

Potential for further commercial development of introduced fruit

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Abstract

Many fruit species are grown and eaten in Papua New Guinea (PNG) and significant quantities of fruit are produced for both subsistence consumption and sale. The main growers are villagers, who produce only a limited quantity of each species. There is still considerable potential for expansion of production for sale, with the sale of sweet fruit into the highlands and in Port Moresby having the most potential. It is critical that further development of fruit production takes place in locations with better access to the Highlands Highway and to Port Moresby, as well as having suitable climatic conditions.

Fruit species with potential for further commercial production are identified and notes given on the major constraints that need to be addressed so that this potential can be realised. Four species in particular – mandarin, mango, mangosteen and rambutan – have significant potential for expanded production. Five well-established species could also be further developed and marketed. These are avocado, banana, orange, pawpaw and pineapple. A group of less common species have some limited potential for further production and marketing. In the lowlands, these are carambola, durian, guava, langsat, longan, pomelo, pulasan, rockmelon (cantaloupe), sweetsop (custard apple) and watermelon. Highland species in this group are banana passionfruit, cape gooseberry, cherimoya, naranjilla, purple passionfruit, black raspberry, strawberry, *suga prut* (*Passiflora ligularis*) and tamarillo (tree tomato).

Introduction

Many fruit species are grown and eaten in Papua New Guinea (PNG). These include well-known fruits that are eaten everywhere in the tropics, such as banana, mango, pineapple and pawpaw, as well as indigenous species that are important in PNG and the Pacific, but not elsewhere, including *marita* pandanus, *ton*, *bukabuk*, *mon* and golden apple. As well, some fruit species are grown on research stations, particularly at the Lowlands Agricultural Experiment Station (LAES) at Keravat, but are not grown for subsistence use or sale by villagers.

There is no single complete list of all fruit species grown and eaten in PNG. The most complete listing is by French (1986), who provides information on 102 species (Table 1).¹ Other species are mentioned by other authors, for example Bourke et al. (2004) give information on the production patterns of 75 species, and information on some of the minor indigenous species is scattered in the ethnobotanical literature. It is likely that 120–150 fruit species are grown and eaten in PNG.

[NOTE TO EDITORS: I have a photo of various fruits from Fergusson Island, which include *Antidesma platyphyllum*. I can provide this photo if you wish to use it in this publication].

Significant quantities of fruit are produced in PNG for both subsistence consumption and sale. Fruits are mainly grown by villagers, who produce a limited quantity of each species and are not particularly oriented to the requirements of the market. Nevertheless, villagers are the most important commercial producers. Future expansion can come from both villagers who grow small quantities as well as from dedicated producers who grow larger quantities.

Considerable potential exists for expansion of production for sale. There is some potential for further sales of fruit in local urban and rural markets, but the biggest potential is for sale of sweet fruit into the highlands and in Port Moresby. There are over two million highlanders, who are fond of sweet fruit, but have only limited access to it. The Port Moresby market has over 300,000 potential consumers who are undersupplied with fruit at a reasonable price and in sufficient quantity.

There are many transport, handling and marketing constraints to overcome for this potential to be realised. Hence it is critical that further development of fruit production takes place in locations with better access to the Highlands Highway and to Port Moresby, as well as having suitable climatic conditions. These locations are in general coastal Central Province and the Markham and Ramu valleys for species that require a distinct dry period, such as mango. For species that do better in weakly seasonal or non-seasonal rainfall environments, locations with reasonable access to the Highlands Highway include coastal areas near Madang and Lae. The most accessible locations to Port Moresby that have a weakly seasonal rainfall distribution are the Cape Rodney to Kupiano area of Central Province and the Malalaua to Kerema area of Gulf Province. For mandarin and orange, the best locations are intermediate altitude locations at 800–1400 m.

¹ References to tables and figures in this paper are to those in the paper ‘An overview of edible fruit and nuts in Papua New Guinea’ in this volume.

