

Kakadu Plum (*Terminalia ferdinandiana*) as a Sustainable Indigenous Agribusiness

Gorman, Julian T.; Wurm, Penelope A.S.; Vemuri, Sivaram; Brady, Chris; Sultanbawa, Yasmina

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3

4 ***Terminalia ferdinandiana* (Kakadu Plum) as a Sustainable Indigenous Agribusiness**

5 *¹Julian T Gorman; ¹Penelope A.S. Wurm; ¹Sivaram Vemuri; ²Chris Brady; ³Yasmina
6 Sultanbawa

7

8 ¹Research Institute for Environment and Livelihoods, Charles Darwin University, NT, Australia,
9 0909.

10 E-mail: Julian.Gorman@cdu.edu.au; ORCID ID: 0000-0002-2013-3770

11

12 ²Northern Land Council, Darwin, NT, Australia, 0801

13

14 ³Queensland Alliance for Agriculture and Food Innovation, University of Queensland, QLD,
15 Australia, 4108

16

17 *Corresponding author

18 <H1>Abstract

19 In northern Australia, commercial use of plant products can provide Aboriginal people with
20 important livelihood opportunities. *Terminalia ferdinandiana* Exell. is a species endemic to
21 northern Australia with exceptional phytochemical properties and industry applications.

22 Aboriginal people have a long history of customary use of many parts of this plant and as
23 scientific research provides evidence for commercial applications, it is under increasing demand.

24 It has the highest level of ascorbic acid of any fruit in the world and commercially important
25 antioxidants. This paper reviews the unique characteristics of *T. ferdinandiana* fruit as a
26 commercial plant product, the people and landscapes in which it grows, and the current state of
27 knowledge for building a successful agribusiness based on these factors. It demonstrates the
28 great potential *T. ferdinandiana* has as a sustainable Indigenous business and identifies the

29 important research and development gaps that need to be addressed. These include improved
30 understanding of taxonomy, floral biology and drivers of variability in the properties in
31 *T. ferdinandiana* leaves and fruit; better understanding of aspirations of Aboriginal suppliers for
32 participation in the agribusiness supply chain, and; specific supply chain models that suit
33 Aboriginal suppliers of *T. ferdinandiana* to service a range of potential national and international
34 markets.

35

36 <H2> Keywords: Aboriginal; enterprise; antioxidant; Indigenous Ecological Knowledge;

37

38 <H1>Introduction

39 The aim of this paper is to bring a multidisciplinary approach to assessing *Terminalia*
40 *ferdinandiana* Exell. for Indigenous agribusiness development. *T. ferdinandiana* is an endemic
41 Australian native plant, with exceptional nutritional and health properties and potential
42 commercial applications. It is an abundant and widespread savanna tree, occurring across
43 northern Australia on lands owned and managed by Indigenous people. There is widespread
44 interest within the Australian Indigenous community in the potential to benefit livelihoods via
45 enterprise business income based on *T. ferdinandiana*. It is hoped that the framework developed
46 in this study will shed light on issues of concern for the growing interest in this agribusiness and
47 how best to address them. It is hoped that identifying knowledge gaps will inform future policy
48 initiatives and the development of the research and development agendas of Australian
49 Governments at all levels, as well as industry and philanthropic groups engaged in directing
50 funds for capacity building for Indigenous enterprise development.

51

52 Globally, many Indigenous people still have a high dependence on plant products for their
53 health, nutritional, cultural and spiritual well-being (WWF 2018). Equally so, ‘western’ markets
54 are also very dependent on wild genetic stock with some 25% of prescription drugs currently in
55 use today having plant origins. Plant compounds contribute to approximately 75% of the new
56 anticancer drugs marketed between 1981 and 2006 (Newman and Cragg 2007; Walsh 2003).
57 There is also a growing demand for ‘functional foods’, which potentially have a positive effect
58 on health above their nutritional value, such as in the prevention and management of health
59 conditions (Tapsell et al. 2006). In 2015, the global functional foods market was valued at
60 US\$129.39 billion and it is forecast to grow to US\$225.10 billion by 2024 (Grand View
61 Research 2016). This rapid market growth is due to increasing consumer consciousness about
62 health, diet and the environment, and greater awareness of foods that are produced in safe and
63 sustainable production systems.

64

65 Australia is well positioned to take advantage of this growing demand for functional foods based
66 on its diversity of endemic flora and Indigenous customary use and knowledge of plant products.
67 Australia has a very diverse array of native flora comprising of over 19,324 vascular plants with
68 the clear majority (~95%) being endemic (Chapman 2009). Many of Australia’s endemic plants
69 have commercial applications in the pharmacy, medicine, food, beverage, cosmetic, perfumery
70 and aromatherapy (Bindon 1996; Clarke 2012; Graham and Hart 1997; Lands 1987; Sultanbawa
71 and Sultanbawa 2016), with increasing international and national demand. Australian agriculture
72 has an excellent international reputation for its environmental stewardship, the quality of
73 products and agricultural practice (Daly et al. 2015), which positions it well to grow its existing

74 supply chains and to service a larger section of the functional foods market. However, to develop
75 these chains and grow a share in the international market, while including the requirements of
76 Aboriginal suppliers, requires careful planning, research and development, including
77 interdisciplinary knowledge across several areas of consideration.

78

79 Australian Aboriginal people are the custodians of the oldest continuous culture on earth and
80 have an extensive ecological knowledge and deep, spiritual connection to their country. Their
81 customary use of natural resources over many thousands of years has resulted in an exceptional
82 knowledge of the value of use of plant products which has been transferred across generations
83 (Lindsay et al. 2001; Puruntatameri et al. 2001). Wild plants and animals continue to be
84 important in contemporary identity building of Aboriginal people and wild food networks will
85 undoubtedly offer opportunities to urban, peri-urban and rural Aboriginal people (Low Chow et
86 al. 2013). There is much that modern medicine and other sectors can gain from this knowledge
87 and, through equitable partnership agreements, the Australian agribusiness sector and Aboriginal
88 people can also benefit greatly (Janke 2018; Robinson 2010).

89

90 *T. ferdinandiana*, best known by the common name 'Kakadu Plum' is one of Australia's native
91 species that has potential to grow into a significant agribusiness. This species has exceptional
92 phytochemical properties in the leaf and fruit which have commercial application and market
93 demand from several industry sectors. It has the highest levels of ascorbic acid of any fruit in the
94 world and high levels of commercially important antioxidants such as flavonoids, polyphenolics
95 (including gallic and ellagic acids) (Cunningham et al. 2009; Netzel et al. 2007; Williams et al.
96 2014). A significant amount of research and development has already been conducted towards

97 the commercialisation of this species but there are clearly knowledge gaps that need to be
98 identified and addressed in growing this from a small-medium scale enterprise to a large-scale
99 agribusiness.

