Future Foods 5 (2022) 100136

Contents lists available at ScienceDirect

Future Foods

journal homepage: www.elsevier.com/locate/fufo

Future flavours from the past: Sensory and nutritional profiles of green plum (*Buchanania obovata*), red bush apple (*Syzygium suborbiculare*) and wild peach (*Terminalia carpentariae*) from East Arnhem Land, Australia

Selina Fyfe[a,b], Horst Joachim Schirra[c,b,d], Michael Rychlik[e,a], Annemarie van Doorn[f], Ujang Tinngi[g], Yasmina Sultanbawa[a], Heather E Smyth[a,*]

[a] *The University of Queensland, Queensland Alliance for Agriculture and Food Innovation, Coopers Plains, Queensland, Australia*
[b] *Griffith Institute for Drug Discovery, Griffith University, Nathan, Queensland, Australia*
[c] *School of Environment and Science, Griffith University, Nathan, Queensland, Australia*
[d] *The University of Queensland, Centre for Advanced Imaging, Brisbane, Queensland, Australia*
[e] *Chair of Analytical Food Chemistry, Technical University of Munich, Maximus-von-Imhof-Forum 2, D-85354, Freising, Germany*
[f] *The Arnhem Land Progress Aboriginal Corporation, Yirrkala, Northern Territory, Australia*
[g] *Queensland Health Forensic and Scientific Services, Brisbane, Queensland, Australia*

ARTICLE INFO

ABSTRACT

The green plum (*Buchanania obovata*), red bush apple (*Syzygium suborbiculare*) and wild peach (*Terminalia carpentariae*) all grow in remote East Arnhem Land, Australia and are eaten by the Yolŋu Aboriginal people who live there. These three fruits have had very little study at present by western food science and there is interest in their use as foods or food products to create sustainable Indigenous agribusinesses. The purpose of this study was to create a nutritional and sensory profile of each fruit. Results show that wild peach is a very good source of vitamin C with 2041 ± 192 mg/100g FW (fresh weight) and green plum is a very good source of folate, containing 118 ± 8 µg/100g FW as folic acid equivalents. All three fruit are good sources of dietary fibre, (green plum 9.5 ± 1.4, red bush apple 6.5 ± 1.0 and wild peach 8.6 ± 1.3 g/100g FW) and minerals and the green plum is a particularly valuable source of potassium (511 ± 22 mg/100g FW). Descriptive analysis of the fruit as whole or pieces of fruit, as a puree and as an ingredient (freeze-dried powder) in semolina and yoghurt describe the green plums flavour as *sweet*, *tart* and *stewed apple* and red bush apple as *sour*, *raspberry*, *citrus*, *apple*, *sweet*, *floral*, *herbaceous* and *spiced tea*. The unique sensory profiles and high nutrient levels indicate they could be used as future smart foods for diet diversity and future flavours in novel food products.

1. Introduction

East Arnhem Land is located in the Northern Territory, Australia and is the home of the Yolŋu people who are the original Aboriginal inhabitants of this land. This study determines the nutritional and sensory profiles of three native Australian fruit that grow in East Arnhem Land and are eaten by the Yolŋu people. The green plum (*Buchanania obovata*) is called *munydjutj* by the Yolŋu people (Yunupingu et al., 1995) and is a well-liked fruit eaten raw or sundried (Burarrwana et al., 2019; Fox et al., 2018; Head, 2002; Hiddins, 2003; Levitt, 1981; Thomson, 1949b). The red bush apple (*Syzygium suborbiculare*) is known as *l̲arran̲i* by the Yolŋu people (Yunupingu et al., 1995) and is eaten raw or lightly roasted (Burarrwana et al., 2019; Fox et al., 2018; Hiddins, 2003; Levitt, 1981; Thomson, 1949b). The

Abbreviations: 10-CHO-PteGlu, 10-formylfolic acid; 5-CH_3-H_4folate, 5-methyltetrahydrofolate; 5-CHO-H_4folate, formyltetrahydrofolate; AI, Adequate intake; ALPA, The Arnhem Land Progress Aboriginal Corporation; AOAC, Association of Official Agricultural Chemists; DHAA, Dehydroascorbic acid; DW, Dry weight; EAR, Estimated average requirement; EDTA, ethylenediamine-tetracetic acid; EER, Estimated energy requirement; FA, Folic Acid; FAO, Food and Agriculture Organisation; FW, Fresh weight; H_4folate, tetrahydrofolate; HPLC, High performance liquid chromatography; ICP-AES, Inductively coupled plasma atomic emission spectroscopy; ICP-MS, Inductively coupled plasma mass spectrometry; ICP-OES, Inductively coupled plasma optical emission spectrometry; L-AA, L-Ascorbic Acid; MU, Measurement of uncertainty; NATA, National Association of Testing Authorities; PteGlu, pteroylmonoglutamic acid (folic acid); QDA, Quantitative Descriptive Analysis; SIDA, Stable isotope dilution assay.

* Corresponding author at: Heather E Smyth, QAAFI – University of Queensland, Block 10, Health and Food Science Precinct, 39 Kessels Rd, Coopers Plains, QLD 4108, Australia.

E-mail address: h.smyth@uq.edu.au (H.E. Smyth).

https://doi.org/10.1016/j.fufo.2022.100136
Received 14 December 2021; Received in revised form 20 February 2022; Accepted 26 February 2022

Fig. 1. Green plums (*Buchanania obovata*), red bush apple (*Syzygium suborbiculare*) and wild peach (*Terminalia carpentariae*) (left to right) from East Arnhem Land.

wild peach (*Terminalia carpentariae*) is known as *mambaṉbu* or *murrŋga* by the Yolŋu (Yunupingu et al., 1995) and is eaten raw (Fox et al., 2018; Hiddins, 2003; Levitt, 1981). All three fruit are popular and important food sources and are said to be favoured fruit (Fox et al., 2018; Levitt, 1981; Thomson, 1949b) (see Fig. 1).

There is growing interest by the Aboriginal peoples in Australia to create sustainable Indigenous agribusinesses. The Aboriginal people of Arnhem Land in Australia have a long history of trading with the Macassan people from Malay and Indonesia (Flinders, 1814; Thomson, 1949a, 1949b; Yunupingu et al., 1995) who traded pottery, knives, material, tobacco and other things for sea cucumbers (trepan) from the waters around Arnhem Land (Burarrwana et al., 2019; Yunupingu et al., 1995). For a sustainable agribusiness to be established there needs to be information about the food's nutritional and sensory properties and an understanding of ways that these foods can be used. These initial and preliminary nutritional and sensory profiles are important to study to further understand the role these fruit could contribute to the diet and health of those who eat them. Nutritional profiles are important for understanding the health benefits of food. There are many databases available that contain nutritional profiles of commercially available fruit but very little is known about these three bush foods. Sensory studies of Australian native foods are important as they can give reliable and meaningful descriptions and product information about these unique ingredients which can be used in product design, to enhance brand elements and in marketing communication (Kemp et al., 2018). Sensory descriptions can be used for promoting the use of these foods, for providing information to the Indigenous communities and the food industry for applications of these ingredients and can be used as quality control targets (Smyth et al., 2012).

There has been one major sensory study of native Australian plant foods which was successful in producing a flavour wheel and lexicon (Smyth et al., 2012). This study used quantitative descriptive analysis (QDA) to evaluate 10 fruit and six herbs/spices with 11 experienced panellists over 15 sessions. The fruit analysed were those considered to be the most commercially significant of the Australian native fruit at that time. However, no updates of this flavour wheel and lexicon have been performed since it was published in 2012 and other native fruit now being considered for commercialisation have not been scientifically described. The fruit included in the flavour wheel study were two species of Davidson plum, desert lime, two varieties of fingerlime, Kakadu plum, lemon aspen, muntries, quandong and riberrry. In another smaller study, five native plant foods and five herbal infusions of native Australian leaves were described using free choice profiling which added a profile of the Illawara plum to the native fruit knowledge (Fyfe et al., 2018b).

