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Rural Industries Research and Development Corporation

New Root Vegetables for the Native Food Industry

— Promising selections from south Western Australia's tuberous flora —

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New Root Vegetables for the Native Food Industry:

Promising selections from south Western Australia's tuberous flora

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Foreword

Rural Australia makes a fundamental contribution to the Australian economy and way of life. In addition to the major industries, numerous new and emerging rural industries bring opportunity, diversity and resilience to rural Australia. New industry development is critical in the drier areas of southern Western Australia (350-600 mm) and these areas desperately need a range of ecologically sustainable industries to address or adapt to declining rainfall, salinity and population decline and biodiversity loss. Australian perennial flora offers opportunity in this regard. Many species have the potential to become economically viable for the oil, food, timber, flower or extractive industries. This project aimed to systematically assess the horticultural potential of southern Western Australia's diverse tuberous flora and commence commercialisation of promising species as new vegetable crops.

The Rural Industries Research and Development Corporation invests in new and emerging industries on behalf of government and industry stakeholders. New industries provide opportunities to be captured by rural producers and investors. They also provide avenues for farmers facing adjustment pressure to diversify and manage change. The establishment of new industries contributes to community resilience and regional development. Increasingly, new industries are also contributing to a distinctive regional character in rural Australia.

While the need for new industries is accepted, we as Australians have not looked at opportunities that lie in our backyard, our native flora.

The importance of this report is that it provides that an overview of progress towards introducing new native vegetable products into the Australian food industry. There is a distinct lack of native vegetable products available and a requirement for native vegetable products was identified by consumers, chefs and suppliers of native foods.

It is recommended that *Ipomoea calobra* (Kulyu) and *Platysace deflexa* (Youlk) were identified as potential new Native Australian vegetable crops for cultivation. Of particular significance, this project has shown the commercial prospects for *I. calobra* to be exceptionally encouraging. This project has clearly shown that the market would enthusiastically embrace product derived from *I. calobra* and that the product could fit within existing vegetable processing, distribution and retail systems, although further research is recommended. This crop offers opportunities for regional and indigenous enterprises.

This project was funded from RIRDC Core Funds which are provided by the Australian Government. Significant cash contributions were also provided by The Australian Flora Foundation, the Great Southern Development Commission and South Coast NRM Inc. Contributions were also received from Tectonic Resources NL, Greening Australia and the Chemistry Centre, Western Australia.

This report, an addition to RIRDC's diverse range of over 1900 research publications forms part of our New Plants Products R&D program, which aims to facilitate the development of new industries based on plants or plant products that have commercial potential for Australia.

Most of RIRDC's publications are available for viewing, downloading or purchasing online at www.rirdc.gov.au. Purchases can also be made by phoning 1300 634 313.

Peter O'Brien
Managing Director
Rural Industries Research and Development Corporation

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The following individuals are thanked for the information they provided to the project, their guidance and technical support: Louis Evans, Lincoln Morton, Chris Robinson, Greg Keighery, Greg Cawthray, Kelly Flugge, Kado Muir and family, Frances Giles, Annie Brandenberg & Veronica Yeo. All landholder and food industry participants are also thanked for their contributions.

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What is the report about

This report documents progress towards introducing new native vegetable products into the Australian food industry. None of the species that were the focus of this study had ever been cultivated on cleared agricultural land and were not used by any sector of the Australian food industry prior to the commencement of this project.

Who is the report targeted at

This report is targeted to those wishing to grow, distribute or utilise new native root vegetables. Funding bodies active in the food industry and companies/development bodies interested in regional opportunities for indigenous and non indigenous people are encouraged to review this document.

Background

The Australian native edible plant industry is rapidly expanding though most of the products are fruit based products or spices/seasonings. There is a distinct lack of native vegetable products available and a requirement for native vegetable products was identified by consumers, chefs and suppliers of native foods. They identified that their industry needed native vegetable foods that could replace traditional vegetables. That is, they required native vegetable food products to be used as “staple bulk foods” to replace the use of carrots, potato and other root vegetables.

The flora of Western Australia contains an extraordinary number of species that form root tubers. Over 85% of 153 tuberous species recorded in Western Australia occur in the south west of the state. This diversity provided an unparalleled resource from which new horticultural crops could be developed. The diversity of the flora is of international significance but had not been surveyed for potential vegetable crops.

Aims/objectives

This project aimed to systematically assess the horticultural potential of southern Western Australia’s diverse tuberous flora and commence commercialisation of promising species as new vegetable crops. For each selected target species the study more specifically aimed to concomitantly: develop a reliable and cost effective propagation system, develop a cultivation system, determine the species productive capacity, investigate the nutritional value of tubers and finally assess the species commercial potential and if warranted, commence commercialisation and product development.

Methods, results and key findings

Although there are many species that produce underground fleshy storage organs, many have undesirable properties and or do not have a clear (unambiguous) history of local consumption. An unambiguous history of consumption was a prerequisite for selection into the target group. Plant and product characteristics of tuberous flora native to southern Western Australia were assessed. Field observation and available information were used to make an assessment of remaining species in regard to their vegetative vigour, reproductive vigour and likely ease of propagation. Attributes such as size, colour, flavour, texture and abundance of the potential product were also assessed. This approach suggested that a target group comprised of *Platysace deflexa*, *Ipomoea calobra* and *Haemodorum spicatum* were worthy contenders for further study.

Propagation systems for all three target species were developed. The development of a mass propagation system for *Platysace deflexa* was extremely difficult, however a reliable system based on tip cuttings taken at certain times of the year, hormone treated, then planted into a free draining media and kept under water limited conditions, produced quality material for cultivation. Seeds of *Ipomoea* *calobra* were highly germinable when mechanically or chemically scarified. *I. calobra* was found to be a prolific seed producer and can be cost effectively established by direct sowing in the field. *Haemodorum spicatum* was easy to establish in the greenhouse and in the field by direct sown seed.

This project has clearly shown that the market would enthusiastically embrace product derived from *I. calobra* and that the product could fit within existing vegetable processing, distribution and retail systems. Its nutritional value is broadly similar to that of sweet potato though some nutritional components differ. The project has also developed a basic propagation and cultivation system capable of producing approximately 35 t/ha of product over a 12 month rotation when cultivated under intensive horticultural conditions at Carnarvon in Western Australia. It can thus be justifiably concluded that *I. calobra* is well on the way to becoming a commercial reality.

Consumers and the food industry in general were excited by product from *Platysace deflexa*, though the supply of cultivated product from the field trials was very limited throughout this project. This limited the ability to undertake a retail trial or to test integration into an existing or new supply chains. Sampling of wild material suggested that 24 t/ha could be achieved, however harvested plants of only 1.5 years produced an equivalent production of 0.75 t/ha which was comprised of very small and unmarketable tubers. Although yield was low it was very encouraging that tuber formation was confined to the mound, and when more mature, the species would be well suited to mechanical harvesting. An opportunity for this product in the food industry exists but due to a very limited initial supply base, the commercialisation of *Platysace deflexa* tubers will need to be incremental and carefully managed, with efforts to expand the market occurring only when supply can be ensured. It is recommended that future investment needs to focus on optimising the cultivation system for maximal tuber production in the shortest possible time.

Following the species selection stage of this project, *Haemodorum spicatum* did not demonstrate further potential as a new vegetable product. Preliminary product research through appraisals highlighted key features contributing to consumer's dislike of the bulb. These include the staining effect (red pigment), fibrous texture and bitter taste. In addition, it was evident that sizeable bulbs may take several years to form, a major factor limiting horticultural development of the species.

Recommendations

Although this project has shown the commercial prospects for *I. calobra* to be exceptionally encouraging, the following recommendations are of paramount importance if this species is to become a commercial reality. Future research needs to determine how the cultivation environment can be engineered to facilitate shallow tuber formation and thus the ability of the crop to be mechanically harvested (a key requirement for profitable cultivation). A participatory development stage needs to commence as soon as possible where production and demand are increased concomitantly. Technical assistance needs to be provided to potential growers and together, researchers and growers should aim to optimise production systems. Promotion of the product should reflect the amount of product available. The high level of demand and interest in the product suggests that demand is likely to be larger than supply in the short to medium term and thus too much promotion without the ability to supply could be damaging and should not be encouraged.

It is recommended that *I. calobra* and *P. deflexa* be persued as new vegetable crops. *H. spicatum* should not be persued as a vegetable crop, though it does have considerable appeal as a spicy food colouring agent and as a dye. If *I. calobra* and *P. deflexa* are to become small but significant species in the food industry, this project will need to be followed by an industry building phase where larger quantities of product are produced, production systems continuously improved and where promotion of the product reflects the amount of product available. This crop offers opportunities for regional and indigenous enterprises.

Introduction

The Australian native edible plant industry, commonly referred to as the "bushfoods" industry, is rapidly expanding (Ahmed and Johnson 2000). In 1997 the industry value was estimated to be worth $12 million, which was based on 14 commercially significant crops; *Acacia spp*. (Wattle), *Acronychia acidula* (Lemon Aspen), *Backhousia citriodora* (Lemon Myrtle), *Eremocitrus glauca* (Desert Lime) and *Microcitrus spp*. (Native Lime), *Hibiscus heterophyllus* and *Hibiscus sabdariffa* (Rosella), *Kunzea pomifera* (Muntries), *Podocarpus elatus* (Illawarra Plum), *Prostanthera spp*. (Native Mint), *Santalum acuminatum* (Quandong), *Solanum centrale* (Bush Tomato), *Syzygium leuhmannii* (Riberry), *Tasmannia spp*. (Native Pepper), *Terminalia ferdinandiana* (=*T. latipes* subsp. *psilocarpa*) (Kakadu Plum) and *Tetragonia tetragonioides* (Warrigal Greens) (Graham and Hart 1997). These species are grown for their edible fruits, leaves or seeds. Most of these species are not currently used by the bushfoods industry (and more importantly the wider food industry) as staple foods and most are used as flavourings, seasonings or additives. Interestingly, there are no Australian native species commercially grown for their edible below ground fleshy storage organs (though development work has started on Boab roots, Johnson *et al* 2002). To date there hasn't been a systematic assessment of the Western Australian flora (particularly species from the mega diverse south-west) for potential vegetable crops. In contrast, the area's rich diversity has been explored (with great success) for new species with floriculture or forestry application.

The flora of southern Western Australia is of international significance and contains an extraordinary number of species that form fleshy underground storage organs. Over 85% of 153 tuberous species recorded in Western Australia occur in the south west of the state (Pate and Dixon 1982). The total number of tuber forming taxa is currently estimated at 400–450 (Keighery 2003 pers. comm.) and this diversity provides an unparalleled resource to survey for potential new vegetable crops.

Table 1 Western Australian taxa with fleshy underground storage organs and those that were consumed as food by indigenous people

(Based on Pate and Dixon 1982 [and references therein], Bindon 1998 and Daw et al 2001)

MAJOR TAXON / FAMILY	Number of species with underground storage organs (WA)	Total Number of species (WA)	Aboriginal food	species	Distribution within WA	Number of species in genus	References
ANGIOSPERMAE							
DICOTYLEDONEAE							
PROTEACEAE	7	779					
Bombacaceae	1	4		*Adansonia gregorii*	north	1	Johnson et al (2002)
PORTULACACEAE	7	60	yes	Portulaca pilosa	north	12	crawford
PORTULACACEAE	7	60	yes	*Calandrinia spp*	north and south	31	Cribb and Crib (1975)
AMARANTHACEAE	1	153					
RANUNCULACEAE	3	15	yes	Clematis spp.	mostly sw	5	Oates
DROSERACEAE	14	98	yes	Drosera spp.	south and north	93	Hammond (1933)
PAPILIONACEAE	4	921	yes	*Vigna lanceolata*	north	9	Bindon 1998
GERANIACEAE	4	20	yes	Geranium solanderi	south	2	Oates (1977); Lampert et al (1973)
POLYGALACEAE		36					
VITACEAE	3	8		*Cayratia trifolia*	north	2	Crawford; Bindon 1998
VITACEAE	3	8		*Ampelocissus acetosa*	north	1	Crawford,
MALVACEAE	1	177					
STERCULIACEAE	1	161	yes	Brachychiton gregorii	south and north	14	Cribb and Crib (1975)
MYRTACEAE	1	1492					
APIACEAE	12	122	yes	Platysace spp	south	19	Hassell (1974, Drummond 1839 , Meagher 1974
PRIMULACEAE	1	11					
GENTIANACEAE	2	9					
ASCLEPIADACEAE	1	37					
CONVOLVULACEAE	3	78	yes	Ipomoea spp.	mostly north, some spp south	22	Crawford, Scott 1972
CONVOLVULACEAE	3	78	yes	*Convolvulus angustissimus*	mostly south, extending into north	6	Oates (1977)
SCROPHULARIACEAE	1	84					
LENTIBULARIACEAE	1	39					
CAMPANULACEAE	1	10					
STYLIDIACEAE	5						
ASTERACEAE	5	600	yes	Microseris scapigera	south	1	Cribb and Crib (1975); Oates (1977)
Nyctaginaceae	1	9	yes	*Boerhavia coccinea*	north and south	7	Bindon 1998
Nymphaeaceae	9	9	yes	*Nymphaea macrosperma*	north	6	Bindon 1998
MONOCOTYLEDONEAE							
JUNCAGINACEAE	1	19	yes (species ID?)	Triglochin spp	south and north	19	Cribb and Crib (1975); Oates (1977)
		128					
Anthericaceae	24	128	yes	Thysanotus spp	south and north	49	Meagher (1974) Oats (1977); Bindon 1998Daw et al 2001
Anthericaceae	24	128	yes	*Caesia spp*	south west	7	Meagher (1974) Oats (1977)
Anthericaceae	24	128	yes	*Dichopogon spp*	south	4	Cribb and Crib (1975)
XANTHORRHOEACEAE	2	10					
HAEMODORACEAE	4	84	yes	Haemodorum spp	mostly south west	15	Moore (1884); Backhouse (1843) Hassel (1936)
HAEMODORACEAE	4	84	yes	*Tribonanthes spp.*	south west	7	Moore (1884); Hammond (1933); Bindon 1998
AMARYLLIDACEAE	3	12	yes	Crinum flaccidum	north west	4	
HYPOXIDACEAE	5	9	yes	Hypoxis spp	mostly south west	13	
HYPOXIDACEAE	5	9	yes	*Curculigo ensifolia*		1	
TACCACEAE	2	2	yes	*Tacca leontopetaloides, Tacca maculata*	north	2	Crawford; Bindon 1998)
DIOSCOREACEAE	2	3	yes	*Dioscorea bulbifera, Dioscorea hastifolia D. transversa*	north except hastifolia	3	Crawford, Hammond (1933); Bindon 1998, Daw et al 2001
IRIDACEAE	1	66					
PHILYDRACEAE	1	3					
JUNCACEAE	1	24					
COMMELINACEAE	3	11	yes	*Commelina ciliata*	north	3	Crawford
COMMELINACEAE	3	11	yes	*Cartonema parviflorum*	north	7	Crawford; Bindon 1998)
COMMELINACEAE	3	11	yes	*Murdannia graminea*	north	1	Bindon 1998
POACEAE	1	647					
ARACEAE	4	9	yes	Typhonium liliifolium	north	4	Crawford
Araceae	4	9	yes	Amorphophallus galbra	north	1	Bindon 1998
ARACEAE	4	9	yes	*Colocasia esculenta*	north	1	Crawford; Bindon 1998)
CYPERACEAE	1	383	yes	*Cyperus bulbosus + C rotundus*	north		Bindon 1998
CYPERACEAE	1	383	yes	*Bolboschoenus caldwellii*	south west	2	Cribb and Crib (1975); Oates (1977)
ORCHIDACEAE	65	383	yes	various	south and north	383	Nind 1831 Hammond 1933
Colchicaceae	27	27	yes	Wurmbea	sw	21	Cribb and Crib (1975); Oates (1977)
Colchicaceae	27	27	yes	*Burchardia*	sw	5	Drummond (1842); Oates (1977); Lampert and Sanders (1973) ; Bindon 1998, Daw et al 2001
Aponogetonaceae	1	3	yes	*Aponogeton euryspermus*	north	3	Bindon 1998

The fleshy underground storage organs produced by some species were routinely consumed by indigenous people prior to European settlement and a number of early settlers consumed and documented encounters they had with vegetable products observed to have been consumed by aboriginals of southern Western Australia. The horticultural potential of one tuberous species (*Platysace cirrosa*) was noted by Europeans as far back as 1835 when G.F. Moore (in Kenneally 1977) recorded in his diary that he had…

> *"discovered a bulbous root like a dark potato, …., which I mean to cultivate and which may be very useful if it succeeds".*

Unfortunately this species had been ignored by researchers since 1835. In the Jerramungup area a European pioneer, Ethel Hassell 1878–1886, (Hassell 1975) experimented with *Platysace deflexa* and

Haemodorum spp. and thought the former to be a pleasant food, particularly when roasted. Given this diversity and history of utilisation, a project that aimed to develop new vegetable products from the flora appeared to have merit.

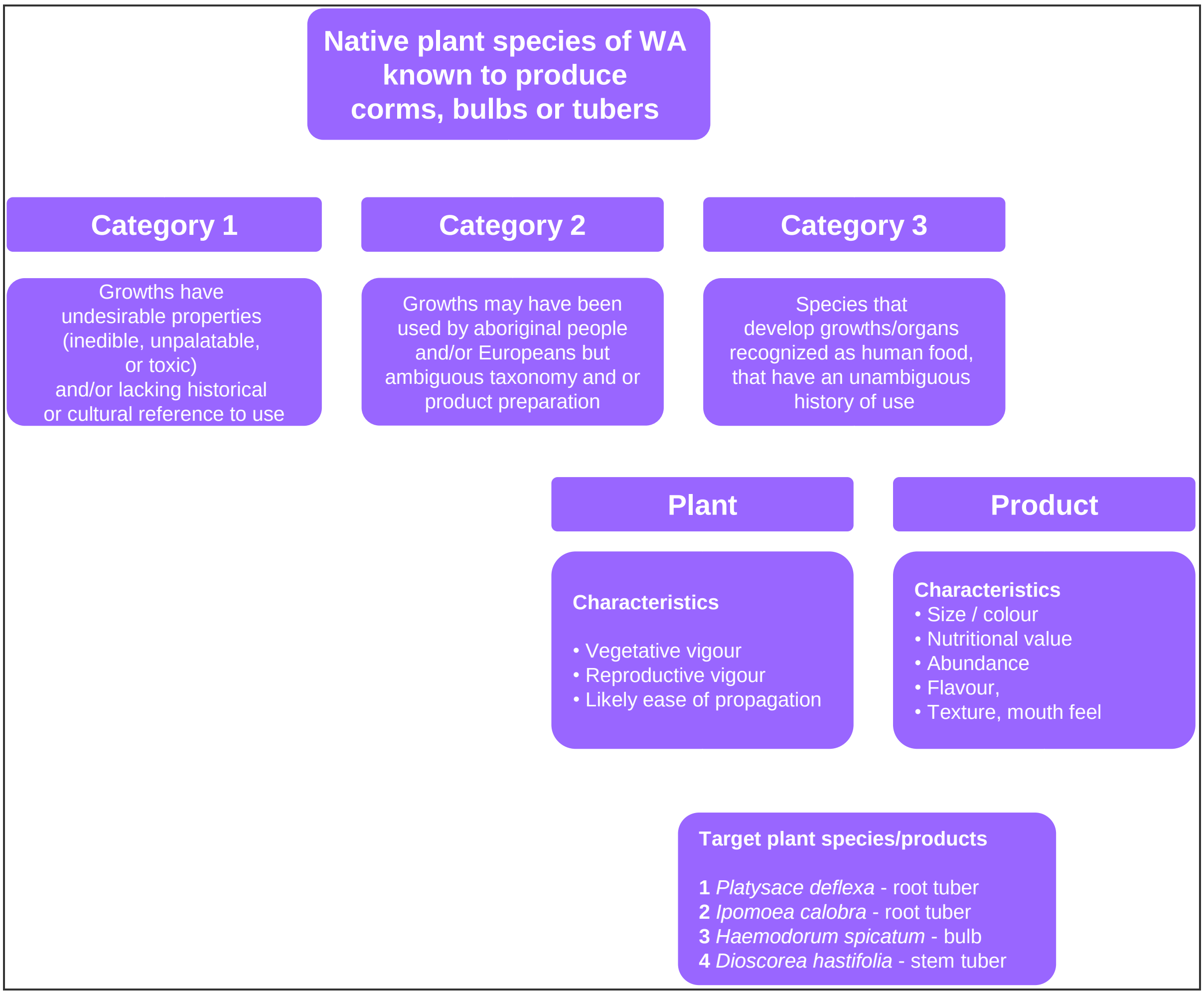


Figure 1 Process adopted for selection of target species

Previous research has shown that tubers of *Platysace deflexa* display promise as a new vegetable product and that the species has many desirable horticultural attributes (Woodall 2003). The first objective of this current study was to determine whether there were other promising species within the flora of southern Western Australia. The approach used to prospect through the flora is outlined in Figure 1 and the net result was the isolation of a small group of a target species from the larger group of tuberous/bulbous native plants. It should be noted that members of the Orchidaceae were not assessed as part of this study.

Although there are many species that produce underground fleshy storage organs (Table 1), many have undesirable properties and or do not have a clear (unambiguous) history of local consumption. An unambiguous history of consumption was a prerequisite for selection into the target group (Figure 1). Species known to be inedible, unpalatable or toxic or known to contain anti nutritional factors were excluded from this study. Plant and product characteristics of the remaining species/genera were further assessed. Field observation and available information were used to make an assessment of remaining species in regard to their vegetative vigour, reproductive vigour and likely ease of propagation. Attributes such as size, colour, flavour, texture and abundance of the potential product were also assessed. This approach suggested that a target group comprised of *Platysace deflexa*, *Ipomoea calobra* and *Haemodorum spicatum* were worthy contenders for further study.

For each target species identified above, this project aimed to develop propagation and cultivation systems, determine the productive capacity of each species, conduct appraisals of the product, and conduct preliminary economic analysis of the products/systems developed.

Platysace deflexa

Introduction

Platysace deflexa (Turcz.) C. Norman is a small herbaceous perennial shrub (up to 0.6 m tall). It is a member of the Apiaceae, a family of plants which includes many horticulturally important food plans including carrots. A common Aboriginal name for this species is “Youlk” and the preferred common name being “Ravensthorpe Radish” or “Ravish” (the latter name suggested by the wife of the Governor of Western Australia when she visited Albany during the project). It has a rhizomatous root system and, in the wild, one to many bushes may arise from the same root system. The species readily suckers in its natural setting whenever the soil is disturbed. The species is endemic to the southwest bioregion and is common in the Jerramungup to Ravensthorpe region of Western Australia, often on light textured, sandy duplex soils that support mallee or heath. This region receives approximately 350–450 mm of annual, mostly winter, rainfall.