Hypothetically, it is possible to export fruit from PNG to nearby countries such as Australia, New Zealand and Singapore, to exploit differences in the peak production period. In practice, there is little realistic possibility of this occurring in the short to medium term because of major constraints of handling, transport, communication and production in PNG. If these constraints could be reduced as production for the domestic market increased, there might be some prospects for export in the future, but that is some time away. (See paper ‘Production patterns for fruit and nut species in Papua New Guinea and some implications for marketing’ in this volume).

In this paper I identify fruit species that have potential for further commercial production and note the major constraints which have to be overcome. For the main species described here, a condensed statement is made on the producing season, but see Bourke et al. (2004) for fuller information. A review of what is known about each species is not provided, although that would be a valuable exercise. Four species in particular have significant potential for expanded production – mandarin, mango, mangosteen and rambutan. There is also potential for further production and marketing of five of the well-established species – avocado, banana, orange, pawpaw and pineapple. Further production and marketing of a group of less common species in both the lowlands and highlands also has potential.

Fruit with significant commercial potential

Mandarin (*Citrus reticulata*)

Mandarin is grown in the lowlands, the intermediate altitude zone and in the highlands up to 1800 m (Table 4). It is commonly grown by only 4% of the rural population (Table 6), although many more people grow the occasional tree. The sweetest fruit is produced in the intermediate altitude zone in the range 800–1400 m (Bourke and Tarepe 1982). Mandarin is a significant cash crop in some locations in this zone, for example, in the Arona Valley in Kainantu District, in the Bulolo–Wau area and parts of the Huon Peninsula in Morobe Province, and the Kokoda Track area of Central Province. Fruit grown in the intermediate altitude zone is popular with consumers in highland and lowland urban markets during the producing season (May–August). Sellers from lower altitude locations readily sell their fruit in highland markets and consumers clearly prefer these to those grown at higher altitudes (1400–1800 m). Many mandarin trees in PNG are old and new plantings are limited.

A number of issues need to be addressed to increase production of mandarin for sale, including:

1. Propagation and distribution of selected cultivars. I am not aware of the introduction of any selected cultivars, but trees with superior fruit could be located in PNG. Propagation could be done by a commercial nursery.
2. Distribution of selected cultivar seedlings in locations in the intermediate altitude zone. It is a higher priority to promote commercial mandarin production in the intermediate altitude zone than in either the lowlands or the main highland valleys, as the fruit is sweeter in the intermediate zone and is more attractive to consumers.
3. Addressing soil fertility problems, including widespread zinc deficiency.

Agriculturalists commonly group mandarin with orange and view mandarin as a minor citrus species. My experience is that mandarin is used differently from orange, with consumers eating mandarin as a snack food, as it is less messy to eat and the skin can be easily removed. I suggest that the potential market for mandarin in PNG is much greater than it is for orange or for the minor citrus species, and that mandarin should be a higher priority than orange as a commercial fruit. Rogers and Movis (1991) also note that mandarin is the most popular type of citrus in local markets.

Mango (*Mangifera indica*)

Mango is one of the most widely grown fruits in the lowlands (Figure 1) with an estimated 44% of the rural population living in households where mango is grown and eaten (Table 6). It grows best in locations with a marked dryer period each year.² Significant quantities are moved from the Markham and Ramu valleys into the highlands during the production season. Even more fruit could be sold if superior cultivars were widely distributed. Virtually all trees in PNG are derived from seedlings rather than from selected clones. Fifteen selected cultivars have been introduced to PNG and are located at Lanakaulana, Pacific Adventist University and NARI Laloki in Central Province, near Cleanwater Plantation in the Markham Valley and at LAES Keravat (Brian Watson, pers. comm. 2005).

Evaluation and distribution of superior cultivars to growers in the Markham and Ramu valleys and coastal locations in Central Province is a high priority for further development of commercial mango production.

