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Investigations into the Nutritional and Sensory Potential of Taewa (Māori Potatoes)

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

DOCTOR OF PHILOSOPHY

Nutritional Science

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Dedication

Ki taku whānau toa: Taku Whaiāipo, me aku Tamariki.

He mihi NUNUI to my whaiapo Jasen Wharemate, my LONG-suffering, patient, supportive eternal companion. You complete me honey.

Biiiiiiig hugs to my three children Szharei (14), Asjanae (8) and Jaran (6) who have sacrificed time with me, prayed so I might finish quickly, comforted me when exhausted and put up with my absence, lack of energy and shortened patience while getting this research done. 😊😊😊.

To you my awesome whānau, I dedicate this work.

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I think that's it. I hope I haven't missed anyone.

KA MAU TE WEHI!!!

Abstract

The term Taewa refers to a collection of at least 18 different potato cultivars belonging to the *Solanum tuberosum* family, which have been cultivated by the Māori peoples of New Zealand for at least 200 years.

Due in part to its economic importance worldwide, the chemical and nutritional composition of today's mainstream potato varieties, and the mechanisms by which composition impacts on their culinary and gastronomic properties, have been extensively researched. However few investigators have studied the nutritional, sensory or potential health properties of Taewa, or which Taewa varieties may be the most preferred for eating. Previous Taewa nutritional research has concentrated on anthocyanin, phenolic or flavonoid content and antioxidant potential, glycoalkaloid content and starch characteristics. The variation in culinary quality and different tuber pigmentation of Taewa suggest that the composition, nutritional and sensory properties of Taewa are diverse and are therefore worthy of investigation.

The first goal of the PhD focused on identifying nutritionally beneficial or commercially viable properties of Māori potatoes. This was carried out by quantifying the macronutrient, selected micronutrient, phenolic and glycoalkaloid components and assessing antioxidant activity (using ORAC and FRAP analysis) of four Taewa varieties (Huakaroro, Karuparera, Moemoe, Tūtaekuri) and comparing them against Nadine, a potato variety commonly available in New Zealand. Analysis was carried out on tuber flesh, tuber skin and whole tuber components over two consecutive harvests. In addition, the effects of 6 months storage at 4°C in 80-90% humidity and par-boiling on the nutrient content were also explored.

The second goal of this research was to ascertain the most popular, commonly eaten and commonly grown Taewa varieties; preferred Taewa cooking and eating practices; the availability of Taewa cultivars across New Zealand and to collate information regarding marketable traits or factors that might affect Taewa consumption. In order to achieve this, group discussions were held with 25 adult participants between 18 to 75 years of age from the Manawatu region. Four key themes emerged from these discussions and were used to develop 20 questions for a larger scale survey from a wider cross-section of Taewa consumers.

The third goal of the research aimed to assess two characteristics of nutritional or health value (increased resistant starch in potato boiled then cooled at 4°C for 24 h) and antioxidant capacity (by measuring the total phenolic content, DPPH and FRAP potential) in four common Taewa varieties (Huakaroro, Karuparera, Moemoe, Tūtaekuri) using a popular Taewa cooking practice (boiling whole with the skin on) to develop a Taewa product with improved health benefits. Consumer acceptance was then measured by assessing the sensory ratings of 56 adult volunteer subjects.

Results of the nutrient analysis consistently showed all four Taewa had promising nutritional value with regards to a greater nutrient content, greater accumulation of resistant starch, greater total phenolic content and antioxidant capacity compared to Nadine. The nutrients in Taewa likely to be of most biologically significant nutritional value in comparison to Nadine and other more common NZ potato cultivars included the soluble and insoluble fibre content, the minerals potassium, magnesium and iron and the vitamins thiamine, pyridoxine and niacin. All four Taewa (particularly Tūtaekuri) also showed excellent potential with regards to accumulating resistant starch and exhibiting antioxidant potential compared to Nadine.

Commonly eaten Taewa varieties included Tūtaekuri, Pawhero, Peruperu, Moemoe, Karuparera and Huakaroro. These Taewa varieties were also grown and eaten by residents in a greater number of regions across New Zealand than other Taewa varieties. Cooking and eating preferences included boiling them whole, unpeeled and cooked on their own; eating them hot or warm, with the skin on and seasoned with butter, salt and pepper. If destined to be pre-cooked or served cold, it was suggested that Taewa varieties should be waxy so as to hold together better, be purple or buttery-yellow to add interest with regards to visual appeal, be an appropriate size for the intended dish and have a sweet, nutty, buttery or delicate taste.