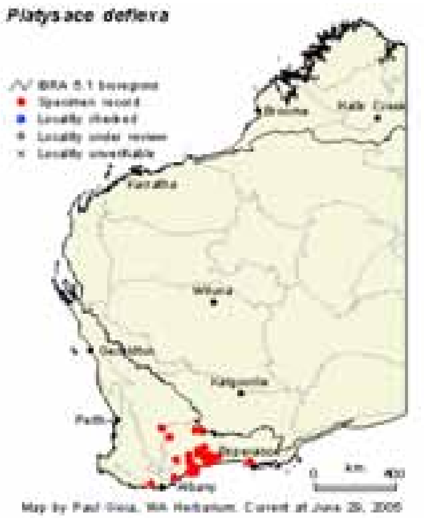


Figure 2 Distribution of *Platysace deflexa*

(Mapping by Paul Gioia. Image used with the permission of the Western Australian Herbarium, CALM (http://florabase.calm.wa.gov.au). Accessed on Tuesday, 18 October 2005)

Figure 3 *P. deflexa* (cream flowers) growing in mallee heath vegetation, north of Ravensthorpe

Compounds that are acutely or chronically poisonous are not expected to be found in *Platysace deflexa* tubers because it is known that indigenous people ate them raw and cooked (Pate and Dixon 1981; Bindon 1998). Indigenous people often intentionally camped at sites where these plants grew and ate numerous tubers during their stay. Early European settler also consumed tubers occasionally.

This study aimed to:

- develop a reliable and cost effective propagation system
- develop cultivation systems
- determine the species' productive capacity
- investigate the nutritional value of tubers
- assess the species commercial potential and if warranted, commence commercialisation and product development.

Methodology

Plant material

Shoot, seed, tuber, rhizome and sucker material of *Platysace deflexa* was sourced from 3 natural populations on the south coast of Western Australia. Locations were: approximately 20 kilometres north of Ravensthorpe, 150 km north east of Albany along the South Coast Highway, and Cocanarup, 25 km West of Ravensthorpe along South Coast Highway.

Propagation: Cuttings

Numerous attempts were made to propagate *P. deflexa* from cuttings (Table 2). After determining (by trial and error) that the species required very careful moisture management and that coarse river sand was a suitable media for cultivation of this species under shade house conditions in Albany the following trial was established.

Propagation: 2006

All samples used in the trial were collected from mature plants during the last 2 days in February 2006. Parent plants were growing in sandy loam over clay soils, and experiencing an active growth phase due to recent rainfall. In the preceding three months rainfall in the region was measured at 11.1 mm for December, 93.3 mm for January, and 4.8 mm for February (BOM climate statistics 2006). Rainfall during January was significantly higher than the 30 year average (1961–1990) of 23 mm indicating that this was a particularly wet summer.

Harvested shoot, rhizome and sucker material was placed in open plastic bags with a small amount of water at room temperature to avoid desiccation during transportation from collection sites to Albany.

Shoot material from the site north of Ravensthorpe was prepared by cutting 50 tip cuttings, 50–60 mm down-stem from the terminal growth point and stripping them of their lower 20mm of leaf material. 50 semi-hardwood cuttings were prepared from older leafless stem material cut to lengths of 50–60 mm. The time between shoot harvesting and preparation of cuttings did not exceed 36 hours. Tip and semi-hardwood cuttings were subjected to the same treatment and control. Treatment of the cuttings involved the dipping of severed, leafless cutting ends into indole-3-butyric acid (IBA), a plant growth regulator, at a concentration of 3 g/L. The cuttings were then planted in coarse river sand to a depth of ~30 mm. Control treatments followed the same methodology without the IBA dip. The experiment began on 01/03/06 at the time of planting, and included 5 repetitions of each treatment and control, with 5 cuttings planted per repetition.

Each repetition was planted in a separate pot of 300mm diameter and 265mm height which included:

- 5 x tip cuttings dipped with IBA
- 5 x tip cuttings minus IBA (control)
- 5 x semi-hardwood cuttings dipped with IBA
- 5 x semi-hardwood cuttings minus IBA (control).

On the 16/06/06 cuttings were carefully removed from the sand using a gentle water shower to ensure the integrity of roots. Data was collected on the basis of cuttings alive or dead, and on the presence or absence of root formation. Data was subjected to one way analysis of variance (ANOVA) interpretation. Cuttings which survived the experiment were transplanted individually into seedling punnets for further cultivation.

Suckers with tubers, suckers without tubers and rhizomes from the 3 collection sites were used for further cultivation studies. 7 rhizome only pieces, 7 suckers with tubers, and 7 suckers without tubers were planted from north of Ravensthorpe, 7 suckers without tubers were planted from 150 km north east of Albany, and 4 suckers without tubers were planted from Cocanarup. Rhizome pieces and suckers were planted individually, in pots measuring 140 mm in diameter and 150 mm height filled with coarse river sand. On the 16/06/06 sucker and rhizome material was assessed on the basis of survivorship.

All cuttings, rhizomes and suckers were observed in a shade house at the Department of Agriculture and Food (Albany). The cuttings were watered at 8am and 4pm daily during the 108 day duration of the experiment.

Temperature records for Albany for the duration of the experiment are shown in Figure 4. The maximum temperature reached during the trial was 28.4°C (mean 19.6°C), and the minimum 6°C (mean 12.1°C).

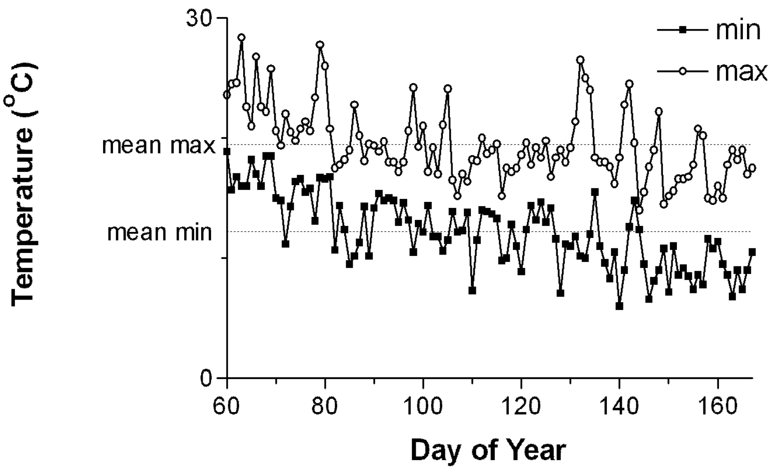


Figure 4 Albany temperature recordings for the duration of the experiment 1/03/06 – 16/06/06 (BOM 2006)

Propagation: Other attempts to propagate from tubers and seed

On many occasions tubers that had been collected from the field were planted in pots (300 mm) in coarse river sand with either the top of the tuber placed approximately 2 cm below the soil surface or with the top 10 mm of the tuber above the soil surface. Shoot and root growth was monitored occasionally for up to a year.

To determine whether tuber sprouting could be enhanced, a bulk collection of tubers was made from wild material approximately located 20 kilometres north of Ravensthorpe (2/2006). Tubers were transported to Albany, stored in cool dry ambient conditions for 5 days before treatments were applied. Treatment included soaking in a 500 uM solution of GAIII for 24 hours and then the dried tubers placed in paper bags and stored in either light (sunny bench top in lab) or dark conditions (cupboard). Controls were then treated in the same manner except soaked in a distilled water solution without GAIII.

Characteristics of seed production in the wild were observed over several seasons during the project. During late summer 2005 umbels containing mature seeds were collected from the Ravensthorpe area. They were stored in paper bags, treated with insecticide and scored in ambient lab conditions for 2 months before germination studies and seed production were assessed. The number of fully formed seeds per umbel was determined by removing each seed and noting whether it was fully formed or whether the seed was empty (by lightly pressing down on the seed with a fine nosed pair of tweezers). Subtle difference in resistance was adequate to determine which seed were fully formed and those which were empty. Seed viability was determined by placing fully formed seeds on moistened (distilled water + forgarid) filter paper (20 seeds) within small vials that were then placed on a lab bench top for 60 days. Germination was noted at day 14, 30 and 60.

Field sowing of seed was undertaken in 2003 (Gairdner 1 site), 2005 (Bremmer Bay site) and 2006 (Gairdner 2 site). At each site seed collected the previous autumn (or the year before) was sown at a depth of 5mm during winter. Usually approximately 1 g of seed/chaff was sown at each of five or more planting spots.

Cultivation and growth

Two field sites and were established during this project for field cultivation and plant growth studies, one at Bremmer Bay and one at Gairdner (Gairdner 2). Growth measurements were also made at a third site (Gairdner 1) which contained approximately 20 cultivated plants, established prior to the commencement of this project (all established from transplanted suckers).

The Bremmer Bay site was scalped (0.05–0.1 m, to remove existing weeds and the soil contaminated with weed seed), ripped (to a depth of 0.4 m) and mounded (mounds 0.3 m high and 0.3m wide) in a one pass operation with a Chatfield’s tree planter behind a 100hp front wheel assist tractor. A second pass was required (with scalper and ripper removed) to produce a taller mound (0.4 m). Site preparation was completed during autumn 2005. The soil at this site was fine sand (to a depth of 0.4–1.0 m) over clay.

At the Gairdner (1) site (approx 0.2 ha) a three point linkage grader blade mounted on an 80hp tractor was used to produce medium sized mounds (0.3 m tall and 0.3 m wide). Rows were 5 m apart. The soil was a sand, over gravel, over clay at 0.5-1.0 m. This site was established in 2002 and plant propagules were planted in the autumn of 2002 (on the mounds) and then in the furrows between rows during autumn 2003.

At the Gairdner (2) site (approx 0.2 ha) a three point linkage grader blade mounted on a 80hp tractor was used to produce large mounds (0.4 m tall and 0.5 m wide). Spacing between rows was 4 m. The soil was a loamy sand with gravel over clay at 0.5 m. The site was prepared in autumn 2006 and propagules planted in autumn 2006 (tubers, suckers, seed and rooted cuttings) and 2007 (rooted cuttings only). A micro-drip irrigation system was installed in April 2007 and plants irrigated for 30 min twice a week.

An estimate of the species' potential yield was determined by partial excavation of wild plants, 20 km north of Gairdner, and Ravensthorpe. A known volume of soil was excavated with a spade and hand trowel and the mass of tubers recovered from the soil measured. Although plants were wild they were all growing in modified environments which may give some indication of the species' productive capacity in the absence of cultivated material. The excavation at Gairdner for example was of plants growing en masse in the spoil of a roadside water management structure (essentially a very large mound over 1 m in width and over 0.4 m tall).

Tuber harvesting and profiling was conducted at the Gairdner 2 trial site, 150 km NE of Albany, on the 17 January 2008. The number and mass of tubers obtained from each plant in a two metre section of row was measured. The mass of tubers was used to determine yield per plant and yield per linear metre. Hand trowel were used to excavate the mound area and dig to a depth of 20 cm below the soil surface. The growth characteristics (height, width and breadth) of each plant were also recorded.

Two plants at the Gairdner 2 trial site were selected to spatially profile tubers. A 1 m^2 frame divided into 100 10 cm^2 squares was used to assign the individual tubers a lateral position (x and y coordinates). The depth of tubers above (+) or below (-) the soil surface (0) and the weight of each tuber were recorded. The lateral position of the stem of each plant was recorded within the 1 m^2 frame.

Analysis

R 2.5.1 was used to generate 3D images of tuber spatial distribution and relative size. GenStat 10.2 was used to test for significant differences, ANOVA (5% least significant difference (l.s.d)).

Nutrition

Wild and cultivated *P. deflexa* tubers harvested for nutritional analyses were washed in distilled water, slices 1 cm thick were cut and then dried at 60^{o}C for 48 hr. Fresh and dry mass were recorded. Samples (bulk samples of more than 4 tubers) were then ground to a powder and sent to the Chemistry Centre (WA) for nutritional analyses. Protein was calculated as nitrogen content x 6.25. Fat was determined by hexane method P7, Fibre by method P6, Ash determine was combustion, Nitrogen Free Extractive (NFE) by calculation, starch by enzymatic method, and mineral by ICP-AES method P2.

For sugar analysis, Tuber samples were oven dried and 50^{o}C for 7 days before being ground to a powder in a coffee grinder. Powder was stored in 50 ml sample vials at 5^{o}C for 4 weeks until despatched for analysis. Each sample was a bulk sample made up of at least 5 medium sized tubers. Individual sugar analysis was done using standard HPLC techniques with appropriate standards. The Chemistry Centre of Western Australia (Department of Industry and Resources) conducted all analyses on a fee for service basis and results were expressed on a percentage w/w.

Young tubers of *P. deflexa* are sweet and ensure that sweetness was not associated with cyanogenesis, four tuber samples were tested on a fee for service basis by Dr. R. Gleadow of the University of Melbourne, using the following method, based on those of Woodrow et al (2002), Gleadow et al (1998) and Brinker and Seigler (1989). Fresh tubers were frozen in liquid nitrogen and freeze dried. Samples were ground in a cooled mechanical grinder. Duplicate samples (100 mg) were weighed into glass vials and moistened with 0.1 M 1 ml citrate buffer (pH 5.5). A further sample was moistened with the same buffer containing 0.2 mg/g beta-glucosidase, extracted from almonds. A well was inserted into each vial containing 0.5 ml 1 M NaOH. Positive controls contained 30 mg freeze-dried Eucalyptus cladocalyx leaves, known to be cyanogenic. Negative controls contained 30 g Eucalyptus fasciculata freeze-dried leaves which are not cyanogenic. Vials were incubated with shaking for 12 hours at room temperature and then at 37^{o}C for a further 24 hours. A 100 uL sample from the well was diluted to 0.1 M with distilled water. Four reactions were performed in microtitre plates as follows: 50 uL samples were neutralized with 50 uL of 0.5 M acetic acid. Colour was developed by adding 125 uL double-strength succinimide reagent, 50 uL barbituric acid-pyridine regent and incubating for 15 minutes at 25^{o}C (Brinker and Seigler 1989). Absorbance was read at 585 nm using a Multiskan microplate reader and compared with positive and negative controls, and standard solutions of NaCN.

Product development

The likelihood of *P. deflexa* being adopted as a commercial vegetable product in the market place was assessed by potential consumers and food industry professionals. This process assisted in the development of food preparation and application recommendations, and the identification of target product specifications based on appeal. This initial research was conducted through product appraisal events and opportunistic feedback.

Product appraisals were sought via:

- 1 foods market – Albany Farmers Market
- 1 “bush foods” event
- opportunistic tastings
- individual appraisals by chefs and food merchants
- Greening Australia’s Gondwana Link groups.

Product was introduced for sampling and tasting at appraisal events. People that were interested and willing to participate in an appraisal were asked to sign a consent form and fill out a product appraisal form indicating their personal impressions relating to the taste, sweetness, texture, colour, size and shape of the product they had sampled.

Results

Propagation

The establishment of new individuals from seed (lab and field studies) and tubers (shade house and field) was always a complete failure or produced very few new plants. For example less than 5% of tubers planted in the field during the 2006 season for example produced a new individual that survived the following summer. Many field planted tubers that didn’t shoot remained for over a year and then rotted/desiccated. Some tubers that did shoot didn’t form new roots and subsequently died. Field sowing seed in 2003, 2005 and 2006 did not result in the establishment of any plants. Application of GAIII did not significantly influence tuber sprouting. Of the 80 (4x20) fully formed seeds placed on moistened filter paper in vials, only three germinated.

Table 2 Attempts made at propagating *P. deflexa* via cuttings and their results

	Technique	Season	Year	Plant material	Result	Notes
1	Premium grade propagation potting mix, cutting placed in 150mm diameter pots watered twice daily	autumn and spring	2002	tip	NIL	
2	Misting with and without bottom heat, with and without GAIII (sand and peat mix)	autumn	2002	tip	NIL	attempted within a Dept of Agriculture facility that was successfully propagating many other Australian natives with floriculture potential
3	Standard methods used by commercial accredited nursery	autumn	2004	tip	NIL	
4	Premium grade potting mix, cutting placed in 150mm diameter pots watered twice daily	autumn and spring	2005	larger tip	NIL	
5	as per above treatment by only watered sparingly by hand	autumn	2005	larger tip	1 out of 20	
6	Coarse river sand used and 150mm pots watered sparingly	autumn	2005	larger tip	4 out of 20	
7	Coarse river sand used and 150mm pots watered sparingly	early autumn	2006	tip	over 60%	this experiment detailed further in the results section

Numerous attempts were made at propagation via cuttings but all early attempts failed (Table 2). During 2004 and 2005 it became apparent that the only plants (with roots and tubers) that were able to survive under shade house conditions in Albany were those transplanted from the wild that were inadvertently potted up with coarse river sand. The use of this media for propagation and nursery cultivation, coupled with very careful water management proved repeatedly successful.

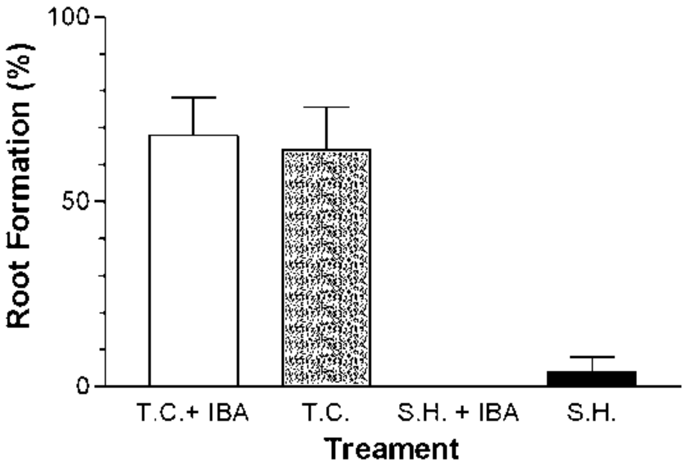


Figure 5 Root formation (with standard error, N=5) of *Platysace deflexa* tip cuttings (TC) and semi-hardwood (SH) samples under treatment with IBA (+ IBA) and control

A reliable mass propagation method via tip cuttings (coupled with the use of a coarse sand media and careful water management) was developed during the project. Propagation from tip cuttings was significantly (ANOVA, $P < 0.001$) more successful than the use of semi-hardwood material (Figure 5). More than 90% of all semi hardwood cuttings died during the experiment, whereas more than 95% of all tip cuttings were still alive at then end of the experiment. Tip cuttings dipped in IBA showed the highest presence of root formation (68%), followed by tip cutting control (64%), though this difference was not statistically significant. Semi-hardwood dipped in IBA showed no presence of root formation (0%), while only 1 semi-hardwood control cutting formed roots (4%, Figure 5).

Tip cuttings were found to vary in position of root development and in extent (Figure 6). Some cuttings developed roots primarily close to the severed end (Figure 6 and 7), while others displayed root growth further from the severed end. Cuttings treated with IBA appeared to have developed a more extensive root system as well as root growth further from the severed end (Figure 7). This observed difference was not quantified as all rooted cuttings produced were needed for further cultivation studies.

Figure 6 Variation in position and extent of root development on tip cuttings

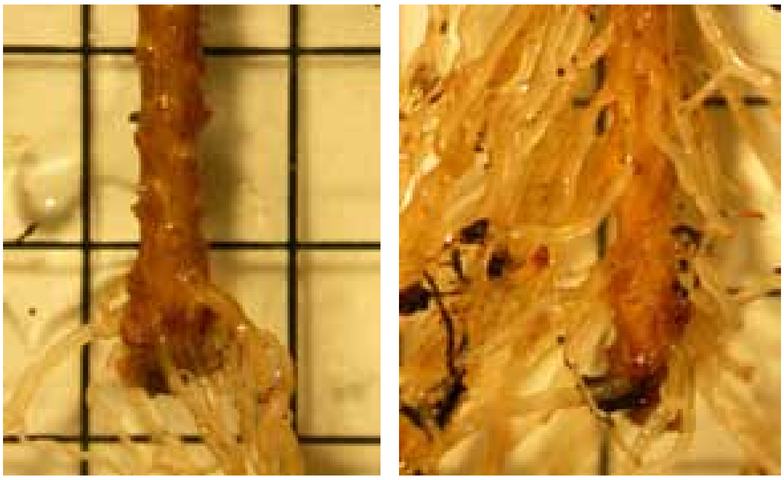


Figure 7 Root development close to severed end of an un treated tip cutting (left) and root development further from the severed end of a hormone treated tip cutting (right) – Background scale 5 mm x 5 mm

The transplanting of suckers as a propagation method has some merit, as, survival of transplanted suckers was excellent (>75%) irrespective of source (Table 3). Survivorship of transplanted suckers with or without tubers was higher than for rhizomes (Table 3). This data indicates that new plantlets can be obtained from suckers with or without an attached tuber, and that rhizome replanting is unfeasible.

Table 3 Percentage survivorship (%) for *P. deflexa* suckers and rhizomes 108 days after transplanting

	Source		
Propagation material	North Ravensthorpe	Gairdner	Cocanarup
Suckers without tubers	100	85.7	75
Suckers with tubers	85.7	—	—
Rhizome only	0	—	—

Although a basic system of propagation from cuttings has been developed more recent attempts at propagation detailed in Table 4 suggests that the source of material used is important and that overall reliability from batch to batch could be improved. Overall the experience gained over several years suggests that water management is critical and that cuttings need to be watered sparingly.

Figure 8 Shoot production from rhizome connected to a tuber (left) and shoot production on tuber (right)

Table 4 Results of 2006 and 2007 *Platysace deflexa* propagation from cuttings

Date	Source	Material	Method	n	Cuttings that formed roots (%)
1 December 2006	Wild Stand	mixed	tray	160	3.1
1 December 2006	Wild Stand	mixed	200 mm pot	103	4.8
1 December 2006	Wild Stand	mixed	55L tub	188	6.9
1 December 2006	Cultivated (Gairdner 2 trial)	specific	55L tub	10	0
1 December 2006	Cultivated (Gairdner 2 trial)	specific	55L tub	10	20
1 December 2006	Cultivated (Gairdner 2 trial)	specific	55L tub	5	0
1 December 2006	Cultivated (Gairdner 2 trial)	specific*	55L tub	10	50
1 December 2006	Cultivated (Gairdner 2 trial)	specific	55L tub	11	9
1 February 2006	Wild Stand	mixed	55L tub	80	67
1 February 2006	Wild Stand	mixed	tray	152	8.5
1 May 2007	Cultivated (Gairdner 2 trial)	specific*	55L tub	75	70.5

* Material collected from the same parent plant. The highest striking (root formation) percentage was 70.5% (n, 75) from material collected from cultivated plants at the irrigated and fertilised Gairdner 2 trial site, material from the same parent plant also produced a 50% (n, 10) striking rate.

Tuber yield of wild plants

The excavation (0.6 m x 0.5 x 0.40 length x breadth x depth = 0.12 m^3) at Gairdner of plants growing en masse in the spoil of a roadside water management structure (essentially a very large mound over 1 in width and over 0. 4 m tall) with a dense cover of *Platysace deflexa* (between multiple stems) yielded 37 tubers (total mass 2.88 kg), the mass of which ranged from 3 g to 354 g (tubers were washed to remove soil and air dried under ambient conditions before mass was determined). Median and mean mass of the harvested tubers was 56 and 78 g respectively. The site harvested was as we would envisage a mature cultivated stand to be: i.e. a continuous canopy of *Platysace deflexa* growing on a mound of sand/sandy loam (0.4 m high). The largest tuber encountered during field excavations had a mass of 420 g.

If the previous situation were able to be replicated in a cultivated field setting, then the above would be equivalent to a yield of 9.6 kg of tubers per linear metre of mound. If mounds were 4 m apart then the system would produce 24 t per hectare. Unfortunately the age of the plants was not able to be determined and so the time required to produce 24 t is unknown.

North of Ravensthorpe two excavations of material growing in the spoil (small mounds) alongside a firebreak yielded 0.8 kg and 0.5 kg of tubers from an excavation 0.4 m x 0.4 m x 0.5 m. A similar hypothetical calculation to that used above suggests a yield of 5 kg and 3 kg per linear metre of mound.