100 Northern Australia is struggling with the incongruity of having unique and abundant cultural and
101 natural resources, but an Aboriginal population suffering from major socio-economic
102 disadvantage (Australian Institute of Health and Welfare 2015). Yet the customary knowledge
103 that Aboriginal people have around plant and animal resources (Jones and Clarke 2018) could be
104 the basis of an improvement of their socio-economic status through creating much needed
105 employment opportunities and continued connection to country. A ‘two tool box approach’
106 (Aslin and Bennett 2005) is required in sharing this knowledge and commercialisation through
107 partnerships of industry and research with the Aboriginal custodians. This approach for
108 collaborative action has worked well in the land management sector. This has occurred as
109 traditional land management practitioners work together with contemporary ‘western’ land
110 management practice through Indigenous Ranger groups (Aslin and Bennett 2005).

111 A similar strategy is needed in business collaborations that sit between the very different socio-
112 economical constructs of remote Aboriginal communities, which are still strongly influenced by
113 traditional culture, with potentially contrasting conventional business structures, which function
114 according to western business principles. Therefore, sustainability involves not only ecological
115 but also economic, social and cultural considerations. All of these are important for realising the
116 internationally recognised Millennium Development Goals which are so important in Indigenous
117 development (Millennium Development Summit 2000).

118 An agribusiness development requires at the very least a supply of and a demand for a product,
119 as well as ‘actors’ willing and able to provide services along the value chain. Within this paper
120 the main consideration is supply of a plant product from Aboriginal lands. We review the unique
121 characteristics of *T. ferdinandiana* fruit as a commercial plant product, the people and landscapes
122 in which it grows, and the current state of knowledge for building a successful agribusiness
123 based on these factors. First, we discuss the economic geography of northern Australia and
124 provide a snapshot of the landscapes, the Aboriginal communities, and their cultural values.
125 Secondly, we review some of the biophysical properties of *T. ferdinandiana* and the commercial
126 use of plant products by Aboriginal people as a livelihood option, with a focus on *T.*
127 *ferdinandiana*. Thirdly, we consider the trajectory of the growing commercial use of *T.*
128 *ferdinandiana* and the challenges that this industry sector will face. This trajectory is then
129 considered in the context of the social and cultural embeddedness that exists in Indigenous
130 businesses globally (Cahn 2008). Enterprise and business developers in this context will need to
131 link with a very different set of conventional business principles, expectations and behaviours.
132 This will require careful planning, communication and perhaps formulation of new models and
133 approaches (Scoones 1998).

134

135 <H1>Northern Australian Landscapes, History and Socioeconomic

136 Status of Indigenous People

137 In this section we will focus on the part of northern Australia in which *T. ferdinandiana* is found
138 which, at its narrowest definition, includes the wet/dry tropics of the Northern Territory (NT) and
139 the Kimberley region of Western Australia (WA) (Cunningham et al. 2009). These areas have an

140 annual rainfall of 600 – 1600 mm which is spread over a 4 -7-month period (Lansberg et al.
141 1966).

142

143 <H2>Northern Australian landscapes

144 The wet/dry tropics of the NT and the Kimberley of WA are characterised by their vast and
145 relatively intact landscapes with extremely low population densities. Outside of the cities the
146 population is sparse and predominantly Aboriginal owned land. Native Title claims, and
147 Aboriginal Land Rights are more progressed in the NT than other states of Australia with about
148 50% of the land and 85% of the coastline under Aboriginal ownership (National Museum of
149 Australia 2019). This land is held either as Aboriginal freehold, leasehold or other tenures that
150 exist concurrently with Native Title. The NT encompasses hundreds of clan estates (AIATSIS
151 2019a) with many either permanently or seasonally occupied in small family or clan settlements,
152 referred to as ‘outstations’. These outstations are generally serviced by regional townships, many
153 of which were started as missions or Government outposts when Aboriginal people were
154 dispossessed from their land (AIATSIS 2019b).

155

156 The NT has an average population of 0.2 person/km² (ABS 2016). The low density of people
157 living on the land is arguably the biggest threat to its natural and cultural resources, as
158 landscapes need active land management at an appropriate scale. With the current low levels of
159 occupation, wildfire, feral weeds and animals, are extremely hard to manage and have
160 devastating ecological, cultural, social and economic impacts. Land management and sustainable
161 use of wildlife play an ever-increasing and important role in the livelihood opportunities of
162 Aboriginal people on their land (Gorman et al. 2008, 2006; Nikolakis 2010). However, without

163 appropriate livelihood opportunities to generate income, there may over time be a drift of
164 Aboriginal people off their traditional lands into larger towns (as quoted in Vemuri and Gorman
165 2012).

166

167 <H2>History and socioeconomic status of Indigenous people

168 The remote Aboriginal economy has been described as a ‘hybrid’ economy, made up of three
169 sectors: customary or subsistence; the State (mainly welfare), and; private sector (e.g. arts and
170 craft, tourism enterprise) (Altman 2001). Although the proportion of these sectors has clearly
171 changed over time the customary or subsistence component of the hybrid economy is still very
172 important to many Aboriginal people living in remote areas. The welfare sector in Aboriginal
173 communities has largely been in the form of a ‘work for the dole’ type scheme called the
174 Community Development Employment Program (CDEP) (Gorman and Vemuri 2017). The
175 funding and employment generated through CDEP have contributed greatly to development of
176 remote regional areas often managed by Aboriginal development corporations such as
177 Bawinanga Aboriginal Corporation in Maningrida (Altman 2016) and Thamarrurr Development
178 Corporation in Wadeye. This CDEP scheme, which has been in existence since the late 1970s,
179 has in part been used as a training program which ‘employed’ people in community-based
180 projects. The CDEP scheme was initially intended to train and transition people onto ‘real’ jobs
181 but there are few non-government jobs available in regional Aboriginal townships (Gorman and
182 Vemuri 2017; Welter 2010). Over time the Federal and State Governments have tried to
183 rationalise expenditure on service delivery (such as for health and education) by trying to
184 encourage Aboriginal people from smaller settlements into bigger townships. When this occurs,
185 Aboriginal people inevitably end up disconnected from their clan estates, creating a loss of

186 culture and language and often contributing to social disharmony in the more concentrated
187 population centres (Kerins 2010).

