# Karaka Nuts:
# A “New” NZ Nutcrop

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# Acknowledgments

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## Executive Summary


- The native karaka (*Corynocarpus laevigatus*) has a long history of cultivation throughout NZ as a traditional Maori food crop - often second only to kumara in importance.
- There is a wide range of plant material available in the form of both deliberately planted and "wild" trees and groves throughout NZ, from Northland to the Chathams, including some producing a high yield (up to 50 kg/tree) of large-sized nuts (up to 58 mm x 23 mm).
- The seed germinates readily and trees can also be propagated by budding or grafting and/or grown from cuttings (including an ornamental variegated form), sometimes flowering/fruiting within as little as 5-6 years (perhaps less) and usually thriving and remarkably pest & disease-free, even in urban settings and without any care and attention.
- The trees are typically biennial bearing and gynodioecious, needing pollen from another (pollinator) tree for optimum fruit set – otherwise seedless berry-only "blanks" may be produced and nut yield (but not berry yield) can be significantly reduced.
- Both karaka nuts, berries and leaves are attractive to a wide range of animals, such as cows, with no apparent ill-effects, and may even have beneficial medicinal or therapeutic properties – yet to be investigated fully.
- Untreated, however, the karaka nuts can be toxic to humans and some other animals, such as dogs (and possibly kiwis!), and the nectar from flowers can also be toxic to honey bees.
- The toxin ("karakin") can be removed by heat treatment/water soaking, though better detoxification methods and quality assurance techniques are needed before adopting this on a commercial scale.
- The nuts are easily stored and handled, have a long shelf and storage life, and are potentially suitable for a wide range of added-value processing applications (eg. roast nuts, crumb, flour, puree, even beer) with a gluten-free, "high-health" nutritional profile.

- The non-toxic berries are high in sugar and also potentially suitable for a range of food processing applications (juicing, jam, liqueur, dried fruit, etc).
- There are also a range of possible "spin-off" applications available in the form of a potential karaka-derived insecticide, possum repellent, wasp repellent, stockfood supplement, and wound-dressing.
- Overall, karaka nuts have much in common with other established NZ horticultural nutcrops (especially chestnuts), and much of the same production, harvest, storage, handling and processing equipment and techniques can successfully be used on both crops.
- Apart from the need for kernel detoxification (like cashew nuts), there seem to be no major constraints to further commercial development and much potential for a new "unique" NZ native nutcrop and revived commercial cultivation, if desired.

## Introduction

The following report summarises the results of trials carried out from 2006-2009 as part of a feasibility study to investigate the potential of karaka nuts/berries (*Corynocarpus laevigatus*) as a "new" NZ nut crop.

The aim of the project was to carry out a preliminary investigation into the feasibility of "reviving" karaka cultivation on a commercial basis, especially in the Waikato, by developing linkages with the existing NZ nut industry, tapping into existing nut production, handling, storage, value-added processing and marketing infrastructure, and making full use of new technology combined with existing expertise and traditional knowledge.

The key questions this project sought to address were……

- What information is already available on the growth and use of karaka nuts and berries?
- Can suitable karaka plantings and germplasm "resources" be found on which an industry could be based?
- Is it feasible to propagate, grow and manage such resources successfully on a commercial basis?
- What is the nutritional and food value and processing suitability of karaka nuts?
- What potential commercial applications can be found for karaka nuts/berries?

New Zealand already has a range of established commercial nutcrop industries (e.g., chestnuts, hazelnuts, walnuts, macadamias and walnuts) and established nut production, harvest, processing and marketing expertise. A further consideration in this project, therefore, was whether karaka could potentially be a useful compliment to the existing NZ nutcrop range, and whether an emerging NZ karaka industry could usefully benefit from existing nutcrop industry experience and resources.

The key question that this report sets out to address therefore is:

- could karaka nuts/berries (and perhaps, later, hinau, tawa, mairie and other edible natives) be a useful addition to NZ horticultural production and "Te Mara a Tane"… ideally as **a "high-health crop, unique to NZ and NZ growing conditions, with good storage, handling and value-added processing potential"**

# Experimental

## I: Collection and collation of existing knowledge and information regarding karaka

> **Ko te kaha – Ko te kaha I te toki**
> **Ko te uaua – Ko te uaua i te pakake**
> **Ko te pakari – ko te pakari i te karaka**
> **Mo te tangata kaha enei whakatauki**[1]

### Background:

The information contained in this section is based on a literature review, and the results of interviews and discussions carried out around NZ with respondents with direct experience of karaka harvest, preparation, cooking and consumption (carried out by Dr. Richard Benton).

### Early history

There is an established tradition of karaka nuts being brought to NZ from Polynesia by the early Maori. However, it appears that the "Hawaiki" of the traditions is rather the Far North, from where they were spread throughout New Zealand, and also taken to the Kermadecs, which seem to have been a staging post for early Polynesian voyagers. Outside the Northland region, there is a very close association between karaka groves and Maori settlements (cf. Stowe 2003, Leach & Stowe 2005). Apart from the apparently adventitious occurrence in the Kermadecs, *Corynocarpus laevigatus* was found only in New Zealand until 1769. Paleobotany studies also suggest that a "remnant" population of karaka was already present in NZ when Maori arrived, pushed northwards into the far north of the N Island by successive ice ages, before gradually spreading southwards again. The name "karaka", however, was carried from Polynesia to Aotearoa. The Proto Polynesian term *kalaka from which it is derived, denoted species of *Planchonella*

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[1] "For strength, strength from the adze; for resolution, resolution from the whale; for sturdiness, sturdiness from the karaka; these sayings concern the resilient man."

(*Pouteria*), trees very similar in appearance both in foliage and the outward form of the fruit, to *Corynocarpus laevigatus*, as do cognate words in most other Polynesian languages (cf. Benton 2009). The New Zealand karaka was introduced to Hawaii in 1929, when large quantities of the seeds were sown broadcast from airplanes on the island of Kaua'i, where they flourished to an extent which now makes them a menace to the indigenous flora.

There are four other species of *Corynocarpus,* found in Australia, New Guinea, Vanuatu, the Solomons Islands, and New Caledonia (*Corynocarpus cribbianus* in New Guinea and Queensland, *C. similis* in Vanuatu, the Solomon Islands, New Britain, New Ireland and the Bismark Archipelago; *C. dissimilis* in New Caledonia; and *C. rupestris* in New South Wales and Queensland) all with fruit which, like that of the New Zealand karaka, is highly toxic (Wagner et al., 1999, p. 566). It appears that it is the NZ form that has been used most a food source, second only for the Maori in overall importance, perhaps, to the kumara….and even more important again in the Chatham Islands, for example, where the kumara could not be grown.

> Many battles were fought over the possession of karaka groves. The Moriori, on a certain day in Summer when the star Puanga was clearly visible, held a ceremony to ensure the fruitfulness of this tree. In the hand of every person present was a stick on whose end were bound seed kernels from the karaka. Each person pointed their stick at Puanga, the star which marked the season of plenty, and recited a karakia to ensure a good harvest. (from *Maori Healing and Herbal: NZ Ethnobotanical Sourcebook* by Murdoch Riley, 1994, p. 177).

Today, Karaka trees can be found throughout NZ, as far south as Otago and the Chatham Islands. Being somewhat frost tender, they are usually found in coastal locations, often in areas where they have been deliberately planted, especially around old marae and pa sites. There is good historical evidence of deliberately planted karaka "orchards" or "plantations" (pā karaka) and the total quantities produced and eaten must have been significant.

Karaka is mentioned in a range of accounts from around NZ, and in a variety of early settler reports and investigations. These have been comprehensively summarized by Chris Stowe in his MSc thesis ("The Ecology and Ethnobotany of karaka (*Corynocarpus laevigatus*)", University of Otago, 2003). The term "horehere" refers to the berry covering the kernel, "karaka horehere" refers to the combined berry and nut, and "kōpī" to the macerated flesh after the berries have been steeped in water. The prepared kernels used as a food supply are sometimes called "kōpia", while "kōpī" is also an alternative name for the tree, especially in the Chatham Islands, and "kopi nuts" is an alternative name for the edible kernels.

There are reports of karaka leaves being used as wound dressings and the wood being used for paddles, in addition to the nuts themselves being used as a food source. They were especially valuable because they could be stored and eaten throughout the winter, when other food supplies may have been in short supply, especially for the elderly. The importance that the early Maori accorded karaka can be seen in the role played by karaka nuts in important ceremonies, funerals, banquets, and in formal exchanges between tribes and high-ranking chiefs. Some trees associated with burials were tapu to all but the descendents of the deceased. Other karaka trees were used as boundary markers and some (hollow) trees were used to store human remains.

Some accounts refer to especially valuable/famous individual karaka trees by name, and some of the Maori terms used, such as "oturu", may indicate that different karaka "cultivars" (in modern terms) were recognized and perhaps deliberately maintained and utilized from the very early stages of settlement. Some trees may have been named after people buried there. Karaka from certain regions also seem to have been especially highly prized by the Maori. In some parts of NZ it seems to have been a staple food, in others a "prestige" food. Some Maori families are referred to as "being especially wealthy because they possessed a good grove of karaka (or hinau) trees". Kupe, himself, was said to have planted the karaka known as the "Whatu kura a Tane" at Papawhero, Patea (from "Forest Lore of the Maori", by Eldon Best, 1977).

It was known that the karaka nut could be toxic, and that the symptoms of karaka poisoning (violent convulsions, spasms, palpitations) could be crippling, if not lethal. Some reports mention victims being buried up to their necks in sand, to immobilize them for their own safety until convulsions subsided

> The poison present in the fruit had to be carefully soaked out in fresh or salt water over a period of several days or weeks. Unfortunately, small children were likely to be the victims of poisoning, being attracted to the trees by the bright orange berries. The victim, child or adult, was first made to vomit, either by being hung upside down over a smoky fire, or by being held under water until almost drowned. Two less drastic remedies tried were to drink the water of boiled puwha leaves or chew the leaves of kohekohe. The poison relaxes the joints so that bones may bend the wrong way and, unless the head is kept straight, dislocation of the neck may occur. Trunk muscles are not affected by the poison, but it is important that the patient be stopped from going into convulsions. One of the old methods used to keep the limbs straight was to bury the patient in the ground up to the chin and put a wooden gag bound around with flax fibre in his mouth so that he could not bite his lips or tongue. As much water as possible was then forced down the throat to induce perspiration. Another method to save life was to have relays of men trampling on

> the limbs to straighten them out, so preventing permanent atrophy of the flexor muscles of the arms and legs taking place. (Riley, 1994).

Standard treatment seems to have involved collection of the nuts, either from the ground or from the tree; removal of the berry flesh, possibly after soaking/shaking in specially woven bags or trampling; cooking the karaka nuts in their shells in an umu (or boiling spring) before soaking them in water to leach out any remaining toxins; then removing the shell and eating the nut. (Some descriptions refer to the cooked karaka as tasting like "an acidic chestnut"). Unfortunately, the precise details of preparation and collection and treatment vary in different accounts and it is not possible to specify exact treatment conditions, temperatures, times, rates etc.

> When the berries were ripe, person ascended the trees by means of rude ladders composed of poles lashed to the trunks, and with the help of rods knocked off the ripened berries; these were placed in baskets and washed in order to remove any foreign matter, after which they were steamed 'for some days' in an umu or steaming pit, being poured in loose. When sufficiently steamed they were re-basketed, the baskets were placed in water, and the berries subjected to a trampling process to remove the pulp. The Moriori then placed the baskets of pulp-free kernels in the stagnant waters of a swamp where they were allowed to remain for about three weeks in order that all traces of the poisonous quality might be dispelled. When taken out they were dried until they became extremely hard, in which state they would keep for years, and form 'a most tasty and nutritious food.' (From Baucke, cited in Elsdon Best's *Forest Lore of the Maori*, 1977).

However, Andrew Crowe, in *A Field Guide to the Native Edible Plants of New Zealand* (1981) notes that:

> I have found that no two authorities agree on the all-important time of steaming and soaking, and all seem rather vague. Dick Hovell, though, assures me that he has often eaten kernels after boiling them for one hour and leaving them in running water for ten days, while Dr Thomson (1859) describes how the kernel was cooked in the oven for ten days, and then steeped for several weeks in a running stream before it is fit for use. Another method of preparation was to place baskets of the ripe fruit in a boiling spring. Kirk (1889) describes how the fruit was cooked from evening till noon the next day, rinsed carefully, then eaten 'with the greatest relish'.

Colenso, an early European observer of karaka preparation, also reported extensive karaka gathering along the Whanganui River in the 1880s, where poles were used to knock berries off the trees. Elsewhere, however, some accounts refer to it being "unlucky" to knock

berries off and let them fall on the ground, and describe a range of other special procedures that had to be followed. One description of cooking in an umu describes the cooking stones being covered by a thick layer of kawakawa, karamu and korokio (*Macropiper, Coprosma* and *Hebe*), with water sprinkled over the leaves (taro leaves or flax mats were also used). All this green foliage is said to have protected the baskets containing the karaka, helped trap the steam, and "to have imparted an appreciated flavour to the nuts".

In some cases, cooking even seems to have been carried out in gourds with small, hot stones added. However, the inherent variability of hangi cooking, gourds, leaching in streams etc. must also have contributed to a certain amount of unpredictability in the outcome, and some of treatment times recorded and reported seem unnecessarily long (compared to the theoretical treatment requirement for detoxification in an autoclave etc. of as little as 1-2 hrs). Some authorities speculate that perhaps just cooking or water soaking (alone) may have been adequate treatment in some circumstances. Perhaps traditional practice was to err on the side of caution, just in case.

Sundried nuts also seem to have been used and are described as "having a virtually unlimited storage life" (though perhaps needing resteaming or boiling to soften them before being eaten) and some accounts mention karaka flour and "cakes" made with bird fat or whale oil, though the use of karaka flour does not seem to have been common Maori practice (hinau or even raupo pollen being more commonly used).

Relatively little use seems to have been made of the edible berry flesh, and accounts differ as to whether ripe fruit and nuts were picked from the tree or harvested from the ground (or both). In some cases there seems to be a warning or even a prohibition issued to children (especially) not to eat the berry flesh. (Though perhaps this was just a way to ensure that no poisonous nuts were consumed by accident). "Kohekohe" has been mentioned as a possible "antidote", along with drinking a lot of water, but this may just be to induce vomiting.

Karaka nuts seem to have been widely used as food by the Maori "while on the march" and at least some of the "natural" distribution of karaka trees today may be the result of seed being accidentally dropped or deliberately planted along well-travelled routes (as well as being spread by wood pigeons).

Incidentally, while on the topic of animals, there seem to be no historical accounts regarding the harmful effect of karaka nuts on animals, although this must have been a concern with so many dogs, horses, pigs, cows, poultry and so on around, especially in early European times. (One other animal-related topic not covered in any reports or accounts is what effect karaka nuts had on moas once the tree had been introduced into areas where moas were present and these birds ingested the kernels through the grinding

action of their gizzard stones. Is karaka poisoning the real reason that moas in NZ are now extinct?)

There are a variety of early European accounts concerning karaka (the symptoms of karakin poisoning seem to have made an especially strong impression) and there is much disagreement about what the karaka nuts and berries actually tasted like. Most descriptions are not very flattering…..”it is an unctuous consistence extremely ill-flavoured to a European” (Nicholas, 1817, cited in Best 1977) and…”tasting nauseous”….”their odour is so offensive that I could never prevail on myself to eat them; but I have known many Englishmen who had acquired a taste for them and described them as very good food”. There are also reports of boiling up cooked (detoxified) karaka nuts “with a cupful of sugar” to make them sweeter and tastier.

## Karaka today

While karaka consumption seems to have still been relatively common throughout the 1930s, 40s and into the 50s….very few people were found during the course of the project who still prepare and eat karaka nuts regularly, if at all. A lot of people remember their grandmother doing so, and there seems to be a lot of fond memories of and nostalgia for karaka, but “karaka culture” seems largely to have skipped a generation or two.

There are still individuals and even maraes occasionally cooking up batches of karaka to eat in “40 gallon drum loads” or similar, but this seems to be quite rare. (For a “contemporary” illustrated step-by-step account of karaka preparation and consumption, by Rangirangi Taylor, see the Matauranga kura Taiao Project website, regarding Aotea Harbour: http://www.aoteamoana.co.nz/tradition/karaka.htm). Similar karaka “processing” is reported to have been carried out on Matakana Island.

Karaka bread, flour and karaka “carrot cake” were also mentioned by respondents (but never actually seen or tasted). The most common karaka story encountered regarding karaka being eaten involved drunken wooden pigeons (having eaten over-ripe/fermented berries) crashing into tents in the evening and waking everybody up! (This seems to be rather common, judging from the number of times it was mentioned).

