempts to precipitate the thoughts and ideas of those involved in the development of indigenous nuts to identify problems, give them priorities and, one hopes, solve them. In conjunction with the country priorities for research and development (Part IV of these Proceedings), this paper is also designed to alert potential donors to the needs of the embryonic industry.

All indigenous nuts with 'significant commercial potential' (see my earlier paper in these Proceedings) are covered here, but the paper will concentrate on the production and processing of canarium nut (*Canarium indicum*, *C. salomonense* and *C. harveyi*) as it currently commands the most commercial attention. Ironically, canarium nut presents some of the most difficult problems, perhaps because we are further down the commercial road and understand it better. Marketing issues are covered in greater detail in these Proceedings in specialist papers by Brown and Kreag, and generally by Houghton, London and McGregor.

Standardised and reproducible techniques for processing indigenous nuts in the South Pacific are the most critical precursors to successful marketing. The relatively high moisture and oil content of most indigenous nut kernels, combined with high ambient temperatures and humidities, makes the kernels particularly unstable unless they are processed quickly and appropriately during all stages of production.

Not long ago there would have been 20 years of research on a crop such as canarium nut before any real attempt was made to commercially develop it. This would have involved resource inventories, variety trials, feasibility studies, market testing and much more. Times have changed. The development of canarium nut has been largely driven by commercial aims, but it is becoming increasingly clear that research is failing to keep pace with the demands of the commercial sector. Tree owners, village enterprises, plantations, processors and marketing experts are starting to ask questions that the few technicians studying indigenous nuts in the region cannot answer.

The commercial development of other non-timber forest products such as Brazil nut and rattan has benefited from a pool of scientific knowledge built from more than 100 years of classical economic botany. South Pacific indigenous nuts do not enjoy the same scientific base. They do, however, enjoy the benefit of a vastly underrated and undervalued wealth of traditional knowledge. A great many of the techniques currently used for the commercial production of canarium nut have been based on this substantial local knowledge. There are limits, however, to the commercial applicability of these traditional techniques: the principles of handling the nuts might remain the same, but the techniques will differ.

The development of indigenous nuts in countries such as Papua New Guinea, Solomon Islands and Vanuatu involves much more than simply commercialising production and marketing. The products are inextricably linked with many aspects of traditional rural life in these countries. There are records of dances and songs associated with the first canarium nut harvest in Solomon Islands, the trees are planted to commemo-

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rate deaths and to mark customary land boundaries, and the nuts are an important nutritional source and barter commodity. If we are really serious about sustainable rural development in these countries, then we must take account of all these factors in a multidisciplinary approach. This will inevitably mean shouldering the cost of what are often seen as 'additional' costs to those of orthodox commercialisation (commodity exploitation) such as ethnobotanical and anthropological surveys, resource inventories and environmental impact assessments. While a natural resource is being used it must be constantly monitored to ensure sustainability (Fig. 1).

The development of canarium nut over the past five years has been fragmented and problematic, but this should not discourage us. Witness the numerous and costly problems associated with the introduction and development of exotic plantation crops in the area. By selecting indigenous plants for commercial development we (hope to) avoid many of these problems, such as pests and disease, but have to carry other costs, such as research into processing, which might not be necessary with well known exotics. Many of the problems associated with the development of indigenous non-timber forest products appear only if there is a shift from smallholder production based on existing trees to plantation-based production. This is a questionable aim and I know that the countries involved are not keen. I certainly would not encourage it. However, supplementary plantation production might be a desirable aim so long as it does not dominate research and development resources as it so often does.

Canarium nut (*Canarium indicum, C. salomonense* and *C. harveyi*)

Table 1 summarises research and development work, completed and required, for the canarium nut production process and a list of persons and organisation involved or required. Most research and development requirements are to do with either resource sustainability (for example, inventories and yield studies) or quality assurance during processing. Details are given below.

Production

Propagation

The variety collections in Solomon Islands (Evans 1991a) and Vanuatu (Walter and Sam 1993) have identified many cultivars of canarium nut with valuable economic characteristics, such as thin shells and large kernels, but we have no reliable way of vegetatively propagating these cultivars. This is, and will be, a huge obstacle to any breeding program and increasing productivity and profitability. Asexual propagation of *Canarium* is necessary to produce true-to-type progeny because of the trees' floral biology. My former colleagues at Dodo Creek Research Station in Solomon Islands have managed to graft some *Canarium* (see paper by Roposi *et al*. in these Proceedings) but strike rates are very low. Greater success has been enjoyed with pili in the

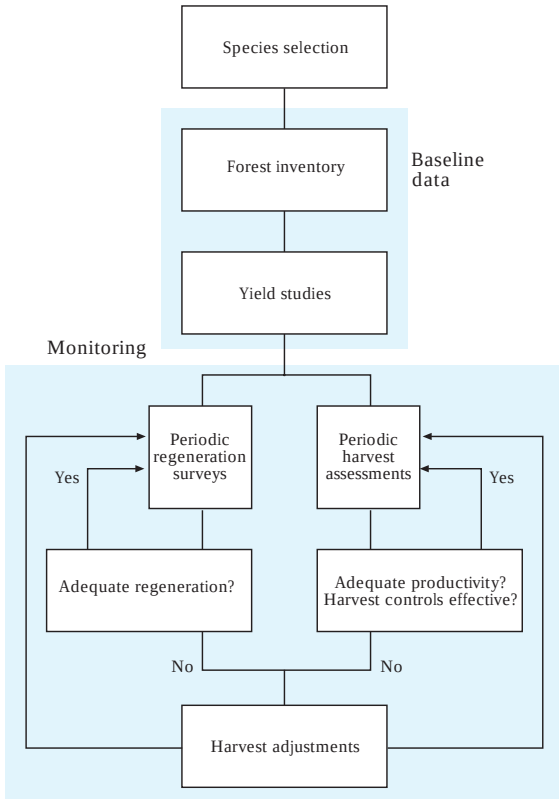

Figure 1. Flow chart of basic strategy for exploiting non-timber forest products, such as South Pacific indigenous nuts, on a sustainable yield basis (from Peters 1994)

Table 1. From forest to shop: Current techniques and research and development requirements for the production and processing of canarium nut

Commodity or subject	Process	R&D requirements	Work to date plus reference where available	Type of specialist required
Traditional knowledge	Arboriculture and processing	Documentation	Yen (1974), Henderson & Hancock (1988), Walter & Sam (1992)	Ethnobotanist
		Development	Henderson and Bonie (1988)	Horticulturist, agroforester
Tree	Identification and classification	Revision, especially cultivars	Leenhouts (1959, 1965)	Taxonomist
		Economic characteristics	Evans (1991), Walter & Sam (1992)	Economic botanist
Tree	Production conservation and sustainability	Resource inventory	Solomon Islands Forest Resource Inventory Project; Vanuatu Resource Inventory System; Kandrian and Gloucester Integrated Development Project, PNG	Geographer
		Regeneration	None	Ecologist
Flowers	Pollination	Vector identification and process	None	Entomologist, plant physiologist
Seed	Propagation	Storage and viability	Chaplin (1988), DCRS, SI Forest Research Department	Horticulturist
Tree	Propagation	Vegetative	Coronel (this vol.) with other species in Philippines; Roposi et al. (this vol.); SI Forest Research Dept; LAES; Nevenimo (1993)	Silviculturist, horticulturist
		Micro	University of Hawaii; LAES	Biotechnologist
Tree	Phenology	Yield, growth, fertilisation, spacing	LAES; DCRS (Evans 1991b); SI Forest Research Department	Agronomist, horticulturist
Tree	Harvest	Pruning	None	Horticulturist, silviculturist
Fruit/NIS	Drying, cracking, storage	Optimum moisture content, cracking, kernel storage	DCRS; NRI; University of Hawaii; University of Technology, PNG	Food processing technologist
Oleoresin	Extraction, processing, storage	Effect on tree yield	None	Horticulturist
		Processing	None (except for related Manila elemi in Philippines)	Agrochemist
NIS/KIT	Mechanical cracking	Optimum moisture content, pregrading	University of Hawaii	Engineer
KIT	Grading systems	Moisture content of kernel-in-shell	None	Food technologist
KIT	Packaging	Media, shelf-life	Long Wah; CSIRO Australia; NRI	Food technologist

DCRS = Dodo Creek Research Station, Solomon Islands LAES = Lowlands Agricultural Experiment Station, PNG
CSIRO = Commonwealth Scientific and Industrial Research Organisation, Australia NRI = Natural Resources Institute, UK

Philippines (see paper by Coronel in these Proceedings), but strike rates are still too low for mass reproduction. Attempts to root *Canarium* cuttings have failed (Evans 1991b), and preliminary attempts at micropropagation through laboratory-based tissue culture have also enjoyed little success.

The problem is further confounded because *Canarium* seeds are recalcitrant, necessitating immediate planting and prohibiting lengthy storage and transport. Erratic seed viability and seedling survival are also problematic.

The answers to many of these questions are prerequisites to any systematic breeding program.

Floral biology

The apparently complex floral biology of *Canarium* needs the attention of a specialist. We are still not sure whether pollen is transferred by wind or by insect. And if by the latter, what type of insect? Are hermaphrodite flowers self-compatible? Do flower sex ratios on polygamo-dioecious species change over time and between trees? These questions will not be easy to answer because of the small size and inaccessibility of *Canarium* flowers, their very short season and the remoteness of suitable specimen trees to study. However, the imminent sexual maturation of research plots in Solomon Islands will help considerably.

Yield

Data on canarium nut yield are very scarce. The lack of suitable research plots, variable and prolonged fruiting season, natural consumers such as birds and mammals, and the overriding urge of workers to eat the nuts make it very difficult to collect yield data. Furthermore, the phenology of *Canarium*, such as production profiles (time to first fruit, growth curves, time of maximum yield, age of decline), is poorly understood and poorly documented.

Basic information on the horticulture of canarium nut, essential for plantations, is also missing. Response to different fertilisers? Spacing and sex ratios: for example, is there a critical minimum ratio of male-flowered trees and how far should they be from female trees?

If existing trees are harvested, which is the case at the moment, what effect does intensive commercial harvesting have on yield sustainability and regeneration? If we are serious about sustainability we need to monitor these things now (see Fig. 1).

Total production and supply

Systematic inventories need to be carried out to accurately assess total production of canarium nut. As a minimum, all future forest inventories in Melanesia should separately classify and record *Canarium indicum* and *C. salomonense*, which are easily distinguishable in the field from the other species in the genera. (Given the fact that many logging companies are still cutting canarium nut, legally and illegally, they too should be required to audit the species separately.)

The numerous and close cultural affinities between Melanesians and canarium nut, combined with other well known market imperfections in the region, make supply difficult to predict and erratic. There is a need for sociologists and economists to measure, document and suggest methods to minimise the effects of these links on commercial supply.

Processing

On-farm processing

We do know that canarium nuts-in-shell (NIS) must be dried on-farm (and centrally) to preserve kernels. But what is the optimum kernel moisture content when stored in or out of shell? Laboratory tests by the CSIRO in Australia carried out under contract for Dodo Creek Research Station show that kernels deteriorate when their moisture content is also kept too low (Evans 1991c).

If NIS were cracked in villages, transport costs would be reduced by as much as 80%, hand cracking productivity would undoubtedly increase and primary producers would receive a much greater share of the final sale price (Evans, unpublished report). On-farm cracking cannot start, however, until kernels can be packaged and stored in villages and transported without damage. A suitable packaging technology needs to be identified or developed and tested on-farm. The containers need to be washable, sealable,

tamper-proof, robust, vermin-proof, reusable, a manageable size and weight, and able to preserve kernels or, preferably, kernels-in-testa (KIT) for up to four weeks under ambient temperatures and humidities.

Centralised processing

A rapid, accurate and standardised method for determining the moisture content of kernels in-shell needs to be developed for monitoring during centralised storage (as well as on-farm) and for grading NIS during purchasing. The visual methods currently used are inaccurate and subjective. For long-term bulk storage of NIS, detailed and cost-effective drying profiles need to be developed for kernels destined for human consumption and for kernel oil production.

For cracking, we need to know the optimum moisture content for kernels and shells before cracking. And, because of the large variation in the shape and size of canarium nuts, it seems that the prototype machines developed by Gautz and others at the University of Hawaii will still need grading of NIS for size before cracking in order for the machines to work efficiently (see paper by Gautz in these Proceedings).

The current method of removing testa by hand after loosening in cold, warm or boiling water is slow, unhygienic and probably detrimental to kernel quality. Rapid rehydration and loosening of the testa by steam followed by removal without hand contact (such as air blowing?) might be more hygienic but might also damage kernels and be more expensive.

Most of the techniques currently used for cooking and roasting kernels have been developed through trial and error. Roasting, glazing, admixing with chocolate, and other types of final preparation must all be professionally developed if indigenous nuts are to enjoy marketing success. To guide marketing and hence direct processing, comprehensive taste trials on the different species and cultivars of canarium nut are required using kernels produced in a standard manner.

Suitable methods for storing kernels in bulk are required that will enable simple and cost-effective grading and transport. Retail packaging is also problematic. Vacuum packing in oxygen-resistant plastic bags—as used in Solomon Islands—is designed to minimise oxidation and hold the delicate kernels together. However, an excessive vacuum appears to draw the oil out of the kernels and the vacuum make the packets difficult to read and unattractive. The hermetically sealed glass jars used in Vanuatu appear to preserve kernels just as well as a vacuum, but the kernels are prone to break apart moving around inside the jar. Glass jars are also expensive, heavy and breakable. A reusable light plastic jar able to withstand sterilisation and designed to minimise movement of kernels inside would be preferable.

By-products and other products

Canarium nut trees (like all *Canarium* spp.) exude an unquantified amount of potentially saleable oleoresin from their wood. How much? And what are the best techniques for tapping, processing and storing the resin? Most importantly, does tapping for oleoresin affect fruit production and kernel yield?

The hard shells of canarium nut are another potentially saleable by-product. Their value is likely to be determined by as yet poorly developed, value-added processing techniques such as charcoal and activated carbon production.

Fuelled by commercial interest, development of centralised processing techniques for kernel oil has received considerable attention, but on-farm storage of oil is still a problem.

Cut nut (*Barringtonia procera, B. edulis* and *B. novae-hiberniae*)

The current herbarium-based taxonomy of *Barringtonia* is inadequate in the field (Evans 1991a, Jebb 1992, Walter and Sam 1993). A comprehensive field-based taxonomic review of cultivated edible *Barringtonia* in Melanesia needs to be carried out so that any economic characteristics can be accurately attributed to named taxa. To date, no agronomic trials have been done on cut nut. Yield, seasonality and propagation studies are priorities.

Many of the processing techniques currently used for cut nut need refining. Cutting the fruit in half to extract the kernel (hence 'cut nut') also cuts the kernels and can cause contamination. A hygienic method of extracting the kernel undamaged is needed. On-farm and centralised preser-

vation methods need to be refined and shelf-life tests need to be conducted. Roasting and dehydration both produce a crunchy and pleasantly flavoured kernel, but many people think it is not a 'nutty' flavour. Either flavour enhancements need to be developed or the new consumer needs to be educated about the product. Perhaps both?

Sea almond (*Terminalia catappa*)

Extracting the relatively small kernels from the fruit of the sea almond is laborious. Production needs to be based on cultivars with the largest kernels and dehusking needs preferably to be mechanised. This will require propagation in nurseries where the large-kernelled cultivars are found (Iwa Island in the Marshall Bennett Group in PNG, the Santa Cruz Islands in Solomon Islands and predominantly the Banks Islands in Vanuatu) andextension programs to distribute seedlings. Trials need to be done on the mechanical cracker developed for the canarium nut (Gautz, these Proceedings) to see if it can be adapted for sea almond (and other nuts).

Okari nut (*Terminalia kaernbachii*)

There is very little scientific information on most aspects of okari, apart from where it grows in PNG, its altitudinal range and its seasonal production pattern (Bourke, these Proceedings). An estimate of total production in New Guinea needs to be calculated. This will require an estimate of tree numbers (perhaps from existing forest inventories?), yield (based on field studies) and a better understanding of the trees' phenology. Few economically significant cultivars have been identified, but they probably do exist. Marketing okari nut will be inhibited until processing techniques are developed, especially on-farm preservation, transport, and techniques to hold the kernel together, such as glazing. There is also very little information on the nutritional composition of the kernels.

Polynesian chestnut (*Inocarpus fagifer*)

For commercial purposes, standard techniques for the removal of the toxins present in Polynesian chestnuts need to be developed. Some cultivars are said to have less toxicity. This needs to be tested. If it is true, low toxin cultivars will need to be propagated and distributed. Regardless of processing technique it seems likely that different flavour enhancements will need to be tested to improve the rather bland taste of the kernel.

Pandanus nut (*Pandanus julianettii*, *P. brosimos* and *P. dubius*)

Scientific information on pandanus nut is limited to its distribution, seasonality and nutritional value in PNG (Bourke, these Proceedings). There is no experience or infomation on processing, packing or selling pandanus nuts commercially. Time to first fruit, yield and the crop's phenology all need investigation. Correlations between the large number of cultivars of pandanus nut and their taste need to be established so that marketing can concentrate on those cultivars with most consumer appeal. For market acceptance outside the New Guinea highlands, flavour enhancements will probably be necessary. The effect of commercialisation of pandanus nut on the diet of New Guinea highlanders needs to be closely monitored by nutritionists.

Conclusion

Although there has been considerable work already carried out on processing techniques for indigenous nuts in Melanesia, it has been mostly fragmented and applied. It seems clear that a more systematic and comprehensive approach is required if the industry as a whole is to benefit. Commercial techniques for on-farm storage and value-added processing seem to be common problems for all indigenous nuts in the region.

The two greatest problems and challenges for the commercialisation of canarium nut are the inability to propagate economically superior cultivars true-to-type and the lack of village-based storage technologies for kernels. True-to-type propagation will enable producer countries to preserve and exploit the great number of cultivars that have been developed over thousands of years by local people. On-farm storage of kernels will ensure that the maximum benefit of this investment is returned to the producers.

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Part II: Developments in the Region

Canarium Nut and Oil Marketing in Solomon Islands

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NGALI NUT is the collective name given by Solomon Islanders to the three edible species of indigenous *Canarium* nut trees that are prevalent in the country's rainforest. Ngali nut is an important part of the local diet: the islanders find the kernels nutritious, tasty and filling; for some, it is a significant source of protein. Trading of ngali nuts among the people is common. Bush people exchange their ngali nuts for fish from the coastal villagers. Ngali nut is also a cash earner, even at subsistence level.

The Solomon Islands Government, through the Ministry of Agriculture and Lands (now the Ministry of Agriculture and Fisheries) decided in 1988 to promote ngali nut as a commercial crop. The Government sees ngali nut as an excellent potential income earner for rural people, in addition to their copra, cocoa and chillies, and established the Ngali Nut Project to develop the crop. The Dodo Creek Research Station (DCRS) of the Ministry of Agriculture and Fisheries, which conducts the research and development, collaborates with the Commodities Export Marketing Authority (CEMA), which markets the products of the project.

This paper briefly highlights aspects of ngali nut as a cash crop, the current marketing structure, the role of government, non-government organisations (NGOs) and international marketers in the ngali nut project, the project's achievements and the difficulties encountered. Finally it briefly outlines what is needed to successfully commercialise ngali nut in Solomon Islands.

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Ngali Nut in Solomon Islands Society

Two of the three species of ngali nut, ngali (*C. indicum*) and adoa (*C. salomonense*), are found throughout the islands. The Santa Cruz nut (*C. harveyi*) occurs only on the outer eastern islands of the country.

Ngali nut is significant in the traditional society of the islands. Besides it being an important source of food, the ownership of both trees and the traditionally processed kernels is a measure of one's wealth or standing in the social hierarchy of a tribe. Traditionally processed ngali nut is a medium of exchange for pigs, plots of land and other traditional shell money. Ngali nut is so important to some of these societies that the nut season is the most important event of the whole year. In fact in some languages the word for 'year' means 'ngali nut season'.

The trees are often grown in groves marking sacred places and old village sites, which in turn become boundary marks for parcels of land between tribes or families. The trees are more sporadically located within the boundary of a given tribal land. Traditionally, ownership is communal unless a tree is actually planted by someone.

The ngali nut owners' perception of the nut is therefore an important consideration when commercialisation (profit motivation) is attempted.

Current Marketing Structure

The ngali nut marketing structure in Solomon Islands can be separated into traditional and commercial. Traditional trading or marketing takes place at the subsistence level, where nut-in-shell (NIS) or processed kernels are exchanged for other goods, services or obligations. Commercial marketing, on the other hand, involves cash, and the activities are more formal, with more

participants at different levels. The simplest example of this is farmers selling nuts at urban markets.

Our ngali nut project is a good example of a commercial undertaking, as the following order of activities shows:

1. Nut grower collects and dries fallen nuts.
2. Grower sells to trader (transporter), who sells to the nearest CEMA buying centre. The nut grower may alternatively sell direct to CEMA.
3. CEMA ships all NIS to Honiara then delivers the NIS to DCRS for cracking.
4. DCRS sends the packaged product to CEMA to sell to consumers and retailers.

The marketing of oil for cosmetic purposes follows the same steps but the oil is then exported. Recently some NGOs have started a village-based oil extraction operation in Makira Province, which allows them to export direct.

Collaborating Institutions and Organisations

DCRS, CEMA and the Ministry of Commerce, Employment and Trade (MCE&T) are the main government agents involved in this project. DCRS conducts agronomic research, product development, processing, packaging and quality assessment. CEMA handles internal trading, exporting and licensing. MCE&T provides advisory, technical and financial support for local entrepreneurs to use the kernels to produce value-added products.

The other organisations involved are the NGOs and their collaborators, who provide the market outlet overseas. Various organisations have also provided finance and training for those involved in the project. All the organisations involved in the project are listed in this paper's Acknowledgments.

Progress in Marketing Ngali Nut and Oil Products

Local purchases

CEMA buys NIS throughout the country through its eight Copra Buying Centres and three other agricultural stations from the growers or traders. The NIS is graded by CEMA produce inspectors and bought if acceptable. The price paid depends on grade, which is determined by the kernel to nut ratio: 20% is first grade and 10%–19% is second grade. Both adoa (*C. salomonense*) and Santa Cruz nut (*C. harveyi*) are automatically first grade.

Current purchase prices at the centres are about $SI1/kg for adoa and Santa Cruz nut, 70¢ for first-grade ngali and 50¢ for second-grade ngali (SI$1.00 ≈ US$0.30).

During the five years from 1989 to 1993, CEMA bought a total of 264 t NIS. Ninety-eight per cent of this was ngali, 1.9% was adoa and 0.1% was Santa Cruz nut. The bulk of the purchases were in 1991 (46 t) and 1992 (205 t). More NIS came from Auki, Malaita Province, (211 t) than from any other island or centre.

Sales

The main products promoted by CEMA are the edible kernels and the kernel oil for cosmetic uses. The market strategy is to supply edible kernels domestically and any excess to neighbouring Melanesian countries. The oil is sold overseas. The by-product of oil extraction, ngali meal, is sold for local livestock feed.

Vacuum-packed roasted kernels (Solomon Nuts) have become very popular in Honiara. Supermarkets, specialised trade stores and hotels are the main buyers. Because of the limited capacity of our equipment, however, we cannot satisfy even the local market.

On the other hand, export of kernels and oil for cosmetics was the main drive in 1992 and 1993. In 1993, CEMA established a special trade link ('Trade Not Aid') with Body Shop International. The first product, tanning lotion, was launched in 1993 with some success, but problems with oil quality have to be solved.

The project has so far achieved part of its objective of making ngali nut a cash crop. More than $SI120 000 has been put into the rural areas and $SI84 000 was earned from the export of kernels and oil. This will increase greatly if producers, processers and marketers all benefit equitably from the trade.

Constraints Encountered

There are several constraints to the commercialisation of ngali nut:

- Identifying the right product lines and the appropriate market niche, especially when the product is unknown and the market is very competitive and conservative.
- Getting a foothold in overseas markets for an unknown product from an unknown supplier.
- Uncertainty of supply associated with sourcing raw materials from villagers scattered throughout the islands and whose priorities are often non-commercial.
- High cost of freight because of the distance between the supplier and the buyer.
- Marketing small quantities.
- Difficulties in meeting stringent quality standards dictated by the market. Sometimes village suppliers get frustrated because the trade link involves contradicting philosophy and technology.
- Unfamiliarity with the technical knowledge, equipment and managerial skills needed to get an unknown product readied for the market. In the case of ngali nut, there is no previous technical body of experience or know-how to use.

Future Directions for the Commercialisation of Ngali Nut in Solomon Islands

Given the challenges and achievements so far, commercialisation of ngali nut in Solomon Islands can be best achieved by the following course of action:

- Priority should be given to solving the kernel oil quality problem, taking into account the need to use as simple a technology as can be adopted at the village production level.
- Establish strong supportive institutions or bodies, either government or NGO, to ensure sustainable trade links between overseas buyers and village nut owners.
- Diversify product lines by exploiting secondary and tertiary products of higher value. Here, the innovative skills of entrepreneurs must be encouraged.
- Ensure that the ngali nut tree owners are given the maximum sustainable return. Whether we succeed or fail depends greatly on the net (socioeconomic) benefit that ngali nut owners receive through ngali nut marketing. But always be mindful that social harmony and well-being cannot be sustained by profits alone.
- Collaborate with others involved in the industry, at whatever level. The Melanesian countries that see *Canarium* nuts as a commodity unique to them must collaborate rather than compete.

Acknowledgments

The Ngali Nut Project in Solomon Islands would not have reached its current stage without the support and encouragement of many people, governments and organisations. We wish to record our appreciation and we look forward to your continued support.

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Marketing and trade: Body Shop International (UK), David Bellamy Associates (UK), Conservation International (USA), Cultural Survival (USA), South Pacific Trade Commission (Australia), and our numerous 'volunteer' salespeople.

Marketing Indigenous Nuts in Vanuatu—a Private Enterprise Perspective

Charles Long Wah*

THE Kava Store in Port Vila, Vanuatu, began buying, selling and processing indigenous nuts in 1989. Since that time we have continuously promoted the planting of nut trees, on radio, in newspapers and on posters.

In 1995 we promoted mainly *Barringtonia* nuts (navele), and have aimed to buy 100 t *Barringtonia* NIS. We will aim for 200 t in 1996 and even more in 1997. We ask for as much nuts as producers can supply. Potentially hundreds of growers could benefit from our market.