Field cultivation and tuber production

All propagules planted in mounds at the Gairdner 1 site during autumn 2002 died due to lack of moisture, except for two transplanted suckers which survived but remained small (single stem 150 mm tall with few side branches). All propagules planted at the Bremmer Bay site in 2005 also died due to waterlogging and inundation following decile 9 rainfall during autumn and winter 2005 (and their wettest autumn day on record, 3 days after site establishment).

During the field cultivation studies it was observed that: the tubers were sweetest during Sept-Dec, the planted suckers and rooted cuttings are at first slow to establish and display rapid growth for over two years, that the young tubers are juicy and become progressively more woody over time (cf carrots), and finally that field cultivated plans did not suffer from any pest and diseases. The Australian plague locusts that caused major damage in the Gairdner area during 2007 were present at the Gairdner 2 site but did not damage the cultivated plants (they appeared to avoid them).

Suckers planted in the in furrows at Gairdner site 1 the following year (autumn 2003) grew rapidly and 75% survived the following summer. Four of these unirrigated, cultivated, 19–23 month old, *Platysace deflexa* plants yielded an average of 1.15 kg per plant. These plants had grown exceptionally well and were on average 0.6 m wide. They were growing in furrows at Gairdner site 1 which were observed to have been effective at harvesting rainfall. Only partial excavations were made as it was intended that the plants be used for further studies. Unfortunately all plants at the Gairdner 1 site died due to waterlogging during a 2 month period following decile 9 rainfall in the area during autumn-early winter 2005.

Table 5 Estimated product yield of four *Platysace deflexa* plants cultivated at the Gairdner 1 site

	planted	harvested	% of root volume	Total fwt of product	estimated product yield per plant
plant 1	May-03	Dec-04	0.4	0.29	0.73
plant 2	May-03	Dec-04	0.3	0.34	1.13
plant 3	Jun-03	May-05	0.6	0.91	1.52
plant 4	Jul-03	May-05	0.5	0.61	1.22

Yields from 20 month old *P. deflexa* harvested from the Gairdner 2 site were lower than the estimated yields obtained at the Gairdner 1 site and those obtained from wild harvested populations. At the Gairdner 2 site maximum yield per plant was 317 grams from plant 4 and the minimum yield was 47 grams from plant 3 (Table 6). Plant 4 recorded the highest mean tuber mass of 8.3 grams (n = 38). There were some significant differences in mean tuber mass between plants. Mean tuber mass of the 20 month old plants at the Gairdner 2 site (5.2 g) was less than 10% of value obtained from wild harvested plants (78 g).

Of the 109 cultivated tubers harvested from the Gairdner 2 field site, 34 grams was the maximum mass recorded for an individual tuber. In comparison the mass of the largest tuber harvested from the wild was 420 grams (12 fold higher).

Table 6 Tuber production at the Gairdner 2 site – Tubers harvested from a 2 m section of row that contained four plants

Plant	No# of tubers	Mass of tubers (g)	Mean mass of tubers (g)	Significant difference between mean tuber weight*	Minimum tuber mass (g)	Maximum tuber mass (g)
1	17	100	5.9	A	2	11
2	38	135	3.6	B	1	10
3	16	47	2.9	B	1	8
4	38	317	8.3	A	1	34
Total	109	599				

(*unequal sample sized ANOVA at the 95% level of significance)

One interesting repeated observation, with implication for product quality, was that tubers excavated from gravely soils were distorted (field trials and wild harvested material) whereas tubers excavated from sand were less distorted.

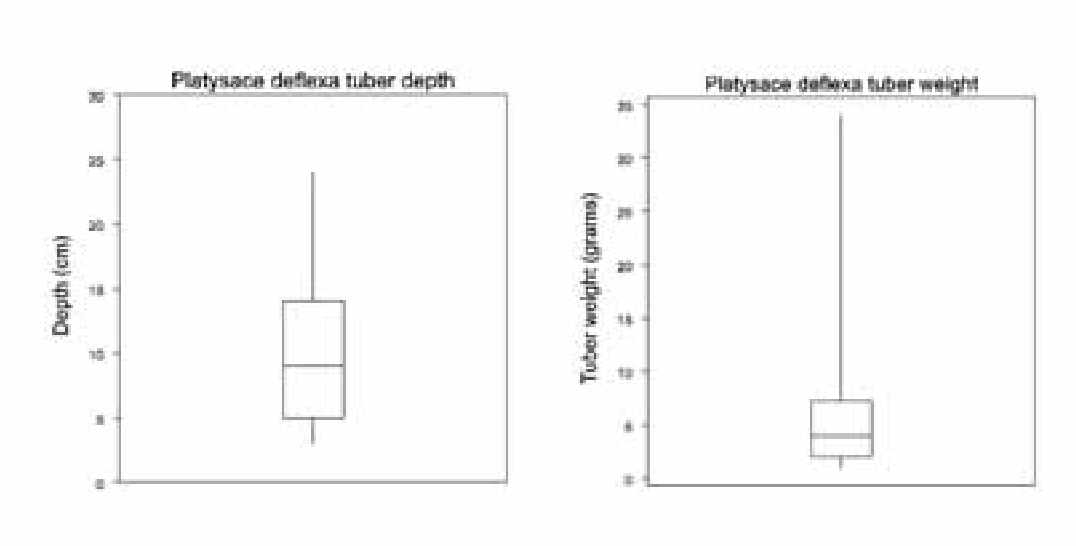


Figure 9 Quartile range plot for tuber depth (left) and tuber mass (right), plant 3 and 4 at Gairdner 2 site

0 cm represent the soil surface and 30 cm represents the top of the mound.

At the Gairdner 2 site tubers were found from 3–24 cm above the soil surface (Figure 9). Tubers were not found out of the mounded area (i.e. below the soil surface, see Figure 10) and the mean depth of 54 tubers was 10.15 cm above the soil surface, that is, most tubers were in the lower parts of the mound as shown in Figure 10. 75% of all tubers harvested in the 2 linear meters of row were between

1 and 7 grams (Figure 9). The mean weight of tubers recovered from the 2 linear meters of row was 5.5 grams and the mean yield per linear meter was 182 grams.

Dimensions of the plants harvested from the Gairdner 2 are shown in Table 7. All four plants were of similar size to mature wild plants. It was noted however that the plants sampled were still in an active and prolific growth phase. All wild plants harvested throughout this project were of similar size but visually appeared to be mature, having less leaf material and did not appear to be in a prolific growth phase. Observations of the tubers harvested from the Gairdner 2 site suggest that the plants were just beginning to produce tubers.

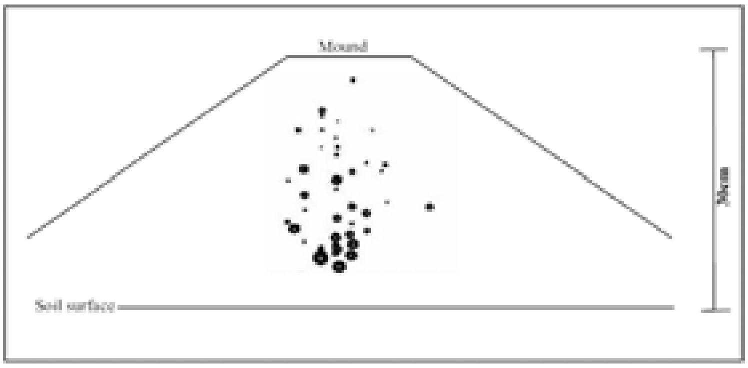


Figure 10 Transverse section through mound showing the distribution of tubers

Note dot size represent tuber mass

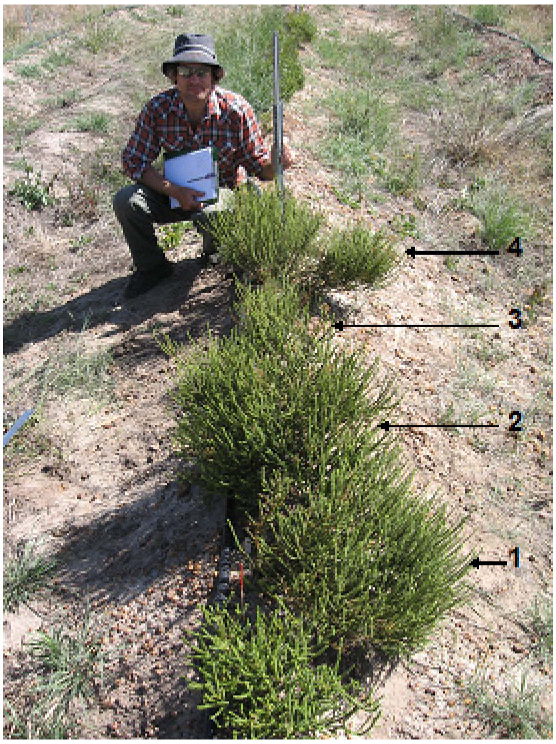


Figure 11 *Platysace deflexa* plants selected for harvesting labelled 1–4, plants are spaced approximately 50 cm apart

Table 7 Growth characteristics of *Platysace deflexa* plants prior to harvest

Plant	Height (cm)	Width (cm)	Breadth (cm)
1	45	45	45
2	53	60	49
3	35	24	24
4	52	80	47

Nutrition

The nutritional value of *Platysace deflexa* tubers was assessed and compared to other common and widely consumed root vegetables. The key result was that the nutritional value of *Platysace* was broadly similar to that of related species of the Apiacae, this is, red radish and carrots (Table 8). Wild harvested *Platysace* tubers were of low nitrogen content (and thus protein) and this may reflects the nutrient poor environment in which they were growing. When cultivated in a nitrogen-rich media the tuber protein content was significantly higher (Table 9).

Table 8 Composition of wild harvested *Platysace* tubers, radish and carrot roots and potato tubers (bulk samples comprised of more than 5 tubers per sample)

	Nutritional Factor											
	N %db	P %db	K %db	Ca %db	Mg %db	Na %db	S %db	Cu mg/kg	Fe mg/kg	Mn mg/kg	Zn mg/kg	Starch %db
Plant Sample												
Platysace	0.2	0.0	2.0	0.9	0.2	0.4	0.1	8.5	51	64	12	9.4
radish	2.7	0.5	5.5	0.3	0.2	0.3	0.4	2.7	58	12	39	2.4
carrot	0.8	0.3	1.6	0.3	0.1	0.7	0.1	2.5	34	14	19	5.9
potato	1.8	0.4	2.6	0.1	0.2	0.1	0.2	6.6	69	10	27	55.7

Table 9 Nutritional composition of cultivated and wild harvested *P. deflexa* tubers

Source	Protein	Fat	Fibre	Ash	Nitrogen free extractives	Starch
Cultivated	4.4	2.1	12.5	9.9	70.8	3.1
Cultivated	4.3	1.9	9.2	9.8	74.6	3.1
Wild (Cocanarup)	2.0	2.7	14.4	12.4	68.4	1.5
Wild (Cocanarup)	2.0	2.9	11.0	11.8	72.7	1.8
Wild (Jacup)	2.4	3.1	23.2	11.0	60.1	0.7
Wild (Nth Ravensthorpe)	2.0	1.4	15.4	12.0	69.0	3.0
Wild (Nth Ravensthorpe)	1.9	1.2	10.5	12.0	74.4	2.4
Mean	**2.7**	**2.2**	**13.8**	**11.2**	**70.0**	**2.2**

Table 10 Sugar composition of cultivated and wild harvested *P. deflexa* tubers

Source	Fructose	Glucose	Sucrose	Maltose	Total	% as sucrose
Cultivated	7.2	8.5	23.1	0.6	39.2	58.8
Wild (Cocanarup)	4.7	6.9	22.4	0.6	34.2	65.5
Wild (Jacup)	2.4	3.8	10.9	0.7	17.7	61.3
Wild (Nth Ravensthorpe)	4.6	9.6	21.5	0.6	36.3	59.3
Mean	**4.7**	**7.2**	**19.4**	**0.6**	**31.8**	**61.2**

Sugar content of *P. deflexa* tubers was variable (Table 10). The wild tubers from Jacup were older (dark yellow) and had the lowest sugar content. When consumed by the author at harvest, these older tubers were less sweet than younger tubers collected elsewhere. All of the younger cultivated and wild material was very pleasant to eat and sweet to taste (author's observation), and as expected, all were of higher sugar content than material from Jacup. The sugar results show sucrose to be the predominant sugar present in the tubers of *P. deflexa* (Table 10).

Although tubers had a sweet taste, particularly young tubers, they were not found to be cyanogenic (Ravensthorpe and Gairdner material). Samples were tested with and without degrative enzymes and all produced completely negative results. This suggests that the tubers of this species are not cyanogenic however it does not rule out that other individuals and or populations of the same species being cyanogenic as many species are polymorphic.

Results and discussion of progress towards marketing & commercialising *Platysace deflexa*

Following the species selection stage of this project *Platysace deflexa* continued to exhibit potential as a new vegetable product. The recommendations provided here for marketing and commercialising *P. deflexa* are based on the information detailed in Appendix 1, though are specific to the unique characteristics, horticultural production and the product research outcomes for this species.

Table 11 Summary of the 67 appraisals received, indicating the number of respondents that nominated each category for a range of preparations: the average values for characteristic ratings indicate the consumers overall like for the product

Parameter	Average value	Rating	1 Strongly dislike	2 Dislike	3 Neutral	4 Like	5 Strongly like
Taste	3.7	Like	0	9	13	31	13
Sweetness	3.7	Like	1	7	12	37	11
Texture	4.1	Like	0	4	14	19	31
Colour	3.8	Like	0	3	20	30	14
Size	3.8	Like	0	1	22	32	12
Shape	4	Like	0	1	23	21	22

Consumer's feedback on the taste and texture of the product indicate the taste to be delicate commonly compared to radish, water-chestnut and coconut and that the texture is firm and crisp akin to radish or apple.

Figure 12 Stall at the Albany farmers market where tasting of *P. deflexa* (an other species) were offered to consumers

Example appraisal of *P. deflexa*: Fresher Only Pty Ltd, Perth

In January 2005 *Platysace deflexa* tubers were bush-picked from the edge of a firebreak north east of Ravensthorpe. The tubers were washed, packaged and 1.5 kg sent to Sam Satterthwaite of Fresher Only Pty Ltd, Perth. Sam has a great deal of experience with the bush food industry and his company distributes many Australian bush food products. Sam tasted the tubers raw and cooked and also distributed small amounts to other chefs.

One chef suggested that the tubers could be used in much the same way as a radish. He suggested that they would complement a spicy salad, that is, a salad that contained rocket and or other hot/spicy ingredients.

When cooked (steamed or boiled) the general feed back was that they were similar to squash in that they did not really have a strong distinctive taste. They commented that the colour (yellow outer skin) of the tubers was attractive.

Sam and the chefs he dealt with were positive about the tubers (and wanted to know when a supply was going to be available) and could see a demand for them. They all strongly suggested that they would only use the tubers if price competitive with other similar foodstuffs. They said that they would pay more for the tubers than red radish or squash but "don't expect truffle prices".

Product specifications

Based on consumer and industry/professional feedback the following recommendations for product specifications are provided.

Season	**October - December**
Size	**30x50mm - 50x100mm**
Weight	**20 - 100 g**
Shape	**Without significant distortions**
Colour	**Yellow**
Skin blemish/damage	**Zero tolerance**

Figure 13 Merchantable Platysace deflexa tubers with distinctive yellow skin

Appraisals of the product indicate it is suitable for presentation to the market as a wholefood. Aspects relating to aesthetic appeal of the tubers; colour, size and shape were confirmed to be appealing to consumers'. Thus, no product modification or processing is necessary for acceptance in to the market.

Food preparation and applications

Based on industry and professional feedback recommendations for preparation techniques and recipe applications of tubers are provided here. Feedback received from chefs and food professionals indicate that the product could be used primarily in three ways; raw, dry-baked/ roasted and fried.

Raw: The crisp and delicate nature of the flesh make it suitable for use in salads, unpeeled and either diced, sliced or grated.

Dried, dry-baked or roasted: Dry-baking the tuber whole and unpeeled turns the yellow skin an appealing golden colour. Although techniques have not been developed to 'crisp' the skin, feedback suggests that baking enhances sweetness and mouth-feel.

Fried: There is a tendency for the flesh to absorb and take-on the flavour of the oil, however there is significant potential for shallow or rapid frying of this product to provide a unique texture and delicate flavour to Asian cuisine such as stir-fry's, akin to the use of water chestnut or varieties of radish.

Quality control

Variably in the product specifications and quality is recommended to be limited in the period of introduction of this new product to the market place. Building the expectations of consumers about a product then demands a sustained focus on ensuring the supply chain delivers quality product, with consistency relating to product size, colour, taste and texture. As a risk minimisation strategy it may be important to limit supply of this product to a well-defined season, ensuring consumers are introduced to the product when it is at its best.

If sufficient scale is achieved, there may also be opportunities for processing of product that doesn't meet these specifications as a pre-chopped or dried ingredient for the production of processed Asian foods such as spring roles or dim sim, as is the case for water chestnut and varieties of radish.

Developing supply

Development of the supply chain, from primary production systems through to processing and packaging needs to be conducted with ongoing consideration of the information generated through the market development process about consumers expectations and preferences relating to the size, colour, taste, texture, seasonality and the 'green' and 'ethical' credentials of the product.

Due to very limited initial supply base, the commercialisation of *Platysace deflexa* tubers will need to be incremental and carefully managed, with efforts to expand the market occurring only when strong market indications exist and production risks and costs are well understood.

Promotion and extension of *Platysace deflexa* as a new crop option needs to be strategic and focus on identifying innovative growers who will be proactive and participate cooperatively in the development of efficient systems of production.

Creating a market for *Platysace deflexa*

Consumer response suggests this new vegetable product has significant appeal for the domestic market based on its striking and unusual colour, sweet taste, crisp texture and indigenous Australian origins. Though, this new, versatile and nutritious vegetable will need to compete successfully with a rapidly diversifying and competitive fresh vegetable market where 'new' vegetable products typically of

Asian origin appear frequently. Product differentiation relies on promoting a combination of unique selling points (USP's) to enable a market niche to be exploited.

Potential USP's of *Platysace deflexa* for product differentiation in promotion/advertising, on packaging, and point of sale material (i.e. information and recipe brochure) are:

- a Western Australian native vegetable
- sweet and crunchy
- opportunity to provide support for indigenous communities
- is environmentally friendly, produced using clean, green and organic production systems
- is nutritious and versatile preparation and application
- is a unique and new product
- has a distinctive yellow colour
- branding/product naming opportunity

This vibrant, new, indigenous product lends itself to marketing to the media generally and food writers specifically, despite significant competition for coverage of new and particularly regionally marketed products. Thus, this significant potential for marketing through the media provides an opportunity for promotion that may be instrumental in raising awareness of this new product in the introduction period.

The supply of cultivated product from the field trials was very limited throughout this project which limited the ability to undertake a retail trial or to test integration into an existing or new supply chain. Although there is scope for the commercial cultivation of *Platysace deflexa* across a broad geographic range as supply is developed the target market for *P. deflexa* will initially be the local/regional market. The plant is indigenous to, and found exclusively on the south coast of WA, particularly within the Great Southern region, and there is likely to be significant advantages in adopting a regional approach in the initial stages of both production and marketing.

General discussion

The yield of field cultivated material was low compared to wild harvested material on a soil volume and per plant basis. This suggests that either the cultivation methods were not appropriate to achieve maximum yield or that tuber production takes longer than expected. The cultivated material grew vigorously and appeared very healthy in comparison to wild material, thus it is unlikely that cultivation conditions were responsible for the low observed yield. The most likely explanation is that tuber formation takes 2–3 years and not the 1.5 years rotation used in this study. When cultivated plants were excavated they yielded many small tubers and presumably if they were grown for another 12 months tubers size and mass would substantially increase as would yield per plant. So although this project was able to grow plants with vigorous shoot growth, the plants had not invested heavily in below ground storage.

It should be noted that the above comparison between wild harvested and cultivated material is inherently problematic due to at least two factors. Firstly, the rhizomatous root system of this species makes it difficult to determine the boundaries of an individual, particularly in its wild state. Secondly, the age of the wild harvested material was unknown.

The Gairdner 2 trial site established during this project still contains many cultivated plants and further examination of tuber production over the a 2–3 year period at this site will generate further useful information. This additional information will be made available as an update to this project report.

A crop rotation length of 2–3 years would suggests that is species is likely only to be grown on low opportunity cost land (i.e. where it occurs naturally) and that a low input system is required for the crop to be economically viable (see chapter 5 for a detailed economic assessment). The long rotation length mean that cultivation of this species in high opportunity cost land, traditionally used to grow horticultural produce, is unlikely, due to competition from other more lucrative, shorter rotation crops.

Results of the spatial profiling of cultivated *Platysace deflexa* were very encouraging as all tubers grew within the mound and had a tendency to form directly below the parent plant in the centre of the mound. The tubers were found at a mean depth of 10 cm above the soil surface, suggesting that the species may suit mechanical harvesting with machinery currently used to harvest other tuberous root vegetables that are grown in mounds.

This project has shown clearly that consumers and the food industry in general are excited by this product. An opportunity for this product in the food industry exists but due to a very limited initial supply base, the commercialisation of *Platysace deflexa* tubers will need to be incremental and carefully managed, with efforts to expand the market occurring only when supply can be ensured.

Ipomoea calobra

Introduction

Ipomoea calobra W.Hill & F.Muell is a deciduous perennial climber (Figure 14) and usually climbs up through Mulga (*Acacia aneura*). Aboriginal names include: Kulyu (Murchison-Gascoyne area Scott 1973, Bindon 1998), Wutha (source: Dolly Muir, Tjupan Ngalia group, Leonora, WA). Scott (1973) documents the name "Intal" for both *I. costata* and *I. calobra* (refered to as *I. longiflora* by Scott 1973 in the Ashburton area). Notes that accompany Western Australian Herbarium specimen No 04328442 state an aboriginal name of "Culya" (collector AA Mitchell). Common names include "Weir Vine" and "Bush Potato". It is a member of the Convolvulaceae (Morning glory family). Stanley and Ross (1986) describe members of this family as being herbs or shrubs, sometimes parasitic (i.e. *Cuscuta*), usually twining or prostrate. This family contains about 55 genera including *Ipomoea,* with approximately 1800 species in tropical, tropical and temperate parts of the world. There are approximately 36 *Ipomoea* species in Australia of predominantly tropical and sub-tropical origin. This group also includes introduced species such as *Ipomoea batatas* (sweet potato), which is an important horticultural crop in many parts of the world and is naturalised in some parts of Australia.

Pink-Purple flowers are produced from January to June. It occurs primarily in red deep sands/sandy loams along drainage lines and is widely distributed within the Ashburton, Carnarvon and Austin botanical districts of Western Australia. The collections made during this project at Terracotta, 12.5 km west of Depot Springs is 150 km further south than known populations shown in Figure 15.