Glen Ayo (Western Bay of Plenty District Council) and Robert McGowan were our main informants on “current karaka consumption”. Glen Ayo offered to prepare a batch of karakas we supplied the “contemporary way” – something he does every year. This involved cooking in an oven, then suspending the nuts in running water in a stream in a mesh sack for 2 weeks. The nuts treated in this way included a range of samples from around NZ, with and without berry flesh still on, and with a variety of storage histories.

Unfortunately, when taste-tested after treatment, all still tasted too “acidic” after 10-15 seconds or so to be regarded as safe, and had to be discarded (although it was suggested that cooking/roasting them further may possibly have helped).

Why this treatment failed when it had always worked previously was a mystery. The best explanation seems to have been that the stream the sacks of nuts were suspended in had flooded during treatment, and the silt-laden water had coated the nuts inside the sack, preventing the toxins leaching out properly. (This could have been made worse by the use of synthetic tightly woven sacks rather than the more usual old-fashioned fabric sacks, which did not impede water flow as much). On the other hand, it may well have been the effects of the mud which caused the already detoxified nuts to take on a bitter taste. This perhaps highlights the “unpredictability” of karaka preparation, even for skilled and experienced practitioners. (As a result, it was not possible to carry out all the toxicity assessments and taste-testing originally planned).

Glen and Robert had both eaten karaka berries (apparently best when the berry flesh has just started to turn wrinkly). It was necessary to wait until they were fully ripe, to offset any bitter taste (which may possibly imply the presence of toxins in unripe berry flesh….though this does not seem to have ever been investigated before). The usual description of the taste of the ripe karaka berry was “somewhat similar to dried apricot”.

NZ Tree Crops Association members were also found to have had some past experience with karaka nuts: budding and grafting; timber drying and sawing; and eating the ripe berries (and spitting out the kernels). NZTCA members also submitted a wide range of samples from around NZ.

Gwen Skinner (1981) in “Simply Living: a gatherer’s guide to New Zealand’s fields, forests and shores” describes karaka berries as follows…”the outer flesh is particularly delicious when fully ripe, but even so, was traditionally considered less valuable than the kernels”….for which she gives the following karaka preparation “recipe”….

> It is best to take the fruit that has fallen, and easier to start off with those which have already lost most of their orange outer flesh. Flesh-covered kernels must have their protective coating removed by either rubbing or peeling. When the flesh is fully removed, place the kernels in a saucepan or pot and cover with cold water. Boil for 3-4 hours. If some of the kernels still have flesh attached when the boiling process has started, they can be removed, cleaned and returned to the pot. After boiling, remove the kernels, place them in a container, cover with cold water and steep for a week. The kernels are now ready to be eaten….When the thin fibre husk is peeled back, the brown oval kernel inside has about the same consistency of a pea, but with a subtle nutty flavour. To store, spread out in the sun to dry, then put

them in either a basket or sugar sack (or any other well-aerated container), then hang in a cool well-ventilated place until needed. Steam again before eating.

[NB: An illustrated account of "modern" karaka preparation and cooking, at Aotea Harbour (courtesy of Rangirangi Taylor), can be found at http://www.aoteamoana.co.nz/tradition/karaka.htm ].

Two farmers were also located who had experience of feeding karaka nuts to animals. One had fed karaka nuts to sheep (apparently without any problems), and the other was a great fan of the medicinal and therapeutic benefits of feeding karaka nuts to dairy cows. As a result of his karaka and dairying experiences, this farmer (Norm Johnson) was later the subject of a "Rural Delivery" radio farming report.

Considering the widespread distribution of karaka trees (even in urban areas), their prolific production of poisonous nuts, and their bright attractive fruit, it is perhaps surprising that there seem to be no reports of accidental poisoning of pets, stock, children or humans. (Though one Asian family had to be stopped from collecting karakas after seeing monitoring and sampling being carried out on a Hamilton street tree).

However, there has been one recent case reported of a kiwi being poisoned by eating karakas (see "Convalescing Kiwi Catches Train to Capital" Friday, 12 December 2008, Press release: Department of Conservation), included in Appendix 12, and the successful efforts of DOC to save it. This seems to be genuine, but no explanation was given of why (or how) a kiwi would have ingested enough karaka seed to make itself that sick in the first place.

Despite the reported toxicity of karaka nectar to honeybees (Palmer-Jones, 1968) and the relative proximity of some karaka trees to hives, no reports could be found of either honey quality problems or bee deaths, and no beekeepers interviewed had ever heard of such a problem in recent years.

During the course of the study, correspondence was received from Hawaii regarding the large population of karakas found there, and possible uses for the nuts/berries. A small S Island-based company carried out some experimental trials making karaka liqueur (from the berry flesh), and Connovation Ltd (pest and rodent control specialists) expressed interest in developing a karakin-based rodenticide. These inquiries and similar karaka-related initiative currently underway are described in more detail later in this report (see appendices).

## 2. Karaka growth, production, flowering and pollination

### Background

Karaka trees are found throughout the Waikato and, for reasons of convenience, those were the trees monitored most closely. In particular, 2 groves of karaka trees growing in Ruakura Research Centre and Waikato University grounds, selected (easily accessible) trees throughout Parana Park, selected trees in the grounds of Hamilton East School, and "specimen trees" in various parks and reserves around the Waikato region were monitored regularly over a 3-yr period, with samples of both nuts and berries collected (both from the ground and from the tree) at weekly intervals throughout the harvest season. All samples were weighed and measured, photographed, and then used for storage trials, quality assessment, nutritional analysis or propagation trials (see later sections). Flowering and fruiting times were noted; flower numbers and fruitset numbers were counted (and fruitset percentages calculated); harvest size was estimated on the basis of visual examination and harvested subsamples; and tree age was estimated (where possible) – see photos (Fig. 1) and further details in the appendices.

Karaka nut/berry samples were also sent in from throughout NZ by members of the NZ Chestnut Council and the NZ Tree Crops Association, in response to requests for information issued at conferences, grower meetings and through various publications. A karaka sample was also collected from the Chatham Islands (courtesy of Trevor James, Agresearch). A large volume of karaka nuts/berries were submitted from the property of Norm Johnson in Taranaki (see details later in this report). Information on karaka was also received from a variety of correspondents around the country and overseas, including Hawaii (see acknowledgements for further details).

### Tree growth and nut/berry production

A very wide range of tree-to-tree variability was observed, combined with pronounced biennial bearing. The single best-performing tree found in the Waikato was actually a large tree (with a nearby "pollinator") in a small park on the corner of Victoria St and Bridge St, virtually in the centre of Hamilton (see Fig. 2). These trees had apparently been deliberately planted there, and a commemorative plaque nearby suggests they may date back to World War 1, or thereabouts. Yield (in a good year) was estimated at up to 50 kg per tree (comparable to the chestnut yield from a tree of a similar size).

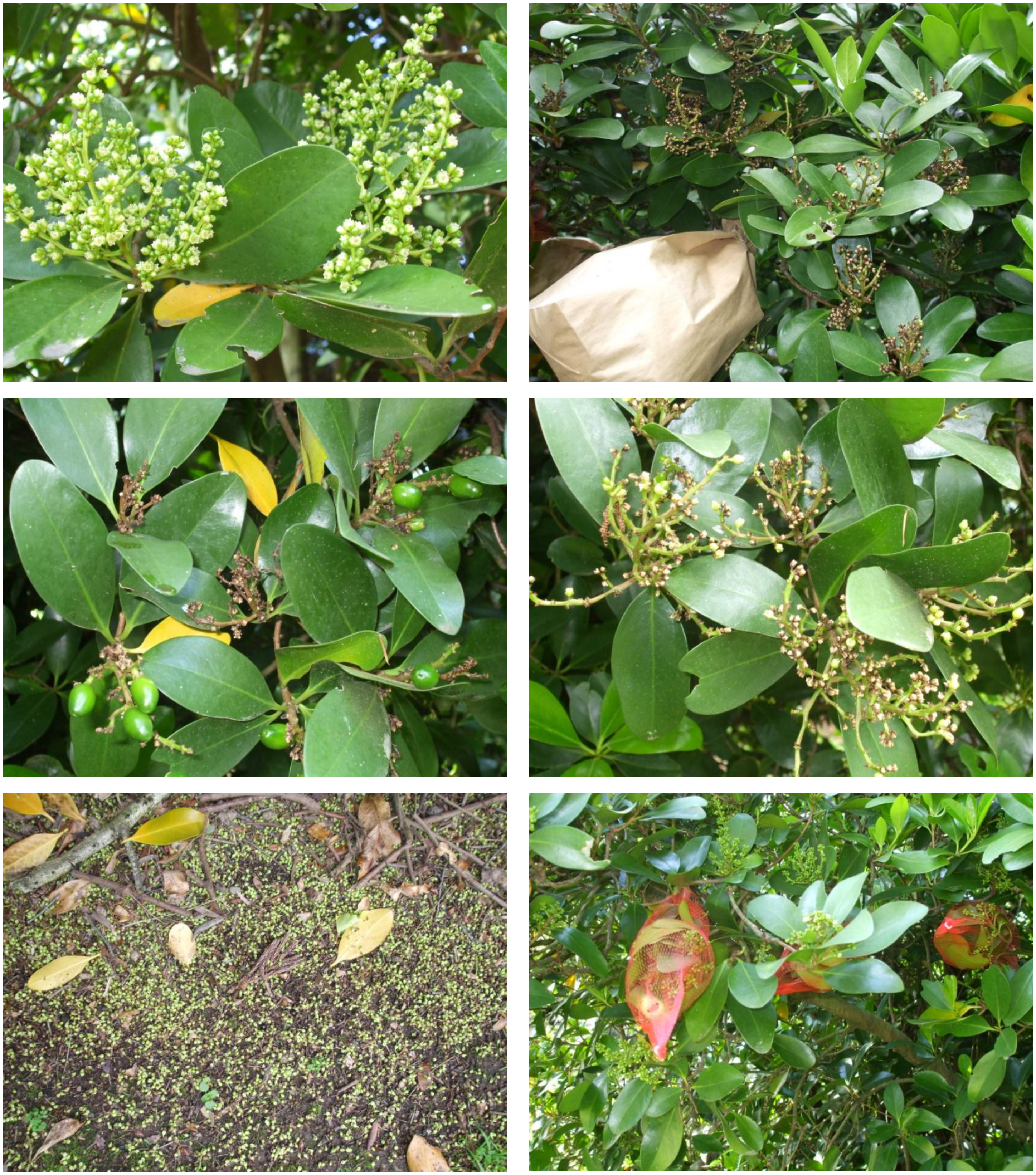

***Fig. 1***. Karaka flowering and fruitset (including insect and pollen exclusion bags; and fallen flowers littering the ground)

This small planting is of particular note because of its proximity to heavy traffic and a built-up urban area, distant from any actual "native bush" (although in close proximity to an ancient Maori pa site); relatively consistent high yield and good nut quality; and the nearby presence of what seems to be a "pollinator" karaka tree of similar size but much lower yield and a much higher percentage of seedless "blanks" (large karaka berries with no actual karaka nut inside). This was the first indication during the course of the project of the importance of pollination to karaka cultivation.

Overall, a surprising number of karaka trees were found in an "urban" setting, and most seemed to be thriving. In the main street of Tauranga, large karaka trees on the footpath regularly threatened to drop copious amounts of nuts into the coffee cups of patrons sitting at outdoor tables of fashionable restaurants….but no poisonings have yet been reported. Similar trees can be found in the centre of Taupo (at Karaka Motel). NB: it may be that the increased "heat accumulation" found in urban settings, especially trees "planted in concrete or asphalt" contributes to their performance and early flowering/fruiting – as it has done with olives elsewhere in NZ. Thus, the Tauranga tree mentioned starts to fruit as early as December in some years (even earlier than some Northland karaka).

In terms of overall nut size, samples from individual large, old "specimen trees" in the Chatham Islands, Pukekohe (Ted Lever), and the Bay of Plenty (Ian Moore) all scored exceptionally well with an in-shell nut size often in excess of 40 mm x 20 mm (see photos and appendices). Similar-sized karaka nuts/berries were reported from Pukekura Park/Broadlands Park (Taranaki) by George Fuller (up to 45mm x 25mm, from a very large/old tree with a trunk 2 m in diameter at ground level). In contrast, nuts from "wild" seedling trees were sometimes no larger than a peanut (20 mm x 13 mm). This suggests that not only is there great scope for further identification and selection of "superior" cultivars, but that some such selection, over time, may already have been carried out by the early Maori (see propagation section). Certainly, there are accounts of karaka nuts being traded and presented and planted as "gifts", and individual trees being referred to "by name". One "gifted" grove of karaka trees was identified at Waotui, near Putaruru, where locals described these trees as originally being a gift from Taranaki tribes. Ron Ashford (1981) reports the largest Taranaki kernels as being 50 x 30 mm and weighing approx. 10g each (100/kg). (NB: The biggest individual karaka nut identified in the study from 2007-2009 was 58 mm x 23 mm…see Fig. 3).

Robert McGowan spoke of an especially big karaka tree at an old pa site near Waitara and seeing karaka trees at least 40-50 years old, deliberately planted and managed in rows.

***Fig. 2.*** Large, heavily cropping tree (top) with lighter-cropping pollinator nearby (bottom) at the corner of Bridge St. and Victoria St., Hamilton.


***Fig. 3.*** A selection of karaka nuts/berries from around NZ (NB: not all to the same scale)

In general, most of the samples collected from around NZ could be grouped into 2 broad categories. A lot of the karaka seed from what often seem to be opportunistic seedlings that have sprung up at random around the country are noticeably small and rounded (like a peanut). At the other end of the scale are much larger nuts from more established, older trees that, in some cases at least, appear to have been deliberately planted. Not only are these nuts much larger (see photos) they are also noticeably longer in relation to their width. Karaka seed from the Chatham Islands may fall into a third grouping….not only large (generally) but "fat" as well, especially in terms of the berry on the outside.

**Flowering and pollination:**

Many nut trees exhibit unusual flowering and pollination behaviour, and karaka seems no exception. Monitoring of trees throughout the country rapidly showed huge variation in timing of flowering, fruit set and pollination, from Kawakawa in Northland (at the property of Toni and Ron Sylvester) to the Chatham Islands.

As with other tree crops, flowering started early in the north (September/October) and, as with harvest dates (December-), became progressively later the further you moved south. (One partial exception to this was Chatham Islands, which seemed to behave more like the southern North Island than the rest of the South Island).

The youngest tree found to be in flower and setting fruit in the Waikato was a seedling 5-6 years old (though it was not possible to age these trees precisely because of the lack of obvious annual growth rings in karaka wood), and approx. 2 m high with a diameter at breast height of approx. 4 cm. (This suggests that a grafted/budded or cutting-grown tree could flower in perhaps 2-3 years from planting: not much slower that chestnuts and much earlier than many native tree species). Ron Ashford (1981) has reported that "the trees can flower and bear in the fourth year; they grow up to 1 m each year". At Helensville, 6-7 year old karaka trees (deliberately planted to attract birds), just over 2 m high, were yielding approx. 10 kg per tree and "had been cropping consistently for some years". On the other hand, some trees known to be at least 12-15 years old were also found that seem to have never flowered or fruited.

Over the course of the study, biennial bearing also seemed to be extremely pronounced in karaka, and a good crop one year on a given tree often meant a very poor crop the next. This seems nothing new. Colenso (cited in Skey 1872) reported that:

> As the same karaka woods did not bear alike plentifully every year, the years of barrenness were to the tribe seasons of calamity and want, the karaka being one of their staple vegetable articles of food.

Tree-to-tree variation was also very marked, even when trees were close together and of similar age and size. Part of this no doubt reflects normal seedling variability, but a large part also seems to be due to the unusual flowering behaviour of karaka.

Very early in the study, some trees were identified that set good crops while other nearby trees, with equally good flowering, set far fewer fruit, many of which also proved to be seedless ("blanks"). In these fruit, the berry was large and fully developed, but there was no kernel inside. The same can be found in chestnuts when pollination has been poor and, like chestnuts, karaka seem to require cross pollination between separate, compatible trees.

To test the need for cross pollination, a bagging trial was set up on several mature trees in the Waikato and insect exclusion nets placed over flowering clusters before they opened. A similar number of flowering clusters were covered with paper bags to exclude both insects and airborne pollen. Trials were replicated on several trees over 3 years (see Fig. 3).

No bagged flowering clusters ever set fruit, despite having 200+ flowers/bag, confirming that self-pollination is not possible. Deliberately collecting and transferring pollen from one tree to bagged clusters on another did result in fruit set, confirming that karaka trees need to be cross pollinated. Clusters that were netted to exclude insects but not airborne pollen did set some fruit, though not nearly as many as unbagged clusters, suggesting that insects are not essential for karaka pollination, but may be useful.