We also promote many other fruits and nuts, including *Canarium* (nangai), *Terminalia* (natapoa), *Calophyllum inophyllum* (tamanu) and *Myristica fatua* (nandai). In 1995 we bought a total of 150 t NIS of various species, an increase on 1994. We intend to export to New Caledonia in 1996. Our sales figures are shown in Table 1.

We buy most of the nuts from villagers in isolated areas of Vanuatu. One person in each village amasses the nuts and prepares them for collection. We provide information on drying the nuts properly, but we often receive bad quality NIS anyway. Not to discourage the growers, we still buy these nuts. It will be many years before we receive good quality nuts from all growers.

Most nuts are shipped to Port Vila for cracking and drying. When we receive them, we crack the shells, dry the kernels, clean them, select the best unbroken ones, roast them, dehydrate them and pack them in sterilised jars or cellophane bags for local sale. We have two small dryers and roasting ovens and plan to build a much bigger dryer, capable of drying 500 kg a day.

We began this approach in 1979 with kava. Today, as a result of our efforts, Vanuatu kava growers receive more than $A1.5m a year in income. Six thousand people took up kava growing and did not have to move to town looking for work.

We have done all this promotion and market development unaided by government or overseas aid agencies. It has cost us around $100 000 so far. There is still a long way to go and any assistance would be appreciated. We need help for promotion and for village-based dryers and oil presses. One pay-off could be employment for a thousand nut farmers.

Table 1. Sales of nut products (kg)

Nuts	1993	1994	1995	1996*	1997*
Canarium (nangai)	100	1 700	400	2 000	4 000
Barringtonia (navele)	200	600	3 000	5 000	7 000
Terminalia (natapoa)	60	100	300	500	1 000
Peanuts (in shell)	10 000	18 000	12 000	15 000	20 000
Peanuts (blanched)	0	2 000	6 000	8 000	10 000
Peanuts (sweet-coated)	300	200	100	500	1 000

* Projected

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The Role of Galip Nut (*Canarium indicum*) in Forest Conservation in East New Britain, Papua New Guinea

Max Henderson*

Forestry in Papua New Guinea

BETWEEN 70% and 77% of Papua New Guinea is still covered in forest. The forests are extremely rich in biodiversity, with between 11 000 and 19 000 vascular plants and more than 2000 tree species.

About 15 million hectares is classified as accessible production forests, containing an estimated volume of approximately 500 million m^3 of commercially valuable timber. This has a calculated value of $US100 billion. According to recent estimates, however, the productive remaining forested area amounts to only 7.2 million hectares, with a commercial timber volume of only 170 million m^3.

The annual decline of forests is estimated by one authority at 1%. This has been attributed to shifting agriculture, followed by mineral exploitation and logging. However, if the moonscapes left by most export logging operations are taken into account, then this figure is absurdly low.

The forestry sector of PNG is undergoing a major change. In 1991 a new Forest Policy and Forestry Act was passed by Parliament. It was designed to remedy the shortcomings of the previous legal framework and to be consistent with the fourth goal of the Papua New Guinea Constitution, which states: 'That Papua New Guinea's natural resources and environment should be conserved and used for the collective benefit of all and should be replenished for future generations.'

The National Forest Policy, based on the new legislation, stresses that the rights of customary land owners shall be fully recognised and respected in all transactions affecting forest resources. Without the consent of the forest owners no operation shall be permitted.

Sustained yield management of production forests is stressed as the guiding principle, with selective logging as the prescribed method for natural forests. Overall responsibility for sound forest management is vested in the State.

In practice, however, the situation is rather different.

Foreign-based companies are completely in control of the sector. One Malaysian company controls 86% of all export logging operations in PNG. Other operators are based in Japan, Korea and China. As much as half of all accessible forests have been allocated to industrial logging operations.

The forests are suffering severe degradation. Operational standards stated in the timber permits are broadly and constantly violated: cutting trees below the minimum diameter (50 cm), felling to the edge of watercourses, skidding logs in river beds, excessive width of roads, construction of roads with slopes beyond 15%, harvesting in forest stands with slopes greater than 30%, and excessive damage to remaining stands and to the soil (estimated 30% to 40% affected).

Villagers are complaining about the pollution of their rivers and the reckless destruction of their personal property, such as gardens, huts and cultural sites. Promised infrastructural developments such as construction of permanent roads, bridges, schools and aid posts are usually far behind schedule and in most instances never materialise.

The employment generated is mostly only temporary and many positions (even semi-skilled labour) are filled by foreigners. Practices like transfer pricing, short-scaling, down-grading species and all kinds of false record keeping are now general practice. With these devices the

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logging companies manage to transfer all the economic rent outside the country. Most logging companies do not show any profits in PNG. This compares with an estimated net profit of $US450 million a year for the entire export logging industry.

The royalties accruing to the landholders are only marginal: in many cases not more than $5/m^3, compared with the profits of the logging companies of approximately $75/m^3. At harvest rates averaging 25 m^3/ha, that gives loggers profits of $US1875/ha. This is substantially higher than can be realised from cocoa, coffee, oil palm or cattle ventures on cleared forest. However, this is a once-only profit. The forest will take more than 50 years to recover. Thus the actual profits can be more realistically calculated at $US1875 for 50 years, or $US37/ha/yr. This is miserable by any standards, as even a commercial cocoa grower will vouch. This is not a profit for PNG anyway, as profits are almost entirely moved offshore.

Thus the financial return to PNG, given that the logging industry is absorbing increasing time and costs for almost every government department, is very likely to be negative in real terms.

Pacific Heritage Foundation

These are the reasons why the Pacific Heritage Foundation (PHF) has acted.

One of the aims of the PHF is to identify and promote non-destructive methods of earning income from forest resources by the traditional landowners. Other aims are:

- to promote an increased awareness among all people of the wealth and diversity of the natural heritage of the Pacific area
- to improve the welfare of the peoples consistent with improved conservation and managed economic programs
- to provide moral, technical and legal support to prevent the destruction of this heritage
- to provide education and assistance to communities to enable them to understand and preserve their heritage
- to provide practical working examples of environmentally sound methods of earning income from the natural resources without unnecessary destruction
- to establish a Conservation Botanical Garden aimed at representing the widest possible collection of plant material
- to support government policies and practices aimed at the preservation of this heritage.

The PHF initially concentrates on education, in an attempt to make villagers more aware of the wider issues, and to reinforce the monetary and biological value of their forest resource. Then it explains how the villagers can derive income from this resource in a non-destructive manner, and in keeping with their traditions and culture as closely as possible.

We recognise that the landholder has a right to use the forest as a source of income. If that means cutting down trees, then we aim to demonstrate that this can happen without destroying the forest, and yet yielding a satisfactory income.

We began by promoting community-based portable sawmills as these provide one of the quickest routes to village participation, training and income. We are aware that this is not necessarily the best or the only alternative, but where they have been successfully established we have bought time to hold off the loggers while we investigate alternatives.

Galip nut

One alternative is indigenous nut production. Galip (*Canarium indicum*) and other forest nuts have great potential. They occur naturally at varying densities in most lowland forest areas, have no known substantial pest and disease problems, require no maintenance, and can be harvested after nut fall with a minimum of effort.

We are keen to develop a product that is indigenous to PNG—that is, one that has adjusted to local conditions, pests and diseases—unlike cocoa, for example, where the farmer has a continuous battle against a massive range of problems.

If our assumptions on the future of galip nut are correct, then we can expect large areas of galip nut to be planted in other countries. This is a good reason to develop the industry now in PNG. The history of boom crops such as kiwi fruit, avocado and macadamia illustrates the advantages of early exploitation.

The product has little value, however, if a

marketing structure does not exist. We have been working towards this for some time, but there are problems. Potential wholesale buyers require reasonable quantities to test their markets but the markets have to exist to provide the cash flow to enable purchases from villages.

We decided to test availability towards the end of the 1994 season by purchasing nuts-in-shell (NIS) from two villages in the Wide Bay area of East New Britain. We were somewhat surprised to receive 3600 kg at the tail-end of the production season. This augurs well for the future, when the villagers will have had adequate advance warning.

We have also been successful in purchasing more than 1000 kg from nearby Tolai villages, which is somewhat surprising given the availability of other cash crops such as cocoa and copra. Again these purchases were at the end of the season when we assumed there would have been little product on the ground.

Dried and roasted samples have been sent to several potential wholesale customers and appear to be have been well received. We are looking at outlets such as food bars, where the nuts could be roasted and served hot direct to the customer. This will overcome an expensive packaging process in the initial stages.

One offshoot of this buying exercise is that the villagers have an increased awareness of their forest resource. We have estimated that the income from the single truck load at the Wide Bay village was greater than any other single shipment of other produce such as copra or cocoa. We have also clearly made the point that the villagers from the adjacent area will not be able to benefit from this new venture as the loggers have removed all the mature galip trees. If we can find the markets to meet the potential production of NIS from these villages, then we can add a permanent reinforcement to our policy of alternatives to industrial logging.

In addition to the collection of nuts from forest trees, we are promoting the planting of galip plots in abandoned garden areas near selected villages. We have received some financial assistance from several overseas donors for a number of trial plots and the clearing and planting of four plots has begun. *Glyricidia* will be planted at high densities to provide shade and to improve the soil. This will suppress weeds and promote the growth of long boles by the young galip trees. The shade can be relatively easily controlled and prunings will increase mulch. After the galip trees break through the shade canopy, decisions can be made on suitable understorey crops. It is likely that valuable tree species such as rosewood *(Pterocarpus* sp.) will be interplanted.

By using high-density plantings, we hope to force early flowering, and the thinnings from year three onwards can be used for buildings or sold as poles. This program is based on results from experiments in Solomon Islands.

The land to be used must be communally owned, and the community needs to identify goals for which the income can eventually be used. As an example, one village requested assistance with a 5 ha plot to provide future income for its community school.

We will involve women's groups in these projects as much as possible, employing them for planting and for weeding and maintenance until a canopy forms. The women are also likely to harvest the nuts.

We hope to identify other crops to be interplanted under the galips; kava might be one suitable addition.

Selection of seed material is important for maximum kernel-to-nut ratios, and a number of seed trees have been identified on the Gazelle Peninsula. Further trials will be carried out in other areas. We are looking for high kernel-to-nut ratios, as well as relatively thin shells to simplify processing. Further trial work is required to identify high-yielding trees within these categories, but this will necessarily be long-term. Compromises with seed material will have to be accepted in the meantime.

With a combination of forest and plot collection of nuts, village incomes will be increased and pressures on the forest will, we hope, be reduced. If this can be part of a wider scheme of non-destructive forest exploitation then there may be some hope for retaining areas of natural forest in PNG. If the landowners cannot achieve these results then we can expect to see the destruction of all accessible forests.

Benefits

Principal benefits of the direct participation of local communities include:

- involvement of landholders in the use of their forest resource and the reinforcement of their long-term commitment to the environment
- improved chances of adhering to environmentally sound harvesting practices
- the opportunity to gain reasonable economic returns
- the generation of permanent employment close to the village
- lower demand for large-scale destructive projects
- incentives for the villagers, particularly young adults, to remain in the rural areas
- self-sufficiency in construction timbers.

During the establishment process and beyond, a great deal of time and effort is involved. Who pays? This is a major consideration. Clearly the Government has neither the capacity nor the will to be involved at this level and for long continuous periods.

Some progress is being made. Our national and international campaign in conjunction with other concerned NGOs in raising awareness of the issues is attracting increasing interest. The national press has responded with increased coverage, and recent overseas television documentaries and major newspaper and magazine articles have highlighted the problems. We are aware of other efforts through diplomatic and finance channels to provide assistance to the Government, and there is a growing awareness by aid donors that NGOs can be the most effective communication and education route.

Increasing numbers of village groups from other areas are coming to the sawmill project for guidance, followed by requests for assistance to establish similar projects in their own areas. To date we have 14 additional projects in various stages of progress through the bureaucratic system, including several that have rejected overtures by Asian loggers.

The landholders want some cash and some development. But they want this without the destruction of their forest, and with projects that are under their control and that employ their labour.

Besides sawn timber and galip nuts, other potential earners include orchids, rattan, traditional herbs and medicinal products, and crocodile and bird breeding.

The various projects either in operation or substantially close will deny loggers more than 100 000 ha of prime rainforest. This figure can increase dramatically if we have access to reasonable funding.

Galip (*Canarium indicum*) as a Cash Crop in West New Britain, Papua New Guinea: Experiences of the Kandrian Gloucester Integrated Development Project

David Wissink*

GALIP NUTS, the fruit of *Canarium indicum*, have been a traditional food crop for people living in the coastal rainforest areas of the northern islands of Papua New Guinea for thousands of years. Rough estimates put the number of trees of edible *Canarium* species at nearly one million within this region of PNG. It is with this in mind that the Kandrian Gloucester Integrated Development Project (KGIDP), a five-year rural development project funded by AusAID (formerly AIDAB), has chosen to examine the potential for creating a galip nut industry in West New Britain Province (WNBP). The knowledge gained from this trial venture will be disseminated to other *C. indicum* growing areas of PNG. This paper details the experiences of the KGIDP to date.

The Kandrian Gloucester Integrated Development Project

Commercial forestry operations in the Kandrian and Gloucester districts of WNBP are currently the driving forces of social and economic change. Logging has brought increased income and employment opportunities and has significantly upgraded rural infrastructure through the provision of roads, shipping services and airstrips. Although there are obvious social, economic and environmental costs associated with logging operations, most landowners, for the time being at least, are prepared to put up with or ignore these costs in anticipation of improved living standards.

The KGIDP is a multifaceted project of which agriculture is but one component. The agricultural component provides funds for provincial government agriculturists and their training and is attempting to initiate innovative ideas to stimulate the rural economy in the Kandrian and Gloucester areas.

The KGIDP began in June 1993. During the preliminary survey work, an abundant resource of galip nut was noted in the project area. Potential production was estimated to be in the order of 1500 t of nut-in-shell (NIS) per year, representing a total income to villagers in excess of K200 000 every year (Bourke et al. 1993). Additional benefits of establishing a galip nut industry within the project area include increased wage-earning opportunities for women, who will operate and jointly own the factory, and increased income-earning opportunities for remote villages and disenfranchised groups. The program will also serve as a means of conserving a traditionally significant and commercially valuable timber resource for future generations.

Project Aims

The aims of the project are to:

- develop an economically viable and environmentally sound, village-based industry within WNBP
- provide the infrastructure for an entirely new business opportunity and take the leading role in galip nut production and processing in PNG
- create employment opportunities in a rural area, more particularly for disadvantaged groups such as women and youth.
- retail a high quality product to the PNG market, with the potential to expand to export status in later years
- develop spin-off ventures using factory by-products such as oil, and encourage diversification away from established cash crops and

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reliance upon logging as a major source of revenue
- help the people of Kandrian and Gloucester to preserve a socially and economically valuable timber species (Carter and Wissink 1994)
- increase household income and improve the delivery of social services within the Kandrian and Gloucester Districts
- improve access to, and management of, the forest revenue available to customary land-users, landowner groups and the provincial government
- expand and diversify economic activity through a range of ecologically sustainable development options
- financially support the development and maintenance of public infrastructure and services
- support the process of participatory planning.

Galip Program Concept

The program consists of three distinct development phases:

Phase 1: Production feasibility and market assessment

Phase 1 of the project began in June 1993. A feasibility study, completed in May 1994, confirmed that there is considerable potential for the establishment of a galip nut industry in WNBP (Evans 1994). Phase 1 also involves the identification of one or more local investment partners for the purpose of establishing commercial directions and committing the necessary resources to infrastructure development. While investment capital is being raised, pilot purchasing and processing activities will begin and a small volume of galip nuts is expected to be packaged and sold.

Phase 2: Infrastructure establishment and product refinement

Phase 2 will begin once investors have made a commitment to the construction of permanent processing facilities and infrastructure required by the project. It is proposed that a company will be incorporated to implement the project and to employ suitably qualified personnel to manage its day-to-day operations. Phase 2 will also involve considerable product refinement and development. Once the permanent processing facility has been constructed, a range of additional food processing options could also be considered.

Phase 3: Full scale production

At full capacity the factory will produce more than 14 t a year of roasted kernels with a total value of K150 000. Operating profit (before tax) at this level of production is estimated at just under 30% of total revenue. Break-even output volumes should be reached at about 10% of full production (1.3 t).

Canarium indicum Resource Base

Canarium indicum is found on all land systems except mangroves and swamps in the Kandrian and Gloucester Districts (Evans 1994). In the natural forest areas of WNBP there are an estimated 600 000 *Canarium* trees, including an estimated 86 000 *C. indicum* trees. In the coastal modified secondary forests there are an estimated 150 000 *C. indicum* trees, or about one tree per hectare. This suggests that in the coastal modified forests of WNBP, there is the potential, if each tree produced roughly 50 kg nuts a year, to supply more than 7500 t nut-in-shell (NIS) each year.

Despite *C. indicum* being a food crop, however, Asian logging companies operating in WNBP classify *C. indicum* in the second most valuable group of timber species in the rainforest. Efforts are under way to have it classified as an excluded species, but for now, logging of *C. indicum* continues. Evans (1994) reported more than 2000 m^3 of *Canarium* in one logging camp alone in West New Britain.

In 1995, KGIDP plans to compile a comprehensive *Canarium* resource inventory of West New Britain in conjunction with the PNG Department of Agriculture and Livestock's Lowlands Agricultural Experiment Station (LAES). The overall goal of the proposed survey is to establish a database for future galip nut research and industry development, primarily in WNBP. LAES is planning to conduct other such surveys in the islands of PNG in order to establish a national galip nut database. This survey would gather relevant and timely information that could be used not only by KGIDP in its efforts to promote the galip nut industry in WNBP but also to

serve as a focal point for other galip-related research in PNG.

Awareness and Extension Campaign

In April of 1994, the KGIDP agriculture team members began an extension campaign to tell the people in the Kandrian and Gloucester Districts of the opportunity to sell galip nuts as a cash crop during the coming galip season. The season typically runs from May to October along the south coast of West New Britain and extends to December along the north coast. The campaign also promoted the long-term sustainability of this type of project as opposed to the unsustainable practices of the loggers. Extension materials and purchasing and grading manuals were produced. Ten buyers from Kandrian, Gloucester and Kimbe and agriculture and livestock officers from the Department of West New Britain were selected and received training in purchasing procedures.

Extensive use was made of talk shows and message programs on Radio West New Britain: more people are reached by radio in West New Britain than by any other form of communication. These radio programs targeted women and children in the remote areas of the province as it is these people whom the program is trying to benefit (Wissink 1994a).

Volume and Value of Nuts Sold by Villagers

In June 1994, KGIDP bought 20 kg nuts from two women from an island near the Kandrian galip nut purchase point. Within two weeks of that first sale, the Kandrian purchase point was teeming with people selling galip nuts. A week later the galip nut purchase point in Gloucester was busy as well. The purchase point in Kimbe opened during the first week of July and it too was overwhelmed with people selling galip nuts.

All totalled, the project bought more than 31 t galip nuts during the 1994 season from 792 people. The total amount of money paid to the sellers was K11 140. The Kandrian centre bought the most, followed by Kimbe and Gloucester. Most nuts were bought in August (K6000) and July (K3865). The average amount bought was 39 kg at a value of K14.

One of the main objectives of the galip nut program is to encourage women to sell the nuts. Despite all our good intentions and efforts to publicise this, however, 65% of sellers were men. Only 34% were women. However, 85% of the men said they were selling galip nuts for their wives. This is because women from villages furthest from the purchase points do not usually come into Kandrian, Kimbe or Gloucester to sell cash crops. We do not know whether this money actually made it back to the village or was spent by the men in the towns. One per cent of the galip nuts (K80.26) came from community school groups using it as a class project (Wissink 1994b).

KGIDP is planning to establish additional purchase points in 1995 and 1996 in more remote locations in an attempt to give women easier access. In 1995 the project would like to identify women's groups in Gasmata and Pililo to assume the role of purchasing agent for galip nuts in their areas. In the longer term, galip nut buying points are to be established along the coast to ensure that remote coastal communities can participate in the project. Some storage facilities are available to receive NIS in these areas, but the initial focus throughout the remainder of Phase 1 of the project should be the establishment of a temporary receipt and processing unit in Kandrian.

Grading and Pricing of Galip Nuts

The KGIDP system of galip nut grading and pricing is quite similar to that used in Solomon Islands. The system consists of checking and sorting the NIS, taking a representative sample, weighing and inspecting the sample to determine the grade and price, then rebagging and weighing the NIS, recording the seller's name and paying the seller.

Kernel to nut ratio (K:N) is used to assess the quality or grade of the NIS purchased. It is calculated from a sample weight of dry kernels-intesta divided by a sample weight of dry NIS and is expressed as a percentage. The mean K:N of galip nut purchased by KGIDP in 1994 was 22%. The minimum K:N was 12% and the maximum was 45%. KGIDP uses the pricing system shown in Table 1 and the quality assessment system shown in Table 2.

Table 1. KGIDP pricing system for galip

Kernel to nut ratio	Grade	Outstation price (Kina/kg)	Factory price (Kina/kg)
≥ 30%	AA	0.35	0.45
20%–29%	A	0.30	0.42
15%–19%	B	0.25	0.35
10%–14%	C	0.20	0.28
< 10%	Reject	–	–

Table 2. KDIGP quality assessment system for galip

Testing for …	Accept	Reject
Insect damage	No damage	Insect larvae or eggs present
Maturity	Testa brown	Testa white
	Kernel firm	Kernel watery
Drying quality	Testa light brown	Testa oily, black or stained
	Kernel white	Kernel cooked or brown
Moisture content	Kernel clean	Kernel green or has fungal growth
	Testa brittle, tight or hard to peel	Testa leathery and easy to peel
	Kernel breaks with a 'snap'	Kernel flexible
	Kernel tightly bound together	Kernel easily falls apart
	Kernel clean white	Kernel yellow or discoloured

The Market for Galip Nuts

Currently PNG imports 30 t of packaged nuts a year, of which peanuts account for almost 75%. Other nut imports include brazil nuts, cashews, almonds and hazel nuts. Most of these high-value nuts are consumed in the major urban centres (DAL 1991).

In 1992 the consumption of processed galip nuts in Honiara (Solomon Islands) was 50 g per person with little market promotion. Based upon this figure it is reasonable to suggest that the minimum market demand for galip nuts within PNG should be at least 18 t a year (equivalent to 120 t of NIS). The demand is likely to be higher given competitive pricing, consumer appeal, a well known taste and the current rapid rise in snack food consumption. Maximising sales and revenue will require a targeted marketing approach and a competitive pricing strategy.

The package presentation and size are critical to successful market penetration. Packages need to be of high quality and to be designed for eye-catching appeal to Papua New Guineans. Package size should be large to allow for proper display and to minimise distortion of the packets during the vacuum packing process. Fifty-gram satchels are considered the most appropriate retail unit. These satchels will be packed in cartons for transhipment.

Labelling needs to advertise that the nuts are locally produced from indigenous trees, that the product has a tradition in PNG and that it is of high nutritional value. It should also advertise the environmental preservation aspects of the product, the appropriateness of the technology and its benefit to village development.

Pricing needs careful attention to ensure that the product is competitive while providing acceptable mark-up for retailers and a profit margin for processors. The suggested selling prices are K6.20/kg for bulk roasted kernels and K10/kg for the 50 g packets.

Galip nuts should be distributed through several major market outlets. Where possible,

exclusive distribution rights should be avoided. This will enable management to pursue sales opportunities as they arise and to maintain a degree of flexibility. It is likely that sales exclusivity in some niche markets will be difficult to avoid. Targets should include:

- **high income nationals**: this market is the largest and also the most likely to continue expanding
- **expatriates**: the galip nut is popular with expatriates, who tend to do more one-stop shopping and have higher disposable incomes
- **mine workers**: a large demand, large catering budgets and limited access to fresh produce makes mines a good target for galip nut products
- **hotels, airlines and catering service centres**: these constitute reliable market outlets for specialty nuts. They are likely to require small packs as bar stock and larger packs for catering
- **tourists**: these people have disposable income and are keen to try local foods. Attractively packaged nuts provide a souvenir or gift to take home.

Processing

Kandrian has been selected as the most appropriate location for a processing factory. Appropriately zoned sites are available in easily accessible areas within the town area that are near the market. A temporary site has been committed to the project by the Kandrian District Manager up until the completion of Phase 1 of the project. Receipt and storage sheds will be required for Gloucester and Gasmata during years two and three.

The factory's central processing unit will consist of three main parts: a storage shed, a cracking shed and a processing unit. The storage shed should be dry, cool, rat-proof, fire-resistant and secure. The cracking shed can be constructed using traditional materials with the addition of a concrete floor capable of withstanding continual hammering from the stones used to crack the nuts. The processing unit will be made up of four areas: a wet area for blanching (skin removal), a dry area for cooking and drying, a store room for keeping bags stacked, and an office. A provisional design for the central processing unit has been developed.

The factory will be able to produce both roasted kernels and oil, but kernels will be emphasised because of the higher commercial margins.

The processes involved in buying, processing and packaging galip nuts are relatively simple. Processing techniques are likely to change as new techniques are developed and refined (Maima, these Proceedings).

NIS will be stored in a custom-designed nut dryer building that has 11 bins, each holding approximately 2.5 t of NIS. Bins provide good air circulation and the building will provide dry conditions. NIS stores well for long periods under these conditions. Some drying will be necessary for nuts stored for more than two months or during extended wet periods.

NIS are cracked by hand using traditional stone hammers. Between 20 and 30 kg of NIS can be cracked per person per day, depending on the expertise and motivation of crackers, nut shape and size, shell thickness and nut moisture content. Broken and whole kernels-in-testa (KIT) are separated during the cracking process. Crackers are employed part-time and are paid on production. Kernel skins (testa) are removed: whole KIT are dipped in boiling water or steamed.

Kernels are roasted for about two hours at 120°C immediately after the testa is removed or they are dehydrated for about 10 hours at 60°C. After the kernels have cooled they are immediately packed in vacuum-sealed plastic bags to give them a shelf-life of about six months. Vacuum packing holds the delicate kernels together and permits visual inspection. Packets are then placed in strong cardboard boxes for wholesale and retail distribution.

Finance

Economic and financial projections completed by KGIDP indicate that the investment offers good financial returns as well as satisfying a number of desirable social development objectives. A summary of the major financial aspects of the project follows.