In 1993 a book of tables of nutrition composition of many Australian native foods was published (Brand Miller et al., 1993), it and its associated papers (Brand et al., 1985; Brand et al., 1983) have formed the basis for much of the study on Australian native foods. It was these studies that discovered the high levels of Vitamin C in the Kakadu Plum (Brand et al., 1983) which led to further analysis and commercialisation of the fruit by an Indigenous agribusiness (Gorman et al., 2020). That study also published basic nutritional profiles of the green plum, red bush apple and wild peach, but instrumentation and methodology have since greatly improved, and updated results using much more sensitive methods and for many more nutrients can now be obtained. The authors of the present study have previously analysed nutritional properties of underripe green plums (Fyfe et al., 2018a) so a subsequent study of the nutritional profile on ripe green plums is necessary.

The sensory analysis in the current study was able to obtain attributes of the fruit to create reliable and meaningful verbal descriptions of the sensory properties of these fruit as whole/bite sizes of fruit, as a puree and as a freeze-dried powder ingredient that could be used in other food products. A rapid sensory descriptive test was required as there were only relatively small volumes of sample available and limited access to the trained sensory panel due to COVID-19 safety restrictions. The sensory analysis method used was free choice profiling (Hunter, 2018; Lawless et al., 1998). Free choice profiling has previously been used in sensory analysis of ham (Guàrdia et al., 2010), coffee (Kitzberger et al., 2016; Narain et al., 2004), hop varieties for beer production (Donaldson et al., 2012), milk (Miettinen et al., 2004), yoghurt (Saint-Eve et al., 2004), and honey (Vit et al., 2017). The use of free choice profiling to obtain sensory descriptions can be criticised as the results can be subject to the desired interpretation of the researcher (Lawless et al., 2010), so this analysis was purposefully aimed to be unbiased in how representative attributes were chosen. The current study had significant limitations outside the control of the researchers, including social/physical distancing requirements and lockdown time restrictions due to the COVID-19 pandemic, and there was difficulty in obtaining enough sample volume of ripe fruit from their remote location to perform a longer version of QDA.

The Food and Agriculture Organisation (FAO) have previously labelled neglected and underutilised species that are nutritionally dense, economically viable, climate resilient and available locally and abundantly in their region as 'future smart foods' (Li et al., 2018). These foods could be used in food products to add diversity to diets to increase the number of foods people eat and protect against persistent malnutrition (Li et al., 2018). The purpose of this study is to establish accurate nutritional and sensory profiles of the green plum, red bush apple and wild peach to provide important information for the possibility of them as future smart foods. This will help with understanding the nutritional value they already provide in the diet of the communities in East Arnhem Land and will give information for the potential use of these fruit in future commercialisation activities by this community and in future novel food products by the food industry.

2. Materials and methods

2.1. Samples

The samples were harvested in East Arnhem Land in December 2018 and January 2020 and were immediately frozen at -20°C. They remained frozen through storage and transportation to Brisbane where they were placed in -20°C freezers until further processing or analyses. Samples were collected by staff and members of The Arnhem Land Progress Aboriginal Corporation (ALPA) and the Gulkula Mining Company and supplied to The University of Queensland under Northern Territory Parks and Wildlife Commission Permits 66293 and 64579. Samples were identified by the environmental officers at Gulkula Mining Company and ALPA and botanical samples of the green plum and wild peach were deposited at the Queensland Herbarium and identified as *Buchanania obovata* (AQ952392) and *Terminalia carpentariae* (AQ952388) respectively. The accepted names according to The Plant List are the green plum as *Buchanania obovata* Engl. from the family Anacardiaceae, the red bush apple as *Syzygium suborbiculare* (Benth.)T.G.Hartley & L.M.Perry from the family Myrtaceae and the wild peach as *Terminalia carpentariae* C.T.White of the family Combretaceae which is an unresolved name (The Plant List, 2013).

Fruit for nutrient analysis and for sensory analysis as freeze-dried powders had the seeds removed, the flesh with skin attached was cut into pieces, and composite samples of the flesh and skin of each fruit species were frozen to -80 °C then lyophilised together in a Christ Gamma 1-16 LSC Freeze Drying Unit (John Morris Scientific, Osterode, Germany) at -30 °C and 0.400 hPa. The samples for nutrient analysis were ground to a fine powder in a hammer mill (Lab Mill, Christy and Norris Ltd., Chelmsford, England) and the samples for sensory analysis were ground to a powder in a grinder (BCG200, Breville, Sydney, Australia), powders were frozen at -20°C until they were analysed.

2.2. Reagents

L-Ascorbic acid, sodium chloride, disodium hydrogen orthophosphate and potassium dihydrogen orthophosphate were from Chem-Supply (Gillman, SA, Australia). 1,4-dithiothreitol (DTT) was from Roche (Basel, Switzerland). Sodium acetate trihydrate was from Merck (Darmstadt, Germany). 2-(N-morpholino)-ethanesulfonic acid (MES) was from Sigma-Aldrich (Steinheim, Germany). Strata SAX cartridges were from Phenomenex (Aschaffenburg, Germany). Folate vitamer standards and labelled isotope were from Merck (Schaffhausen, Switzerland) and Schircks Laboratories (Bauma, Swtizerland). Chicken pancreas was from Pel-Freez Biologicals (Rogers, AR, USA) and rat serum was from Bio-Rad (Gladesville, NSW, Australia). Yoghurt was from Raybek Foods (Upper Coomera, QLD, Australia) and semolina was from Sostanza (De Pasquale Bros, Ravinvic Enterprises Pty Ltd, Brisbane, QLD, Australia).

2.3. Proximate analysis

Proximate analysis (excluding moisture content) was performed on freeze-dried and ground samples by Symbio Alliance (Eight Mile Plains, Queensland, Australia) which is a National Association of Testing Authorities (NATA) accredited laboratory that complies with ISO/IEC 17025:2017 using AOAC International official methods of analysis (Horwitz et al., 1970) and accredited in-house methods. Moisture was measured by gravimetric method (AOAC 925.10) with a measurement of uncertainty (MU) of ± 15%; crude protein by Kjeldahl method (AOAC 990.03) and ash by gravimetric method (AOAC 923.03) with MU of ± 10%; total sugar was measured using HPLC (CFH001); dietary fibre using a gravimetric method (AOAC 985.29 and 993.19) and crude fat using a gravimetric method (AOAC 991.36) with MU of ± 15%; and saturated fat, mono-unsaturated fat, poly-unsaturated fat and trans fat were measured by method CFH068, energy by CF030 and carbohydrate by CF029. Energy and carbohydrate are calculated values.

Moisture content was measured on pieces of fruit flesh using the AOAC method 920.151 (1990) in triplicate for each sample using a vacuum drying oven (Series RVT, Heraeus, Berlin, Germany) at pressure 200 Torr and temperature 70 °C until samples reached constant weight.

2.4. Analysis of metals, minerals and trace elements

Analysis of metals, minerals and trace elements of the green plum and wild peach were analysed in triplicate using methods described in Akter et al. (2020) and Carter et al. (2015). Briefly, 0.3 g samples were digested overnight at room temperature using concentrated nitric acid (4.0 mL), then microwave digested (MarsXpress, CEM, Matthews, NC USA) at a gradual increase in temperature. Minerals were analysed by inductively coupled plasma optical emission spectrometry (ICP-OES, 700 Series, Agilent, VIC, Australia) and trace elements by inductively coupled plasma mass spectrometry (ICP-MS) (Agilent, Tokyo, Japan). Standard reference materials (CRM ERM – CE278k Mussel Tissue; CRM IRMM BCR-679 White Cabbage) were used for quality control and were treated similarly to the samples. Details of the reference material analysis has been described elsewhere (Hungerford et al., 2020).