The flowers themselves are very small and insignificant, but borne in large numbers up to several hundred per fruiting branchlet, rather like olives. Also like olives, the flowers proved quite delicate and susceptible to wind/storm damage and easily lost. There are also reports of possums and rats eating flower buds. Flowering/fruit set was typically better on the exposed/sunny side of the tree, but counts still showed a very low level of fruitset overall: with 1-200 or more flowers often required per fruit. On some trees ("pollinators") this flower/fruit ratio was much lower again, especially in terms of "berries with a kernel inside", rather than unpollinated "blanks".

Some karaka trees seemed to be acting as pollinators for other more heavily cropping trees nearby. However, there were no obvious "male or female" trees and even close examination of the flowers showed no obvious differences between males and female flowers, branches or fruitlets, as in most other tree crops.

There is very little published information available on karaka flowering and pollination, but partway through the study, the first-ever comprehensive study of karaka flowering was published (Garnock-Jones et al., 2007). This confirms that karaka is "gynodioecious", and that while the flowers look the same on all trees, and have both male and female parts, on

some trees the female flower parts are largely non-functional, producing pollen and berries but relatively few nuts. This helps explain the odd flowering behaviour noted.

Garnock et al. also report that "male trees produced fruit that were broader than the fruit on female trees. It may be that these trees had a good supply of resources for the few nuts that matured, allowing each to reach optimal size". (Although this was not confirmed in the present study, if true, it could be a useful way of distinguishing good "pollinator" trees in future).

Overall, much "natural" karaka pollination seems to be grossly inadequate and there seems to be significant scope for improvement, especially if specific "pollinator" trees and cultivars could be selected and propagated and orchards planted with the optimum ratio of fruiting trees: pollinators in close proximity (and insect pollination also encouraged). A similar problem was encountered in the early days of the chestnut industry and other NZ nutcrops. Based on their experience, overall yield could be expected to increased by several 100-1000% if pollination could be improved….even greater if "artificial pollination" (deliberate pollen collection and later reapplication) could be adopted, as currently used extensively by the NZ kiwifruit industry.

Perhaps this was appreciated by the Maori in the past as well. In the Chatham Islands, where karaka have long been especially important, an ancient grove of fruiting karaka trees exist, planted in a circle with a single, separate tree at the centre. It would be interesting to know if this central tree had been deliberately planted to act as a pollinator for the others in order to ensure good yields.

Some of these Chatham Island trees also display mysterious dendroglyphs carved into the trunk. It is not known for sure what these signify (one suggestion has been that they indicate tree "ownership"), but some early documents also refer to special techniques practiced by the Maori to get karaka trees to flower/fruit and crop better. Colenso (1880) wrote of "an old priest mentioning a secret tabooed way to make a young karaka tree, after being transplanted, become fruitful" and there are reports of Maori deliberately "tearing strips of bark" off old trees. Avocados are somewhat similar to karaka, especially with regard to their unusual flowering and fruiting behaviour, and "girdling" or "cincturing" of the trunk and bark is a common technique used to promote flowering and fruiting in some commercial avocado orchards. It would be interesting to know if this also works on karaka, and if this was another karaka management technique already known to the Maori. There is also the old nutcrop management adage of "a woman a dog and a walnut tree….the more you beat them the better they'll be". Does this perhaps apply to karaka trees also?

One option not available to the early Maori was the use of honey bees to improve pollination and fruitset. On other nut crops this has proven very beneficial, with useful

spin-offs in the form of products such as “chestnut honey” (highly valued for its health and medicinal properties) and bee-collected “pollen pellets” (widely sold in healthfood shops). However, there is evidence that karaka nectar can be toxic to honeybees (Palmer-Jones, 1968) so the advisability of having beehives near karaka trees needs to be investigated further.

Conversely, while there are obvious benefits in maximizing flowering/pollination success in order to ensure a good nut crop…..deliberately minimizing flowering/pollination success (to produce seedless karaka berries) may also be advantageous under some circumstances (e.g., for karaka liqueur production or other berry-derived products…see later sections in this report). This may also be a way of minimizing damage to bee populations.

## 3. Selection, propagation and plant improvement

### Background

Some of the seed collected from the trials described in section 2, above, was supplied to Waikato Research Orchard for nursery, germination and propagation trials. Bud and graftwood was collected from selected trees and a range of standard horticultural propagation and nursery techniques were compared, based on standard NZ nut industry (chestnut, walnut and hazelnut) best practice, carried out by an experienced nut propagator (Stuart Rentoul of WRO). Potted karaka trees were then grown on in an open nursery bed, heated glasshouse, or controlled growth room with controlled humidity and bottom heat.

### Germination and propagation

It was noted that karaka seed and seedlings were usually found in abundance in bush settings wherever mature karaka trees were found (even in areas of native bush subject to intense possum/goat/animal damage). Natural root cuttings were also occasionally encountered where severe tree/trunk damage had sometimes induced regrowth from the trunk, at or just below ground level (suggesting that karaka can be grown successfully from cuttings, unlike chestnuts where propagation by cuttings has so far proven impractical, despite many attempts around the world).

Likewise, Harris & Kapoor (1990) in “Nga Mahi Maori O Te Wao Nui A Tane: Contributions to an International Workshop on Ethnobotany” commented favourably that “the seeds germinate readily, as anyone can see from the carpet of seedlings under seed trees protected from grazing animals. Some trees are clearly better producers of fruit than others, and there is ample scope for plant selection, either from cuttings which strike readily, or from seed breeding programmes”.

A request for information circulated throughout NZ by the NZ Tree Crops Association and the NZ Chestnut Council (via each group’s respective membership and in-house publications) produced evidence of past trials undertaken by NZTCA researchers on karaka propagation, indicating that it was possible to propagate karaka via budding/grafting and cuttings (though not as easily as with some other tree crops). The procedure outlined by Ron Ashford (1980) in “The Journal of the NZ Tree Crops Association”, Vol. 5, No. 1, was as follows…..

1. collect seed once fallen
2. store together in a plastic bag, allowing the pulp to ferment and rot until good and slimy. Wash the seed clean with a hose and a screen then plant by just covering them in peat pots. Place in a glasshouse, cold frame or similar and grow on till spring
3. wait until roots are coming through the pot before planting out and wait until the last frost as they are frost-tender until established
4. plant in their final location as they resent their fleshy roots being cut or damaged
5. you may need to stake for one or two years to prevent root “rocking”

George Fuller, ex-groundskeeper of Pukekura Park (long since retired) was also able to confirm that selected ornamental lines of karaka trees had once been grown commercially from cuttings and sold locally by Duncan & Davies nurseries (long since closed) and possibly, more recently, through Palmers Garden Centres. Further investigation discovered a grower who still had one of these trees in her garden (Penny Luckens, Wellington). While it had originally been a decorative variegated karaka (!) it had apparently gradually lost the variegated foliage characteristics that it originally possessed.

Talking to one of the old Duncan & Davies propagators, it seems as if propagation of these variegated forms was initially by grafting, but that this was later replaced by the use of semi-hardwood cuttings (easy to root and cheaper to produce than grafted plants). Two variegated cultivars are recorded – described in catalogues as follows:

*C. laevigatus* ***"Alba Variegatus":*** the dark green leaves are narrowly margined with white and the outlines of the leaves show a tendency to slight irregularity

***C. laevigatus "Variegatus":*** With this cultivar the leaves are broadly margined with a golden yellow. It is the more handsome of the two, although both are worth growing. Like the typical form, they are both good as pot or tub plants.

In trials conducted at Waikato Research Orchard, germination of karaka seed was not a problem. Provided the kernels were not unpollinated "blanks" (easily tested for by floating/sinking in water) and provided the seed had not dried out too much after harvest (to below approx. 40% moisture content….very similar to the germination threshold of chestnuts) germination percentages were usually well in excess of 90% (compared to 50% or less for some commercial chestnut cultivars).

The germination percentage could, however, be reduced or at least delayed if the seed was planted too deep (more than 2-3 cm). Stratifying (cold treatment in a coolstore before planting – a standard treatment for many nut crops) actually made germination worse rather than better, presumably reflecting karakas semi-tropical and tropical (rather than cool temperate) origins. Some seeds produced 2 or more shoots when they sprouted (multiembryonic nuts), similar to some commercial chestnut cultivars.

A commercial nursery was located in the Bay of Plenty where several thousand karaka seedlings were being grown successfully and planted out for revegetation purposes (see Fig. 4). There had been a problem with some seedlings dying soon after sprouting ("damping off"). Closer examination showed root damage and death, caused by the common soil pathogen *Phytophthora* (also a major problem on chestnuts). Relatively few karaka seedlings had been affected however. Karaka trees grown commercially from seed can also be obtained from "Naturally Native" nurseries throughout NZ (their catalogue describes the karaka fruit as smelling like "ripe apricots").

A good illustration of the relative ease of karaka growth and propagation, overall, can been seen in the case of *Corynocarpus laevigatus* in Hawaii, where karaka seeds from NZ were apparently airdropped over Hawaii by a light plane in the 1920s, in a well-intentioned if misguided attempt to introduce a "beneficial" plant species. Karaka has multiplied so successfully since then that it is now a major noxious weed and considerable sums are spent each year on its eradication. Apparently, the NZ Boy Scouts Association has, in the past, also been responsible for spreading seed around the country in areas of native bush.

In trials carried out at WRO, budding was more complicated than with most nut crops because of the difficulty of identifying individual buds on karaka, and their small size. Grafting was easier. Results to date have been rather patchy, and trials are continuing, but some of the budded/grafted seedlings have survived into their $2^{nd}$-$3^{rd}$ year. It is still too

***Fig. 4***: Karaka trees grown from seed in a nursery for reforestation purposes (Ian Moore, Tauranga)

early to quantify the results accurately, however, because it is not known yet if rootstock incompatibility is going to be a problem. (This is major problem on some nutcrops such as chestnuts when scion or budwood from one tree may prove partially or wholly incompatible with seedling rootstocks from another. On chestnuts, the only way to reliably minimize this effect is to use scion/budwood and seedling rootstocks from the same cultivar. It is not known yet if this will also be necessary for karaka).

**Selection and plant improvement.**

Karaka certainly seems easier to propagate that many NZ native tree species, many of which are notoriously hard to propagate and, so far, seems no more difficult than other established commercial nut crops such as walnuts. Even the brief preliminary survey conducted so far has also revealed a very large amount of natural seedling variability and large tree-to-tree differences in terms of growth, yield, nut size etc. There seems to be great potential for the further identification and selection of "high performance karaka cultivars" (as has been done for NZ chestnut, hazelnut and walnut selections).

It seems highly likely that some deliberate selection has already been done by the Maori themselves. Certainly, some of the material collected from very old, deliberately planted karaka groves in the Chatham Islands seems much better in terms of size and quality that many "wild" seedlings found locally (see previous section). Various written historical accounts also refer to individual karaka trees named by the Maori throughout NZ being of considerable local significance, and what sounds like specific named karaka "cultivars" in pre-European or early European times. One account mentions a specific large tree at Okaki Pa, Taranaki (long since lost?) that regularly produced nuts "double the size of normal trees" surrounded by a mass of younger seedling regrowth (seed from the same tree) which had "reverted" to normal size nut production (as would be expected if this had been a deliberately selected high-performance "mother" tree, surrounded by randomly pollinated "wild" seedling progeny).

Should propagation by budding, grafting or cuttings ultimately prove too slow or difficult for widespread commercial application, as it has with some other commercial nutcrops around the world, there is always the possibility of laboratory-based tissue culture. (This does not yet seem to have been attempted for karaka). Indications so far, however, suggest that this should not be necessary.

## 4. Nutritional composition and food value

### Background

Some of the karaka samples collected in section 2) above were subjected to compositional analysis (Roger Hill Labs, Crop & Food CRI, AsureQuality). Further details regarding the nutritional composition and food value of nut crops were obtained from a literature search, and results for karaka were compared with other commercial tree crops (almond, brazil nut, cashew, chestnut, hazelnut, macadamia, pecan, pine nut, pistachio, and walnut).

### Nutritional composition/food value

"Nutritionally, karaka provided a valuable addition to the Maori diet. The berries contain the sugars sucrose and glucose, and the fatty acids stearic and oleic acid, and 6 of the 8 essential amino acids (leucine, methionine, phenylaniline, tryptophan, and valine) while the treated kernels have a food value resembling that of oatmeal" (McCurdy, 1947, in Bell, 1974), and while oatmeal may not sound very exciting or appetising, it has gained an enviable reputation in recent years as a balanced, high-health food with a wide range of proven health benefits.

There is also anecdotal evidence that the nutritional content (and toxicity) of karaka nuts can vary markedly from region to region, but hard data to support this are lacking.

The main nutritional/food value attribute to the early Maori seems to have simply been that the karaka nut, being easy to handle, store and transport, was available throughout the winter months and in areas where it was not possible to grow the kumara (eg. the Chatham Islands). A closer examination of the nutritional content of karaka nuts, from a more modern-day perspective, suggests that the Maori knew a good thing when they saw it.

Testing carried out by "AsureQuality" as part of this project has now, for the first time, shown that the karaka nut is also gluten free: a valuable attribute that puts karaka nuts in the same category as chestnuts, and makes them especially suitable for people with coeliac disease (estimated to be up to 10% of the population in some countries). This is a rare attribute in food crops and places karaka firmly in the high-value "healthfood" category.

A complete breakdown of the nutritional composition of karaka nuts (both raw and cooked) carried out by Crop & Food CRI is attached (see Appendices).

**Comparison with other tree nuts**

The nutritional composition and food value of a range of other common, commercial tree nuts is shown in the table entitled “2009 Nutrient Composition of raw, Unsalted Tree Nuts” (courtesy of the “Nuts for Life” website). (NB: peanuts have been excluded because they are **not** a tree nut, and their “bad reputation” with regard to potentially lethal nut allergies etc is often unfairly attributed to proper “tree nuts” as well, whereas most are tree nuts are generally extremely nutritious and healthy, with a low glycemic index).

“Calculations suggest that daily nut eaters gain an extra 5-6 years of life free of coronary disease and that regular nut eating appears to increase overall longevity by approx. 2 years…..Despite the fat/oil content of nuts, the consumption of 30-60 g of tree nuts per day does not seem to cause weight gain” (Dr John Livesy, scientific Officer, Department of Endocrinology, Christchurch Hospital).

Compared to chestnuts, karaka nuts can be seen to be low in starch but high in protein (about 8x that of chestnuts) and with significantly higher fat content, similar to walnuts. Walnuts, because they contain n-3 fatty acids, are considered to be especially healthy. Karaka nuts also have relatively high levels of fatty acids, only slightly less than walnuts and well above other tree nuts.

Compared to chestnuts, karaka nuts also have high dietary fibre content (higher than any other tree nut) and a higher “energy content” (kJ/kcal) - attributes which would make karaka nuts a useful component of a “health bar”, “survival rations” or the like. Compared to other common nut species, karaka is perhaps most similar, nutritionally speaking, to a hazelnut - or might be considered as an extra-healthy “low fat/oil peanut”.

Fats, in general, do not have a very healthy reputation but the fat content of tree nuts such as walnuts, hazelnuts, almonds etc has, in recent years, increasingly been recognized as extremely beneficial to human health and recent work carried out by Otago medical School, Lincoln University and others has confirmed this (as reported on several recent TV/radio news items and food programmes). The consumption of various species of tree nuts is now actively recommended as a component of many diets and health programmes (eg. the Pritikin diet and the Atkins diet) and significant beneficial effects have been confirmed, around the world, with regard to reduced cholesterol, blood pressure, diabetes, dementia, gallstones and the risk of both heart attacks and strokes. A comparison between karaka nuts and some of these other tree nut species suggests that karaka nuts could also justify further investigation for their nutritional and perhaps even medicinal value.

Some farmers interviewed as part of the project described stock as being partial to not only karaka nuts but also karaka leaves, and karaka has sometimes been deliberately fed to

dairy cows with no apparent ill effects (Norm Johnson). There may even be definite beneficial medicinal/therapeutic effects involved, as with other nutcrops. An analysis was therefore carried out of the leaves from karaka trees as well (courtesy of Dr Adrian Spiers, Primaxa Ltd and Roger Hill Laboratories Ltd) and results compared with other plant species that stock are deliberately known to seek out and consume, such as buttercup and chicory. Karaka leaves showed especially high levels of trace elements such as zinc, manganese and, especially, calcium and boron. Where karaka leaves compared best with "regular" dairy pasture, however, was in terms of the more specialized nutrient ratio indices calculated to evaluate the suitability as "dairy feed", such as the "Grass Staggers Index", the "K/Na ratio", the "Ca/P ratio" and the "DCAD" (dietary cation-anion difference). Karaka was significantly better, in all respects, than conventional pasture. This could well be worth further investigation.

