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The Botany and Proximate Analyses  
of some edible species of the  
New Zealand Flora

A thesis  
presented in partial fulfilment  
of the requirement for the degree of

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at Massey University

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## Abstract

1. The edible organs of some New Zealand plant species have been assessed at light microscope level for their botanical basis, and for their nutritional basis by proximate analysis and Plasma Emission Spectrometry.
2. The species investigated, listed by Colenso (1880) as the most valued plant foods of the pre-European Maori, were:  
*Pteridium esculentum* (rhizome), *Corynocarpus laevigatus* (kernel), *Elaeocarpus dentatus*, (pericarp), *Sonchus asper* (herb), *Calystegia sepium* (rhizome), *Cyathea medullaris* (frond stipe), *Cordyline australis* (leaf bases, root), *Rhopalostylis sapida* (apical shoot), *Typha orientalis* (pollen and rhizome), *Beilschmiedia tawa* (kernel), *Marattia salicina* (rhizomal scale), *Porphyra columbina* (frond), *Auricularia polytricha* (basidiocarp), *Arthropodium cirratum* (rhizome), *Bolboschoenus fluviatilis* (rhizomal tuber), *Gastrodia cunninghamii* (rhizome) and *Asplenium bulbiferum* (immature frond).
3. Specimens were collected at the appropriate traditional seasons (except for *Gastrodia cunninghamii*) and samples prepared by freeze-drying and milling. Samples were also prepared of the cooked organs of *Corynocarpus laevigatus*, *Elaeocarpus dentatus*, *Sonchus asper*, *Cyathea medullaris*, *Beilschmiedia tawa* and *Porphyra columbina*.
4. Analytical determinations were made for lipid, by extraction with di-ethyl ether; nitrogen, by micro-Kjeldahl method and colorimetric measurement of ammonia using indophenol; protein, by Bradford procedure using Coomassie Brilliant Blue and colorimetry; dietary fibre, by Englyst procedure using enzymatic digestion and colorimetry; soluble sugar, by acid hydrolysis and colorimetry; and starch, by enzymatic digestion and colorimetry.
5. Botanical investigations were made following histological procedures and microtechnique using paraffin wax embedding and staining with safranin and fast green; and by differential staining of hand-cut sections using Sudan Blue, iodine and Coomassie Brilliant Blue.

6. Analytical determinations were made for 23 trace, minor and major constituent elements, using inductively-coupled argon plasmas in a simultaneous emission spectrometer.
7. Proximate analyses showed high levels of lipid in *Corynocarpus laevigatus*, *Cyathea medullaris*, and *Sonchus asper*; of protein in *Corynocarpus laevigatus*, *Sonchus asper*, *Rhopalostylis sapida*, *Typha orientalis* (pollen) and *Asplenium bulbiferum*; of dietary fibre in *Auricularia polytricha*, *Beilschmiedia tawa*, *Marattia salicina* (root) and *Porphyra columbina* (uncooked); of soluble sugar in *Cyathea medullaris*, *Cordyline australis* (leaf bases and root), *Typha orientalis* (rhizomes and pollen) and *Pteridium esculentum*; and of starch in *Corynocarpus laevigatus*, *Elaeocarpus dentatus*, *Marattia salicina*, *Calystegia sepium* and *Gastrodia cunninghamii*.
8. High levels of essential minerals and trace elements were measured in many samples, and some excess levels of toxic metals were recorded.
9. The nutritional and ethnobotanical aspects of a pre-European Maori diet were related to the analytical and botanical findings of the investigation.

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### Abbreviations

DMSO	di-methyl-sulphoxide
DNS	di-nitrosalicylate
FAA	formalin-acetic-acid
NSP	non-starch polysaccharides
PES	Plasma Emission Spectrometry
rcf	relative centrifugal force
TBA	tertiary butyl alcohol

## Introduction

A group of 18 New Zealand indigenous food plants has been researched for this thesis, these plants having been listed and described by William Colenso, FLS, in his paper, "On the Vegetable Food of the Ancient New Zealanders before Cook's Visit" (1880). Parts I and II of this paper deal with plants formerly cultivated; it is from Part III, subtitled "Of the Wild or Uncultivated Food-producing Plants of the Ancient New Zealander" that this list of plants has been drawn, and this has provided the framework of the research.