Analysis of metals, minerals and trace elements of the red bush apple were analysed at Symbio Alliance laboratories using NATA accredited in-house methods. Sodium, potassium, calcium, magnesium, phosphorous, iron and zinc were measured using inductively coupled plasma atomic emission spectroscopy (ICP-AES) (ESI02), and manganese, cobalt, nickel, copper and chromium were measured using ICP-MS (ESM02). Potassium, calcium, magnesium, phosphorous, nickel and cobalt had an MU ± 5% and sodium, zinc, iron, manganese, copper and chromium had an MU ± 10%.

2.5. Vitamin C (Ascorbic Acid) analysis

Vitamin C (Ascorbic Acid) (L-AA) was extracted following the method published by (Campos et al., 2009) with some modifications. In brief, 200 mg of lyophilised fruit powder was extracted with 3% metaphosphoric acid, 8% acetic acid and 1 mM ethylenediamine-tetracetic acid (EDTA). Dehydroascorbic acid (DHAA) in the samples was reduced to L-AA using the method of Spínola et al. (2012). Total vitamin C (L-AA + DHAA) was determined using a Waters ultra-performance liquid chromatography photodiode array (UPLC-PDA) system (Waters, Milford, MA USA) with a HSS-T3 column (100 × 2.1 mm i.d; 1.8 µm; 25°C) with the mobile phase of aqueous 0.1% formic acid (0.3 mL/min) and isocratic conditions. Quantification was obtained by an external calibration curve of L-AA that was run with the samples.

2.6. Folate analysis

Folate vitamers were measured in triplicate using a stable isotope dilution assay (SIDA) and ultra-high performance liquid chromatography photodiode array – mass spectrometer/mass spectrometer (UHPLC-PDA-MS/MS) (Striegel et al., 2018b). Briefly, 60-90 mg of lyophilised fruit powder was equilibrated with 10 mL of extraction buffer (200 mmol/L 2-(N-morpholino)-ethanesulfonic acid hydrate (MES), 114 mmol/L ascorbic acid, and 0.7 mmol/L DL-dithiothreitol (DTT), pH 5.0). Labelled isotopological internal standards were added at appropriated concentrations, [$^{13}C_5$]-PteGlu, [$^{13}C_5$]-H_4folate, [$^{13}C_5$]-5-CH_3-H_4folate and [$^{13}C_5$]-5-CHO-H_4folate. 300 µL of rat serum and 2 mL of chicken pancreas suspension were added for enzyme deconjugation and incubated overnight before purification with strong anion-exchange solid-phase extraction. Samples were analysed on a Shimadzu UHPLC-PDA-MS/MS system (Shimadzu Corp., Kyoto, Japan) that was equipped with a Shimadzu 8060 triple-stage quadrupole mass spectrometer and a Raptor ARC-18 column (2.7 µm, 100 × 2.1 mm) (Restek, Bad Homburg, Germany). Multiple reaction monitoring in positive mode was optimized to quantify individual folate vitamers and the labelled isotopes. External calibration curves were used to quantify the folate vitamers based on the peak area ratios of analysers versus internal standards. Folate vitamers analysed were the main folate vitamers found in food: pteroylmonoglutamic acid (PteGlu)(folic acid), tetrahydrofolate (H_4folate), 5-methyltetrahydrofolate (5-CH_3-H_4folate), 5-formyltetrahydrofolate (5-CHO-H_4folate) and 10-formylfolic acid (10-CHO-PteGlu). Results are expressed as µg/100g Folic Acid (FA) equivalents.

2.7. Sensory evaluation

This study has Institutional Human Research Ethics Approval from The University of Queensland Human Research Ethics Committee A and complies with the Australian *National Statement on Ethical Conduct in Human Research* and the regulations governing experimentation on humans (Approval Number: 2018001365).

2.7.1. Panellists

A trained panel of 15 (12 female and 3 male) individuals participated in the study, they were aged between 19 and 57 years with an average age of 39 years. The panellists were sourced from a pool of experienced trained assessors who had previously been screened for sensory acuity according to established methods (Meilgaard et al., 2016) and were employed for participation in sensory evaluation studies at the Health and Food Science Precinct at Coopers Plains, Brisbane.

2.7.2. Sample presentation

There were four sample formats presented and assessed for each fruit by sensory evaluation in the study: unadulterated whole fruit (green plums, 3 g) or pieces of fruit (5 g) in their natural form; purees of fruit pulp (7 g); 2% freeze dried powder mixed in cooked semolina (10 g); and 2% freeze dried powder mixed in a natural yoghurt (17 g). Both carriers had previously been determined to be neutral carriers to be used in sensory analysis (Olarte Mantilla et al., 2020; Smyth et al., 2012). A reference sample of each carrier was presented to the panellists alongside the samples so panellists could distinguish the attributes of the fruit powder from the attributes of the carrier. Samples were presented in 30 mL plastic cups with lids that were labelled with three-digit blinding codes. Random numbers between 1 and 999 were generated using the random number generator on random.org https://www.random.org. Twelve samples were presented at the same time along with the two reference samples. The samples were all presented twice, once each on two consecutive days.

2.7.3. Free choice profiling method

Free choice profiling was used to articulate descriptions of sensory qualities as a rapid method to obtain meaningful descriptions that could be used under social/physical distancing requirements (1.5 m) (Lawless et al., 2010).

Panellists were asked to elicit words to describe the qualities of aroma, appearance, texture, flavour and aftertaste of each sample. They were given a copy of a native plant food flavour wheel (Smyth et al., 2012) as a reference vocabulary but were not restricted to that lexicon. A panel discussion ensued after individual assessments of each set of three samples.

2.7.4. Data analysis

Data from free choice profiling was analysed using Generalised Procrustes Analysis to reach a consensus configuration of each descriptor (Lawless et al., 2010). After completion of testing each descriptor used was transferred to Microsoft Excel software spreadsheets (v 2013, Microsoft Corporation, Redmond, WA, USA), and descriptors were tallied. The analyst grouped like words together into a single attribute which best represented groups based on: the frequency of descriptor use; logical lexicon representation of that group; and ensuring consistent vocabulary use across the different sample formats. The total for each attribute was placed in numerical order and were used to write the descriptive sentences and sensory profile for each quality. Attributes for each fruit were compared using cobweb charts in Microsoft Excel to understand the attribute similarities and differences across the types of sample presentation.

3. Results and discussion

Results for the nutrient analysis of the green plum, red bush apple and wild peach are presented in Tables 1–3. These profiles are comprehensive lists of the proximates (Table 1), macro-minerals, trace elements (Table 2), vitamin C and folate vitamers (Table 3) found in 100g fresh weight (FW) of these fruit flesh and skin. The tables also shows the dietary reference intake values as advised by the National Health and Medical Research Council (2017) with values for a 31-50 year old female shown as an indicative value.

The nutritional results show the green plum is a good dietary source of potassium, calcium, magnesium, phosphorous, iron, dietary fibre and folate. There are some differences between the results in this study of the ripe green plums and results from a previous study on slightly underripe green plums that were from a different location (Fyfe et al., 2018a). The protein is lower in the present study, with protein 1.69 g/100g FW compared to 2.69 g/100g FW in the previous study. Fat is slightly higher with 0.94 g/100g FW in the present study compared to 0.53 g/100g FW. The level of dietary fibre is slightly lower in the present study 9.5 g/100g FW compared with 11.571 g/100g FW, although both studies show green plum is a good source of dietary fibre. The difference in ripeness can clearly be seen in the sugar levels which in the ripe green plums is 6.9 g/100g FW and in the underripe green plums was 0.6 g/100g FW. The results for metals, minerals and trace elements are consistent with those of the under-ripe green plums (Fyfe et al., 2018a) and those by Medley et al. (2016) who studied the green plum as a plant. All three studies show the green plum is a very good source of potassium (respectively and in dry weight (DW) for comparison: 1687, 2274 and 1657 mg/100g DW) and is a good source of calcium (259, 426 and 716 mg/100g DW), magnesium (278, 571 and 510 mg/100g DW), phosphorous (62.8, 216.8 and 167 mg/100g DW) and iron (2.55, 3.8 and 2.4 mg/100g DW) compared with the estimated average requirements of the dietary reference intakes published by the National Health and Medical Research Council (2017). The high potassium level seen in the green plum (511 mg/100g FW) is consistent with the potassium in other fruit of the same family, Anacardiaceae (Fyfe et al., 2020), including the marula (355 mg/100g FW) (Jaenicke et al., 1999), sumac (526 mg/100g FW) (Kizil et al., 2010), terebinth (762 mg/100g FW) (Kizil et al., 2010), yellow mombin (288 mg/100g FW) (Tiburski et al., 2011), ovo (250 mg/100g FW) (Kozioł et al., 1998), Burdekin plum (458 mg/100g FW) (Brand Miller et al., 1993) and the mango which has a slightly lower level (168 mg/100g FW) (USDA, 2019).