Figure 14 *Ipomoea calobra,* twining shoot (left) and wild harvested tubers (right), fresh mass of the largest tuber (front left) was 1.4 kg

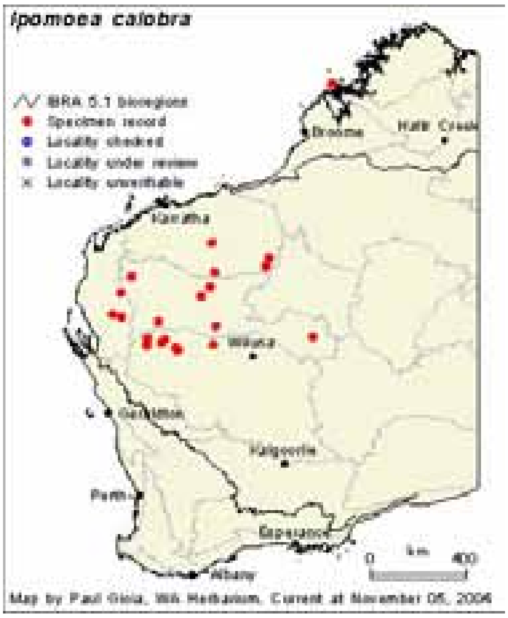


Figure 15 Distribution of *I. calobra*

(Mapping by Paul Gioia. Image used with the permission of the Western Australian Herbarium, CALM (http://florabase.calm.wa.gov.au). Accessed on Tuesday, 18 October 2005)

Ipomoea calobra has a clear and unambiguous history of use by indigenous people and early settlers. Tubers are baked in hot ashes and sand; young whitish tubers are sometimes eaten uncooked (Scott 1973). A similar preparation protocol was obtained from Kado Muir's family (an Aboriginal family from Leonora) in January 2005.

The objectives of this study were to:

- develop a reliable and cost effective propagation system
- develop cultivation systems
- determine the species' productive capacity
- investigate the nutritional value of tubers
- assess the species commercial potential and if warranted, commence commercialisation and product development.

Methodology

Plant materials

Seed/tubers used for propagation studies and nutritional analysis were sourced from Depot Spring station, Western Australia. After completing this work all seed and other plant materials were returned to their indigenous custodians. A separate bulk collection of seed was made from plants at Byro Station and Boolardy Station (both in the Murchison region of WA) this seed was used for the Carnarvon field trials.

Propagation

Attempts were made to cultivate this species from seed, shoot material and tubers, under greenhouse conditions in Albany. The major focus was on propagation from seed as observations made during the first field trip to Depot Springs station suggested the species to be a prolific seed producer.

The mass of 100 seeds collected 12.5 km west of Depot Springs and stored under ambient conditions for three months was used to determine the number of *Ipomoea calobra* seeds per gram.

Seed Scarification 1: A plus and minus seed scarification pot trial was established in December 2004. A small section of the seed coat was removed with coarse sandpaper. Five pots were sown with 10 seeds (5 scarified and 5 intact) and the emergence of seedlings monitored for 42 days.

Seed Scarification 2: To determine the most appropriate scarification technique, trials using mechanical, chemical, and hot water immersion methods were conducted on *I. calobra* seeds collected from Byro Station, Western Australia.

Mechanical scarification methods involved:

- Individual seed clipping; apex of seeds were clipped with pliers to reveal untouched kernel.
- Sanding method 1; seeds were run through a conventional mechanical scarification machine (Nindethana seed service, Albany WA) set on second fastest gear (3^{rd}). Four repetitions were required until all seed apices were ground to kernel.
- Sanding method 2; seeds were run through the conventional mechanical scarification machine set on fastest gear (4^{th}). One repetition of this process was enough to grind all seed apices to kernel, with damage done to some kernels.

Sulphuric acid (H_2SO_4 18 Molar (98.08%) was used to chemically scarify the seed. Seeds were fully immersed for two time periods:

- H_2SO_4 treatment 1 hour.
- H_2SO_4 treatment 9 hours.

Immersion in near boiling water was trialled for two time periods:

- H_2O treatment 30 secs.
- H_2O treatment 120 secs.

Control treatment seeds were left untouched.

Four replicates were planted per treatment, consisting of 10 seeds per replicate. Replicates were planted in separate pots at a depth of 10mm. Pots were bottom lined with paper towel covered with a 20 mm layer of potting mix; pots were then filled with yellow sand. All replicates were planted on 1/11/05; the number of successful emergents was measured on day 48 (18/12/05).

Cultivation and growth

Plants produced by the scarification trial were cultivated under greenhouse conditions for the duration of the project so that general observations of growth could be made and used as a source of cultivated tubers for product development studies.

Greenhouse growth and tuber initiation trial

The trial was conducted over a 10 month period from October 2006 to July 2007. *Ipomoea calobra* was grown from seed under greenhouse conditions for the term of the trial. 40 seeds were each established in a 150 mm pot consisting of a 1:1 ratio of fine yellow sand to potting mix. At 11 weeks the seedlings were transferred into 200 mm diameter pots with latticework secured on each pot to provide support for the developing vine (shoot material). Plants were transferred into 280 mm diameter pots at 32 weeks to further accommodate tuber growth. The stock watered 10 minutes per day by an above sprinkler system and were fertilized with ‘Thrive’ liquid fertilizer at the recommended rate for leafy vegetables approximately once per week.

Four plants were randomly selected for harvest at approximate 4 week intervals to investigate tuber development. At harvesting the shoot material was separated from the root material. The media was then removed from the pot and water used to gradually wash away soil surrounding the tubers. All material was rinsed and dried under ambient conditions in the laboratory prior to recording the fresh weights of tubers. The fresh weight (grams) of the tubers was recorded for each plant.

Field cultivation

Having determined how to propagate the species it was important to obtain some information about the species' productive capacity. Glasshouse studies in Albany could potentially be used to generate yield information but they may or may not reflect yield under field conditions. Additionally, the species did suffer from rust fungus, mites and aphids when cultivated under greenhouse conditions in Albany. Carnarvon was chosen as the location for field experimentation because: it has a similar climate to the area in which the species naturally occurs and because an existing horticultural industry is present at Carnarvon. Also it was likely that farmers in the area would have well developed horticultural skills relevant to the inaugural cultivation of *I. calobra* (cf limited horticultural skills within the graziers of the station country east of Carnarvon and where the species occurs naturally).

The following advert was placed in the local Carnarvon newspaper:

> **Vegetable grower required for research project**
>
> Dr Geoff Woodall seeks the assistance of a local vegetable grower to participate in a research project that is trialing new vegetable crops. For further information please contact Dr Geoff Woodall, Post-Doctoral Research Fellow, Centre of Excellence in Natural Resource Management, University of Western Australia by phone (08) 98928427 or email gwoodall@agric.wa.gov.au

Four farming enterprises responded to the advert and the two most appropriate selected, site 1 & 2. Landholder experience, soil, cultivation system, enthusiasm and history of innovation were the main factors used to select growers for this project.

The aim was to employ a best bet cultivation system at two sites and monitor growth and tuber yield. It must be remembered that cultivation of this species in its infancy and the systems employed may not in fact be optimal, it is however a starting point from which improved systems can be developed and benchmarked against.

Site 1: South of Gasgyone River, Carnarvon – Organic farming operation

Chris Armstrong's farm is located on the corner of the North West Coastal Highway (South) and Robinson Road, the main street through town. Chris, her husband Neil, and Howard (farm manager) work 3 separate businesses from this property. Chris runs a farm-stay and is involved in the general administration for Neil and Howard. Neil runs an excavation, light engineering and heavy equipment rental business and also does the moving of composting material. Howard is the farm manager and is passionate about vegetables! The farm is run under organic farming conditions with Howard making use of mass composting to improve soils, and rotational and companion planting to keep pests, mould and fungi at bay. He is an extremely knowledgeable and capable farmer. Howard is a successful sweet potato farmer. There is a variety of soil types on this property depending on the extent of compost treatment applied over the last few years. The fruit and vegetables were; bananas, chillies, sweet potato, bok choi, pumpkin, eggplant, daikons, potatoes, corn etc. Ecogrowth seaweed kelp and fish emulsion PK only fertilizer is used, as N goes against the organic protocol. Field peas are sequentially planted to up soil nitrogen levels.

Rows for the *I. calobra* trial were 20 meters in length and mounds were 25 cm in height by 100 cm in width. The rows were at 1.2 m spacings. A rotary hoe was used to prepare the site (topsoil to 20 cm) prior to mounding. Watering regime consisted of tape irrigation daily for 1 hr in the morning, though the site was not irrigated if deemed to be too wet due to prevailing weather conditions. Hand weeding was undertaken on 2 occasions. Fertiliser input consisted of diluted seaweed solution and fish emulsion.

Site 2: North of Gasgyone River, Carnarvon – Traditional farming operation

The Bumbaks own a property on North River Road, north east of the town centre. This area is the ‘light agricultural area’ of town and both sides of the 10 km long road are bordered with fruit and vegetable plantations of all kinds. The Bumbaks run a small shop located on the property selling home made ice cream and preserves as well as their varied grown produce. They currently grow grapes, sweet potato, mango, pumpkin and a small and varied bunch of fruit trees. The growing site was located ~2 km from the house at the rear of a mounded, irrigated area bordered on 1 side by a sweet potato/pumpkin crop, and the other by remnant bush land.

Rows were 20 meters in length and mounds were between 8–10 cm in height and 50 cm wide. The rows were spaced 1.3 m apart. Rip lines along rows were to a depth of 40 cm. The watering regime consisted of tape irrigation being 4 hours watering 3 times per week. When crops adjacent to the trial site were harvested irrigation was less regular, being flooded and then dried out for extended periods. Fertiliser input was consistent with the regime adopted on farm being 80 kg/ha Nitrogen, 120 kg/ha Potassium and 80 kg/ha Phosphorus. Hand weeding was conducted on 2 occasions. The site had not been weeded during the 4 months from January to April. The farm managers did not use herbicide to control weeds because the Ipomoea vine was also growing between and along the rows.

Sampling method for tuber profiling and yield

To gauge maximum yield potential sampling plots were selected which represented the best performing sections at each trial site. Selection was based upon an assessment of the number and size of stems and the growth and vigour of vine material per linear meter of row.

Two 1 m^2 excavations were made at each trial site. On the Armstrong’s property, one excavation was made to a depth of 0.6 m below ground level, while the other three excavations were made to a depth of 0.8 m. Trenches were cleared to a depth of 0.5 m on either side of the designated excavation plot to enable clearer access to the tubers as soil was gradually removed. Hand trowels were used to a depth of 0.6 m to carefully remove soil without disrupting or damaging tubers. Once the spatial profile of a tuber was measured (see below) the tuber was removed, and further excavations were made. Working at depths deeper than 0.6 m required the aid of a mattock and shovel due to compacted soil.

The lateral position of tubers within the 1 m^2 plots was determined using a grid system. A 1 m^2 ridged steel quadrat was divided into 100 10x10 cm squares, with each square allocated a number (1–100). The tubers were then assigned a lateral position within the quadrate, to within 10 cm, based on the square in which their approximate centre of mass lay. Depth of the tubers was recorded as the distance in centimetres below (negative) or above (positive) ground level, ground level was recorded as 0.

All tubers of mass above 20 grams were recorded with their associated depth and grid position. The mass of tubers weighing less than 20 grams was recorded collectively. The collective weight of tubers growing below 60 cm in depth was recorded separately. Tubers that had decomposed more than 50% were not weighed. Tubers were washed and towel dried then digital scales used to weigh the material in grams.

Analysis

The statistical software R 2.5.1 was used to generate the 3D profiles of excavation plots and GenStat 10.1 used for all other statistical analyses.

Tuber nutrition

When samples were being collected and processed for nutritional analysis cultivated material was not available. In the absence of cultivated product, four wild harvested tubers were processed for nutritional analysis. Tubers were collected with the assistance of local indigenous people from Depot Spring station. They were washed in distilled water, slices 1 cm thick were cut and then dried at 60^{o}C for 48 hr. Fresh and dry mass were recorded. Four tubers of *I. batata*s were purchase from retain outlets in Albany and processed as per *I. calobra*. Samples were then ground to a powder and sent to the Chemistry Centre (WA) for nutritional analysis. Protein was calculated as nitrogen content x 6.25. Fat was determined by hexane method P7, Fibre by method P6, Ash determine was combustion, Nitrogen Free Extractive (NFE) by calculation, starch by enzymatic method, and mineral by ICP-AES method P2.

The moisture content of tubers produced in the greenhouse growth and tuber initiation trial was also measured. Four plants were randomly selected for harvest at approximate 4 week intervals. The fresh mass (grams) of the tubers was recorded for each plant. The dry mass (grams) was also recorded; tubers were placed in paper bags inside an oven at between 60–100 degrees Celsius for 48 to 72 hours. Larger tubers were cut into smaller pieces prior to oven drying.

Product development

The acceptance of *Ipomoea calobra* tubers as a vegetable product in the commercial market was assessed by potential consumers and food industry professionals. This initial research was conducted through product appraisal events and opportunistic feedback. Successful horticultural trials in Carnarvon WA, produced enough product which allowed for additional product research on supply chain integration and for retail trials to be conducted. Outcomes of the research have guided the recommendations for food preparation and application, and product specifications based on appeal and have provided insight into actual opportunity within the market place.

Product appraisals were sought via:

- one stall at farmers market, Albany WA
- one “bush foods” event
- numerous opportunistic tastings
- two retail trials, Perth WA.

Results

Propagation

Propagation of *I. calobra* from seed, tubers and shoots was trialled in Albany under greenhouse conditions. Propagation from seed was simple once are requirement for scarification was determined. Observations of pot cultivated material confirmed that this species can also be propagated by layering shoots during periods of active shoot growth (Figure 16) Plants can also be propagated from tubers, or parts thereof, though it was more problematic (e.g. rotting off) than propagation via seed or layering.

Field observations of wild plants suggest that *I. calobra* to be a prolific seeder. The seeds are quite large, the mass of 100 seeds collected 12.5 km west of Depot Springs and stored under ambient conditions for three months was 13.41 g, and thus each gram contains 7–8 seeds. Observations of plants cultivated at Carnarvon concur with the observations made on wild plants. Of interest was that plants cultivated from sown seed at Carnarvon grew, flowered and produced large quantities of seed within one year. The results suggest that material being cultivated for tubers will also be a large and easy to collect source of seed. Thus the requirement for low cost seed should not be an impediment to industry expansion.

Once scarified the seeds of *I. calobra* germinate readily (Figure 17). Hand scarification with sand paper gave 100% germination (Figure 3.4). In a subsequent experiment 47.5% emergence was achieved by clipping by hand Table 12, however more cost effective methods such as 9 hr treatment with sulphuric acid produced a good result (55%).

Figure 16 A layered *I. calobra* shoot showing root/tuber formation at many each nodes

(scale increments are 10 mm)

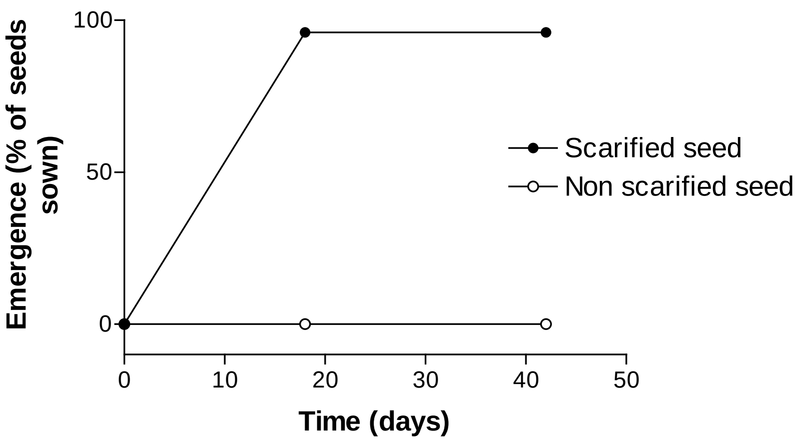


Figure 17 Emergence of scarified (fine sandpaper) and non-scarified *Ipomoea calobra* seed

(each point represents the mean n=5)

Table 12 *Ipomoea* scarifying trial, percentage emergence

(LSD at 5% level = 20.3)(n=4, 10 seeds per replicate)

Treatment	Mean (%)
Clipped	47.5
Mechanical 4x3rd gear	37.5
Mechanical 1x4th gear	20
Sulphuric acid 1hr	10
Sulphuric acid 9hr	55
Boil 30 seconds	2.5
Boil 120 seconds	5
Control	0

Results varied greatly between scarifying methods (Table 12), as well as between replicates. The control treatment was the only treatment with no emerged seedling in all four replicates. Hot water immersion proved unsuitable; maximum mean emergence using this method was 5% (H_2O 120 seconds). H_2SO_4 immersion for 9 hours was the most successful scarifying method, with mean 55% emergence percentage success however varied by up to 60% between replicates. Hand clipped seeds were the second most successful (47.5%), though with variation of up to 40% between replicates. Mechanically treated seeds undergoing 4 repetitions in 3rd gear through a conventional seed scarifier showed a mean success rate of 37.5% emergence; maximum variation between these replicates was 30%.

Cultivation and growth: Wild harvest

A partial excavation (Depot Springs Station) of less than 10 percent of the estimated soil volume occupied by a mature wild plant yielded five tubers (fresh weight of 50 g, 320, 620, 640 and 1400 g 3.5 kg total, tubers sown in Figure 14). The excavated vine was assumed to be old and its total tuber mass was estimated at 35 kg (fresh weight). No other wild vines were excavated as it was not culturally acceptable to do so.

Cultivation and growth: Pot culture

Swelling of the major roots commenced after seedling emergence. The fresh mass of tubers per plant increased with time (Figure 18). Mean fresh mass of tubers harvested between weeks 11–22 was 28 grams, increasing to 97 grams between weeks 26 and 41. The maximum tuber mass was 349.5 grams recorded at 36 weeks. Results suggest that a small carrot sized product can be produced within a period of 6–12 weeks (Figure 19). The growth of *I. calobra* in the greenhouse at Albany was however compromised by pests (aphid and mites) and diseases (leaf rust fungus). It was noted that cultivation in shallow pots distorted tuber shape (Figure 3.7).

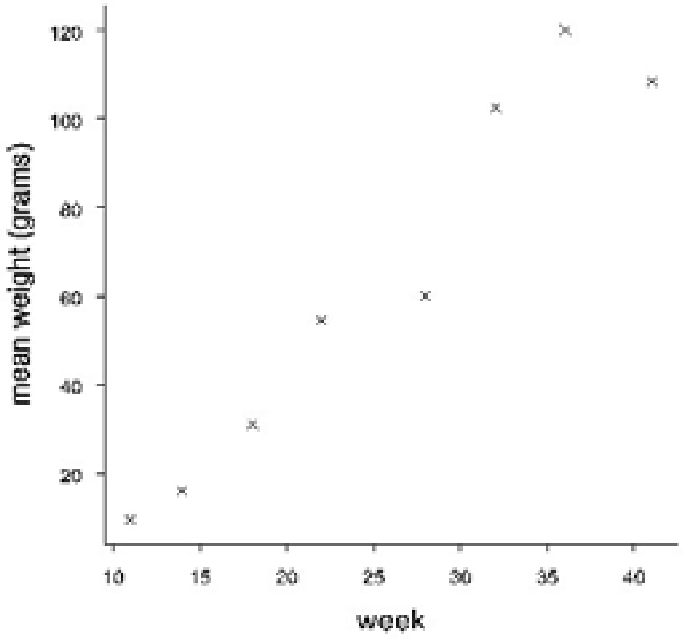


Figure 18 Mean fresh mass of tubers per plant harvested between 11 and 41 weeks

Figure 19 Initiation of tuberous roots in 6 week old *I. calobra* seedlings

Figure 20 Distortion of tuber development under shallow pot culture (right), and those produced in deep free draining tubs tubers – all material 12 week old

Cultivation and growth: tuber profiling and yield of field cultivated material

Table 13 Yield of tubers from excavation plots at Carnarvon

Plot	Size	Site	Tuber mass (g)			Total (g)
			Tubers >20g	Tubers <20g	Tubers 60-80cm depth	
1	0.6 m^3	1	2886	192		3078
2	0.8 m^3	1	2457	207	224	2682
3	0.8 m^3	2	3895	319	635	4849
4	0.8 m^3	2	2638	253	676	3567

The four excavation plots produced a mean yield of 3.5 kg of tubers. The maximum yield was, 4.8 kg recovered from site 2, plot 3 (Table 13). Results of this study suggest that the climate and soils of the Carnarvon horticultural area are ideal for the cultivation of *I. calobra*, where the species was robust and highly productive. No pest and disease issue were encountered during the trial. The average yield of 3.5 kg per sample in this study is equivalent to 35 tonnes of product per hectare after 12 months.

The maximum weight of an individual tuber was 374 grams. 75 % of all tubers recovered weighed between 20 and 101 grams. The mean weight was 78 grams (Figure 22). Tubers were found at a maximum depth of 61.5 cm below the soil surface. 75% of all tubers were found between +5 to 42 cm. The mean depth of tubers was 29 cm (Figure 22).

The use of a standard potato harvester (Figure 23) was completely unsatisfactory and this method harvested less than 5% of the available tubers. The failure of this approach was due to the fact that the equipment was not able to dig deep enough to extract the tubers.

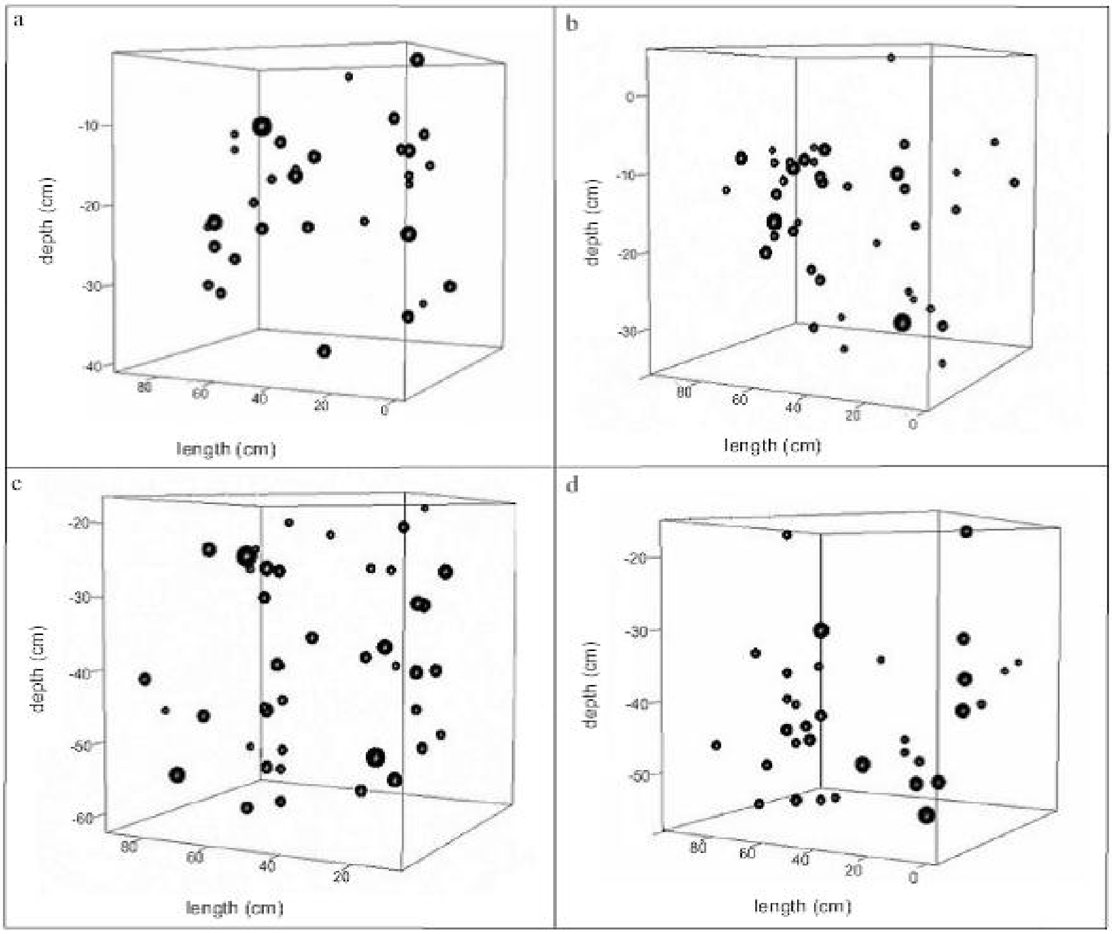
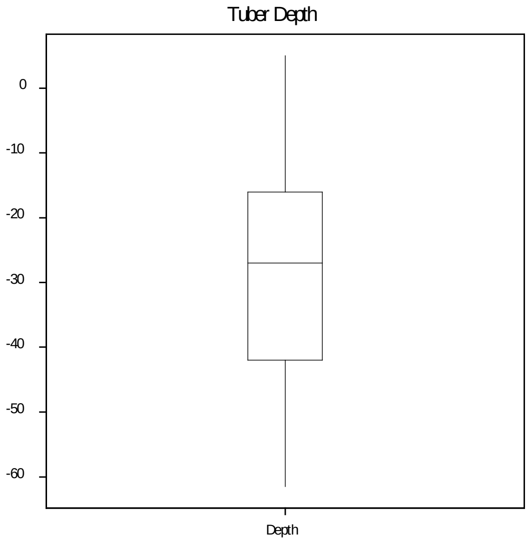


Figure 21 The spatial distribution of tubers at four excavation plots

The 3D images represent relative size (not shape) and position of tubers, Site 1: **a** and **b**; Site 2: **c** and **d.** Each image represents the area tubers were located in that plot not the total area excavated.