Mangosteen (*Garcinia mangostana*)

Mangosteen is a lowland fruit that does best in locations with a high rainfall. It is uncommon in PNG and until a few years ago was limited to experimental plantings at LAES Keravat, Aropa Plantation on Bougainville Island, some agricultural stations, some plantings in towns and a handful of villages on the Gazelle Peninsula. It is difficult to propagate and this explains its limited distribution, despite seed and seedlings being distributed from Keravat over the past 35 years. Some fruit is now being sold in markets on the Gazelle Peninsula in the producing season (November to March). Fruit is very popular with consumers and Tio Nevenimo in his presentation at this workshop described it as ‘the hottest fruit in town during the season’.

Mangosteen is popular in its South-East Asian homeland, and production is steadily expanding elsewhere, for example, in far north Queensland. I suggest that a large number of fruit could be sold in PNG urban centres, especially Port Moresby and Lae, and in the highlands.

The priority for development of commercial mangosteen production is propagation of a large number of seedlings and distribution of these in lowland locations where rainfall is even throughout the year, especially those places with reasonably good access to the Highlands Highway and to Port Moresby.

² See the paper ‘Production patterns for fruit and nut species in Papua New Guinea and some implications for marketing’ in this volume for a description of locations where mango is most productive in PNG. Two indigenous species, *Mangifera minor* and *M. foetida*, are also grown and eaten. They seem to be more common in locations where *M. indica* does not bear because there is no dryer period each year, such as on the south coast and interior of New Britain.

Rambutan (*Nephelium lappaceum*)

Rambutan grows well in some lowland locations where rainfall is well distributed throughout the year. In South-East Asia it is grown at medium elevations, that is, up to about 800 m altitude. It is a minor crop in the north-east lowlands of the Gazelle Peninsula of East New Britain and on Bougainville and Buka islands in Bougainville Province. It is only sold in markets on the Gazelle Peninsula and in Bougainville, where it is a popular fruit during the producing season in February to May.

There is considerable potential for expansion of rambutan production. It could be sold in all urban markets, and is likely to be especially popular in the highlands where there are few types of sweet fruit. The intense colour of the fruit is an additional feature. A number of selected clones have been introduced into PNG and three clones have been released by NARI (Tio Nevenimo 'Exotic fruits with potential in the lowlands', this volume). These should be evaluated in different environments, particularly in locations near the main markets, and distributed to growers. They should be distributed throughout the lowlands, but the highest priority locations are those with reasonable access to the Highlands Highway and to Port Moresby.

Well-established species with potential for expanded commercial production

Five fruit species – avocado, banana, orange, pawpaw and pineapple – are already well established in PNG, but have potential for expanded commercial production. These five species grow in all altitude zones to the highlands, although the most favourable locations vary between species.

Avocado (*Persea americana*)

Avocado grows from sea level to 2050 m (Table 4). It is a relatively minor fruit in PNG and is grown by an estimated 6% of the rural population. It is most commonly grown in Simbu and Eastern Highlands, as well as mountainous parts of Central and Morobe provinces (Tables 6, 7). The main producing season is January to April. Avocado has increased in importance over the past 40 years, especially in the highlands. People tend to use it as a spread on bread, as they might use butter or margarine. Avocado has an important contribution to human nutrition in PNG as it is rich in energy. The staple food diet of rural people tends to have low energy density and energy-rich foods, such as avocado, are often lacking in the diets of rural people, especially children (Marks 1992). For this reason, avocado deserves to be promoted widely as a subsistence and marketed crop.

There is potential for further sales, especially in the Port Moresby market. The main limiting factor is poor handling as fruit is easily damaged. The priority for further commercial production is more plantings in locations near Port Moresby and training of growers and middlemen in handling and packing of fruit.

Banana (*Musa cvs*)

Banana is not an introduced crop in PNG, but it is covered here because the more common types sold in PNG are introduced cultivars, such as the various Cavendish types and Yawa. Recent research at Kuk in Western Highlands Province has confirmed earlier suggestions that banana was domesticated in New Guinea (as well as in South-East Asia). Denham et al. (2003) found that banana was being intensively cultivated

from about 7000 years ago in the Kuk area, well before migration of the Austronesian speakers from Asia to the New Guinea region. Kennedy and Clarke (2004) provide a useful overview of banana in PNG and its role in prehistory.