Establishment costs

The estimated cost of establishing the factory's central processing unit is K87 000 (K31 000 for buildings, K29 000 for processing equipment, K7000 for office equipment and K20 000 for a vehicle). Construction of the factory is proposed to begin in the first quarter of year 2 of the project. Major capital items associated with processing equipment include a vacuum packer, an oil press and an oven. NIS costs vary, but they are estimated at between K27 000 and K35 000 a year at the factory's full production capacity.

Production

It is most likely that kernels and oil will be produced simultaneously because of kernel damage and other factors. Assuming that 10% of kernels are broken and that roasted kernels are the main product, production of kernels is estimated to be 60 kg a day (14.4 t a year). Six litres of kernel oil should be produced daily (1440 L a year). Estimated labour requirement at full production is 24 people.

Sales returns and profitability

At full production, annual sales of roasted kernel are expected to exceed 250 000 50-g packets. Oil, shells, testa and cake will also generate considerable revenue. Annual revenue is expected to exceed K150 000, resulting in a pre-tax operating profit of nearly K50 000 a year, about 30% of total revenue.

Sensitivity

Operational profitability will depend upon four main variables:

- purchase price of NIS
- kernel content (kernel to nut ratio)
- NIS cracking rates
- blanching rates.

Kernel content has a critical effect upon returns, hence a premium will be paid for NIS with larger kernels. This policy will be implemented at the quality assessment and grading stage of the process and to encourage the delivery of large nuts with high kernel to nut ratios.

Women's Participation

The KGIDP galip nut program has significant potential to benefit women, providing that practical and strategic gender issues are addressed. The Governments of Australia and Papua New Guinea have adopted policies to promote the participation of women in development programs such as the KGIDP galip nut initiative.

Seasonal collecting of galip nut and other non-cash tree crops is mainly women and children's work. Since KGIDP began buying galip nuts in May 1994, the sale of nuts has generally followed the prevailing marketing trends, whereby women sell the nuts if the point of sale is reasonably close to the community, but men sell the nuts if the sale involves a substantial journey. The first year's purchase results demonstrate that women will benefit the most from the galip nut program if they can sell directly to the buyers themselves instead of having their men transport and sell the nuts for them.

This is the first galip nut program in PNG and thus there is no precedent for the division of labour between sexes in processing, managing, marketing and ownership. In practical terms women are significant players in the collection of galip nuts and in other small-scale food processing ventures. The role that women play in supplying and processing is not likely to be challenged as this is a traditional role for PNG women.

In strategic terms, the galip nut program represents an opportunity to strengthen women's profile in enterprise management and ownership. If this can be achieved then KGIDP will have made a significant contribution towards raising the status of women by treating them as more than just suppliers of raw nuts and labour. As this is a new venture, there is scope to set business ground rules that will be a precedent for development and expansion of galip nut processing in PNG on terms favourable to women (Price et al. 1994).

Although there is much potential to raise the status of women in the Kandrian and Gloucester Districts through the galip nut program, there are several possible constraints that could dampen

the intended effect of the program's benefits for women. The first of these constraints is that women in the project area are at a relative disadvantage to men in education, income and political power. Women have less access to logging royalties as well as more demands on their income for daily family needs. There are also cultural constraints that restrict the travel of women. If they are to benefit directly from the sale of galip nuts then the purchase points will have to be decentralised. A final constraint is that women in the project area have little experience working as paid labourers, and have social and cultural obligations that will detract from the amount of time available to work.

KGIDP is currently developing a strategy to address the constraints imposed by the division between sexes that have been identified within the galip nut program. The first of these strategies is to decentralise the galip nut purchasing points. In 1994 galip nuts were bought at Kandrian, Gloucester and Kimbe. In 1995 the project plans to establish additional galip nut purchase points at Gasmata and Pililo. It is envisaged that these purchase points will be run by women's groups. Women's groups will also be encouraged to identify, tend and plant seedlings from and map good quality galip trees.

Another way to encourage the greater participation in the galip nut program by women is to decentralise certain aspects of processing. The KGIDP food technologist is planning village-based processing and transport trials for 1995. There is the possibility of cracking the galip nuts in selected areas, sealing the KIT in airtight containers and then shipping it to Kandrian for the final stages of processing and packaging. This not only would lower transport costs for the NIS (80 per cent of the weight of NIS is in the shell), it would also provide additional income-earning opportunities for women as well as training in food processing and handling techniques that would benefit both the galip nut program and the everyday lives of the women.

Lessons Learned from Past Experience

Government and private bodies throughout the Pacific have made considerable investments during the last few years to develop the market for indigenous nuts such as the galip nut. A number of important lessons learnt as a result of the efforts of researchers and others are summarised below.

- **Regular and continuous purchasing is critical** to maintaining a good supply of nuts from season to season.
- **Factory gross margins very much depend upon the kernel content** of nuts delivered in their shells. Suppliers should be offered financial incentives to deliver nuts with large kernels.
- **Marketing of the product should initially be confined to the domestic market** until it is saturated. Quality must be completely under control before produce is sent abroad.
- **Precautions must be taken to avoid contamination** of food during processing. Samples of nuts should be tested for aflatoxin.
- **Attempts should be made to identify trees with good nut-in-shell characteristics** in order that the trees can be conserved and their seedlings can be multiplied for wide distribution. The project should make every effort to protect the remaining galip trees in the supply areas by ensuring that all timber permit holders include the galip tree on their list of restricted species.

In general, the project is expected to have a low effect on the environment. It will encourage land and tree owners to protect existing galip trees and to re-establish trees on logged areas. The project will also have a significant effect on women's development around the processing unit as it will employ mostly women as nut crackers and food processors.

Author's Note

Since the original draft of this paper in November 1994, several noteworthy events have occurred:

- January 1995: AusAID (formerly AIDAB) withdrew all funding for the galip nut program. Because of this, the food technologist position was cut. However, one landowner company invested a large sum of money to keep the pilot project afloat. Galip nuts were processed and successfully marketed in several large

centres in PNG and trial shipments of galip nuts were made to the USA and Australia. Demand for the product far exceeded supply.

- March 1995: The Niugini Nut Company Pty Ltd was officially registered and began to market roasted galip nuts in PNG.
- June 1995: WWF South Pacific came to the rescue of the KGIDP and Niugini Nut Company with a grant for the purchase of galip nuts.
- August 1995: AusAID conducted a mid-term review of the KGIDP. Its findings indicated that the galip nut program was indeed an asset and not a liability as it once thought. Increased funding has been committed. A new food technologist has been selected and will continue with processing and packaging trials.

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Production and Market Development of Okari Nuts (*Terminalia kaernbachii*) on the Managalas Plateau in Papua New Guinea

Damien Ase*

THIS paper summarises the production and market development of the okari nut (*Terminalia kaernbachii*) in Papua New Guinea and discusses impediments to intellectual property rights of indigenous peoples in the context of indigenous nuts.

In PNG, community-based tenurial systems, including rights to forests, land, water and fisheries, are recognised by the Government. Nearly 97% of the land is owned by clan groups. Ownership of non-timber forest products, including fruits and nuts, is directly connected with ownership of land.

Nuts and other forest products recently started reaching the domestic markets. However, lack of knowledge and available markets, the high cost of market studies and high transport costs have held back their market development.

The experiences gained from Okari Ecoenterprises demonstrate some of the difficulties faced by villagers in producing and marketing indigenous nuts commercially. (See the papers by Micael Olsson and Ken Houghton in these Proceedings for more information on Okari Ecoenterprises.)

Production and Processing of Indigenous Nuts in Papua New Guinea

Okari nuts are grown and produced for local consumption in six provinces in Papua New Guinea: Western, Gulf, Central, Morobe, mainland Milne Bay and Oro Provinces. (See Fig. 2 in the paper by Michael Bourke in these Proceedings.) They grow abundantly in Oro Province, especially on the Managalas Plateau, where villagers identify four cultivated and two or three wild varieties. Because of the monetary value placed on non-timber forest products, more communities are realising the importance of nut production. People plant trees in old gardens and along boundaries between clan land.

The villagers collect nuts and bring them back to their village, where they use traditional methods to crack the shells and retrieve the kernels for sale or consumption. Most sales are in the Port Moresby markets.

Partners With Melanesians is developing plans to process okari nuts into a value-added, commercially viable product. We intend to provide small grinders to families on the Managalas Plateau to grind their nuts for oil. Villagers will carry this oil to a central collection station for weighing and paying. The oil will then be prepared for shipment overseas.

Market Development of Indigenous Nuts in Papua New Guinea—the Okari Nut Marketing Experience

The first study of the feasibility of marketing okari nuts was conducted under the Department of Agriculture and Livestock's Smallholder Agriculture Development Program in 1985 (PwM 1985). The first nuts from the Managalas Plateau reached the domestic market in Port Moresby in 1993 as part of the Conservation Areas Program. This program was funded by the Biodiversity Support Program, a USAID-funded consortium of the World Wide Fund For Nature, the World Resource Institute and Conservation International. The project is conservation-driven, not commercially orientated. One hope is to create incentives through the development of ecoenterprises so that the landowners can conserve and use their resources sustainably rather

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than depleting them.

Fresh kernels arrive from Managalas by aeroplane and are stored in Port Moresby. Local vendors buy them from us at K3/kg for informal markets and K4/kg for formal markets. They sell them at street corners for 10 toea each (1 kina = 100 toea).

We negotiated with Associated Distributors (Steamships) in 1994 to take 80% of our total production. We will sell the remaining 20% to the informal sector.

Expressions of interest have come from the USA, England, Sweden and Japan. We have sent samples to the Churchill Nut Company and Sees Candy in California, Michael Mars Candy Bars in Arizona and Cultural Survival Enterprises in Massachusetts, but have not received any results or made any arrangements with them to date.

Intellectual Property Rights Law on Indigenous Nuts

Currently there is no intellectual property law in Papua New Guinea, although customary law already provides for this. Some moves are being made to develop it.

An emerging issue in the debate about the rights of indigenous peoples concerns whether their traditional knowledge might be entitled to protection under the national and international system of intellectual property law. This looks doubtful, however, because developing countries have generally subordinated protection for intellectual property to rapid economic development. The rights of indigenous peoples are ill defined. Existing and proposed international agreements on intellectual property provide little support for the notion.

All forms of intellectual property could be involved in the development, production and marketing of forest products, but patents may be the most important because they give their owner the opportunity to control the production and marketing of drugs or other products for several years and thus to reap economic benefit from them. However, the requirements of patent laws that an invention be novel, useful, not obvious and not a product of nature appear to be insuperable obstacles for indigenous intellectual property. If indigenous property rights cannot be established, foreign interests could take the best varieties of nuts, for example, to Hawaii or Queensland, and plant them and develop their own markets.

The Barai people of the Managalas Plateau are very concerned that their rights to control and use their non-timber forest products could be taken away from them if outsiders are involved. The Barai have been selecting the best nut varieties for hundreds of years and have come up with what may be the biggest and best tasting nuts in the Pacific. They want to be able to patent their varieties and earn royalties from any plantings overseas. International laws are not fully developed on this so we and the Barai would like to make an issue visible on the international scene and get some influential people to act, perhaps through the United Nations.

Recommendations for Further Work

- Establish a database of all indigenous nuts in the South Pacific region.
- Train people involved in production and marketing of indigenous nuts in the South Pacific.
- Develop intellectual property law, especially the laws of patent, to protect the rights of indigenous people to non-timber forest products.
- Develop guidelines for the cooperation of South Pacific indigenous peoples in producing and marketing indigenous nuts.
- Persuade the governments in the region to recognise the importance of indigenous nuts and other non-timber forest products and to provide funding to help local people market these products.

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Okari Ecoenterprises: A Snapshot of Participatory Rural Development

Micael Olsson*

THE distribution and sale of packaged okari nuts through a commercial distributor, supermarkets and shops to outlets in Port Moresby, Papua New Guinea, mark a breakthough for local entrepreneurs in small enterprise development on the remote Managalas Plateau. Few shoppers, however, can really appreciate the challenges that have been overcome to get the seasonal nuts from the remote sites where they are collected to these urban markets. (See the papers by Houghton and Ase in these Proceedings on marketing okari nuts from the Managalas Plateau in Papua New Guinea.)

Background

The Managalas Plateau in the Oro Province of Papua New Guinea is a good example of the country's rich biological wealth. It was highlighted in the comprehensive PNG Conservation Needs Assessment (CNA) report (Alcorn and Beehler 1993) as an area of significant biodiversity. Ten thousand villagers live in small villages and hamlets surrounded by subsistence gardens and smallholder coffee plots. The plateau itself, about 750 m high, is bounded by vast forested ranges on all sides and encompasses roughly 300 000 ha from alpine heaths at 3600 m to both primary and secondary lowland rainforest.

Small plots of a high grade of Arabica coffee and money from relatives working in towns provide only a modest income for the local population. Primary schools, health centres, churches and small trade stores are scattered throughout the area but lie primarily along a hand-cut and poorly maintained road that reaches from the coastal port at Oro Bay into the centre of the plateau. Five airstrips that were closed when the road was completed have since been reopened, including one at the local government station at Afore. Communication is mainly by two-way radio with the neighboring Central Province, although most of the local health centres are linked to the local provincial capital by a church-run service. A provincial radio station serves the area with music, news, development programs and an important public announcement service.

The clan groups of the Managalas Plateau are fortunate to have their community-based tenurial systems on rights to forests, land and water recognised by the national government. They have gained experience in recent years in collaborating with one another and with outside agencies and organisations on several local development initiatives. These have included the organisation of a coffee cooperative, a coffee rehabilitation program, a 'walk-about' sawmill program, an innovative vernacular pre-school program, and various adult literacy and non-formal education programs.

There has been growing concern among the people of the plateau about the potential destruction of their forests through logging or strip mining. This has given rise to a keen interest in developing economic alternatives for sustainably managing this resource base. One such potential alternative is *Terminalia kaernbachii*, known locally as the makame or okari nut. (Makame is the local Barai word for *Terminalia kaernbachii*. Okari is from a regional trade language that originated in another area.) The okari nut, the Queen Alexandra Birdwing butterfly, artifacts, eco-timber and organically grown coffee make up the primary local resources that clan groups are pursuing as part of an integrated conservation and resource development program.

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Brief Project History

The idea of a project focusing on the commercial marketing of the valued okari nut evolved in 1984 when the young government of Papua New Guinea announced its Smallholder Agriculture Development Program. The Barai, on the eastern side of the Managalas Plateau, were among the first groups to qualify for feasibility study funds under the program and had been selected for full funding when the program was terminated owing to shifting budget priorities.

In June of 1992, the Barai decided to develop an integrated conservation and development plan for sustainably managing all the forest resources upon which they so heavily depend. Initial funding for the project was secured from the USAID-funded Biodiversity Support Program. (The BSP is a consortium of WWF, the Nature Conservancy and the World Resources Institute. It was established in 1988 with funding from USAID. Its mission is to promote efforts to conserve biological diversity while enhancing human livelihoods in developing countries, through improved conservation and use of biological resources.) The Liz Claiborne/Art Ortenberg Foundation, the Macarthur Foundation, Kennecott and Cultural Survival International later contributed at various stages to the development of the enterprise, called Okari Ecoenterprises. The project launch was the first in a series of stakeholder forums that brought together a number of national and international interests in conservation and development with local clan elders and community leaders to discuss issues and options specifically related to the local situation.

Further valuable planning and promotional activities took place under two successive Biodiversity Conservation Network planning grants. (BCN is administered by the Biodiversity Support Program and is funded by the United States – Asia Environmental Partnership, which is led by USAID.) The clans of the plateau are now confident after their limited but important success with marketing okari nuts that it is indeed possible, although difficult, to develop profitable, locally controlled and managed ecoenterprises on the plateau. The successful use of income to support the sale of several plane loads of nuts during 1995 now substantiates that assessment. This is a kind of empowerment that is likely to spread to other groups.

Wide Area Participation and Consensus

The participative design and development process used in establishing the project was critical to its success. Although there is currently much rhetoric about the importance of community participation and consensus-building in rural development, little is said about how to link activities in communities spread throughout a geographic area. The development of Okari Ecoenterprises required such a model in order to incorporate all the communities of the plateau. In so doing, experience has been gained in concurrently building consensus within a smaller local group and across a collection of groups within the larger project area.

Few models of participation address the deeply ingrained assumptions brought by stakeholders from different cultural backgrounds to the discussion process. Traditional consensus-building styles are clearly too time-consuming and yet the opportunity they give for each individual of the community to participate is highly valued in many indigenous settings. On the other hand, voting and representation, which are usually fundamental to newer forms of participation, can actually become divisive in traditional settings. Voting could be seen to create winners and losers in a context where traditional consensus-building carefully builds only win-win situations. Similarly, representation could create alienation in groups where identity is linked to how one contributes to the group.

This was the situation faced during the development of Okari Ecoenterprises. Outside technical assistants and advisers wanted to move quickly based on decisions made with a representative group in isolation. Local stakeholders, however, were reluctant to move until they had consulted the groups they represented. As a result, the process that evolved created two tiers of participation. One moves more slowly and involves everybody in weekly evening meetings at the local village level. The other involves representation and voting, but with an extra step of local community ratification following that rep-

resentative decision. This combination keeps the process moving at a faster pace while still accommodating the need for everyone at the community level to contribute.

A participative model of this kind has potential to hold local 'big men' responsible to the shared opinion of the larger group. It might be worth trying out this model at the local government level in PNG if increased resources could be made available.

The Evolution of Culturally Relevant Management Structures

An inadvertent consequence of the cooperatives organised across Papua New Guinea during the 1970s was their tendency to neutralise the capacity of member clan groups to outdo each other in amassing and distributing wealth. Traditionally, an individual clan or clan group achieved status by giving away more yams or more pigs to the neighboring clan than it had received the previous year. Now, however, organising one management structure for a large group that crosses these boundaries frustrates this deep underlying motivation. One critical lesson being learned through the growth and development of Okari Ecoenterprises is that traditional clan organisation should influence the organisation of management structure. This holds even though larger overarching affiliations will likely be needed to achieve the economies of scale needed to minimise transport expenses and meet contract quotas.

The early model of distribution and marketing used by Okari Ecoenterprises followed the efficiency models of the West. It had a relatively strong central management and a peripheral role for buying and storage centres in each of ten culture zones across the plateau. The emerging model, however, gives much greater independence to each of the zones. It gives them the means to collaborate on matters of mutual interest such as shared arrangements with charter companies or the need to meet large production quotas for specific retailers. Figure 1 attempts to capture the two contrasting positions. Model A is the emerging model; Model B is the earlier one.

Local clans are also very sensitive about having to share the benefits of their resources with middle men or institutions, especially as the middle men's role involves making judgments on the allocation of these benefits on behalf of the local groups. There has been growing apprehension regarding the role of national and international NGOs in this regard.

Okari Ecoenterprises eventually endorsed a fellow Papua New Guinean with broad local business experience and trusted ties to the local community to advise them on creating links to urban supermarkets and on appropriate transport and storage arrangements. The relative success of this stage of the project's development will be further tested by the anticipated increase in volume from several sites, which will be managed by a complex of collaborating institutions.

Learning for Informed Participation

Although it is widely recognised that effective participation in the design and implementation of rural development projects inevitably involves some kind of learning program, the costs and the time frame involved often prohibit such learning components. Similarly, the relevance and feasibility of incorporating indigenous knowledge into either the design or the implementation of such projects is also frequently questioned. The Okari Ecoenterprise experience, on the other hand, depended heavily on learning activities that were incorporated into the participation process itself. At the same time, indigenous knowledge relevant to the project also emerged through the participation process and had significant influence on design and implementation. It became important then for the information sharing process to capture and package that information, particularly for the benefit of the stakeholders from outside the area.

Examples of knowledge contributed by a community include:

- a preliminary record of local customary practices of tenure and rights of access
- baseline data on land use patterns
- current slash-and-burn agricultural practices
- management of sacred forest plots
- current forest harvesting practices
- locally appropriate nut-cracking technology
- locally appropriate packaging and transport from the forest to roads and airstrips

- locally appropriate drying and storage techniques.

Examples of knowledge contributed by outside expertise include:

- a system of monitoring plots to estimate yield and sustainability requirements
- how locally developed, natural resource management guidelines can be formally recognised under current PNG legislation
- global conditions that give rise to international conservation funding
- how to make use of international conventions to secure copyright, patents, trademarks and so on to maximise local economic benefit from the resources
- pitfalls and possibilities in the global marketplace
- local marketing opportunities and contracting arrangements
- financial accountability and reporting methods.

Information packages for use in the development of Okari Ecoenteprises clearly needed to

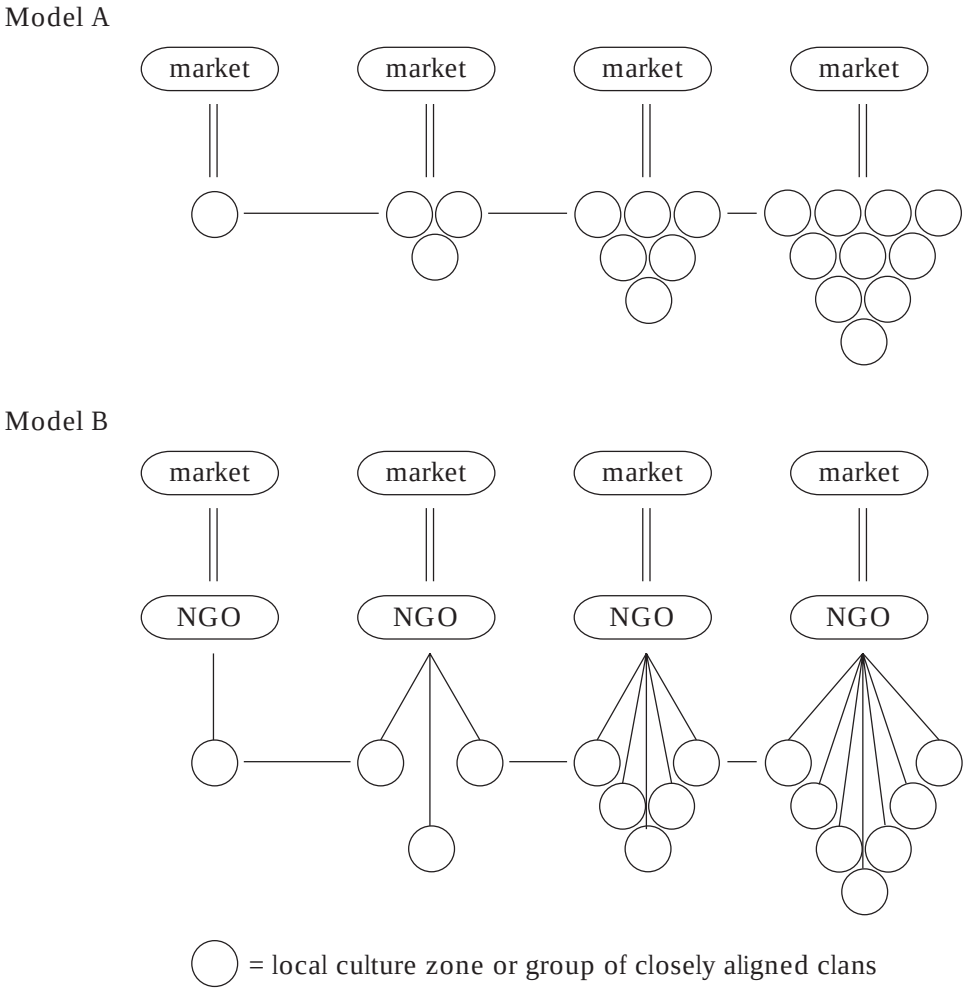

Figure 1. Contrasting levels of local participation in initiating and expanding marketing arrangements. In Model A, as the number of local clan groups involved in marketing the nuts expands, the number of groups collaborating in adjusting and endorsing those marketing arrangements also expands. In Model B, however, the marketing arrangements are in the hands of a 'helping' intermediary that then deals independently with each population group that begins marketing nuts.

draw on both sources of knowledge. The local Barai Nonformal Education Association, which was already producing vernacular materials for local preschools, prepared the bulk of the print material for the awareness packages. It relied on collaborating national NGOs for external information.

The material included information sheets circulated before the discussion groups and illustrated flip charts with trigger questions to guide the group facilitator. Related written material used in schools, literacy classes and community groups is shared orally and thus further contributes to informed participation at the open meetings. Awareness videos powered by portable generators further contributed. Local radio stations broadcast announcements and special interviews.

Although the awareness program that supported the development of Okari Ecoenterprises lacked continuity because of sporadic funding, it does demonstrate how information packaging and dissemination critical to such development can build on local institutions and skills and be surprisingly cost-effective.

Continuing Challenges

The key concern at the moment is revitalising the participatory process to develop a structure to link the marketing of okari nuts across all the culture zones of the plateau. The model could then be extended to incorporate organic coffee, butterfly farming and, perhaps, community forestry.

Trying to string together various pieces of short-term funding from a variety of donors has made it difficult for staff to maintain the participation process or to effectively plan harvesting activities ahead of the season. The same applies to local efforts to build relationships with outside stakeholders with an interest in the project. The lack of funds for travel or telecommunications ultimately has meant spotty and ineffective communication with key agencies.

The low volume involved in the early learning phase may have been a blessing in disguise. It meant that early mistakes were corrected with minimal consequences. There were eleven charter flights during the 1993 season, with between 400 and 700 kg of kernels per flight, which were sold in open markets in Port Moresby. Lessons from spoilage owing to poor packaging, changes in flight schedules and warm storage conditions, for example, were all learned with these small volumes. Now, with several cultural zones starting up operation from different sites across the plateau, production levels will be much higher, but with a greatly reduced risk of loss.

Overhead expenses were high through the early stages but gradually decreased as the staff and the harvesters learned by experience how unnecessary expenses cut into profit.

National NGOs found it difficult to deliver on requests from the local communities for specific kinds of information available only in Port Moresby. Two problems persisted: first, obtaining the information from national institutions, and second, adjusting the language contained in original documents to everyday terminology.

Developing a management structure that satisfies the demand for transparency in the handling of funds and that shares any earnings equally among the participating clans has been difficult to satisfy. For this reason, the management structure has been revised following each combined structuring forum. Each revision makes the management structure more appropriate culturally, but care must be taken to be sensitive to the tradeoffs between cultural appropriateness and any related increase in overhead expenses.

