



## Abstract

The market in Australia for coconut products, especially virgin oil, coconut water and yoghurt – based on imported coconut milk - has grown strongly in recent years. Local primary production of coconut, however, is mostly confined to the harvesting of fruit from ornamental palms located mainly on public land and private gardens. There is also an expanding market to small investors for seedlings of the dwarf palm. There has been considerable investment in Australian research, particularly supported by the Australian Centre for International Agricultural Research (ACIAR), into the status of the coconut industries in neighbouring countries, especially in the south Pacific. Recent research has concentrated on perfecting tissue culture protocols for the multiplication of some elite genotypes identified elsewhere.

Two things are now needed to transform this development of research capacity into a productive industry to serve demand for elite plantlets from our neighbours, but also to provide a robust genetic foundation for expansion of coconut production in Australia. Firstly, a body to coordinate coconut interests in Australia. This organisation would act on behalf of all those in the coconut production chain, by co-ordinating communication regarding relevant research, risk, and investment opportunities for the industry. Members would be diverse and include, among others, farmers, research institutions, nurseries, tissue culture companies, importers, processors and organic certification bodies. Secondly, we propose an internal focus to the industry, as Australia currently imports the vast majority of its coconut products. A strong technical foundation and market outlook for coconut production in Northern Australia would stimulate increased investment by current and new primary producers. An obvious beneficiary would be indigenous communities provided with new business and employment opportunities where suitable land is available.

## Introduction

Coconut (*Cocos nucifera*) is grown in humid tropical regions and is known as the 'tree of life', as all parts of the plant have commercial value (Foale, 2003). The fruit has a solid endosperm (mature kernel) containing edible fibre, lipid, protein, and inorganic minerals. Products gained from the fruit can include drinks, fresh kernel and milk, and refined products, such as virgin oil, shell charcoal, husk fibre and cocopeat for potting mixtures.

Virgin coconut oil (VCO) contains potent antioxidants (Marina *et al.*, 2009), antimicrobial characteristics (Chakraborty and Mitra, 2008), and potential anti-cancer actions (Koschek *et al.*, 2007). Therapeutic benefits, from either fresh or processed coconut products, have been demonstrated in the prevention and treatment of cardiovascular disease, hypertension, obesity, diabetes, HIV, hormonal imbalance in postmenopausal women, ulcers and other gut illnesses (Ross, 2005, Lim, 2012, Pham, 2016).

Coconut is generally classified into two groups, Tall and Dwarf types. The Tall begins to flower at four to seven years of age, with Dwarf at three to four years. The Tall is predominantly cross-pollinated and the Dwarf highly self-pollinated. The fruit reaches its full volume six months after pollination. The bunch, on an average palm in ideal conditions, contains approximately 10 fruit of uniform size, shape and colour. The immature Tall fruit is generally bronze or green, while the Dwarf has sub-populations of yellow, orange, green and brown. At six months the fruit contains a soft husk and shell and a large vacuole filled with liquid endosperm (coconut water). The gelatinous endosperm firms on the insides wall of the nut over time, to be solid and fibrous at 12 months. The palm can produce up to 200 fruit in a year depending on the average size of its fruit. Grown in a monoculture the Dwarf has the potential to produce more than 25,000 fruit/year/hectare (Foale and Roebeling, 2006). Nuts with an internal diameter of 100 mm would contain about 500 ml water before any kernel developed, implying a maximum yield of coconut water of 12 500 L/ha. See Table 1 for potential productivity of Dwarf palms.

The Tall achieves peak productivity at approximately 15 years and continues until about 35 years when a gentle decline in productivity begins. Depending on environmental variables there can be years of high or low productivity and there is a tendency for biennial bearing to occur. Fruit production is best within 18 degrees of latitude north or south of the equator, in areas with well drained deep fertile soil of neutral pH and year-round rainfall or irrigation equivalent to an annual rainfall of 2000 mm. Palms can be grown close to the beach as far south as Byron Bay on Australia's East Coast, but only from the Mackay region north is there consistent kernel development as fruit matures best when the annual daily mean is above 21°C (Foale, 2003).

## Co-ordination of the Australian coconut industry

Most coconut products (desiccated coconut; refined oil; virgin oil; cocopeat; fibre products) are imported into Australia. There is increasing demand for Australian grown coconut products and seedlings of the dwarf palm (conversations with industry members). The local primary production of coconut is currently at small volumes and predominantly focussed on the harvesting of fruit from ornamental palms located on public land or private gardens. There has been significant Australian research investment in coconut, mostly financed by the ACIAR, with a focus on improving the coconut industries of our neighbours, particularly in the south Pacific (Foale and Adkins, 2014). This research has the potential to provide the foundation for a productive domestic industry by providing elite plantlets for our neighbours and the expansion of local coconut production. To take advantage of domestic and international research there is need for a body to coordinate coconut interests in Australia. An entity like Horticulture Innovation Australia, Sugar Research Australia and Dairy Australia, would provide development, marketing and research for the industry. This organisation could represent all those involved in the coconut production chain, by co-ordinating communication regarding relevant research, risk, and investment opportunities for the industry. Ideally members would be diverse and include, among others, farmers, research institutions, nurseries, tissue culture companies, importers, processors and organic certification bodies. At the least, even a simple web forum dealing with current research outcomes could provide a much needed focus for the industry.