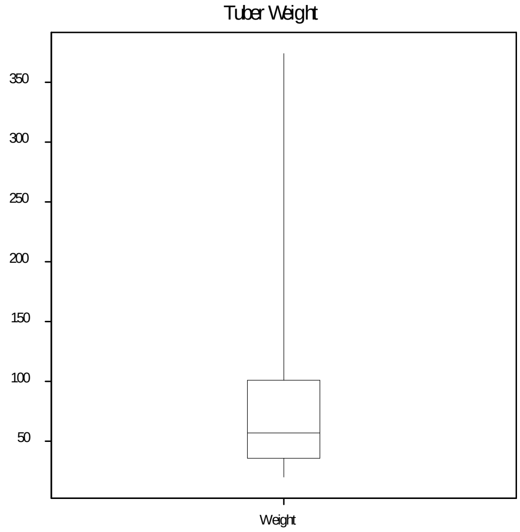


Figure 22 Quartile ranges for tuber depth (left) and mass (right)

Figure 23 Attempting to harvest *I. calobra* tubers mechanically with a potato harvester

Tuber composition

The mean moisture content of tubers produced by 32 *Ipomoea calobra* plants grown in pot culture was 81.5% and generally decreased with time (Figure 3.11). The maximum recorded mean moisture content was 87.5% at 11 weeks, with a mean minimum of 76.9% at 41 weeks. The range of moisture content for individual tubers was between 91.6% to 75.5% at 11 and 41 weeks respectively.

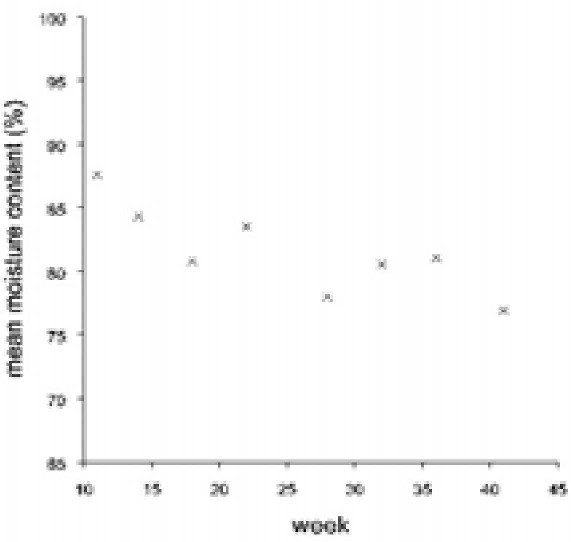


Figure 24 Mean moisture content of tubers harvested between 11 and 41 weeks

The mature tubers of *I. calobra* are nutritious and broadly similar nutritionally to sweet potato (*I. batatas*) as shown in Table 14 and 15. Notable differences between *I. calobra* and *I. batatas* were: higher starch concentrations in *I. calobra* and higher concentrations of potassium (K), copper (Cu) and zinc (Zn).

Interestingly, during the processing of tubers for nutritional analysis it was observed that some tubers, from a single parent plant, exhibited browning of the freshly cut tissue while other tubers did not. Browning was localised within and around severed vascular bundles.

Table 14 Proximate analysis of Ipomoea tubers on a percentage (%) dry mass basis

Source	Moisture	Protein	Fat	Fibre	Ash	Nitrogen free extractives	Starch
Ipomoea batatas cultivated	88	11.7	0.6	4.6	4.6	78.0	12.1
Ipomoea batatas cultivated	84	9.2	0.6	4.0	4.8	81.2	10.2
Ipomoea batatas cultivated	94	11.2	0.6	4.2	3.8	79.7	16.5
Ipomoea batatas cultivated	87	10.2	0.6	3.6	4.0	81.4	16.2
Mean	**88.3**	**10.6**	**0.6**	**4.1**	**4.3**	**80.1**	**13.8**
Ipomoea calobra wild	80	5.9	0.5	6.5	7.6	79.0	46.5
Ipomoea calobra wild	79	8.4	0.4	6.9	8.1	75.9	50.1
Ipomoea calobra wild	78	9.7	0.2	8.6	12.2	68.3	9.5
Ipomoea calobra wild	79	8.5	0.5	7.9	10.0	72.3	45.2
Mean	**79.0**	**8.1**	**0.4**	**7.5**	**9.5**	**73.9**	**37.8**

Table 15 Elemental composition of Ipomoea tubers, on a percentage dry mass basis (macro nutrients) – B, Cu, Fe, Mn and Zn all mg per kg of dry mass

Source		P	K	Na	Ca	Mg	S	B	Cu	Fe	Mn	Zn
Ipomoea batatas cultivated		0.4	1.4	0.6	0.1	0.1	0.1	6.3	2.3	26.4	57.0	7.4
Ipomoea batatas cultivated		0.2	1.7	0.5	0.1	0.1	0.1	7.3	3.6	23.1	48.2	8.4
Ipomoea batatas cultivated		0.3	1.3	0.4	0.1	0.1	0.1	5.3	2.7	21.2	15.9	7.4
Ipomoea batatas cultivated		0.3	1.3	0.5	0.1	0.1	0.1	5.3	2.2	24.2	32.6	5.3
	Mean	**0.3**	**1.4**	**0.5**	**0.1**	**0.1**	**0.1**	**6.1**	**2.7**	**23.7**	**38.4**	**7.1**
Ipomoea calobra wild		0.1	3.6	0.0	0.2	0.1	0.1	6.3	9.9	26.4	23.2	19.0
Ipomoea calobra wild		0.1	3.6	0.0	0.4	0.1	0.2	7.4	5.7	20.1	39.1	18.0
Ipomoea calobra wild		0.1	5.9	0.0	0.3	0.1	0.2	8.8	19.8	61.6	62.7	15.4
Ipomoea calobra wild		0.1	4.5	0.0	0.5	0.1	0.2	8.7	7.2	34.8	59.7	16.3
	Mean	**0.1**	**4.4**	**0.0**	**0.4**	**0.1**	**0.2**	**7.8**	**10.7**	**35.7**	**46.2**	**17.2**

Results and discussion of progress towards marketing and commercialising *Ipomoea calobra*

Ipomoea calobra has shown significant potential in the pre-commercial phase of product development both in product appraisal and horticultural production. The recommendations provided here for marketing and commercialising *I. calobra* are based on the information detailed in Appendix 1, though are specific to the unique characteristics, horticultural production and the preliminary product research outcomes for this species.

Product specifications, preparation and application

Preliminary appraisal of the product suggests this new vegetable has significant market appeal for the domestic market based on its crisp texture, versatility of use and its indigenous Australian origins. Appraisals highlighted the unique taste, being sweet and slightly nutty in flavour; and texture, which is crisp/crunchy though succulent. Premium product can be considered that without significant shape distortion or damage/blemish of the outer skin. Results of the retail trials indicate that the product is suitable for presentation whole and loose (as per sweet potato) for purchase on a $ per kg basis.

Four Perth-based chefs participated in a formal tasting of the product. All ‘liked’ or ‘strongly liked’ the taste and texture of the raw and oven-baked samples they tasted, with a preference shared by all four for the raw, uncooked product, with less enthusiasm for the boiled sample. All were interested in purchasing and using the product in a dish on their menus, and indicated that they would pay a price similar to sweet potato. There was a positive response to the flesh of the tuber, and its ability to bring something unique to a dish without being too foreign in its flavour.

Feedback from chefs, food professionals and ‘foodies’ that have had some experience with, and exposure to the product indicated that the product could be used primarily in three ways:

- *Raw:* The crisp and delicate nature of the young tuber flesh make it suitable for use in summer salads, unpeeled and either diced, sliced or grated as fennel bulb is sometimes used. As tubers age their starch content increases and consequently become less appealing to consume raw.
- *Dried, dry-baked or roasted:* Even when baked/roasted the flesh does not break down, remaining firm and somewhat crunchy. Although techniques have not been developed to ‘crisp’ the skin, feedback at tastings suggest that baking enhances sweetness and mouth-feel.
- *Fried:* the tubers potential to hold and absorb flavours make it suitable for use in dishes that contain herbs, spices and marinades, for example in Asian style stir frys and curries dishes.

Retail trial and supply chain integration

Irrigated horticultural cropping has continued in Carnarvon WA since the 1920s and the region has developed an industry based on a range of fruit and vegetable produce. A distribution network supplies produce to Perth, the State's major market, situated 900 km south of Carnarvon.

Three main transport companies Youngs, Toll West and Centurions operate from the facilities of Gascoyne Gold, who act as an intermediary between the market, freight companies and growers. Produce is delivered to Gascoyne Gold for storage, grading and packing or arrives pre-graded and packed on farm by the growers. Distribution of produce to the desired market is pre-arranged and is delivered overnight to central locations in Perth for further distribution to retailers. Approximately 9–15 trucks deliver produce from Carnarvon to Perth six days per week.

A retail trial of *Ipomoea calobra* tubers was conducted to determine the product's ability to integrate into this existing produce supply chain. Two Perth retailers, Mr Organics (Fremantle Markets), and The Boatshed Fresh Foods (Cottesloe) were selected based on relevance to and suitability for the target market (detailed in Appendix 1).

The product was harvested on Tuesday 28 August 2007. All preparation for market was done on farm including washing, drying, grading and packing. The produce was delivered to Gascoyne Gold the following morning and was then transported overnight by Centurions Freight Company arriving at Market City's Central Fruit Sales (CSF) in Canning Vale, Perth (Market City is a base for fruit and vegetable wholesalers). The produce arrived at Mr Organic on 30 August via the delivery link between CFS and the Fremantle Markets.

At Mr Organics a price assessment of *I. batatas* (comparable product) available at the markets on the morning of trade was conducted to determine a suitable market price for the *I. calobra* product. A price was set between 1.5 to 2 times the average price of non-organic sweet potato. 12 kg of product was available at $6.50 per kilogram generating $78 in sales. The product was well received by customers with all available product sold on the day of presentation. Feedback from the staff and management of Mr Organic was very encouraging, regular customers commented favourably and inquired as to when the product would be available again.

At the Boatshed Fresh Foods, product sold for between, $6.25–7.99/kg. A small amount of product did not meet the high product presentation standards (this highlights the importance of quality and presentation). However, this trial was also very successful generating interest form customers and staff with the majority of product sold over a short period.

Figure 25 *Ipomoea calobra* tubers (left) displayed at Mr Organics, Fremantle Markets and a customer selecting tubers for purchase (right)

The supply chain is an essential link in securing a product's place in the market. This trial confirms the ability of *I. calobra* product grown in Carnarvon WA to successfully integrate into the existing produce supply chain, from the farm gate in Carnarvon to Perth fruit and vegetable wholesalers and retailers and ultimately to the consumer.

Creating a market for *Ipomoea calobra*

The Gascoyne region plays and important role in food production for WA (Erlich *et al* 2005) the region has a successful local market established, the Gascoyne Growers Markets, and are based on the large variety of fruits and vegetables produced in the region. The markets are held in Carnarvon every weekend during May to October and provide an excellent marketing opportunity to the local region as well as tourists.

While support from the local community and tourism is of importance initially these can not be expected to support an industry of significant scale. As product supply is developed in the local region there is an excellent opportunity join the existing produce supply chain from Carnarvon the Perth and begin market expansion beyond the 'region of origin'. Trails have confirmed the products ability to successfully integrate into this distribution network and that actual retail opportunities exist in the Perth metropolitan region, (also indicated by successful retail trials).

Retail outlets participating in the early commercialisation phase need to be able to demonstrate their enthusiasm for the products and willingness to display Point of Sale material, and have a role in educating their customers on preparation and use. These products will need to 'fit' with their position in the market, and are likely to be specialty foods where quality and point of difference are often more important than price.

Marketing/promotion will assist in familiarising consumers with this new product in the initial stages of commercialisation. Target market education and familiarisation should focus on the outcomes of preliminary product and market research, and on unique selling points (USP's). Combined, these form the initial base for developing Point of Sale material and information brochures. See appendices for examples of preliminary material based on these aspects developed for this project). Potential points of difference for *Ipomoea calobra* include:

- a Western Australian native food
- remains crunchy when cooked (cf *I. batatas*)
- support for Indigenous communities (assuming Indigenous involvement in this new crop)
- environmentally friendly - produced using clean, green and organic production systems
- nutritious
- versatile
- entirely new to the commercial market.

This new, versatile and nutritious vegetable will need to compete successfully with a rapidly diversifying and competitive fresh vegetable market where 'new' vegetable products typically of Asian origin appear frequently. It is critical that the product is successfully differentiated as a nutritious vegetable of Australian origin. A contemporary product name or brand that implies the unique, indigenous and/or regional character of the product may need to be adopted to differentiate the product from other new vegetables of Asian origin.

It will be beneficial to package and present the product to consumers clean, whole and intact. Additionally, tight quality control through product grading to remove product that doesn't meet specifications for this fresh wholefood market is essential. Building the expectations of consumers about a product then demands a sustained focus on ensuring the supply chain delivers quality product, with consistency relating to product size, colour and texture. As a risk minimisation strategy it may be important to limit supply of this product to a well-defined season, ensuring consumers are introduced to the product when it is at its best. Maintaining control over the visual quality and integrity of the product being presented to retail customers and consumers will be critical to the successful introduction of this new vegetable.

Promotion and extension of *Ipomoea calobra* as a new crop option needs to be strategic and focus on identifying innovative growers who will be proactive and participate cooperatively in the development of efficient systems of production and the generation of solutions to inevitable production challenges. Due to very limited initial supply base, the commercialization of *Ipomoea* tubers will need to be incremental and carefully managed, with efforts to expand the market occurring only when strong market indications exist and production risks and costs are well understood.

General discussion

This current study confirmed the seeds of *I. calobra* to be highly germinable when mechanically or chemically scarified, consistent with the general recommendation of Ralph (1997). A cost effective scarified seed propagation system has been developed and this is a key step towards the species becoming a commercial reality. The species' requirement for scarification explains why attempts by indigenous people to propagate this species from untreated but fresh seed collected from Terracotta and sown in Leonora had mostly been unsuccessful, as were early germination attempts conducted by the author. Further trials could aim to optimise scarification and investigate the use of H_2SO_4 over various time scales. Chemical scarification may prove useful for large scale seed treatment in a vat set up.

Results of this study suggest that the climate and soils of the Carnarvon horticultural area are ideal for the cultivation of *I. calobra*, where the species was robust and highly productive. The average yield of 3.5 kg per sample in this study is equivalent to 35 tonnes of product per hectare after 12 months. This is very encouraging for the species commercial potential especially when considering a good yield per hectare of sweet potato is 20–30 tonnes (Burton 1989). At this stage we do not know whether the cultivation of *I. calobra* is suited to other horticultural districts of Western Australia and elsewhere. This study clearly demonstrated that greenhouse conditions in Albany were far from ideal, with considerable tuber rotting, pest and disease problems (cf Carnarvon).

I. calobra grown in large tub culture or that of field cultivated product have a round to oblique shape. The tubers grown in small shallow pots however were distorted in shape due to the confined growing area of the pots. It is recommended that cultivation in small shallow pots not be used to grow product due to the reduced aesthetic appeal of the distorted tubers produced by this method. These observations suggest that tuber shape can be altered by the growing environment and it would be useful to determine whether soil characteristics such as tilth, bulk density, rock, gravel or clay clods can influence tuber shape.

At the retail trial of *I. calobra* tubers ranging between 20 and 90 grams were sold. Tubers between 50 and 90 grams were preferred by consumers and thus considered to be the premium product. Tuber mass was highly variable with the mass of tubers collected from 12 month old plants cultivated at Carnarvon ranging between 20–370 grams. It is therefore recommended that product be graded into classes prior to sale. It is suggested that the following classes be used: 20–40 g (small), 40–100 g (medium), greater than 100 grams (large). It was encouraging that 50% of the product cultivated at Carnarvon was premium grade, that is, of between 40–100 g (medium).

Variation in tuber depth between the two Carnarvon sites was observed. Site 1 had a mean depth of –17.5 cm significantly different to site 2 with a mean depth of –41 cm. The different methods used to prepare the sites may have contributed to this difference. In comparison to site 1, *Ipomoea calobra* at Site 2 was cultivated on smaller mounds (approx. 15 cm difference in height) and on rows prepared with a 40 cm rip line which provides greater opportunity for roots to penetrate soil via loosening the soil profile. Though preliminary and not statistically comparable, these observations may suggest there may be opportunities to engineer the soil to encourage shallow tuber formation. Shallow tuber formation is essential of this crop is to be harvested cost effectively via mechanical means.

Tubers were of variable shape, size and mass. Individual plants produce numerous tubers, the largest of which may have a fresh weight of >1.5 kg (unknown aged wild material) and have dimensions of 15 cm (width) x 30 cm (length) x 6 cm (depth). These observations are somewhat different to those of Pate and Dixon (1982) who described the tubers of this species as only being 2–4 cm wide and 2–25 cm long. They also state that the tubers are produced along the main root; we have confirmed this and also noted that tubers form at intervals along roots other than the main root.

In this study the mean moisture content (81.5%) of pot grown tubers is similar to that recorded for horticultural tuber species by Cashel et al (1989). Mean moisture content of four wild harvested tubers was 88%, significantly higher than, but in a similar range to, the mean of 79% obtained for five sweet potato tubers (*Ipomoea batatas*) (t-test, $P<0.01$). A similar moisture content of 77% (*I. batatas*) was published in the "composition of foods Australia" (Cashel et al 1989). Some 70% of the Western Australian species sampled by Pate and Dixon (1982) showed water contents of from 60–85% and the tuberous species being developed as a horticultural crop in the north of Western Australia, *Brachychiton gregorii*, is reported to have a moisture content of over 85% (Pate and Dixon 1982). Scott (1973) recorded *Ipomoea calobra* to be more succulent than *Ipomoea costata*.

The composition of the two Ipomoea species were different when compared, but are broadly similar when compared to other unrelated root vegetables, i.e. those listed in the "Composition of Australian Foods" (Cashel et al 1989). For *I. batatas* Cashel et al (1989) reports an ash, protein, fat and starch content of 2.6, 6, 0.43, 55 respectively on a percentage of dry matter basis. The 37% starch content reported here for *I. calobra* is midway between the 55% starch content of *I. batatas* recorded by Cashel et al 1989 and the 15 % for *I. batatas* recorded by this study. A similar situation to that described for starch also exists for protein. Tubers of both species were low in fat and this is inline with all 150 species examined by Pate and Dixon (1982) which all had amounts less than 3% of dry weight.

In summary, this project has clearly shown that the market would enthusiastically embrace the product derived from *I. calobra* and that the product could fit within existing vegetable processing, distribution and retail systems. The project has also developed a basic propagation and cultivation system capable of producing approximately 35 t ha of product over a 12 month rotation when cultivated under intensive horticultural conditions at Carnarvon in Western Australia. It can thus be justifiably concluded that *I. calobra* is well on the way to becoming a commercial reality.

Although the commercial prospects for the species are exceptionally encouraging two areas of research and development are of paramount importance if this species is to become a commercial reality. Future research needs to determine how the cultivation environment can be engineered to facilitate shallow tuber formation and thus the ability of the crop to be mechanically harvested. A participatory development stage needs to commence as soon as possible where production and demand are increased concomitantly. Technical assistance needs to be provided to potential growers and together researchers and growers should aim to optimise production systems. Promotion of the product should reflect the amount of product available. The high level of demand and interest in the product suggests that demand is likely to be larger than supply in the short to medium term and thus too much promotion without the ability to supply could be damaging and should not be encouraged.

Haemodorum spicatum

Introduction

Haemodorum spicatum R.Br. is endemic to south western Western Australia and usually occurs in nutrient poor sandy soils. It is a member of the Haemodoraceae, a family better known for unique and beautiful flowers such a Kangaroo Paws than food plants. This species and its close relatives are commonly referred to as "blood roots". The systematics of the genus suggest that *H. spicatum*, *H. simplex* and *H. brevisepalum* are very closely related (George 2001). Aboriginal names for *H. spicatum* included Meen, Mardja, Bohn, depending on location. It is a perennial herbaceous geophyte (bulb), 0.3–1 m high. Black flowers are produced in October-November on an inflorescence spike up to 1.5 m in height.