## 5. Future prospects: value-added processing and possible products

### Background

Traditionally, the only processing usually carried out on karaka berries/nuts by Maori was:

- physical separation of the berry flesh from the nut at harvest (often after water soaking)
- detoxification of the kernel by steaming/leaching in running water
- removal of the shell and pellicle before eating
- discarding any rotten or suspect nuts, and
- drying/storing for later consumption

This is a difficult, labour-intensive process and usually means that most/all of the berry flesh is lost. Traditional Maori karaka "processing" was limited by the available technology and resources. Therefore, a revised processing sequence was tested, adapted from existing NZ nut industry practice, using contemporary equipment, procedures and treatments, as follows:

1. mechanical flesh/berry separation in a modified commercial mixer/beater (used for stockfeed): collecting and keeping the berry flesh for later use
2. cooking/detoxification in a commercial autoclave (industrial-sized pressure cooker)

3. mechanical shelling and peeling: removing the shell and pellicle in a standard commercial chestnut shelling machine
4. separation of “blanks” and rotten nuts by means of density grading (a standard chestnut industry treatment)
5. controlled drying (both berries and kernels): in either a conventional hot air drier; a continuous flow microwave; or a dehumidifier drier
6. storage in a coolstore (2C) or freezer (-20C)

This allowed the production of test batches of a range of new products and the identification of some novel applications.

**Karaka berries:**

When tested, the raw (fresh) berry flesh had a high moisture content and sugar content comparable to that of nashi or similar sweet fruit (as high or higher than kiwifruit, grapes or apples). The highest sugar content (Brix) measurement recorded was 27.0, well above most other fruit. Ripe berry flesh recovered from the nuts was successfully dried using the same techniques and equipment used for commercial dried apricots, fruit slices etc. This reduced the water content and raised the sugar content even further (suppressing fungal moulds), producing a product very similar to dried apricots…though with a rather stronger and more distinctive aroma and with a slightly stronger taste.

This suggests that karaka berries (dried or fresh) could be a feasible, nutritious and simple-to-produce food product. The ripe berry certainly seems attractive to animals and evidence was found for both possums, rats, mice, a variety of birds, quail (and even ducks!) stripping the berry flesh from the nut….sometimes even leaving a perfectly “peeled” nut still hanging attached on the tree (see Fig. 5).

Anecdotal reports exist of drovers and the like sucking on ripe karaka berries while mustering on hot days….eating the juicy flesh but spitting out the kernel. There have also been reports of the berry flesh being used in “carrot cake”-type recipes. However, the berry itself (either fresh or dried) does not seem to have been widely used by the Maori (Kahikatea “berry” being preferred). Tutu berry “jelly” seems to have been a popular product though. Perhaps something similar could be made from karaka berries?


***Fig. 5***. Karaka berries (including the use of a ripe banana to ripen green karaka berries)

One reason why the berry flesh may not have been used much, before now, is that karaka nuts harvested from the ground often already have most of the berry flesh eaten away by animals or otherwise dried out or lost before collection. (Because of the high moisture content, berry flesh allowed to dry down while still on the nut forms a very thin, hard crust that is difficult to remove). It is better if the ripe berry flesh can be removed from the kernel before drying, but because the berries often ripen unevenly on the tree they may not fall before they are overripe and partially or fully dried out.

One possible solution to this problem was to harvest direct from the tree using long-handled loppers/grabbers and snipping off complete clusters of berries – the way dates, for example, can be harvested. When tested, this proved to be a very quick and easy way of harvesting a large volume of karaka berries/nuts, although it did have the disadvantage that unripe (green) berries were usually also included along with ripe ones. However, it was possible to easily ripen up green karaka berries after harvest by simply storing them with a ripe or overripe banana (see Fig. 5). The ethylene produced ripened the karaka berries very quickly and easily, producing good colour and taste, regardless of the degree of ripeness when "picked".

As has been done with bananas, and the "facilitated" harvesting of chestnuts and similar crops, it could therefore be relatively quick and easy to harvest karaka berries commercially in the field, straight from the tree, if required. One further attribute that makes this possible is that the karaka nuts/berries seem to "size up" before they fully "ripen up". This is a useful quality in that picking too early should not, therefore, incur a penalty of size, quality or yield loss.

(NB: While most sources agree that ripe karaka berries are not toxic, M E Bell (1974) in "Toxicology of karaka kernel, karakin and B-nitropropionic acid" in the NZ Journal of Science, Vol. 17, 327-334, cites results from McChesney (1949) that show low levels of karakin (0.025-0.08%) present even in "whole ripe berries". Whether this refers to the berry flesh or the kernels inside, however, is unclear).

**Karaka liqueur, juice and other beverages**

Samples of karaka berries and nuts were put through various standard commercial juice extraction and testing processes. When either the karaka berry (over 90% water) or the karaka nut (50-60% water) was put through a commercial chestnut juice extraction process, a very sweet "juice" was extracted, with sugar contents sometimes in excess of 15-20 Brix (very similar to chestnuts and with a comparable rate of recovery: approx. 1L per 5 kg of chestnuts).

If left to stand, karaka juice then fermented rapidly, suggesting that it should be possible to produce either a karaka "ginger beer" or a true "karaka beer" – both of which have proven successful with chestnuts – with the added advantage of being gluten-free, and therefore suitable for coeliacs (ie. a "health beer").

As a result of these findings, a small Christchurch-based company (Brendon Hale/Greg Watson) is now experimenting with "karaka liqueur", hoping to capitalize on the high colour and volatile, aromatic compounds associated with karakas, as well as their high sugar content.

One problem with any juice/beverage/liqueur process involving karakas is the possible presence of toxins. The liqueur company (above) is addressing this by only using the berry flesh, not the kernel, but there is always a possibility that untreated (potentially toxic) kernel could be included. It may be possible that passing a "juice" or other extract through charcoal may detoxify the karakin extract (Easterfield, 1901, in "Transactions and Proceedings of the Royal Society of New Zealand", Vol. 34). Incidentally, Easterfield also reported the presence of "karaka oil" (apparently non-toxic).

Another possible way to avoid toxicity problems could be to use only the berries from unpollinated "blanks". As described earlier, 50% or more of the berries collected from some trees may not have any actual kernel inside, even though the berry itself is large, fully developed and ripe. As in chestnuts, this seems to reflect lack of pollination between different cultivars, so it should be possible to deliberately produce a "berry only" (kernel-free) crop by deliberately restricting pollination (removing pollinator trees). This would also "maximize" berry production. (NB: "blanks" can easily be separated from normal nuts by dropping them into a bucket of water…."blanks" float while normal nuts sink).

Trials on karaka "beverage" production are continuing, in parallel with commercial trials of chestnut beer, chestnut juice and chestnut liqueur (some of which are already available commercially).

**Other food-related products**

Karaka kernels were mechanically scrubbed to remove berry flesh, mechanically shelled to remove the shell and pellicle, then dried, ground, pureed or roasted, using standard chestnut industry processing machinery and procedures (see Fig. 6).

***Fig. 6.*** Karaka nut processing. Clockwise from top left: mechanically shelled & peeled nuts; mechanical chestnut & karaka sheller/peeler; karaka harvesting; crumbed/powdered nuts; shelled chestnuts (for comparison).

It was actually easier to remove the shell and pellicle from karaka nuts than it was to shell and peel chestnuts. The same machinery could be used, without modification, but at increased throughput and with less wastage and breakage. Pellicle removal, especially, was significantly easier and, because of the smaller nut size, drying, grinding, roasting etc was also easier, faster and cheaper….with little or no modification required to existing commercial machinery.

The karaka nuts separated easily from the shell/pellicle and could be stored open to the air without the risk of blackening and oxidation (which requires shelled/peeled chestnuts to be stored in water or frozen). The nuts also stored and handled significantly better than chestnuts, both at room temperature and in coolstorage. The risk of fungal moulds and rots was also extremely low compared to chestnuts. These are all significant advantages.

As a result, karaka nuts could easily be stored, dried and ground into crumb or flour (gluten-free) and can therefore be expected to have useful baking and cooking potential….at least as good as chestnuts. A further advantage of the karaka was that, because of the ease and completeness of pellicle removal, it produced a very white, clean, fine-textured flour, crumb and puree (compared to coarser, darker chestnut product). This, in turn, should mean that karaka is suitable for products such as bakery goods, bread, polenta, fritters, porridge, confectionary, pikelets, stuffing, puree, icecream etc (all of which are currently being made out of chestnuts at present). Gwen Skinner (1981) in Simply Living: A gatherer's guide to New Zealand's fields, forests and shores" also describes pan-roasting karaka nuts, with salt. Roast chestnuts, prepared similarly, are a very popular product throughout Europe and Asia and are consumed in very large quantities.

Roasting karaka nuts had an interesting and unexpected side-effect….during the roasting process the whole kernels invariably split down the centre-line, shrank, turned dark brown and "curled" somewhat. This produced a roast karaka nut that looked very like a roast coffee bean! So perhaps "karaka coffee" is another potential product. (Chestnut-based and hazelnut-based coffee substitutes are already available in the US).

**Pest & disease control**

The "karakin" toxin has been reported to be a potent natural insecticide. During the course of the project, Dr Brian Tapper from Agresearch (Palmerston North) expressed interest in the further development of the insecticidal properties for, amongst other things, a natural grass grub eradicant. Based on published findings, to date, karaka extracts could also prove effective against a range of other common insect pests.

The nectar in karaka flowers has also been reported to affect honeybees. At low rates it seems to cause "intoxication" and erratic flying (like wood pigeons!). At higher rates it seems able to cause bee death (but does not seem to affect honey production or honey quality, fortunately). While some data have been published for honeybees, it would be even more interesting to know if this toxin could be used as an attractant/toxin for unwanted wasps. Perhaps the planting of karaka trees in wasp-prone areas is to be encouraged?

During the course of the project, Duncan MacMorran of Connovation Ltd also expressed interest in the use of karaka nuts for pest control (rats and other rodents) after seeing some results showing that "karakin" was, at low doses, an effective possum repellent (making them vomit almost instantly) and, at much higher doses, a lethal toxin. Certainly, even in the most possum/rat-infected areas of NZ native bush, karaka trees can be found growing with an almost continuous carpet of healthy karaka seedlings beneath them, seemingly untouched by animal grazing. Likewise, there are many healthy karaka trees on the slopes of the Mount (Mauao) at Mt Maunganui, where other edible natives such as hinau and tawa have been very seriously depleted by possum damage.

The karaka tree itself also shows conspicuously few pest and disease problems. Likewise, the nuts and berries are also conspicuously free of fungal, bacterial or insect problems, and very few pests or pathogens have ever been reported on karaka before (though one, as yet unnamed bacterial spot on karaka berries in Hamilton is still being investigated by Plant & Food CRI….see Fig. 7). It may be that there are naturally occurring biological control agents (BCAs) associated with karakas that help protect against pests & diseases.

(Further investigations on BCAs associated with karaka and the potential for karaka extracts to be used in pest & disease control are continuing).

### Animal medicinal and therapeutic effects

It is not altogether clear in the literature which animals find karaka nuts toxic. Humans and dogs seem most at risk (though very few cases of accidental death ever seem to have been reported…especially considering the wide availability of karaka nuts during karaka season and their widespread presence on footpaths etc when they fall). There seem to be contradictory reports of how toxic (or not) karaka nuts are to poultry, goats and horses. Cows, pigs and sheep seem to suffer no ill effects.


Fig. 7. Karaka diseases & disorders (clockwise from top left: unpollinated “blanks” and muliembryonic nuts; *Phytophthora* root rot; external mould (healthy kernels inside); bacterial spots on berries; unpollinated “blanks”; multiembryonic nuts

On one dairy farm at least (Norm Johnson, Taranaki) the planting of karaka trees has been actively encouraged and the karaka nuts and leaves are collected and deliberately fed to stock….especially to any sick animals and calves. The stock seem to rapidly gain a taste for karaka nuts and actively seek them out, with no ill effects. There seems to be no problem with toxins in the milk and, indeed, the milk quality from this particular farm has been widely praised over many years.

Anecdotal evidence suggests direct animal health benefits on such stock fed on karaka nuts. While hard data are lacking, there is perhaps supporting evidence from chestnuts, where the high polyphenol and tannin content in chestnut shells/burrs/pellicle etc is unappealing to humans but actually seems attractive and beneficial to stock. This has been utilized commercially in a range of chestnut-derived stockfood supplements which act as appetite stimulants (causing stock to gain weight faster), act as natural dewormers, and significantly reduce gut *E. coli* and other harmful bacterial counts.

According to Ron Ashford (1981)….”Karaka holds potential as a stock-fodder tree, as leaves twigs and berries are all highly palatable to most types of stock. It not only has feed value but a medicinal/tonic effect as well. “If a cow refuses karaka, give her the .22” is a familiar saying amongst a few farmers in the district [Taranaki]. Pigs, cows, sheep and cattle all eat the berries, preferring it to grass as they rush the trees when let into a paddock containing karaka.”

There is also the precedent of tawa or miro berry-fed pigs being especially good to eat (and chestnut-fed pork being a high-priced delicacy in Europe), so perhaps karaka-fed pork could also be a useful product.

Further trials are planned to combine karaka with chestnut extract for commercial stockfood use. This area deserves more investigation.

## Miscellaneous

While lying outside the scope of the original project, some other karaka attributes were identified that could also repay further investigation in the future.

Karaka is faster growing than most other native tree species and karaka wood is reported to have had some specialist applications in the past for items such as paddles (does this mean that it is low density and will float?). It also seems naturally very rot resistant (see the pests & diseases section). Chestnut wood has proven to be very valuable overseas for its natural ground durability (without the need for treatment) and high utility for construction, furniture manufacture and grapevine supports in organic vineyards, and the like. Chestnut

wood is also a preferred substrate for growing a range of high-priced exotic mushrooms, such as Shiitake. Is karaka wood equally useful or valuable?

The leaves are also reported to have had medicinal applications for Maori as wound and burn dressings, which could indicate the presence of natural bioactive compounds deserving further study…..

"The leaves of the karaka tree are wonderfully healing if applied to wounds, but care must be taken to place the shiny green upper surface to the wound, as the duller or whitish undersurface of the leaf draws equally as the under surface heals……A decoction of ngaio and karaka leaves can be used as a wash to relieve pain….for small burns from fire, bathe the burn with karaka oil then cover the burn with karaka leaves and bind" (Riley, 1994).

The ripening fruiting clusters also seem to produce potent volatile "defoliant" chemicals, which cause adjacent foliage to abscise, thereby making the fruiting clusters far more noticeable and accessible to birds. Despite the fruit having a very bright colour and extremely strong smell, the chemical compounds involved do not seem to have been studied in depth yet (Fountain, 1984).

Finally, since one of the effects of the "karakin" extract is that "it relaxes the joints so that bones may bend the wrong way", could it perhaps even have some application in the treatment of arthritis and similar afflictions?

## 6. Suitability for managed, commercial cultivation

### Background

There is good evidence that the Maori once deliberately planted and managed karaka orchards, perhaps tens of hectares (or more) in extent, with trees carefully selected, arranged (sometimes in rows), cared for and managed. No such orchards exist today, but they could potentially be revived. However, would this be feasible in a modern commercial horticultural environment?

The feasibility of applying modern nut industry machinery and harvest, handling and storage practice to karakas was therefore investigated further.

**Harvest**

Traditionally, karaka berries/nuts have been harvested when they ripen and fall to the ground. However, because of the size and the period over which they fall (the season stretches from January to April) this can be labour-intensive and difficult. Several alternatives were tried, based on NZ nut industry experience…..

**** mechanical harvest:***

a range of existing nut industry mechanical sweepers ("E-Type Engineering"), vacuum harvesters ("Greystone Vacs"), macadamia harvesters ("Bag-a-Nut") and hand operated, pushalong wire-cage walnut harvesters ("Lourdan Grove") were compared. The small size of karaka nuts compared to other commercial nutcrops was a problem for most of the mechanical and sweeper systems, and the presence of berry flesh (sometimes rotten) made vacuum harvest rather unpleasant and impractical. However, the wire-cage "Lourdan Grove" harvesters (see photos) proved very successful and were able to harvest large quantities of berries and nuts very quickly and easily. This increased speed and ease of harvest at least ten-fold.

**** harvesting karaka nuts direct from the tree:***

Many nuts and other fruit crops are harvested direct from the tree by either tree or branch shaking, or picking…which can also help reduce bird and animal damage, and spoilage from nuts/berries coming in contact with the ground. Hand picking karaka was not usually an option because of tree height, but use of a long-handled pruner/grabber did prove very effective (see the "karaka berries" section).