188

189 The private sector is also an important component of the hybrid economy (Altman 2001). On
190 Aboriginal lands, the labour requirements of private sector activity typically have been
191 mismatched with the existing Indigenous skills or have involved work opportunities that are not
192 desirable to Indigenous people (Altman and Sanders 1991, McRae-Williams and Gerritsen
193 2010). This is reflected in workplace participation rates being extremely low outside of major
194 cities (Altman and Sanders 1991). For example, the Aboriginal Township of, Wadeye (Figure 1),
195 had a workplace participation rate of 16.7% in 2006. In contrast, culture-based enterprise
196 activities have higher levels of Indigenous interest and engagement. They are often more
197 flexible, can work in with cultural and social obligations, and are based on existing knowledge
198 systems and connections to country (Altman and Sanders 1991; Gorman et al. 2008, 2006).
199 These include, arts and craft, tourism, natural and cultural resource management, and wildlife-
200 based enterprise (Koenig et al. 2011; Luckert et al. 2007; Nikolakis 2010; Tremblay and Wegner
201 2009; Zander et al. 2014).

202

203 In recent times, there has been a call by some Indigenous leaders for an increase in private sector
204 investment (Mundine 2010; Pearson 2009; Yunupingu 2008). In encouraging this pathway,
205 attention must be given to economic viability of enterprise and the process of choosing
206 appropriate enterprises. Culture and social structure have an important role in decision making in
207 Aboriginal communities. Further complicating decision making and governance in Aboriginal
208 communities is that community members are often on the board of several organisations and part

209 of important decision making while at the same time also being part of a family group which is a
210 beneficiary of these decisions. This could be viewed as being a conflict of interest but given the
211 size of some of these communities, the relatively small number of Traditional Owners who are
212 decision makers and the complexity of multi-cultural governance, it is difficult not to have such
213 overlap. Cultural factors such as kinship systems, totems and decision-making authority, are
214 factors which have potential to influence aspects of a natural resource-based enterprise by
215 determining who can be involved, what country it can happen on and when it can happen.

216

217 CDEP has been the mainstay of employment in Aboriginal communities since the late 1970s
218 (Gorman and Vemuri 2017). Under this scheme, participants were expected to work 4 hours a
219 day (36 hours a fortnight) which provided flexibility to participate in social and cultural
220 activities. Many of these CDEP programs were initiated around social outcomes and the author
221 has observed high turnover of projects along with CDEP coordinators. Enterprises initiated under
222 this scheme were seldom expected to be financially viable and could best be described as ‘social
223 enterprise’. This has distracted from the real economic viability of business as many of the costs
224 of operations have been subsidised by the CDEP scheme and the supporting organisations within
225 the communities. True accountability of business will need to include all operational costs for
226 them not to be dependent on subsidies which may not exist into the future.

227

228 Land management and sustainable natural resource-based activities and enterprise have been
229 long identified by Aboriginal communities as high on their list of development aspirations
230 (Gorman 2006, 2008; Whitehead 2012; Whitehead et al. 2006). This is because they provide a
231 mechanism to accommodate economic, social and cultural priorities. Similarly, it has been found

232 that Maori-led economic development also has a strong emphasis on cultural values and world
233 views and are essential in social and economic development in Maori communities (Bishop and
234 Tiakiwai 2002; Carter et al. 2011).

235

236 In the Northern Territory, the Indigenous population has a much faster growth rate than other
237 groups (Taylor et al. 2006). This further emphasises the need for appropriate employment
238 opportunities on Aboriginal lands. It is important that the approach to the development of
239 employment opportunities is community-based. This will ensure Aboriginal people are
240 empowered and have ownership of the processes of economic development and can decide how
241 to best maintain their cultural values and connections while at the same ensuring their people are
242 still able to access the economic and knowledge resources of mainstream society.

243

244 In summary, northern Australian landscapes are vast, relatively intact, with a rich natural and
245 cultural diversity. The landscapes require active land management at an appropriate scale to
246 maintain the natural and cultural values. There are many Aboriginal communities which are
247 welfare dependent, arguably because of the history of establishment of the townships in which
248 they live, contributing to a lack of appropriate employment opportunities through the private
249 sector. Land management and use of wildlife offers livelihood opportunities which Aboriginal
250 people have a knowledge and interest in pursuing. Choosing and establishing such enterprise
251 needs input and ownership from the communities who will service them. There are complex
252 cultural, social and institutional factors, which influence decision making and economic viability,
253 that need to be considered in developing natural resource-based enterprise. Much of Aboriginal

254 land is under communal title and still governed by traditional lore and practice which requires a
 255 different approach to conventional business development.

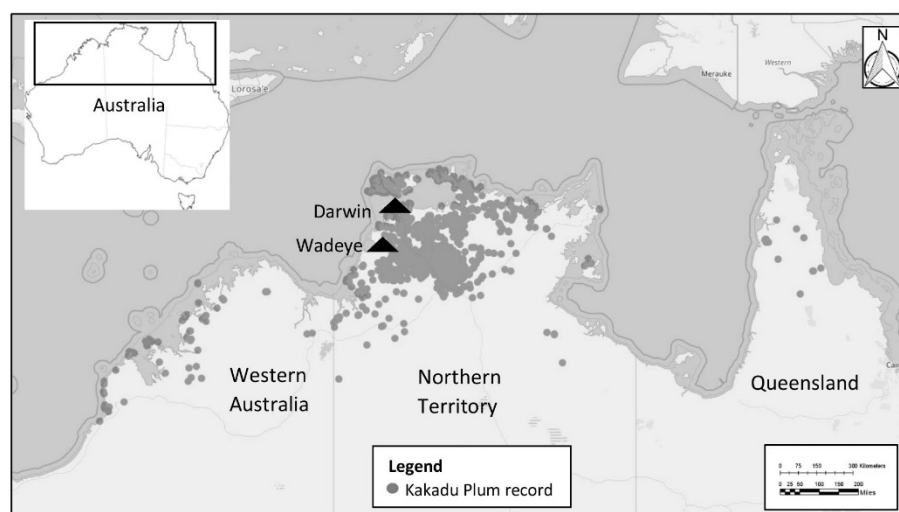
256

257 <H1>*Terminalia ferdinandiana* Exell.

258 <H2>Taxonomy

259 *T. ferdinandiana* Exell. is a member of the Combretaceae family (Wheeler 1992) and endemic
 260 to northern Australia (Figure 1). This family contains 20 genera and 500 species that are
 261 widespread in tropical and subtropical regions of the world (Dunlop et al. 1995). The genus
 262 *Terminalia* consists of about 200 species, of which 29 species or subspecies are native to
 263 Australia (Dunlop et al. 1995). Fourteen species occur in the Kimberley of Western Australia
 264 (WA), 12 in Northern Territory (NT) and 16 in north Queensland (Pedley 1995) with some
 265 species overlapping in distribution.