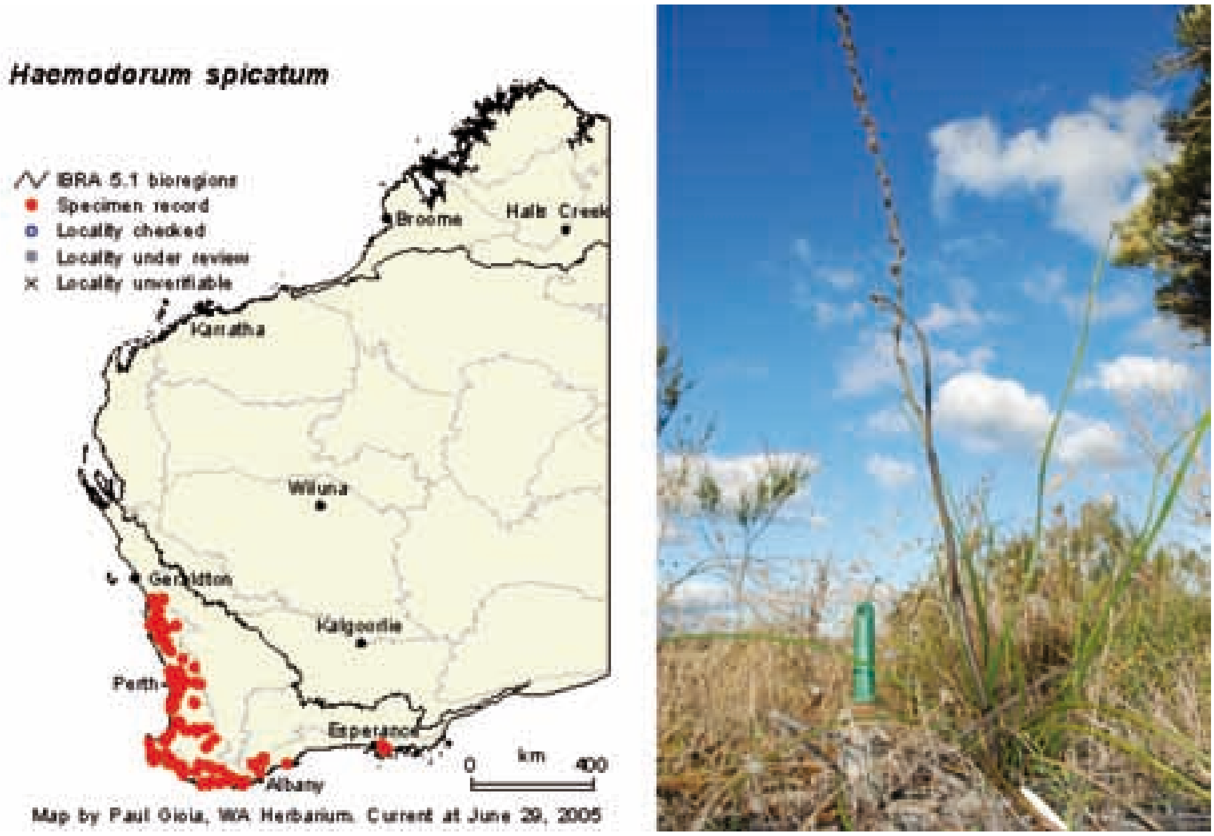


Figure 26 left Distribution of *Haemodorum spicatum*

(Mapping by Paul Gioia. Image used with the permission of the Western Australian Herbarium, CALM (http://florabase.calm.wa.gov.au). Accessed on Tuesday, 18 October 2005) right a mature *H. spicatum* specimen

The attractive red bulbs have a documented and unambiguous history of consumption and were eaten raw or roasted. Backhouse (1843) states that: "It is prepared for eating by being roasted, and beaten up with the earth, from inside the nest of the White Ant, or with a red substance, found on burnt ground". A different *Haemodorum* species (Quirting=*H. laxum*) was according to observations made by Ethel Hassell in the 1880's (Hassell 1975) prepared in the following way "I watched the women smash them up into a slimy looking mass, knead them into flat cakes and put into the wood ashes to bake, telling me the fire took a good deal of the heat out of them. They also eat a little of it raw after a meal as a digestive. The bulb is spicy/hot when consumed raw or cooked. When Hassell prepared a stew with *H. laxum* in it for her station workers it was so hot that the workers could not eat it and she describes the stew as being inedible.

The red colour of Haemodorum bulbs is due to the presence of a compound called Haemocorin (Cooke and Segal 1954) (Figure 27) which is a phenylphenalenone. Phenylphenalenones are aromatic natural products occurring in the plant families Haemodoraceae, Musaceae, Pontederiaceae, and Strelitziaceae (The Max Planck Institute for Chemical Ecology in Germany 28/10/2005 http://www.ice.mpg.de/nmr/research/Phenylphenalenones/Phenylphenalenone_research.htm). These are very different phenolic compound to the water soluble anthocycanin phenolics that are mostly responsible for the pink-red-purple colour fruits and vegetables. Phenylphenalenones are a subgroup of diarylheptanoids and one notable example is curcumin, which is widely used as a food dye and spice, e.g. in curry (The Max Planck Institute for Chemical Ecology in Germany 28/10/2005 http://www.ice.mpg.de/nmr/research/Phenylphenalenones/Phenylphenalenone_research.htm). Daw et al (2001) states that Haemocorin shows promise as a pharmaceutical, having both antitumour and microbial properties. The original source of this information appears to be Harborne et al (1999).

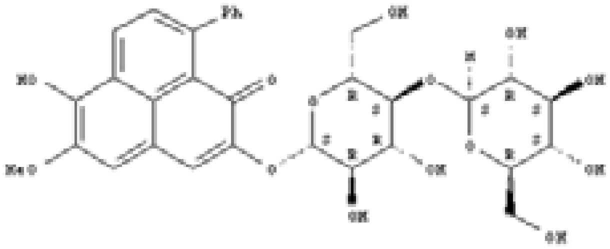


Figure 27 Structure of Haemocorin, C32 H34 O14 (Stevens 2001)

An important preliminary observation made during field studies of natural populations in the south coast region of WA was that *Haemodorum spicatum* colonised disturbed environments adjacent to remnant vegetation. Road verges adjacent to remnant vegetation, cleared and recently ungrazed (>2 years) farmland adjacent to remnant vegetation and firebreaks through remnant vegetation were sites where colonisation was observed. Shoots of these plants always appeared healthy, more so than those plants growing in adjacent remnant vegetation. Similar occurrences are documented with many voucher specimens held by the Western Australian Herbarium (e.g. PERTH 2085356, Perth 02085410, 6936830, 05389623, 2085399, 03079228) and the observations of George (2001). These desirable colonising characteristic suggests that cultivation on cleared sandy, low opportunity cost, farmland could be possible and potentially productive.

There is evidence to suggest that *Haemodorum spicatum* may accumulate organic acids. The first item of evidence was a review of oxalate crystals in monocotyledons which reported raphides (bundles of narrow, elongated needle-shaped crystals) and styloids (prismatic crystals) to be present in some taxa of the Haemodoraceae (Prychid and Rudall (1999). The second piece of evidence was that cell inclusion have been observed (unpuplished) in *Haemodorum spp* (Stephen Hopper Kew Gardens UK pers. comm.). The third and final item of evidence was the reference to Haemodorum bulbs being mixed with clay or ash prior to consumption to remove bitterness (Backhouse 1843). Ash being alkaline could potentially neutralize the acidity of organic acid or may interact in some other way that makes the bulb either more palatable or detoxifies it is it is indeed toxic.

Organic acid have various function within plants and can be feeding deterrents and or toxic (Harborne 1997). Oxalate is toxic but only when associated with the sodium or potassium ion to give a soluble salt, the calcium salt, by contrast is insoluble and may pass through an animals body without being absorbed (Harborne 1997). Oxalic acid if found in plant foods and it accumulates in rhubarb, particularly in the leaves (Harborne 1997, Brown 2000). The potentially toxic nature of organic acids and evidence supporting accumulation in Haemodorum, albeit circumstantial, suggested that a detailed study of organic acids contained within the bulb was warranted.

This study aimed to:

- Develop a reliable and cost effective propagation system
- Develop cultivation systems
- Determine the species' productive capacity
- Investigate the nutritional value of tubers
- Assess the species commercial potential and if warranted, commence commercialisation and product development.

Methodology

Field examination

During 2004 and 2005 many field trips were carried out to investigate the species' distribution and gain an appreciation of its ecology and biology. Selected plants from Eneabba (250 km north of Perth WA) through to Kojonup (250 km south east of Perth), Albany and Esperance were excavated from private lands and their characteristics observed and some individuals collected and grown for further study in Albany.

Propagation

Twenty seeds collected from wild plants in the Albany region were sown at depths of 0, 5, 10, 15, 30 and 60 mm in coarse sand during October 2005. There were three replicates each in a separate 300 mm (diameter) pot. Pots were placed in a greenhouse and watered three times a week with overhead irrigation. Emergence was monitored for 100 days post sowing.

Cultivation and growth

Field cultivation Site 1: A 0.25 ha site 8.5 km SW of Bremer Bay was chosen for field trials (50H 0709228, UTM 6188469). The site was cleared agricultural land previously used for grazing livestock with a annual ryegrass/cape weed and clover based pasture (annual pasture). The soil was fine white silica sand over clay and rock at 0.3 to over 1 m. Both *Haemodorum spicatum* and *Platysace deflexa* occur locally in sites of similar landscape position and soil type. The property was owned and operated by an indigenous corporation. The site was fenced with the corporation paying for all fencing materials.

It was thought that harvesting product would be made easier if plants were cultivated on mounds. A mounder used in the horticulture and forestry industry was not deemed to be appropriate because such equipment would mound up soil containing an enormous seed bank of weed species and in particular annual ryegrass. A weed free planting/sowing niche was required to avoid the used on herbicides and therefore, a Chatfields tree planter was used to scalp, rip and mound the site prior to sowing/planting in a one pass operation. A larger mound was created by going over the lines again with the same equipment but with the scalper and ripper removed. The use of herbicide was avoided as the consequences of their use were unknown.

Field cultivation Site 2: At Manypeaks, 30 km North East of Albany a small 0.1 has site was sown with *H. spicatum* in July 2006. The soil at the site was deep white silica sand (over 2 m deep) and this cleared agricultural site was previously used for stock grazing. The site was sprayed with glyphosate at 1.5 l/ha 14 day prior to sowing. The lines were scalped (50 mm) ripped (150 mm) and sown (100 g/ha) with a prototype revegetation seeder, that had a combine type cog driven small seeds box fitted.

In September 2007, seedlings of *H. spicatum* were harvested from the 14 month old trial. The fresh and dry mass of bulbs from 10 seedlings was recorded to determine product yield.

Nutrition

Detailed nutritional analysis was not conducted on this species as it was apparent from preliminary appraisal made by the author and others that the species did not have merit as vegetable product. Before this conclusion was reached research on the potential accumulation of organic acids within the bulb had commenced.

Bulb samples for organic acid analysis were collected from wild populations NE of Albany. 5 bulbs were bulked together to form one sample from each collection location. On arrival back in Albany the roots and shoots were removed from the bulbs. Bulbs were then washed in distilled water (several times) and the outer necrotic or dead leaf bases were removed from each bulb. Bulbs were then dried with paper towel and then sliced (5–10 mm thick) with a kitchen knife. Samples were then oven dried at $60^{o}C$ for 48 hours, then ground into a coffee grinder. Samples were then stored for 2 weeks in small 50 ml vials at room temperature, before organic acid analysis.

Organic acids were extracted with 5% Perchloric acid (PCA) and analyses by an improved reversed-phase liquid chromatographic method (Cawthray 2003). Analyses were conducted by the School of Plant Biology at The University of Western Australia on a fee for service basis.

Product development

Fresh, dried and powdered, roasted and an olive oil extract of *H. spicatum* were appraised by consumers and the food industry at the same events as that detailed for *P. deflexa* (see Chapter 2 for details). All material used was wild harvested material from the Albany region.

Results

Haemodorum spicatum is widely distributed and bulbs collected form various locations during this study (Eneabba, Collie and Albany) differed markedly. Bulbs collected in November 2005 from Eneabba were an orange colour whereas bulbs from Collie, Kojonup and Albany (collected at the same time) were a deep red colour. The orange colour is confined to the outer tissues of the swollen leaf bases with the inner tissues being white. In contrast all tissues of swollen leaf bases that comprise bulbs collected from Albany and Collie are red though the pigment is somewhat concentrated towards outer most tissues. Bulbs from distant populations have a different taste. For example, Eneabba bulbs are very mild when consumed raw and bulbs from south-western populations are very hot (particularly those from the Albany to Walpole to Kojonup to Collie region).

Figure 28 Bulbs of *Haemodorum spicatum* sourced from Eneabba (left) and Albany (right)

Figure 29 Longitudinal section through bulbs of *Haemodorum spicatum* sourced from Albany (left) and Eneabba (right)

Propagation

Seed of *H. spicatum* was simple to germinate without pre-treatment. Seedlings were slow to emerge, with maximal emergence observed at day 97 (Figure 30). Indeed, further emergence may have occurred if the experiment was run for a longer period of time. A sowing depth of 15 mm was found to be optimal when propagated in sand (the natural substrate of the species) as shown in Figure 30. Field emergence at field site 2 was approximately 22.5% (base on results of 3x1 m sub-samples). Although seedling emergence in the field and in the greenhouse was generally good, survival of seedling was often compromised by what appeared to be a fungal disease. Yellowing, then Necrotic leaf blades were the first sign of fungal infection that ultimately resulted in seedling death.

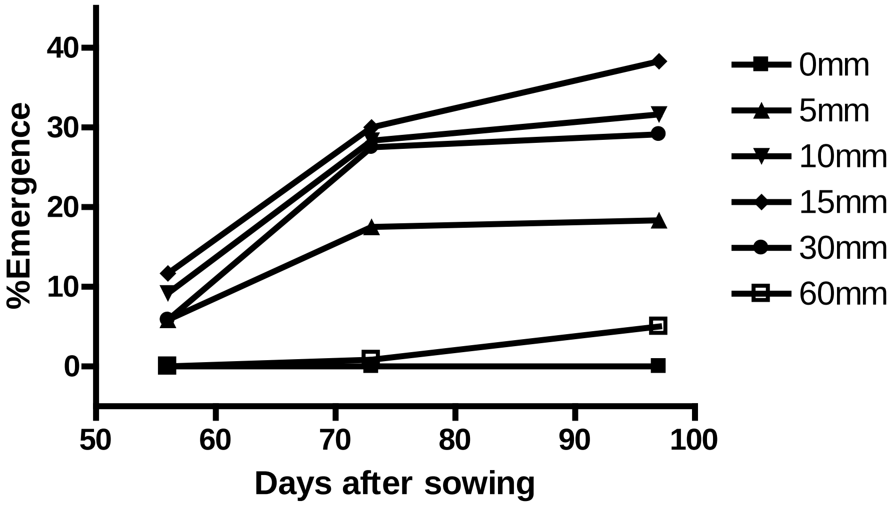


Figure 30 Emergence of *H. spicatum* seedlings from seed sown at various depths

Figure 31 Seedlings of *Haemodorum spicatum* at 5 months of age

Cultivation and growth

The first attempt at cultivation (site 1) failed due to excessive rainfall and subsequent persistent inundation and waterlogging (2005 see also chapter 2 for details). At the second field site total bulb yield was 0.7 grams from 10 seedlings after 14 months, the mean fresh weight of the bulbs was 0.0661 grams and the mean dry weight was 0.0149 grams. In contrast the mean fresh and dry mass of wild harvested mature bulbs (cleaned product) was 39 g (coefficient of variation 48%) and 14 g (coefficient of variation 55%). Thus after 14 months the dry mass of cultivated bulbs was approximately 100-fold lower than unknown aged mature bulbs. These results suggest that *H. spicatum* is very slow growing and that mature wild plants collected during this study could be very old (likely to be over 10 years old).

Detailed nutritional analysis was not conducted on this species as it was apparent from preliminary appraisal made by the author and others that the species did not have merit as vegetable product. Before this conclusion was reached research on the potential accumulation of organic acids within the bulb of this species was investigated, the results of which are shown in Table 16. The results clearly show that bulbs of *H. spicatum* accumulate organic acid, but much lower than the concentrations present in other fresh foods known to accumulate organic acids. Interestingly *Haemodorum* only accumulated low levels of oxalic acid and total organic acid content was about 10 fold lower in *Haemodorum* compared to rhubarb.

Figure 32 14 month old field cultivated Haemodorum spicatum seedlings

Table 16 Organic acid composition (mg/g dwt.) of *Haemodorum* bulbs from two locations close to Albany and from 30 km NW of Kojonup

Results of bulked rhubarb petiole and celery petiole are included for comparison.

	Oxalic	malic	malonic	citric	succinic	fumaric	shikimic	Total (mg/g dwt.)
H. spicatum Albany	4.0	8.3	5.3	5.6	0.9	0.0	1.9	26.0
H.spicatum Albany 2	1.8	8.3	5.3	5.6	0.8	0.0	1.9	23.7
H. spicatum Kojonup	2.3	2.2	5.3	8.5	ND	0.1	0.4	18.8
Rhubarb	102.7	122.5	ND	12.7	ND	0.0	ND	237.9
Celery	2.6	49.6	ND	ND	ND	0.8	0.3	53.3

Results and discussion of progress towards marketing and commercialising *Haemodorum spicatum*

Following the species selection stage of this project *Haemodorum spicatum* did not demonstrate further potential as a new vegetable product. Preliminary product research through appraisals highlighted key features contributing to consumer's dislike of the bulb these include the staining effect (red pigment), fibrous texture and bitter taste. In addition, it was evident that sizeable bulbs may take several or more years to form, a major factor limiting horticultural development of the species. Thus, a marketing and commercialisation strategy for *H. spicatum* as a vegetable product was not perused. This project did however identify other non vegetable products and uses for this species; as a dye, and as a spice. Such applications are only relevant to material sourced from particular areas which contain high levels of haemocorin.

The heat/mouth feel of the bulb is quite different to the heat of horse radish and chilli, and is more similar to that of pepper or curry powder. The heat in the mouth is not instantaneous: instead, the hotness builds slowly in the mouth and then persists. Given this characteristic, it is easy to consume too much of the product prior to the consequences of the consumption becoming apparent. Fortunately, dairy products such as milk and yogurt are effective at tempering the hot taste (though not 100% effective) of this product as they are in tempering the heat of curry powder.

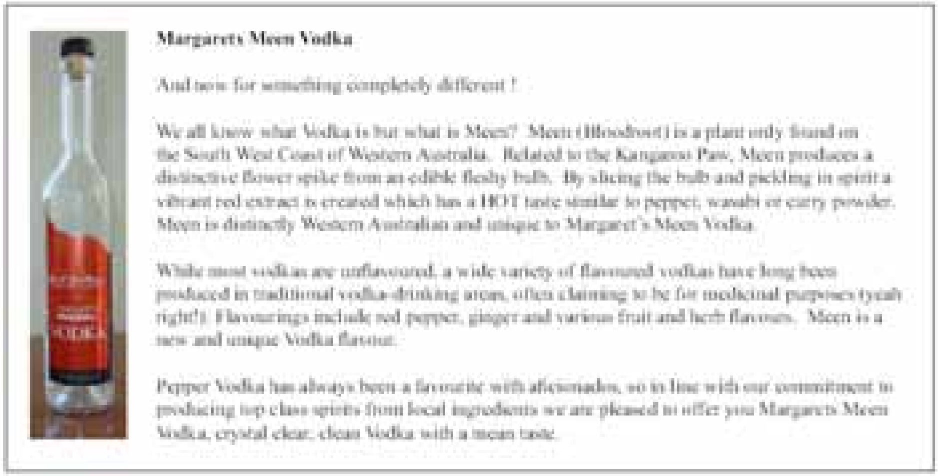
When dark red bulbs are cut, the surface oozes a gelatinous material and the bright red colour rapidly darkens (oxidises) to a brown colour. Bulbs darken similarly when air dried under ambient conditions or when dried at elevated temperatures (cf extraction via alcohol, oil and fats in following sections).

Spice powder

The spice industry is based on a large variety of plants for the aromatic and flavour qualities of their leaves, bark, seeds, stems, and roots. A component of this market is for those with hot, peppery and spicy characteristics. The red colour and hot-spicy flavour of Haemodorum bulbs is due to the presence of Haemocorin. Native Australian plants utilised as herbs and spices in the bushfoods industry for example include *Acacia sp.* Wattle seeds, *Ocimum tenuiflorum* Native thyme, *Prostantheria rotundifolia* Native Mint, *Apium prostratum* Sea Parsely and *Tasmannia lanceolata* Native Pepper, all dried and either ground or flaked. Investigations confirm that dried samples of *H. spicatum* retain their strong spicy flavour (but not red colour). RIRDC (2006b) indicates that the Australian herb and spice industry experiences an annual growth rate of 20%, further research may confirm the potential for *H. spicatum's* application as a commercial spice in this growing industry.

Alcohol and infused oil products

During this present study it became evident that Haemocorin, the compound responsible for the colour and heat of the bulb, could be extracted and is highly soluble and stable in alcohol and oils (lipids). This has lead to promising markets in the oil and alcohol industries. This project provided the Great Southern Distilling Company, Albany, with product and technical assistance to develop a Vodka (Figure 33), and trialled infused oil products (Figure 34) with an olive oil processing facility from the Great Southern Region, WA.



Margarets Meen Vodka

And now for something completely different !

We all know what Vodka is but what is Meen? Meen (Bloodroot) is a plant only found on the South West Coast of Western Australia. Related to the Kangaroo Paw, Meen produces a distinctive flower spike from an edible fleshy bulb. By slicing the bulb and pickling in spirit a vibrant red extract is created which has a HOT taste similar to pepper, wasabi or curry powder. Meen is distinctly Western Australian and unique to Margaret's Meen Vodka.

While most vodkas are unflavoured, a wide variety of flavoured vodkas have long been produced in traditional vodka-drinking areas, often claiming to be for medicinal purposes (yeah right!). Flavourings include red pepper, ginger and various fruit and herb flavours. Meen is a new and unique Vodka flavour.

Pepper Vodka has always been a favourite with aficionados, so in line with our commitment to producing top class spirits from local ingredients we are pleased to offer you Margarets Meen Vodka, crystal clear, clean Vodka with a mean taste.

Figure 33 The Great Southern Distilling Company's Meen Vodka product description

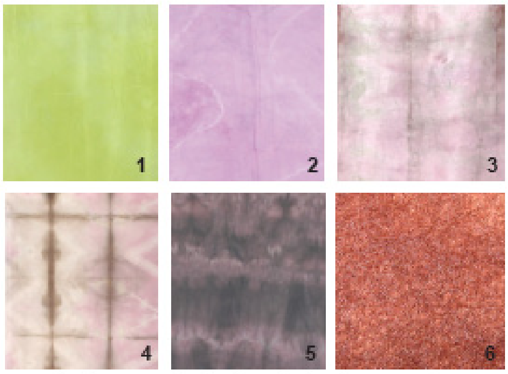
(Great Southern Distilling Company, Albany, <**http://www.distillery.com.au/vodka.aspx**>, viewed 5 January 2008).

Figure 34 Olive oil (Left) and olive oil infused with *Haemodurum spicatum* (Right)

Although the species has a clear and unambiguous history of consumption, the extraction of haemocorin, the agent responsible for the red and spicy character, via alcohol or fats is vastly different from the preparation done by indigenous people. It may be prudent therefore to consider food safety issues on an individual product basis.

Natural dye

Plants of the Haemodoraceae Family (Bloodroots) have been utilised as a dye source by indigenous people in many parts of the world (Johnston and McMah 2006). In northern Australia Aboriginals used *Haemodorum coccineum* a relative of *H. spicatum* for dying natural fibres (ANBG 2008 <http://www.anbg.gov.au/hort.research/haemodorum.coccineum.desc.html> viewed 5 January 2008). Both professional textile artists and hobbyist have shown great interest in the use of *H. spicatum* as a natural dye and though not traditionally used for this purpose, investigations confirm it to be an effective and versatile dye (Trudy Pollard, Textile Artist, pers. comm.). The distinctive vibrant red bulbs are not the only part of the plant that can be utilized to dye both natural and synthetic fibres; the seed, leaf and stem all produce a dye. Shades of red, purple, pink and green can all be achieved (Figure 35). The project developed an information brochure on *H. spicatum's* use as a natural dye as a result of continued interest in this characteristic (refer to Appendix 2).



Photographs above: Silk dyed with the leaves and stem (1), bulb (2,3), seeds (4,5) and wool dyed with the seeds (6) of *Haemodorum spicatum*, from a selection of work by WA textile artist Trudi Pollard.

