Impact of a ‘vegetables first’ approach to complementary feeding on later intake and liking of vegetables in infants: a randomised controlled trial

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

Doctor of Philosophy

In

Nutritional Science

at Massey University, Albany,

New Zealand.

Jeanette Rapson

2021

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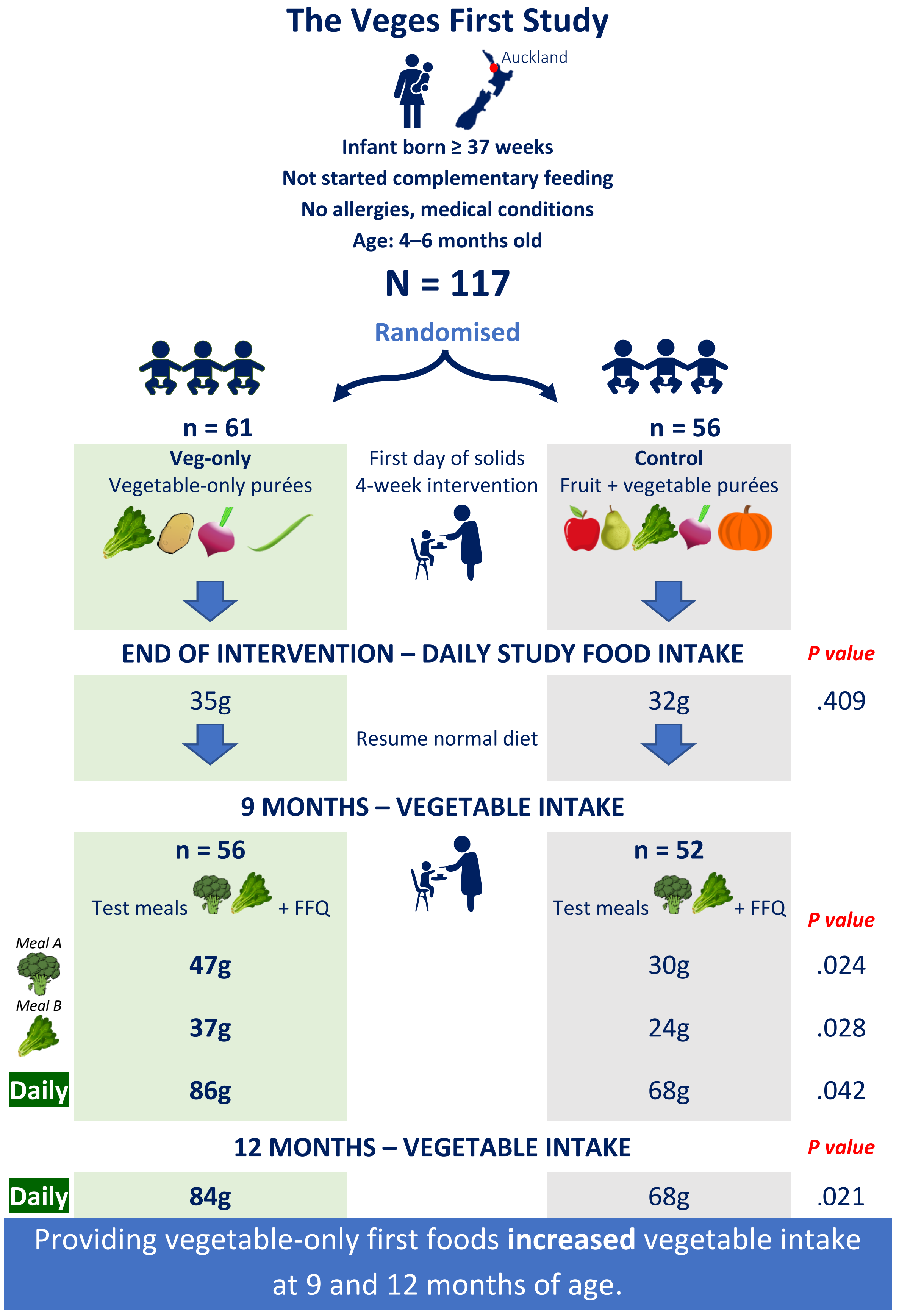
Declaration

I declare that no part of this thesis has been submitted for a degree at Massey University or any other tertiary institution. This thesis describes original research conducted by the candidate, Jeanette Patricia Rapson under the supervision of primary supervisor Associate Professor Cathryn Conlon and co-supervisor Professor Pamela von Hurst.

Abstract



Graphical abstract of key outcomes of the Veges First Study; precedes full-text abstract. FFQ = food frequency questionnaire.

Background: Most children worldwide do not meet vegetable intake recommendations, which has implications for health, including an increased risk of obesity and chronic diseases later in life. A 'vegetables first' approach to complementary feeding has emerged as a promising strategy to promote vegetable consumption in children. This approach prioritises vegetables as first foods, capitalising on young infants' willingness to try new foods and establish food preferences that comprise healthy eating. While some authorities have started to encourage the introduction of vegetables first, more longitudinal randomised, controlled studies are needed to strengthen the evidence-base. In addition, there is a concern that a focus on vegetables as first foods may negatively impact infant iron status, which needs to be addressed.

Aims and objectives: The overall aim of this study was to determine whether exposure to vegetables-only during the first four weeks of complementary feeding increases later vegetable intake and liking, compared to a control group which includes both fruit and vegetables. The primary objective was to examine whether providing vegetable-only first foods results in higher intake of vegetables at 9 months of age, compared to a control. Secondary objectives were to examine infants' acceptance of vegetable-only first foods, to assess whether intervention effects are maintained at 12 months of age, and to describe the iron status of infants who had participated in the trial.

Methods/Design: In this longitudinal randomised, controlled, parallel-group study, 117 Auckland mother-infant dyads, received either vegetables-only (veg-only, n = 61) or a combination of fruit and vegetables (control, n = 56) for a duration of four weeks, starting from the first day of complementary feeding at around 4–6 months of age. At 9 months of age all infants were offered target vegetables at home: broccoli (day 1), spinach (day 2) and pear (day 3). At 12 months of age, mothers completed infant feeding questionnaires only. The primary outcome measure was intake (grams) of vegetables at 9 months of age. Additional food acceptance variables were mother-rated liking (5-point Likert scale), frequency of positive/negative behaviours (%), rate of eating (grams/min), rate of acceptance (video coding) and daily intake/preferences of fruit and vegetables (food frequency/liking questionnaires). Infants' iron status (n = 75) was assessed at baseline, post-intervention and 9 months of age via capillary blood samples. Independent t-tests and Mann-Whitney tests were performed for the primary analysis. Demographic data was collected at baseline via an online questionnaire, and written consent obtained from all participants.

Results: Of those who completed the 4-week intervention, 108 (92 %) provided intake data needed for the primary analysis at 9 months of age (veg-only, n = 56; controls, n = 52). Most (> 90 %) mothers had a university qualification or higher and were European ethnicity with adequate access to food. Intake of the target vegetables at 9 months was significantly higher among veg-only infants than controls: median (25th, 75th percentile) for broccoli was 47.0 (27.0, 72.0) vs 30.0 (16.0, 62.0) grams, P = 0.024, respectively; spinach was 37.0 (19.0, 55.0) vs 24.0 (12.0, 41.0) grams, P = 0.028, respectively. Daily vegetable intake was also significantly higher: veg-only group, 86.3

(52.5, 146.3) grams vs controls 67.5 (37.5, 101.3) grams, $P = 0.042$. Veg-only infants consumed the target vegetables at a faster rate (broccoli, $P < 0.001$; spinach, $P = 0.004$) and showed greater acceptance than controls (all target vegetables $P = 0.018$). Fruit intake (target and daily) was similar, as were all other acceptance variables. At 12 months of age ($n = 107$), these effects were maintained as daily vegetable intake was 20 % higher in the veg-only group, than controls ($P = 0.021$); daily fruit intake and liking of vegetables and fruit remained similar.