266



267 Figure 1: Map showing distribution of the endemic *T. ferdinandiana* (as plotted using tree
 268 records from Atlas of Living Australia 2019) and approximate locate of Darwin and the
 269 Aboriginal Community Wadeye

270
271 *T. ferdinandiana* was originally named and described as *T. edulis* by Muell in 1860
272 (Cunningham et al. 2009). Later, the Australian Plant Census, which is the authority for
273 Australian plant names, adopted Byrnes' (1977) *Revision of Combretacea in Australia*, and
274 considered *T. ferdinandiana* and *T. latipes* as separate species. However, there is some dispute
275 about this decision. Pedley (1995) in *Flora of Australia* merged *T. ferdinandiana* and *T. latipes*
276 (while recognising the latter as *T. ferdinandiana* subsp. *psilocarpa*). Currently *T. ferdinandiana*
277 is considered a synonym of *Terminalia latipes* subsp. *psilocarpa* and vice versa in many plant
278 databases. However, the Northern Territory Herbarium does not recognise Pedley's (1995)
279 revision and maintains Byrnes (1977) version (where *T. ferdinandiana* and *T. latipes* as separate
280 species). Additionally, there is also taxonomic uncertainty about whether a prostrate variety
281 should be recognised as the distinct *Terminalia prostrata*, or as a prostrate form of the same
282 species (Dunlop et al. 1995; Pedley 1995). Across northern Australia there are also many natural
283 hybrids amongst these *Terminalia* species (Keneally et al. 1996) making the taxonomy unclear.

284
285 These taxonomic uncertainties about the status of *T. ferdinandiana* need to be resolved. Wild
286 harvest collection permits and export licenses require species identification and proof of
287 appropriate management and a sustainable harvest plan (Australian Government 2018).
288 Management of wild populations should be based on knowledge of species distribution and
289 mitigation of threats which requires taxonomic certainty. Taxonomic clarity will also inform
290 further investigations of plant properties.

291

292 <H2>Ecology

293 *T. ferdinandiana* is a small to moderately sized, semi-deciduous tree that is a dominant mid-
294 storey species in *Eucalyptus tetradonta* and *E. miniata* woodlands in the upper rainfall band of
295 the Australian wet/dry tropical savannas. The density of *T. ferdinandiana* mature trees of fruit-
296 bearing age (>2 m in height) has been recorded at more than 500 trees ha⁻¹, with the highest
297 densities on or near the coast (Woods 1995). In a separate study, the coastal strip in the greater
298 Darwin region was found to have mature trees (>2m in height) at 272 ± 169 ha⁻¹ (Whitehead et al.
299 2006). While in central Arnhem land, surveys conducted at 5km intervals from the coast to 50
300 km inland, gave an average density of 14.4 ± 24.3 trees/ha. The highest density was found along
301 the narrow coastal strip (82 trees/ha) and on clay soils 40 km inland (31 trees/ha) (Gorman et al.
302 2006; Whitehead et al. 2006). In some places they could be considered ‘natural plantations’ due
303 to their high densities. However, further inland the average density drops considerably with clay
304 soils supporting slightly higher densities. *T. ferdinandiana* fruit from different regions across
305 northern Australia have considerable variation in their phytochemical and antioxidant properties
306 (Konczak et al. 2014). The cause for this variation is not well understood and could be related to
307 a variety of genetic and/or biophysical relationships i.e. soils, insect herbivory, response to ultra
308 violet light, rainfall, fire, pollinators and other variables.

309
310 Soil water holding capacity and fire regimes have been found to be important variables that
311 determine occurrence of deciduous, non-eucalypts in this vegetation type (Lawes et al. 2011;
312 Murphy et al. 2015). As an understory tree it is difficult to define the distribution and density of
313 *T. ferdinandiana* with any accuracy using remote sensing imagery. However, developments of
314 land-based LIDAR imagery could be used for this purpose into the future. Fire ecology literature

315 and field observations indicate that fire intensity and frequency are causing a ‘bottleneck’ in
316 recruitment of non-eucalypt, deciduous species in tropical savannas (Lawes et al. 2011; Lehmann
317 et al. 2009; Murphy et al. 2015). This may be impacting on the population dynamics of *T.*
318 *ferdinandiana*. If fruit is to be harvested from the wild in large volumes, it will be important to
319 know more about the species distribution, density, habitat preferences and impact of disturbance
320 factors such as fire. There are likely to be several arboreal mammals and birds that feed on the
321 fruit of *T. ferdinandiana* which may be impacted upon under certain commercial harvest
322 regimes. This requires further research.

323
324 An understanding of the reproductive biology of a plant is necessary to understand the factors
325 that influence fruit quality and quantity. There is currently no information on the reproductive
326 biology of *T. ferdinandiana* in the public domain, information which is critical to improve
327 yielding and planning the layout of plantations. The structures of flowers, the pattern of opening,
328 the sequence of activity of stamens and carpels, the self-compatibility, types of pollinators and
329 their rewards, are all important for understanding wild harvest and horticultural production. This
330 is an important research gap to be filled.

331
332 Fire is also a key determinant of savanna structure and diversity. It will also be necessary to
333 better understand the impact of fire regimes on population structure, and on flowering and
334 pollinators as this may influence yields. Land management and natural resource use offer
335 important livelihood opportunities as well as increased health and well-being to Aboriginal
336 people on their country (Burgess et al. 2009; Gorman et al. 2008, 2006; SRRATRC 1998). The
337 issues for this type of enterprise development have been well documented and relate generally to

338 remoteness as well as issues more specific to Aboriginal culture and social structure (Nikolakis
339 2010; Rose 1996).

340

341 <H2>Traditional Use

342 Customary use of plant products such as *T. ferdinandiana*, where there is existing knowledge
343 about their nutritional or medicinal benefits, is often a “flag” for potential commercial pathways.
344 There are many products that Aboriginal people are already familiar with having harvested, often
345 stored and traded for customary purposes (Blake et al. 1998; Pascoe 2014; Smith and Kalotas
346 1985; Smith and Wightman 1990; Wightman et al. 1992).

347

348 Plants of the genus *Terminalia* are globally well recognised as being widely used for traditional
349 medicine (French 2013) and laboratory chemical analysis provides evidence to support their
350 many medicinal uses (Cock 2015). *T. ferdinandiana* also has long been harvested by Aboriginal
351 people as a food and for treatment of a variety of other ailments. The inner bark has been used to
352 treat skin disorders and infections (wounds, sores and boils) as well as fungal infections such as
353 ringworm and bacterial infections including treatment of leprosy (Gorman et al. 2006). The fruit
354 of *T. ferdinandiana* was consumed by Aboriginal people on hunting trips for quick energy and
355 refreshment (Brock 2001). Central Arnhem Land clans regarded it as more a medicine than a
356 food (Isaacs 1987). In addition to the fruit being eaten for medicinal purposes (to treat colds and
357 congestion) (Lindsay et al. 2001; Puruntatameri et al. 2001; Raymond et al. 1999) the sap was
358 roasted, and the bark was boiled in water and used to treat skin conditions and sores or drunk as a
359 tea for colds and flu (Lindsay et al. 2001). Traditionally, both the fruit and seed of *T.*
360 *ferdinandiana* were eaten raw. Different Aboriginal language groups have different names,