Banana is widely grown throughout PNG with most rural households growing it, up to its usual altitudinal limit of 2150 m. Production was estimated in 2000 as 436,000 tonnes per year. Banana provides an estimated 7% of food energy from locally grown staple foods, making it the second most important of the staple foods, just ahead of sago and cassava, although very much less than sweet potato, which provides 66% of the food energy from staple crops (Bourke and Vlassak 2004). Cultivars are grown for cooking and for fresh fruit. Dual-purpose types are also grown.

The market for sweeter fruit, including Cavendish types, in the urban areas is probably not saturated, particularly in Port Moresby. The Pacific Adventist University supplies significant volumes of banana (as well as watermelon and pawpaw) to retailers in Port Moresby (McGregor 2003). A detailed study of demand for banana and other fruit for the Port Moresby market would assist planning.³ The main issue, as with much fruit sold in urban markets, is poor handling and consequent poor quality of the marketed product.

Orange (*Citrus sinensis*)

Orange grows from sea level to 1800 m (Table 4). It is grown by an estimated 13% of the rural population, with trees most common in intermediate altitude locations in the mountains of Morobe, Oro, Gulf and Central provinces (Table 6). As with mandarin, the best quality fruit is grown in the 800–1400 m altitude zone, although good quality fruit can also be produced at slightly higher altitudes in the main highland valleys (Bourke and Tarepe 1982). The main producing season is April to August, but the pattern is quite variable from year to year. Large plots were established in Eastern Highlands and Western Highlands provinces from the early 1980s onwards. The Department of Agriculture and Livestock promoted orange and mandarin production in the highlands in the late 1980s and early 1990s (Rogers and Movis 1991).

There is a limited demand for orange in both rural and urban locations, much less than for mandarin. As with mandarin, the main issues that need to be addressed to promote greater production are planting in the optimum altitude zone; use of selected cultivars on appropriate rootstock; and attention to soil nutrition, including application of zinc and possibly other micronutrients such as manganese and boron.

Pawpaw (*Carica papaya*)

Pawpaw (papaya) is widely grown from sea level to 1700 m (Table 4), although the quality of fruit is poorer above 1200 m altitude. After banana, it is the most commonly grown fruit in PNG, with an estimated 64% of the rural population living in households where pawpaw is grown and eaten (Table 6). Many trees are self-sown and villagers commonly eat fruit when they are working in food gardens or moving around. Production is not seasonal in the lowlands, so it is available year round. It is somewhat seasonal in the highlands, with fruit more plentiful in August–October. Pawpaw is commonly sold in urban markets. The main issue to improve marketing is greater attention to handling and transport.

³ McGregor's 2003 study gives a valuable overview of marketed horticultural produce in PNG. A more detailed study of market demand is suggested here.

Pineapple (*Ananas comosus*)

Pineapple is grown from sea level to 1800 m (Table 4). The smooth leaf type is more common in the highlands above 1500 m. The sweetest fruit is grown over the altitudinal range 400–1200 m. It is widely grown, with over half of the rural population living in households where pineapple is grown and eaten (Table 6). Production is greatest in East Sepik, Morobe, Western Highlands and Madang provinces, although those statistics reflect the fact that these are populous provinces.

Production is seasonal, with the best supply usually between October and March, although the period of peak production varies somewhat from year to year. It is easy to induce flowering and fruiting throughout the year and this is standard practice in countries where there is significant commercial production, such as Australia, Malaysia and the Philippines. Ethephon is the chemical used for flower initiation and it is available under a range of brand names in Australia, including Promote 480, Ethrel, Ethepon and Bounty.

The main issue that needs to be addressed to expand production and consumption in PNG is the use of chemicals to induce flowering and hence make fruit available throughout the year. Any producer who can grow fruit in periods when supply is low will be able to readily sell fruit at a high price. Poor handling is less an issue for pineapple than for most other fruit.