Conclusion

Broad community participation in both design and implementation, supported by appropriate new information as the situation demands, has played an important role in the measure of success that Okari Ecoenterprises has experienced to date. The challenge now is to maintain and expand that participation to support shared, long-term, sustainable development guidelines across all cultural zones on the plateau. Such guidelines are likely to enjoy widespread support as long as the economic benefits of the activities are strong enough to diminish the appeal of the ecologically damaging logging and strip mining.

Reference

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Domestic Market Development of Okari Nuts (*Terminalia kaernbachii*) in Papua New Guinea

Ken Houghton*

ASSOCIATED DISTRIBUTORS began marketing okari nuts (*Terminalia kaernbachii*) from the Mangalas Plateau in the Oro Province of Papua New Guinea in 1994. (See the paper by Micael Olsson in these Proceedings for information on production on the Managalas Plateau.)

Most sales of these nuts had previously been in local markets and by street sellers, but the amount available has far exceeded the capacity to sell. In marketing okari nuts we are trying:

- to help land owners develop a cash income as an alternative to income from logging
- to increase the return to growers and gatherers
- to encourage growers to sustain that income without support.

In the first year a local business group called Barai Investment bought okari kernels from villagers for K1.50/kg. We paid Barai Investment K4.50/kg. This included the cost of air transport to Port Moresby. Retail price was approximately K7.80/kg. We received two shipments of 600 kg each in 1994. The nuts were of reasonable quality but had a high breakage factor.

We presented the nuts for sale in Steamships stores in Port Moresby. The response was good, but some problems occurred: customers tended to slip a few into their pockets or ate them in the store, and staff treated them like peanuts, leaving them on the shelf out of the refrigerator. We found that the best method was to sell them prepacked on the vegetable cooler cabinet.

If we are to succeed at selling the raw nuts, the supply chain—handling, purchasing and post-harvest—will need to improve. We believe that we can succeed if we use the same approach as we use for our fruit and vegetables.

In our fruit and vegetable operations our strategy is to negotiate an agreeable price, volume, quality, supply sustainability, method of packing, post-harvest procedures and point of delivery. We bypass the middle-men, whose objective seems to be to buy at the lowest price and sell at the highest. These middle-men tend to be opportunist and have done nothing to develop sustainable growing or a stable market.

From the point of delivery we move the fruit and vegetables as quickly as possible to our points of distribution and sale. At the point of sale, we train our staff to have a better understanding of the characteristics of the products and their storage and handling needs, and in methods of presentation and display.

The purchase and sale of fresh nuts is a short-term project. In the long term we would like to sell processed, value-added products. This will help us to achieve our objectives of better returns to growers and a sustainable market.

We believe that the future of the nut business lies in sales to local consumers. These people already know the product and very little market research is required. Given better access and a better quality product, we doubt that any export is needed yet. In the long term, though, export will allow us to improve the return on the product.

We foresee a potential long-term problem, however. As income increases, aspirations generally increase. It may well happen that increased aspirations will exceed the income from sustainable products and again put pressure on villagers to log the forest. This will need to be dealt with.

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Conservation-based Enterprises: Business Development and Product Marketing

Ted London*

ECONOMICS drives much of the world's rainforest and marine ecosystem destruction. Local people clear forests or destroy reefs to grow crops, raise cattle, harvest timber, catch fish or pursue industrial development. Conservation International (CI) helps create an alternative to environmental degradation by developing enterprises based on sustainable use of natural resources. These sustainable enterprises market 'biodiversity products' such as tree oils, plant fibres, nuts, latexes and reef products harvested in an ecologically sound manner from key biological areas. In doing so, they demonstrate that sustainable enterprises can help local people earn their living by managing and harvesting biologically rich ecosystems instead of destroying them for short-term economic gain.

Conservation International

Conservation International strives to protect the natural systems that support life on Earth. It has operations in 23 countries. With local partners, it applies innovative tools and perspectives to the conservation of priority ecosystems.

CI works in 'hot spots' of biological diversity, areas distinguished by exceptional numbers of species and the imminent threat of destruction. CI strives to protect tropical rainforests, where the highest biological diversity is found, and other important ecosystems such as wetlands, savannas, temperate rainforests, deserts and marine ecosystems.

CI provides technical assistance to local conservation enterprises that create incentives to protect local biodiversity. This includes training and technical advice to help establish or support community-level enterprise management. Support is also given to help local entrepreneurs, cooperatives and non-government organisations develop markets for biodiversity products. CI undertakes detailed feasibility and marketing studies and evaluates local community commitment to conservation.

CI refrains from direct product marketing and instead links resource owners and existing product manufacturers and sellers.

The Asia and Pacific Regional Program

Conservation International's program in the Asia and Pacific (A–P) region takes an integrated approach to ecosystem conservation. We seek to integrate conservation biology, human ecology and conservation enterprises. This is combined with a strong emphasis on building local capacity in communities within the ecosystem and on the formation of partnerships with local institutions for planning and implementing field activities. The mix of skills and expertise represented by national partners ranges from grassroots development to tropical biology.

Within Asia and the Pacific, CI works in six countries (Indonesia, the Philippines, Papua New Guinea, Solomon Islands, Fiji and Vanuatu) and one territory (New Caledonia). Within each country, CI is typically working in one to three ecosystem sites.

At each site, we collaborate with local communities in an area proposed for conservation. These include permanent villages and communities living in and off the forests or reefs. Usually these communities have limited infrastructure development and infrequent contact with the outside world. The local people directly involved in CI's conservation efforts represent some of the world's last surviving experts on sustainable resource management for their particular ecosystems.

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The A–P program works with local institutions, particularly non-government organisations (NGOs), and with local universities and colleges, sharing our findings. Issues of tenure, equity, gender and other social issues, which have enormous effect on the long-term success and sustainability of conservation activities, are important.

Our field programs incorporate long-term biological research, both marine and terrestrial. The intention is to provide a scientific basis for conservation and resource use and to increase national scientific capacity and information sharing. Part of the research is often directly related to evaluating long-term sustainability of various forest and marine products.

The socioeconomic portion of our field activities includes studying local use of natural resources. Ethnobiology, or the study of traditional uses of plants and animals for medicinal, ritual, subsistence and other purposes, is an important focus of research at most of our sites.

The collection of baseline social data allows socioeconomic monitoring of the effect of program activities. Participatory Rural Appraisals are used to help communities assess their natural and human resources and identify problems and opportunities. A goal of this activity is the creation of a community-developed resource management plan to help the future planning and use of community resources.

At most of CI's A–P sites, a program to support the development of conservation-based enterprises is actively pursued. This strategy is coordinated by CI's Conservation Enterprise Department (described in the next section). The objective is to promote locally owned and operated enterprises that offer incentives for conservation of biological diversity.

CI collaborates with local NGOs and communities to establish businesses that promote to both domestic and international markets. The long-term goal is to enable communities to benefit economically from conservation enterprises that promote biodiversity protection, and to participate in the management of their natural resources. More than one business is developed at each site to ensure diversification of the local economy and the stability of income and support for participants and conservation activities.

Conservation Enterprise Department

The Conservation Enterprise Department (CED) synthesises approaches from business, community development and conservation science. CI scientists evaluate overall conservation priorities and establish the viability of sustainably harvesting specific products. CI establishes a foundation of community involvement through its conservation-based development approach. The CED's team of experienced business professionals helps establish local enterprises and makes the necessary linkages to bring forest and marine products to market.

CI's sustainable enterprise work

Although the use of sustainable forest resources can provide powerful incentives for conservation, newly formed conservation-based enterprises face significant obstacles to success. These include insufficient access to information, technology, financing and markets. Recognising this, CI began working in the area of community enterprise development in 1990 with its launch of the Tagua Initiative, the first of its projects to market sustainably harvested biodiversity products. Since that time, CI has promoted enterprises that supply biodiversity products to the clothing, food and personal care industries.

The Tagua Initiative

The Tagua Initiative markets products such as buttons and jewellery made from the ivory-like nut of the tagua palm. The tagua is harvested from biologically rich forests of north-west Ecuador without disrupting the forest ecology.

In less than four years, the initiative has sold more than 1000 t of raw materials and 20 million finished buttons. It has created more than 1300 part-time jobs in the community area, including skilled jobs manufacturing hand-carved buttons for export. In addition to the community enterprise, the initiative works with four major button manufacturers, two manufacturers of tagua carvings, a major jewellery manufacturer and a button distributor to the retail market. Dozens of garment manufacturers have joined the initiative, including such companies as the Gap, Esprit, Timberland, and Smith & Hawken.

More importantly, the initiative has been an

example of alternative land use, and a focal point in local debates over forest stewardship. It played a role in persuading local people to reject a proposed a 12 000 ha banana plantation, and in the development of a regional land use plan.

The Croda–CI partnership

With the launch of the Personal Care Project, product exploration expanded from the tagua sites in Ecuador and Colombia into CI ecosystems around the world. Enterprises were developed around botanical products and oils from trees. To facilitate market access, CI formed an innovative partnership with Croda Inc., a well respected manufacturer of raw materials for cosmetics and a leading supplier of specialty ingredients to the personal care industry. Croda purchases biodiversity products from CI enterprises and processes them into specialty ingredients that it markets with CI's support.

Additional enterprise activities

CI marked its entry into the food industry by financing the purchase of a Brazil nut processing plant by a local non-profit organisation in Peru. The Brazil nut factory now exports 55 t of Brazil nuts annually. In Guatemala, CI collaborated on development of a rainforest potpourri made entirely from sustainable forest products. The potpourri was successfully launched on the US market in 1994 and has been in strong demand among several national retail chains. Other new enterprises are under development in Asia, Africa and Latin America.

Conservation Program on Makira Island

One example of ecosystem conservation in the Asia and Pacific Region is the Conservation in Development (CID) program on Makira Island in Solomon Islands. The CID program is a partnership between Conservation International, the Maruia Society (a New Zealand based NGO) and the Solomon Islands Development Trust (SIDT, an indigenous NGO). The program is managed from SIDT's offices in Honiara.

Nearly all land in Solomon Islands is owned by indigenous family groups and is held under traditional tenure. Commonly, people live in villages that vary in size from twenty people to up to several hundred. In most areas landowners live subsistence lifestyles, dependent on their gardens, reefs and forests. There are few opportunities to earn cash, which landowners need to buy manufactured goods and to establish development opportunities. The lack of development opportunities is driving many landowners to consider large-scale development of their forests including logging.

In 1990, as a result of a national ecological forest survey in Solomon Islands conducted by the International Council for Bird Preservation, the Maruia Society and CI, Central Makira was identified as a national conservation priority. In 1992, after finding significant interest for a conservation program within the local communities of Central Makira, CID began developing a pilot conservation and development program. This covered 63 000 ha of forest (including lowland, highland and cloud forest), which includes 35 villages and more than a thousand permanent residents. The forest contains a number of endemic species and is representative of Solomon Islands tropical forests.

Initial support for this program was provided by the US-based MacArthur Foundation. An additional grant was given by the Biodiversity Conservation Network, a consortium of the World Wide Fund for Nature, The Nature Conservancy and the World Resources Institute, with funding by the United States Agency for International Development.

The basis of this program is that it is centred around people and their communities, which lead the program development through workshops and active participation. The following are critical to program success:

- Ownership of the conservation program by landowners
- Enterprise development that is dependent on natural resource conservation
- Landowners' understanding of and commitment to conservation and resource management planning
- United communities with effective leadership.

The program's activities are summarised below under three headings: Biological, Sociological and Enterprise.

Biological activities

The extraction of ngali nut oil (*Canarium* spp.) has been the subject of a research and development program for several years within the Solomon Islands Ministry of Agriculture and Lands and by CI. Based on feasibility analysis, business plan development and extensive discussions with the local communities, the CID program concluded that ngali nut harvesting was a prime candidate for an ecologically sustainable enterprise with appropriate biological monitoring.

For the Makira operation, long-term monitoring is planned. Initial baseline data will be collected during the first year of harvest. This will determine the effect of harvesting on the regeneration rate.

Two sets of scientific research surveys are planned. Firstly, a team of scientists will visit Makira to assess the ecological status of the area, and to provide baseline data for future monitoring and decision making. The monitoring will be structured so that local communities will be doing it themselves in the future after training from the scientists. Secondly, a year-long study of numbers of birds hunted and management requirements for hunting will be undertaken by a fruit pigeon expert. This research will also look at the effect of the local hunting of pigeons on the propagation of ngali nut trees, as the birds could act as major seed dispersers.

Information from these biology surveys and socioeconomic data collected from the local communities will be computerised and analysed using CI's Geographical Information System (CISIG), housed at SIDT offices in Honiara. CISIG will permit the CID program to better visualise and present the data, and can serve as an important planning tool with village communities and in monitoring.

Sociological activities

SIDT staff have regularly visited the communities in Central Makira to discuss the conservation and development program and its activities. The SIDT field workers initially met every village to discuss conservation through ecologically sustainable development, and the socioeconomic program. This activity contains two main components: socioeconomic monitoring and participatory rural appraisal (PRA) for resource management and land use planning.

Household surveys are carried out in each community. The results are then collated, analysed and taken back to the communities as part of the PRA workshop. In these workshops, resource management problems are identified and discussed, and the development needs of the community are studied. In the PRA process, issues of priority are identified and groups are set up to study them. Maps of the area are produced, land use plans are developed and enterprise options are discussed. After two years, the baseline survey will be repeated to monitor socioeconomic changes within the community.

Enterprise activities

Producing oil from ngali nuts is the first village-based enterprise being piloted on Makira. This enterprise involves a group of communities in the Warihito River area. Before any work was begun, community commitment to environmental protection was confirmed and a conservation partnership was established with the local villages. A critical component was the decision by the six villages that surround the Warihito to work together on this project and to form a committee representing the villages to oversee the enterprise development.

Following a detailed feasibility and planning phase, a shed to house the oil press was built and the press was installed in Warahino village. Pressing began with a number of trial runs. The Dodo Creek Research Station in Honiara had already developed a prototype oil press and done significant analysis of oil press technology and yield maximisation. This information proved valuable in the establishment of the production facilities on Makira.

CID staff have regularly visited the Warihito River communities to help them manage the pressing operation. Four local staff are now trained to run the ngali nut operation without outside assistance. The process includes sorting, grading and weighing nuts for sale, then grinding, mixing and pressing nuts, storing the oil and cleaning the equipment.

With the assistance of the Commodities Export Marketing Authority, a statutory develop-

ment and marketing body for export crops of Solomon Islands, the first shipment of 200 L of *C. indicum* oil departed Honiara for the USA in June 1994. This ngali nut oil sample will be tested for use in cosmetics by Croda, with whom CI has formed a partnership. The marketing of the ngali nut oil and the development of the partnership with Croda are discussed in greater detail in the next section.

Continuing activities include building leadership skills within the participating communities, providing assistance to resolve any potential conflict, examining quality control issues, re-evaluating costings, and determining a pressing season and schedule for the future. Project staff will receive training in bookkeeping, administration and time management.

To provide a wider range of economic alternatives, a community-based ecotourism enterprise is being piloted in the Central Makira Highlands. A pilot ecotourism tour took place in June, comprising five people from New Zealand and three expatriate residents of Honiara. The purpose of the tour was to assess the commercial feasibility of such an enterprise, and to give the communities the experience by which we could ascertain their interest in an ecotourism venture.

CID staff members have also explored the potential for other conservation-based enterprise projects. They found considerable community interest in beekeeping, paper making and butterfly farming. Feasibility studies are planned for each of these potential enterprises.

Marketing of a Rainforest Product: Ngali Nut Oil

In marketing conservation-based rainforest and marine products, Conservation International does not follow a traditional strategy. Instead of engaging in actual product marketing, CI's goal is to help establish links between producers and markets.

There are several reasons for this strategy. First, CI does not have the resources or industry connections to bring a large number of individual products to market. Second, establishing a retail marketing program would entail adding another layer of product distribution costs with the creation of a new organisation or department focused on handling direct marketing and sales of the product. Finally, CI would find itself in direct competition with companies more experienced in marketing these products.

CI prefers to form partnerships with companies already actively involved in the particular market. This helps eliminate competition and creates economies of scale. In addition, when given the opportunity, CI will try to work with wholesale distributors instead of end manufacturers. The product is then not limited to one retailer, but can be marketed through the distributor to a wide variety of end manufacturers. This gives the product a much wider market presence.

Once a mutually beneficial partnership is identified, a licensing agreement is established. This guarantees that products will be bought only from designated local suppliers. This also ensures that the economic benefits are directed to the specific communities involved in the project and that the sustainability of the product harvesting is being monitored.

The distributor's sales force takes the active lead in marketing the product. However, CI assists in the marketing effort by meeting and making presentations to key companies. This adds credibility to the environmentally sensitive aspect of the marketing program. CI also often uses its own contacts to bring new clients to licensed distributors. Finally, CI lends the use of its logo for some products to promote the conservation and direct local community benefits of the product.

In the case of personal care, CI recognised the importance of the industry as a vital and untapped market for oils, waxes and balsams from natural sources. Personal care companies are continually searching for new and different ingredients for a wide variety of products. Raw materials from rainforest and marine ecosystems offer the industry an opportunity to develop innovative specialty ingredients for consumer products.

An extensive overview was conducted first. It examined market segmentation, competition, industry concentration, industry shipments, demographics, recent industry trends, distribution channels, the raw material market (particularly for oils, waxes and balsams), private label contractors, the natural (or 'green') segment, and the various specific market segments. The study

also evaluated how plants are used in the cosmetics industry and the effects of the Green movement on the image, products and regulations of the industry. The results of the study indicated that the best strategy was to form an alliance with one of the wholesale distributors. Most technical research on new ingredients for the personal care industry is typically done by these distributors. A partnership with a distributor would also allow for the use of their laboratory facilities for product formulation and analysis and for US Food and Drug Administration approval. The distributor's sales force, with assistance from CI, could also market the products to a wide variety of end manufacturers.

After receiving feedback from industry sources and studying the various companies, CI approached and initiated discussions with several companies. Croda eventually agreed to form a partnership with CI to identify and market new rainforest and marine materials as ingredients for personal care products such as shampoos and creams.

Croda is responsible for:

- identifying the market niche for products and targeting accordingly
- refining the original starting material to meet standards of cosmetic acceptability
- guaranteeing quality control and adherence to the highest market standards
- testing raw materials for efficacy, unique characteristics and safety
- creating sample formulations to demonstrate performance of ingredients in finished products
- providing the sourcing and distribution network for ingredients
- instituting sales and marketing programs that reach end manufacturers.

Conservation International is responsible for:

- identifying marketable materials that can be sustainably harvested from threatened ecosystems
- creating links between harvesters, producers and manufacturers
- establishing harvesting and processing systems that most benefit local communities
- monitoring the biological effects of projects on the ecosystem and the sociological effects of projects on communities
- training local people in the necessary business and management practices
- helping to build the infrastructure for successful conservation-based development projects.

Some of the products will be marketed by Croda as environmentally friendly and will use a joint CI–Croda logo. However, product development will focus on price competitiveness and good quality. To maximise long-term prospects, the sales effort will try to avoid potential short-term market trends and will focus on products that are truly competitive on their own merits.

Before developing a specific ecosystem product such as ngali nut oil, CI's A–P program carefully evaluates the long-term viability of the potential environmentally sensitive enterprise. The activities should be community-centred and participatory, and provide leadership training and community strengthening. The following criteria are used as guidelines:

Integrated approach. A successful business venture should solicit input from all concerned groups including government, NGOs, local business people and residents. Each of these groups has specific knowledge and expertise to contribute and should be consulted.

Promoting local conservation. Each proposed business must contribute to the conservation of the site. Enterprises are evaluated on whether they create incentives to preserve local biodiversity, and whether the proposed venture challenges existing environmentally unsound business practices including non-sustainable harvesting.

Business viability. A sound business plan that carefully analyses the market and considers various financial scenarios is essential. Preliminary market studies and business analyses should be completed to ensure that the enterprise can survive in an unsubsidised competitive environment.

Ecological effects. Harvesting levels and methods need to be researched to verify long-term environmental sustainability of the proposed product or service. The business venture should strive to have no effect on the biodiversity of the site.

Maximising local benefits. Critical to success is ensuring that local residents receive significant long-term benefits from the private enterprise being considered. Included in this is the recognition and protection of intellectual property. For each proposed business concept, analyses should be undertaken to identify intellectual property and to evaluate how much of the income generated will be returned to the local community. By establishing and protecting local participation, incentives are created to safeguard the local biodiversity.

Training. In order to ensure the long-term sustainability of the private enterprises, local communities and entrepreneurs need to be trained in appropriate business skills and effective resource management.

Diversification. A survey of local businesses needs to be completed. New ventures should avoid competing with existing businesses that already promote local conservation. Pursuing diversification minimises the risk that the failure of a single business concept will have a significant negative effect on environmental protection activities. The effect of price and demand fluctuations on a single product will also be reduced.

Evaluation and feedback. Baseline surveys need to be conducted to assist in the future evaluation of the project's effect. Once the project is under way, its activities and their effect on the community and the environment should be continually monitored and evaluated. This will ensure that both conservation and local business development are actually being promoted.

All of these eight criteria need not be fulfilled immediately, but the resources should be available to successfully achieve each goal.

For the evaluation of the business viability of a ngali nut oil enterprise, an in-depth business analysis and a market study were done. Areas of focus were the current market, competing producers, quality standards, different geographic markets, market trends and competing products. The study also examined production capacity for ngali nuts, transportation costs, the export process and associated costs, import procedures, production costs and pricing. The results indicated that ngali nut oil would be easier to market than the nut itself.

Before any production activities were initiated, a complete business plan, including a detailed cash flow analysis, was completed, and samples of the oil were sent to Croda. Only after positive results were received were plans initiated to implement a conservation-based ngali nut oil enterprise.

Part III: Aspects of Developing the Resource

A. Production Aspects

The Canarium Nut: Research and Development at the Lowlands Agricultural Experiment Station, Keravat, Papua New Guinea

Will Lungat Akus*

PAPUA NEW GUINEA (PNG) is blessed with numerous species and varieties of edible indigenous nuts. Some trees are cultivated but many grow wild in their natural stands and the nuts are harvested only when needed. Cultivation practices and production areas differ between species. *Pandanus julianettii*, for example, is cultivated between 1800 and 2600 m above sea level, but *Inocarpus fagifer* is restricted to only a narrow lowland belt. The distribution and their cultivation zones give some indication of the species' economic importance and their preference within PNG.

The nuts perform a very useful role in giving variety to the people's diet. They give bulk to other foods, and many are highly nutritious, with high protein and energy contents. The introduction of new species and varieties has broadened the already good genetic base and given PNG growers and consumers the luxury to choose which to eat.

Despite the rich variety of nut species available, interest in many has declined. There are two main reasons, but there could be others. The first is changes in people's dietary habits. There is more to choose from to cultivate or buy now than 30 years ago. Introduced nuts such as the peanut (*Arachis hypogaea*) are much easier to grow, harvest and prepare than some of the indigenous species.

The second reason is competition for resources from other crop species. Land, labour, money and time are in short supply. The land that once provided sanctuary for these species is now in short supply and cash crops such as coconut and cocoa are given priority when new land development programs happen. The time and labour needed to find and collect nuts are simply not available.

The decline in importance and use of some indigenous fruits and nuts will continue. One species, though, has gained prominence recently. This is *Canarium indicum*, or the galip nut as it is commonly called in PNG. The rest of this paper reports the use of the galip nut over the years, and highlights the current research and development efforts on the crop at Lowlands Agricultural Experiment Station (LAES) at Keravat.

The Edible Canarium Nut

The galip nut (*C. indicum*) is indigenous to PNG (Leenhouts 1956; Henty 1982; Aburu 1982). It is also reported growing in Indonesia, Solomon Islands, Malaysia and Vanuatu (Carlos and Dawes 1990). I have also seen what is probably *C. indicum* growing in Tonga, where it would have been planted.

Other edible *Canarium* species include *C. ovatum*, *C. salomonense*, *C. harveyi* and *C. kaniense*. The pili nut, *C. ovatum*, was once a major crop in the Philippines (Tolentino 1986, B. R. Evans, pers. comm.). *C. salomonense* and *C. harveyi* have long been traditional foods in Solomon Islands. *C. kaniense* is reported to be endemic in the eastern parts of PNG (Henty 1982). It is highly likely that *C. salomonense* also exists in eastern PNG. Other species produce nuts that are not edible (Leenhouts 1956).

Canarium indicum in PNG

Galip nut is a cultivated species in PNG but wild stands are also known to be common. It is grown and used on the islands of Bougainville, New Ireland, New Britain and Manus, the Milne Bay islands and the north-eastern coast of PNG (Akus, unpublished).

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The galip often varies in tree height and nut size (T. Nevenimo and J. E. Moxon, pers. comm.; Akus, unpublished). It is reported to be dioecious, although one author has described it as monoecious. A mature galip tree often attains a height of 40 m. It takes a seedling between seven and ten years to flower, but the tree then remains in production for more than 50 years (Akus Snr, pers. comm.). The fruits are green and turn blackish purple when ripe. The fleshy endocarp dries and splits to expose the hard-shelled nut in which the kernel sits. There is usually one kernel but there can be up to three kernels per nut.

The main product is the kernel. Traditionally the kernel is eaten fresh, dried or cooked over a fire. On Karkar Island oil is extracted using a mortar and pestle. The oil is then used for cooking or for making banana and taro cakes. A number of small islands in the Bismarck Archipelago grow, process and use galip in the same way. On Unea (Bali) Island it is a common trade item.

Canarium timber is used as a general hardwood and is suitable for mouldings, interior joinery, veneers and furniture (Pleydall 1970, Chaplin 1988). Another important product is the galip nut shell, which is used as fuel in a number of ways.

Lately there has been much talk of and interest in *Canarium*. Several aid-funded development programs and divisions within the PNG Department of Agriculture and Livestock (DAL) have proposed buying and exporting galip nut products. There is also growing interest among individuals and established plantations in buying and selling the nut. At this very early stage, however, there is very little indigenous information published on the galip nuts. Several figures have been put forward for the standing bearing population. Much of this is speculation and the rest is only very rough estimates. There is much secrecy about pricing and export markets for galip nut products.

The little indigenous information available includes the botanical classifications and distribution of *Canarium* generally throughout Melanesia and Asia by botanists many years ago and reports from opportunistic and amateur agriculturists in PNG. Information is also starting to come in from work begun recently by LAES.