Table 1: Potential income from Dwarf coconut

Fruit produced/tree/yr	Fruit produced/hectare/yr in monoculture planting	Product price (based on conversation with current Australian producers/on-sellers)	Annual income/hectare
200	25,000	\$25/L packaged virgin oil (equivalent to 15 fruit)	\$41,666
		\$2/ whole drinking fruit	\$50,000
		\$5/L packaged water (equivalent to 2 fruit)	\$62,500
		\$10/150g shaved snack (equivalent to 1 fruit)	\$250,000

## Growth of the domestic coconut industry

We propose that there is need for an increased domestic focus for the Australian to the coconut industry. Until recently, coconut as an Australian crop was unattractive likely due to potential high labour and transport costs, and low price for traditional coconut products. With cloning technology (the capacity to multiply elite genotypes) being close to commercialisation, recent advances in agricultural automation, potential expanding product markets, and the promotion of mixed farming systems to safeguard incomes, it is worth reconsidering coconut as an economically viable crop for an Australian environment.

Demand for elite coconut varieties has grown rapidly recently; there is now an urgent need to cost effectively produce new seedlings with desired traits for supply to overseas markets (Nguyen *et al.*, 2015). This may be best achieved with the *Somatic Embryogenesis* (cloning) technology currently in development at the School of Agriculture and Food Sciences at The University of Queensland (Adkins *et al.*, 2016, Nguyen *et al.*, 2016).

Australian agricultural businesses have a strong track record of innovation. Research by The Australian Bureau of Statistics indicates that in 2009–10 over 32% of agriculture, fishing and forestry businesses were actively innovative, spending close to \$102 million (\$98 million self-funded) on agricultural research and development. As a result of technological advances, between 2000 and 2011, agriculture had the highest average annual growth rate in labour productivity of all industries at 5.3% (Australian Bureau of Statistics, 2012). Technologies are already in place in many coconut growing areas that would likely reduce labour costs if used in a domestic context, including optimisation of water (Gordon and Jackson, 2017) and VCO extraction (Seneviratne *et al.*, 2009), automated opening and deshelling (Jarimopas and Kuson, 2007, Jarimopas and Ruttanadat, 2007), and there are new technologies including climbing and harvesting robots on the horizon (Dubey *et al.*, 2016).

New markets are emerging for traditional and new coconut products. There is growing demand for coconut products with higher economic value, such as elite coconut types with unique fruit characteristics overseas (for example the tasty jelly-like endosperm of the makapuno or flavoursome aromatic water (Samosir *et al.*, 2006)), niche food products such as coconut sugar and dairy substitutes (ice-creams and yogurts), beverages, oils and environmentally friendly products. Coconut water is now a 300+ million dollar industry (Gordon and Jackson, 2017). Coconut is a renewable source of materials of value in the plant nursery and building industries. World coconut oil demand has increased over the last decade (Pham, 2016). New coconut oil markets include virgin coconut oil, biofuel, biolubricants, nutraceuticals and cosmeceuticals.

Coconut is generally grown overseas in a variety of mixed farming systems with animals (pigs, cattle, goats) and other crops (Arulandoo *et al.*, 2017). Palms can provide shade, which reduces evaporative stress, and wind protection for other crops. In a mature coconut grove there is space for other tree and/or annual crops that prefer light at 50-60% intensity that is common under older palms. Crops that are commonly grown overseas include cacao, vanilla, kava and coffee (Foale, 2003). It has been demonstrated that mixed farming systems can be valuable in Australia to reduce risk (Kandulu *et al.*, 2012), and the coconut has been recommended for mixed farming with sugarcane in Australia (Foale and Roebeling, 2006). Coconut palms have many attributes that make them ideal for mixed farming systems, including:

- Year-round harvest of fruit
- Wide range of products
- Product choice can be adapted depending on demand
- Every component of the palm and fruit can be used
- Resilient to environmental stresses such as cyclone following the first 12 years of growth
- Can be grown in marginal areas not suitable for other crops
- Tolerant of mild salinity
- Can provide protection against strong wind for companion crops
- Building friendly (roots pose no risk to buildings, pipes or soil-covering structures)
- Products containing oil have proven health benefits



## Conclusion

Even though the absence of industry coordination is a major disadvantage for domestic coconut producers, the already strong technical foundation for coconut production combined with market intelligence is likely to stimulate increased investment by current and new primary producers. Indigenous communities of Northern Australia in particular could be provided with new business and employment opportunities.