Less common fruit species with limited potential for further commercial production

Lowland species

Carambola (Five corner) (*Averrhoa carambola*). This species is a minor fruit in the lowlands and is occasionally grown into the lower highland valleys up to 1300 m (Table 4). It is a popular fruit in some lowland markets. Production is irregular, but non-seasonal in the lowlands and appears to be seasonal near its upper altitudinal limit. Most trees arise from seedlings, not from selected clones, and the fruit is somewhat sour. Eight clones with sweeter fruit are grown at LAES Keravat (Tio Nevenimo, ‘Exotic fruit with potential in the lowlands’, this volume). It would be useful to evaluate these clones in different environments, especially in locations with access to the Highlands Highway and to Port Moresby, and to propagate and distribute cultivars with sweet fruit that perform well in those locations.

Durian (*Durio zibethinus*). Durian trees in PNG are mainly confined to LAES Keravat, Vunakanau Plantation on the Gazelle Peninsula and Aropa Plantation on Bougainville Island. The main producing period is between November and April. Fruit from LAES and Vunakanau can be readily sold to people from South-East Asia in the Rabaul area. Durian is a very popular fruit in much of South-East Asia and has become more popular with Papua New Guineans. Fruit at LAES in the 1970s was rarely eaten, but now security guards are required to watch over ripening fruit at LAES to prevent its theft (Tio Nevenimo, pers. comm.). Five clones were introduced into PNG in 2000 and their evaluation should be done at sites drier than Keravat or on better-drained sites (Brian Watson, pers. comm.). Eight clones have been released from LAES Keravat (Tio Nevenimo, this volume).

My feeling is that durian could be sold to people from South-East Asia living in Port Moresby, Lae and other urban centres. It is also possible that it could become popular with rural and urban Papua New Guineans. Certainly three of the presenters at this workshop (Tio Nevenimo, Brian Watson and Steve Woodhouse) see durian as having considerable potential in PNG. The highest priority is to get planting material of a range of clones to growers in various lowland locations, including sites with reasonably good access to the Highlands Highway, such as coastal areas near Lae and Madang, and sites near Port Moresby.

Guava (*Psidium guajava*). Guava is a minor fruit in many lowland locations and grows into the highlands up to 1850 m. An estimated 18% of the rural population live in households where guava is commonly grown, with production greatest in Bougainville, East New Britain, Morobe, Madang and West New Britain provinces (Table 6). Production is not seasonal in the lowlands, but is seasonal in the highlands (Bourke et al. 2004). The so-called Vietnamese guava was introduced to PNG, probably in the 1980s, and it is now commonly grown in some lowland locations.

Guava is a nutritious fruit with a particularly high content of vitamin A. It is not clear how much unsatisfied demand exists, but it is likely that more fruit could be sold if fruit with a good flavour and of good quality was available. The main limiting issues are poor handling and the high incidence of fruit fly.

Langsat (*Lansium domesticum*). This is a minor species. It is grown at LAES Keravat and planting material has been distributed in the past. The producing season is March–April. It is not sold in markets as far as I know. Langsat is quite popular in parts of South-East Asia and deserves to be grown and eaten more widely in PNG. In the Philippines it is very popular and is usually planted under coconuts (Coronel 1983). I suggest that planting material should be widely distributed in the lowlands.

Longan (*Euphoria longan*). This species from southern China and India does not appear to be present in PNG, as neither French (1986) nor Woodhouse (1991) mention it. It has become popular in far north Queensland (Brian Watson, this volume) and fruit is commonly sold in supermarkets in southern Australia. Watson (this volume) ranks longan as having high potential for PNG and this is supported by the experience in north Queensland over the past 30 years (Menzel et al. 1995). It would be useful to introduce a number of clones from north Queensland and evaluate them in several lowland locations.

Pomelo (*Citrus maxima*). This minor citrus species grows up to 1300 m (Table 4). It is more common in New Britain and New Ireland than on the New Guinea mainland (Table 6). It is sold in some lowland markets, especially in the Islands Region. Production is non-seasonal. The fruit is sweet and has potential to be sold in the highlands and in Port Moresby if more fruit was available near those locations.