The 18 plant organs, and in some cases groups of plants, were taken by Colenso "as they (the pre-European Maori) valued them and used them" (1880:20). For each, he described the pertinent botanical characteristics and distribution, the seasonal collection times and traditional methods of collection, the use made of the particular edible organ and traditional methods of treatment for food preparation.

References to these plants by Colenso and other early writers of the 18th and 19th centuries contain many comments acclaiming their "highly nutritious" value, or "wholesomeness" as foods, but there has been scant analytical data to verify these claims. Conversely, it has often been assumed that diets of indigenous people have been nutritionally inadequate. The New Zealand Maoris are no exception to this group and indeed, to quote the Maori anthropologist, Makereti Papakura, writing in the 1920s, "Much nonsense has been written about the starving Maori" (Makereti 1938:157).

This thesis seeks to examine the value of this group of uncultivated plants in the New Zealand flora in the pre-European Maori diet, by analysing the edible plant organs for their nutrient components and further by examining them at the light microscope level to gain knowledge of their structural and analytical basis. Some species have additionally been tested after cooking, bringing the total number of samples to 26. The proximate analyses carried out have been conventionally performed for plant food data, namely for the determination of moisture, lipids, nitrogen, proteins, dietary fibre, sugars and starch. The standard analysis for ash determination, having less relevance in this investigation, has been omitted. Samples were also analyzed by Plasma Emission Spectrometry (PES) for the determination of 23 elements.

These 18 food plants belong to diverse groups of the plant kingdom, and include fungi, algae, pteridophytes and angiosperms; of the latter there are trees, shrubs and herbs. There is also a variety in the type of plant organ utilized for food, and this includes roots, rhizomes, tubers, stem pith, leaves and shoots, pollen and fruits, of the latter both flesh and kernels.

This group certainly by no means exhausts the wild plant foods of the early Maori. There were many other uncultivated species in New Zealand's flora that formed some part of the early New Zealanders' diet, and these included the many seasonal fruits of the forest flora (Colenso 1880).

#### **Plant species under investigation.**

The following plants are those named and numbered by Colenso in order of his assessment of their value to the Maori:

1. *Pteris esculenta*, fern-root, *aruhe*, *roi*, *marohi*
2. *Corynocarpus laevigata*, *karaka*
3. *Elaeocarpus dentatus*, *hinau*
4. *Sonchus oleraceus* var., common sow-thistle, *puwha*
5. *Convolvulus sepium*, common convolvulus, bindweed, *pohue*
6. *Cyathea medullaris*, black tree-fern, *korau*, *mamaku*
7. *Cordyline australis*, cabbage tree, *tii*, *kouka*, *whanake*
8. *Areca sapida*, southern palm-tree, *nikau*
9. *Typha augustifolia*, common bulrush, *raupo*
10. *Nesodaphne tawa*, *tawa*
11. *Marattia salicina*, *para*
12. *Laminaria* sp., *karengo*
13. Several fungi:
  - Lycoperdon fontanesei*, *pukurau*
  - L. giganteum*, *pukurau*
  - Agaricus adiposus*, *harore*
  - Hirneola auricula-judae*, *hakekakeka*
  - Ileodictyon cibarium*, *paruwhatitiri*
14. *Arthropodium cirratum*, New Zealand lily, *rengarenga*
15. *Typha augustifolia*, common bulrush, *raupo*

16. *Scirpus maritimus*, tall sedge, *riiriwaka*
17. *Gastrodia cunninghamii*, *perei*
18. Several smaller plants, as leafy vegetables:

*Solanum nigrum*, *raupeti*

*Barbara australis*, *toi*

*Taraxacum dens-leonis*, *tohetake*

*Asplenium bulbiferum*

*A. lucidum*

Some of the plants have since been renamed; presently classified, the plant list reads as follows:

1. *Pteridium esculentum* (Forst.f.) Kuhn; Dennstaedtiaceae
2. *Corynocarpus laevigatus* J.R. et G.Forst.; Corynocarpaceae
3. *Elaeocarpus dentatus* (J.R. et G.Forst.) Vahl; Elaeocarpaceae
4. *Sonchus asper* (L.) Hill; Asteraceae
5. *Calystegia sepium* (L.) R.Br.; Convolvulaceae
6. *Cyathea medullaris* (Forst.f.) Swartz; Cyatheaceae
7. *Cordyline australis* (Forst.f.) Endl.; Agavaceae
8. *Rhopalostylis sapida* Wendl. et Drude in Kerch.; Palmae
9. *Typha orientalis* C.B.Presl.; Typhaceae
10. *Beilschmiedia tawa* (A.Cunn.) Benth. et Hook.f. ex Kirk; Lauraceae
11. *Marattia salicina* Smith in Rees; Marattiaceae
12. *Porphyra columbina* Montagne; Bangiaceae
13. *Auricularia polytricha* Montagne (Saccardo); Auriculariaceae
14. *Arthropodium cirratum* (Forst.f.) R.Br.; Liliaceae
15. *Typha orientalis* C.B.Presl.; Typhaceae
16. *Bolboschoenus fluviatilis* (Torrey) Soják; Cyperaceae
17. *Gastrodia cunninghamii* Hook.f.; Orchidaceae
18. *Asplenium bulbiferum* Forst.f.; Aspleniaceae

Further taxonomic discussion of numbers 1, 4 and 12 is presented in the respective sections of plant data. Of the groups of fungi and leafy vegetables listed previously under numbers 13 and 18 respectively, only one species from each has been chosen for investigation. The five cited species of fungi are presently classified as follows:



*Calvatia utriformis* (Bull. ex Pers.) Jaap; Lycoperdaceae

*C. gigantea* (Batsch ex Pers.) Lloyd; Lycoperdaceae

*Pholiota aurivella* (Batsch ex Fr.) Kummer; Cortinariaceae

*Auricularia polytricha* (Montagne) Saccardo; Auriculariaceae

*Clathrus cibarius* Micheli ex Pers.; Clathraceae

Of these, *Auricularia polytricha* has been collected and used for analysis; this choice has been based on the relative abundance and ease of identification of the species. The five cited species of smaller plants are presently classified as follows:

*Solanum nigrum* L.; Solanaceae

*Barbarea australis* J.D.Hook.; Brassicaceae

*Taraxacum megellanicum* Comm.ex Sch.Bip.; Asteraceae

*Asplenium bulbiferum* Forst.f.; Aspleniaceae

*A. lucidum* Forst.f.; Aspleniaceae

Colenso gives no botanical information on these species. The plant named as *Barbara australis* (*sic*), or *toi*, may have been *Barbarea intermedia*, as the only (other) record of *B. australis* from New Zealand (Hooker 1852) is based on a specimen of *B. intermedia* (Webb *et al.* 1988). *Taraxacum dens-leonis* may refer to the indigenous *T. megellanicum* or possibly the introduced *T. officinale*; both are known now by the same Maori name, *tohetake*, which Colenso used for *T. dens-leonis*. *Asplenium bulbiferum* has been chosen from this group for use in this investigation; this choice has been based on the ease of identification of the species and a lack of ambiguity regarding its classification.

The accuracy of Colenso's records, both botanical and historical, has been viewed and assessed by comparison with records of other early writers. These include the early discoverers Cook (Beaglehole [Ed] 1955) and Banks (Beaglehole [Ed] 1962); explorers and botanists Dieffenbach (1842), Wakefield (1845), Angas (1847), Hooker (1852), Bauke (1928) and Best (1942); and some of the many missionaries, Yate (1835), Wade (1842), Taylor (1855) and Stack (Reed [Ed] 1935).

In his study of the New Zealand flora, Colenso was in regular contact with other botanists of his day. Notable amongst these were Cunningham and Hooker. Allan Cunningham, as colonial botanist of Sydney, visited Colenso in the Bay of Islands and was influential in encouraging the amateur botanist to further his study of plants (Bagnall and Petersen 1948). Dr Joseph Hooker, as assistant surgeon and naturalist to the

"Erebus", also visited Colenso while making botanical investigations in that area. Both professional botanists partook of field trips with Colenso who was considered by Hooker to be the foremost New Zealand botanical explorer of the time (Hooker 1852).

Colenso had come to New Zealand in 1834 and between then and his death in 1899 recorded his findings in detail and sent numerous specimens to Kew for identification, confirmation and herbarium preservation.

During this 65 years in New Zealand Colenso became intimately acquainted with the Maori, and made detailed recordings of their knowledge and use of plant species. In this respect the validity of his contribution to the ethnobotanical literature is held in high esteem (Best 1942; Bagnall and Petersen 1948).

The use of the term "Maori" in the text refers only to the New Zealand Maori regardless of their individual or collective origins in the Pacific and should not be confused for example with indigenous peoples of the Cook Islands.