361 dreaming stories and uses for this species (Lindsay et al. 2001; Puruntatameri et al. 2001;
362 Raymond et al. 1999). Aboriginal people have a strong affiliation with this species through their
363 long history of customary use, and there has been increasing involvement and expressed
364 aspirations from Aboriginal people across its distribution to commercialise it (Gorman et al.
365 2016). Traditional foods are still a very important part of the diets of many Aboriginal people
366 today and a recent study conducted over five remote Aboriginal communities in the Northern
367 Territory found 89% of the people interviewed consumed a variety of traditional food fortnightly
368 (Ferguson et al. 2017). Wildlife based enterprises involving traditional foods such as Kakadu
369 Plum are likely to increase time on traditional lands, better facilitate inter-generational transfer of
370 knowledge, allow for increased physical activity and facilitate consumption of traditional foods,
371 which will all contribute to better health and well-being (Burgess et al. 2009; Gorman et al.
372 2006)

373

374 <H2>Phytochemical Properties

375 *T. ferdinandiana* is well known for its phytochemical properties. It was first recognised for its
376 extremely high levels of Vitamin C (ascorbic acid) in 1982 through a study of the nutritional
377 composition of bushfood used by Australian Aboriginal people (Brand et al. 1982; Miller et al.
378 1993). In this study, they found ascorbic acid contents of 2,300 - 3,150 mg per 100g of fruit wet
379 weight (2.3 – 3.1%). Recently, ascorbic acid levels have been recorded at $14,038 \pm 701$ mg per
380 100g of fruit dry weight (~14%) (Williams et al. 2014). As a comparison, the Barbados Cherry
381 (or acerola, *Malpighia glabra*), a native to Brazil which previously laid claim to the highest
382 levels of Vitamin C in the world (Clein 1956), had an average Vitamin C content of 1.7 % wet
383 weight (Johnson 2003). Citrus, which is very well known for its source of natural Vitamin C is

384 about 0.5% by wet weight (Cunningham et al. 2009). So clearly, *T. ferdinandiana* has
385 exceptionally high natural levels of ascorbic acid in the fruit compared to other species.

386

387 The fruit and leaf are also found to have extremely high levels of polyphenolic compounds.
388 These include mainly ellagic and gallic acid which, along with Vitamin C, provide high
389 antioxidant values known to reduce the risk of several diseases, such as cardio-vascular disease,
390 cancer, stroke and rheumatoid arthritis (Mohanty and Cock 2012; Ohno et al. 1999; Sirdarta et
391 al. 2015; Tan et al 2011; William et al. 2014; Willet 2002). Furthermore, *T. ferdinandiana* has
392 much higher levels of ellagic acid (879.6 ± 15.6 mg per 100g DW) than boysenberry (168.4 ± 3
393 mg per 100g DW), which is a fruit considered to have high levels of ellagic acid (Williams et al.
394 2014). *T. ferdinandiana* was also found to have a much higher free to total level of ellagic acid
395 (70.6%) compared to strawberry (3.3%) and boysenberry (3.3%) making it more available for
396 uptake. It is thought that ascorbic acid plays a role in protecting the degradation of the ellagic
397 acid (Williams et al. 2014). The leaves are found to have much higher levels of ellagic acid than
398 the fruit, although there does appear to be much variability in these phytochemical levels
399 between trees (Williams et al. 2016).

400

401 There are several possible explanations as to why the phytochemicals levels are high in *T.*
402 *ferdinandiana* and why they are so variable. Herbivory rates are higher in tropical forests than in
403 temperate forests and the most damage to tropical leaves occurs when they are young and
404 expanding. This is in contrast with temperate forest trees where the damage occurs mainly in the
405 mature leaves (Coley and Barone 1996). As a defence mechanism to herbivory, plants have
406 evolved chemical, mechanical and phenological traits to protect themselves. We see these traits

407 in *T. ferdinandiana* with extremely high levels of ascorbic acid and polyphenolic compounds;
408 leaves which are fibrous with high tannin levels and not very palatable especially as they age;
409 and a synchronous leaf and flower flush in the later dry season, when insect numbers are at their
410 lowest (Coley and Barone 1996). These strategies would help reduce herbivory from insects and
411 arboreal mammals. This can be particularly important in areas where soils are relatively poor
412 such as the monsoonal tropics (Coley and Barone 1996). The evolution of chemical defence
413 mechanisms against predation has been found to be more pronounced in plants with long lived
414 leaves (Coley and Barone 1996). However, *T. ferdinandiana* have relatively short lived, semi-
415 deciduous leaves which drop in the middle of the dry season which contradicts common
416 explanations for the heavy metabolic investment in chemical defence plants.

417

418 There is also evidence that phenolic compounds have antioxidant capacity which may protect
419 plants from photodamage (Close and McAuthur 2002). Plants grown under conditions of high
420 light or limited nutrients have been shown to produce increased amounts of leaf phenolics,
421 including tannins (Close and McAuthur 2002). This was demonstrated in an early study on
422 phenolic compounds, where leaves from the sun-exposed side of the canopy of *Prunus*
423 *domesticata* var. Victoria trees were seen to have significantly higher levels of phenolic
424 compounds than leaves from the shaded side (Hillis and Swain 1959). The leaves of *T.*
425 *ferdinandiana* have been found to have very variable levels of ellagic acid and this may be due to
426 different exposure of ultra-violet light among different trees and/or within the canopy of a single
427 tree. More research is required to confirm this. However, if the leaf is to be commercially
428 harvested, there is a need to better understand how and why ellagic acid levels vary throughout
429 the life of the leaf and if this changes seasonally and between and within populations.

430

431 The seeds of *T. ferdinandiana*, which were previously discarded in the pulping process, have
432 recently been identified as having potential to be utilised as a novel protein source for dietary
433 purposes and a non-conventional supply of linoleic, palmitic and oleic acids (Akter et. al. 2018).

434 The multiple uses of products from the fruit and leaves will continue to attract commercial
435 attention and contribute to profitability when production and processing happens at scale.

436 However, we need a better understanding of what is driving the exceptional levels of
437 phytochemical compounds of both the *T. ferdinandiana* fruit and leaves and the variability. If
438 variability is chiefly environmental there may be ways to manipulate environmental factors
439 (sunlight, pollination) to increase concentration of the desirable compounds, reduce variability,
440 and hence economic returns.

441

442 <H1>Historical and potential future commercial uses

443 Despite the exceptional properties of the *T. ferdinandiana* fruit and leaf and the diversity of
444 commercial applications it offers, the rate of growth of this industry has been slow and
445 inconsistent (Gorman et al. 2016). Above, we referred to agribusiness in its simplest form as
446 needing to involve a product supply, a demand and participation of ‘actors’ willing and able to
447 provide the services along the value chain. In this section we will review progress of business
448 development.