Pulasan (*Nephelium mutabile*). Both the fruit and tree is similar to rambutan (Chin and Yong 1980). There is a small experimental planting at LAES Keravat. I have seen beautiful pulasan fruit sold in Buka market in Bougainville Province. Presumably the village trees on Buka or Bougainville came from the collection at Aropa Plantation near Kieta airport. At Keravat, fruit ripens between November and March, but the pattern varies considerably from year to year. The fruit is visually attractive and has a sweet taste. It is likely that fruit could be readily sold in urban lowland and highland markets.

Seedlings should be grown in locations with a well-distributed rainfall pattern, including near Lae and Madang.

Rockmelon (cantaloupe) (*Cucumis melo*). This is a very minor fruit, occasionally grown for sale. It only produces well in locations with a distinct dry season, such as the Markham Valley and coastal locations in Central Province. It is subject to fungal disease and the recommended planting period is April–May (Antonio 1986). Fruit is sometimes available in August–November. It could be promoted as a cash crop for sale to hotels and supermarkets in the Markham Valley and coastal Central Province.

Sweetsop (custard apple) (*Annona squamosa*). Sweetsop or custard apple is a very minor fruit in PNG. It is more common in lowland locations that experience a distinct dry season, such as near Port Moresby. Fruit is occasionally sold in markets during the season, which seems to be December to February. It may be useful to introduce superior cultivars, including the horticultural custard apple varieties from Australia, which are a cross between sweetsop (*Annona squamosa*) and cherimoya (*A. cherimolia*) (Alexander et al. 1982).

Watermelon (*Citrullus lanatus*). This is a popular fruit in many lowland locations and is grown up to 1700 m, although it is uncommon above 1200 m. An estimated 28% of the rural population live in households where watermelon is grown and eaten, with it being most common in Milne Bay, Bougainville, Central, East New Britain and Oro provinces (Table 6). It is a significant cash crop in the Markham and Ramu valleys and much fruit is sold to highlanders. Production is seasonal, with the best supply occurring in November to March. There is probably potential to sell more watermelon, at least in the highlands. Sale or distribution of seed of suitable varieties is the key to increasing production, especially in the Markham and Ramu valleys and near Port Moresby.

Highland species

Banana passionfruit (*Passiflora mollissima*). This species occurs as self-sown plants at high to very high altitudes (1850–2800 m). Small quantities are sold in highland markets and, in recent years, it is being sold to hotels in Madang. It is a pleasant fruit and has potential to be sold to hotels and supermarkets in Port Moresby and other lowland towns.

Cape gooseberry (*Physalis peruviana*). This is a very minor fruit in the highlands, growing over an altitudinal range of 950–2800 m. Production appears to be non-seasonal. Small quantities are sold in the market at Ukarumpa near Kainantu. The fruit makes very good jam and small quantities could probably be sold to expatriates in lowland urban centres, particularly in Port Moresby.

Cherimoya (*Annona cherimolia*). There are a few bearing trees in the Kainantu area, and in the Wapenamanda and Laiagam areas of Enga Province (Bourke et al. 2004:23). These few trees seem to bear reasonably well and the species may have potential for further production in the highlands.

Naranjilla (*Solanum quitoense*). This fruit was introduced into PNG in the early 1960s. It grows wild in the Kainantu area where it grows well and produces continuously. Fruit has been sold to expatriates (Tarepe 1982). I have also seen plants in south Bougainville Island. Naranjilla has potential as a minor cash crop for the highlands with sales targeted at expatriates in urban areas.

Purple passionfruit (*Passiflora edulis* f. *edulis*). This species grows over an altitudinal range of 800–2300 m (Table 4). It was a significant cash crop for the export market in the 1960s, but production has steadily declined over the past 30 years. An estimated 11% of rural villagers live in households where the various passionfruit species (purple, *suga prut* and banana passionfruit) are grown and eaten (Table 6). Production of purple passionfruit is markedly seasonal, with most fruit available in January to April. As with the other passionfruit species, there is potential for sale of fruit in lowland urban centres, especially to Port Moresby. This species is more likely to appeal to expatriate tastes, with the sweeter *suga prut* more popular with Papua New Guineans.