Figure 35 Examples of *Haemodorum spicatum* as a natural dye on silk and wool

Other properties

While reviewing literature on *H. spicatum* during the project it became apparent that there was reference to haemocorin as having anti tumour properties (Harbourne 1999). This was viewed as a possible positive attribute and that the occurrence of this compound may create product development opportunities if substantiated.. The aglycone of haemocorin was stated by Harborne as showing antitumour, antibacterial and anti-inflammatory activities. It was beyond the scope of this current project to attempt to confirm that the red pigment in *H. spicatum* was in fact haemocorin and to quantify the concentrations of such compounds in the bulbs. It became apparent from extensive field work that: The large bulbs of *H. spicatum* from the Collie-Kojonup-Albany area appeared to be rich in the haemocorin (or some other similar compound) That *H. spicatum* produced the largest bulbs in comparison to all other members of the Haemodoraceae that occur in southern Western Australia and thus *H. spicatum* is likely to be the best bulk source of such compound(s).

Field examination of the species throughout its distribution showed that bulbs collected from some locations contained very high levels of the compound (based on the visual intensity of the bulbs red colouration when freshly cut) whereas the same species collected from other locations contains very low levels.

A real opportunity to take this area of R+D forward was identified and the above information was duly provided to Prof Louis Evans who facilitated the inclusion of the species in work to be conducted by a PhD candidate based at the school of pharmacy at the University of Western Australia. The candidate has been provided with extracts of *Haemodorum spicatum* samples, made by this RIRDC project. The samples representing low and high levels of haemocorin were tested for their ability to inhibit the proliferation of cancer cells. Cells from a panel of cell lines representing the five most common types of cancer and one non-tumourigenic line were exposed to the samples for 48 h and then assessed for changes in proliferation rates as measured by the routinely used MTT assay.

General discussion

H. spicatum has desirable colonising characteristic which may have suggested that cultivation on cleared sandy, low opportunity cost, farmland could be possible and potentially productive (based on observation made prior to and during this project and those of George (2001) and those on voucher specimens held by the Western Australian Herbarium). This study and that of George (2001) have both shown that it is relatively easy to propagate. However, economically viable cultivation of this species is hindered by its slow growth which dictates that a crop rotation period is likely to be several years if not much longer. Even when cultivated on low opportunity cost deep sands where it often grows naturally it will be difficult for cultivation to be economically viable due to the length of the rotation, even if high value, non vegetable, products were developed.

Western Australian native species as root vegetable crops — a preliminary economic assessment

This chapter presents preliminary economic analyses of *Platysace deflexa* and *Ipomoea calobra.* It gives indicative costs and returns of producing and marketing the tubers of these species as vegetables for human consumption. An economic assessment of *Haemodorum spicatum* was not conducted as does not have potential as a vegetable crop and the time taken to produce a product (large bulb) is unknown (see Chapter 3)

This economic assessment is one component of a project which aims to systematically assess the horticultural potential of southern Western Australia's diverse tuberous flora and commence commercialization of promising species as new vegetable crops.

Economic analysis

Analysing the costs and returns of a root vegetable, like any other crop, requires consideration of the crop, the farm business of which it is a part, and the industry as a whole i.e. consumers, retailers, wholesalers, processors, and storage and transport services. The needs and constraints of each sector may affect other sectors.

In the long term, the retail price will influence consumer decisions to substitute one root vegetable for another in their shopping basket. Likewise the farm gate price must exceed the unit cost of production in order for a grower to sustain production. The interplay of these consumption and production decisions will determine the size of the industry. If a crop requires a high capital investment and specialised machinery and/or equipment, there are likely to be fewer growers with larger enterprises. Less capital intensive crops manageable with less specialised equipment favour a more widely dispersed industry e.g. pumpkins.

Industry level considerations

Food markets are competitive, with many opportunities for consumers to substitute one product for another depending on the particular benefits offered by each, and their respective prices. Western Australians' consumption of native root vegetables is likely to be as an alternative to similar products such as carrots, radish, parsnips, swede, turnips, beetroot, sweet potato, pumpkins or potatoes.

Total consumption of each will depend upon consumer awareness of the product and its price relative to close substitutes.

Consumers and retailers require continuity of supply and consistent quality. This means the industry needs to have either an extended harvest season or storage technique that maintains product quality.

Crops such as melons, grapes and tomatoes can be grown in a wide range of latitudes for harvest at different times of the year, hence local consumers can be supplied almost year round from within Western Australia.

Controlled atmosphere (CA) storage techniques have been developed which allow storage of some crops for up to 10 months while maintaining acceptable quality e.g. Pink Lady ™ apples. Optimum temperature and CO_2 concentration in the storage facility are specific to each species and cultivar.

Consumer appeal

A number of marketing/product appraisal events have been held and potential consumers have generally been excited by the products from the three target species. Further market/product development is ongoing but limited by supply, that is, a lack of cultivated product. Product information sheets have been produced and they have been valuable educational tools. The project ran a highly successful stall at a farmers market during 2006, over 200 people visited the stall which provided information and samples of products made from the three target species. This experience clarified that consumers like these products and that they would purchase them when they become commercially available.

In time, consumer interest in these species could stem from their desires to:

- buy local
- manage household food costs
- vary their diet
- enjoy any particular health benefits that may be demonstrated, and/or
- appreciate or identify with Western Australia's natural and indigenous heritage as a culinary and cultural experience.

Grower interest

Why would someone wish to cultivate these species to produce marketable food products? Conceivable attractions of these native root vegetable species include:

- increasing farmers' net returns in areas suited to these species, or
- reducing dependence on inorganic fertilisers, irrigation and oil (used to produce fertilisers and used during crop cultivation).

Platysace deflexa (Apiaceae)

General description

A native shrub that produces fleshy yellow tubers that are sweet and pleasant to taste. It is a relative of carrots, parsley, parsnip, dill and coriander.

These tubers have an unambiguous history of consumption by Aboriginal people and/or early settlers. Indigenous Australians, like other human races, have used root vegetables as an important source of essential nutrients – especially energy, fibre, vitamins and minerals.

Youlk occurs naturally in plant communities ranging between Lake King, Munglinup and Wellstead, particularly in open mallee heathland, a major vegetation type on duplex soils that are slightly acidic. It appears to prefer sites with deeper sand.

The first low input, field cultivated (unirrigated) plants of *Platysace deflexa* yielded approximately 1 kg of marketable product per plant suggesting that a planting density of 2,000–4,000 stems per hectare would yield 2–4 t of marketable product per hectare.

Root vegetables such as potatoes and carrots are normally harvested by machines which cut below the zone of tuber growth and lift the tubers through the soil to the surface by means of a series of horizontal metal rods mounted on a pair of continuous rotation chains. The spacing between the rods allows the soil to fall back onto the ground. This is specialised machinery not used by farmers in the districts where Youlk occurs naturally.

The alternative of hand digging has been discontinued by potato growers since the 1950's as labour costs increased relative to mechanical harvesting with improved machinery design.

Marketing

The potential retail price of Youlk will be influenced by how it is positioned in the food market.

If introduced to consumers as a basic foodstuff, this product would most likely be compared to carrots. Carrots are a familiar product consumed almost universally due to a combination of their qualities and price, and are thus a good benchmark as a staple root vegetable food. Carrot production in Western Australia peaked at 88,200 tonnes in 2001–02 when export markets were strong. By 2004–05 production had declined to 66,200 tonnes due to competition from other suppliers in some export markets[1].

As a major crop carrots have been the subject of extensive development over a long period, and yield in the order of 50 tonnes per hectare of consistent quality roots. The carrot industry has developed a growing system that produces high yields of juicy product, washed and packed for consumer convenience. Carrots are most easily produced on sandy soils found close to the main population centres, which is good for product quality and minimises freight cost. Carrots sell in the Perth market for between 60 and 80 cents per kg[2], from which commission (approx 15%) and freight (>15 c/t/km) are deducted to give a farm gate price.

Positioning Youlk as a basic foodstuff would limit its price to something like that of carrots. If cultivation methods were similar, in order to remain viable farmers would have to achieve a yield similar to that of carrots, which is an order of magnitude greater than that obtained in early field trials with Youlk. Freight is a significant cost for crops grown on the south coast to supply the main domestic market, Perth. The Perth wholesale prices quoted above for carrots would translate to a farm gate price between 45 cents and 60 cents per kg for Youlk tubers.

Even the sustainability questions, associated with high use of water and artificial fertilisers, hanging over carrots are unlikely to raise their price to a level with which Youlk can compete.

It will therefore be essential to position Youlk as a high value product available only at selected retail outlets and restaurants where consumers can appreciate the "story" associated with the product, much like we do with wines. This adds value to the product.

Industry scenario

Vegetable crops are usually grown in rotation with other crops, to manage pest and disease threats and for efficient use of land, infrastructure, machinery and labour. Market gardens are rarely associated with broadacre farming because they require different machinery and equipment, deep friable soils, plentiful supplies of good quality water, and close proximity to markets (due to the high water content and perishable nature of the products).

While experimental and small-scale pioneer commercial crops might be grown in a broadacre farming environment, the above logic suggests that in time the industry may be located in traditional horticultural areas such as peri-urban and high rainfall districts.

Few growers can be expected to enter the industry until some growers make profits and a simple and reliable growing system is proven. While the new industry remains small, higher prices may prevail

[1] Source: ABS cat No. 7123.5.55.001

[2] Source: Alan McKay, leader of carrot industry research and development, DAFWA.

based on the restaurant trade, with Youlk positioned in the market as bush tucker with “curiosity” value.

Enterprise scenarios

To illustrate how costs and returns might range widely depending on the intensity of management applied to this crop, two scenarios are presented – a high input enterprise designed to supply only premium markets, and a low input enterprise designed to minimise cost in order to compete in the staple food market.

Scenario 1 – Platysace deflexa in the central south coast region – produced for the restaurant market

This hypothetical scenario assumes that a broadacre south coast farmer grows a 5 hectare crop; plants cuttings at close spacing (3 m x 0.5 m, i.e. 6,660 cuttings per ha) for $1 each in May and irrigates them as required until winter rains set in; applies the same rate of nutrients used in trial plots to date; and grades tubers before sale in crates. 90 per cent of cuttings thrive and each produce 0.67 kg of tubers, of which 90 per cent are marketable. The tubers are harvested with a second hand potato harvester. Total marketable yield is approximately 3.6 t/ha.

Indicative costs and returns are shown in Table 17.

Table 17 Indicative budget for a 5 hectare ‘intensive’ Youlk enterprise for premium market (restaurant trade)

Income		**$/ha**	**$ total**
Tuber sales	5 ha @ 3.6 t/ha @ $3,500/t	12,600	63,000
Expenses			
Plants	6,660 cuttings per ha @ $1.00 ea	6,660	33,300
Fertiliser	180 kg N + 37 kg P + 60 kg K per ha	452	2,260
Herbicide	1 Pre-plant + 1 post-plant	22	110
Irrigation	Storage, pumping, mainline & T-tape	509	2,547
Fuel		262	1,310
Repairs & maintenance		331	1,655
Labour	60 hrs/ha @ $25/hr	1,500	7,500
Post-harvest	Cartage, bin hire & coolstore charges	76	380
Share of fixed costs	incl depreciation & cost of capital	2,506	12,530
Total expenses		**12,318**	**61,592**
Surplus/deficit		**282**	**1,408**

Under the assumptions shown, and with full costing of resources used, this intensive enterprise produces a financial surplus.

A key assumption underlying this budget is that the restaurant trade could use 18 tonnes of this product within the period for which tuber quality could be maintained in coolstore. Staggering the harvest might be possible, thus storing some tubers in the ground, though this may increase harvest cost.

Sensitivity analysis

Profitability is highly sensitive to yield, price and the cost of cuttings. As yield and price are the least certain assumptions in the analysis, the effects of varying price and yield are shown in Figure 36.

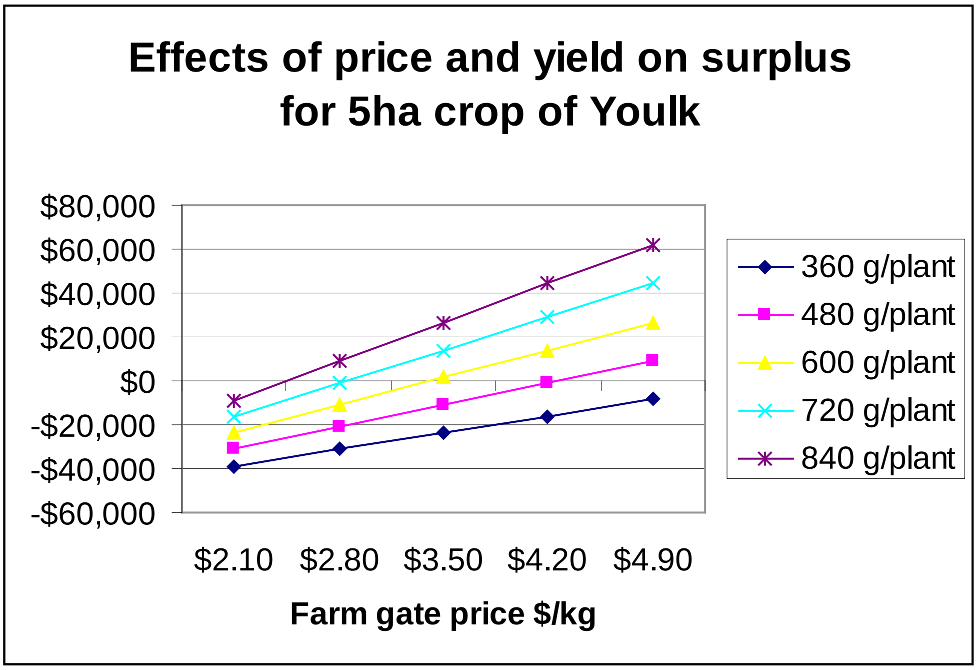


Figure 36 Sensitivity of intensive Youlk enterprise surplus to price and yield changes

It can be seen from Figure 35 that if paddock yield were 480 g per cutting planted, this enterprise would require a farm gate price in excess of $4.20/kg to break even. If however yield were 720 g per cutting planted, the enterprise would break even with a farm gate price of about $2.45/kg.

Reducing the cost of propagating cuttings would also improve enterprise profitability – for each reduction of 10 cents per cutting, enterprise surplus would be increased by $3,870.

The prices assumed here are in the order of 5 to 9 times higher than could be expected for Youlk sold as a staple food through major food outlets. It would become necessary to market Youlk this way if the crop became popular with growers. This second scenario is depicted below.

Scenario 2 – Platysace deflexa in the central south coast region – low input ‘commodity crop’

This second hypothetical scenario assumes that more broadacre farmers in the central south coast region enter the industry. In this example the farmer grows a 10 hectare crop and reduces costs where possible. The example assumes that 6,660 cuttings are planted per hectare after a late autumn rain event, some means is found to reduce the cost of cuttings to 50 cents each in the ground, and 75 per cent of these cuttings are able to survive without any irrigation. The grower applies half the rate of fertiliser used in trial plots to date; and sells ungraded tubers in field bins.

Two winters of growth are allowed before harvest. Crop yield averages 0.5 kg per cutting planted. Tubers are sent to market in bins un-washed. Indicative costs and returns are shown in Table 18.

Table 18 Indicative budget for a hypothetical 10 hectare 'low-input' commodity Youlk enterprise

Income		**$/ha**	**$ total**
Tuber sales	10 ha @ 2.4 t/ha @ $500/t	1,200	12,000
Expenses			
Plants	6,660 cuttings per ha @ $0.50 ea	3,330	33,300
Fertiliser	180 kg N + 37 kg P + 60 kg K per ha	226	2,260
Herbicide	1 Pre-plant + 1 post-plant	22	220
Fuel		260	2,600
Repairs & maintenance		328	3,280
Labour	30 hrs/ha @ $25/hr	750	7,500
Post-harvest	Cartage, bin hire & coolstore charges	51	510
Share of fixed costs	Incl. depreciation & cost of capital	1,410	14,100
Total expenses		**6,377**	**63,770**
Surplus/deficit		**-5,177**	**-51,770**

Although this hypothetical scenario attempts to represent a low input enterprise, it is based on the only growing system that has been investigated to date. Even without washing, costs are far above what can be justified by the gross returns.

This scenario shows no prospect of profitability for Youlk without the price premium available from a niche market. The key drivers constraining profitability are again propagation cost, yield and price. Sensitivity analysis is not warranted until a lower cost production system can be developed.

Conclusions and recommendations

Neither of the above budgets would encourage most potential investors to start an industry based on this species, but there appears to be scope for an enthusiastic pioneer to test this crop on a semi-commercial basis.

The results of the above analyses indicate that further investigations are warranted to further reduce uncertainty about yield, price and the amount of labour required.

Commercialisation may become feasible as cultural techniques are refined and consumer interest is cultivated through promotion. The future for Youlk as a crop appears to depend on whether research and development can reduce the cost of propagation and increase yield, and whether the product can be positioned to capture a price premium through associating the product with customer benefits beyond it's basic nutritional value.

Past success in raising yields over a long period in agriculture with traditional crops, through selection of superior genetic material and improved cultural techniques, suggests there is potential to do the same with this species.

Reducing the cost of propagation seems more problematic if vegetative means are required.

Ipomoea calobra

General description

Kulyu (*Ipomoea calobra*) is a deciduous perennial climbing plant from the arid inland of Western Australia that produces an abundance of large, succulent and starchy tubers. Tubers are formed at a range of depths, with a proportion of them as deep as one metre. Tuber size is also variable, depending partly on age. Small tubers can be harvested in December from vines planted in August, whereas the larger tubers required to achieve higher yields may be harvested 12 months after planting.

The tubers have been baked and consumed by Aboriginal people of the arid inland of Western Australia and early settlers, but can also be eaten raw, steamed or boiled. Kulyu is similar to sweet potato, but unlike sweet potato it remains crunchy when baked or roasted.

Pot trials (55 lt) of *Ipomoea calobra* produced an impressive yield of 3.3 kg of saleable product per pot. Small scale trials have been conducted in the Carnarvon horticultural district of WA on the properties of two commercial vegetable growers under standard conditions and using organic growing methods.

Marketing

In the mainstream food market Kulyu (*Ipomoea calobra*) tubers would most likely be regarded by consumers as an alternative to sweet potato. Under these circumstances potential growers would compare costs and returns of Kulyu with those for sweet potato.

Sweet potatoes are produced commercially in the Gascoyne irrigation area near Carnarvon, and there is a well-established system of growing, harvesting, post-harvest washing and packing, and transport to Perth market agents. A small Kulyu industry could potentially be modelled on this sweet potato industry.

An alternative approach would be to harvest tubers from plants that grow in the wild and position that product differently in the market i.e. as “bush tucker” available only in selected restaurants. The concept of assisted wild harvest has been used in a bush tomato enterprise in Central Australia.

Industry scenario

A plausible scenario for commercialisation of Kulyu is its addition as a sideline enterprise in a horticultural business in a sub-tropical environment, so that there is a ready-made infrastructure. If that is to be a realistic proposition the Kulyu needs to perform well enough to justify substituting it for some part of an existing enterprise.

An alternative scenario is one of “bush picking” in which large tubers are harvested from wild plants in the rangelands where they occur naturally, such as the southern goldfields.

This more dispersed low intensity industry would rely on access to suitable rangelands. Under section 106 of the *Land Administration Act 1997*, pastoral leases must not be used for purposes other than pastoral purposes, except in accordance with a diversification permit. If you want to carry out any other activity on the pastoral lease other than grazing the native vegetation with authorised stock in an ecologically sustainable manner, you need to apply for a diversification permit. You can get a diversification package (including an application form and a description of the application process) from the Pastoral Lands Board. You must complete the application form and enclose the required maps and application fee. For most proposed activities, the application process takes around eight to ten weeks. Much of this time is to allow government departments and the native title claimants and their representative bodies to comment on proposals.

Enterprise scenarios

Intensive cultivation in the Carnarvon irrigation area and bush digging on a pastoral lease are the two scenarios considered below.

Scenario 1 – Kulyu (Ipomoea calobra) production in the Carnarvon irrigation area under intensive cultivation

Scenario 1 assumes the crop is established from seed sown in early spring, grown on 1 metre high trellising, irrigated with T-tape and harvested 12 months later when the highest total yield of tubers can be realised.

It is assumed that most tubers can be harvested by conventional means e.g. lifted into a trailer mounted bin with a potato harvester. This is not currently feasible as a proportion of Kulyu tubers in Carnarvon trials occurred deeper in the soil profile and were recovered by more costly means. It is unlikely that these deep-set tubers would be economically recoverable due to the volume and weight of soil that would need to be moved. It is therefore assumed that means will be found to ensure the plants set their tubers within economically harvestable depth.

It is assumed that the enterprise takes advantage of machinery, equipment and other infrastructure that is already in place for existing crops, thus limiting their cost. The budget also assumes that the 1 metre trellis would be erected and dismantled with the same amount of labour as is used for trellising French beans, i.e. 200 hours per ha.

The assumed farm gate price of $1.08/kg is based on a retail price of $3/kg, from which is deducted retail mark-up (100%), commission (15%) and freight ($0.20/kg). The retail price is within the range of prices for sweet potato, and less than half of the price at which small trial consignments were sold at Fremantle markets in August-September 2007.

Table 19 Indicative budget for a 1 ha 'intensive' Kulyu enterprise at Carnarvon

Income	•	**$ total**
Tuber sales	1 ha @ 29.2 t/ha, 90% packed @ $1,080/t	28,382
•	•	•
Expenses	•	•
Seed	5 kg @ $50 /kg	250
Fertiliser	A regime based on sweet potatoes	760
Herbicide	1 Pre-plant + 1 post-plant	110
Water	1,950 kl @ $0.50/kl	975
Fuel	•	316
Repairs & maintenance	•	334
Labour	408 hrs/ha @ $25/hr	5,195
Trellis	Labour, replacement & cost of capital	5,800
Post-harvest	•	1,587
Share of fixed costs	•	2,257
Total expenses	•	**17,584**
Surplus/deficit	•	**10,798**

The indicative budget shows a large surplus as a proportion of gross income. This is evidence that it would be worthwhile to develop cultural techniques to ensure that tubers are set within reach of conventional harvesting machinery.

Sensitivity analysis

Sensitivity analysis is warranted to explore the range of values for input quantities, yields and prices at which the enterprise is likely be viable.

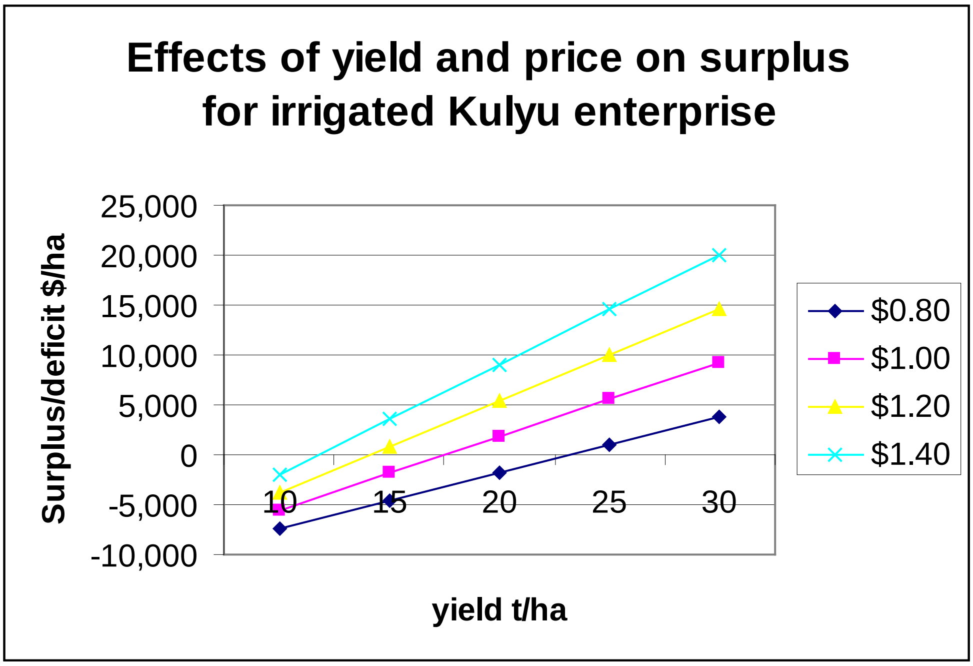


Figure 37 Sensitivity of intensive Kulyu enterprise surplus to price and yield changes

Figure 37 indicates that conventional harvesting equipment must recover at least 16 t/ha in order for the enterprise to break even at a farm gate price of $1.08 per kg.