This study also confirms that the green plum is a very good source of folate in the ripe fruit. The previous study on under-ripe fruit discovered the high level of folate (161 µg/100g FW) (Fyfe et al., 2018a) and although the result is not as high in the present study (118 µg/100g FW) it still is higher than many other fruit and shows green plum is an excellent dietary source of folate. The data confirms that the 5-CH_3-H_4folate is the main folate vitamer found in the green plum and that the fruit also contains the folate vitamers H_4folate and 5-CHO-H_4folate in lower amounts. The folate content is high enough that green plum could be classed as a promising tropical fruit high in folate as it contains a higher amount than mango (55.8-74.5 µg/100g FW), guava (91.0 µg/100g FW), papaya (61.6-90.7 µg/100g FW) and jack fruit (52.9-83.6 µg/100g FW) (Striegel et al., 2019) which all are classed as having high levels of folate. However, the level is still within the natural range and is lower than the amount in passionfruit (136-271 µg/100g FW) (Striegel et al., 2019) and in durian fruit (175-440 µg/100g FW) (Striegel et al., 2018a).

The red bush apple is a good source of dietary fibre and a good dietary source of sodium, calcium, manganese and copper (Table 2). As a fresh fruit it is not as good a source of nutrients as either the green plum or the wild peach, possibly because it has a higher moisture content and lower solids content (12.2%).

The wild peach is also a good source of dietary fibre and a good source of calcium. This fruit is particularly high in vitamin C and a good dietary source of it. The Australian native food nutrition tables lists a level of 1995 mg/100g FW (Brand Miller et al., 1993), which is slightly lower but consistent with the level of 2040 mg/100g FW in this study. The total vitamin C in the wild peach is very high for a fruit. The wild peach is in the same genus as the Kakadu plum (*Terminalia ferdinandiana*) which has even higher reported levels of vitamin C of up to 22 490 ± 5290 mg/100 g DW (Konczak et al., 2014), which is double the level of the wild peach in this study of 11 237 ± 1052 mg/100g DW.

The sensory profiles for each of the three fruit in four sample presentations are listed in Tables 4–6, with each profile containing the descriptive vocabulary for the aroma, appearance, texture, flavour and aftertaste. For the presentations of the green plum (Table 4) between 55 and 113 descriptive words were used by panellists for each quality. For the red bush apple (Table 5) there were between 60 and 106, and for the wild peach (Table 6) there were between 60 and 105. Some of the reasons for the attributes used are evidenced by the nutrition results in Tables 1–3, e.g. the *sweet* flavour from the sugar that is present. Some attributes for the freeze-dried powders come from the product they are presented in, e.g. the flavour of *dairy confection* from yoghurt and the appearance of *semolina* from the semolina. Some puree attributes come from the process used to make the puree, such as *lumpy* or *bitsy* texture.

Table 1
Proximate results of green plums, red bush apple and wild peach from East Arnhem Land. Results are expressed in g/100g as mean ± standard deviation (n=3) Fresh Weight (FW) for moisture content and result ± measurement of uncertainty FW for all else. Dietary reference intakes are those for a 31-50 year old female.

Proximates (g/100g)	Green Plum	Red Bush Apple	Wild Peach	Dietary Reference Intake (NHMRC, 2017)
Protein	1.69 ± 0.17	0.46 ± 0.05	1.20 ± 0.12	37 g/day EAR
Fat	0.94 ± 0.14	0.16 ± 0.02	0.27 ± 0.04	90 mg/day AI
-Saturated fat	0.22 ± 0.03	0.05 ± 0.01	<0.2	
-Mono-unsaturated fat	0.43 ± 0.06	0.01 ± <0.01	<0.2	
-Poly-unsaturated fat	0.29 ± 0.04	0.08 ± 0.01	<0.2	
-Trans fat	<0.01	<0.01	<0.02	
Moisture	69.7 ± 0.9	87.8 ± 1.0	81.8 ± 1.3	
Ash	1.8 ± 0.2	0.7 ± 0.1		
Total sugar	6.9 ± 1.1	3.4 ± 0.5	6.0 ± 0.9	
Dietary fibre (total)	9.5 ± 1.4	6.5 ± 1.0	8.6 ± 1.3	25 g/day AI
Available carbohydrate	16.4	4.3		no reference value
Energy (kJ/100 g)	418	140	201	6.8 MJ/day EER

na = not analysed, AI = adequate intake, EAR = estimated average requirement, and EER = estimated energy requirement.

Table 2
Minerals, trace elements and metals of the nutritional profile of green plums, red bush apple and wild peach from East Arnhem Land. Results are expressed in mg/100 g as mean ± standard deviation (n=3) Fresh Weight (FW) except for the red bush apple minerals which are result ± measurement of uncertainty FW. Dietary reference intakes are those for a 31-50 year old female.

Nutrient (mg/100g FW)	Green Plum	Red Bush Apple	Wild Peach	Dietary Reference Intake (NHMRC, 2017)
Macro-minerals				
Sodium	7.8 ± 0.1	35.1 ± 3.5	9.5 ± 0.1	460-920 mg/day AI
Potassium	511 ± 22	173 ± 9	198 ± 5	2800 mg/day AI
Calcium	79 ± 2	101 ± 5	57.7 ± 0.5	840 mg/day EAR
Magnesium	84 ± 1	30 ± 2	27.6 ± 0.2	265 mg/day EAR
Phosphorous	19.0 ± 0.4	9.5 ± 0.5	9.5 ± 0.1	580 mg/day EAR
Trace elements				
Selenium	<0.01	na	<0.01	50 μg/day EAR
Zinc	0.19 ± 0.0	0.11 ± 0.01	0.24 ± 0.01	6.5 mg/day EAR
Iron	0.77 ± 0.25	0.28 ± 0.03	0.31 ± 0.03	8 mg/day EAR
Manganese	0.09 ± 0.0	1.13 ± 0.1	0.26 ± 0.01	5 mg/day AI
Copper	0.07 ± 0.0	0.60 ± 0.06	0.11 ± 0.0	1.2 mg/day
Nickel	0.01 ± 0.0	0.06 ± 0.003	0.02 ± 0.0	no reference value
Cobalt	0.01 ± 0.0	0.01 ± 0.001	0.01 ± 0.0	
Chromium	0.01 ± 0.0	0.07 ± 0.007	<0.01	25 μg/day AI
Vanadium	<0.01	na	<0.01	no reference value
Boron	0.33 ± 0.01	na	0.36 ± 0.02	no reference value
Molybdenum	<0.01	na	<0.01	34 μg/day EAR
Strontium	0.58 ± 0.01	na	0.57 ± 0.01	
Barium	0.04 ±0.0	na	0.04 ± 0.0	
Antimony	<0.01	na	<0.01	
Silver	<0.01	na	<0.01	
Aluminium	0.59 ± 0.21	na	0.25 ± 0.03	
Heavy metals				
Mercury	<0.005	na	<0.005	
Lead	0.02 ± 0.0	na	<0.01	
Cadmium	<0.005	na	<0.005	
Arsenic	<0.01	na	<0.01	no reference value

na = not analysed, AI = adequate intake, EAR = estimated average requirement,

Table 3
Vitamin C and folate content of green plums, red bush apple and wild peach from East Arnhem Land. Results are expressed as mean ± standard deviation (n=3) Fresh Weight (FW). Dietary reference intakes are those for a 31-50 year old female.