With respect to secondary outcomes, intake, rate of eating and liking of the study foods during the 4-week intervention were similar between groups and increased significantly between week one and four (all $P < 0.001$). Frequency of negative behaviours in response to study foods in both groups significantly decreased over time (both $P < 0.001$) while positive behaviours did not change (veg-only $P = 0.07$; control $P = 0.147$). In terms of iron status, most were iron sufficient at baseline (93 %) and at 9 months of age (92 %).

Conclusion: Providing vegetables as first foods increased vegetable intake at 9 months of age, and may be an effective strategy for improving child vegetable consumption and developing a preference for vegetables in infancy. Meanwhile, vegetable-only first foods were well-accepted and iron status maintained, which may be of encouragement to parents. However, given limited generalisability, more research investigating ways to support families in feeding vegetables as first foods at a population level is warranted.

Thank you

I would first like to thank my supervisors, Associate Professor Cath Conlon and Professor Pam von Hurst, whose expertise, guidance and support have made my PhD enjoyable. Thank you for believing in me, including me in the study design, and allowing me the freedom to make the research my own. This opportunity has made me grow as a researcher and a person, and I'm excited to take these experiences into the next phase of my career.

I would also like to thank experts in this field, Professor Marion Hetherington, Dr Sophie Nicklaus and Dr Kameron Moding, with whom I have been privileged to collaborate and meet. Your valuable input and advice were pivotal to the quality of our research.

My deepest gratitude goes to the mothers and families who wholeheartedly participated in this study and made this research possible. Thank you for your commitment and for everything you taught me. Thank you for sharing your baby's first taste experiences with me and allowing me to be a part of this special milestone – your happy, growing babies always brightened my day!

Many thanks to the wider team, including Kimberley Brown, Lesley Savage, Owen Mugridge and PC Tong who have helped with recruitment, data collection and clinic visits. Thank you to the Riddet Institute for supporting this research and valuable professional development opportunities. I'd like to acknowledge Citrus Consulting Group for generously providing secure data storage to house all the feeding videos. A special thanks to Maureen Conlon for sewing and embroidering personalised baby bags for our participants, which truly added that extra touch to the study.

Thank you to my colleagues and friends who have made the PhD journey less lonely. Emily Jones, I've enjoyed all the laughs, the early morning walks, learning from your expertise in infant feeding and simply having someone to be real with. Lesley Savage – I could not have managed all the follow-ups without you! Hajar Mazahery, thank you for your patience and the time you put toward helping me with statistical analysis, and for pushing me to explore the data further. You have all offered a sympathetic ear and have been of great encouragement.

Finally, I am so grateful to my family (Mum, Dad, Gran, Gareth, Vicki, Willow, and my cats Sandy and Minx). I could not have completed this dissertation without you cheering me on. Thank you for being the voice of encouragement, providing happy memories, instilling a sense of determination and for simply being proud of me. I love you so much!

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Abbreviations

CF	Complementary feeding
AAP	American Academy of Pediatrics
AGA	Appropriate for gestational age
AIHW	Australian Institute of Family Studies
BEBQ	Baby Eating Behaviour Questionnaire
BLISS	Baby-Led Introduction to Solids Study
BLW	Baby-led weaning
BM	Breast milk
CEBQ	Child Eating Behaviour Questionnaire
CHD	Coronary heart disease
CI	Confidence interval
CRP	C-reactive protein
CVD	Cardiovascular disease
EAR	Estimated Average Requirement
EBF	Exclusive breastfeeding
EFSA	European Food Safety Authority
ESPGHAN	European Society for Paediatric Gastroenterology, Hepatology and Nutrition
FANTA	Food and Nutrition Technical Assistance
FAO	Food and Agriculture Organization
FCQ	Feeding Choices Questionnaire
FFQ	Food Frequency Questionnaire
FIBFECS	The Feeding Infants: Behaviour and Facial Expression Coding System
FITS	Feeding Infants and Toddlers Study
FNQ	Food Neophobia Questionnaire

FSANZ	Food Standards Australia New Zealand
GI	Gastrointestinal
GUiNZ	Growing Up in New Zealand
Hb	Haemoglobin
HHS	United State Department of Health and Human Services
HNRU	Human Nutrition Research Unit
ID	Iron deficiency
IDA	Iron deficiency anaemia
IF	Infant formula
INSIGHT	Intervention Nurses Start Infants Growing on Healthy Trajectories
IOM	Institute of Medicine
NHMRC	National Health and Medical Research Council
NHS	National Health Service
NZ	New Zealand
Orange-fleshed sweet potato	OFSP
OTIS	Optimized complementary feeding study
PAHO	Pan American Health Organization
RCT	Randomised controlled trial
RDI	Dietary Reference Intakes
RNI	Reference Nutrient Intake
SACN	Scientific Advisory Committee on Nutrition
SD	Standard deviation
SF	Serum ferritin
SGA	Small for gestational age
STAI	Stait-trait Anxiety Inventory
sTfR	soluble transferrin receptor

TSF	Traditional spoon-feeding
UK	United Kingdom
UNICEF	United Nations Children's Fund
US	United States
USDA	United States Department of Agriculture
WHO	World Health Organization

List of papers and conference presentations

The following publications were written during the PhD candidature. Publications that are directly related to this thesis research have been presented first and as individual chapters within this thesis as indicated (see **Appendix T** for contribution forms). Other publications are then listed, followed by oral/poster presentations.

Peer-review publications

Paper I *In Chapter 3*	**Rapson, J. P.**, von Hurst, P. R., Hetherington, M. M., Conlon, C. A. Impact of a 'vegetables first' approach to complementary feeding on later intake and liking of vegetables in infants: A study protocol for a randomised controlled trial. *Trials, 22*(1), Article 488. https://doi.org/10.1186/s13063-021-05374-7

Publications under review or to be submitted

Paper II *In Chapter 4*	**Rapson, J. P.**, Conlon, C. A., Hetherington, M. M., von Hurst, P. R. Vegetable acceptance and liking at the start of complementary feeding: a randomized controlled trial.
Paper III *In Chapter 5*	**Rapson, J. P.**, von Hurst, P. R., Hetherington, M. M., Conlon, C. A. Starting complementary feeding with vegetables only increases vegetable acceptance at nine months: a randomized controlled trial.
Paper IV *In Chapter 6*	**Rapson, J. P.**, von Hurst, P. R., Hetherington, M. M., Conlon, C. A. Higher vegetable consumption maintained at 12 months of age when infants start complementary feeding with vegetables-only: follow-up of a randomised controlled trial. (not submitted)
Paper V *In Chapter 7*	**Rapson, J. P.**, Conlon, C. A., Mazahery, H., von Hurst, P. R. Iron status of infants participating in a 'vegetables first' complementary feeding intervention.

Additional peer-reviewed publications completed during the candidature

Rapson, J., Conlon, C., Ali, A. (2021). Early Childhood Education Teachers' Nutrition Knowledge For 2-5-Year-Old Children in Childcare: A Narrative Review. *Journal of Food Nutrition and Health, 2*(1), 1-11.

Rapson, J., Conlon, C., Beck, K., von Hurst, P., & Ali, A. (2020). The development of a psychometrically valid and reliable questionnaire to assess nutrition knowledge related to pre-schoolers. *Nutrients*, *12*(7), 1964-1974.

Rapson, J., Conlon, C., & Ali, A. (2020). Nutrition knowledge and perspectives of physical activity for pre-schoolers amongst early childhood education and care teachers. *Nutrients*, *12*(7), 1984-2001.

Brown, K., von Hurst, P., **Rapson, J.**, & Conlon, C. (2020). Dietary choices of New Zealand women during pregnancy and lactation. *Nutrients*, *12*(9), 2692-2707.

Oral presentations

Rapson, J. P., von Hurst, P. R., Conlon, C. A. (2019). Vegetables as first foods for babies: a randomised controlled trial. Presented at the Massey University Early Life Nutrition Symposium, August 2019, Auckland, New Zealand.

Rapson, J. P., von Hurst, P. R., Conlon, C. A. (2019). Vegetables as first foods for babies: a randomised controlled trial – an update. Presented at the Postgraduate and Early Career Nutrition Conference, November 2019, Auckland, New Zealand.