Mechanical whole tree shaking (as used for olives) also proved impractical due to tree size and access, but a portable olive-industry hand-held motorized branch shaker did work well…although the karaka nuts/berries still had to be picked up off the ground whereas the tree pruner/grabber above could pick individual clusters and carry them down intact, into a bag, without the ne need to harvest them off the ground.

***growth regulators:***

A drawback of all direct tree harvest systems is that unripe nuts/berries were inevitably collected along with ripe ones. This is a problem that other nut industries have also faced, and one solution has been "facilitated nut harvesting". This involves applying growth regulators to promote ripening, ideally so that all nuts/fruit on the tree ripen together, then they can either be shaken down or another growth regulator applied to induce abscission so that all harvest can be completed in one go, rather that having to be repeated at regular intervals over a period of weeks. (Both systems have been used successfully in NZ before on chestnuts and macadamias).

Applying unregistered growth regulators to native tree species was not attempted in this study, but a modified form of "facilitated harvest" was tested…picking ripe and unripe fruit/nuts alike, direct from the tree, then artificially ripening them later using the ethylene generated naturally from a ripe banana (see the "karaka berry section"). This worked very well (see photos). Other crops use controlled ripening rooms and/or a range of ripening-promoting chemicals. Based on the results in this preliminary study, these techniques should also apply to karakas as well, if required.

**Handling and storage:**

Karaka berries and pre-peeled chestnut kernels (in-shell, all berry flesh removed, shell & pellicle removed) were stored under a variety of conditions, in either plastic bags or open trays: at room temperature; at 30C (in a heated glasshouse); at 2C (in conventional coolstorage); at -20C (in a commercial freezer), using chestnuts as a comparison. Overall, karaka nuts were much easier to handle and store successfully without a significant loss of quality (surface mould, fungal rot, spoilage, weight loss, loss of flavour, texture or sugar content).

Chestnuts can rarely be stored in good condition for more than 6 months (useful to match demand from northern hemisphere export markets). However, even that requires careful packaging in either ventilated plastic bags to minimize moisture loss and storage in a coolstore between 2C and -2C to minimize the growth of fungal storage rots and suppress germination, or careful drying to below 15% moisture content.

Karaka nuts required virtually none of these precautions. They could be stored in the open, at air temperature (in shell) for several months with no significant deterioration, other than water/weight loss (slow by chestnut standards) and an insignificant amount of fungal mould/rot (negligible by chestnut standards). Storage life could be extended further by

coolstorage or freezing, and germination in storage was not a problem. Karaka nuts were easier to dry than chestnuts (being smaller) and once dry could be stored virtually indefinitely.

Overall, storage and handling was remarkably straightforward compared to other NZ commercial nut crops (which matches the Maori experience being able to keep harvested karaka nuts as a food source through the winter).

Trying to store nuts still the berry flesh on was more problematic. If left on, the berry flesh would rapidly decay at room temperature and support the growth of fungal moulds and rots. Even in a coolstore, these would gradually spread and completely cover all nuts (see photos). The species of fungi involved mainly comprised *Penicillium* and *Botrytis*, with other occasional species encountered such as *Botryosphaeria*, *Glomerella*, *Fusarium* and *Aspergillus* (all common NZ nutrot fungi). Compared to chestnuts though, the range of species commonly encountered was quite limited and, most importantly, even when the berry was completely rotted and the outside of the nut completely covered with mycelium, once the nut was cut open and examined the kernel inside was often still rot and infection free (see Fig. 7)….quite different to chestnuts.

This perhaps helps explain why Maori usually removed all berry flesh, sometimes by soaking and pulping in water, even though it was a laborious process and potentially "wasteful" in terms of the loss of a potential food source (the berry flesh itself). Incidentally, a traditional European technique for helping store chestnuts for long periods (known as "Curatura") is to soak them in water first (helping suppress subsequent fungal growth and spoilage). It would be interesting to know if this was also part of the reason for the Maori "soaking in running water" treatment.

Another possible storage treatment that was not tested but which may be useful on karaka nuts/berries in the future is packing in native Sphagnum moss. This has been trialled experimentally on other NZ fruit and nut crops, making use of the natural acidifying, water-absorbant and antimicrobial properties of fresh (or dry) Sphagnum. It was also possible to store karaka successfully, still with the berry flesh on, by partially drying them first (leaving them in full sun in a glasshouse or similar at 30C). This rapidly dehydrated the berry flesh (within 24-36 hours) to a thin "crust" over the shell before fungal moulds or rots had a chance to develop.

Karaka nuts from which the berry flesh had been removed could also be easily dried without damage, at any temperature up to approx. 50C (after which they started to cook/roast and change colour). In chestnuts, drying at more than 30C is problematic because of the development of off-colours, odours and taints. This was not a problem for karaka nuts.

In chestnuts, partial drying also helps shell and pellicle removal (which is often very difficult). This was not a problem for karaka nuts. Once shelled and peeled, chestnuts also oxidize and blacken very rapidly, which usually necessitates them being held in water until processed. Shelled/peeled karaka nuts showed no tendency to oxidize or blacken on exposure to air. However, they did (naturally) dry out over time causing progressive weight loss and also a characteristic tendency to split in two down the centre line (like peanuts). Some natural "browning" did occur over time, but this did not detract from overall appearance or processing suitability.

It was extremely rare to find a single karaka nut with an internal fungal rot (inside the kernel rather than on the outside of the shell), whereas such rots could be found in well over 50% of chestnuts stored the same way. This is a major advantage for karaka nuts should they be commercialized further.

One characteristic that both chestnuts and karaka nuts shared was the occasional presence of polyembryonic nuts (more than one embryo per seed) and empty/unpollinated/seedless 'blanks" (complete berries, shells and pellicles….but with nothing inside: see pollination section later in this report). See also Figs. 6 & 7.

Freezing kept karaka nuts in good condition indefinitely. After thawing, they did not blacken/oxidize immediately, like chestnuts, and could be easily processed for juice or other beverages using standard chestnut processing systems.

# Conclusions

## Karakas and chestnuts : similarities and differences

Comparing karakas and chestnuts (see below), it can be seen that there are a number of similarities, suggesting that karaka could well be successfully commercialised in a similar manner to that of chestnut, involving…..

- the identification and selection of high-performance cultivars
- nursery propagation to produce consistent high-performance cultivars for sale
- managed orchard plantings (with a mix of cultivars & pollinators)
- spray-free/chemical-free/organic production
- mechanical/assisted harvesting (using the same technology as that for chestnuts)
- long-term coolstorage and/or drying (as for chestnuts)
- value-added processing (using the same technology as for chestnuts)
- producing both a range of value-added food products, and ingredients
- targeting the high-health market
- combined with by-product utilization for stockfood supplement, pest control and bioremediation

Moreover, because of the similarities involved, there may be definite advantages in being able to combine resources, make use of the same plant & equipment, make use of the same sales and marketing channels etc.

**Similarities……**

- both produce a similar-sized tree and yield per tree at maturity
- both exhibit a wide range of seedling variability
- both are amenable to propagation by grafting and cuttings

- both show a great deal of scope for variety improvement via selection and propagation
- both are relatively pest & disease free: suitable for no-spray/organic production
- both can be harvested using the same "pick-up" machinery (sweeper, vacuum, other)
- both produce a high-health gluten-free nut
- both nuts have an outer shell and inner, thinner pellicle
- both nuts can be coolstored or dried and kept for long periods
- both nuts are suitable for the same range of value-added applications
- both can make use of the same processing machinery (shelling, peeling, drying etc)
- both have similar (sometimes difficult and unusual) pollination requirements
- both could benefit from insect or artificial/assisted pollination (but it is not essential)
- both can produce a lot of "blanks" (non-pollinated fruit)
- both produce a significant number of "multi-embryonic" nuts
- both have a range of potential by-product (non-food) uses with commercial applications of their own

**Differences…….**

- karaka is slightly slower growing and slower to come into production
- the selection process for improved cultivars is much more advanced with chestnuts
- likewise, the use of cuttings/budding/grafting is more advanced
- karaka has a higher oil content than chestnuts (not necessarily a bad thing, as walnut/hazelnut oils have all been shown to be nutritionally beneficial)
- if anything, karaka is easily to harvest, handle and store than chestnuts

- and significantly easier to shell and peel
- and with a much lower incidence of internal rots
- and with an edible berry
- the main difference is the toxicity found in the (untreated) kernels and the flower nectar…though the tannin content in chestnuts (astringent but not actually toxic) could perhaps be considered equivalent (along with the toxic compounds present in horse chestnuts "conkers", cashews, almonds etc.)

## Feasibility of commercial karaka production

While there are a number of possible constraints to reviving commercial karaka production in NZ (see below), none of these appear insurmountable. They are, in fact, remarkably similar to the constraints affecting a variety of other small/emerging industries in NZ….especially nutcrop industries. The key area needing to be addressed would seem to be that of "karaka toxicity" and while addressing that problem could require a significant commitment of resources, there is a very successful precedent in the form of cashew nuts.

In its raw, unprocessed state the cashew nut contains the same toxic chemical (urushiol) as found in poison ivy. Even just accidental physical contact with the oil in the cashew nut shell can blister the skin and cause severe, fatal allergic reactions. A complicated and involved handling, preparation and treatment/cooking/soaking process is required to make the cashew nut safe to eat, but the cashew nut is still a very profitable and successful crop. There are also much more dangerous/toxic NZ native plants (such as the stinging nettle).

There could be much easier ways to deal with karaka nuts (see below). There are also some definite "advantages" that karaka has over other NZ horticultural tree crops…..

### Potential constraints to commercial karaka cultivation: "top 20" liabilities

- nut toxicity to humans and some animals
- nectar toxicity to honeybees (and other insects?)
- lack of a standard, certified detoxification system
- lack of any standard test for toxicity and any "safe to eat" quality assurance system

- laborious and costly harvest requirements (if done from ground level)
- competition from other animals eating the berries/nuts
- difficult and unusual pollination requirements to be met
- the possible need for separate pollinator trees/cultivars
- lost production from seedless "blanks" and multiembryonic nuts (difficult to process)
- lack of consistent high-performance selections/cultivars
- possible IP (intellectual property) and PVR (plant variety rights) protection issues if such cultivars are developed
- the difficulty of harvest "from the wild"
- the lack of established orchards (and nurseries to get new trees from)
- slower growth and the time taken to begin flowering/fruiting (compared to some horticultural crops…but not all)
- lack of suitable handling and processing facilities
- lack of established products to sell and markets to sell into
- frost sensitivity
- a relatively long and uneven ripening season (requiring multiple harvests)
- biennial bearing
- the smell! (offensive to some people, appealing to others, and certainly not as bad as Gingko fruit…another useful, high-value nut comparison)

**Potential advantages to commercial karaka cultivation: "top 20" assets**

- a native crop
- new and novel
- unique to NZ

- naturally pest & disease-free
- little or no maintenance, pruning, training etc required
- suitable for spray-free/chemical-free production
- suitable for organic production
- suitable for use with existing nut industry machinery/processing/marketing facilities
- relatively fast growing and heavy cropping (for a native)
- found throughout most of NZ
- well- adapted to NZ growing conditions
- proven gluten-free
- good nutritional value, generally
- both the nut and the berry are edible (and "complement" each other, nutritionally)
- several possible value-added food processing applications exist (for both nuts and berries)
- possible uses for both wood and leaves as well
- possible insecticide/pesticide/rodenticide uses
- possible animal stockfood/medicinal/therapeutic uses
- possible chemical/colour/volatile/BCA by-product applications
- a successful historical (Maori) precedent and knowledge base to build on

## Toxicity testing and detoxification

There is no "standard" internationally recognized, ISO-approved or similar accepted technique for assessing karakin concentrations in karaka nut/berry-derived products, or determining when "treated" karaka nuts or products are safe to eat. Published information on toxicity is often incomplete and sometimes contradictory. Much of the published information available is very old and possibly out of date and/or suspect. It is not clear

what animals are most at risk. It is not clear whether "karakin" ($C_{15}H_{21}O_{15}N_3$, 1:4: 6-tris-(β-nitropropionyl) D-glucopyranose [Carter 1951]) is the only toxin present, or if there are other harmful chemicals present also (eg. four related nitropropanoyl glucosides: corollin, corynocarpin, coronarian and cibarian). Karaka nectar has also been reported to be toxic, and there are also anecdotal reports of unripe karaka berries sometimes being toxic, and that the risk posed can vary with ripeness, growing conditions and time of year.

Some evidence also suggests that some karaka selections may also be more toxic than others, and that toxicity may also vary with nut storage conditions (and may dissipate over time). Thus, Easterfield and Aston (1902) reported that karakin concentration diminished from 0.3% in fresh drupes to only 0.1% 3 months later, and less again after 12 months (raising the possibility that simply storing karaka nuts [fresh, dried or frozen] for long enough may be all that is required to remove the toxin). In support of this, there are reports that possums and rats will not eat "freshly fallen" karaka nuts, but will eat old nuts that have lain on the ground for many months….suggesting the toxins may have leached out or broken down. The toxicity of karaka nectar is also reported to decline over time.

The known visible symptoms of karakin poisoning are quite severe, potentially fatal, and reportedly irreversible (although Kohekohe [*Dysoxylum spectabile*] leaves were given to afflicted persons after they were buried up to the neck as a partial antidote "or at least to help straighten the limbs before death" [Pickmere 1941, quoted in Riley 1994, p. 210] – this possibly only worked as a result of being able to induce vomiting). Even on trials conducted for possum eradication, experiments had to be suspended because of major animal ethics concerns (Gregory et al., 2000). Recorded descriptions of traditional Maori detoxification treatments are themselves sometimes confusing and do not always translate easily into a standard, repeatable, reproducible format involving specific treatment temperatures/times etc under controlled conditions. (This is even more of a problem for "new and novel" processing applications for which there is no traditional Maori precedent at all). Nor, with the current state of technology, is there any way to quickly and reliably test whether a given karaka nut or product has been properly detoxified or not, or certifying whether or not it is safe to eat.

For the above reasons, it was not possible (for food health & safety and "liability" reasons) to carry out the full range of toxicology testing, taste testing, animal testing and by-product test as originally intended. This will need to be the focus of a future study, and given the costs of properly run animal assays, chemical assays, laboratory assays and so on….the costs involved could be significant (many times larger than the total cost of this whole project).

Glen Ayo (Western Bay of Plenty District Council) did carry out traditional Maori treatment of a range of different samples provided from different sources and in various

forms but, as described earlier, this was not successful on that particular occasion. This perhaps emphasizes the unpredictability involved.

On the other hand, available evidence suggests that the detoxification treatment process for karaka is not necessarily technically very difficult. Thus, in a comprehensive summary of karaka toxicity issues in "Flora of NZ" Vol. 1, by H. H. Allan (1982) it is noted that "It is now known that karakin is hydrolysed in boiling water to B-nitropropanoic acid and that this acid decomposes at 100C**"…."Autoclaving for one hour at 100C eliminated toxicity and also completely decomposed the acid".** This is not a difficult process and well within the capability of existing food processing/cooking technology.

Quite separate to the detoxification treatment process, however, a "safety assurance" test is also needed to confirm that any treated product is guaranteed safe to eat. There is no precedent for this for karaka and such a test would need to be developed from scratch.

The ideal would be a user-friendly, non-destructive "quick-test" that could be used on the final product, after detoxification treatment. Hortresearch has developed similar quick-test colour change labels and packaging that indicate when fruit are ripe and best to eat. Since the mechanism of karakin toxicity is similar to "nitrite poisoning" there may be another useful precedent available in the form of the standard "urine test strips" based on the Gneiss nitrite-specific diazonium salt reaction. Perhaps this, or similar, technology could also be developed into a useful technique for karakas.

There is another possible "detoxification route" that could be worth further investigation. As noted earlier, ruminants seem to be immune to any adverse effects from karaka. In a recent review of toxicity problems in livestock forage (Anderson et al., 2005) it is suggested that "an obligate anaerobic nitro-respiring bacterium, *Denitrobacterium detoxificans*, may be particularly important in conferring protection to animals consuming the nitrotoxins [such as karakin] as the bacterium metabolises the toxins……rates of ruminal nitrotoxin metabolism can be enhanced by modifying the rumen environment through dietary manipulation (using dietary supplements such as protein)". It may therefore be possible to develop a biologically based detoxification system, using either bacteria or enzymes (and perhaps develop a true antidote for karakin poisoning).