Nutrient	Green Plum	Red Bush Apple	Wild Peach	Dietary Reference Intake (NHMRC, 2017)
Vitamin C (mg/100g)				
L-AA	96 ± 1	1.6 ± 0.0	1711 ± 24	
DHAA	9.1 ± 0.0	3.4 ± 0.1	330 ± 168	
Total Vitamin C	105 ± 1.0	5.0 ± 0.1	2041 ± 192	30 mg/day EAR
Folate (μg/100g as FA)				
PteGlu	<LOD	<LOD	<LOD	
H_4folate	0.25 ± 0.25	<LOD	1.0 ± 0.2	
5-CH_3-H_4folate	109 ± 7	0.9 ± 0.1	7.9 ± 0.5	
5-CHO-H_4folate	8.5 ± 0.9	3.0 ± 0.1	6.8 ± 0.3	
10-CHO-PteGlu	<LOD	<LOD	<LOD	
Total Folate	118 ± 8	3.8 ± 0.3	15.7 ± 0.4	320 μg/day EAR

<LOD = less than the limit of detection, EAR = estimated average requirement

Table 4
Sensory profiles of green plum as whole fruit, as a puree and as an ingredient (freeze-dried powder) in semolina and yoghurt. Attribute order is from most frequent to least frequent for each quality.

Sample	Sensory description
Green plum whole 	*Aroma* is fruity, pickled, sweet note, stewed apple and citrus with notes of fresh herbaceous and olive. *Appearance* is olive or pea-like, with a green/yellow colour, soft looking, glossy, slightly mottled and small. *Texture* is soft and velvety, with slightly chewy skin, with some dissolving and juicy and with a hard pip. *Flavour* is tart and sweet with some bush scrub, fruity and stewed apple. *Aftertaste* is tart fruity, slightly drying and sweet and has a clean finish.
Green plum puree 	*Aroma* is fresh herbaceous, pickled, stewed apple, citrus and a sweet note with notes of olive, fruity, chemical and oily. *Appearance* is like mashed or smashed avocado and is glossy, a green/yellow colour and lumpy. *Texture* is bitsy, soft, slightly fibrous and velvety. *Flavour* is tart and of stewed apple with some fruity, spiced fragrant, sweet and herbaceous. *Aftertaste* is tart, fruity, drying with a clean finish and sweet.
Freeze-dried green plum in semolina 	*Aroma* is of stewed apple and citrus with a sweet note, pickled and olive oil notes and is mild. *Appearance* is a pale green colour and is mashed, lumpy and consistent. *Texture* is pasty, sticky, velvety and bitsy. *Flavour* is of stewed apple, tart and citrus and is mild, sweet and herbaceous. *Aftertaste* is tart and is mild with some drying, slight bitter and sweet.
Freeze-dried green plum in yoghurt 	*Aroma* is of stewed apple, citrus, a sweet note, dairy confection and a fruity note. *Appearance* is bitsy and is a pale green colour and glossy. *Texture* is bitsy and velvety with some dissolving and slight drying. *Flavour* is stewed apple and sweet with some citrus, fruity, dairy confection and herbaceous. *Aftertaste* is drying, sweet, tart, stewed apple, dairy confection, fruity and is mild.

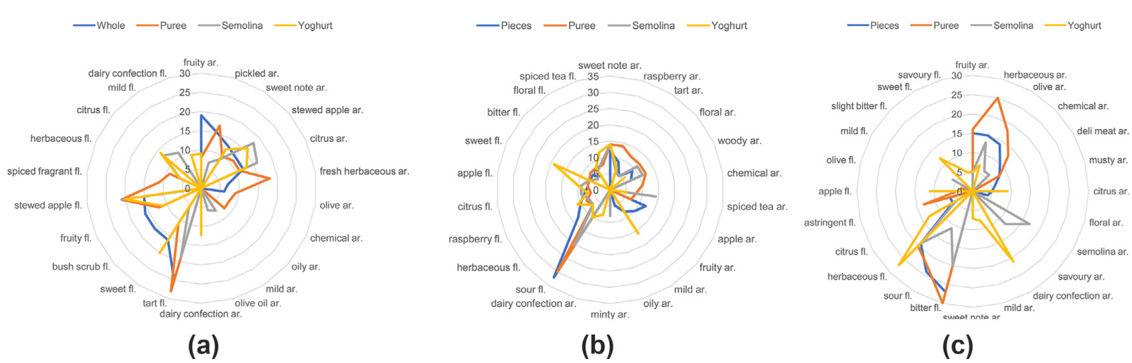


Fig. 2. Cobweb plots of the number of responses of each aroma (ar.) and flavour (fl.) attribute of (a) the green plum, (b) the red bush apple and (c) the wild peach as a comparison of the panellists attribute responses across each sample presentation for each fruit.

The descriptions in Tables 4–6 show the attributes in order of frequency used for that quality, with the order arranged from most to least frequent. Further information about the aroma and flavour attributes of each fruit and a comparison of the number of responses from each presentation is depicted in the cobweb plots in Fig. 2.

The cobweb plot in Fig. 2 shows for the green plum the aroma attributes of *sweet note, stewed apple* and *citrus* are evident in all presentations and these score in the flavour of the green plum as *sweet, stewed apple, tart* and *citrus*. The *velvety* texture of the green plum is evident in the whole fruit, the puree and in the yoghurt. The *tart, sweet* and *drying* aftertaste attributes were described in all samples and the *clean finish* was described in the whole fruit and the puree.

The green plums are well liked by the Aboriginal communities (Fox et al., 2018; Head, 2002) and are said to be an important food and one of the most popular (Levitt, 1981). The fruit has been described in bush food literature as being very sweet (Fox et al., 2018) and as sour but pleasant (Hiddins, 2003). Anecdotal feedback from the sensory panel was very positive, and many of them said they especially liked it

Table 5
Sensory profiles of red bush apple as pieces of fruit, as a puree and as an ingredient (freeze-dried powder) in semolina and yoghurt. Attribute order is from most frequent to least frequent for each quality.

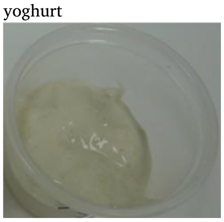
Sample	Sensory description
Red bush apple pieces 	*Aroma* has a sweet note and is of apple, fruity, floral and raspberry with notes of woody, tart and oily and is mild. *Appearance* is of dark pink-red skin with creamy white flesh, similar to a red apple and it is juicy. *Texture* is initially juicy then subsequently dry and fibrous, chewy and tough with slight crunch and firmness. *Flavour* is sour, herbaceous and raspberry with notes of citrus, apple, sweet, bitter and floral. *Aftertaste* is sour and mild with clean, drying, herbaceous and bitter notes.
Red bush apple puree 	*Aroma* has a sweet note and is of raspberry, tart, floral and woody with notes of chemical spiced tea and apple. *Appearance* is dark pink colour and it looks bitsy and mashed, similar to sorbet, and appears moist and dry. *Texture* is initially juicy then subsequently dry and is fibrous, hard to clear, chewy and bitsy. *Flavour* is sour with notes of floral, spiced tea, raspberry, bitter, apple, sweet, herbaceous and citrus. *Aftertaste* is sour, drying, hard to clear, clean and herbaceous.
Freeze-dried red bush apple in semolina 	*Aroma* has a sweet note and is of spiced tea, floral and woody with notes of minty, raspberry and tart. *Appearance* is a pale pink colour and it looks mashed and dense. *Texture* is pasty, sticky, bitsy, smooth and drying. *Flavour* is sour, citrus, apple, spiced tea, raspberry, floral, herbaceous, sweet and has a bitter note. *Aftertaste* is drying sour, mild, sweet, hard to clear and clean.
Freeze-dried red bush apple in yoghurt 	*Aroma* is mild with a sweet note and notes of dairy confection, raspberry, floral and apple. *Appearance* is a slight pink colour with separated liquid on top and it is glossy and bitsy. *Texture* is bitsy, powder and smooth. *Flavour* is sweet and of spiced tea, raspberry, apple and sour with notes of floral, citrus and herbaceous. *Aftertaste* is sweet and drying with some bitsy and notes of sour and raspberry.

in the yoghurt. The green plum could be a popular fruit with both the Aboriginal communities who already eat it and with the wider community in Australia.