Galip is a promising tree crop for domestic and export markets. The potential for galip as a cash crop for the export market is being investigated. Indications so far are that there is a good possibility of it developing into a new industry in the near future. It has many attractive qualities:

- Galip is a traditional nut crop with no known major pests and disease problems.
- The farmers are familiar with it.
- It has a high quality nut that is easily sold.
- The logs can be used for timber.
- The logs are a source of fuel wood.
- The nut shell is a very good source of fuel for cooking.
- Galip could be used for shade in cocoa plantations or in other intercropping combinations.
- It provides sanctuary for wildlife, particularly birds.

Research on *Canarium indicum* at LAES

Work on *Canarium indicum* started only recently but will intensify soon. Other species of edible *Canarium* will also be considered.

A number of investigations were and are being carried out at LAES. These include a survey of the galip trees on the Gazelle Peninsula and experiments on the vegetative propagation of the galip nut tree. Proposals for future research are also being formulated.

Galip survey on the Gazelle Peninsula

In 1991 a survey was carried out by LAES in the Gazelle Peninsula area of East New Britain to identify good yielding trees in farmers' fields. Heavy bearing trees with large nuts and high kernel to shell ratio were identified (Moxon 1992). In the past, LAES has been distributing seeds from trees at LAES that bear relatively small nuts. Now that better yielding trees have been identified, LAES needs to collect, multiply and distribute these to growers.

Galip grafting

Four major grafting techniques were tested to identify the most successful technique. Results showed that grafting is difficult and has a very low success rate (Nevenimo 1993). Side grafts,

covered and raised in a humidity house, showed some success. It may be possible to increase the strike rate by reducing some of the problems reported by Nevenimo (1993).

Galip marcotting

Trial results showed that galip can be marcotted but the success rate is very low. I am confident, however, that it can be increased with improved nursery care and fine-tuning of the marcotting work itself. A second trial has been planned to include several new treatment combinations as well as those that had some success from the first experiment.

Future research

There is much to be done on the crop. Immediate future research will concentrate on identifying techniques for successful vegetative propagation of the galip tree. A success in this area will ensure that pure clonal material can be obtained from trees with the desired characteristics. Through vegetative propagation it may be possible to reduce the time taken from planting to first flowering. A proposal for propagating galip by tissue culture is being formulated.

I am proposing a clonal trial to evaluate all good galip varieties already known to us. The desired traits include high nut yields, high kernel to shell ratio, high kernel yields, nuts that are easy to crack, good general tree health and acceptable quality of kernel oil.

Developmental research, processing and marketing are of high priority. The Food Management Division of DAL at LAES has plans in this area.

Acknowledgments

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Research and Development on Edible Nut Tree Crops in Solomon Islands

Noel Roposi*

In 1988 the Dodo Creek Research Station (DCRS) at Honiara, Solomon Islands, began research and development on indigenous edible nut tree crops. A pilot program was established with the aim of building on existing local knowledge to develop simple processing and marketing facilities that would enable smallholders to supply nuts in a formalised marketing system.

Collections of superior varieties of ngali nuts (*Canarium* spp.) were established at five field experiment stations to provide seed for future planting and baseline information on the performance of varieties from around the country. Yield per tree is not yet known.

The ngali nut grows in rainforest throughout Solomon Islands. The kernels are eaten locally. There are three edible *Canarium* species in Solomon Islands: *Canarium indicum*, *C. harveyi* and *C. salomonense*. Nuts from all three species are processed into various finished products and by-products and sold locally and overseas.

Processing for Market

There is a marketable surplus of ngali nuts in Solomon Islands beyond that required for domestic consumption. Supply of dry nuts-in-shell (NIS) bought from smallholders by the Commodity Export Marketing Authority from 1989 to 1993 ranged from 140 kg in 1989 to 205 t in 1992. Development of export markets for ngali nut products would help preserve the rainforest by providing an income for producers from non-destructive use of the trees. The tree is a protected species and its presence helps to restrict destruction of the rainforest, particularly at the forest edge.

Traditional methods of harvesting ngali nuts are still preferred in Solomon Islands. Two methods are used. In the first, naturally fallen ripe fruits are picked up. In the second, villagers climb up and cut down branches. The fruits are then carried back to the village in traditional woven baskets or rice sacks.

The villagers remove the flesh (mesocarp) from the fruit by either bashing the fruit with stones or leaving the flesh to rot either in heaps or in woven baskets or sacks. Fruit with sweet flesh is normally boiled in saltwater and the nuts-in-shell are squeezed out. The cooked yellow flesh can then be eaten.

The NIS are placed in fresh water. Those that float have rotten kernels and are discarded. The good NIS (those that sink) are dried in the sun for three to seven days. Properly dried NIS rattle when shaken.

NIS are cracked by hand using two stones. Skilled workers can crack about 5 kg of NIS an hour. The kernel-in-testa (KIT) and shells are separated by hand. For testa removal, KIT can be soaked in cold tap water overnight or in hot water for five minutes.

Research at DCRS

In trials at DCRS, 35 kg of NIS yielded between 2.5 and 6.5 kg of KIT. It took workers between 45 and 125 minutes to separate the shells from the KIT and between one-and-a-half and two hours to remove the testas from the KIT. Aspects of quality considered during the trials were rotten kernels, contamination of kernels with shell pieces, broken kernels and moisture content. Analysis found 8% rotten *C. salomonense* NIS and 18% rotten *C. indicum* NIS.

At DCRS, half a kilogram of kernels is roasted in a microwave oven for 15 minutes on high

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power. The kernels are allowed to cool overnight in an air-conditioned room, weighed into 150 g portions and vacuum packed. Each worker produces about twenty packets (3 kg) a day this way.

Samples of kernels were sent to the Natural Resources Institute in the UK for nutritional analysis. Results are given in Table 1.

Table 1. Nutritional value of *Canarium indicum* kernels-in-testa (T. W. Hammonds, pers. comm.)

Oil	74.9 g/100 g
Protein	14.2 g/100 g
Carbohydrate	5.5 g/100 g
Fibre	3.2 g/100 g
Energy	2705 kJ/100 g
Calcium	119 mg/100 g
Iron	3 mg/100 g
Carotene	27 µg/100 g
Thiamin	950 µg/100 g
Riboflavin	120 µg/100 g
Niacin	400 µg/100 g

Discarded shells are traditionally used as fuel for cooking. They can also be used for the production of charcoal for cooking or for further processing into activated charcoal. Table 2 gives analyses for the shells and the charcoal from the shells.

Oil extraction tests were also done. Kernels were ground in a meat mincer, mixed with water and placed in cotton bags in a screw press. After one hour's pressing, 12 kg of KIT produced 5 L of oil. The oil was found to have a free fatty acid content of 2% and to have some contamination by *Penicillium* sp. and *Aspergillus* sp.

The cake (residue) after oil extraction was sun-dried and stored for animal feed.

Table 2. Proximate and ultimate analysis of ngali nut shells and charcoal (G. Sarwar, pers. comm.)

	Shells	Charcoal
Proximate analysis		
Particle size (µm)	148	
Moisture (%)	5.8	4.5
Volatiles (%)	76.3	38.6
Ash (%)	1.4	2.0
Fixed carbon (%)	15.9	54.9
Ultimate analysis		
Carbon (%)	49.6	74.6
Hydrogen (%)	6.19	4.3
Oxygen (%)	44.8	14.6
Ash (%)		2.0
Moisture (%)		4.5
Gross calorific value (MJ/kg)		
As received (wet)	19.5	28.7
Dry	20.6	30.0
Dry, ash-free	21.0	

Propagation

Propagation of *Canarium* by grafting and top-working has proved difficult. Successful grafting combinations so far have been *C. indicum* onto *C. harveyi*, *C. harveyi* onto *C. indicum* and *C. harveyi* onto *C. harveyi*. Successful top-working combinations so far have been *C. indicum* onto *C. indicum* and *C. harveyi* onto *C. indicum*.

Further work

Work planned at DCRS includes tree nutrition, tree spacing, grafting, shade effects, intercropping, coppicing, breeding, pollination, pruning and tree shape, mulching, kernel flavour, pests and diseases, varieties and root stocks.

The Status of *Canarium* as Forest Timber Trees in Solomon Islands

Semion Iputu*

THERE are a number of species of the genus *Canarium* in Solomon Islands. Two species, *Canarium indicum* and *C. salomonense*, are widely planted in small-scale plantings, normally in old gardens or in vacated village sites. The *Canarium* nut is a traditional food crop in most islands in the Solomons and is used for bartering or for paying compensation. Rural people use the nuts in a variety of recipes such as lasagne-like 'puddings', which contain layers of crushed vegetables, staples (taro, cassava) and kernels. The trees also produce useful general-purpose timber.

Nomenclature of *Canarium*

Chaplin and Poa (1988) report that the name *Canarium* was derived by latinising the word kanari, which is the local name for the genus in the Amboina Moluccas. Kanari is probably cognate with the Kwara'ae word *ngali*, which is used for *C. indicum* on the island of Malaita. In the Western Province of Solomon Islands, *C. indicum* is known as *okete* in the Roviana language. *C. salomonense* is known as *adoa* in Kwara'ae and *tovinia* in Roviana. In Pidgin English, the lingua franca of Solomon Islands, both species are known as ngali, ngali nut or nali nut, though in some places these names can refer to *C. indicum* only.

The Natural Distribution of *Canarium* in Solomon Islands

In Solomon Islands, *Canarium* is found in the lowland rainforest throughout the islands, whether planted or naturalised.

According to Chaplin and Poa (1988), eight species of *Canarium* are known from Solomon Islands. These species and their distribution (Whitmore 1966) are as follow:

C. asperum Benth.: Guadalcanal, Santa Isabel and Choiseul
C. harveyi Seem.: Guadalcanal, Santa Isabel and Gizo
C. hirsutum Willd.: Guadalcanal, Santa Isabel and Makira
C. indicum L.: throughout Solomon Islands except Santa Cruz
C. liguliferum Leenh: only on Rob Roy Island, off Choiseul
C. salomonense Burtt.: throughout Solomon Islands except Santa Cruz
C. vitiense: throughout Solomon Islands
C. vanikoroense Leenh.: endemic only to Vanikoro Island.

Current Research

The Department of Forestry has established some trial plots of *Canarium* to investigate its silviculture and timber potential. Aspects being studied include germination, fruit yield, spacing and thinning. *Canarium* is not, however, a priority species.

The Department established a 2.5 ha trial at Poitete, Kolombangara, in 1984. The plot is planted with *C. indicum* and a small portion of *C. salomonense*. The trial aims to determine growth, yield and performance of *Canarium*, to establish a source of seed or vegetative propagation material for future planting, and to observe and measure the yield over time of the two species.

The growth rate of *Canarium* is less than half that of *Gmelina arborea* and *Eucalyptus deglupta*, but the genus will still be recommended for a long rotation crop. Trees that have been

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given their first thinning display a nicely cylindrical bole with a reasonable commercial length to the first branch. The trees in this trial have reached fruiting age. About 300 kg of fruit were produced in 1993 and 1994.

A similar trial was established at Viru in 1993. Because of the higher altitude (400 m v. 50 m at Poitete), the young trees are less vigorous than at Poitete.

Trees of up to 92 years old are known. Trunk diameter and tree height continue to increase with age, from approximately 25 cm and 15 to 25 m at ten years to 146 cm and 37 m in the 92-year-old tree.

Kolombangara Forest Products Ltd is running a local provenance trial to study growth, yield and survival of *Canarium*. The trial has eight provenances, which give good representation of the islands. There seems to be little variation in growth between the provenances.

Rendova *Canarium* Plantation

A privately owned pilot plantation of about 40ha was established by a businessman in 1990 on Rendova Island, Western Province. This is the only *Canarium* plantation in the Solomons. Trees of *Canarium harveyi*, the Santa Cruz nut, were established on a coralline soil under a coconut plantation. They are not yet bearing.

The plantation is suffering from a number of problems:

- Being shaded by the coconut palms, the trees are chlorotic.
- Most of the trees are developing multiple shoots as a result of continuous attack by shoot borers (noctuid borers (*Anigrae* sp.) and *Amblypelta cocophaga*).
- The soil lacks nutrients.
- The area was previously used for cattle and the soil is therefore compacted.
- The tree spacing of 10 m × 7 m seems to be too wide.
- Initial maintenance is poor in most parts of the plantation.
- *Canarium harveyi* is not well suited to this part of Solomon Islands.

Timber Value

There has been no work done so far on the timber value of planted *Canarium.* The density and strength properties of both species in our trials could be measured in the near future.

The density of natural-grown *Canarium* varies between 200 and 300 kg/m^3, which is generally considered to be greater than that of plantation trees. The timber is easy to season and warps little. The sapwood is susceptible to pinhole borers. The timber has a fine texture and is generally easy to work. It is used for general purpose construction work but its strength characteristics are not known. The current FOB price of the timber is SI$125/m^3.

Future Research

We suggest that the following research is needed for *C. indicum* and *C. salomonense*:

- Selection, evaluation and improvement of promising varieties for timber production.
- Investigation of silvicultural aspects, including spacing and thinning.
- Initiation of phenological studies.
- Establishment of local provenance trials.

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Part III: Aspects of Developing the Resource

B. Processing

Processing of Galip (*Canarium indicum*) in Papua New Guinea

Mary Maima*

Galip in Papua New Guinea

GALIP NUT (*Canarium indicum*) grows in the rainforests of the coastal lowlands of the New Guinea mainland and islands. There are 21 species of *Canarium* in New Guinea (Evans 1994). Galip is propagated mainly by birds or flying foxes (fruit bats). Trees are also planted by people, but cultivation is not intensive.

Galip nut is regarded as a delicacy in production areas. It is preserved in the nut-in-shell (NIS) form by dehydration in the sun or in smoke houses. It is normally kept in this form until it is cracked open for consumption. Uses vary from region to region but the nuts are normally used to complement staples or are eaten as snacks. The dried NIS are used for trade and food exchange; in parts of Madang Province, galip nut is also part of bride price payment.

The nuts have a high oil content. The oil is suitable as a base for cosmetics, as cooking oil or even for lamps.

The galip tree is used for canoe making. Sap collected from the tree is burnt and used as an insect repellent, and men in New Ireland use the bark for love charms. The shells are used for earrings, finger rings and musical instruments.

Supply Potential

Currently galip nut is not cultivated on a commercial scale. Galip trees form part of the natural forest and a number of trees are owned by families in galip growing areas. The number of trees of bearing age is not known, but the response received to the call for people in the Kandrian area of West New Britain Province to sell galip nut indicates that there is a significant quantity available. An industry based on the existing trees is therefore possible.

The nuts-in-shell come in various shapes and sizes. For long-term industrial uses, selection is required to identify varieties suitable for processing. Research on this is being carried out at the Lowlands Agricultural Experiment Station (LAES) at Keravat.

For local consumption, storage as NIS is sufficient; nuts can last up to a year. The hard shell provides a natural protective barrier, but the actual shelf life of each batch of nuts depends very much upon the weather and handling conditions before arrival at the processing centre. For marketing out of the local area, however, the shell and testa need to be removed and suitable packaging is required to extend the storage life of the processed product.

Commercial Processing

At the Food Processing and Preservation Unit (FPPU) at the University of Technology (Unitech) in PNG, where some work has been conducted on processing galip nuts, a typical process used is shown in the flow diagram in Figure 1. A potential large-scale process in shown in Figure 2.

Grading of nuts-in-shell

Grading procedures should ensure that only good quality galip nuts are processed. Nuts should be big and well dried and have a high kernel to shell (K:S) ratio.

Storage of nuts-in-shell

After buying and grading, all nuts should be stored in drying houses that have heaters. Dry-

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ing is the normal form of preservation for nuts. Unless fresh nuts are dried immediately they spoil and go mouldy. The drying house should be fumigated occasionally to limit aflatoxin growth.

The galip season on the south coast of New Britain is also the heavy rainy season; rainfall of 1000 mm a month is typical. This results in mostly wet and damp nuts. In this environment, galip nut buying should be delayed until the end of the wet season. When galip nut becomes a cashcrop for villagers, there is a tendency for them not to dry the nuts properly.

A consistent and rapid method of assessing the moisture level is required. The tendency for mouldy nuts to produce aflatoxins needs research attention, and the use of fungicides should be tested as well.

Excessive drying will result in oil exuding out of the kernel and turning rancid. Therefore the effects of different drying methods also require further research.

Cracking of nuts-in-shell

Traditionally, the NIS are cracked with rocks. Cracking rocks can be found in each household in galip producing areas. At Unitech a vice was used.

According to Evans (1991), the ease of cracking nuts is influenced by the species, variety, NIS shape, size and moisture content, shell thickness, K:N ratio, and operator skill and motivation. Currently nuts are cracked by hand. This is time-consuming: cracking rates established during trials range from 2.0 to 2.5 kg/person/hour. Until varieties suitable for processing are selected, mechanical cracking will not be suitable. A mechanical cracker that takes into consideration all the above factors is yet to be designed.

Blanching and testa removal

Though the testa is edible, for commercial purposes it needs to be removed because of its

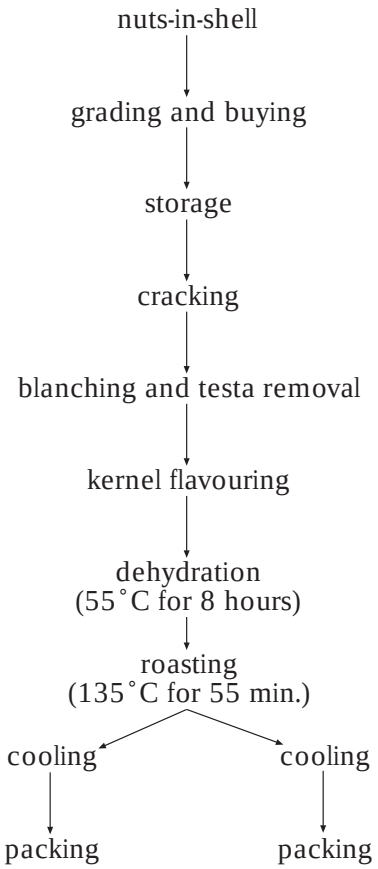

Figure 1. Galip nut processing method used at the FPPU

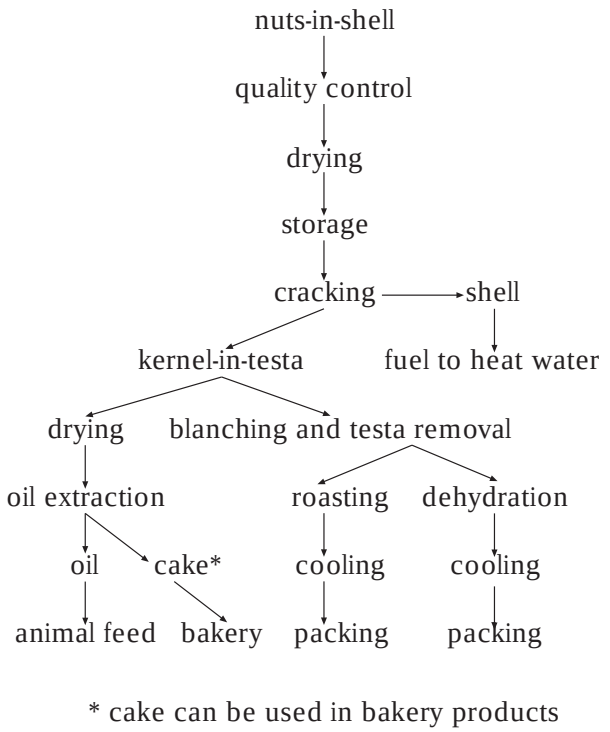

Figure 2. General processing potential for galip

leathery feel. The testa of a well dried kernel is tightly bound and hard to remove. Blanching in steam or hot water loosens it and facilitates removal. Dry roasting followed by blowing away the testa results in incomplete removal of testa and kernel breakage during agitation (Evans 1991). Comparisons between water and steam blanching need to be made to determine suitable combinations of temperature and time. No differences have been reported between species and variety in the ease of testa removal.

Flavouring

After testa removal, the nuts can be flavoured. Trials need to be conducted for different flavours with different target groups, but plain roasting and salting have done very well. Soaking in 4% salt solution gives the desired salted flavour and facilitates testa removal. Coating in syrup or spice mix is also possible, but flavouring should really be dictated by market feedback.

Roasting

No detailed research has been carried out on roasting. The only research to date has tried dry roasting at 100° to 120°C for one to two hours and at 135°C for 55 minutes in a forced air oven (Evans 1991). The higher the temperature, the shorter the time it takes to roast, but further work is required to determine a suitable temperature–time combination for a given storage environment.

Drying of processed nuts

The only drying trial done so far dried nuts at 55°C for eight hours in a cabinet dryer. This gave a suitable product. Leaving the testa on kernels helps to keep the kernel intact and prevents kernel breakage. More work is required to test taste acceptance, final product yield and work input.

Cooling

When products are removed from a roasting or drying oven, they absorb moisture until they reach ambient temperature. While the product is hot, water continues to vaporise: if the product is not properly cooled before packing, moisture from vapour in the packet will encourage product spoilage. Therefore cooling needs to be carried out in a dry environment. Air conditioning is preferred but is an expensive exercise for small operations.

Packaging

The shelf-life of the product depends very much on the type of packaging material and the storage environment. Material with a good barrier to moisture and air is required. Vacuum packaging is desirable to prevent oxidation of oil in the nut. In trials, nuts were packed in polyethylene bags and glass jars. Those packed in glass jars lasted one year, unlike those in plain plastic bags, which were attacked by ants.

Kernel oil

Dried kernel contains about 75% oil (Maima, unpublished). No trials have been carried out on extraction apart from the analytical determination of total oil content (Table 1). Galip nut is delicate and breaks easily. Oil can be pressed from a dried or roasted kernel between the forefinger and thumb.

Table 1. Composition of edible *Canarium* spp. (Evans 1991; Maima, unpublished a, b)

Physical	**%**
Nuts-in-shell	100
Shell	83–84
Kernel and testa	17–18
Testa	3–4
Kernel	11–12
Roasted kernel	9–10
Dehydrated kernel	14–15
Analytical	
Moisture of fresh kernel	23–24
Moisture of dried kernel	2–3
Free fatty acid (roasted kernel)	0.34
Nutritional	
Total oil (dried kernel)	75
saturated	36.6
monosaturated	28.5
polyunsaturated	10.3
Protein	14.2
Carbohydrate	5.5
Fibre	3.2

By-products

The hard shells are good for fuel. They can be used to heat the water for nut blanching or steam generation. Charcoal production is an alternative. The testa or seed coat is high in protein. It could be dried and used for animal feed or used to make compost. The cake could be used for biscuit manufacturing and is a rich source of nutrition.

Further Work Required

Much more research is needed into galip nut before it can become a commercial proposition:

- Varietal selection is required to identify processing varieties. Galip nut is currently not cultivated commercially, but trees are selected by villagers for bigger nuts and higher K:N ratio.
- Compositional analysis of physical and chemical properties is required to identify processing varieties.
- Oil extraction trials using different methods and equipment are needed.
- An effective grading system that will take into consideration factors such as moisture level, kernel to nut ratio and size of nuts needs to be developed.
- The effects of different drying methods on the NIS need to be studied to establish an optimum moisture level for given storage conditions.
- A mechanical cracker needs to be designed and tested, taking into consideration all the factors that affect the cracking rate.
- Blanching and testa removal operations need to be studied in relation to temperature–time combinations for water and steam blanching and their effects on the ease of testa removal.
- Taste panels of different target groups need to assess flavours.
- Further work is required to determine the best temperature–time combination in roasting equipment to produce products for a given storage environment, with and without testa.
- Research with different packaging materials is needed to establish the shelf-life of products.

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Commercial Manufacture and Use of Mechanical Crackers of *Canarium* and Related Nuts in Vanuatu

Loren Gautz*

SALES of *Canarium* and other nuts could be increased if more nuts could be shelled in the islands. At present, nuts are cracked by hand with rocks. Mechanical nut crackers would allow the same number of people to crack many more nuts. Shipping costs would be reduced as the volume and weight would be reduced by up to 85%.

Under my guidance in Hawaii in early 1994, Michou Kalsao of Bodiam Engineering in Port Vila, Vanuatu, built two prototype *Canarium* nut crackers. One is electrically powered. According to tests in Hawaii and Vanuatu, this one can crack 20 kg/hour of dry nuts-in-shell (NIS), or four times the rate of cracking by hand, yielding 60% by count of whole kernels or large pieces. The other is hand-powered. It can crack 3.6 kg/hour of NIS, 1.5 times the manual rate, yielding practically 100% whole kernels.

Both nut crackers were demonstrated at the South Pacific Indigenous Nuts Workshop. Interest among the conference participants was high, although no commitments were made for the purchase of machines. Immediate interest was in the hand-powered cracker.

Using price quotes for parts and materials from suppliers in New Zealand and my estimates for manufacturing time, Bodiam Engineering priced the electrical cracker at US$5000 and the hand-powered cracker at US$500. Either cracker will pay for itself after cracking 4 t of NIS based on current cracking costs and the productivity increases projected from tests to date.

The electrical cracker can currently be adjusted to handle nuts from 15 mm to 35 mm diameter, the full range of nuts observed in the market. However, too wide a range of nut sizes could lower the percentage of whole kernels. During testing the machine was adjusted to crack nuts ranging from 20 mm to 35 mm diameter.

Installation of the hand cracker is important. The cracking lever must be placed at a height where it can be operated with the maximum force without tiring the operator. This places the nut at or slightly below the waist of the operator. During demonstrations the lever was pushed horizontally. This works well for all operations: loading, sizing, cracking and unloading. The base has to resist the force being applied to the cracking lever and should extend sufficiently for the operator to stand or sit on it.

The electrical cracker can probably also be used for *Terminalia* and *Barringtonia* nuts, but neither was in season during testing, making samples hard to find. The nuts will have to be dried to the proper degree and the cracker will have to be adjusted. A more efficient mechanism is needed for removal of the fibrous shell of these nuts.

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Part III: Aspects of Developing the Resource

C. Marketing

Business Associations Can Help to Increase Your Profits

John Kreag*

IMPROVEMENTS in product quality will almost always increase profits for producers faster and more easily than increased production. Two types of business associations can achieve this: product-specific industry associations and producer-owned cooperatives.