## Recommendations:

### 1. Karaka opportunities worth developing: "top 20" suggestions

- dried karaka nuts
- karaka flour, puree, and gluten-free bakery products
- roast karaka nuts/karaka coffee
- dried karaka berries (like dried apricots)
- karaka liqueur (potentially juice, beer and wine also)
- karaka stockfood supplement (appetite stimulant/natural dewormer)
- karaka wood (for specialist, niche applications)
- karaka pollen pellets (healthfood)
- karaka "health bar" (combined with other nuts)
- karaka porridge
- karaka cake (like carrot cake)
- karaka (vegetarian) fritters
- natural wasp attractant/toxin
- natural possum repellent
- natural rodenticide
- natural insecticide
- natural wound treatment
- biocontrol agents for pest & disease control
- new and novel volatiles and colour/taste compounds from the fruit
- colour change labels or a similar "quick test" method for toxicity indication

## 2. Unanswered questions: “top 20” suggestions

- do karaka nuts cause allergic reactions? (like peanuts)
- is there any value in karaka oil? (like walnut oil, avocado oil, grape seed oil etc)
- is there more than one toxin involved in kernel toxicity?
- are unripe berries potentially toxic?
- what animals are at risk of poisoning? (does this really include kiwis?)
- can an antidote be developed? (from kohekohe?)
- is the flower nectar toxic to native bees? (and other beneficial insects)
- does toxicity vary over time? (and will something as simple as long-term storage or freezing/thawing neutralize the toxins?)
- does toxicity vary from tree to tree and region to region?
- if so, is there a non-toxic karaka out there just waiting to be discovered?
- or can a non-toxic karaka cultivar be developed?
- can the ornamental, variegated karaka be revived?
- does nut nutritional composition vary from tree to tree and region to region?
- can you ripen karaka nuts/berries on the tree using growth regulators? (and do a once-only harvest?)
- can karaka be “artificially pollinated”? (using previously collected pollen)
- can specialist “pollinator” karaka cultivars be produced
- what insects are involved in karaka pollination? (and how important, or not, are they?)
- are Chatham Island karakas significantly different to those found elsewhere in NZ?
- can karaka nuts help prevent heart attacks, strokes, diabetes, arthritis etc?
- does karaka consumption materially benefit stock? (and how)

## Disclaimer/Postscript:

Not all the project went to plan, in accordance with the planned schedule, aims, objectives and milestones. In particular….

- The planned University student survey/questionnaire objective/milestone was not implemented as intended because of the loss of several prospective candidates to other jobs, careers, motherhood etc. This objective was later implemented in revised form by Dr Richard Benton and Dr Robert McGowan (ex-Waikato University).

- The establishment of a permanent collection at WRO, as a germplasm repository/nursery was not fully implemented due to significant changes in the ownership/leasehold provisions at WRO (administered by Tainui Group Holdings Ltd).

- In relation to the above point, while suitable propagation techniques for karaka were developed and evaluated at WRO and selected "high-performance" cultivars identified, these cultivars were not propagated further and established in dedicated nursery, plant collection or "arboretum"-type plantings due to possible complications with intellectual property rights, plant variety rights, and change of ownership provisions. (NB: all necessary plant material and resources have, however, been maintained ready for later use in this capacity, if required).

- The unusual pollination and flowering behaviour of karakas had not been anticipated and included as a study objective in the original project plan, but was rapidly found to be a very significant factor affecting several nut quality, yield, harvest, tree growth and management considerations (ie. across several objectives and milestones), and incurred a significant amount of additional work.

- In relation to the above point, unexpectedly high variability from year to year (at least partly due to the unusual karaka flowering and pollination behaviour mentioned above) meant that several field trials and collection trips had to be repeated, adding significantly to the total amount and expense of field work required.

- Some of the field monitoring sites were also raided by the police when cannabis plants were found to have been planted in amongst the prolific karaka seedling understory, leading to a loss of data and the need to reestablish trial sites elsewhere

- A major CRI reorganization mid-way through the project (Crop & Food CRI/Hortreseach) led to the loss of previously prepared and submitted samples for

nutritional and other analyses, causing some to be cancelled/carried out elsewhere and significantly delaying others.

- While a range of test processed products (from both karaka nuts and berries) and by-products were developed, taste testing was not always carried out fully because of difficulties obtaining safety clearance regarding the possible presence of toxins. Nor could animal testing be carried out in lieu of human taste-testing because of animal ethics and animal welfare considerations (see also, the termination of karakin possum eradication trials carried out by Gregory et al., 2000).

- These difficulties with toxicology concerns were not all apparent before the trials commenced (see below) and severely curtailed involvement by Hortresearch, Solvent Rescue NZ Ltd and other labs and CRIs subject to official regulations and food health & safety standards. This affected both toxicity testing and taste testing (which will need to be carried out as part of separate assessment programme)

- These safety considerations also caused unanticipated limitations on the hosting of field-days, public participation events, and participation at various specialist food fairs and displays (to which “karakas” were invited and which we would have otherwise have happily attended and taken part in). The amount of detail regarding “detoxification” of kernels in this final report is also limited for the same reasons (in case readers are tempted to “try this at home”).

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# Appendices

## Appendix 1: Expressions of interest in karaka nuts: individuals/companies that made contact during the course of the project…..

- **Ron Trigg, Mike's Premium Organic Beer Ltd**, Taranaki: keen to develop an organic, gluten-free karaka beer in conjunction with Venture Taranaki and Massey University.
- **Greg Watson/Brendon Hale, "This Design Ltd":** keen to develop a karaka liqueur
- **Dr Brian Tapper, Agresearch, Grasslands Research Centre, Palmerston North**: keen to develop insecticidal applications and a "non-toxic" karaka
- **Tamai Sinclair, Te Puni Kokari**, Akaroa Peninsula tree planting programme
- **Duncan MacMorran, Connovation Ltd**: interested in developing a karaka-based rodenticide and possum repellent
- **Richard Bentley, "Rural Delivery" TV1** producer: hosted an item on karakas at Norm Johnson's property, Taranaki
- **Vincent Perry, Manukau City Council**: council/community tree planting (via Derek Craig of NZTCA)
- **Wildfoods Festival (Hokitika):** request for karaka participation
- **Stephen MacCauley**, Agmardt: expression of interest in further R&D
- **Jackie Bedford, "The Orchardist":** request for article and photos
- **Jin-Wah Lau**, Hawaii: request for information and recipes
- **Roimata Minnhinnick**: request for information
- **Chris Ryan, Guthrie Smith Trust Board Arboretum**, Lake Tutira, Napier: request for karaka involvement/cultivar collection
- **Postdoc. Marsden Fund Application**, L Shepherd/P Lockhart (plus 2 x MSc projects)
- **Stephen Hoyte**: access to two 100-year old karakas gifted from Ngati Raukawa in Horowhenua to land belonging to Mrs Parpara, near Tikitu marae at Putaruru
- **Ian Moore**, nurseryman, Bay of Plenty: karaka seedlings dying with *Phytophthora*
- **NZ Horticultural Society**: request for information and speakers

## Appendix 2: Karaka flowering and fruit set

**2007:**

First flowering (Hamilton): 1 October

Last flowering (Hamilton): 13 November

Second flowering flush: 15 December (and February 15!)

Harvest : 25 January – 22 February, 2008

**2008:**

First flowering (Auckland): 9-10 October

First flowering (Hamilton): 12-13 October

Peak flowering (Hamilton): 23 October (most flowers now fully open and some falling off when touched)

Second flowering flush (a few clusters only): 10 December

Last flowering: 13 December 2008

Harvest : 25 January - 28 February 2009

**2009:**

First flowering (Hamilton): 1 November

Peak flowering (Hamilton): 12 November

Last flowering (Hamilton): 19 November

**Fruit set trials:**

Individual flowering clusters were tagged and monitored from flowering through to fruit set. On average, 100 flowers/cluster at flowering (October) produced 10 fruit per cluster at fruit set (December) and only 5 fruit per cluster at harvest (January). Maximum of 30 fruit/cluster on especially good trees.

**Bagging trials:**

- 50 paper bags (wind and insect exclusion) and net bags (insect exclusion only) were place over unopened flowering clusters (at least 500 flowers/bag) on 14/10/08
- bags were removed after fruit set (late November/early December) and numbers of fruit counted
- only 2 fruit were found in the net bags in 2008, and none in the paper bags

**Conclusions:**

- like other nut crops (eg. chestnuts), karaka can exhibit a second (small) flowering flush
- most flowering/fruit set is found on the sunny side of trees, but the flowers are easily damaged and lost before fruit set in high wind, bad weather etc. and fruit set is low
- like olives, avocados and chestnuts, the natural fruit set percentage per flower is quite low (with potentially much scope for improvement)
- cross pollination between trees is essential

## Appendix 3: Unpollinated, empty (“blank”) karaka berries

- A significant number of full-sized, ripe karaka berries were found that either had no kernel inside the berry, shell and pellicle or only vestigial remnants. These fruit could be easily recognized because they floated in water (sound, pollinated nuts with a kernel inside and in good condition would always sink) and also sometimes “rattled”.
- The incidence of such fruit was highest on single trees, far from any other “pollinator” tree and/or on “pollinator” trees themselves (sources of pollen for other, usually more heavily cropping trees)
- The incidence of unpollinated “blanks” was also highest in the very earliest fall of nuts from all trees
- (This is a common characteristic of nut trees in general, where unpollinated fruit are often shed first before the “real” harvest begins)
- This had no significant effect on berry size, weight or yield

**Example of nut size/weight from a “pollinator” karaka tree:**

Victoria St. (Hamilton) pollinator tree : max. nut dimensions (mm) : 29 x 18

min. nut dimensions (mm) : 23 x 13

ave. nut dimensions (mm) : 26 x16

weight of 10 nuts (g) : 4.0

(ie. nut dimensions are normal but nut weight is less than 1/10 that of a “normal” nut)

**Example of the varying incidence of “blanks” on a pollinator tree over time:**

Day 1 (first harvest) : 100% of all fallen fruit float in water

Day 4 : 90% of all fallen fruit float in water

Day 7 : 72% of all fallen fruit float in water

Day 10 : 48% of all fallen fruit float in water

Day 15 - : 23% of all fallen fruit float in water

## Appendix 4: Karaka harvest: a selection of samples collected from around NZ

1. Wanganui River (T Jolly)
   max. nut dimensions (mm): 40 x 20
   min. nut dimensions (mm): 30 x 16
   ave. nut dimensions (mm): 35 x 20
   weight of 10 nuts (g) : 44.7 g (some drying out)

2. Ruakura (Hamilton)
   max. nut dimensions (mm): 38 x 28 (43 x 30 in berry)
   min. nut dimensions (mm) : 30 x 18
   ave. nut dimensions (mm) : 33 x 22
   weight of 10 nuts (g) : 60.1 g

3. Victoria St. A (Hamilton)
   max. nut dimensions (mm) : 33 x 20
   min. nut dimensions (mm) : 25 x 15
   ave. nut dimensions (mm) : 28 x 18
   weight of 10 nuts (g) : 45.0 g

4. Victoria St. B (Hamilton)
   max. nut dimensions (mm) : 32 x 18
   min. nut dimensions (mm) : 26 x 16
   ave. nut dimensions (mm) : 29 x 17
   weight of 10 nuts (g) : 40.7

5. School tree (Hamilton East)
   max. nut dimensions (mm) : 33 x 20
   min. nut dimensions (mm) : 23 x 18
   ave. nut dimensions (mm) : 27 x 19
   weight of 10 nuts (g) : 46.5

6. Karekare A (Auckland)
   max. nut dimensions (mm) : 25 x 14
   min. nut dimensions (mm) : 23 x 12
   ave. nut dimensions (mm) : 22 x 15
   weight of 10 nuts (g) : 17.2

| | |
|---|---|
| 7. Hoyte farm (Putaruru) | max. nut dimensions (mm) : 30 x 18<br>min. nut dimensions (mm) : 22 x 15<br>ave. nut dimensions (mm) : 25 x 17<br>weight of 10 nuts (g) : 30.0 |
| 8. Kirk's Bush (Auckland) | max. nut dimensions (mm) : 20 x 14<br>min. nut dimensions (mm) : 16 x 11<br>ave. nut dimensions (mm) : 17 x 13<br>weight of 10 nuts (g) : 9.1 |
| 9. Pararaha (Auckland) | max. nut dimensions (mm) : 30 x 20<br>min. nut dimensions (mm) : 23 x 12<br>ave. nut dimensions (mm) : 28 x 18<br>weight of 10 nuts (g) : 23.7 |
| 10. Tauranga (D. Harwood) | max. nut dimensions (mm) : 39 x 20<br>min. nut dimensions (mm) : 33 x 17<br>ave. nut dimensions (mm) : 35 x 18<br>weight of 10 nuts (g) : 40.1 |
| 11. Cornwall park (Auckland) | max. nut dimensions (mm) : 38 x 24<br>min. nut dimensions (mm) : 27 x 15<br>ave. nut dimensions (mm) : 30 x 18<br>weight of 10 nuts (g) : 39.3 |
| 12. Karekare B (Auckland) | max. nut dimensions (mm) : 36 x 18<br>min. nut dimensions (mm) : 32 x 16<br>ave. nut dimensions (mm) : 34 x 17<br>weight of 10 nuts (g) : 37.7 |

| | | |
|---|---|---|
| 13. Welcome Bay (I Moore) | max. nut dimensions (mm): 40 x 23 (48 x 26 in berry) | |
| | min. nut dimensions (mm) : 36 x 18 (39 x 22 in berry) | |
| | ave. nut dimensions (mm) : 38 x 19 ( 42 x 23 in berry) | |
| | weight of 10 nuts (g) : 75.1 (145.0 in berry) | |
| 14. Chatham Is. (T James) | max. nut dimensions (mm) : (40 x 30 in berry) | |
| | min. nut dimensions (mm) : (37 x 25 in berry) | |
| | ave. nut dimensions (mm) : (38 x 27 in berry) | |
| | weight of 10 nuts (g) : 72.8 (150.0 in berry) | |
| 15. Pukekohe (T Lever) | max. nut dimensions (mm) : 58 x 22 | |
| | min. nut dimensions (mm) : 31 x 17 | |
| | ave. nut dimensions (mm) : 38 x 19 | |
| | weight of 10 nuts (g) : 71.0 | |

## Appendix 5: Ripening karaka berries after picking

Green and partially ripe karaka berries were picked directly from the tree and placed in separate, sealed plastic food containers at room temperature on 29/1/08…

- green fruit, with half a ripe banana
- green fruit, alone
- partially ripe fruit, alone (part green, part orange)

**After 4 days (2/2/08)….**

- green fruit, with half a banana, were fully ripened (bright orange colour)
- (NB: green fruit left in the open air near bananas also ripened up)
- all other fruit were only partially ripe

**After 7 days (5/2/08)….**

- all fruit were fully ripe (bright orange)

**Conclusions:**

- Unripe karaka berries will ripen up, off the tree, after harvest.
- This process can be accelerated by the presence of ripe bananas (generating ethylene).
- Presumably, artificial, commercially available ethylene-generating treatments or ripening agents would be just as effective, if not more so.