In the aroma of the red bush apple presentations the attributes *sweet note, raspberry* and *floral* were described in all presentations. *Apple* was in all except for semolina and *woody* and *tart* were described in all except for yoghurt. For the appearance of the red bush apple, the *dark pink-red skin* and the *creamy white flesh* combine in the puree to become a *dark pink colour* and as a freeze-dried ingredient it gives a *pale pink colour* to the semolina and a *slight pink colour* in the yoghurt. The texture of the pieces and puree are both *initially juicy* and then they become *subsequently dry* and *fibrous*. The red bush apple moisture content is very high at 87.8% which gives the *initially juicy* and the fibre content is 6.5 g/100g (Table 1). A future study of the red bush apple to understand how the structure of the flesh relates to this interesting and very unusual texture profile could be of interest. The texture could well relate to the *drying* that was described in the aftertaste of all the presentations. The *initially juicy* could also be related to the *separated liquid* that was seen on the top of the yoghurt samples. It would be of interest to understand if there is something in the red bush apple that causes the juice to separate from the fibre and the yoghurt. Some panellists suggested that the red bush apple could be used as a juice and it could be that the juice can easily be separated from the fibre to be used for its flavour attributes. Panellists also commented how much they liked the red bush apple in the yoghurt.

Fig. 2 shows the flavour *sour* scored higher in the red bush apple than all other attributes in the pieces, puree and semolina and is also used as an attribute in the yoghurt. Red bush apples have previously been described in bush food literature as being fairly sharp (Fox et al., 2018) and as having a crisp texture and a slightly acidic taste (Hiddins, 2003). As an ingredient in yoghurt and semolina the *sour* did not score as high as when the product was in pieces or as a puree. All of the presentations had flavours of *raspberry, citrus, apple, sweet, floral* and *herbaceous*, with varying scores in the different presentations. *Spiced tea* was described in the puree, semolina and yoghurt and low scores of *bitter* were noted in all except the yoghurt. The riberry, *Syzygium leuhmanii* is in the same genus as the red bush apple, is also native to Australia and has previously been described as having a flavour of '*tart* and *astringent* with some *sweetness*'. Its aroma also includes *sweet spiced tea* which is described as spices, cloves, cardamom, cinnamon and chai tea (Smyth et al., 2012). The Davidson plum has been described as a flavour of *intensely tart* and *astringent* (Smyth et al., 2012) and is now commercialised as a bush food and is available in a number of gourmet products including ice-cream. The red bush apple could possibly be used commercially in similar types of products as what the riberry and Davidson plum are already used and sold in.

Table 6
Sensory profiles of wild peach as pieces of fruit, as a puree and as an ingredient (freeze-dried powder) in semolina and yoghurt. Attribute order is from most frequent to least frequent for each quality.

Sample	Sensory description
Wild peach pieces 	*Aroma* is fruity, herbaceous, olive and chemical with notes of deli meat, musty, citrus and floral. *Appearance* is dry, it is an olive green colour and has leathery skin and soft flesh and the skin is furry and mottled. *Texture* is chewy with tough skin and is slimy, dry, rubbery, hard to break down, has soft flesh and is furry. *Flavour* is bitter, sour and herbaceous with notes of citrus and astringent. *Aftertaste* is bitter with some astringent, sour, drying, herbaceous and slimy mouthcoat.
Wild peach puree 	*Aroma* is herbaceous, olive, fruity and chemical with notes of citrus and deli meat. *Appearance* is like mashed avocado and is fibrous, olive green colour, dry and bitsy. *Texture* is dry, slimy, bitsy, fibrous, thick, chewy and hard to clear. *Flavour* is bitter, sour, herbaceous and astringent with notes of apple and olive. *Aftertaste* is bitter, astringent and herbaceous with a slimy mouthcoat and drying.
Freeze-dried wild peach in semolina 	*Aroma* is like semolina and is herbaceous and savoury with notes of olive, chemical, citrus and fruity. *Appearance* is a pale green/grey colour and is bitsy, mashed, dry and looks like semolina. *Texture* is thick, sticky, drying, slimy and bitsy. *Flavour* is bitter, herbaceous and sour, and is mild with notes of citrus and apple. *Aftertaste* is sour, drying, bitter, hard to clear, astringent, herbaceous and has a slimy mouthcoat.
Freeze-dried wild peach in yoghurt 	*Aroma* is of dairy confection with some citrus and is mild with a sweet note and notes of herbaceous and fruity. *Appearance* is bitsy, is a pale green/grey colour and it looks glossy and thick. *Texture* is bitsy and is thick, fibrous and sticky. *Flavour* is herbaceous, citrus, slight bitter and apple with notes of sweet and savoury. *Aftertaste* is herbaceous, bitter, astringent, drying, throat catching, sour and a slimy mouthcoat.

The overwhelming attribute of the wild peach was that it was *bitter* in flavour and aftertaste. It scored high in *sour* in its flavour although this attribute scored lower in the semolina and yoghurt. The panellists described the texture as both *dry* and *slimy* which appear to be contradictory to each other but may come from separate parts of the peach such as the skin and the flesh. The taxonomically related Kakadu plum, which has very high vitamin C content, is also native to Australia and has been commercialised as an Indigenous agribusiness (Gorman et al., 2020). The flavour of the Kakadu plum is *tart* and *bitter* with a strong *stewed fruit* flavour intensity as an unadulterated fruit puree (Smyth et al., 2012). Comparatively, the wild peach puree flavour is *bitter, sour, herbaceous* and *astringent* with notes of *apple* and *olive*, which is similar to the Kakadu plum in its *sour* and *bitter* attributes. The high vitamin C levels enable the Kakadu plum to be used as a natural food preservative in the food industry in Australia including as a preservative dip for prawns (Sultanbawa, 2016). It is also used as food supplements, in skin products and as an ingredient in gourmet bush foods (Konczak et al., 2014). The wild peach is also a good source of vitamin C, however, the overwhelming *bitter* taste may be a hindrance to its use in food products. Further studies of the antimicrobial and antioxidant properties of the wild peach should be done to determine if it could also be used as a natural preservative, and subsequent sensory analysis at the levels required for these properties would be warranted to determine if the *bitter* flavour is still detectable. The wild peach is said to have been gathered from under the tree, on the ground, and tastes like a partially ripe peach (Fox et al., 2018; Levitt, 1981). It has previously been described as sour but becomes agreeable after eating a few (Hiddins, 2003). It is possible that the ones used in this analysis were under-ripe as they were harvested from the tree, not from the ground under it.

These three fruit fit the description that FAO use to describe neglected and underutilised species as ‘future smart foods’ (Li et al., 2018). The interesting and unique sensory profiles, the high levels of key nutrients and their abundant growth in East Arnhem Land suggests that these foods could be used as ‘future smart foods’, and the green plum and red bush apple as future flavours. We designate them as future flavours because they are not yet commercialised, yet they have the potential to be commercialised as sustainable agribusinesses and to be a desired food ingredient.