New Zealanders should be encouraged to both eat and grow Taewa due to their value as a popular inexpensive food of high nutritional quality, their promise as a means through which to develop functional food products with added health benefits and their cultural significance to all New Zealanders as a unique heritage food. Government agencies, those involved in the Potato Industry, research institutions and funding agencies should be encouraged to work with Māori growers, to ensure the increased production and nationwide availability of Taewa and support the development of Taewa-based functional and snack food products in way that will be beneficial to all.

List of Abbreviations

AA	Amino Acid
AO	Antioxidant Activity
ACYN	Anthocyanin
AI	Adequate Intake
Ala	Alanine
AMG	Amyloglucosidase
ANOVA	Analysis of Variance
AOAC	Association of Official Analytical Chemists International
Arapy	Arabinose pyranoside
Araf	Arabinose furanoside
Arg	Arginine
Asp	Aspartic Acid
AusNZ EAR	Australian and New Zealand Estimated Average Requirement
AusNZ RDI / AI	Australian and New Zealand Recommended Dietary Intake / Adequate Intake
BOIL	Boiled potatoes
°C	Degrees Celcius
C	Carbon
c16:0	Palmitic Acid
c18:0	Stearic Acid
c18:2n6	Linoleic Acid
c18:3n3	Alpha Linolenic Acid
C24:0	Lignoceric acid
Ca	Calcium
Cl	Chlorine
CS	Chemical score
Cu	Copper
Cy3g E	Cyanidin-3-glucoside equivalent
Cy-gal	Cyanidin-3-galactoside
Cy-glu	cyanidin-3-glucoside
Cys	Cysteine
DF	Dilution Factor

df	Degrees of Freedom
DPPH	2, 2-Diphenyl-1-picrylhydrazyl
ΔE	Absorbance (reaction) read against the reagent blank
EAA	Essential Amino Acid
EB	Eaten Before
Fe	Iron
FW	Fresh weight
FWB	Fresh weight basis
FRAP	Ferric Reducing Antioxidant Power
g	Gram
GAE	Gallic Acid Equivalent
Gal	Galactoside
Glu	Glutamic Acid
Gly	Glycine
GM	Genetically Modified
GOPOD reagent	Glucose oxidase/peroxidase reagent
h	Hour
His	Histidine
K	Potassium
KOH	Potassium Hydroxide
kg	Kilogram
ICP-OES	Inductively Coupled Plasma – Optical Emission Spectrometry
IDF	Insoluble dietary fibre
Ile	Isoleucine
Kj	Kilojoule
L	Litre
LCMS	Liquid chromatography-mass spectrometry
Leu	Leucine
Lys	Lysine
M	Molar
min	Minute
Met	Methionine
Mg	Magnesium
mg	Milligram
ml	Millilitre
Malv-glu	Malvidin-3-glucoside

mm	Millimetre
mM	Millimolar
Mn	Manganese
MUFA	Monounsaturated Fatty Acids
N	Nitrogen
NaCl	Sodium Chloride
ND	Not Detected
NEB	Never Eaten Before
NM	Nano Meters
NRF	Nutrient Rich Foods Index
NZANS	New Zealand Adult Nutrition Survey (2008-2009)
ORAC	Oxygen Radical Absorption Capacity
P	Phosphorus
Phe	Phenylalanine
PKT group	Potato, Kumara, Taro group
Pro	Proline
PUFA	Polyunsaturated Fatty Acids
Q	Quercetin
RAW	Raw Potatoes Samples
REML	Residual Maximum Likelihood Technique
Rha	Rhamnoside
RH18	Boiled, 24 hour Cooled, Reheated to 18 degrees Celsius Potatoes
RH55	Boiled, 24 hour Cooled, Reheated to 55 degrees Celsius Potatoes
RPM	Revolutions Per Minute
RS	Resistant Starch
RSC	Resistant Starch Content
RDS	Rapidly Digestible Starch
Rut	Rutinoside
SCFA	Short Chain Fatty Acids
SD	Soluble Dietary Fibre
SDS	Slowly Digestible Starch
Se	Selenium
Ser	Serine
SEM	Standard Error of the Mean
SFA	Saturated Fatty Acid
S	Sulphur

TAC	Total Anthocyanin Content
TE	Trolox Equivalents
TFA	Total Fatty Acids
Thr	Threonine
TMAH	Trimethylammonium hydroxide
TMS	Trimethylsilyl Sugars
TPC	Total Phenolic Content
TPTZ	2,4,6-tripyridyl-s-triazine
Trp	Tryptophan
Trolox	6-hydroxy-2,5,7,8-tetramethyl-chroman-2-carboxylic acid
Tyr	Tyrosine
µg	Microgram
µl	Microlitre
Unk	Unknown
UEB	Unsure if Eaten Before
Val	Valine
Vse	Volume of Solvent Extract
V/V	Volume to Volume
W	Weight
Xyl	Xyloside
Zn	Zinc

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