Rapson, J., Conlon, C., Beck, K., von Hurst, P., & Ali, A. (2019). The development of a psychometrically valid and reliable questionnaire to assess the nutrition knowledge of early childhood education teachers. *Multidisciplinary Digital Publishing Institute Proceedings*, *37*(1), 5. Presented at the Nutrition Society Annual Scientific Conference, November 2019, Napier, New Zealand. Recipient of Nutrition Society Travel Award.

Rapson, J., Conlon, C., & Ali, A. (2019). Nutrition and physical activity for pre-schoolers: knowledge and perspectives amongst early childhood education teachers. *Multidisciplinary Digital Publishing Institute Proceedings*, *8*(1), 32. Presented at the Nutrition Society Annual Scientific Conference, November 2018, Auckland, New Zealand.

Rapson, J. P., von Hurst, P. R., Conlon, C. A. (2018). Vegetables as first foods for babies: a randomised controlled trial protocol. Presented at the Postgraduate and Early Career Nutrition Conference, November 2018, Auckland, New Zealand.

Poster presentation

Rapson, J. P., von Hurst, P. R., & Conlon, C. A. (2021). Vegetable acceptance and liking at the start of complementary feeding: a randomized controlled trial. Presented at the Riddet Institute Student Colloquium, March 2020, Wellington, New Zealand (See **Appendix R** for poster).

Researchers' contributions

Contribution by the PhD Candidate (Jeanette Rapson) and Other Researchers

Stage	Task	Contribution
Candidate contributions		
Trial preparation	Study design	- Co-designed trial based on the literature and in collaboration with supervisors
	Ethics application	- Completed the ethics application through the Massey University Human Ethics Committee; submitted amendments (i.e., addition of researchers) as required throughout the study period
	Trial registration	- Registered the trial with the Australian New Zealand Clinical Trials Registry (ANZCTR); updated this annually
	Funding application	- Completed the application for post-graduate research funding; assisted with Lotteries funding grant application
	Infant food product development	- Created eight vegetable/fruit recipes; completed product development and testing in consultation with supervisors, Abby Thompson (Food HQ) and FreshAs°
	Participant forms	- Developed the information sheet and consent form
	Questionnaires	- Developed all study questionnaires online using Qualtrics software
	Liking tool	- Adapted and developed the in-home validated tool to assess infant liking tool, in consultation with the authors
	Weighed food diary	- Created all food diaries using visually appealing and easy to follow instructions

Stage	Task	Contribution
	Infant feeding resources/materials	- Created and developed all infant feeding resources with expert and target audience feedback: 3 x fridge magnets, 6 x videos and a food safety booklet - Completed ordering of materials, including printing/binding booklets, kitchen scales, baby bags/blankets, petrol vouchers, mobile phone tripods, website domain, infant foods, magnets
	Phlebotomy training	- Completed practical IV Cannulation and Phlebotomy Course at the University of Auckland School of Medicine
	Standard operating procedures and protocols (SOPs)	- Developed SOPs for data collection: anthropometry, blood collection, clinic visits, questionnaire administration, participant education, video upload and coding
	Video data storage	- Liaised with Citrus Consulting Group who kindly sponsored highly secured video storage space
Recruitment	Trial website	- Created and developed trial website www.vegesfirststudy.co.nz
	Advertising material	- Created and developed all advertising materials, including posters, flyers, trial banner/logo, social media posts
	Targeted emails	- Composed recruitment emails for relevant organisations (e.g., playcentres, Space groups, fitness classes)
	Site visits	- Completed visits with the help of a research assistant to mother groups (e.g., community centres, early childcare centres, libraries)
	Press release	- Reviewed press release to promote recruitment with the Massey University communications advisor, which was published on the Massey University website and then picked up the NZ Herald
	Oh Baby! Magazine	- Composed paid targeted advert for Oh Baby! magazine Facebook page

Stage	Task	Contribution
	Radio	- Interviewed on national radio (NewsTalk ZB) to promote participation in the study
	Conferences	- Completed oral presentations at the Early Life Nutrition Symposium and Post-graduate and Early Career Nutrition Society conference to promote recruitment to health professionals working with families - Completed poster presentation at the Riddet Student Colloquium 2021
	Facebook – targeted advertising	- Joined and completed a series of posts in over 100 mother and community Facebook groups in Auckland
Administration	Point of contact	- Was the main contact for all participants, food product development and those interested in the study
	Clinic and home visits	- Scheduled all the appointments for clinic and home visits via email, text or phone call
	Infant feeding packs	- Arranged all bags to be named with infant name; packed or checked all infant feeding bags prior distribution
	GP referral letters	- Composed GP referral letters for primary caregivers when blood results were not normal
	Website	- Updated website with study progress, including the completion of recruitment and expected availability of results
	Volunteer supervisor	- Trained and directed volunteers to complete some administration work (i.e., sticking labels on food packets, packing baby bags)
	Participant documentation	- Kept all participant information up to date in a secure Massey shared drive; added consultation notes (e.g., job, hobbies) after each visit to maintain rapport

Stage	Task	Contribution
Video coding	Training and supervision	- Developed SOP for video coding with peer-review from Dr Kameron Moding - Trained and supervised an independent researcher to code videos
Confirmation	Documentation	- Prepared all documentation for confirmation August 2019, including a confirmation report and oral presentation - Was present for the duration of the examination to answer any questions
Veges First RCT	First visits	- Conducted all first visits at the Massey University Research Unit (clinic) (n = 152) - Administered participant education on infant feeding and study protocol - Completed anthropometric measurements: height, weight, head circumference - Assisted phlebotomist Owen Mugridge with heel prick blood collection
	Follow-up visits	- Conducted all follow-up visits (unless unwell) at the clinic or home - Completed all follow-up anthropometry: post 4-week intervention, 9 months and 12 months - Administered infant feeding advice post 4-week intervention and instructions for 9-month experiment - Assisted phlebotomist with heel prick blood collection: post 4-week intervention and 9 months
	Participant support	- On call for participant queries throughout the study period; referred to GP or dietetic clinic as necessary - Composed weekly check-in emails during the 4-week intervention; then once at 9 months and 12 months - Composed birthday e-cards and holiday greeting cards to keep participants engaged

Stage	Task	Contribution
		- Developed a newsletter reporting on all study outcomes for primary caregivers, as required by ethics application
Data management	Qualtrics™	- Created all questionnaires using survey and data management software Qualtrics - Exported data as Microsoft Excel spreadsheets to secure Massey shared drive
	Citrus Consulting Group	- Videos stored on One Drive large storage space provided and protected by a specialised data management company Citrus Consulting Group
	Data cleaning and transformation	- Identified incorrect, duplicate or incomplete data within the dataset; and removed as necessary. Formatted, organised and/or combined multiple data sets into single excel spreadsheets for SPSS analysis. Coded data as required and kept a record of rules, definitions and assumptions
Data Analysis	SPSS	- Analysed all data using SPSS, and exported to Microsoft Office applications
Publications	Manuscripts	- Drafted all manuscripts and submitted to co-authors for peer-review, before submitting to peer-review journals
Collaboration	Foster international research relationships	- Contacted research experts in the field (Professor Marion Hetherington, Dr Sophie Nicklaus and Dr Kameron Moding) for advice on study design and tool development - Set up access to videos (with ethics approval) to collaborating researchers for prospective studies

Stage	Task	Contribution
Covid-19 management	Protocol adjustment	- Reviewed protocol and identified items that could not be completed due to Covid-19 restrictions (i.e., blood sampling, anthropometric measures). Reported these to the research team and made a collective decision on protocol changes
	Participant communication	- Drafted e-mail communication to participants providing protocol updates, next steps, reassurance and support; these letters were reviewed by supervisors; acted as first point of call for participant queries - Conducted additional Zoom or phone call support as required - Composed email instructions for completion of anthropometry by participants at home when unable to complete visit - Arranged contactless pick-up/drop-off of study materials and food diaries