4. Conclusions

The results show that the green plum is a particularly good source of folate (118 ± 8 μg/100g FW as folic acid equivalents), and wild peach is a valuable source of vitamin C (2041 ± 192 mg/100g FW). All three fruit are good sources of dietary fibre (green plum 9.5 ± 1.4, red bush apple 6.5 ± 1.0 and wild peach 8.6 ± 1.3 g/100g FW), with 100 g of each fruit making a significant contribution to the adequate intake of fibre. The green plum is a very good source of potassium (511 ± 22 mg/100g FW) and is also a good source of calcium (79 ± 2 mg/100g FW), magnesium (84 ± 1 mg/100g FW), phosphorous

(19.0 ± 0.4 mg/100g FW) and iron (0.77 ± 0.25 mg/100g FW). The red bush apple is a good source of sodium (35.1 ± 3.5 mg/100g FW), calcium (101 ± 5 mg/100g FW), manganese (1.13 ± 0.1 mg/100g FW) and copper (0.60 ± 0.06 mg/100g FW), and the wild peach is a good source of calcium (57.7 ± 0.5 mg/100g FW). The green plum and red bush apple both have interesting and unique sensory descriptions and elicited many positive responses from the panellists, especially in the yoghurt presentations. The green plums flavour is *sweet, tart* and *stewed apple* and the red bush apples is *sour, raspberry, citrus, apple, sweet, floral, herbaceous* and *spiced tea*. The sensory results show the flavours of green plum and red bush apple could be used in novel food products, as they are natural, unique and well liked. These three fruit all show different and unique nutritional and sensory profiles which show they have potential for commercialisation in a sustainable Indigenous agribusiness, which could give employment opportunities to remote Aboriginal communities through food industry uptake and use in novel future food products.

Funding source

This project is funded by an Australian Government Research Training Program scholarship and the University of Queensland and The Australian Research Council Transformational Training Centre for Uniquely Australian Foods Grant number IC180100045. The funding sources had no involvement in the study design, collection, analysis and interpretation of data, in writing the report or in the decision to submit the article for publication.

Declaration of interest

None.

CRediT authorship contribution statement

Selina Fyfe: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Data curation, Writing – original draft, Writing – review & editing, Visualization, Funding acquisition. **Horst Joachim Schirra:** Conceptualization, Supervision, Writing – review & editing. **Michael Rychlik:** Conceptualization, Funding acquisition, Methodology, Supervision, Writing – review & editing. **Annemarie van Doorn:** Conceptualization, Resources, Writing – review & editing. **Ujang Tinngi:** Formal analysis, Investigation, Methodology, Resources, Validation, Writing – review & editing. **Yasmina Sultanbawa:** Conceptualization, Data curation, Funding acquisition, Methodology, Project administration, Resources, Supervision, Validation, Writing – review & editing. **Heather E Smyth:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Methodology, Project administration, Resources, Supervision, Validation, Visualization, Writing – review & editing.

Acknowledgments

The authors acknowledge the Yolŋu people who are the Traditional Owners of the lands on which these fruit grow and respect the knowledge and experience the Traditional Owners hold regarding the care, harvest and use of these plants.

References

Akter, S., Netzel, M., Tinggi, U., Fletcher, M., Osborne, S., & Sultanbawa, Y. (2020). Interactions between phytochemicals and minerals in *Terminalia ferdinandiana* and implications for mineral bioavailability. 7(287). 10.3389/fnut.2020.598219

Brand, J.C., Cherikoff, V., 1985. The nutritional composition of Australian Aboriginal food plants of the desert regions. In: Wickens, G.E., Goodin, J.R., Field, D.V. (Eds.), Plants for Arid Lands: Proceedings of the Kew International Conference on Economic Plants for Arid Lands held in the Jodrell Laboratory, Royal Botanic Gardens, Kew, England, 23–27 July 1984. Springer, DordrechtNetherlands, pp. 53–68.

Brand, J.C., Mcdonnell, J., Lee, A., Cherikoff, V., Truswell, A., Rae, C., 1983. The nutritional composition of Australian Aboriginal bushfoods. Food Technol. Austr..

Brand Miller, J., James, K.W., Maggiore, P.M.A., 1993. Tables of composition of Australian Aboriginal foods. Aboriginal Studies Press, Canberra, Australia.

Burarrwana, L., Ganambarr, R., Ganambarr-Stubbs, M., Ganambarr, B., Maymuru, D., Wright, S., Suchet-Pearson, S., Lloyd, K., 2019. Song Spirals. Allen & Unwin, Australia.

Campos, F. M., Ribeiro, S. M. R., Della Lucia, Pinheiro-Sant'ana, H. M., Stringheta, P. C. J. Q. N., 2009. Optimization of methodology to analyze ascorbic and dehydroascorbic acid in vegetables. Química Nova 32 (1), 87–91.

Carter, J., Tinggi, U., Yang, X., Fry, B., 2015. Stable isotope and trace metal compositions of Australian prawns as a guide to authenticity and wholesomeness. Food Chem. 170, 241–248. doi:10.1016/j.foodchem.2014.08.037.

Donaldson, B.R., Bamforth, C.W., Heymann, H., 2012. Sensory descriptive analysis and free-choice profiling of thirteen hop varieties as whole cones and after dry hopping of beer. J. Am. Soc. Brew. Chem. 70 (3), 176–181. doi:10.1094/ASBCJ-2012-0710-01.

Flinders, M., 1814. A voyage to Terra Australis, Volume 2. G and W Nicol, London, England.

Fox, G., Garde, M., 2018. An-me Arri-ngun: The food we eat. Gundjeihmi Aboriginal Corporation, Australia.

Fyfe, S., Netzel, M.E., Tinggi, U., Biehl, E.M., Sultanbawa, Y., 2018a. *Buchanania obovata*: an Australian Indigenous food for diet diversification. Nutrit. Dietetics 75 (5), 527–532. doi:10.1111/1747-0080.12437.

Fyfe, S., Smyth, H.E., Schirra, H.J., Rychlik, M., Sultanbawa, Y., 2020. The nutritional potential of the Native Australian Green Plum (*Buchanania obovata)* compared to other Anacardiaceae fruit and nuts. Front. Nutrit. 7 (311). doi:10.3389/fnut.2020.600215.

Fyfe, S., Sultanbawa, Y., Smyth, H.E., 2018b. Sensory vocabulary for five native Australian plant foods and five native Australian leaf tea's. Paper presented at the 12th Australia and New Zealand Sensory and Consumer Science Symposium, Brisbane, Australia.

Gorman, J.T., Wurm, P.A., Vemuri, S., Brady, C., Sultanbawa, Y., 2020. Kakadu Plum (*Terminalia ferdinandiana*) as a sustainable Indigenous agribusiness. Econ. Bot. 74 (1), 74–91. https://link.springer.com/article/10.1007/s12231-019-09479-8.

Guàrdia, M.D., Aguiar, A.P.S., Claret, A., Arnau, J., Guerrero, L., 2010. Sensory characterization of dry-cured ham using free-choice profiling. Food Qual. Preference 21 (1), 148–155. doi:10.1016/j.foodqual.2009.08.014.

Head, L., 2002. Country and garden: ethnobotany, archaeobotany and Aboriginal landscapes near the Keep River, northwestern Australia. J. Soc. Archaeol. 2 (2), 173–196.

Hiddins, L., 2003. Explore wild Australia with the bush tucker man, New ed. Explore Australia, South Yarra, Victoria, Australia.

Horwitz, W., Chichilo, P., Reynolds, H., 1970. Official Methods of Analysis of the Association of Official Analytical Chemists. Association of Official Analytical Chemists, Rockvale, MA.

Hungerford, N.L., Tinggi, U., Tan, B.L.L., Farrell, M., Fletcher, M.T., 2020. Mineral and trace element analysis of Australian/Queensland *Apis mellifera* Honey. Int. J. Environ. Res. Public Health 17 (17), 6304. doi:10.3390/ijerph17176304.