449

450 Permits for wild harvested fruit

451 Legislation to harvest native plant products varies between states and territories in Australia. In
452 the NT, permission to harvest is regulated by the Department of Tourism and Culture
453 (administration of collecting permits), Department of Environment and Natural Resources
454 (advice on the ecological sustainability of planned activities) and Department of Trade, Business
455 and Innovation (administration of bioprospecting regulations and benefit sharing arrangements).
456 Collection for commercial purposes involve permits to ‘Take’ and ‘Return’ fruit. ‘Take’ permits
457 are required for all commercial harvest offtakes on all titles of land. Applications for these
458 permits need to provide details about the proposed harvest volume, area, and land title of the
459 collection area. The applications are assessed for sustainability and appropriate sharing of
460 benefits before being granted. In the case of Kakadu Plum, a specific management plan exists
461 (*Management Plan for Kakadu Plum 2019 – 2023*) (Gorman et al. 2019) which stipulates extra
462 management considerations. At the end of harvest season, a ‘Return’ Permit must be completed
463 with actual harvest volume and, if harvested from Crown Land, a royalty (per kg) payment is
464 required.

465 In the NT, any commercial activity on Aboriginal land required consent from the Traditional
466 Owners of that land, according to the *Aboriginal Land Rights Act* (Northern Territory) 1976.
467 This needs to be facilitated through one of the NT Land Councils, which have regional
468 jurisdictions within the NT. Subsequently a Land Use Agreement (LUA) between the collecting
469 party and the relevant Land Trust needs to be agreed to. Unfortunately, there are large backlogs
470 and time delays in this process. In many cases in the past, harvest permits for Kakadu Plum have
471 been granted without going through the LUA process (Julian Gorman, pers. obs. 2019). This has
472 occurred where the proponents have been Traditional Owners and their families on their own

473 land, not involved in an exclusive activity, and where the collection has been small scale and
474 mostly ‘trial’ harvest, rather than a commercial activity.

475 The Northern Territory Government has introduced a *Biological Resources Act* 2006,
476 administered by the NT, which is largely concerned with third parties making agreements related
477 to bioprospecting on all tenure types. Partnership agreements are drawn up and royalty rates
478 discussed if bioprospecting is being conducted. Issues around biological patents and property
479 rights have been an important consideration in recent years and there have been a number of
480 examples of attempts to establish international patents for commercial products which use
481 Kakadu Plum (i.e. Mary Kay patent attempts). These claims have been disputed on the basis of
482 existing Traditional knowledge (Robinson 2010). These attempts over the years by international
483 companies to patent products using Kakadu Plum ultimately benefit indirectly from Indigenous
484 Knowledge. These patent attempts are likely to be contributing to a strong desire from
485 Aboriginal groups to protect and manage their knowledge for their own enterprise development
486 (Janke 2018).

487

488 <H2>History of commercial use

489 The growth of an agribusiness around *T. ferdinandiana* fruit has been characterised by
490 inconsistent market demand which in turn has contributed to poorly structured and resourced
491 supply chains. Sustainable agribusiness chains will only develop in response to positive market
492 signals. Inconsistent and variable market signals can be misinterpreted and lead to premature
493 establishment of value chains, emphasising the supply. The supply is more complex when it is
494 predominantly from wild harvest and largely on Aboriginal lands, which are often remote and

495 with limited infrastructure. Yields can also vary with annual weather events in the monsoonal
496 north. Aboriginal communities are also often grappling with how to integrate the social and
497 cultural connectedness of their businesses with conventional supply and value chains which
498 operate according to economically focused business principles. There are solutions to these
499 issues, and over time the community members themselves will determine their own approach and
500 priority of family vs. community benefits and business structure. Globally, indigenous peoples
501 are dealing with similar issues. For example, people from Papua New Guinea blend introduced
502 business concepts with indigenous ideals to create a unique form of entrepreneurship (Currie
503 1999, 2003). Cahn (2007) describes people in the Pacific Islands organising enterprises around
504 individuals, family and kin while also achieving community outcomes and enhanced social
505 networks.

506 The history of commercial use of *T. ferdinandiana* can be characterised by three main phases.
507 The first was between 1996 and 2007 where processed fruit was in demand from the food and
508 beverage sector for its high Vitamin C content and flavour. The second was between 2006 and
509 2010 where demand grew for its nutraceutical values. Coradji Pty LTD, an Australian, Sydney-
510 based company, bought fruit from communities in the Kimberley, WA, and in the NT. This fruit
511 was supplied to Coradji, trucked frozen to Sydney where it was pulped and then to Melbourne
512 where it was freeze dried into a powder. It was then distributed to an American manufacturing
513 company called Mannatech, who used the *T. ferdinandiana* powder in a supplementary health
514 tablet called “Ambrotose” ®. In both these early phases, Aboriginal people supplied the fruit but
515 had little desire or opportunity to play a role further up the value chain. The third phase was
516 based on subsequently discovered antimicrobial properties and an increased awareness of the
517 exceptional properties of this species. This resulted in *T. ferdinandiana* powder being awarded

518 the "Best Novel Food Ingredient" at the Natural Products Expo in West/Engredea Show in
519 Anaheim CA (USA) in 2014. At around this time, Aboriginal communities and their Resource
520 Centres in the NT and the Kimberley started investing in and forming collection hubs and
521 increased their annual harvest from hundreds to thousands of kilograms of fruit per season. There
522 was discourse around creating Aboriginal owned cooperatives to consolidate production from
523 different regions; taking on processing and product development and dealing with different
524 markets. Several WA Aboriginal communities became more involved in horticulture, trialling a
525 variety of production systems. Many established connections with small markets that they could
526 work with as a community-based enterprise. A more in-depth history of commercial use of *T.*
527 *ferdinandiana* can be found in Gorman et al. (2016).

528

529 <H2>Horticultural production systems

530 Monoculture horticulture and wild harvest from the bush lie at opposite ends of a spectrum of
531 production systems. Contemporary horticulture requires the development of plant varieties which
532 have the most desirable phenotypic qualities such as tree shape, growth vigour, flowering
533 duration, fruit quality and yields. This is based on identifying and crossing varieties with the
534 best traits from across the distribution. Monoculture horticulture generally involves clearing,
535 irrigation and, use of fertiliser and pesticides, with the aim of maximising profit. There are
536 alternative production systems that may be better suited to Aboriginal lands, where cultural,
537 totemic and customary significance and social priority are considered. Alternatives to
538 contemporary horticultural production systems include enrichment and multispecies plantings,
539 managing natural stands for increased recruitment and yields, and growing high performing,
540 local phenotypes (Leahey et al. 2003; Lee and Courtenay 2016). It will be important to seek

541 opinion of Aboriginal land owners about cultural attitudes to mixing genetics between
542 populations, which may come from different clan estates. It will be necessary to make sure there
543 is cultural authority for this, as plants and animals are totems and have different cultural
544 significance to different Aboriginal clans.