Other researchers' contributions	
Associate Professor Cath Conlon Primary supervisor	Conceptualisation and design of trial, mentorship, connecting PhD candidate with key collaborators and volunteers, contributing/reviewing funding and ethics applications, reviewing thesis and all manuscripts
Professor Pamela von Hurst Secondary supervisor	Conceptualisation and design of trial, acquisition of funding and ethics approval, mentorship, budget and research contract management, reviewing thesis and all manuscripts
Professor Marion Hetherington Contributing author	Reviewed and contributed to manuscripts presented in chapter 3, 4 and 5
Dr Hajar Mazahery Contributing author	Reviewed and contributed to manuscript presented in chapter 7, and supported statistical analysis
Owen Mugridge HNRU trial manager	Conducted phlebotomy, prepared and stored blood samples, managed randomisation

PC Tong Laboratory technician	Provided laboratory/administrative assistance, ensured health and safety on research premises
Emily Jones Speech language therapist	Assisted with recipe testing and reviewed appropriateness of texture of infant foods used on the study
Lesley Savage Research assistant	Assisted with administrative work, clinic visits, follow-ups and coded the 9-month infant feeding videos
Kimberley Brown	Assisted with initial stages of participant recruitment and design of demographic questionnaire
Acknowledgements:	
Dr Kameron Moding	Provided advice on the video-coding tool
Dr Sophie Nicklaus	Provided advice on the infant liking tool
Alissa Hickley (mother) and Ryan Hickley (infant)	Provided footage for the videos and photographs used for infant feeding resources
Massey University	Awarded the PhD candidate with the Massey University Vice Chancellor's Excellence Scholarship
The Riddet Institute	Paid for doctoral programme fees for the PhD candidate; provided opportunities to attend student workshops, conferences and extend research networks

Chapter 1. Introduction

This chapter provides an introduction and justification for this thesis, followed by the aims and objectives, hypothesis, thesis structure and researchers' contribution.

Permission to use the images introducing each chapter was provided by the photographed subject. Icons and images used throughout this thesis were sourced online and free for use, with any necessary attributions included in Appendix S.

1.1. Introduction and justification

Most children around the world are not eating enough vegetables (Barends et al., 2019; Ministry of Health, 2020). This means that they may be missing out on important nutrients for growth, development and health, including the prevention of obesity and obesity-related illness later in life (Boeing et al., 2012; Wallace et al., 2020).

Less than half (45.6%) New Zealand children are eating enough vegetables

No improvements over the last 2 years

New Zealand Health Survey 2019/20.

Enjoyment of food is a key predictor of fruit and vegetable intake, and vegetables are often disliked by children (Bell et al., 2021; Chambers, 2016). Innate preferences for sweet flavours drive an inclination towards the consumption of sweet foods, e.g., breast milk, and an avoidance of bitter-tasting foods, e.g., green leafy vegetables. This predisposition is thought to have adaptive value as sweetness indicates the presence of sugar, a safe source of energy, whereas bitterness may signal harmful toxins (Mennella & Bobowski, 2015). Fortunately, new preferences for vegetables can be learned through experience and if established early may track into adulthood, highlighting the importance of promoting vegetables at the earliest opportunity (Chambers, 2016).

The start of complementary feeding is the first moment in life when children begin to eat vegetables. At this time, infants are particularly willing to try all new foods including vegetables, and food preferences are easy to shape (Harris & Mason, 2017). Recently, a 'vegetables first' approach to complementary feeding has capitalised on this sensitive period for taste with promising results, which have piqued research and media interest (Chambers et al., 2016; Slawson, 2015). The feeding practice prioritises the introduction of vegetables during the early weeks of complementary feeding, with the hypothesis that early vegetable exposure will help infants establish a lifelong preference for vegetables (Barends et al., 2019; Bell et al., 2021; Chambers, 2016; Chambers et al., 2016).

Of the few studies that have investigated a vegetables first approach to complementary feeding, all were robust in study design, namely randomised controlled trials (RCTs), and findings comparable given similar outcome measures (e.g., vegetable intake and liking) (Barends et al., 2013; Barends et al., 2014; Fildes et al., 2015; Hetherington et al., 2015). Moreover, all provided consistent evidence to show that starting complementary feeding with vegetables facilitates vegetable acceptance, at least in the short term. As a result, consensus has been reached in the UK to start translating the science to practical messages for parents and caregivers (Chambers et al., 2016), such as introducing single vegetables that are not too sweet as first foods (National Health Service [NHS], Fewtrell et al., 2017; 2019). This is within the context of also introducing foods that are iron-rich since infants' iron stores, accumulated in utero, begin to deplete at around 6 months of age and breast milk alone is no longer sufficient to meet high iron requirements (Ministry of Health, 2008).

Yet, there is considerable heterogeneity within the evidence base. Interventions have varied in duration, lacked long-term follow-up, been conducted within unnatural settings (laboratory), used relatively small samples, are specific to the Netherlands or UK, tested few vegetable types, and/or used control groups that did not necessarily reflect common practice, e.g., providing fruit, vegetables and iron-rich first foods. Greater use of recently validated tools to accurately assess infant food preferences is needed (Madrelle et al., 2017; Moding et al., 2020; Nekitsing et al., 2016). In addition, the potential effects on iron status have yet to be considered, which is concerning given the importance of meeting infants' iron requirements and providing evidenced-based advice regarding iron within the context of feeding vegetables as first foods. Thus, generalisability of findings, safety and long-term intervention effects are inconclusive, and may be the reason why many authorities including New Zealand are yet to provide more specific advice around focusing on vegetables as first foods.

Vegetables have always been a cornerstone of complementary feeding guidelines, but in the absence of scientific evidence, current advice remains broad and sometimes vague. New parents and caregivers need consistent and simple key messages that they trust will help their infant learn to like and eat vegetables (Bell et al., 2021). This message could be to ‘start your baby with single vegetables, including varieties that are not too sweet such as broccoli, cauliflower and spinach’.

The author invites the reader to consider the following key points that provide justification for this thesis research:

Vegetables are recommended throughout the lifecycle due to many known health benefits, thus improving current poor vegetable consumption is imperative.

Young infants can easily learn to like vegetables, with early acceptance thought to predict later vegetable intake.

There is urgent need to investigate and identify the most effective strategies to promote vegetable consumption, especially around vegetables as first foods given recent attention.

Translational research, or the process of moving knowledge from basic science to practical implications that improve human well-being, is a global priority (Fort et al., 2017). This thesis is highly translational as it involves a human RCT within a natural setting, and results are intended to develop key infant feeding messages for better health outcomes.

This dissertation is the first to report an infant feeding trial comparing the effects of a vegetables first approach to CF versus starting with fruit and vegetables, all within the home setting. Such a comparison is relevant because many infant feeding guidelines recommend fruit and vegetables as first foods in no set order, and infants typically receive sweet fruit and vegetables as first foods (Miles & Siega-Riz, 2017; Morison et al., 2018; Siega-Riz et al., 2010; Szymlek-Gay et al., 2010). In addition, despite limited evidence, some authorities are advocating for a focus on single vegetables at the start of CF. While this thesis by no means presumes to definitively address the evidence gaps on this topic, it is a first step to justify ongoing research. Findings may lead to a future study examining the feasibility and implementation of a nationwide infant feeding programme focusing on vegetables as first foods.

Overall, scaling up promising interventions, focusing on early prevention (i.e., targeting childhood), and conducting high quality research (e.g., cause-effect clinical trials) for the development of dietary guidelines have been promoted as key activities for improving population health (Gluckman et al., 2015; Shekar & Popkin, 2020) – all of which align with the aspirations of this thesis.

1.2. Study aims and objectives

The aim of this study is to determine whether exposure to vegetables-only during the first four weeks of complementary feeding increases later intake and liking of vegetables in infants, compared to a control group receiving both fruit and vegetables.

The objectives of this research are:

1) To determine whether starting complementary feeding with vegetable-only first foods results in:

a) higher intake of vegetables (target: broccoli, spinach) at 9 months of age, compared to the control group;

b) higher liking and acceptance of vegetables at 9 months of age, compared to the control group;

c) differences between groups in vegetable-only and combined fruit and vegetable first food intake and liking in infants at the end of the intervention period;

d) increased intake of vegetables at 12 months, compared to the control group.