Hunter, P.H., 2018. Free Choice Profiling. In: Kemp, S.E., Hort, J., Hollowood, T. (Eds.), Descriptive Analysis in Sensory Evaluation. John Wiley & Sons, Chichester, UK.

Jaenicke, H., Thiong'o, M.K., 1999. Preliminary nutritional analysis of marula (*Sclerocarya birrea*) fruits from two Kenyan provenances. Paper presented at the II ISHS Conference on Fruit Production in the Tropics and Subtropics 531.

Kemp, S.E., Ng, M., Hollowood, T., Hort, J, 2018. Introduction to Descriptive Analysis. In: Kemp, S.E., Hort, J., Hollowood, T. (Eds.), Descriptive Analysis in Sensory Evaluation. John Wiley & Sons, Chichester, UK.

Kitzberger, C., Scholz, M., Da Silva, J., Benassi, M., Pereira, L., 2016. Free choice profiling sensory analysis to discriminate coffees. AIMS Agricult. Food 1, 455–469.

Kizil, S., Turk, M., 2010. Microelement contents and fatty acid compositions of *Rhus coriaria* L. and *Pistacia terebinthus* L. fruits spread commonly in the south eastern Anatolia region of Turkey. Nat. Prod. Res. 24 (1), 92–98. doi:10.1080/14786410903132555.

Konczak, I., Maillot, F., Dalar, A., 2014. Phytochemical divergence in 45 accessions of *Terminalia ferdinandiana* (Kakadu plum). Food Chem. 151, 248–256. https://www.sciencedirect.com/science/article/pii/S030881461301683X?via%3Dihub.

Kozioł, M.J., Macía, M., 1998. Chemical composition, nutritional evaluation, and economic prospects of *Spondias purpurea* (Anacardiaceae). J. Econ. Botany 52 (4), 373–380. doi:10.1007/BF02862067.

Lawless, H.T., Heymann, H., 1998. Sensory evaluation of food: principles and practices. Chapman & Hall/International Thomson Pub, New York.

Lawless, H.T., Heymann, H., 2010. Descriptive Analysis *Sensory Evaluation of Food: Principles and Practices*. Springer New York, New York, NY, pp. 227–257.

Levitt, D., 1981. Plants and people: Aboriginal uses of plants on Groote Eylandt. Australian Institute of Aboriginal Studies, Canberra.

Li, X., Siddique, K.H.M., 2018. Future Smart Food - Rediscovering hidden treasures of neglected and underitilized species for Zero Hunger in Asia. Food and Agriculture Organization of the United Nations, Bangkok.

Medley, P., Bollhöfer, A., 2016. Influence of group II metals on Radium-226 concentration ratios in the native green plum (*Buchanania obovata*) from the Alligator Rivers Region, Northern Territory, Australia. J. Environ. Radioact. 151 (Part 3), 551–557. doi:10.1016/j.jenvrad.2015.07.013.

Meilgaard, M., Civille, G.V., Carr, B.T., 2016. Sensory evaluation techniques, Fifth edition. CRC Press, Taylor & Francis Group, CRC Press is an imprint of the Taylor & Francis Group, an Informa business, Boca Raton.

Miettinen, S.-M., Hyvönen, L., Linforth, R.S.T., Taylor, A.J., Tuorila, H., 2004. Temporal aroma delivery from milk systems containing 0–5% added fat, observed by free choice profiling, time intensity, and atmospheric pressure chemical ionization–mass spectrometry techniques. J. Agric. Food Chem. 52 (26), 8111–8118. doi:10.1021/jf040218v.

Narain, C., Paterson, A., Reid, E., 2004. Free choice and conventional profiling of commercial black filter coffees to explore consumer perceptions of character. Food Qual. Preference 15 (1), 31–41. doi:10.1016/S0950-3293(03)00020-X.

National Health and Medical Research Council, 2017. Nutrient Reference Values for Australia and New Zealand Retrieved 22nd Feb, 2021.

Olarte Mantilla, S.M., Shewan, H.M., Shingleton, R., Stokes, J.R., Smyth, H.E., 2020. Ability to detect and identify the presence of particles influences consumer acceptance of yoghurt. Food Qual. Preference 85, 103979. doi:10.1016/j.foodqual.2020.103979.

Saint-Eve, A., Paçi Kora, E., Martin, N., 2004. Impact of the olfactory quality and chemical complexity of the flavouring agent on the texture of low fat stirred yogurts assessed by three different sensory methodologies. Food Qual. Preference 15 (7), 655–668. doi:10.1016/j.foodqual.2003.09.002.

Smyth, H., Sanderson, J., Sultanbawa, Y., 2012. Lexicon for the sensory description of Australian native plant foods and ingredients. J. Sens. Stud. 27 (6), 471–481. doi:10.1111/joss.12012.

Spínola, V., Mendes, B., Câmara, J.S., Castilho, P.C., 2012. An improved and fast UHPLC-PDA methodology for determination of L-ascorbic and dehydroascorbic acids in fruits and vegetables. Evaluation of degradation rate during storage. Anal. Bioanal.Chem. 403 (4), 1049–1058. doi:10.1007/s00216-011-5668-x.

Striegel, L., Chebib, S., Dumler, C., Lu, Y., Huang, D., Rychlik, M., 2018a. Durian fruits discovered as superior folate sources. Front. Nutrit. 5, 114. doi:10.3389/fnut.2018.00114.

Striegel, L., Chebib, S., Netzel, M.E., Rychlik, M., 2018b. Improved stable isotope dilution assay for dietary folates using LC-MS/MS and its application to strawberries. Front. Chem. 6, 11. doi:10.3389/fchem.2018.00011.

Striegel, L., Weber, N., Dumler, C., Chebib, S., Netzel, M.E., Sultanbawa, Y., Rychlik, M., 2019. Promising Tropical Fruits High in Folates. Foods 8 (9), 363. doi:10.3390/foods8090363.

Sultanbawa, Y, 2016. Food Preservation and the Antimicrobial Activity of Australian Native Plants. In: Sultanbawa, Y., Sultanbawa, F. (Eds.), Australian Native Plants: Cultivation and Uses in the Health and Food Industries. CRC Press, Taylor & Francis Group, Boca Raton, FL, pp. 251–263.

The Plant List, 2013. Version 1.1. Retrieved 24th February, 2021. from http://www.theplantlist.org/ .

Thomson, D.F., 1949a. Arnhem Land: explorations among an unknown people Part III. On foot across Arnhem Land. Geographl. J. 114 (1/3), 53–67.

Thomson, D.F., 1949b. Arnhem Land: explorations among an unknown people. Part II. The people of Blue Mud Bay. Geograph. J. 113, 1–8.

Tiburski, J.H., Rosenthal, A., Deliza, R., De Oliveira Godoy, R.L., Pacheco, S., 2011. Nutritional properties of yellow mombin (*Spondias mombin* L.) pulp. Food Res. Int. 44 (7), 2326–2331. doi:10.1016/j.foodres.2011.03.037.

U.S. Department of Agriculture: Agricultural Research Service, 2019. April 2018. FoodData Central. Retrieved 17th June 2020. from https://fdc.nal.usda.gov/index.html .

Vit, P., Pedro, S.R.M., Vergara, C., Deliza, R., 2017. Ecuadorian honey types described by Kichwa community in Rio Chico, Pastaza province, Ecuador using Free-Choice Profiling. Revista Brasileira de Farmacognosia 27 (3), 384–387. doi:10.1016/j.bjp.2017.01.005.

Yunupingu, B., Yunupingu-Marika, L., Marika, D., Marika, B., Marika, B., Marika, R., Wightman, G., 1995. Rirratjingu ethnobotany: Aboriginal plant use from Yirrkala, Arnhem Land, Australia. Conservation Commission of the Northern Territory, Darwin, Australia.