[NB: for some reason, “artificially ripened” karaka berries seemed to have less smell than tree-ripened ones]

# Appendix 6: FOODINFO karaka compositional data (copyright Crop & Food CRI) - kernel raw - kernel cooked

**KARAKA**, kernel, cooked

*Corynocarpus laevigatus*

| Amount in 100 g edible portion | Units | Mean | Std Error | No. | Src. |
|---|---|---|---|---|---|
| PROXIMATES | | | | | |
| Water | g | 4.76 | - | 2 | z |
| Energy | kcal | 319 | - | - | c |
| Energy | kJ | 1326 | - | - | c |
| Protein | g | 16.6 | - | 1 | z |
| Total fat | g | 13.82 | - | 1 | z |
| Carbohydrate, available | g | 32.0 | - | - | z |
| Dietary fibre (Englyst, 1988) | g | 37.25 | - | 1 | z |
| Ash | g | - | - | - | - |
| NUTRIENT ELEMENTS | | | | | |
| Sodium | mg | 8 | - | 1 | z |
| Magnesium | mg | 57 | - | 1 | z |
| Phosphorus | mg | 204 | - | 1 | z |
| Sulphur | mg | 61.0 | - | 1 | z |
| Chloride | mg | - | - | - | - |
| Potassium | mg | 178 | - | 1 | z |
| Calcium | mg | 120.0 | - | 1 | z |
| Manganese | µg | 971 | - | 1 | z |
| Iron | mg | 3.24 | - | 1 | z |
| Copper | mg | 1.63 | - | 1 | z |
| Zinc | mg | 1.33 | - | 1 | z |
| Selenium | µg | T | - | 1 | zl |

VITAMINS

| | | | | | |
|---|---|---|---|---|---|
| Retinol | µg | 0 | - | - | p |
| Beta-carotene equivalents | µg | - | - | - | - |
| Total vitamin A equivalents | µg | - | - | - | - |
| Thiamin | mg | - | - | - | - |
| Riboflavin | mg | - | - | - | - |
| Niacin | mg | - | - | - | - |
| Potential niacin from tryptophan | mg | - | - | - | - |
| Vitamin B6 | mg | - | - | - | - |
| Pantothenate | mg | - | - | - | - |
| Biotin | µg | - | - | - | - |
| Folate, total | µg | - | - | - | - |
| Vitamin B12 | µg | 0 | - | - | p |
| Vitamin C | mg | - | - | - | - |
| Vitamin D | µg | - | - | - | - |
| Alpha-tocopherol | mg | - | - | - | - |
| Vitamin E | mg | - | - | - | - |

OTHER LIPIDS

| | | | | | |
|---|---|---|---|---|---|
| Cholesterol | mg | 0 | - | - | p |

| | g/100 g edible portion | | | | mg/g Nitrogen | | | |
|---|---|---|---|---|---|---|---|---|
| AMINO ACIDS | Mean | Std Error | No. | Src. | Mean | Std Error | No. | Src. |
| Isoleucine | - | - | - | - | - | - | - | - |
| Leucine | - | - | - | - | - | - | - | - |
| Lysine | - | - | - | - | - | - | - | - |
| Methionine | - | - | - | - | - | - | - | - |
| Cystine | - | - | - | - | - | - | - | - |
| Phenylalanine | - | - | - | - | - | - | - | - |
| Tyrosine | - | - | - | - | - | - | - | - |
| Threonine | - | - | - | - | - | - | - | - |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Tryptophan | - | - | - | - | - | - | - | - |
| Valine | - | - | - | - | - | - | - | - |
| Arginine | - | - | - | - | - | - | - | - |
| Histidine | - | - | - | - | - | - | - | - |
| Alanine | - | - | - | - | - | - | - | - |
| Aspartic acid | - | - | - | - | - | - | - | - |
| Glutamic acid | - | - | - | - | - | - | - | - |
| Glycine | - | - | - | - | - | - | - | - |
| Proline | - | - | - | - | - | - | - | - |
| Serine | - | - | - | - | - | - | - | - |
| Hydroxyproline | - | - | - | - | - | - | - | - |

| | g/100 g edible portion | | | | g/100 g total fatty acids | | | |
|---|---|---|---|---|---|---|---|---|
| FATTY ACIDS | Mean | Std Error | No. | Src. | Mean | Std Error | No. | Src. |
| 13:0 | - | - | - | - | 9.476 | - | - | z |
| 16:0 | - | - | - | - | 1.611 | - | - | z |
| 18:0 | - | - | - | - | 4.9815 | - | - | z |
| Total saturated fatty acids | - | - | - | - | 16.068 | - | - | zc |
| 16:1 | - | - | - | - | 14.8435 | - | - | z |
| 18:1 | - | - | - | - | 22.2975 | - | - | z |
| 20:1 | - | - | - | - | 1.124 | - | - | z |
| 22:1 | - | - | - | - | 0.711 | - | - | z |
| Total monounsaturated fatty acids | - | - | - | - | 38.975 | - | - | zc |
| 18:2 | - | - | - | - | 44.379 | - | - | z |
| 18:3 | - | - | - | - | 0.551 | - | - | z |
| Total polyunsaturated fatty acids | - | - | - | - | 44.93 | - | - | zc |

| Additional information (in 100 g edible portion) | Units | Mean | Std Error | No. | Scr. |
|---|---|---|---|---|---|
| Alcohol | g | 0 | - | - | p |

| | | | | | |
|---|---|---|---|---|---|
| Carbohydrate, available | g | 32.0 | - | - | z |
| Carbohydrate, total (by difference) | g | 64.8 | - | - | c |
| Dietary fibre | g | 37.25 | - | 1 | z |
| Dry matter | g | 95.24 | - | 2 | z |
| Fructose | g | 0 | - | - | p |
| Glucose | g | 0 | - | - | p |
| Insoluble non-starch polysaccharides | g | 10.56 | - | 1 | z |
| Lactose | g | 0 | - | - | p |
| Maltose | g | 0 | - | - | p |
| Soluble non-starch polysaccharides | g | 26.69 | - | 1 | z |
| Starch | g | 31.97 | - | 1 | z |
| Starch (monosacc) | g | 35.17 | - | 1 | z |
| Sucrose | g | 0 | - | - | p |
| Total available sugars | g | 0 | - | - | p |
| Total available sugars (monosacc) | g | 1.08 | - | 1 | z |
| Total nitrogen | g | 2.66 | - | 1 | z |
| Carbohydrate exchange | | 3.2 | - | - | c |

**KARAKA**, kernel, raw

*Corynocarpus laevigatus*

| Amount in 100 g edible portion | Units | Mean | Std Error | No. | Src. |
|---|---|---|---|---|---|
| PROXIMATES | | | | | |
| Water | g | 46.10 | - | 1 | z |
| Energy | kcal | 208 | - | - | c |
| Energy | kJ | 866 | - | - | c |
| Protein | g | 8.81 | - | 1 | z |
| Total fat | g | 10.36 | - | 1 | z |
| Carbohydrate, available | g | 19.9 | - | - | zx |
| Dietary fibre (Englyst, 1988) | g | 19.05 | - | 1 | z |
| Ash | g | - | - | - | - |

| | | | | | |
|---|---|---|---|---|---|
| NUTRIENT ELEMENTS | | | | | |
| Sodium | mg | 2 | - | 1 | z |
| Magnesium | mg | 96 | - | 1 | z |
| Phosphorus | mg | 189 | - | 1 | z |
| Sulphur | mg | 54 | - | 1 | z |
| Chloride | mg | - | - | - | - |
| Potassium | mg | 565 | - | 1 | z |
| Calcium | mg | 68 | - | 1 | z |
| Manganese | µg | 598 | - | 1 | z |
| Iron | mg | 1.6 | - | 1 | z |
| Copper | mg | 0.8 | - | 1 | z |
| Zinc | mg | 1.0 | - | 1 | z |
| Selenium | µg | T | - | 1 | zl |
| VITAMINS | | | | | |
| Retinol | µg | - | - | - | - |
| Beta-carotene equivalents | µg | - | - | - | - |
| Total vitamin A equivalents | µg | - | - | - | - |
| Thiamin | mg | - | - | - | - |
| Riboflavin | mg | - | - | - | - |
| Niacin | mg | - | - | - | - |
| Potential niacin from tryptophan | mg | - | - | - | - |
| Vitamin B6 | mg | - | - | - | - |
| Pantothenate | mg | - | - | - | - |
| Biotin | µg | - | - | - | - |
| Folate, total | µg | - | - | - | - |
| Vitamin B12 | µg | 0 | - | - | p |
| Vitamin C | mg | - | - | - | - |
| Vitamin D | µg | - | - | - | - |
| Alpha-tocopherol | mg | - | - | - | - |
| Vitamin E | mg | - | - | - | - |

OTHER LIPIDS

| | | | | | |
|---|---|---|---|---|---|
| Cholesterol | mg | - | - | - | - |

| AMINO ACIDS | g/100 g edible portion | | | | mg/g Nitrogen | | | |
|---|---|---|---|---|---|---|---|---|
| | Mean | Std Error | No. | Src. | Mean | Std Error | No. | Src. |
| Isoleucine | - | - | - | - | - | - | - | - |
| Leucine | - | - | - | - | - | - | - | - |
| Lysine | - | - | - | - | - | - | - | - |
| Methionine | - | - | - | - | - | - | - | - |
| Cystine | - | - | - | - | - | - | - | - |
| Phenylalanine | - | - | - | - | - | - | - | - |
| Tyrosine | - | - | - | - | - | - | - | - |
| Threonine | - | - | - | - | - | - | - | - |
| Tryptophan | - | - | - | - | - | - | - | - |
| Valine | - | - | - | - | - | - | - | - |
| Arginine | - | - | - | - | - | - | - | - |
| Histidine | - | - | - | - | - | - | - | - |
| Alanine | - | - | - | - | - | - | - | - |
| Aspartic acid | - | - | - | - | - | - | - | - |
| Glutamic acid | - | - | - | - | - | - | - | - |
| Glycine | - | - | - | - | - | - | - | - |
| Proline | - | - | - | - | - | - | - | - |
| Serine | - | - | - | - | - | - | - | - |
| Hydroxyproline | - | - | - | - | - | - | - | - |

| FATTY ACIDS | g/100 g edible portion Mean | Std Error | No. | Src. | g/100 g total fatty acids Mean | Std Error | No. | Src. |
|---|---|---|---|---|---|---|---|---|
| 12:0 | - | - | - | - | 0.5 | - | - | z |
| 14:0 | - | - | - | - | 0.1 | - | - | z |
| 16:0 | - | - | - | - | 17 | - | - | z |
| 17:0 | - | - | - | - | 0.2 | - | - | z |
| 18:0 | - | - | - | - | 5 | - | - | z |
| 20:0 | - | - | - | - | 3 | - | - | z |
| Total saturated fatty acids | - | - | - | - | 25.8 | - | - | zc |
| 16:1 | - | - | - | - | 0.5 | - | - | z |
| 18:1 | - | - | - | - | 28 | - | - | z |
| 20:1 | - | - | - | - | 0.7 | - | - | z |
| Total monounsaturated fatty acids | - | - | - | - | 29.3 | - | - | zc |
| 18:2 | - | - | - | - | 45 | - | - | z |
| Total polyunsaturated fatty acids | - | - | - | - | 45 | - | - | zc |

| Additional information (in 100 g edible portion) | Units | Mean | Std Error | No. | Scr. |
|---|---|---|---|---|---|
| Alcohol | g | 0 | - | - | p |
| Carbohydrate, available | g | 19.9 | - | - | zx |
| Carbohydrate, total (by difference) | g | 34.7 | - | - | c |
| Dietary fibre | g | 19.05 | - | 1 | z |
| Dry matter | g | 53.90 | - | 1 | z |
| Insoluble non-starch polysaccharides | g | 4.45 | - | 1 | z |
| Lactose | g | 0 | - | - | p |
| Lactose (monosacc) | g | 0 | - | - | p |
| Soluble non-starch polysaccharides | g | 14.60 | - | 1 | z |
| Starch | g | 12.83 | - | 1 | z |
| Starch (monosacc) | g | 14.12 | - | 1 | z |
| Sucrose | g | 7.10 | - | - | x |
| Sucrose (monosacc) | g | 7.45 | - | - | x |
| Total available sugars | g | 7.1 | - | - | x |
| Total available sugars (monosacc) | g | 7.45 | - | 1 | z |
| Total nitrogen | g | 1.41 | - | 1 | z |
| Carbohydrate exchange | | 2 | - | - | c |

# Appendix 7: AsureQuality gluten-free analysis report

AsureQuality Auckland
131 Boundary Road
Blockhouse Bay
PO Box 41
Auckland
New Zealand

Phone: +64 9 626 8000
Fax: +64 9 626 8282
email: vlabauckland@asurequality.com

AsureQuality

03 Jun 2008

Waikato Research Orchard
10 June Place
Hamilton

| | |
|---|---|
| Submitted By | Waikato Research Orchard |
| Job Type | Routine |
| Date/Time Submitted | 25 May 2008 00:00 |
| Date/Time Received | 27 May 2008 09:45 |

Attention: **David Klinac**

***Final LABORATORY REPORT - Job Number 891784***

| Lab Ref | Sample Description | Dates | Test | Test Result |
|---|---|---|---|---|
| 891784-1 | Karaka Nuts in Shell 100g | | Gluten / Gliadin Quantitative ppm | <3 |

| Comment | |
|---|---|
| Lab Ref: 891784-1 | Gluten / Gliadin Quantitative - The Ridascreen Gliadin Assay test kit was used for the analysis and the Limit of Detection is 3 ppm gluten. |

| | | |
|---|---|---|
| **Method Reference** | Gluten / Gliadin Quantitative | ELISA Immunoassay Kit |

K. A. Cave

Kristoph Cave
Analyst - Chemistry

AsureQuality Ltd - Report No 956887 - Page 1 of 1

## Appendix 8: 2009 Nutrient composition of raw, unsalted tree nuts

# 2009 Nutrient Composition of Raw, Unsalted Tree Nuts

| Per 100g | Energy (kJ) | Protein (g) | Fat Total (g) | Fat Saturated (g) | Fat Monounsaturated (g) | Fat Polyunsaturated (g) | Fat Omega 3 as ALA (mg)[1] | Trans Fats (g)[1] | Carbohydrate Total (g) | Carbohydrate Sugars (g) | Dietary Fibre (g) | Sodium (mg) | Potassium (mg) | Magnesium (mg) | Calcium (mg) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Almond | 2503 | 19.5 | 54.7 | 3.7 | 35.9 | 12.8 | 0 | 0 | 4.8 | 4.8 | 8.8 | 5.0 | 740 | 260 | 250 |
| Brazil Nut | 2886 | 14.4 | 68.5 | 14.8 | 21.8 | 29.0 | 0 | 0 | 2.4 | 2.1 | 8.5 | 2.0 | 560 | 350 | 150 |
| Cashew | 2437 | 17.0 | 49.2 | 8.4 | 31.1 | 7.5 | 0 | 0 | 16.8 | 5.5 | 5.9 | 11.0 | 550 | 250 | 34.0 |
| Chestnut[3] | 732 | 3.4 | 0.6 | DU | DU | DU | DU | DU | 34.3 | 3.8 | 8.1 | 0.7 | 574 | 33* | 13.4 |
| Hazelnut | 2689 | 14.8 | 61.4 | 2.7 | 48.8 | 7.2 | 120 | 0 | 5.1 | 4.4 | 10.4 | 3.0 | 680 | 160 | 86.0 |
| Macadamia[5] | 3080 | 9.2 | 74.0 | 10.0 | 59.8 | 3.8 | 99[5] | 0 | 7.9 | 4.6 | 6.4 | 1.4 | 410 | 130# | 85.0# |
| Pecan | 2973 | 9.8 | 71.9 | 4.5 | 39.3 | 25.0 | 620 | 0 | 4.9 | 4.3 | 8.4 | 3.0 | 500 | 110 | 51.0 |
| Pine Nut | 2925 | 13.0 | 70.0 | 4.2 | 23.0 | 39.8 | 0 | 0 | 4.5 | 3.4 | 5.1 | 3.0 | 600 | 230 | 11.0 |
| Pistachio | 2389 | 19.7 | 50.6 | 5.8 | 26.7 | 15.8 | 0 | 0 | 6.8 | 5.9 | 9.0 | 7.0 | 950 | 100 | 90.0 |
| Walnut | 2904 | 14.4 | 69.2 | 4.4 | 12.1 | 49.6 | 6280 | 0 | 3.0 | 2.7 | 6.4 | 3.0 | 440 | 150 | 89.0 |
| Mixed Tree Nuts[4] | 2754 | 14.6 | 63.3 | 6.5 | 33.2 | 21.2 | 791 | 0 | 6.2 | 4.2 | 7.7 | 4.3 | 603 | 193 | 94 |

| Per 100g | Iron (mg) | Zinc (mg) | Thiamin (mg) | Riboflavin (mg) | Niacin (mg) | Folate (µg) | Pantothenic acid (mg)[2] | Vitamin B6 (mg)[2] | Vitamin A (µgRE) | Vitamin E (mg)[2] | Copper (mg)[2] | Manganese (mg)[2] | Selenium (µg)[2] | Arginine (g)[2] | Plant sterols (mg)[2] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Almond | 3.9 | 3.7 | 0.19 | 1.4 | 3.90 | 29 | 0.47 | 0.14 | 2.0 | 26.2 | 1.0 | 2.29 | 2.5 | 2.45 | 141 |
| Brazil Nut | 2.2 | 4.1 | 0.60 | 0.43 | 0.00 | 22 | 0.18 | 0.10 | 2.0 | 5.7 | 1.74 | 1.22 | 1917 | 2.15 | DU |
| Cashew | 5.0 | 5.5 | 0.64 | 0.19 | 1.80 | 25 | 0.86 | 0.42 | 1.0 | 0.9 | 2.20 | 1.66 | 20 | 2.12 | DU |
| Chestnut[3] | 0.8 | 0.5 | 0.28 | 0.09 | 1.97 | 70 | 0.55* | 0.50* | 1.0* | 0.5* | 0.51* | 1.18* | 1.2* | 0.23* | DU |
| Hazelnut | 3.2 | 2.2 | 0.39 | 0.17 | 2.20 | 113 | 0.92 | 0.56 | 3.0 | 15.0 | 1.73 | 6.18 | 2.4 | 2.21 | 96 |
| Macadamia[5] | 3.7# | 1.3# | 1.20# | 0.16# | 2.50# | 11# | 0.76# | 0.28# | 0# | 0.5# | 0.76# | 4.13# | 3.6# | 1.40# | 116# |
| Pecan | 2.4 | 3.9 | 0.42 | 0.18 | 1.30 | 25 | 0.86 | 0.21 | 4.0 | 1.4 | 1.20 | 4.50 | 3.8 | 1.18 | 102 |
| Pine Nut | 4.1 | 5.3 | 0.57 | 0.19 | 4.30 | 34 | 0.31 | 0.09 | 2.0 | 9.3 | 1.32 | 8.80 | 0.7 | 2.41 | 141 |
| Pistachio | 3.9 | 2.3 | 0.58 | 0.29 | 1.50 | 81 | 0.52 | 1.70 | 22.0 | 2.3 | 1.30 | 1.20 | 7.0 | 2.03 | 214 |
| Walnut | 2.5 | 2.5 | 0.33 | 0.18 | 1.40 | 70 | 0.57 | 0.54 | 4.0 | 0.7 | 1.59 | 3.41 | 4.9 | 2.28 | 72 |
| Mixed Tree Nuts[4] | 3.4 | 3.4 | 0.55 | 0.35 | 2.17 | 45.6 | 0.61 | 0.45 | 4.4 | 7.0 | 1.43 | 3.71 | 218 | 2.03 | 126 |

DU = Data Unavailable

Figures from NUTTAB 2006 unless otherwise indicated.