2) To describe the iron status of the infants from baseline to 9 months of age.

Hypotheses

Hypothesis 1: Exposure to vegetables-only during the first four weeks of complementary feeding results in higher intake of a vegetables at 9 months and 12 months of age, compared to a control group.

Hypothesis 2: Exposure to vegetables-only during the first four weeks of complementary feeding results in greater liking and acceptance at 9 and 12 months of age, compared to a control group.

Hypothesis 3: No difference in infants' acceptance of vegetable-only versus fruit and vegetable first foods.

Hypothesis 4: A vegetables first approach does not negatively impact iron status.

1.3. Structure of thesis

This is a thesis with publication. After this introductory chapter, a review of the literature is provided (chapter 2), which primarily examines the importance of improving vegetable intake and promising strategies to achieve this (i.e., introducing vegetables as first complementary foods). A brief review of the literature on iron for infants is included due to concerns that a focus on vegetables during this critical period could negatively impact the provision of iron-rich foods. This is followed by five manuscripts, which stand as chapters and follow a logical order: the study protocol described the materials and methods for the RCT that is central to this thesis (chapter 3); the findings during the 4-week intervention (chapter 4); the primary outcome at 9 months of age (chapter 5); the follow-up study at 12 months of age (chapter 6); and the iron status results for participating infants (chapter 7). There may be repetition given that each is presented in the form of a manuscript ready for publication, but this has been minimised where possible. Publications are in their original wording unless otherwise noted, and reformatted to ensure consistency in language, layout and referencing style. The thesis concludes with a discussion which brings to light the knowledge gained from the research including its significance, relevance, impact, and methodological strengths and limitations (chapter 8). This final chapter includes concluding remarks and recommendations for future research.

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Chapter 2. Literature review

This chapter has been a research journey in itself and an iterative process in that the candidate continued to review the literature throughout the project. Through a documented search strategy, key evidence on a vegetables first approach to complementary feeding has been identified, as well as current knowledge supporting infant feeding guidelines and the importance of vegetable consumption during childhood. The chapter critically engages with and synthesises this information to present the necessary background to and justification for study design and implementation. Furthermore, this process has allowed the candidate to develop a voice on the topic.

2.1. Introduction

Vegetables are a key component of a healthy diet, and a child's intake and liking of vegetables may help to establish healthy eating habits for life (Barends et al., 2019). Like fruit and other plant foods, vegetables are a rich source of vitamins, minerals, dietary fibre and phytochemicals. However, based on consistent evidence suggesting that vegetable intake is inversely associated with risk of developing disease, consuming a greater quantity of vegetables than fruit is now recommended (Ministry of Health, 2020c; U.S. Department of Health and Human Services [HHS], 2015). During childhood, vegetables provide nutrients that support growth and development, immune function, digestive health in early life (Appleton et al., 2016; Ministry of Health, 2008); and may reduce the risk of developing certain adult chronic illnesses, including obesity (Ledoux et al., 2011; te Velde et al., 2007) and cardiometabolic disease (Funtikova et al., 2015).

Most children around the world are not reaching the recommended intakes of vegetables and fruit (Miller et al., 2016), and vegetables consumption is particularly low (Barends et al., 2019). A rejection of vegetables is largely due to a dislike of sensory characteristics, including bitter taste, that become increasingly difficult to accept with age (Bailey et al., 2019), underscoring the need to identify strategies that improve vegetable intake from an early age (Appleton, Hemingway, et al., 2018; Barends et al., 2019; Nekitsing et al., 2018).

A vegetables first approach to complementary feeding is a novel and promising area of research for improving vegetable consumption in children (Chambers et al., 2016; Nekitsing et al., 2018). The approach prioritises the introduction of vegetables when solid foods first start to complement breast milk in the infant's diet (Chambers et al., 2016). Early vegetable exposure gives infants an opportunity to establish a lifelong preference for vegetables relatively easily from a young age (Chambers et al., 2016; Nekitsing et al., 2018).

This literature review will begin by exploring the importance of vegetables for children, then describe current vegetable consumption in New Zealand children and worldwide. In acknowledging the fundamental influences that breastfeeding and complementary feeding have on a child's health trajectory, a critique of the development of dietary guidelines and current practices for each will be provided. This leads to a discussion on dietary strategies to improve children's vegetable consumption, focusing on a vegetables first approach to complementary feeding due to recent attention among infant feeding experts (Barends et al., 2019; Bell et al., 2021; Chambers et al., 2016) and the media (BBC News, 2019; Black, 2017; Slawson, 2015). The review will then examine common assessment methods for vegetable liking and intake, including the development of a new infant liking and video-coding tool to assess food acceptance. Finally, in response to concerns that focusing on vegetables as first foods may unduly neglect the provision of foods that are iron-rich, a discussion on iron during infancy will be included. Together, this information was used to inform the 'Vegetables as First Foods for Babies Study' (also known to the public as the 'Veges First Study'). This was a randomised controlled trial (RCT) which investigated the effects of a vegetables first approach to complementary feeding on infants' vegetable acceptance.

2.2. Search strategy

MEDLINE ®/PubMed, Scopus and Google Scholar® were searched for the period of August 2018 through to May 2021. Search strategies were divided into four categories of interest: (1) vegetables for children, including health benefits and consumption; (2) infant feeding guidelines, including the introduction of complementary foods; (3) dietary strategies to promote children's vegetable consumption, including a vegetables first approach to complementary feeding; and (4) iron for infants, including dietary intake and sources. Table 2.1 shows the keywords, Medical Search Headings (MeSH), MeSH major topics and free text terms used to find relevant articles, as well as search strategies that returned useful results. Additional publications were identified by manually searching reference lists of key papers and following links to related articles. Dietary guideline documents were found via targeted website searches and, since the anticipated new infant feeding guidelines for New Zealand were not available at the time of this literature search, the Food and Nutrition Guidelines for Healthy Infants and Toddlers (Aged 0-2): A background paper (Ministry of Health, 2008) was taken as the most current. Only literature published in English was included

Table 2. 1. Keywords and MeSH terms used to build search strategies for categories of interest

Concept	Keywords	MeSH terms
Category 1 **Vegetables for children: health benefits and consumption**		
Concept	*Keywords*	*MeSH terms*
Children	infant*, toddler*, preschool*, babies, baby, child, newborn*, kindergarten, “children under 2”, “children under 3”, adolescent*	Child, Infant*, newborn*, Preschool, Adolescent
Health	health, growth, development, digestion, digestive, obesity, weight, chronic disease*, illness*, diabetes, cardiovascular, “heart disease”, mortality, cardiometabolic, immune, immunity, infection, cancer	Health, Child Health, Infant Health, Child Development, Pediatric Obesity, Chronic Disease
Vegetable consumption	“vegetable consumption”, intake, “eat vegetables”, “vegetable recommendations”	Vegetables, Nutritional Requirements
Search strategies		
Google Scholar	“health benefits of vegetables review”. Filter: Since 2017	
Scopus	vegetables AND health. Filters: Review, Systematic review, 5 years	
PubMed	(((vegetables) AND (child)) AND (health)) AND (infant). Filters: Review, Systematic review, 5 years	
Note. Given limited availability of child specific articles, recent review papers on the health benefits of vegetables in adults were searched by omitting child terms.		
Category 2 **Infant feeding guidelines including the introduction of complementary foods**		
Concept	*Keywords*	*MeSH terms*
Children	infant*, child, toddler*, “early childhood”	Child, Infant*, newborn*
Dietary guidelines	diet*, guideline*, recommendation*, “Infant feeding guidelines”, “dietary recommendations”, “nutritional requirements”, food, “review process”, “early life nutrition”, feeding, “food based”, “position paper”	Nutritional requirements, Recommended Dietary Allowances, Dietary requirements
Breastfeeding	breastfed, breastfeeding, duration, formula	Breastfeeding
Complementary feeding	“complementary feeding”, weaning, “starting solids”, timing, introducing, introduction	Weaning
New Zealand	New Zealand, Australia, Australian	-
Search strategies		
Google Scholar	complementary feeding OR complementary feeding guidelines. With/without filter: Since 2017	
Scopus	infant AND feeding AND guidelines AND NOT preterm. Filter: Review	
PubMed	infant AND weaning AND nutritional requirements *or* infant AND feeding AND guidelines	
Note. International and national infant feeding guidelines and background papers were accessed from government websites (e.g., Ministry of Health, WHO)		
Category 3 **Dietary strategies to promote vegetable consumption: a vegetables first approach to complementary feeding**		
Concept	*Keywords*	*MeSH terms*
Children	infant*, toddler*, preschool*, babies, baby, child, newborn*, kindergarten, “children under 2”, “children under 3”, adolescent*, “early life”	Child, Infant*, newborn*, Preschool,