In Europe, the USA, Japan and many other countries, cooperatives have been hugely successful, particularly in agriculture. In fact, they are often the industry leaders. One of the most successful cooperatives in the world is Blue Diamond of California; one of its biggest competitors is Sun Diamond, another cooperative. In many situations, cooperatives can always return more profits (or sell farm supplies at lower prices) to their members than other types of enterprises. There are also hundreds of examples throughout the world of industry associations that have been a critical element in the development of their particular industries.

In many developing countries, however, cooperatives and industry associations have a bad reputation. Too many industry associations are perceived as being more interested in preserving the profits of their members than in developing the industry they purport to represent. This need not be so, however.

Industry associations can have several important roles:

Establishment and enforcement of quality standards. This is extremely important as the price of a product depends not just on its quality but also on its reputation. Californian nuts receive a higher price than identical quality Chinese ones, for example.

Establishment of research priorities and funding for research. This achieves an early exchange of ideas with researchers and helps to direct research work to areas where it will be most likely to produce cost-effective results. In many cases industries increase their funds by attracting matching or supporting funds from governments. And because an industry has used some of its own money to sponsor the work, the results tend to be adopted much faster than where the research is not sponsored. Successful examples are the sugarcane industry in Fiji and the coffee and cocoa industries in PNG.

Product promotion. There is a role in almost every food industry for generic promotion. This is promotion of an overall industry aimed at increasing market size, instead of specific advertising to increase a company's market share at the expense of its competitors.

Lobbying governments. Industry associations can lobby for the creation of better conditions for the industry to work in. These conditions include better and cheaper infrastructure, the creation and enforcement of grading, health and environmental standards, the direction of research to meet industry needs, export promotion, and the opening of potential export markets that are closed because of unreasonable tariffs, quotas or quarantine standards. On the other hand, there have been many instances where lobbying has worked against the public interest; for example, the creation of subsidies, price supports, tariff and quota barriers, limits to competition and monopolies. Many of these efforts result in high costs for local consumers, industries that cannot compete in international markets and the direction of resources into inefficient industries.

Competition is an essential part of a healthy industry, but governments and business associations need to take a more active role in promot-

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ing healthy competition, which can maximise the incentives to growers to continue to expand their production. Destructive competition, in contrast, can lead to lower quality and lower prices.

In the late 1970s I was working in Liberia, helping to develop coffee and cocoa marketing cooperatives. At the time it was a stable country with one of the strongest economies in West Africa. Coffee and cocoa were grown entirely by smallholders. Throughout most of the country there were hundreds of individual coffee buyers. Yet in one county, Lofa County, there were almost no private buyers, because the cooperatives offered a better price. The cooperatives were big enough to achieve economies of scale, thus reducing their per-kilo unit costs, and they exercised strong quality control over their purchases.

So why weren't the other businesses achieving the same economies of scale? Certainly they were just as capable of achieving savings as cooperatives, and often did. The problem was that they were reluctant to pass the savings along to the producers. They quickly decided that it was more profitable for them to keep the price high and do a little less business than to get into a price war, get more business, and do a lot more work for the same or lower profits.

As a result it was relatively easy for small operators to start up and the coffee-buying business continued to get further fragmented and inefficient. Buyers tend to rely upon relatives and friends to provide their supplies. In these cases price competition plays only a small role in the decision of the grower of whom to sell to. Inevitably the system is inefficient and the growers receive lower prices than necessary.

There is also a problem of quality. Because there were so many buyers each seemed afraid to reject any poor quality coffee in case they lost a supplier. They hoped that they would be able to buy enough good coffee to mix with the poor and that it would all be accepted by the exporter. The result was a continual decline in quality.

When I was in Liberia, I thought it was a local phenomenon. Since then I have become aware that this kind of destructive competition in agricultural industries is common throughout the world. After much thought, I believe that it occurs most often when the middle-men have no significant investment in the business. Middlemen tend to take their percentage regardless of quality. Thus volume is far more important in determining profit than quality.

The answer is to find a way to ensure that competition works for the benefit of the industry, not against it. Three things need to happen:

- Every large industry should establish firm and enforceable grading standards.
- It is more important to have several kinds of competition than to have many people in the business. Thus in addition to the traditional buyer-exporters there should also be grower-owned cooperatives that truly represent the business interests of the farmers. Such cooperatives should have only one significant objective, to make money for their grower-owners.
- The processors need to contract directly with the growers. This seems to work well as the processors must ensure that their product has a consistently high quality.

The indigenous nuts industries of the Pacific can gain a lot from the establishment of industry associations and cooperatives. If the industries can establish enforceable quality standards and different types of marketing arrangements, including cooperatives and processors buying direct from growers, this should lead to a positive competitive environment where there is genuine price competition that encourages production of high quality nuts.

Are There Profits to be Made from Tourism Sales of Value-added Nuts and Spices?

Michael W. Brown*

THE tourism industry is projected to expand in most South Pacific islands well into the next century. Industries allied to tourism have the potential to benefit from the expected expansion. The food industry, in particular snack foods, could directly benefit from increased regional tourism. Therefore tourism could also benefit the development of indigenous nut and spice industries in the South Pacific.

It will require the ingenuity of local entrepreneurs to determine what forms of nut products will be most attractive to people visiting their countries. In order to maintain continuity of supply the production of indigenous nuts must present a compelling economic incentive to village producers to warrant their participation. Therefore, appropriate market strategies to maximise product value are paramount for a sustainable industry. The benefits of nut and spice sales to tourists go beyond individual entrepreneurs to rural and urban employment, reduction of rainforest logging, strengthening tourist trade and improvement in nutrition.

Food can represent a country or region's image; for example, the USA is known for its hamburgers and hot dogs, Italy for spaghetti, Mexico for tortillas, Australia for meat pies, tropical islands for coconuts and papaya, and Asia for rice. The potential for indigenous nuts and spices to develop as a food image for the Pacific is good.

Research will be required for marketing, processing and production of indigenous nuts and other non-timber rainforest products for years to come. To finance and maintain this research, increased earnings and market expansion must occur to justify it. A new industry that can demonstrate its progress with increased sales or earnings has a better chance of receiving additional assistance, financial or technical. The research in turn will improve the fledgling nut industries and allow villagers and manufacturers to earn more income. Value-added nut and spice sales to tourists may be one niche market that can help increase villager incomes and give credence to continued research.

Pacific Rim

The Pacific Rim consists of the most dynamic and expansive economies in the world: Australia, New Zealand, Western South America, Central America, Western North America, the Korean Peninsula, Japan, China, Taiwan and Southeast Asia. Projected growth in the region's tourism is linked to the continued economic expansion of Southeast and northern Asia, and the strengthening of the US and Australian economies.

GATT, the General Agreement on Tariffs and Trade, will not only have an effect on trade in the region, it will indirectly improve tourism as well. The gradual phase-in of GATT to 2000 will reduce tariffs on imports including food products, thereby allowing more importation of goods that can be used to support tourist industries. The liberalisation of trade fostered by GATT will increase business travel and stimulate more hospitality development to accommodate the increased numbers of business travellers. On the other hand, with the lowering of trade barriers, there will be more intense business competition.

The East Asia and Pacific region was the fastest growing tourist destination in the world in 1993, with an encouraging 12.6% increase on the previous year. The region represented 14% of international arrivals in 1993.

As well as the movement of people from developing countries to developed countries in the

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past three decades, there has also been movement of rural dwellers to cities. An outcome of this is consumer sophistication, which leads to more demand for convenient foods and services. The massive urbanisation now occurring in the Pacific Rim region is changing food tastes as urban dwellers demand more value-added foods that provide convenience and value. South Pacific nut manufacturers would be well advised to produce high quality and professionally packaged products to meet the demand of the increasing number of urbanised buyers.

The South Pacific Situation

The tourism industry is a major contributor to economic growth in the South Pacific. Fiji remains the region's leader in tourism (more than 280 000 arrivals in 1993) because of its centralised location, its well organised infrastructure, and most importantly its years of experience in the tourist industry. Second to Fiji in tourism are Tahiti and the other French Polynesian islands.

To achieve the success in tourism that Fiji and French Polynesia have developed, other South Pacific countries must consider:

- increasing the availability of direct tourist routes, particularly from Australia and Asia
- intensifying and sustaining promotional tourism campaigns
- developing and supporting food establishments, accommodation and transport
- improving marketing
- what the market needs.

South Pacific tourism is growing. The total number of tourist arrivals in the South Pacific rose to 744 000 in 1993, a 32% increase from 1987. The earnings gained from tourism can have a significant effect on a country's GDP. Earnings from tourism ranged from 43% of GDP for the Cook Islands to 1.2% of GDP for Papua New Guinea.

Indigenous nut producers should consider that:

- continued economic growth and political stability in the region increase both business and pleasure travel
- many travellers coming to the South Pacific are familiar with tropical products that they purchase at home; they know good from bad
- the types of tourists arriving are more diversified (ethnicity, wealth, origin etc.). Therefore promotion will become more complex
- regional tourism can be a catalyst for the promotion of rainforest products throughout the Pacific Rim.

Tourism will remain important for most South Pacific island countries. Therefore it can be expected that foreign assistance (private or aid donations) will continue. For example, the European Union gave a grant of Fiji $19 923 000 for the continuation of the Pacific Regional Tourism Development Program. This is a positive sign for the strengthening of collaborative regional promotion. Local entrepreneurs may wish to investigate what funds may be available for food industries linked to the tourist trade. Some contacts are given in Appendix 1.

Tourism has proved a viable industry for the South Pacific. The combination of high and continued economic expansion in the Asia–Pacific region, large population centres, expansion of major airlines and pleasant tourist attractions make this part of the world very attractive for tourism. There will be some turbulence in the start-up phases of some of the newer travel destinations. Nevertheless, the Asia–Pacific region will continue to be one of the most dynamic tourist destinations in the world. It will be up to local entrepreneurs to develop the strategies and means to sell their nut and spice products in this proven market.

The Customer

Overseas visitors can be divided into three broad categories: tourists, business travellers and relatives. Tourists will probably buy the most nuts and spices; but business travellers and relatives can also make significant purchases.

The amount of money spent by tourists in a country is very important for local food manufacturers. This is where the local industry can make substantial profits if it targets the tourist market appropriately.

Cultural, personal and social preferences can differ greatly between people coming from different parts of the world. Tourist industries, particularly the food industry, must remain aware of this. As time progresses, though, knowledge

and experience grow. For example, the mango is universally known throughout the region, yet just ten years ago many North Americans would not have known what a mango was.

The Competition

The niche market for tourism is highly competitive, demanding continual monitoring and innovation to stay ahead of one's competition. Indigenous nuts and spices will face competition not only from other food products, but from just about anything on which the tourist might spend his or her dollar.

Indigenous nuts are a unique product, but there are many unique food products available today. The USA alone marketed more than 8000 new processed food products in 1993. For the average tourist the rainforest nut is just another food item in the hundreds of food snacks available in local markets. Indigenous nuts can help save rainforests, provide jobs and income for local villagers and help generate hard currency for the nation, but they must appeal. First-time buyers are going to ask:

Are they appealing?
Are they safe to eat?
Are they high in calories?
Are they reasonably priced?
Do they taste as good as other nuts?
If I eat too many will they give me digestive problems?

Addressing these questions in relationship to quality, promotion and information is essential for South Pacific nut entrepreneurs to attract and maintain tourist sales. It is important to remember that promoting the natural image of rainforest nuts is not the only marketing strategy to use.

Indigenous nuts and spices are luxury food items generally selling at a premium. These foods are generally not considered a priority purchase by visitors. If non-food items are increasing in price there will be less money to spend on luxury goods. Nut producers and manufacturers need to be aware that non-food purchases have a direct effect on snack food sales.

In the South Pacific, direct competition will come from locally and imported peanut products and deep fried chip products (potato, wheat, corn and banana). On the other hand, complementary products can stimulate the purchase of other products. For example, the increased consumption of beer might increase the sales of peanuts in local taverns, as peanuts are commonly eaten with beer. Economic research is one area where government assistance could benefit local commerce. In addition, development of industry associations could give specific guidance and partly finance future research and promotional needs.

Marketing

How will the entrepreneur market his or her luxury nut or spice product to out-compete the more common forms of snack foods and spices? For instance, would it be feasible to try to replace peanuts with *Canarium* nuts for sale in local taverns? Much will depend on the marketing mix of the four Ps: product, price, placement, and promotion.

Product

Indigenous nuts should be fresh, free from mould and foreign material, crunchy, not stale, and have good odour and eye appeal. Nuts must be handled properly from production to retail to ensure that clean and high quality products are sold. Sanitation is required not only to promote sales but to minimise microbial contamination, which could make people ill.

The nut or spice products to be sold should be only the best. To establish a good company reputation the product must maintain consistent market quality standards. Inconsistent quality could jeopardise future sales.

This is where total quality management (TQM) systems are highly beneficial. In TQM, quality standards or checks are set up throughout a production and processing system to reduce the distribution of inferior or unsafe product. Regardless of how small a food supplier is, TQM principles can be applied. Nut producers would be well advised to use TQM to remain competitive in the tourist market.

Nut products are not limited to just direct tourist sales in shops. Besides snack food packs of fresh, roasted or spiced nuts, nuts can also be used by local restaurants and food manufacturers for baked goods, stir fries, butters and oils

that would be sold primarily to tourists. As the nut industry develops it could also produce diced, sliced and cracked nut pieces that could be used for dessert toppings. Such a specialty market exists for almonds and walnuts.

Nuts have a wide product diversification. This is highly beneficial for increasing tourist sales and can reduce post-harvest losses, increase quality and guarantee consistency of product into multiple markets. South Pacific indigenous nuts could be made into many more products when production levels increase.

Product packaging

Packaging is very important for generating and expanding snack food sales. Food packaging has become more complex and sophisticated in recent years. Not only must the package protect the food and extend shelf life, but in many countries there are laws requiring packaging material to be environmentally sound. Packaging should enhance the appearance of nut and spice products. Product pack size is important if you are supplying various sectors of the tourist trade such as restaurants, hotels and airlines. Here again, size will depend on the buyer's needs. Therefore the supplier must be flexible to meet changing market demand. Food packaging should:

- protect the product
- promote the product (name, origin, use-by dates etc.)
- be cost-effective
- be adaptable to changing environments
- be market-approved
- be government-approved
- be environmentally sound.

Using less packaging without compromising product quality or promotion is beneficial in today's world of rising disposal and packaging costs. Entrepreneurs and the public departments that help food industries should subscribe to the numerous packaging and food technology journals published in the Pacific Rim. These publications will help local food industries to stay current in food packaging research and trends.

A use-by date on the package is recommended for locally produced snack food products to help compete with foreign snack foods, which generally have use-by dates. Use-by dates on package labels can increase consumer confidence to buy a product.

Keep in mind that packaging requirements for tourist sales in the South Pacific may not be as stringent as for food products that are to be sold overseas. Check with the importing country's packaging and labelling laws before sending your product.

Price

The sales price is determined by production costs and market demand. Pricing is very important to being competitive in the tourist industry. Production, processing and marketing methods that reduce costs will help develop competitive prices. High prices can reduce overall markets for all rainforest products and give buyers and manufacturers a reason to find cheaper alternatives. Market penetration will therefore require optimum quality and consistent promotion.

Though South Pacific indigenous nuts are unique products, this may not be justification for selling them at high prices. They could be sold on the merits of protecting the rainforest and being environmentally sustainable, but the average tourist might not care enough to pay the difference. If the product is unattractive and is priced beyond the means of most people it will not sell well, regardless of how environmentally sound it is. It will be up to the seller and the market situation to determine whether or not a market exists for premium-priced nuts and spices. This is another area where government-assisted studies could help local industries.

The need for promotion, advertising and merchandising

Most tourists have never heard of indigenous nuts. Their first contact with these products will probably be as they browse through local shops. This is where promotion, advertising and merchandising are essential to attracting the customer to a product and not to a competing snack food.

Promotion is the method used to present a positive image of a company's name or its product. Promotional strategies are great ways to let the consumer know that you exist. A good example of local promotion is how one of the main hotels

in Solomon Islands serves a scrumptious fruit salad covered with cracked canarium nuts. Another example is sponsorship of sports teams.

The objective of advertising is to expand the market by increasing volume of sales, obtaining higher prices, or both. Traditionally in the South Pacific region, locally produced snack foods are often sold with minimal or no labelling or advertising. This is no longer acceptable in the highly competitive snack food industry. A look at imported snack products commonly found in the islands demonstrates the extent to which foreign snack food manufacturers go to attract customers. They use bright, laminated, coloured wraps with catchy names and advertise in the media.

Advertising does not have to be expensive, but it is a major component of successful food manufacturers' costs. Luxury items such as indigenous nuts are more suited to promotion than common foods. Foods such as rice and bread are purchased routinely, whereas indigenous nuts would not be a primary choice for most tourists. Hence the need to attract consumers.

The target audience must be selected with care. Once the audience is selected the theme or message used must be appropriate and well understood. For example, 'healthy', 'nutritious', 'great taste' and 'low calories' are phrases that have appeal.

Advertising can be generic, such as for oranges or fruit juice, or regional, such as for Pacific vanilla or Mexican mangoes. Government can help promotion and advertising by supporting campaigns. This is a common practice used in the fresh food industry. An example is the Solomon Islands' Commodities Export Marketing Authority's promotional advertisement in the *Island Business Magazine*'s October 1994 issue. On the whole, though, marketing and sales are best left to the private sector, not government.

Merchandising is the method used to get the customer to your product. Examples are sales advertisements, in-store product displays, free sampling or prize give-aways. One way of merchandising nut products is giving out taste samples when tourists first arrive at airports and wharves. This can be an expensive proposition, but if you have a good product that is strategically placed in the main tourists shops the returns can more than outweigh the costs.

Placement

Where to sell is important. Learn where the tourists go. Arrange with business owners to sell your product. This may first require free samples to be distributed to generate interest. When you have found places that will sell your product, try to have your goods presented in areas that receive a lot of customer visibility, such as near the cashier, the store entrance or complementary items like drinks and ice cream. Try to keep your product from being placed in some lonely corner of a shop.

Keep track of your product. Even with the best packaging and product, extensive storage time in warm climates will gradually deteriorate the quality of nuts. Some major snack food manufacturers even remove old product from the shelves to ensure customer satisfaction.

Given that Fiji and French Polynesia are the top two tourist destinations in the South Pacific, arrangements by other islands' nut manufacturers to sell value-added nut products to these countries could be very profitable. Processed nuts have few quarantine restrictions and their low volume-to-weight ratio makes them suitable for both air and ocean shipping.

A Possible Marketing Strategy

An example of a marketing strategy is shown below. Keep in mind that no strategy can work for all markets and that marketing is always changing.

The product

Indigenous nut; dry roasted, fresh or seasoned with spices

The customer

Tourist (age range late twenties to retirement age)

Income bracket (middle to upper income)

First exposure to the South Pacific

Active and health-conscious

From a city

The competition

Peanuts, almonds, macadamias, chocolate

Potato and other chips and crisps

Popcorn

Complementary products

Soft drinks

Beer

The four Ps marketing strategy

Product

High fibre, unique, exotic

Protein, new snack

Natural, rainforest product

Ideal snack food, environmentally friendly product

Packaged in eye-catching, retail-sized bag or jars

Price

Calculate price by determining production costs and market demand

Promotion

Advertise on local radio, in newspapers and in tourist gift packs

Develop low-cost brochure

Give tours of nut processing facilities

Attend food fairs

Sponsor local sports teams

Bite-size packets for airlines and cruise ships

Government-sponsored generic or regional promotion

Placement

Hotels, taverns, airport gift shops, major tourist destinations, duty free shops

Fiji, French Polynesia

Information

Subscribe to commercial magazines on food packaging, tourism, nut processing

Attend commercial food and tourism conferences in your region or request proceedings

Become a member of a food or tourism association.

Conclusion

The benefits of tourism sales of South Pacific indigenous nuts are:

- the potential for immediate earnings for the industry
- promotion of the industry in and outside the region
- that the market is accessible to local food processors and retailers.

There are profits to be made by selling value-added nuts to tourists if the following points are implemented:

- Know the customer. He or she is boss!
- Present only the best quality.
- Be consistent and reliable.
- Be price-conscious.
- Be flexible to trends.
- Be willing to conduct some promotion; be innovative.
- Know the trade regulatory requirements of government and industry.
- Seek government support to ensure product quality and standards and to promote national image.
- Use the four Ps diligently in establishing a marketing strategy.

Development of commercially sound nut industries that aim part of their production toward tourist sales is one way to improve people's standards of living and help preserve rainforest.

Appendix 1. Regional Contacts

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Part III: Aspects of Developing the Resource

D. Lessons from Elsewhere

History and Current Status of Pili Nut (*Canarium ovatum*) Production in the Philippines

Roberto E. Coronel*

PILI (*Canarium ovatum*) is an important nut-producing tree in the Bicol region of the Philippines, though it is mainly a backyard tree. The tree is a regular and heavy bearer of one of the tastiest nuts in the world. The kernel is very nutritious and is a desirable raw material for the commercial production of edible oil. The pulp is also edible and contains some oil, but its greatest use in agriculture is in compost making, being rich in nitrogen and potassium. The shell is a good material for making ornaments and charcoal, although this potential has not been tapped.

A lot of basic information about pili has already been generated through research, mainly by the College of Agriculture of the University of the Philippines in Los Baños. Information includes sex expression, flower biology, fruit development, seed germination, seedling growth, varietal selection, asexual propagation, and nutrient composition of leaves and fruits.

Still lacking is basic knowledge about the tree's requirements as an orchard crop, including training, pruning, plant nutrition and water relations. This requires the establishment of experimental orchards in several climatically different regions of the country, but there is no financial support for this from government. Lack of financial support for its development from the national and local governments is one major reason why pili has not become a major crop. It will not be surprising if other countries produce pili commercially ahead of the Philippines.

Origin and Distribution

Canarium ovatum, commonly known as pili, is indigenous to the Philippines. Production today is centred in all five provinces of the Bicol region (Fig. 1), although trees are also found in other regions (Southern Tagalog, Eastern Visayas). Nuts come primarily from trees grown from seedlings, although some plantings of grafted trees have been started recently.

Pili has been introduced in other countries, notably in Hawaii (USA) and Brazil, and there

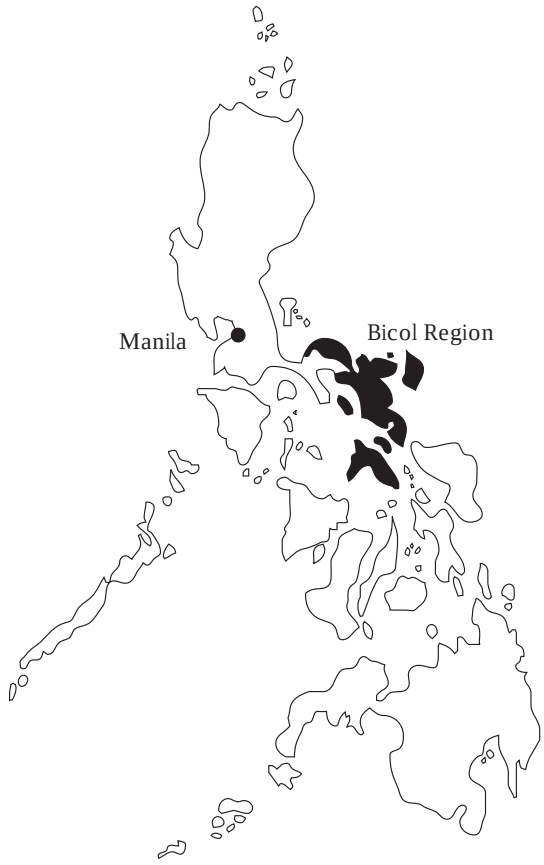

Figure 1. Production of *Canarium ovatum* is centred in the Bicol region of the Philippines

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is apprehension that it will be developed as a commercial crop in these places faster than in its native country.

Canarium ovatum is one of about a hundred species in the genus in tropical Asia and the Pacific. In the Philippines alone there are about 35 species. Aside from *C. ovatum, C. luzonicum* is important, not as a source of edible nuts, but for its oily resin, which is tapped from its trunk and when processed is known commercially as Manila elemi.

Other countries have species that also produce edible nuts. *C. indicum* is grown in Indonesia (kanari), Solomon Islands (ngali), Papua New Guinea (galip) and Vanuatu (nangai). Solomon Islands also grows *C. salomonense* and *C. harveyi.* Thailand, Vietnam and China grow *C. album,* known in English as Chinese olive.

Climatic Adaptation

In the Bicol region, the total mean annual rainfall is 3330 mm from 225 rainy days. Rainfall is well distributed throughout the year, although there is more rain from June to January (average 333 mm a month) than from February to May (average 167 mm a month). The rainiest months are November and December (average 477 mm a month). Mean temperature ranges from 25.5°C in January to 28.2°C in June. Relative humidity ranges from 81% to 85%.

The four regions in Mindanao have well distributed rainfall and should be able to grow pili successfully. The fact that pili also grows well in Southern Tagalog, where there are distinct wet and dry seasons (May–October and November–April), suggests that pili can also be grown in other regions with similar rainfall distribution.

Botany

Sex

Pili is a dioecious species. In both male and female trees, the flowers are borne on cymose inflorescences at the leaf axils of young shoots. A female inflorescence has far fewer flowers than a male inflorescence. A female flower has a functional pistil and six non-functional stamens whereas a male flower has six functional stamens and an aborted pistil. A small percentage of male trees produces an equally small percentage of perfect flowers that may set undersized fruit.

Growth and development

Germination begins about 30 days after sowing. The seedling initially grows slowly after transplanting but soon picks up. After three or four entire leaves, leaves with three leaflets follow. Eventually the leaves have five to nine leaflets. In the mature tree, the leaves are alternate and about 40 cm long. The leaves are odd-pinnate, rather thick, smooth, dark green, rounded at the base, pointed at the tip, 10 to 20 cm long and prominently veined.

The juvenile tree grows to a height of 2 m or more in about three to four years before branching occurs. At this stage the tree may produce its first flowers. On average, however, seedling trees start producing fruit five to six years after seed germination. Most flushes are reproductive. Lateral shoot growth ultimately gives the tree a more or less round canopy.

Pili trees flush in March to May. Leaves fall a year later, from March to September (Fig. 2). When leaves from the previous year's flush are starting to fall, new leaf and flower buds begin to break. As leaf fall progresses, flowering and leaf development continue. When the last leaf falls, the current season's flush is fully grown. Pili is thus a deciduous tree.