Scenario 2 – Kulyu (Ipomoea calobra) wild harvest enterprise on stations north of Kalgoorlie

This scenario is much less well defined than the first as the information is not based on observations from on-ground trials.

Key assumptions which remain to be tested are:

- the enterprise is based on a 100,000 ha pastoral lease
- mature vines can be readily located and harvested at a density of 1 per 100 ha per year
- tubers can be sustainably dug at the rate of 10 kg per plant, because this would leave one third of the total weight of tubers in the ground, from which new plants grow
- digging is by hand and requires 2 people for 1 hour for each vine
- each vine that is harvested requires 5 km of travel by a 4-wheel drive vehicle at a speed of 10 km/hr and vehicle cost of $1 per km
- labour cost is $25/hr
- tubers are packed and transported to market at a cost of $4/kg
- tubers are sold for $10/kg delivered
- overheads are $10,000.

Table 20 Indicative budget for a 1 million hectare 'bush-digging' Kulyu enterprise

Income		**$ total**
Tuber sales	1,000 vines @ 10 kg/vine @ $10/kg	100,000
Expenses		
Vehicle	1,000 vines @ 5 km/vine @ $1/km	5,000
Harvest labour	2 hrs/plant @ $25/hr	50,000
Travel labour	1,000 vines @ 5 km/vine @ 20 km/hr x 2 persons @ $25/hr	12,500
Post-harvest	1,000 vines @ 10 kg/vine @ $4/kg	40,000
Share of fixed costs		10,000
Total expenses		**117,500**
Surplus/deficit		**-17,500**

This purely financial analysis costs labour at a 'standard' rate of $25 per hour. Social benefit cost analysis must have regard for unpriced values typically associated with environmental and social benefits. Indigenous Australians whose 'country' is the southern rangelands are likely to have skills and knowledge for this enterprise and may not currently be employed. To the extent that this is true, the *social opportunity cost* of their labour may be much less than $25 per hour, because from a societal viewpoint their employment in this enterprise would reduce their need for support payments through Centrelink. If labour were costed at a social opportunity cost of $15 per hour, the enterprise would produce a surplus of $7500. Additional social benefits which would be more difficult to measure include the value of re-connecting some indigenous people to their country and of maintaining or strengthening local knowledge of country and its flora.

This exploratory budget suggests that a bush picking enterprise is unprofitable from a private sector perspective but may be profitable from a societal perspective. The assumptions about the time and travel required to find and harvest the tubers have yet to be tested. A related issue is the rate at which the vine population will regenerate naturally, because this would determine the sustainable level of harvest, hence the scale of such an "industry".

Conclusions and recommendations

Kulyu could become an attractive crop with which growers in the Gascoyne irrigation area could diversify production, as an alternative to part of their sweet potato crop, if it can be shown that sufficient tubers can be recovered with conventional harvesting machinery. This could spread growers' risk, making them less vulnerable to lower prices or sweet potato-specific diseases, and possibly increasing total demand for Carnarvon vegetables.

A logical issue for future research would be techniques for better concentrating tuber set within the range of conventional harvesters. It may also be useful to experiment with Kulyu grown without trellis, as that would have a significant cost advantage.

There are some significant uncertainties about major variables affecting the viability of a Kulyu enterprise based on bush-digging in a pastoral lease.

The above analysis shows that it is important to measure the time taken for travel and digging, and the yields per vine in the wild. It is likely that all of these vary widely across the landscape, which means that a large number of observations would be warranted to ensure sufficient reliability of estimates from field investigations.

Overheads should also be assessed for some specific stations, which will require a test case application to the Pastoral Lands Board.

Local indigenous people should be partners in future investigations so that they have the opportunity to determine whether they should build their own capacity for managing such an enterprise.

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Appendix 1: Generic aspects of marketing and commercialising new native vegetable products

Introduction

The first component deals in generic terms with progress over a period of 18 months towards development of a strategy for the commercialisation and marketing of a group of three prospective new vegetable crops as a collective. Outlining some preliminary considerations for the commercialisation and marketing of these promising new products. Species specific coverage of commercialisation is covered in Chapter 2 (*P. deflexa*) and Chapter 3 (*I. calobra*) and Chapter 4 (*H. spicatum*).

The authors are unaware of any effort to cultivate and commercialise these products prior to the commencement of this project. Consequently they are entirely new and unfamiliar to consumers. This presents both particular challenges and opportunities for the business entities that invest in their development. A key principle of this strategy is to minimise commercial risks by ensuring that the commercialisation is driven by consumer demand, incremental in its growth and fostered by a local or regional community. The strategies outlined are based on information derived from a combination of qualitative and quantitative data, and both formal and informal discussion with a spectrum of interested and relevant individuals, both local and interstate.

The edible foods that are produced by these wild native plants can be defined as 'commercial' when retail consumers are creating demand for them by purchasing them preferentially over alternative, competing products. To maximise the likelihood of commercial success, their unique selling points and competitive advantages need to be carefully considered in both positioning these products in the market, and developing systems for their production.

As indicated by RIRDC there needs to be mutual co-development of the two components of this research and development project. Successful commercialisation relies on the development of reliable production systems that are informed by the development of appropriate marketing strategies and vice-versa. Although early response to the products from consumers has been very encouraging, research and development of these plants is in a pre-commercial, crop trial phase, with cultivation and production systems under ongoing development. Due to their pre-commercial status, the strategies documented here are somewhat premature and general in nature, but aim to address a requirement to market-lead development of these products. It is acknowledged that there will need to be significant development and refinement of the strategies touched on here should their commercialisation be pursued.

Identifying the target market: Market trends

It is important to identify who will be likely to make purchases of these products and to make an assessment of current consumer trends within retail food markets to assist with positioning these products in the market (DAFWA 2003). The current generation of consumers are the wealthiest in our nation's history and a very high percentage can afford to be discerning on points of difference other than price. Additionally, food preferences are changing relatively rapidly in Australian society due to increasing awareness and consideration of the health, social and environmental impacts associated with food production and consumption (DAFF 2005; DAFWA 2003). The effect of these influences combined is a significant positive shift in the viability of small-scale food production for specialty and niche markets, including seasonally and regionally focussed approaches.

There is also an increasing emphasis of place of origin labelling and traceability within food industries and evidence of a rapid adoption of product endorsements and labelling that highlight responsible or ethical production. This combined with the explosion of interest within Australia in new and gourmet foods, and particularly foods with a regional market profile, suggests there is significant competitive advantage that can be exploited to create a market for these unique products.

Organics

The growth of the market share for foods branded as organic has increased rapidly in recent years in Australia with consumption growing at 25–40% per year (RIRDC 2006a). Currently domestic production isn't able to keep up with demand. Regular consumers of organic produce represent the most discerning section of the market, and are customers that accept price premiums (DAFF 2004) and that are rapidly growing in number both domestically and internationally (RIRDC 2006b). Organic certification should certainly be considered to ensure access to this consumer group.

Local farmers markets

There has been a dramatic resurgence in the popularity of Farmers Markets in Western society (Paul (ed.) 2002). While farmers markets alone won't be sufficient to support production at any significant scale, they are important. Firstly, because they highlight the changes occurring in the behaviour and preferences of consumers and secondly, because they provide an ideal environment to introduce and test new products (DAFWA 2003), with feedback coming directly and instantly from both customers and non-buyers.

The target market

Defining the target market is crucial in developing a successful product. It may be expected early adopters of the products are likely to be innovative commercial chefs and 'foodies' with a predisposition to testing and exploring new foods and flavours, that are keen to introduce something new to their dining customers and households. They may well have a preference for organic and regional foods and the development of contemporary cuisine.

Some possible characteristics are:

- they are well educated & financially secure
- they have an interest in health and wellbeing
- they generally prepare and cook their own meals
- they have a preference for locally owned or family owned suppliers
- they consider themselves 'foodies' and part of the food revolution
- they are interested in social & environmental ethics
- they are interested in the diversification of Australian society.

Target market — product education and familiarisation

Critical to the successful commercialisation and marketing of any new food product is a focus on familiarising and educating the target market on the qualities and characteristics of the food, and suggestions on how it might be prepared and incorporated into meals and dishes. There are excellent promotional prospects for these products both nationally and internationally based on their respective unique selling points, underpinned by their unique indigenous cultural and historical origins. There are also very good prospects based on these unique aspects for winning media interest, including radio, newspapers and a plethora of food focussed magazines and publications. Development of a range of promotional and educational materials including point of sale (POS) material is recommended to assist advertisement and target market familiarisation of these products.

Generic points of difference or selling points

Although these products meet a recognised need with the Australian Native Food Industry for the discovery and development of a versatile, staple vegetable, the fact that these products are indigenous or Australian native foods should not be the primary focus of a marketing campaign. While their native origins need to be incorporated into the 'story' or selling proposition adopted for these products, with recognition and acknowledgement of their indigenous cultural significance, this report recommends that rather than being promoted as 'bush food' or 'bush tucker' as the primary point of difference, this aspect should be viewed as one of many potentially unique selling points (USP's).

Product identification and differentiation will be essential to avoiding confusion with other products in a rapidly diversifying food retail sector. A list of potential USP's and mechanisms for their promotion are provided in Table A.1.

Table A.1. Potential USP's or credence values and mechanisms for their promotion

Unique Selling Point	Mechanism for Promotion
The product is 'clean' & produced with low input or organic systems	Labelling, Accreditation, Endorsement
The product is 'green' & produced sustainably with low environmental impact	Low input production systems Labelling, Accreditation, Endorsement
The product is a striking & unusual colour	Product packaging & presentation that promotes the colour
It is totally new to international cuisine It is an Australian native food It is uniquely & exclusively Western Australian	These may or may not be grouped and explained as a 'story' in POS material and/or labelling
It is healthy & nutritious	Labelling, POS material, Endorsement
The product is socially ethical	Labelling, Accreditation, Endorsements that substantiate links to indigenous communities

Discussion of the merit associated with adopting an initial regional approach for commercialisation and marketing is provided and is followed by strategies for marketing within the region, and an additional discussion on market expansion.

Regional approach

This report recommends a regional focus as an initial 'incubation' phase in market development and commercialisation, with the region of origin acting as a test-bed for the fledgling market, and advocates an initial focus on marketing 'to' the region, before significant investment in marketing these products 'from' the region. A regionally based 'retail trial' allows production systems and strategies for market expansion to be developed and refined with minimal commercial risk.

According to the WA Department of Agriculture (Food – On the Retail Shelf 2003) there is "*the growing desire of consumers to support local agriculture and industry and the knowledge that local produce is generally of a very high standard and is considered trustworthy. Add to this pride in one's own state or region and it becomes clear why many people are choosing to seek out local produce in favour of the 'foreign' competition*."

Cultivation and production systems for these products are still very much under development. Reliable and cost-efficient cropping systems have to be developed and refined, and scale achieved before marketing efforts are expended beyond the region. Production is likely to be experimental and small scale for some time into the future, with a number of key challenges yet to be overcome, and significant information gaps and risks to be addressed. Restricting production to the relevant region, and to carefully selected growers enables closer coordination of the supply chain and control of product quality, minimising key risks throughout the early developmental phase, and reducing transport costs.

In addition the regional community is highly receptive to supporting local initiatives, and has demonstrated capacity in product marketing, particularly in food, wine and tourism. The response from key individuals and food professionals involved in the marketing of foods from the region to the prospect of developing and commercialising locally indigenous products as new foods has been enthusiastic. These products have the potential to become iconic, and provide the region with an opportunity to diversify, enhance its unique selling points and further differentiate itself from competing regions. A regional approach can help create a sense of ownership and enable this enthusiasm for the product to be harnessed. Generating a ‘critical mass’ of interest also provides for the generation of low cost, ‘word of mouth’ marketing.

With a regional approach the primary research can be conducted within the region enabling opportunities to engage the regional community and business networks in product and market development through tasting panels, surveys and retail trials, and provides a manageable starting point for education. Educating not only consumers, but the whole supply chain will be a critical success factor.

In summary, advantages of a regional approach to the introduction of these products into the market include:

- a higher level of market acceptance of a product produced and developed locally that can further differentiate the region, and local businesses from competitors
- a genuine cultural connection with local indigenous groups
- an opportunity to develop regional ownership to capitalise on the growth of interest in developing and promoting the regionalisation and traceability of food products
- an existing regional marketing association and established business networks with an emphasis on food, wine and tourism
- that the market is close to the existing supply base, reducing transport costs
- relatively low cost of capturing market data & intelligence
- opportunity to test & refine product processing, presentation & packaging, and develop product specific food technology and local expertise prior to market expansion.

Strategies for marketing within the region

The aim of this approach should be to facilitate a transition of behaviour by creating opportunities to maximize the number of local and regionally based consumers and retailers that are aware of the product and its regional origins; recognize it when they see it; are familiar with its use and consumption and have been exposed to the ‘story’; have had direct experience with tasting and/or cooking it and ultimately, are motivated to purchase.

Opportunities need to be created to engage and educate consumers about the product’s local origins and potential uses need to be pursued, with a particular emphasis on marketing the product locally to key business people and food professionals. ‘Word-of-mouth’ is a powerful early-phase marketing mechanism within relatively small regional communities and food-focused business networks.

There is a clear opportunity to make use of the existing, extensive program of events that have a strong, regional, food & wine focus or theme. Additionally a more tailored promotional program can be developed. Possibilities include:

- A community based competition promoted through school visits & the media to raise awareness and provide the products with their commercial/brand names.
- A product launch and free tastings stall at the weekly Farmer's Market, combining both products e.g. oven-baked tuber with a hot *Haemodorum* dipping sauce.
- A season opening coinciding with the Noongar Seasons with Noongar participation & dance. Tubers were traditionally dug in 'Djilba' (August & September) and 'Kambarang' (October & November). Tastings could be made available at a number of in-store and market locations.
- Food as Art – incorporating the products into an Art exhibition.
- An invitation only, in-kitchen creative workshop over 1 day to introduce the products to prominent local food and marketing enthusiasts and visiting and local chefs, caterers and food technologists involving preparation of the products, exploration of creative uses, new cuisines and tastings.
- The region could host a state or national native food festival highlighting the local product.
- Facilitate a regional focus group to identify marketing opportunities and potential commercial partners and synergies.
- Promotion and tastings at thematic dinner events associated with visiting delegations, trade visits and civic receptions.

The target market is a subset of the regional community. As the product becomes commercially available, identifying and defining who is regularly purchasing the product enables the target market, and their characteristics to be described, forming the foundation of a market expansion strategy.

Strategies for market expansion

There needs to be evidence that the products are achieving market traction prior to scaling up and exploring new markets. Market expansion is contingent on developing successful and reliable production systems that are scaleable and repeatable and that can keep apace with the foreseen growth in demand. Initially the rate of market expansion is likely to be limited by product supply.

Prospects for winning market share beyond the region may involve exploring opportunities with major food retailers, establishing a grocery line in Perth and other regional centres, as well as the potential for interstate and export markets. Additionally these new products could have significant appeal in rapidly developing Asian markets as they both have analogous products well established as staples within Asia, and lend themselves to Asian cooking and cuisine. Extending the market to include Perth, interstate or export markets involves higher levels of risk and is likely to demand additional costs associated with transport, product promotion, brokering and regulation requirements. A range of factors need to be carefully considered to maximise the opportunities associated with a market push beyond the region:

- a clearly defined target market
- supply chain & distribution arrangements
- pricing
- value adding opportunities
- reliability & timing of supply
- product consistency & quality control
- product presentation & packaging
- legal / contractual arrangements
- transport costs
- Point of Sale material
- product endorsements.

The Great Southern Region has developed regionally based business networks, a brand, and a program of promotional events relevant to the marketing of food products that are produced in, and traceable to the region. The Great Southern Region Marketing Association promotes products produced regionally under the slogan "Great Southern Taste, Western Australia". A significant challenge for this organisation and the region is to differentiate itself from competing regions. This network has a strong regional focus and provides a foundation for exploring marketing and promotional opportunities for local products.

Another key contact to aid in market expansion is the Food Industry Association WA Inc. One of the aims of this association is to "facilitate and encourage market development and the export of food and beverage products from Western Australia", <http://foodindustry.org.au/> viewed 28 February 2008. In addition, the native food industry contacts provide an excellent avenue for promotion within existing networks. There are a number of associations and groups with websites and magazine/bulletin distributions to their members who have a specific interest in native food plants and may be promoters, producers, hobbyists and/or purchasers of native products.

Appendix 2: Product information brochures

Native Foods
of the South Coast of Western Australia

Youlk
Ravensthorpe Radish
Platysace deflexa

General description: A native shrub that produces fleshy yellow tubers that are sweet and pleasant to taste. It is a relative of carrots, parsley, parsnip, dill and coriander.

History of use: Routinely consumed by Noongar people and early settlers of the south coast of Western Australia.

Distribution: Found locally from Jerramungup to Esperance and Lake King.

Availability: Not yet commercially available, likely 2009.

Product description: Firm and crisp flesh akin to radish or apple with pale to intensely yellow skin. When consumed raw it has a sweet, mild radish flavour.

Preparation & use: Suitable raw, with or without the skin for use in salads, but can also be fried in oil or whole-baked.

Nutrition: Broadly similar to carrots.

Storage: The product keeps best when stored whole in cool dry conditions or under standard refrigeration.

Research & Development: The potential to develop this product as a new, commercial vegetable crop is currently being investigated.



NEW PRODUCTS • NEW MARKETS • NEW CROPS

Youlk
Ravensthorpe Radish
Platysace deflexa

Information about this project: Southern Western Australia contains an extraordinary number of plants that form root tubers or related storage organs (over 150 species).

While the diversity of the flora is of international significance it had not been surveyed for prospective vegetable products.

This project has systematically assessed the horticultural potential of southern Western Australia's diverse tuberous flora and commenced commercialization of promising species as new vegetable crops.

To be selected for further development, species required the following: various horticulturally desirable attributes, produce a desirable product (size, taste, colour etc) and have an unambiguous history of consumption by Aboriginal people and/or early settlers.

This work is being conducted by the Centre of Excellence in Natural Resource Management (CENRM) with funding provided by the Rural Industries Research & Development Corporation (RIRDC). Additional financial support has been provided by the Great Southern Development Commission (GSDC), the Australian Flora Foundation, the Reconnections Project (Shell Development - Australia and Greening Australia WA) and Tectonic Resources.

For more information, contact Dr Geoff Woodall at the Centre of Excellence in Natural Resource Management, UWA Albany. Email gwoodall@agric.wa.gov.au

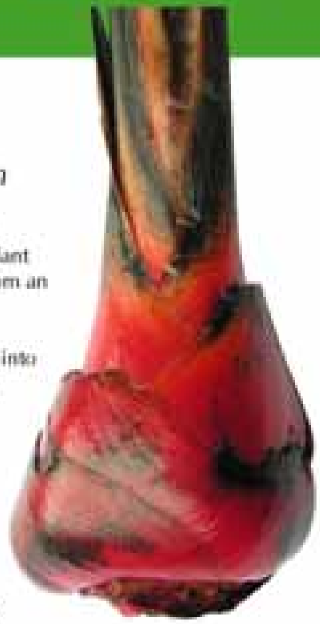
Australian Government
Rural Industries Research and Development Corporation

Centre of Excellence in Natural Resource Management

This project may enable the development of new rural industries based on one to several species and provide enterprise opportunities for indigenous and non-indigenous Australians in the future

NEW PRODUCTS • NEW MARKETS • NEW CROPS

Native Foods
of the South Coast of Western Australia



Meen
Bloodroot
Haemodorum spicatum

General description: A relative of Kangaroo paws, this herbaceous plant produces a distinct flower spike from an edible fleshy bulb.

History of use: Generally blended into food and often baked by Noongar people prior to consumption.

Distribution: Common on sands along the south and west coast of Western Australia from Geraldton to Esperance and inland to Kojonup.

Availability: Not yet commercially available.

What can you do with them: The compound responsible for the red colour and hot taste is soluble in oil and easy to extract by slicing the bulb and pickling in oil. The vibrant red extract has application as a colouring, flavouring, spice or additive in sauces or chutneys. Dry powdered product has application as a hot spice but does not have application as a red colouring.

Product description: HOT. The typically vibrant red bulb is both fibrous and gelatinous and produces a slow to develop, but lasting heat similar to pepper or curry powder. Bulbs collected from some areas have a more mild taste.

Research & Development: The potential to develop this product as a new, commercial vegetable crop is currently being investigated. It also has potential as a commercial dye.

NEW PRODUCTS • NEW MARKETS • NEW CROPS

Meen
Bloodroot
Haemodorum spicatum

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NEW PRODUCTS • NEW MARKETS • NEW CROPS

A native vegetable of Western Australia

Kulyu
Ipomoea sp.

General description: A deciduous perennial climbing plant from the arid inland of Western Australia that produces an abundance of large, succulent and starchy tubers.

History of use: Regularly baked and consumed by Aboriginal people of the arid inland of Western Australia and early settlers.

Availability: Not yet commercially available, likely 2008/09.

Preparation & use: Best eaten when baked, roasted or steamed though can also be eaten raw.

Nutrition: Similar to sweet potato.

Storage: The product keeps best when stored whole in cool dry conditions, similar to storing potato (Solanum tuberosum).

Research & development: The potential to develop this product as a new, commercial vegetable crop is currently being investigated.

NEW PRODUCTS • NEW MARKETS • NEW CROPS

Kulyu
Ipomoea sp.

Information about this project: Southern Western Australia contains an extraordinary number of plants that form root tubers or related storage organs (over 150 species).

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This project may enable the development of new rural industries based on one to several species and provide enterprise opportunities for indigenous and non-indigenous Australians in the future

NEW PRODUCTS • NEW MARKETS • NEW CROPS

New Root Vegetables for the Native Food Industry

— Promising selections from south Western Australia's tuberous flora —

RIRDC Publication No. 09/161

By G.S. Woodall , M. L. Moule , P. Eckersley , B. Boxshall and B. Puglisi

This project aimed to systematically assess the horticultural potential of southern Western Australia's diverse tuberous flora and commence commercialisation of promising species as new vegetable crops.

The importance of this report is that it provides that an overview of progress towards introducing new native vegetable products into the Australian food industry. There is a distinct lack of native vegetable products available and a requirement for native vegetable products was identified by consumers, chefs and suppliers of native foods.

RIRDC is a partnership between government and industry to invest in R&D for more productive and sustainable rural industries. We invest in new and emerging rural industries, a suite of established rural industries and national rural issues.

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RIRDC books can also be purchased by phoning 1300 634 313 for a local call fee.

Cover photo: *Ipomoea calobra* tubers displayed at Mr Organics, Fremantle Markets
Back cover: Attempting to harvest *Ipomoea calobra* tubers mechanically with a potato harvester

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