545
546 Given different markets focus on specific properties of processed *T. ferdinandiana*, it may be
547 possible to link them with their best matched supply region. This may allow for processing
548 systems to be practiced in regions which suit the price structure of the appropriate market,
549 perhaps reducing competition between regions for the similar market and allowing for a more
550 regional development of wild enrichment management or horticulture systems of production and
551 early processing systems for the relevant market. Product marketing could also benefit from links
552 with regions with promotion of the culturally specific names and stories from that area. Further
553 research is required to understand the reasons for phytochemical variations and to the
554 contribution of genetics and environmental factors, to fully realise market potential.

555
556 There have also been a number of industry and government funded research and development
557 projects related to the horticulture of Kakadu Plum in recent years and there are some existing
558 plantations in both the Northern Territory and Kimberley Region. In the 1990s, there was
559 commercial interest in Kakadu Plum from a private company, Access Business Group
560 International LLC (ABG) (a business of the Alticor Group and sister company of Amway), in
561 partnership with Cognis Australia Pty Ltd. This agronomic research resulted in a plantation of
562 approximately 6000 trees being established just east of Darwin (NT), at Wildman River
563 (Robinson 2010, Cunningham et al. 2009). However, in May 2004, ABG and Cognis Australia

564 tried to export Kakadu Plum tissue culture to Amway’s facility in Brazil, without authority from
565 the Australian Government, nor setting up benefit sharing agreements with land owners where
566 they had sourced the material. This controversial action ultimately led to the demise of this ABG
567 and Cognis Australia Research Group venture at Wildman River (Cunningham et al. 2009). A
568 plantation of Kakadu Plum still exists at the Wildman River site and in recent years extra trees
569 have been planted and the fruit harvested by Wild Harvest NT.

570

571 A number of different plantations exist in the Kimberley region of Western Australia. In 2007,
572 the North Regional TAFE set up a training and research centre just outside Broome in
573 partnership with the WA Department of Conservation and Land Management and with the
574 endorsement of the local Yawuru Traditional Owners. This site is called Balu Baru, which is a
575 Yawuru term meaning “place of trees” (Lee and Courtenay 2016). A trial plantation of Kakadu
576 Plum (locally named Gubinge), was set up as trial to test horticultural methods. There are now
577 have over 1000 trees in place as enrichment plantings (i.e. supplementary planting amongst wild
578 stands) (Lee and Courtenay 2016). Kim Courtenay, a horticulturalist with North Regional TAFE,
579 has trained and facilitated development of many small plantations on Aboriginal lands in the
580 Kimberley. The most productive of these is at Bidyadanga Aboriginal Community, 200 km south
581 of Broome. They have established enrichment and monoculture plantations of mature trees
582 which are yielding over one tonne of fruit annually. Another group that has adopted the
583 enrichment planting system is the Aboriginal Resource Centre, of the Mamubulanjin Aboriginal
584 Corporation, in Broome. This group has a number of small plantations of Kakadu Plum and sell
585 fruit wholesale.

586

587 With the exception of the plantation originally created at Wildman River in the NT, there are no
588 significant plantations of Kakadu Plum under non-Indigenous ownership. The bulk of current
589 supply is coming from wild harvested sources. A significant opportunity exists for Indigenous
590 groups to continue to work towards their ‘whole of business’ approach based on wild harvest
591 while investigating other production systems to increase supply.

592

593 <H2>Value chains and business models

594 There has certainly been progress in many areas in developing value chains. Several Aboriginal
595 groups have linked directly with industry partners and provided a supply of *T. ferdinandiana* as
596 an ingredient for a variety of retail products. The Aboriginal business, Twin Lakes Cultural Park,
597 located on the Dampier Peninsula, north of Broome in Western Australia, is an example. They
598 have had a partnership agreement for several years directly with the company Loving Earth PTY
599 Ltd. This company uses *T. ferdinandiana* powder as an ingredient in chocolate (Twin Lakes
600 Cultural Park 2019). Other Aboriginal communities, such as those in the Thamarrurr Region of
601 the NT (Figure 1), have clearly demonstrated their capacity to wild harvest more than 10 tonnes
602 of fruit in a season and have progressed up the value chain by processing this harvest locally
603 (Thamarrurr Development Corporation pers. comm. 2019). Processing procedures for pulping
604 and freeze drying are already developed. The resulting pulp and powder have been assayed and
605 found to be of pharmaceutical quality (Yasmina Sultanbawa pers, comm. 2018). However
606 overall, the processing steps need to be tailored to the costs structure of individual markets and
607 end products. Markets which are not reliant on high concentrations or nutraceutical grade
608 phytochemicals, may be serviced by more economical methods of local processing. The markets
609 that are currently buying fruit for its anti-microbial properties are satisfied with the quality and a

610 high price structure. Market signals suggest that substantially higher volumes of fruit will soon
611 be demanded by this market. When this happens, there will be a need for coordination of supply
612 chains to deliver in the quantities and quality required.

613

614 An important consideration going into the future is how the *T. ferdinandiana* business should
615 develop to meet market demands and social and cultural concerns of suppliers. There has been
616 some movement towards an alliance of Aboriginal companies supplying Kakadu Plum fruit and
617 extracts for the Australian market. This initiative, which has been supported by the Indigenous
618 Land Corporation, is called the Northern Australian Aboriginal Kakadu Plum Alliance
619 (NAAKPA) and was established in August 2018 (NAAKPA 2018). NAAKPA is an alliance of
620 Aboriginal companies that ethically harvests and process Kakadu Plum across northern
621 Australia. They were established to protect the interests of Aboriginal enterprises and
622 communities in the Kakadu Plum industry (NAAKPA 2018). One of the key objective of
623 NAAKPA is to become leaders in all aspects of the business (research, harvest, processing and
624 marketing) and to empower Aboriginal people to draw on land assets and the Traditional
625 Ecological Knowledge and intellectual property within communities. The formation of
626 NAAKPA and interest in this ‘whole of industry’ development approach illustrates
627 empowerment in driving an Aboriginal led economic development strategy. Many would feel
628 they are entitled to lead this wildlife-based enterprise given they have hundreds of years of
629 customary use of this product and decades of commercial participation. Another cooperative,
630 trading under the business name Traditional Homeland Enterprises (T.H.E.), is supported by the
631 philanthropic group Kindred Spirits Enterprises. T.H.E. has the stated goal of having an
632 Indigenous, majority owned company structure (Traditional Homeland Enterprises 2019). As the

633 overall Kakadu Plum business grows, these company structures will continue to evolve. The
634 success of the industry will require more coordinated supply chains, which align with the
635 business realities while meeting the goals and aspirations determined by the Indigenous
636 enterprises.