Dietary strategies	"dietary strategy", strategies, "repeated exposure", "vegetables first approach", "starting complementary feeding with vegetables only", "maternal diet", "responsive feeding", mother*, "feeding environment", "nutritional intervention", intervention*, prevention	Weaning
Vegetable acceptance	"vegetable acceptance", "food preference*", experience, taste*, innate, dislike*, like*, liking, wanting, access, availability, learning, "vegetable intake", "increased vegetable consumption", "eat more vegetables"	Food Preferences, Food Fussiness
Search strategies		
Google Scholar	Vegetables first approach to complementary feeding. With/without filter: Since 2017	
Scopus	infant AND feeding AND guidelines AND NOT preterm. Filter: Review	
PubMed	infant AND weaning AND food preferences or infants AND feeding AND food preferences. With/without filter: Clinical trials	

Category 4

Iron for infants including dietary intake and sources

Concept	*Keywords*	*MeSH terms*
Children	infant*, toddler*, preschool*, babies, baby, child, newborn*, kindergarten, "children under 2", "children under 3", adolescent*	Child, Infant*, newborn*, Preschool, Adolescent
Iron	Iron, "dietary iron", "iron intake", "dietary intake", "iron deficiency", anemia*, "iron requirement", "iron-rich", "dietary intake", meat, cereal	Anemia
Search strategies		
Google Scholar	Iron for infants. With/without filter: Since 2017	
Scopus	infant AND iron AND intake AND weaning. Filter: Human	
PubMed	infant AND iron NOT preterm; or infant AND weaning AND iron NOT preterm. With/without filter: 2015-2021; Clinical trials or Review	

Note. Before submission of this dissertation, an additional search for papers published in 2021 that directly related to a vegetables first approach to complementary feeding using was conducted using search strategies described in category 3. One additional paper was found and included where relevant.

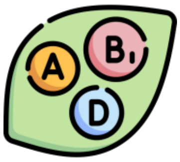
2.3. Vegetables for children

Health benefits of vegetables

Vegetables are an important part of a healthy diet and if consumed in sufficient amounts, can help to prevent chronic illness, including obesity, cardiovascular disease (CVD), type 2 diabetes and some cancers (Angelino et al., 2019; Appleton et al., 2016; Aune et al., 2017; Boeing et al., 2012; Wallace et al., 2020; World Health Organization [WHO], 2005). In a systematic review and dose-response meta-analysis of prospective cohort studies, Aune et al (2017) investigated fruit and vegetable intake and the risk of chronic disease in adults. It was found that for each 200 gram per day increment intake of fruit, vegetables and fruit/vegetable combined, there was a reduction in relative risk of coronary heart disease (CHD), stroke, CVD, total cancer and all-cause mortality (8–16 %, 13–18 %, 8–13 %, 3–4 % and 10–15 % reductions, respectively) (Aune et al., 2017).

Similarly, a critical review of the health benefits of fruit and vegetables reported convincing evidence for increasing vegetable consumption to reduce the risk of hypertension, CHD and stroke (Boeing et al., 2012). A systematic review and meta-analysis of randomised controlled trials examining the effects of fruit and vegetable consumption on weight gain found adults with a high fruit and vegetable intake gained less body weight compared to those with a low fruit and vegetable intake, and that promoting increased fruit and vegetable consumption could be important for weight maintenance or loss (Mytton et al., 2014), which is important for preventing chronic disease (Zou et al., 2019).

The evidence demonstrating the health benefits of fruit and vegetable consumption in children is relatively less clear, largely due to a lack of intervention data and the availability of only a few cohort studies that often reveal no risk relations (Barends et al., 2019; Boeing et al., 2012; Ledoux et al., 2011). Nevertheless, eating fruit and vegetables during childhood can be protective against chronic disease in later years, while providing essential nutrients for growth and development, strengthening the immune system and improving digestion (Appleton et al., 2016; Ministry of Health, 2008). Given that vegetable consumption is markedly lower than fruit consumption amongst children (Barends et al., 2019), the aim of the following section is to explore the literature concerning vegetables as a health protective food for children, with a nutritionally adequate diet for infants and children (Arimond & Ruel, 2004; Food and Nutrition Technical Assistance [FANTA], 2006; Kennedy et al., 2007; Steyn et al., 2006; Zhao et al., 2017).



Nutrient-dense diet for a healthy start to life

Vegetables are a rich source of nutrients for overall child health.

Each type of vegetable has a unique nutrient profile, thus consuming a variety of vegetables in different combinations can help meet overall nutrient requirements for health, growth and development during childhood (Arimond & Ruel, 2004; Dias, 2012; Kennedy et al., 2011; Liu, 2013; Wallace et al., 2020; Zhao et al., 2017). Food composition tables are typically used to estimate the nutrient content of foods, including vegetables (Grande & Vincent, 2020). The Concise New Zealand Food Composition Database, jointly owned by Plant and Food Research and the Ministry of Health, provides reliable estimates of the usual composition of foods in New Zealand; and is managed and regularly updated by Plant and Food Research. Despite natural variations in nutrient values across databases, vegetables feature as important dietary sources of vitamins, minerals, fibre and phytonutrients (Kennedy et al., 2011; Marles, 2017; The New Zealand Institute for Plant and Food Research Limited & Ministry of Health, 2019).

The colours of the edible parts of vegetables typically indicate the presence of specific nutrients (Griep et al., 2011). For example, the natural red-violet pigment of beetroot is indicative of betalins like betacyanin which may have antiviral, antioxidant and anti-inflammatory properties (Panghal et al., 2017). Using vegetable colours has been a useful tool to translate nutrition science into dietary guidelines for the public (Heber & Bowerman, 2001), with several resources encouraging children to eat red, yellow/orange, brown/white, green and blue/purple vegetables (5+ A Day, n.d.; Healthy Kids Association, 2014; Life Education, n.d.).

While there is no international consensus on categorising vegetables by colour, the Food and Agriculture Organization (FAO) guidelines for measuring dietary diversity (a proxy measure for nutrient adequacy) provide four groups that address vegetable variety:

(1) ‘White tubers and roots’ (e.g., potatoes) that are good sources of energy and dietary fibre;
(2) ‘Vitamin A rich vegetables and tubers: pumpkin, carrots, squash or sweet potato that are orange inside’;
(3) ‘Dark green leafy vegetables’ (e.g., spinach) which contain iron, vitamin A and folate;
(4) ‘Other vegetables (e.g., tomato, onion, eggplant)’ which are considered rich in health protective bioactive compounds such as lycopene and anthocyanins.

(FAO, 2013)

Eating vegetables from each of these groups may contribute to higher dietary diversity scores that positively correlate with a nutritionally adequate diet for infants and children (Arimond & Ruel, 2004; FANTA, 2006; Kennedy et al., 2007; Steyn et al., 2006; Zhao et al., 2017).

Growth and development

Vegetable intake helps growing infants meet high nutritional needs.

Infants and young children have high nutritional requirements due to rapid growth and development of the body and major organs such as the brain, gastrointestinal tract and pancreas (Alles et al., 2014). For example, a 7–12-month-old breastfed infant (average body weight of 7-9 kg) requires almost five times as much dietary vitamin C (mg) per kg of body weight per day, compared to an adult male (average body weight 70kg). This, along with their increased vulnerability to infection and relatively small stomach capacity, emphasises their need to consume a wide variety of foods that are nutrient-dense, including vegetables (Dewey, 2013; Maggini et al., 2018; Yu et al., 2018).