Flowers open in April to July (Fig. 2). Fruits set from May to July and ripen in May to August of the following year. At about the time when fruits of the previous season's flush are ripening, new fruits are setting and starting to develop. This gives the wrong impression that pili is an everbearing tree when in fact flowering and fruiting are highly seasonal.

From pollination, the fruit takes about ten months to reach maturity. Fruit ripening takes another two months, at which stage the skin turns from dark green to dark purple or almost black. It is interesting to note that the kernel (anatomically the cotyledons) does not begin substantial development until the fruit has reached maturity. The kernel grows while the fruit ripens.

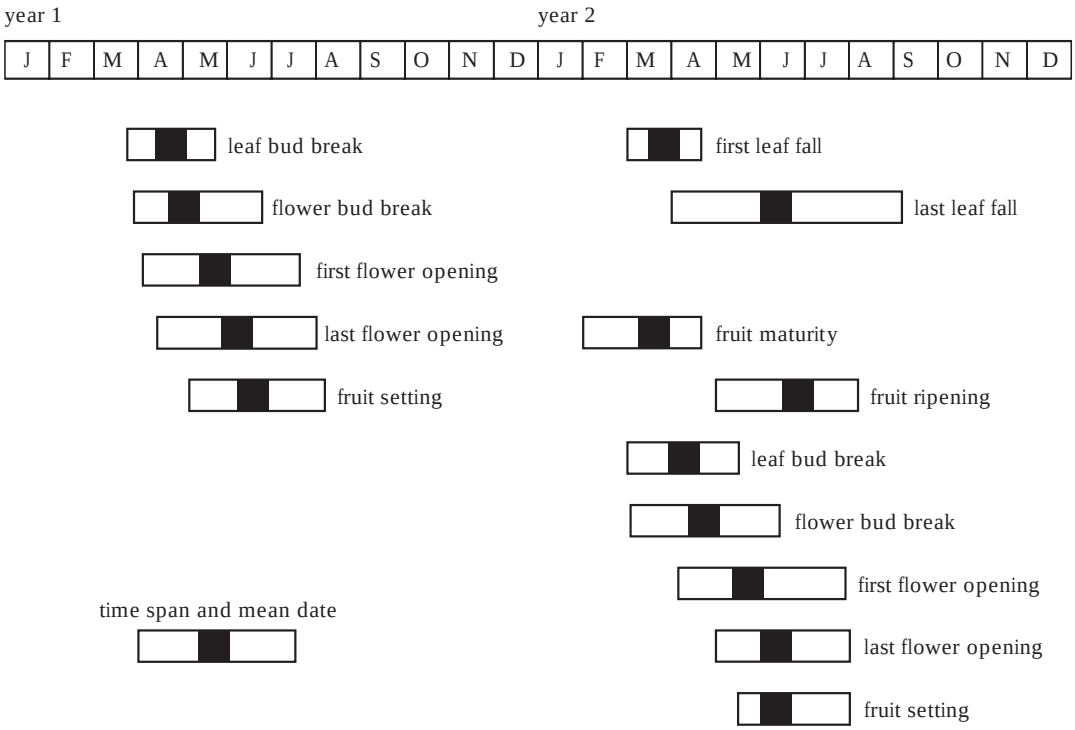

Figure 2. The two-year flushing, flowering and fruiting cycle of a pili tree

Varietal Improvement

As pili is a predominantly dioecious species, a high degree of cross-pollination takes place. Consequently, seedling trees differ in many reproductive characters (sex, number of inflorescences per shoot, number of flowers per inflorescence, fruit size and shape, yield per tree); vegetative characters (growth habit, stem diameter of shoot, shoot number per tree, leaf size and number per shoot, petiole length, dry weight of various organs); season of flushing, flowering, fruit setting, fruit development, leaf abscission; nutrient content and uptake of various organs; and response to asexual propagation.

Based on initial evaluation of numerous seedling trees in Los Baños, Laguna, six were considered outstanding and were given cultivar names. Fruit evaluation and tree characterisation continue.

Varietal selection standards for pili were established in 1994. An outstanding pili tree should be precocious and prolific and have the following characteristics: medium to large, short oblong to globose fruit (≥25g) and nut (≥10g); at least 90% of nuts filled; thin shell (≤4mm); medium to large white kernel (≥2.5g) that ripens quickly; at least 20% shelling recovery; a strong, spreading tree with profuse branching; at least 5000 fruits per season for a mature tree; tolerance or resistance to pests and diseases; resistance to typhoons; and a success rate of 80% to 85% for cleft grafting and 70% to 75% for patch budding.

Propagation

Pili can be propagated by seed or by asexual methods such as marcotting, grafting and budding. Seed propagation is currently still the most popular method but is now being discouraged in favour of asexual propagation because half of the trees turn out to be male, seedlings have a long juvenile period, and there is a high degree of variability among seedling trees.

Marcotting or air layering is the simplest asexual propagation method for pili, but success can range from nil to 100%. The biggest prob-

lem in marcotting is the low survival rate of the successfully rooted branches after they are severed from the mother tree.

Cleft or wedge grafting is one of the two methods recommended for propagating pili commercially. The seedling rootstocks need to be established in large containers or directly in the field so that they will attain sufficient girth quickly to match the diameter of the budsticks. Defoliated budsticks are better to use. Done in the cool and dry months of November to February, success in cleft grafting can be as high as 85%.

Patch budding is the most efficient way to propagate the pili and is recommended for large-scale propagation. As in cleft grafting, the seedling rootstocks are better established in larger containers or directly in the field to induce them to attain sufficient girth quickly. Frequent watering and nitrogen applications also encourage the seedlings to grow actively. Defoliated budwoods are better to use. Young actively growing trees are good sources of budwood materials because the nodes on the shoots are far apart. Done in the cool and dry months of November to February and with a lot of practice, success in patch budding can be as high as 75% to 80%.

Field Establishment

Pili trees, especially those grown from seeds, eventually grow into huge trees that may reach a height of 30 to 40 m and a crown diameter of 20 to 30 m. Because of the dwarfing effect of fruiting, however, female trees are usually smaller than male trees.

If the use of seedlings cannot be avoided, the seed should at least be obtained from trees of named varieties or from other outstanding trees. The seedlings should be planted at least 12 m apart. As half of the trees will be male, two seedlings should be planted at each tree position, 30 to 50 cm apart. When the trees start to flower and their sex can be identified, most male trees should be cut down, leaving only a few to serve as pollen source. A ratio of one male to 20 to 25 female trees may be adequate.

Until dwarfing rootstocks become available, asexually propagated planting materials should be planted at least 8 m apart. It is also necessary to interplant male trees, especially when the planting is quite isolated.

A triangular or square system of planting can be used. In places with well distributed rainfall, planting can be done any time of the year. In other places, the best time to plant is at the onset of the rainy season.

Cultural Practices

There is very little information available on the best cultural practices for pili trees. Experimental orchards need to be established to determine their field requirements as a plantation crop.

Training and pruning

Marcots usually form lateral branches early and do not require training. Seedling, grafted and budded trees tend to grow upright initially and need to be trained at an early age to induce the formation of lateral branches. This may be done by pinching off the terminal bud when the tree is about half to one metre tall. This is done repeatedly on all the subsequent shoots until the newest shoots turn reproductive. This process may take two to four years.

Once the tree starts fruiting, very little pruning is necessary, as fruiting has a marked dwarfing effect on pili trees.

Irrigation

In the Bicol region and in places with well distributed rainfall, irrigation is unnecessary. Limited experience in other areas, however, shows that the first dry season after planting is critical for the successful establishment of the trees. It is therefore necessary to provide water during this period.

In places with a distinct dry season, irrigation is necessary for trees of bearing age, as flushing and flowering occur during this time. These processes require an adequate supply of water to the trees.

Nutrition

The fertilizer needs of pili trees can be determined using the results of studies of nutrient content and uptake.

Nitrogen content is high in the kernel (2.49%), leaf blade (1.16%) and fruit pulp (1.03%). Phosphorus content is high in the kernel (0.47%),

petiole (0.37%), stem (0.31%) and shell (0.24%). Potassium content is high in the pulp (2.62%), peduncle (1.74%) and stem (1.40%).

Nitrogen uptake is high in the kernel (0.31 kg per tree), leaf blade (0.53 kg) and fruit pulp (0.20 kg). Phosphorus uptake is high in the shell (0.24 kg). Potassium uptake is high in the leaf blade (0.18 kg) and fruit pulp (0.50 kg).

The nutrients removed by the leaves are returned to the soil when the leaves fall and decompose. However, it takes some time before these nutrients are absorbed by the roots of the tree. After harvest, the fruits are removed from the site of production and the nutrients they contain are considered lost from the soil.

Thus the leaves and fruits of a pili tree remove 1.28 kg N, 0.39 kg P and 1.03 kg K. In terms of fertilizer equivalents, these would correspond to an application of 6.4 kg ammonium sulfate, 2.0 kg superphosphate and 1.7 kg potassium chloride per tree.

When analysing tissues to determine the nutrient requirements of pili, the sixth and seventh leaves from the tip of the shoot should be taken during September to December.

Control of pests and diseases

No serious pests and diseases have so far been observed that have needed any control.

Harvesting and Yield

Seedling trees, on average, start fruiting four to five years after planting. Grafted trees produce after three to four years. Assuming an average yield of 2000 nuts per tree per season for 10- to 15-year-old trees, this equals 20 kg dried nuts per tree. The harvest lasts from May to October with a peak in June to August. It is best to harvest only well ripened fruits.

The present system of harvesting is a laborious process because the harvester climbs the tree and picks the ripe fruits individually using a bamboo pole with a wire hook at the tip. The harvested fruits are placed in sacks and brought to the house for processing. Should commercial orchards be established, ripe fruits could simply be allowed to fall to the ground and be collected by hand or machine.

Processing

There are two ways to separate the fleshy pulp from the nut. One method involves soaking the fruits in water until the pulp becomes soft. On average, it takes two to three days for all the fruits in a batch to soften. This method is recommended when the nuts are intended for germination. The other is to soak the fruits in water at 40° to 50°C. All fruits soften in a few hours. Nuts cleaned this way remain in good condition longer, but they may have poor germination when used to grow seedlings. A de-pulping machine is needed.

The nuts are thoroughly washed to remove the slimy material adhering to the shell. All nuts that float in water are discarded.

When they are to be used for germination, the clean nuts are simply air-dried. For long storage, the nuts are sun-dried for two to three days. Studies show that oven-drying the nuts at 30°C for 27 to 28 hours reduces the moisture content from 40%–50% (harvest moisture) to 3%–5%. Kernels dried this way are milky white, are not oil-soaked and have a pleasant flavour.

Kernel extraction is presently a purely manual operation. With the use of a special knife the worker cuts the shell crosswise at the mid-section. Great skill is required so that the stroke does not cut through the shell. A skilled worker can shell two sacks of nuts in an eight-hour day.

Marketing

Pili is usually marketed as dried nuts or shelled kernels. Experienced traders, however, prefer to buy whole fruits because these are cheaper and the traders can select only fully ripe fruits.

Prices are usually low during the harvest season (May to July) and high during the rest of the year, with a peak in December.

Kernel Uses

The kernel can be eaten raw or roasted with or without the testa. When used for processing, the kernel is rid of the brown testa by soaking it in warm water until the testa slips readily when the kernel is slightly squeezed with the fingers.

The clean kernel can be used as a flavouring for ice cream. It is presently used commercially

in many ways, including glazed candies, puddings and cakes.

Packaging of the processed products is still crude. For example, sugar-coated kernels are usually packed in plastic bottles. As they are not packed in vacuum, the processed products last for only a few months. Moreover, during hot weather, the plastic material reacts with the oil to produce an unpleasant odour. Packaging studies are therefore needed to prolong the shelf life of processed pili.

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Macadamia: A Tropical Nut Industry Example

Andrew McGregor*

HORTICULTURAL exports from developing countries have experienced dramatic growth during the last 30 years. Although this growth has now slowed, it remains above that of agricultural exports as a whole. Tree nuts have been a significant component of this growth. Their share of horticultural trade remained constant at around 10% for the entire period. The value of tree nut exports now stands at about US$1000 million annually, of which macadamia nuts account for around 3%.

Worldwide macadamia nut production is expanding rapidly and will continue to do so in the foreseeable future. The expectation is that the market will be in broad balance by the end of the decade, with a little less than 60% of supply coming from Hawaii. The actual outcome, however, depends on various factors, including the level and success of promotional efforts and whether the production forecasts of the emerging macadamia producers are realised.

Analysis indicates that the trade in macadamia nut kernel is entering a transitional phase from a high-value, narrow-niche product that is always in short supply (with no carryover stocks) to one that is more characteristic of the widely traded quality nut commodities such as cashews and almonds. As an undersupplied niche commodity facing a highly inelastic demand (unresponsive to price), this nut's prices have been exceptionally high. As the supply increases and the market matures, prices will fall toward those of competing luxury nuts. The macadamia market will also experience periods of excess supply and accumulated stocks. Given the highly inelastic short-run demand, sharp short-run price fluctuations can be expected, superimposed on a longer-term price cycle. The level and effectiveness of promotional efforts will be a crucial determinant of future demand growth. The industry needs to develop its own market and production forecasting capability.

Demand prospects are likely to be best for those horticultural commodities that have experienced rapid growth in recent years but whose per capita consumption remains relatively low. These commodities are unlikely to have been exploited anywhere near their full market potential. Pistachio and macadamia nuts fall into that category. In contrast, almonds, a commodity that has experienced dramatic expansion during the last 20 years, appear to be approaching full exploitation of existing market opportunities.

Review of Macadamia Nut Supply and Trends

Global overview

Although the macadamia nut tree is native to Australia, commercial development began in Hawaii. Edible nuts come from two species of the genus *Macadamia*: *M. integrifolia* (smooth-shell) and *M. tetraphylla* (rough-shell). Most of the world's commercial industries are based on the smooth-shelled variety, which has a higher oil content and is considered superior for roasting. Macadamias can be grown between 34° north and 30° south latitude, but most commercial production lies between 16° and 24° both north and south latitude, in frost-free locations (Ito and Hamilton 1985).

Macadamia nuts are the most recent tree nuts to enter international trade and are by far the least significant (0.5%) of the commercial tree nuts (Table 1). They are, however, the most rapidly expanding nut crop. World production in 1994 was estimated at approximately 44 000 t wet-in-shell (WIS), or around 9000 t of raw kernel.

World production and trade are dominated by

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Table 1. World tree nut production and trade (thousands of tonnes)

Crop	1986–87	1987–88	1988–89	1989–90	1991–92	1992–93
Almonds (kernel)						
production	232	403	362	368	348	394
exports	129	179	193	179	196	194
Hazel nuts (in-shell)						
production	422	421	541	614	581	742
exports	317	282	346	385	379	360
Pistachios (in-shell)						
production	70	61	79	72		
exports	6	13	14	17		
Walnuts (in-shell)						
production	430	502	480	469	509	493
exports	145	137	151	151	170	175
Cashews (kernel)						
production	277	348	376	389		
exports	61	54	51			
Brazil nuts (in-shell)						
production	50	41	41			
Macadamias (kernel)						
production	5	5	6	7	8	9

Sources: USDA Horticultural Products Review *Tree Nuts: Production, Supply and Distribution*, various issues; USDA *World Horticultural Trade* and *US Export Opportunities*, various issues; Gill and Duffus *Edible Nut Statistics*, May 1989; Gill and Duffus *Edible Nut Market Report*, Dec 1989.

Hawaii (Fig. 1), although non-Hawaiian production has been expanding more rapidly during the last decade. In 1990 Hawaii produced approximately 24 000 t WIS of macadamia nuts, which is 62% of estimated world production. This percentage is down from around 90% at the end of the 1970s, although Hawaii's production has grown steadily, increasing by more than 50% during the last decade. Hawaii is now entering a more rapid expansion phase, with production expected to double during the next decade as existing plantings come into full production. However, its share of total world production is expected to fall to about 60% by the end of the century owing to an even more rapid expansion in other areas, particularly Australia and Costa Rica.

Macadamia nuts are grown commercially in Australia, eastern and southern Africa (Kenya, South Africa, and Malawi), Central America (Costa Rica and Guatemala) and Brazil. Other minor producers are China, Mexico, Thailand, Indonesia and New Zealand. Non-Hawaiian production was estimated at around 11 000 t WIS in 1989, but reliable production figures exist only for Australia, the world's second most important producer (18.5% of production in 1989).

The general trend that emerges from production estimates is that worldwide macadamia nut production is expanding rapidly and will continue to do so in the foreseeable future. World production is projected to range from 65 000 to 80 000 t in-shell (or approximately 14 000 to 17 000 t kernel assuming a modest improvement in extraction rates) by the end of the century. World consumption requirements are projected to be approximately 15 000 t; thus the market should be in balance by the end of the decade.

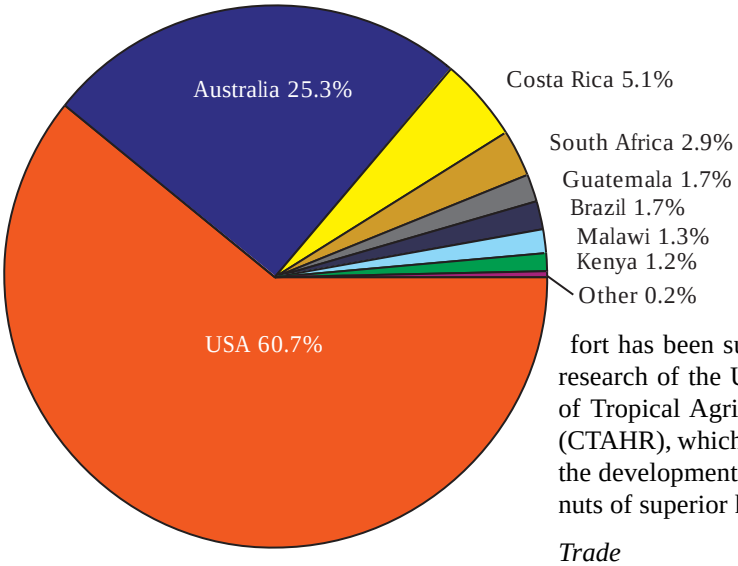

Figure 1. World macadamia nut production and forecasts, 1994 (tonnes nut-in-shell)

Hawaii

History

Macadamia nuts were introduced into Hawaii from Australia in 1881. Commercial development, however, dates from 1949, when tree varieties suitable for large-scale orchard plantings under Hawaii's conditions were developed and 300 ha was established on the Big Island of Hawaii. By 1993 more than 9000 ha of macadamia had been planted in both large and small orchards on Hawaii. Rapid growth of Hawaii's tourism industry provided a ready market for the sale of macadamia, primarily in the form of salted snack and chocolate-covered products.

Production and productivity

Current production is around 23 000 t of nut-in-shell, or 5750 t of kernel. This production generates a farm income of more than US$45 million, which makes macadamia nuts Hawaii's third major agricultural crop after sugar and pineapples and the State's leading diversification crop. New plantings in recent years have stabilised at a modest rate of 20 000 trees a year. Thus while production continues to increase, the industry will enter a mature production phase during the next decade as most trees reach full production.

The yield of nuts-in-shell in Hawaii ranges from 5.8 t/ha on poorer land to 8 t/ha on better land.

The industry has been built on vigorous agribusiness participation, which has been actively involved in promotion and market development. The lead taken by the Mauna Loa Macadamia Nut Corporation has been a key factor. This effort has been supported over the years by the research of the University of Hawaii's College of Tropical Agriculture and Human Resources (CTAHR), which has been particularly strong in the development of high yielding varieties with nuts of superior kernel characteristics.

Trade

Hawaii dominates the world macadamia nut economy. It is not only the main producer of macadamias (approximately 62%) but also the world's largest consumer (approximately 34%). If sales to the US mainland are considered as exports, then Hawaii is by far the largest exporter. It is also a major importer of kernel, accounting for about 30% of nuts imported into the US. The estimated value of Hawaii's chocolate-covered macadamia nut industry alone is estimated at more than US$100 million (Yokohama *et al*. 1990).

Japan is the main market for raw kernel, usually importing around 200 t a year from Hawaii. However, Hawaii's main exports to Japan are taken home by tourists and represent at least US$15 million a year (USDA 1990, p. 5).

Industry structure

Farms of around 4 ha predominate, but most production comes from a small number of large orchards.

The industry operates within a strong institutional environment. An active Hawaii Macadamia Nut Association sponsors seminars and acts as an industry interest group in areas such as determining research priorities for the CTAHR. However, the industry has no power to levy its members to fund research, development and industry-wide promotion, which is seen as an institutional weakness for the longer-term development

of the industry. The Hawaii State Department of Agriculture, in cooperation with the industry, has developed quality standards.

Australia

Despite the fact that macadamia is native to Australia, commercial development of the Australian industry has occurred only during the last 25 years.

Production and productivity

Australia now represents the world's fastest growing production area, with production increasing from 262 t WIS in 1975–76 to 15 000 t for 1990. The farm gate value of this production has increased from $0.2 million to $20 million (Thew and Vock 1989, p. 1). Farm prices have been high during the second half of the 1980s as a result of shortfalls in supply, high overseas demand, competition among processors for nuts, and the low Australian–US exchange rate (Fig. 2).

With investors expecting a high rate of return there was a rapid rate of planting peaking at 150 000 trees a year or between 600 and 750 ha, which compares with around 20 000 trees for Hawaii. A large percentage of Australian plantings are thus yet to come into bearing. Accordingly, Australia's market share can be

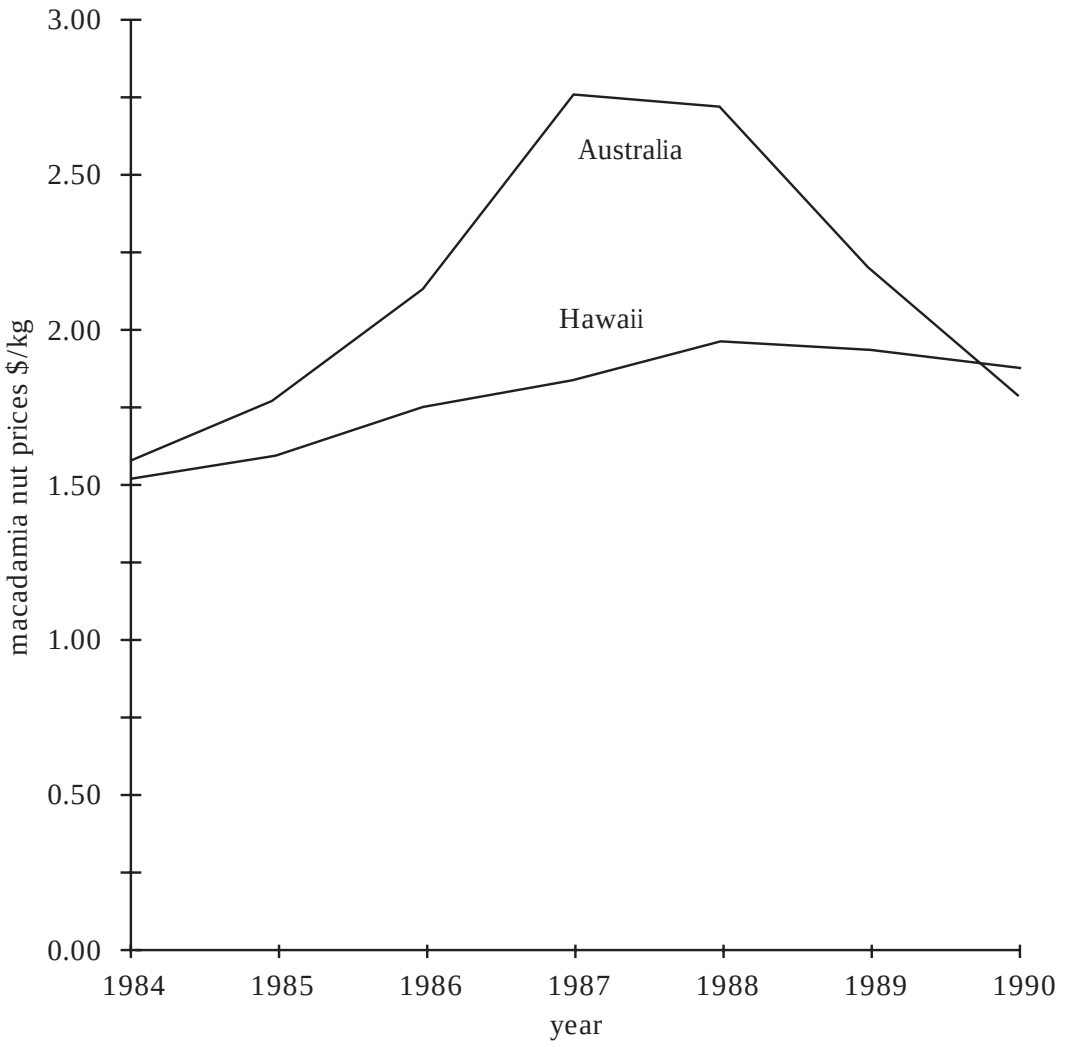

Figure 2. Comparative macadamia nut farm gate prices (US$/kg)

expected to increase significantly from its present level during the next decade.

Trade

Currently around 80% of Australia's macadamia nut production is exported. North America is the main market (80%), followed by Japan (15%) and Europe (5%). Australia accounted for 60% of US kernel imports, compared with only 4% in 1982 (Martin 1990). The current value of exports is around $A20 to $A30 million. Stephenson (1990) forecasts the value of Australian exports to be $A70 million by 1995.

Industry structure

The Australian industry also has the involvement of large corporate groups, investor orchards managed by specialist consultants, and smallholdings operated by part-time macadamia enthusiasts. Most farms, at around 40 ha, are much larger than the 4 ha Hawaiian norm.

Recent years have seen a proliferation of small processing plants, the so-called contract or 'backyard' processors, which often involve one or two growers marketing their own product. In the long term, these small processors are detrimental to the growers' interests by undermining orderly marketing and compromising quality. The small processors do not make the necessary investment in marketing and processing infrastructure and have sought to maintain market share during the supply excess by undercutting prices. The contract processors also threaten to undermine Australia's high quality reputation, which is a major concern of the industry. The Hawaiian industry could learn from the Australian experience and not encourage the proliferation of small processors.