637

638 There are however many extenuating circumstances that make it difficult to initiate and operate
639 business from remote Aboriginal communities. Often there is not enough time spent on
640 clarification of Indigenous aspirations for enterprise and community-based approaches to map
641 the types of enterprises they aspire towards and where they see their involvement along value
642 chains. This will suit investors with capital and business expertise that can embrace the unique
643 social geography of northern Australia and Aboriginal people, be adaptive in their partnerships
644 and conscious of the importance of cultural and social embeddedness. Rather than pre-determine
645 the way of doing business, this investor awareness may create the pathways for *T. ferdinandiana*
646 and many other commercial opportunities that are currently linked with Indigenous knowledge
647 systems.

648

649 There are non-Indigenous suppliers involved in both plantation production and wild harvest of *T.*
650 *ferdinandiana*. In the WA Kimberley region, there are several short value chains with Indigenous
651 communities supplying fruit directly to markets in reasonably small volumes (Twin Lakes
652 Cultural Park 2019). Given northern Australia is vulnerable to cyclones and other disruptions, a
653 more coordinated model which links across a broad geographic range to spread risks of losing
654 markets may be another approach worth considering. Such a model would also be important for
655 linking with a market that requires a large and consistent supply and in turn assist with risk

656 management. As other production systems develop it is likely that fruit with more consistency
657 will be produced. However, wild harvest is likely to be the main source of fruit for the short
658 term, and for some communities the longer term, as it will be their production system of choice.

659

660 <H1>Conclusion

661 This paper has demonstrated that *T. ferdinandiana* has the inherent characteristics to be an
662 Indigenous agribusiness and has potential to be sustainable. However, there are many
663 multidisciplinary questions that need to be addressed. These questions relate to Indigenous
664 aspirations; non-conventional business structure and function; *T. ferdinandiana* genetics and
665 production systems; and will be specific to each Aboriginal community.

666

667 Aboriginal stakeholders, as the main landowner across northern Australia, hold access rights to
668 most of the genetic resources of this species and have knowledge, capacity and desire to be
669 involved and have ownership of the supply chain and connections to the diversity of markets. To
670 facilitate participation along supply chains requires a multidisciplinary and multisector approach
671 that can accommodate the social and cultural embeddedness of Indigenous business into the
672 more conventional economic models. This will require the development of appropriate and
673 sustainable supply chain models that service suppliers managing traditional estates as well as
674 national and global markets.

675

676 There are many production and market directions this industry can take. As markets demand a
677 greater volume of supply there is bound to be interest from large horticultural ventures that can

678 grow the product at considerable volume for a competitive price. This has not happened to date
679 because market demand has been inconsistent, and the investment risks in establishing large
680 scale horticulture too high. There is a window of opportunity for Aboriginal landowners who
681 have *T. ferdinandiana* of different varieties on their land to establish and service current market
682 demands. This could be through wild harvest of managed and unmanaged landscapes as well as
683 through establishment of regional varieties in a choice of production systems (enrichment,
684 mixed, monoculture and managed wild areas) suited to their cultural and social desires. As
685 markets increase their demand for *T. ferdinandiana* there will inevitably be greater interest from
686 horticultural companies to service these markets. This will make production very competitive.
687 Aboriginal communities currently have access to the wild stock and the genetic resources and
688 land to increase production into the future. It is integral that they establish themselves as
689 suppliers and build the networks and relationships to supply markets in this early phase of
690 industry development if they are to take advantage of this opportunity.

691 There is however, need for further research to progress this industry. A better understanding of
692 the variability of phytochemical properties of the fruit and leaf from different regions, seasons
693 and populations could help direct markets to certain areas where the fruit has more of the desired
694 property. The demand for a commercial application will determine the volume and price
695 structure of the processed products and therefore will affect the most appropriate technique of
696 processing according to the required quality of the end product demanded by different models.

697 Sustainable agribusiness, requires a market, a supply and 'actors' along the value chain, and
698 needs coordination for these components to align. When markets have production chains in
699 place, they require the other sections of the value chain to be ready as well. Across northern
700 Australia this species occurs at densities which could supply an annual demand of around a

701 hundred tonnes of fruit. However, even wild harvest requires a large amount of upfront
702 investment and coordination. The Aboriginal communities that have proven their ability to wild
703 harvest tonnes of fruit in a season have had to invest in collection, storage and processing
704 infrastructure, and training and transferable knowledge. How, or if, these communities wish to
705 join in a cooperative arrangement to supply large volumes, it is for them to decide. This will
706 ultimately be determined by the markets they connect with and their ability to manage the many
707 complexities of a supply chain.

708 There is generally high failure rate of smaller businesses (Bickerdyke et al. 2000) but no
709 evidence to suggest increased failure of business success in remote areas or for those operated by
710 people who identify themselves as Indigenous (Whitehead 2012). However, initiating any sort of
711 enterprise in remote Indigenous townships is difficult because of the transport and access costs,
712 as well as many other cultural, social and political factors (Rose 1999; Whitehead et al. 2006).
713 As Government approaches to welfare and outstation support change, Aboriginal people will
714 need to become more economically independent. Their natural resources and knowledge may
715 play an important role in providing future livelihood opportunities. For Aboriginal people to play
716 a greater role in the whole of value chain will require consideration to be given to training and
717 education, infrastructure support, governance and business approaches and models.

718 *T. ferdinandiana* has many properties for commercial success and with its distribution being
719 endemic to northern Australia and abundant on Aboriginal land. It offers a great opportunity to
720 provide opportunities for employment and income generation that are much needed by
721 Aboriginal people in these areas. There are undoubtedly other native plants which have had long
722 Aboriginal customary use which have commercial application. The value chains developed for *T.*
723 *ferdinandiana* may well allow easier commercialisation for these species into the future.

724 This paper demonstrates a great potential for *Terminalia ferdinandiana* to be a sustainable
725 Indigenous business so long as the gaps identified are addressed. These gaps include: improved
726 understanding of taxonomy, floral biology and drivers of variability in the properties in *T.*
727 *ferdinandiana* leaves and fruit; improved knowledge of the aspirations of Aboriginal suppliers
728 for participation in the agribusiness supply chain, and; understanding of the specific supply chain
729 models that suit Aboriginal suppliers of wild harvested *T. ferdinandiana* to service a range of
730 potential national and international markets.

731

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740

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1110

1111 **Figure Caption**

1112 Figure 1: Map showing distribution of the endemic *T. ferdinandiana* (as plotted using tree

1113 records from Atlas of Living Australia 2019) and approximate locate of Darwin and the

1114 Aboriginal Community Wadeye