Evidence showing the direct effects of vegetable consumption on an infant's growth and development are limited, primarily for ethical and practical reasons. However, a cross-sectional analysis using data from Demographic and Health surveys from 11 low-income countries found greater dietary diversity, including vegetables, to be significantly associated with improved height-for-age scores (linear growth) in infants aged 6–23 months (Arimond & Ruel, 2004). Likewise, a Nepalese longitudinal cohort of 205 children (baseline mean age 14 months), found a positive relationship between child development and dietary diversity and the consumption of specific food groups such as vegetables (Thorne-Lyman et al., 2019). Child development was assessed using the validated Ages and Stage Questionnaire-3 (Singh et al., 2017), which provides scores for five development subscales, i.e., gross motor, fine motor, personal-social, problem-solving and communication. After adjusting for confounders (e.g., child age, maternal education), each additional day of consuming a minimum dietary diversity (≥ 4 out of 8 food groups) was associated with a 35 % reduction in the odds of low total child development scores (sum of subscales). A higher total development score was associated with consumption of fruit and vegetables, and more specifically, green leafy vegetable intake was associated with about 40 % lower odds of a low score on the fine motor, problem solving and personal-social subscales. Despite some limitations, including the small sample size and difficulty to control for all confounders (e.g., home environment, parental care), it was concluded that fruit, vegetables and animal source foods may be important for child development, which is consistent with previous observational and experimental results (Sigman et al., 1989; Wachs et al., 1995; Whaley et al., 2003).

Another source of evidence to understand the importance of vegetables for infant growth can be found in studies examining the maternal diet during pregnancy and lactation. Several studies have shown that a maternal diet that is rich in vegetables may lead to improved infant growth outcomes, including a reduced risk of small for gestational age (SGA) and/or low birth weight (Garay et al., 2019; Gomez Roig et al., 2017; Jang et al., 2018; Kjøllesdal & Holmboe-Ottesen, 2014; C. Wang et al., 2019). A cross-sectional prospective study compared fetal growth during the third trimester of mothers with SGA (n = 46) and those with appropriate for gestational age (AGA) fetuses (n = 81) (Gomez Roig et al., 2017). It was observed that mothers in the AGA group ate significantly more vegetables, especially green beans, carrots and lettuce, compared to mothers in the SGA group. Despite limited generalisability due to the small sample size and the use of a specific urban Catalan population, these results suggest that maternal vegetable intake has the potential to improve intrauterine growth conditions.

Similarly, a large cohort study of 1138 Korean pregnant women found an increased intake of fruit and vegetable or vitamin C at mid-pregnancy is associated with increased fetal and infant growth up to 6 months of age (Jang et al., 2018). The large sample size was a strength, but the reliance on retrospective self-reported dietary data using a single 24-hour food recall likely introduced information bias. Overall, further inquiry using more reliable dietary periods of time may be needed to clarify the relationship between vegetable intake and child growth, but thus far a positive relationship seems plausible.

Protection against infection

Vegetable consumption may support immune function in early life.

Infants are born with relatively immature immune systems (Maggini et al., 2018; Yu et al., 2018), thus require a particularly good supply of immune supportive nutrients such as iron, zinc, selenium, vitamin A, vitamin C, vitamin E, flavonoids and carotenoids, as is found in nutrient-dense foods, including vegetables (Alpert, 2017; Maggini et al., 2018). While all vegetables are important, green leafy and orange coloured vegetables contain large amounts of beta-carotene that the body converts to vitamin A, which are particularly helpful for establishing a strong immune system (Haskell, 2012; Low et al., 2017; van Jaarsveld et al., 2005; WHO, 2009).

To evaluate the efficacy of daily consumption of boiled and mashed orange-fleshed sweet potato (OFSP) for improving vitamin A status, South African children aged 5–10 years were randomised to two groups, either consumption of OFSP (treatment) or white-fleshed sweet potato (control) devoid of beta-carotene for 53 days (van Jaarsveld et al., 2005). It was concluded that eating OFSP regularly improved vitamin A status and liver stores compared to the control group. This aligns with previous studies demonstrating that other vegetable types (e.g., red sweet potato, orange fruit, squash, dark-green leafy vegetables and carrot) improved vitamin A status in marginally vitamin A deficient children (De Pee et al., 1998; Jalal et al., 1998). Although the impact on infection risk requires further assessment, such evidence supports efforts to promote the consumption of vitamin A rich vegetables as a way to alleviate disease caused by vitamin A deficiency, particularly in developing countries (Anderson et al., 2007; Low et al., 2017).

Infection as an outcome measure was investigated in Netherlands through a prospective cohort study of 61 children age 1–6 years (Ten Velde et al., 2013). The study found a change of diet towards green vegetables, beef, whole milk and full-fat butter following dietary advice led to a statistically significant reduction in days with respiratory infections, fever and antibiotic use compared to the control group (Ten Velde et al., 2013). The exact mechanisms and effects of green vegetables on the immune system was unclear due to various factors including difficulties in measuring physiological differences in a child's nutrient absorption and actual consumption of foods and nutrients. Yet, the dietary pattern including vegetables had no negative side-effects and was considered realistic for families to adopt or practitioners to recommend in order to reduce a child's risk of infection.

Enhance digestive health

Vegetable intake during childhood may support gut function.

In addition to supporting growth, development and immune function, vegetables are also considered paramount for sufficient gastrointestinal (GI) function. A healthy digestive system is critical for a child's ability to absorb nutrients from food, and therefore grow, develop and reach optimal health (Lenfestey & Neu, 2018; Neu, 2007). The evidence demonstrating a relationship between vegetable intake and gut health outcomes in children is limited, again for ethical reasons. However, review articles that focus on dietary fibre, which is naturally found in plant foods, suggest that vegetables may help to keep bowel movements regular, optimise nutrient absorption, and assist with the growth of beneficial gut bacteria during childhood (Aggett et al., 2003; Edwards & Parrett, 2003; Korczak et al., 2017).

Many operative definitions of dietary fibre exist around the world, but from a physiological perspective, dietary fibre is a broad term used to describe carbohydrate-based plant materials that cannot be hydrolysed or digested by endogenous enzymes in the upper GI tract (Aggett et al., 2003; Dhingra et al., 2012; Grundy et al., 2016; Jones, 2014). Soluble fibre (e.g., pectins, gums) and insoluble fibre (e.g., cellulose) are the two common types that are differentiated by their physico-chemical properties (e.g., particle size, solubility, viscosity) (Aggett et al., 2003; Blackwood et al., 2000).

The health benefits of consuming sufficient amounts of dietary fibre include delayed gastric emptying to regulate satiety and energy intake; delayed absorption of nutrients such as glucose and fats; binding and excretion of bile acids to lower serum lipid and cholesterol level; and adding bulk to stools to improve laxation

(Blackwood et al., 2000; Dhingra et al., 2012; Grundy et al., 2016). Much of what is known about the effects of dietary fibre-rich vegetables is based on *in vitro* and *in vivo* mechanistic studies in animals and adults (Grundy et al., 2016); however, there is some recent evidence that is specific to children.

A recent review identified 12 studies that examined the effects of fibre-containing foods (e.g., grains and vegetables) and/or supplements on digestive health outcomes in children (Korczak et al., 2017). It was found that partially hydrolysed guar gum from cluster beans, glucomannan from the konjac plant and bran may positively support gut outcomes, including transit time and stool frequency. However, due to considerable heterogeneity across studies (e.g., different age ranges, study durations and dietary assessment tools), comparability of findings was limited. In addition, the review was unable to identify studies examining the direct effects of whole vegetable intake on gut function, thus a causal relationship is difficult to determine.

A better understanding of the relationship between vegetable intake and gut outcomes can be found in studies examining an association between common GI problems and dietary intake. Two cross-sectional studies of dietary habits and childhood constipation reported low dietary fibre intake, particularly from vegetables, may increase the risk of hard stools and constipation (Okuda et al., 2019; Taylor et al., 2016). However, it is possible that undue emphasis was placed on the single nutrient of dietary fibre without considering the whole diet and synergistic interactions between a range of foods/nutrients that support the gut. In addition, given the cross-sectional design, causality between dietary intake and constipation was not fully resolved and future RCTs may be required to elucidate a beneficial relationship.