Raspberry, black (*Rubus lasiocarpus*). There are a number of indigenous raspberries in PNG, none of which has a strong flavour nor is particularly sweet⁴. Black raspberry, an introduced species, grows over an altitudinal range of 950–2250 m. It produces the best fruit at about 1000–1400 m, especially in the Arona Valley in Eastern Highlands Province, where there is a regular dry period each year. Production is non-seasonal. Small quantities are sold in Ukarumpa market in the Kainantu area. It can be used to make wine and liquor. There is potential for sale of this species in lowland urban centres, especially Port Moresby. As with all raspberries, fruit is delicate and spoils easily. If fruit could be packed and transported to Port Moresby so that it arrived undamaged, some could probably be sold there.

Strawberry (*Fragaria* sp.). Strawberry grows over an altitudinal range of 800–2450 m. Minor quantities are grown and sold to expatriates in the highlands and some is transported to lowland towns, including Lae and Madang. There is potential for sales to hotels and supermarkets in Port Moresby during the producing period (June–September). Strawberry is a delicate fruit and must be handled gently and consumed within a few days of being picked. This is the major limitation at the moment. Producing strawberries and marketing them in Port Moresby could be a lucrative small business for growers and middlemen who were prepared to handle the fruit properly and get it to market quickly.

***Suga prut* (Highland yellow passionfruit)** (*Passiflora ligularis*). *Suga prut* grows over an altitudinal range of 800–2350 m. It was formerly a minor species in the highlands, but has become much more common over the past 30 years. The sweet flesh is appreciated by highlanders. Production is non-seasonal. It is occasionally sold in lowland towns, including Madang. As with the other passionfruit species, there is probably potential for further sales in Port Moresby and other lowland urban centres.

Tamarillo (Tree tomato) (*Cyphomandra betacea*). This species grows over an altitudinal range of 1050–2300 m (Table 4). It is grown in the highlands and in mountainous locations in Morobe and Central provinces (Table 6). Minor quantities are sold in some highland and lowland markets, including Madang. There may be potential for further sales, especially in Port Moresby.

Discussion

Significant potential exists for greater sales of a number of introduced fruits, especially mandarin, mango, mangosteen and rambutan in the highlands and in Port Moresby.

⁴ The red raspberry *Rubus moluccanus* grows from sea level to 2150 m, while *Rubus rosifolius* grows from a mean of 950 m to 2800 m (Table 4).

There is also potential for more sales of some well-established species, in particular, avocado, banana, orange, pawpaw and pineapple. Potential is limited for sales of species that grow best in the highlands, such as strawberry and tamarillo, as these mainly appeal to expatriate tastes. More highlands fruit could probably be sold in Port Moresby and other urban areas. A number of poorly known species, including rambutan, mangosteen, durian, guava and longan, could be sold in large quantities, especially into the highlands where there is a small amount of sweet fruit.

A number of issues are common for many of the species reviewed here. The first is the need for improved handling, particularly for more delicate fruit such as avocado, banana, pawpaw, raspberries and strawberries. The second is the need to evaluate improved varieties at locations nearer the main markets on the mainland rather than at Keravat, where the demand for fresh food is less because of the limited population and shipping to the New Guinea mainland is expensive.

Some effort was made by the PNG Government to develop the domestic fruit industry, especially in the 1980s and early 1990s, but there has been little input since then. Greater effort by the government, supported by donors, is likely to result in greater production, sales and income to rural villagers. There are many benefits, including diversification of the income base for villagers. A few of the fruits are rich in energy, especially avocado, and deserve to be widely promoted for that benefit.

PNG is blessed with environments that have contrasting rainfall and temperature regimes. This means that different species can be grown in different locations and traded. However, this is unlikely to happen without further research and development by the PNG Government. A modest increase in effort could result in significant increases in production and sale of fruit on the domestic market.

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