1. Fatty acid database Revision 6.0 RMIT Lipid Research Group, Foodworks 2007 Version 5.00, Xyris Software
2. United States Department of Agriculture National Nutrient Database for Standard Reference Release 21, 2008, ASCII
3. Australian data for dry roasted chestnuts www.chestnutgrowers.com.au *US data for European roasted chestnuts
4. Average quantities excluding those nuts with unavailable data and chestnuts
5. Macadamia data taken from 2002 lab analysis provided by Australian Macadamia Society except where indicated
   #US data for raw macadamias

This information has been prepared by Nuts for Life for educational purposes only.

Nuts for Life – An initiative of the Australian Nut Industry and Horticulture Australia.



For more information on the Nuts for Life Program refer to www.nutsforlife.com.au

## Appendx 9: Karaka processing parameters: moisture and sugar contents

- When making commercial dried nut products/flour, moisture content is very important. Most commercial nuts (like chestnuts) are around 50% moisture content, when fresh, and must be dried down to approx. 5-8% moisture content for dried nut pieces, slices or crumb; and down to 3-5% moisture content for flour
- While nuts are not usually thought of as having high sugar content (Brix), chestnut kernels actually have a Brix level of 20-30, compared to most fruit which are in the range of 15-30. High sugar content usually means good value-added processing potential and suitability for products such as jams/spreads, confectionary, liqueur, beer, bakery goods etc.
- Moisture contents were determined by drying berry/kernel samples to constant weight in a 50C drying oven, then calculating the weight loss due to the water removed. Sugar contents (Brix levels) were measured with a refractometer after "juicing".

**Karaka moisture contents:**

kernels (only) harvested off the ground : 30.0 – 34.8% (ave. : 32.4%)

kernels (only) harvested off the tree : 36.4 – 48.3% (ave. : 43.7%)

kernels & berry (combined) : 53.9 - 65.9% (ave. : 59.3%)

berry flesh (only) : 68.3 – 77.9% (ave. : 72.7%)

old dry fallen kernels (or glasshouse dried): 23.8 – 29.4% (ave. : 25.8%)

old, dry kernels (after 12 months storage) : 7.1 - 9.6% (ave. : 8.1%)

**Karaka kernel/berry recovery ratios (by weight):**

NB: this ratio could vary hugely from 100% berry weight (0 kernel weight) in the case of unpollinated "blanks" to 100% nut weight (0 berry weight) in the case of fallen kernels from which the berry flesh has all rotten off/been eaten.

For a complete berry/kernel harvested intact from the tree, a typical berry/kernel breakdown was:

Berry flesh from 10 fruit (g): 58.0 = 57%

Kernels from 10 fruit (g): 43.8 = 43%

**Karaka sugar contents:**

Berry flesh : 14.9 – 27.0 Brix (ave.: 19.3)

Kernel : 21.2 – 25.2 Brix (ave.: 23.5)

- the above values are all broadly comparable with other commercial fruit and nut crops (eg. chestnuts)
- karaka nuts/berries should therefore be suitable for use in established fruit/nut processing applications

# Appendix 10: Hill Laboratories analysis report – karaka berries

**Hill Laboratories**
BETTER TESTING **BETTER RESULTS**

R J Hill Laboratories Limited
1 Clyde Street
Private Bag 3205
Hamilton 3240, New Zealand

**Tel** +64 7 858 2000
**Fax** +64 7 858 2001
**Email** mail@hill-labs.co.nz
**Web** www.hill-labs.co.nz

## ANALYSIS REPORT



| | | | |
|---|---|---|---|
| **Client:** | Omnia Primaxa Limited | **Lab No:** | 741799 shpv1 |
| **Address:** | PO Box 201041<br>Auckland Airport<br>AUCKLAND 2150 | **Date Registered:** | 07-Nov-2009 |
| | | **Date Reported:** | 10-Nov-2009 |
| | | **Quote No:** | |
| | | **Order No:** | |
| | | **Client Reference:** | |
| | | **Submitted By:** | Dr Adrian Spiers |

**Sample Name:** Karaka Berry **Lab Number:** 741799.5
**Sample Type:** General, Non-specified NZ (P10)

| Analysis | | Level Found | Medium Range | Low | Medium | High |
|---|---|---|---|---|---|---|
| Nitrogen | % | 2.7 | | | | |
| Phosphorus | % | 0.20 | | | | |
| Potassium | % | 1.0 | | | | |
| Sulphur | % | 0.13 | | | | |
| Calcium | % | 3.59 | | | | |
| Magnesium | % | 0.37 | | | | |
| Sodium | % | 0.11 | | | | |
| Iron | mg/kg | 78 | | | | |
| Manganese | mg/kg | 110 | | | | |
| Zinc | mg/kg | 22 | | | | |
| Copper | mg/kg | 8 | | | | |
| Boron | mg/kg | 27 | | | | |
| Chloride | % | 0.36 | | | | |
| Grass Staggers Index* | me | 0.1 | (<1.8 recommended, >2.2 increased risk) | | | |
| K/Na Ratio* | | 9 | (<10 recommended, >20 increased risk) | | | |
| Ca/P Ratio* | | 18.0 | (>1.5 recommended, <1.2 increased risk) | | | |
| DCAD* | me | 124 | (<200 recommended, >200 increased risk) | | | |

The above nutrient graph compares the levels found with reference interpretation levels. NOTE: It is important that the correct sample type be assigned, and that the recommended sampling procedure has been followed. R J Hill Laboratories Limited does not accept any responsibility for the resulting use of this information. IANZ Accreditation does not apply to comments and interpretations, i.e. the 'Range Levels' and subsequent graphs.

### Analyst's Comments

Normal range levels for each nutrient have not been printed on this report. Either the plant species or the plant part submitted for analysis has not been clearly specified or identified, or the normal range data is not available.

Please contact the Laboratory for more information: Ph (07) 858 2000, mail@hill-labs.co.nz or check our website, www.Hill-Laboratories.com

The nutrient ratio indices have been calculated to assist in evaluating the suitability of this sample as a dairy feed. Although based on published calculations, they should be used with caution, as metabolic disorders can be induced by a multitude of factors, and not just these nutrient ratios alone. For further details of the calculations, please contact this laboratory.

## Appendix 11: Karaka storage trials

Intact karaka nuts, either still in the berry or with all berry flesh removed, were stored at room temperature, in open trays in a coolstore at 3C, in plastic bags in a coolstore at 3C, or in a freezer at -20C. Some nuts, either still in the ripe berry or with all berry flesh removed, were air/sun dried in a glasshouse at 30C for 48 hrs before storage. All samples were inspected at regular intervals for external surface mould, discolouration and internal rot.

**Results:**

**1. fresh nuts/berries at room temperature:**

- after 1 week at room temp. (in berry) : 100% discolouration, surface mould and rot
- after 1 week at room temp. (kernels only) : some discolouration but no mould/rot
- after 1 month at room temp. (in berry) : all rotten (as above)
- after 1 month at room temp. (kernels only) : some discolouration/surface mould; <5% rot
- after 6 months at room temp. (in berry) : all rotten (as above)
- after 6 months at room temp. (kernels only): most nuts with some discolouration & surface mould; significant dehydration (nuts rattling inside shell); <10% rot
- after 12 months at room temp. (in berry) : all rotten
- after 12 months at room temp. (kernels only): as above; up to 25% rot

**2. after air/sun drying first:**

- after 1-12 months (either in berry or kernels only): some dehydration; <5-10% rots

**3: fresh nuts/berries in coolstorage at 3C:**

- after 1 month (in berry) : 100% discolouration/surface mould; <5% rot
- after 1 month (kernels only) : no significant change over time
- after 6 months (in berry) : 100% discolouration/surface mould; <25% rot
- after 6 months (kernels only) : some discolouration; significant dehydration
- after 12 months (in berry) : 100% discolouration/surface mould; <35% rot
- after 12 months (kernel only) : most nuts with some discolouration/surface mould; significant dehydration; <15% rot

**4: fresh nuts/berries in coolstorage at 3C in plastic bags:**

- after 1-12 months (in berry) : as above, but with negligible dehydration
- after 1-12 months (kernels only) : as above, but with negligible dehydration

**5: fresh nuts/berries in freezer storage at -20C:**

- after 1-12 months (either in berries or kernels only): no significant change over time

**Conclusions:**

- storage is easier than for most other commercial nutcrops
- external discolouration/surface mould is usually only a cosmetic/surface problem: not necessarily affecting internal nut quality
- nuts store significantly better/longer without the berry flesh still attached
- predrying before storage improves storage life (though increasing dehydration/weight loss)
- dehydration/weight loss also becomes significant over time (1-6 months+)
- plastic bags can be used to prevent/control dehydration in storage
- successful storage for 6-12 months is possible using basic coolstorage procedures

**NB:** 6 months storage for nutcrops facilitates out-of-season access to Northern Hemisphere markets. 12 months storage for nutcrops facilitates year-round processing and the release of product onto early season markets in the subsequent year (when nut prices are usually highest)

## Appendix 12: DOC kiwi toxicosis media release: December 2008

# Media releases

## Convalescing kiwi catches train to capital

**Contact:**

Rosemary Vander Lee,

**Pukaha Mount Bruce National Wildlife Centre**

**Phone:** +64 6 375 8004

**Address:** State Highway 2
Masterton

**Date:** 11 December 2008

A little spotted kiwi from Kapiti Island that has been convalescing at Pukaha Mount Bruce after succumbing to the toxic effects of karaka berries, was well enough to travel by train yesterday, for the next stage in his recovery - a stint in the protected wilderness of Karori Sanctuary.

The adult male kiwi was taken to Massey University for treatment in March when he was found close to death on the island after eating the berries of karaka (***Corynocarpus laevigatus***). Karaka berries contain a toxin (karakin), which can cause weakness, hind leg paralysis and convulsions in kiwi.

**DOC captive breeding rangers Darren Page and Annetta Hunt with the kiwi they have been nursing back to health**

In June, and weighing just 800 grams, he was moved to Pukaha Mount Bruce National Wildlife Centre where he was force-fed for nearly a month before being introduced to an artificial diet.

By early July he was eating on his own and is now a healthy 1050 grams - fit enough to travel by train from the Wairarapa to Wellington yesterday for the next stage in his journey back to health.

He is now at the Karori Sanctuary where, because of some residual neurological deficiencies, he will be assessed as to his suitability to be released back into the wild.

**DOC programme manager Rosemary Vander Lee accompanies the kiwi by train to Wellington**

Department of Conservation captive breeding ranger Darren Page said it had been “very satisfying” to be involved in nursing the kiwi back to health.

“It’s incredibly rewarding to see him take the next step on the road to recovery.”

BNZ Save the Kiwi works with Department of Conservation and community groups nationwide to support the recovery of kiwi.

In the Wellington region, only Kapiti Island and Karori Sanctuary are home to the little spotted kiwi.

## Appendix 13: History of the word "Karaka"

From Te Māra Reo website - http://www.tumanako.org

*Te Māra Reo ~ The Language Garden*

PROTO-POLYNESIAN ETYMOLOGIES

# *Kalaka

*Planchonella (Pouteria) spp.*, [Sapotaceae].

*From* PROTO OCEANIC **kalaka (Planchonella spp.)*

**NOTE - THIS PROTO-PAGE IS STILL IN THE EARLY STAGES OF CONSTRUCTION!**

This name has been used to denote a local species of the genus Planchonella in many Oceanic languages. The botanical classification of the trees has been disputed over the decades, and the species have been shifted between the related genera Planchonella and Pouteria several times in recent years, and will be found under one classification or the other in different works. Fortunately, there seems to be general agreement about the family (Sapotaceae). The status of the species is also a subject of controversy, because of the variability in the form of individual plants -- the native New Zealand and Fijian plants have been grouped together as a single species, *Planchonella costata* by some botanists, on occasions along with the Polynesian species noted here under the name *P. grayana*, and regarded as separate species by others. They are forest trees, with individual mature plants of the found in both the canopy and subcanopy. In New Zealand, Planchonella is found mostly in coastal areas in Northland, Auckland, the Bay of Plenty and the East Coast regions.

The trees have a milky sap, and conspicuous leaves and even more conspicuous large berries with change gradually from green to bright red as they ripen.The tree also has a milky latex sap. It is not at all surprising that the early Polynesians mistook the New Zealand karaka, Corynocarpus laevigatus, for its tropical namesake. The trees are in their general appearance at all stages of growth very much look-alikes. The nature of the fruit is different, however. Desptite their attractive appearance the Pouteria fruit are not really edible, although Malcolm Ross reports that on the island of Santo Planchonella fruits are sometimes roasted and eaten after being washed to remove the latex (*Lexicon*, Vol. 3, p.203). If this was also done occasionally in Polynesia, it would have been a useful practice in the preparation of the *Corynocarpus* fruits, whose kernels were an important food source, but had to be heated and washed first to remove the powerful toxic glycoside they contained. (They also had the precedent of the "Tahitian chestnut", Inocarpus fagifer, which requires similar treatment to make it edible.)

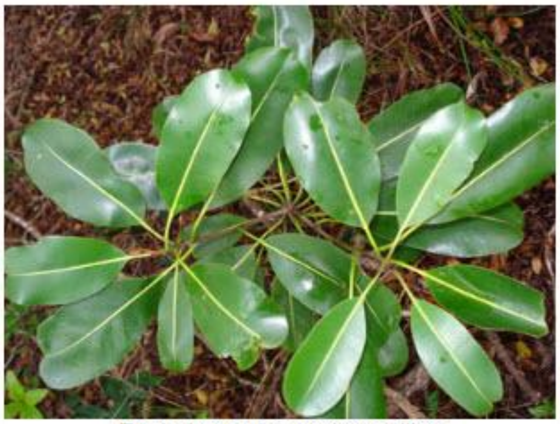
**Reflexes:**
*Tongan*: **Kalaka** *(Planchonella grayana)*
*Niuean*: **Kalaka** *(P. grayana)*
*Samoan*: **Ala'a** *(P. garberi, & Chariessa samoensis [Icacinaceae])*
*Hawaiian*: **'āla'a** *(P. sandwicensis)*
*Tuamotuan*: **Karaka** *(P. grayana)*
*Rarotongan*: **Karaka** *(P. grayana & Elaeocarpus rarotongensis [Elaeocarpaceae])*
*Maori*: **Karaka** *(Corynocarpus laevigatus [Corynocarpaceae]* & **Karakariki** *(Streblus heterophyllus [Moraceae])*

*Pouteria sandwicensis*: in flower

*Pouteria sandwicensis* unripe fruit

Chariessa samoensis, which also has been given a name derived from *kalaka, is a small forest tree growing from 3 to 8 metres high and found in lowland and high altitudes. I have not been able to find any photographs of it. The Rarotongan *Elaeocarpus* is a relation of the New Zealand hinau, and like the Planchonellas and the other "*kalaka" trees, has large, conspicuous fruits and striking foliage.

*Corynocarpus laevigata* ripe fruit



*Pouteria sandwicensis* seedling

*Pouteria sandwicensis* young tree

***Further information***. The Cook Islands biodiversity database

http://cookislands.bishopmuseum.org/species.asp?id=6094 Elaeocarpus info

http://cookislands.bishopmuseum.org/species.asp?id=6572 Pouteria info & picture

***Source of photographs***: Karaka fruits: http://www.kererudiscovery.org.nz; *Pouteria sandwicensis*: R.B. (the seedling was in the Kahanahāiki Forest, Oahu, Hawaī; the others are of trees in the Koke'e Forest Park, Kaua'i).

Te Mära Reo, c/o Benton Family Trust, "Tumanako", RD 1, Taupiri, Waikato 3791, Aotearoa / New Zealand