## References

- ADKINS, S. W., NGUYEN, Q. T. & FOALE, M. (2016) Improving the availability of valuable coconut germplasm using tissue culture techniques. *Cord*, 32, 28-35.
- ARULANDOO, X., SRITHARAN, K. & SUBRAMANIAM, M. (2017) The coconut palm. IN THOMAS, B., MURRAY, B. G. & MURPHY, D. J. (Eds.) *Encyclopedia of Applied Plant Sciences*. 2nd ed., Elsevier Inc.
- AUSTRALIAN BUREAU OF STATISTICS (2012) Farming in Australia. *Year Book Australia*. Canberra, Australian Bureau of Statistics.
- CHAKRABORTY, M. & MITRA, A. (2008) The antioxidant and antimicrobial properties of the methanolic extract from *Cocos nucifera* mesocarp. *Food Chemistry*, 107, 994-999.
- DUBEY, A. P., PATNAIK, S. M., BANERJEE, A., SARKAR, R. & SARAVANAKUMAR, R. (2016) Autonomous control and implementation of coconut tree climbing and harvesting robot. *Procedia Computer Science*, 85, 755-766.
- FOALE, M. (2003) *The coconut odyssey: the bounteous possibilities of the tree of life*. Canberra, Australian Centre for International Agricultural Research.
- FOALE, M. & ADKINS, S. W. (2014) Australian contributions to coconut (*Cocos nucifera* L.) research (a review article). *Cord*, 30, 37-43.
- FOALE, M. & ROEBELING, P. (2006) Potential for profitable coconut production in northern Queensland. IN ADKINS, S. W., FOALE, M. & SAMOSIR, Y. M. S. (Eds.) *International Coconut Forum*. Cairns, Australian Centre for International Agricultural Research
- GORDON, A. & JACKSON, J. (2017) Case study: application of appropriate technologies to improve the quality and safety of coconut water. IN GORDON, A. (Ed.) *Food Safety and Quality Systems in Developing Countries*. Elsevier Inc.
- JARIMOPAS, B. & KUSON, P. (2007) A young-coconut-fruit-opening machine. *Biosystems Engineering*, 98, 185-191.
- JARIMOPAS, B. & RUTTANADAT, N. (2007) Development of a young coconut fruit trimming machine. *Journal of Food Engineering*, 79, 752-757.
- KANDULU, J. M., BRYAN, B. A., KING, D. & CONNOR, J. D. (2012) Mitigating economic risk from climate variability in rain-fed agriculture through enterprise mix diversification. *Ecological Economics*, 79, 105-112.
- KOSCHEK, P. R., ALVIANO, D. S., ALVIANO, C. S. & GATTASS, C. R. (2007) The husk fiber of *Cocos nucifera* L. (Palmae) is a source of anti-neoplastic activity. *Brazilian J Med Biol Res*, 40, 1339-1343.
- LIM, T. K. (2012) *Cocos nucifera*. IN LIM, T. K. (Ed.) *Edible medicinal and non-medicinal plants*. Berlin, Springer-Verlag Berlin.
- MARINA, A. M., MAN, Y. B. C., NAZIMAH, S. A. H. & AMIN, I. (2009) Antioxidant capacity and phenolic acids of virgin coconut oil. *Int J Food Sci Nutr*, 60, 114-123.
- NGUYEN, Q. T., BANDUPRIYA, H. D. D., FOALE, M. & ADKINS, S. W. (2016) Biology, propagation and utilization of elite coconut varieties (makapuno and aromatics). *Plant Physiology and Biochemistry*, 109, 579-589.
- NGUYEN, Q. T., BANDUPRIYA, H. D. D., LÓPEZ-VILLALOBOS, A., SISUNANDAR, S., FOALE, M. & ADKINS, S. (2015) Tissue culture and associated biotechnological interventions for the improvement of coconut (*Cocos nucifera* L.): a review. *Planta*, 242, 1059-1076.
- PHAM, L. J. (2016) Chapter 9. Coconut (*Cocos nucifera*). IN MCKEON, T., HAYES, D., HILDEBRAND, D. & WESELAKE, R. (Eds.) *Industrial Oil Crops*. Elsevier Inc.
- ROSS, I. A. (2005) *Cocos nucifera* L. IN ROSS, I. A. (Ed.) *Medicinal Plants of the World, Vol 3*. Humana Press.
- SAMOSIR, Y. M. S., RILLO, E. P., MASHUD, N., VU, T. M. L., KEMBU, A., FAURE, M., MAGDALITA, P. M., DAMASCO, O. P., NOVARIANTO, H. & ADKINS, S. W. (2006) Revealing the potential of elite coconut types through tissue culture. IN ADKINS, S. W., FOALE, M. & SAMOSIR, Y. M. S. (Eds.) *Coconut revival - new possibilities for the 'tree of life'*. *Proceedings of the International Coconut Forum held in Cairns, Australia, 22-24 November 2005*. ACIAR Proceedings No. 125.
- SENEVIRATNE, K. N., HAPUARACHCH, C. D. & EKANAYAKE, S. (2009) Comparison of the phenolic-dependent antioxidant properties of coconut oil extracted under cold and hot conditions. *Food Chemistry*, 114, 1444-1449.