The Australian Macadamia Society (AMS) gives the industry a strong organisational base. The AMS sets quality and grading standards. Through the instigation of the AMS, a pricing system that penalises poor quality kernel has been imposed. The AMS is involved in promotion and marketing efforts on behalf of the Australian industry.

Costa Rica

Costa Rica is outside the optimum zone for macadamia nut production, but soil and climatic conditions are suitable for macadamia in the higher elevation areas.

The commercial development of the industry dates from the late 1970s and is based entirely on smooth-shell varieties. Current production is around 1400 t WIS. The industry receives strong government support and benefits from a stable political environment. Vidgen and Leeson (1987) predicted that Costa Rica will be the world's fastest growing area during the next decade. It has now surpassed South Africa as the third most important growing area.

South Africa

South Africa produces an estimated 1700 t WIS. Most of the production comes from three large orchards. Unlike Hawaii, Australia and Costa Rica, plantings have remained relatively static during the last decade. Many existing plantings are based on poor varieties (including the rough-shell), although some material has been imported from Hawaii.

Poor varieties and generally harsh conditions mean that South African yields are low. There is also high rejection of kernel at the factory owing to insect damage and mould, and the overall quality of kernel is regarded as low.

Malawi

Malawi produces around 700 t WIS. Extensive recent plantings are reported following a period of prolonged stagnation. The Commonwealth Development Corporation is contemplating a major macadamia development.

Malawi's one processing factory produced approximately 150 t of saleable kernel in 1989. The kernel is of relatively poor quality overall, although most plantings are of the preferred smooth-shell variety. Like South Africa, Malawi experiences a high rejection rate (nearly 20% in 1989); and insects are a major problem.

Kenya

Kenya has had long involvement with macadamia nuts. More than 3000 ha of trees was planted in 1971, most of which were the rough-shell variety (FAO 1971, p. 1). According to an Agricultural Attaché report, 237 000 trees were planted in 1969 alone.

Unfortunately for the Kenyan industry, development was allowed to proceed before the necessary varietal research had been done. Current production is estimated at around 500 t WIS. There is Japanese investment and aid in the industry, which would account for Japan's being Kenya's main export market and Kenya's being Japan's main raw kernel supplier. This situation is somewhat surprising given Kenya's reputation for poor quality.

Guatemala

Production is around 700 t WIS. Better Hawaiian varieties have generally fared poorly, and insects are a problem (HMNA 1989). The industry has suffered major losses from wind damage. There has been no new capital investment in recent years in line with Guatemala's general deteriorating economic situation. Furthermore, some orchards have been located in areas of rebel activity. Thus limited growth from Guatemala can be expected during the next decade.

Brazil

Brazil has been described as the 'sleeper' of the world scene, with very little production as yet but considerable potential (HMNA 1989). Brazil dominates the world citrus, coffee and Brazil nut economies and has a major influence on the market for commodities such as sugar and cocoa. It might have the same effect on macadamia nuts; a great variety of plans and acreages are reported for Brazil.

California

About 2000 ha of rough-shell macadamia has been planted in the San Diego area, which is mainly on hobby farms of less than 2 ha. Current production is around 70 t WIS, none of which is commercially processed.

China and Thailand

At present these two industries are insignificant. Ito (pers. comm.) reports that China and Thailand have planted 300 ha and 200 ha, respectively, of which none is bearing. He forecasts that the combined production from these two countries will be only 11 t in 2000, but believes that both countries have the potential to develop major export industries next century.

New Zealand

Macadamia nuts are grown in the north of the North Island of New Zealand. At about 34° south the location is far from optimum. Production to date has been minimal (1 t of kernel in 1989) and has been based on the rough-shell variety. Clarke (1986) reports that because *M. integrifolia* selections have been very poor croppers in New Zealand, they have had to accept the rough-shelled *M. tetraphylla* species and hybrids. Both show encouraging results but require modified processing to produce a similar acceptable product. Because little is known worldwide about the best processing criteria for *M. tetraphylla* or its hybrids, New Zealand is having to pioneer its own techniques with limited resources.

Macadamia Markets and Demand

The USA accounts for an estimated 85% of the world's consumption (around 7000 t of kernel). Japan and Europe constitute the only other significant macadamia markets.

The US market

Despite its world dominance, the US market for macadamia nuts is still largely undeveloped. Most metropolitan areas have little exposure to macadamia products. Annual per capita consumption for macadamia nuts stands at 0.027 kg, which is comparable to hazelnuts (0.041 kg) and pistachios (0.086 kg) but is well below almonds (0.299 kg), pecans (0.236 kg), walnuts (0.200 kg) and cashews (0.151 kg). Total annual tree nut consumption in the USA is estimated at 1.04 kg per head, of which macadamia nuts represent 2.7%. However, during the last decade per capita macadamia nut consumption has grown by 100%, second only to pistachios in growth. Almonds are regarded as the closest substitute to macadamias and are thus likely to provide the best indicator of a future consumption pattern for macadamia nuts.

The US market consists of two distinct submarkets: the developed Hawaiian market, which accounts for more than half of the total sales, and the relatively undeveloped US mainland market. The annual per capita consumption

of macadamia nuts in Honolulu, 0.66 kg, is some 20 times the national average (Scott and Sisson 1985). This figure provides an indication of the immense growth potential for the product under full market development. The Honolulu market is considered fully developed as macadamia nuts are fully distributed, virtually all consumers are aware of them, and most of the population (both resident and visitor) has consumed them.

The metropolitan areas of the mainland USA have had relatively little exposure to macadamia nuts. Macadamia products, both snack nuts and other consumer products, are only sparsely distributed in most areas. California and the north west regions, both leading tourism markets for Hawaii, constitute the main market.

In 1990 approximately 2200 t of macadamia nuts were imported as raw kernel. Australia is the main source of imports (around 65%). Costa Rica, Guatemala and Malawi are also significant sources. Industry expresses concern that the processors sell imported kernel as 'Hawaiian Macadamia' to satisfy sales commitments. This action undermines Hawaii's superior quality reputation and cashes in on the position of Hawaii in the market place.

Japanese market

The principal market for macadamias outside the USA is Japan. In 1988 Japan imported about 540 t of kernel, approximately 70% of the total world macadamia exports, excluding those to the USA. Macadamia nut kernels account for less than 1% of nut imports into Japan by volume but more than 2% by value. The kernel is used mainly by the food processing industry as ingredients for candies, cakes and ice cream topping.

Figures for raw kernel imports into Japan significantly underestimate the actual level of macadamia nut consumption. A significant percentage of Hawaiian sales are to Japanese tourists, who buy gift-packed macadamia nuts as a customary gift ('omiyage') when returning from a vacation. Retailers report that Japanese tourists 'often buy several boxes, or even a case, of macadamia nut products, while mainland US tourists usually buy one or two boxes' (USDA 1990, p. 5). These so-called 'suitcase' exports are estimated at $15 million a year but may be considerably higher (USDA 1990, p. 5). Hawaii also exports substantial amounts of chocolate confectionery to Japan, which contain a significant macadamia nut component.

Australian market

The estimated per capita consumption of macadamia nuts in Australia is 0.015 kg, approximately half that in the USA. In the Australian market the cashew is the leading tree nut and is regarded as the main competitor to macadamia (McEvoy and Heselwood 1983, p. 6). As elsewhere in the world, macadamia is a gourmet nut whose price is 25% to 45% higher than that of cashews (McEvoy and Heselwood 1983, p. 7).

Other macadamia nut markets

Very little information is available on the European market for macadamia nuts. Both the USA and Australia export small quantities of macadamias to Germany and some other European countries. Western European countries have well established and diversified tree nut markets and, as for Japan, market development will probably have to emphasise product development that uses the macadamia nut with other ingredients to overcome the inherently high kernel price of macadamias in relation to competing nuts. In view of the success of the Californian almond industry in developing European markets, the potential for macadamias appears quite favourable.

Canada, Hong Kong, Singapore and Taiwan also import macadamia nuts. Although the quantities involved are quite small, they offer considerable growth potential for the future, provided exporters can provide a reliable supply, maintain high quality standards and, most importantly, develop a much larger range of products to meet the unique needs of the individual country markets.

The Determinants of Macadamia Nut Demand and Price

Price and income elasticities

Macadamia nuts, as a luxury product with very low per capita consumption, can be expected to have a low price elasticity and a high income elasticity. This means their consumption will be relatively unresponsive to price changes but highly responsive to changes in income.

This result has important implications for the future development of the macadamia market. In the short to medium term considerable fluctuations in price can be expected in response to changes in supply. Until recently the market has tended to be undersupplied, leading to exceptionally high prices. However, the market is entering a phase when, from time to time, it will be oversupplied. In these situations prices can be expected to fall sharply. The drop in the export price of Australian kernel is probably a reflection of things to come in this respect. Australian production almost doubled in the space of a year, and even a substantial drop in prices was insufficient to clear the market. It will take time for steadily increasing demand to absorb this increase in production. Advertising and promotion will be the key factor in determining the rate at which demand increases.

As the market matures and per capita consumption increases, demand can be expected to become more price elastic. This development would lead to a more stable price environment.

Health and nutrition considerations

The nutritional status and health considerations are factors in macadamia nut consumption and are likely to be increasingly important in future market development. The effect could be both positive and negative. The rapidly expanding market for natural foods in developed countries is increasing the demand for all nuts. Most nuts, including macadamias, are an excellent source of natural calcium, phosphorus, iron, potassium and certain vitamins.

Nuts are also very rich in calories and fat, however, and macadamia is higher than most. In surveys of Honolulu and Los Angeles households, 9% of respondents indicated they did not buy macadamias because they considered them to be fattening (Scott and Sisson 1985). Yet macadamia nuts have a high percentage of unsaturated fatty acid, particularly monounsaturated fatty acid. Thus a research priority is to clarify the nutritional characteristics of the macadamia so that the industry can deal with this issue in market development, particularly the development of new products.

Determination of macadamia nut price

The retail price of macadamia nuts is substantially higher than that of comparable nuts, and the gap has been widening. Biological characteristics help explain the large price differences. The very hard shell makes kernel recovery costs higher because of the large capital costs of the processing equipment. Kernel recovery rates are also lower than from other nuts. Hawaii's average kernel recovery rate from nut-in-shell was 23.5% for the 1989 season. In comparison, the main Californian almond variety, 'Nonpareil', has a kernel yield of at least 50%. Harvesting costs are also higher for macadamias, representing between 15% and 20% of growers' costs. Macadamia nuts are typically harvested once a month (by gathering nuts from the ground by hand or machine) during the season, which, depending on tree variety, can last up to six months. Almond orchards, on the other hand, are typically harvested at one time by mechanical shaker. Cashews, in comparison, are produced and processed primarily in countries that have very low labour costs.

Thus if the level of profitability is to be maintained, it will be necessary to reduce the cost of macadamia nut production. Increasing the yield offers the best prospects in this respect. There are also opportunities for cost reductions through using by-products, such as burning shells in boilers and driers and applying husks as compost.

Future Market Development and Demand Prospects

World macadamia production is expected to at least double during the next decade. Indications are that macadamia demand will increase substantially during the same period, particularly in the North American, European and Japanese markets.

During the past decade, US tree nut consumption has increased rapidly, growing at almost 3% each year. However, the annual per capita growth for macadamia nuts has been more than 7%, leading to a doubling of per capita consumption during this period. A similar growth rate could be achieved during the next decade. This forecast is based on the following observations:

- The considerable differences in per capita consumption between mature macadamia markets (Hawaii and to a lesser extent Los Angeles) and other markets
- The high income elasticity of demand for macadamia nuts
- Product and industry similarities between macadamia nuts and almonds and the growth that occurred in the latter
- The priority given to promotion and market development by the major macadamia nut companies
- Growth in Hawaii's tourism.

There is a definite need for the industry to develop its own capability for market and production forecasting. In the meantime, a much more judgmental approach has been adopted in this paper. A 'best' estimate of world macadamia nut consumption at the end of the decade is 15 000 t of kernel, which compares with 8000 t estimated as the current level of consumption. This quantity could be considerably more, however, if promotional and product development efforts are stepped up. On the other hand it could be lower if the current level of promotion is not sustained.

This forecast is well within the market potential forecasts of other authors. Scott and Sisson (1984) estimate a world market potential of 29 000 t of kernel, which includes 13 000 t of kernel for the US mainland. Surono (1987), using Los Angeles data, estimates the potential US market to be 22 000 t of kernel.

The consumption of 15 000 t of kernel would require approximately 70 000 t of nuts-in-shell, depending on extraction rates and moisture content. This compares well to the forecast production figure of 14 000 to 17 000 t. Thus the world macadamia nut market could be in broad balance by the end of decade.

Analysis of supply, demand and market development indicates that the trade in macadamia nut kernel is entering a transitional phase from a high-value, narrow-niche product that is always in short supply (with no carryover stocks) to one that is more characteristic of the widely traded quality nut commodities such as cashews and almonds.

As an undersupplied niche commodity facing highly inelastic demand (Cahyono 1988, p. 63),prices have been exceptionally high. As supply increases and the market matures, prices will fall toward those of competing luxury nuts. The macadamia market will also experience periods of excess supply and accumulated stocks. With a highly inelastic short-run demand, sharp, short-run price fluctuations can be expected, superimposed on a longer-term price cycle.

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McGregor, A. 1991. A review of the world trade and marketing of macadamia nuts. Paper presented at the 31st annual meeting of the Hawaii Macadamia Nut Association, 3–4 May 1991, Kona, Hawaii.

This version of the paper has been adapted from an expanded second version and a talk given at the South Pacific Indigenous Nuts Workshop.

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Part IV: Country Priorities for Research and Development

Country Priorities for Research and Development

Paul Ferrar*

At the end of the South Pacific Indigenous Nuts Workshop, participants from the South Pacific countries were asked to discuss their priorities for future research into and development of nuts and nut industries. They met as four discussion groups: one each for Papua New Guinea, Solomon Islands and Vanuatu, and one for Fiji and Western Samoa. They were asked to indicate the species they thought had the most potential, potential markets and uses, and what research or development was needed to achieve objectives. This paper summarises their conclusions. Their priorities are listed below on a scale of 1 to 5, where 1 is the highest priority and 5 is the lowest.

Papua New Guinea

Species	Priority
Canarium spp. (galip) and *Terminalia kaernbachii* (okari)	1
Pandanus julianetti and *P. brosimos* (karuka)	3

Markets	
Domestic and tourist markets	1
Export markets (kernel?)	2

Production issues requiring research and development

DAL = Department of Agriculture and Livestock
KGIDP = Kandrian Gloucester Integrated Development Project
Unitech = University of Technology, Lae
NGO = Non-government organisation
KIT = kernel-in-testa

Issue	Who will do	How	Time-frame	Priority
Development of existing resources and trees	DAL, KGIDP	Integrated farming system research	Short	1
Development of plantations	DAL		Long	5
Agronomy of galip	DAL research station; on-farm trials; indigenous knowledge	Research program (DAL to set *Canarium* as research priority)		

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Issue	Who will do	How	Time-frame	Priority
Resource assessment	DAL, KGIDP, NGOs	Collect all existing information	Short	1
Social constraints to commercial supply	DAL, KGIDP	Village-level surveys		
Research to keep pace with production	DAL and private	Market-driven research		
Intellectual property right considerations	DAL	Investigate	Long	3

Processing issues requiring research and development

Issue	Who will do	How	Time-frame	Priority
Research into processing and storage, including processing hygiene, packaging materials, assessment of KIT quality in-shell	KGIDP, DAL, Unitech	Research programs (DAL needs funds and staff)	Short	1
Mechanical cracking	Max Henderson		Short	1
Training in post-harvest handling techniques	KGIDP			

Marketing issues requiring research and development

Issue	Who will do	How	Time-frame	Priority
Appropriate packaging	KGIDP; other processors	R&D program	Short	1
Market targeting and strategy	Processors	Heavy domestic promotion of galip	Short	1
Quality standards (for example, size, colour, presentation)	Processors	Dictated by consumers	Short	1
Join International Nut Council			Long	3

Other

Establish a PNG-specific working group on indigenous nuts, perhaps with newsletter 1

Solomon Islands

Species	Priority
Canarium spp. (ngali)	1
Preliminary collection and evaluation of some other species to assess prospects	3

Markets

Domestic market (kernels and oil)	1

Production issues requiring research and development

MAF = Ministry of Agriculture and Fisheries (formerly Ministry of Agriculture and Lands)
MFC = Ministry of Forestry, Environment and Conservation
CEMA = Commodity Export Marketing Authority
MFA = Ministry of Foreign Affairs
MAN = Melanesian Association of Nuts
NGO = Non-Government Organisation
K:N ratio = kernel to nut ratio
KIT = kernel-in-testa

Issue	Who will do	How	Time-frame	Priority
Development of existing resources and trees	NGO, MAF		Medium to long	1
Development of plantations	MFC	Agroforestry	Long	5
Agronomy of ngali, including pollination (survey insects), and pests (assess extent of problem and damage)	NGO, MAF, MFC	Gather existing information to set research needs	Short to long	3 (pollination study) 1 (rest)
Resource assessment	NGO, MAF, MFC, CEMA, farmers	Collate existing information, including indigenous knowledge; germplasm evaluation and propagation trials		
Social constraints to commercial supply	NGO, MAF, private	Monitor socio-economic effect of commercialisation	Medium to long	2
Financial support for individuals or groups wishing to start nut production	NGO and private		Medium to long	2
Intellectual property right considerations	MFA			

Processing issues requiring research and development

Issue	Who will do	How	Time-frame	Priority
Research on processing and storage, including processing hygiene, packaging materials, assessment of KIT quality inshell	MAF, CEMA, MAN, NGO, donor agencies	R&D program	Short to long	1
Mechanical cracking—further development	Private developers	Will depend on product line and volume of supply	Long	
On-farm determination of K:N ratio	MAF, NGO, farmers	Through training and public awareness	Medium to long	2
Training in postharvest handling techniques	CEMA, MAF, NGO	Training programs	Short to long	2
Bulk storage and transport of KIT	CEMA, MAF, NGO	Through development work	Short to long	1
Central nut-cracking operation	Employers		Short to medium	3
Product development facility (which can be used to develop other commodities when nut work is finished)	Aid donors	Construction	Short to long	1
General product development and improvement	MAF and private agencies	R&D	Short to long	1

Marketing issues requiring research and development

Issue	Who will do	How	Time-frame	Priority
Appropriate packaging	CEMA, MAF, private	Testing available packaging materials and machinery	Short to long	1
Market targeting and strategy	CEMA and private	Market surveys and studies; national promotion for domestic market	Short to long	1

Issue	Who will do	How	Time-frame	Priority
Common marketing name	MAN	Create and establish name (especially for international marketing)	Short to long	1
Partnership with overseas companies	CEMA, private	Investigate possibilities		
Join International Nut Council	Through MAN			
Quality standards (for example, size, colour, presentation)	MAF, CEMA, private	Will depend on market target	Short to long	3
Formation of farmers' groups	Nut owners	Encourage	Short to long	1
Diversification of products	NGO, private, overseas agencies, MAF, MFC	Investigate mesocarp, shell, cake, testa, resin, timber	Medium to long	3

Other

Establish a regional association and a national association for nuts and development of nut industries. The regional association should publish a newsletter. 1

Vanuatu

Species	Priority
Canarium spp. (nangai) and *Barringtonia* spp. (cut nut)	1
Calophyllum inophyllum	2
Terminalia spp., Polynesian chestnut (*Inocarpus fagifer*) and macadamia will be considered once development of the first three nuts is achieved.	3

Markets

Domestic market (nangai, *Terminalia*, *Barringtonia*)	1
Tourist and export markets (kernel and nut-in-shell)	3
Export markets (oil)	4

Production issues requiring research and development

FSA = Farm Support Association
FSP = Foundation for the Peoples of the South Pacific
CIRAD = Centre de Coopération Internationale en Recherche Agronomique pour le Développement
ORSTOM = L'Institut Français de Recherche Scientifique pour le Développement en Coopération (L'Office de la Recherche Scientifique et Technique d'Outre-Mer)
USAID = United States Agency for International Development
CAD = Commercial Agricultural Development Project (of USAID)
KIT = kernel-in-testa K:N = kernel to nut ratio

Issue	Who will do	How	Time-frame	Priority
Development of existing resources and trees	Charles Long Wah, FSA, Forestry Department, Summit Estate		Short	1
Development of plantations	FSA, Summit Estate, Department of Forestry		Short	2
Agronomy of nangai	CIRAD in collaboration with Departments of Agriculture and Forestry	Studies on production, growth pattern, vegetative propagation, plantation spacing	Medium to mostly long	1
Production of field guide			Long	1
Resource assessment	CIRAD and Department of Agriculture	Continue to assess (collection already established)	Short	1

Processing issues requiring research and development

Issue	Who will do	How	Time-frame	Priority
Research on processing and storage, including processing hygiene, packaging materials	Charles Long Wah	Establishment of factory	Medium to long	1
Assessment of KIT quality in-shell	Chanel Sam	Continue existing ORSTOM survey	Short	4
On-farm determination of K:N ratio	Chanel Sam	Continue existing ORSTOM survey	Short	1
Mechanical cracking	Alex Bodiam, CAD, USAID	Continue existing development	Short	1
Training in postharvest handling techniques	Charles Long Wah, FSP, Department of Industry	Train 200 villagers; funding needed	Short	1
Cracking in villages		5000 solar dryers to be made in New Zealand and distributed to every village	Medium	1

Issue	Who will do	How	Time-frame	Priority
Bulk KIT storage and transport	Summit Estate, FSA			
Evaluation of composition of oil and its variability	Food and drug industry partners	Chemical analyses	Long	2

Marketing issues requiring research and development

Issue	Who will do	How	Time-frame	Priority
Appropriate packaging	Charles Long Wah			
Common marketing name for regional and international marketing		South Pacific Nuts as a general name, with specific name for each nut		

Other

Newsletter 1

Fiji and Western Samoa

Species Priority

Barringtonia spp. (cutnut), Polynesian chestnut (ivi: *Inocarpus fagifer*) and candle nut (*Aleurites moluccana*) 1

Markets

Domestic market for fresh and traditionally processed nuts (cutnut and ivi); candle nuts for the tourist market; vacuum-packed ivi nut kernels for export (to Polynesians in USA); candle nut oil for export cosmetics markets. 1

Production issues requiring research and development

MPI = Ministry of Primary Industries (Fiji)
CAD = Commercial Agricultural Development Project
WWF = World Wide Fund for Nature
FAO = Food and Agriculture Organization of the United Nations
FTIB = Fiji Trade and Investment Board
KIT = Kernel-in-testa

Issue	Who will do	How	Time-frame	Priority
Development of existing resources, trees and plantations	Ron Gatty to coordinate with MPI	Encourage agroforestry systems that include nut trees	Medium to long	1
Resource assessment	WWF	Survey ivi, cutnut and candle nut	Medium to long	3
Social constraints to commercial supply		Find out why it is difficult to get villagers to supply nuts on a regular basis		

Processing issues requiring research and development

Issue	Who will do	How	Time-frame	Priority
Research on processing and storage, including processing hygiene, packaging materials, assessment of KIT quality inshell	Ron Gatty, MPI, FTIB, FAO	FAO to be asked to send food technologist to help with research	Short	1
Mechanical cracking	CAD	Continue development	Short	1
Training in post-harvest handling techniques; on-farm determination of K:N ratio; bulk KIT storage and transport		All needed, but currently lack of expertise in Fiji	Short	3
Cracking in villages or centrally		Difficult with ivi but easier with candle nut	Short to medium	3
Processing of ivi (for Polynesian market in USA)	Iustino Wilson, Wilex, W. Samoa	Parboil or bake in umu, and vacuum-pack	Short	1
Candle nut oil	CAD	To be extracted and sent to Body Shop for testing	Short	1

Marketing issues requiring research and development

Issue	Who will do	How	Time-frame	Priority
Appropriate packaging	Ron Gatty	Test packaging with various nuts (packaging expertise needed)	Short	1
Market targeting and strategy	CAD	Candle nut oil to Body Shop first (use established Hawaiian name of kukui)	Short	1
Partnership with overseas companies	CAD	With Body Shop	Medium	1
Clarify needs for labelling for export	Gift Shop, Lautoka; FSP	Collect regulations for all target countries; summarise for exporters' guidance	Short	2
Quality standards		Later, when market requirements have been established		

Other

No need for an association or newsletter yet.

Concluding Comment

The tables above still have a few gaps. This is not because the subject was unimportant and there was no commitment, but rather that discussion groups ran out of time before all the desirable subjects had been discussed fully (or in a few cases, even with time they were unable to decide on the detail). Any subject that appears in the tables was considered by the group concerned to require research or development attention.

What use should now be made of this information? It would be a great pity if the investment of time, effort and funds in the workshop did not lead to some development of indigenous nut production and marketing in the South Pacific. The tables above are a valuable summary of the key needs for each country, and represent the distilled wisdom of experts from all fields of work concerned. They provide a good planning resource for each of the countries, and a useful guide for donor agencies looking to help the South Pacific in this area of development. The workshop participants and organisers hope you will use the information well!

Part V: Bibliography of South Pacific Indigenous Nuts

Bibliography of South Pacific Indigenous Nuts

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OVER the past 15 years, three of the authors (Walter, Evans and Bourke) have independently prepared bibliographies of South Pacific indigenous nuts, with a somewhat different geographical and subject emphasis. Walter and Evans concentrated more on botanical papers, Bourke more on the ethnographic literature. Walter concentrated on Vanuatu and the French language literature; Evans on Solomon Islands; and Bourke on Papua New Guinea. We considered that it would be useful to combine the three bibliographies and publish the compilation in these workshop proceedings. Patty Hobsbawn of the Australian National University did this.

The bibliography is not exhaustive. Coconuts, breadfruit and betel nut have been excluded, consistent with the coverage of the workshop. Papers published in this volume are not cited. We have included only a limited sample of papers that refer to nuts in archaeological excavations. Coverage is restricted mainly to the South Pacific, but a number of papers from Southeast Asia on species common to both regions are included. Two extensive bodies of literature, based on botanical taxonomy and ethnographies, are only partially represented. We have included some of the more important and easier-to-find taxonomy papers, but there are many more specialised papers (see Walter et al. (in preparation) for a more complete listing). Many ethnographies mention at least indigenous fruit and nut species, and many contain useful information on distribution, usage and seasonality of fruiting. The coverage of ethnographies is more complete for Papua New Guinea, especially for karuka nut *Pandanus*, than for other parts of the South Pacific.

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