Beyond modifying the rate of gastric content through the GI tract, it is of increasing interest as to how a diet rich in vegetables may improve the gut microbial ecosystem (De Filippo et al., 2010; Han & Xiao, 2020; Kisuse et al., 2018; Laursen et al., 2016). A small (n = 45) cross-sectional study amongst school-aged children in Thailand found children who consumed a traditional vegetable-based diet had better gut microbiota outcomes (e.g., improved colonic short chain fatty acid fermentation that may sustain intestinal homeostasis), compared to those with a diet characterised by high fat foods and fewer vegetables (Kisuse et al., 2018). Another study examining the gut microbiota of two different cohorts of infants born to either healthy (n = 114) or obese mothers (n = 113) found complementary foods rich in protein and dietary fibre, as found in vegetables and grains, were the main drivers for establishing a complex microbiota during infancy and childhood (Laursen et al., 2016). For much of this research the health impact of an altered microbiota as an effect of vegetable consumption remains unknown. Currently, more clinical trials are underway, including the New Zealand *Nourish to Flourish* study trialling infants on freeze-dried kūmara powder with the hypotheses that its consumption has a positive effect on infant gut bacteria and infection risk (Australian New Zealand Clinical Trials Registry, 2019).

Disease prevention: obesity and related illness

Vegetable intake may be protective against chronic disease.

Vegetable consumption in childhood may help to prevent chronic disease in a number of ways, either directly through the establishment of a lifelong healthy dietary pattern (Nicklaus & Remy, 2013) or as an effect of improving body weight and other chronic disease risk factors (Wallace et al., 2020). While there is good evidence to show that dietary patterns early in life track into adulthood (Gregory et al., 2011; Madruga et al., 2012; Nicklaus & Remy, 2013; Pearson et al., 2011), the evidence supporting a reduction in a child's risk of developing disease remains less clear (Barends et al., 2019; Boeing et al., 2012; Ledoux et al., 2011).

This research gap regarding the association between vegetable intake and child disease outcomes was demonstrated in a recent review by Boeing et al. (2019), which stated that there was insufficient evidence for an association between fruit and vegetable consumption and weight development – but only papers published before December 2010 were included. Prior to this, a systematic review investigating the relationship between fruit and vegetable intake and adiposity identified only one experimental and four longitudinal studies in children, compared to 11 and seven for adults, respectively (Ledoux et al., 2011). These studies were further limited by the use of less reliable dietary assessment methods (e.g., 24-hour recalls), inconsistencies regarding fruit and vegetable classification, short follow-up periods and/or small sample sizes; and no association between fruit and vegetable consumption and reduced adiposity among overweight children was found.

More recent data offer more positive results. For example, in the Infant Feeding Practices Study II and Year 6 Follow-Up Study, a longitudinal study following about 2000 mother-infant dyads, Rose et al. (2017) found infants with higher vegetable consumption at 9 months were less likely to be overweight at 6 years compared to infants with diets high in energy-dense food (e.g., French fries and sweet desserts) and lower vegetable consumption. A 2015 comprehensive review of available epidemiological and experimental evidence identified that fruit and vegetable consumption was positively linked to young people's cardiovascular health (Funtikova et al., 2015). This is supported by several recent observational studies suggesting that higher vegetable consumption at a young age may improve adult CVD risk factors, such as high blood pressure, elevated low density lipoprotein, high cholesterol (Mellendick et al., 2018) and overweight/high body mass index (Kepper et al., 2016; Rose et al., 2017; Wall et al., 2018). One study showed that specific vegetables (greens and beans) were negatively related to cardiometabolic risk factors, namely, total cholesterol and low-density-lipoprotein (Mellendick et al., 2018). Despite study limitations, including non-representative sampling and a reliance on self-reported child food intake, positive results affirm the assumption that vegetable consumption during childhood helps to prevent future disease.

Children's vegetable consumption

The following section addresses whether children are eating enough vegetables (quantity and variety), and potential barriers to intake.

Vegetable intake

Children are not eating enough vegetables.

Children's vegetable consumption is below recommendations worldwide (Mihrshahi et al., 2019; Miller et al., 2016; Ministry of Health, 2020b; NHS Digital, 2019). The latest national UK statistics show that only 14 % of children (5–7 years) eat five or more portions of fruit and vegetables per day, with an average intake of 2.9 portions per day (NHS Digital, 2019). Similarly, poor vegetable consumption is reported in other parts of Europe (e.g., Belgium, Spain, Iceland) (Huybrechts et al., 2008; Yngve et al., 2005) and in the US (Lorson et al., 2009). In the Netherlands, less than 1 % of 4- to 6-year-olds met vegetable intake recommendations in 2008, while 25 % met those for fruit (Ocké et al., 2008). In fact, vegetable consumption was overall very low, with 79 % of 2- to 3-year-olds not eating the recommended

50–100 grams of vegetables per day, and almost all 4- to 6-year-old children not eating the recommended 100–150 grams per day.

Australian and New Zealand children may be doing slightly better, but fruit and vegetable consumption is inadequate, particularly for vegetables. Findings from the 2014/15 Australian National Health Survey found only 20.2 % of 2- to 3-year-olds consume the recommended amount of vegetables, compared to 96.9 % consuming the recommended amount of fruit (Mihrshahi et al., 2019). New Zealand National Survey statistics show that the number of children (2–4 years) consuming the recommended two or more servings of vegetables has declined from 72.7 % in 2011 to 65.4 % in 2018/19 (Ministry of Health, 2020a); those consuming the recommend two or more servings of fruit has increased from 75.6 % to 80.6 %. These results are supported by data from the Growing Up in New Zealand (GUiNZ) study, a contemporary nationally representative longitudinal study following the development of New Zealand children (N = 6435) from before birth (over the period of 2009–2012) until adulthood (Gontijo de Castro et al., 2018; Morton et al., 2017). In this cohort, just above half of children (54 %, n = 3281) were meeting recommended fruit and vegetable intakes at 4 years of age, with more children meeting intakes for fruit (84 %) than vegetables (60 %) (Morton et al., 2017).

There is considerably less data for infants' fruit and vegetable intake, with no national survey of infant feeding in New Zealand, and those overseas have either discontinued (McAndrew et al., 2012) or typically do not report on vegetable/fruit consumption (Australian Institute of Health and Welfare [AIHW], 2011; Begley). This may be due to a lack of standardised measurable indicators of adequate fruit and vegetable intake for infants (Ministry of Health, 2008). Nonetheless, GUiNZ devised 'eating fruit and vegetables twice or more daily at 9 months old' as a key indicator of adequate fruit and vegetable intake (Gontijo de Castro et al., 2018); low adherence for fruit (37 %) and vegetables (33 %) was found, and some children (12 %) ate vegetables less than daily or never.

The Feeding Infants and Toddlers Study (FITS), the largest (n = 3235) national cross-sectional survey in the US evaluating the diets and feeding practices of infants and children < 48 months of age. Results from FITS 2008 found that among infants aged 9 to 11.9 months, about 20 % did not eat a fruit and 28 % did not eat a vegetable at least once in a day (Siega-Riz et al., 2010). A greater number of infants aged 6 to 8.9 months were not eating fruit or vegetables on any given day (36 % and 37 %, respectively). At the age of 12 to 23.9 months, about 20 % and 30 % of children did not consume any fruit or vegetables on a given day, respectively (Roess et al., 2018).

While vegetables appear poorly consumed during infancy, more research is needed, particularly as current data is limited in breadth and by various sources of bias, including the use of food frequency questionnaires or 24-hour food recalls, inconsistent dietary assessment methods across studies and poor availability of standardised indicators of adequate fruit and vegetable intake during infancy.

Types of vegetables and fruit

Sweet and starchy vegetables/fruit are popular amongst children.

Recent data on the types of fruit and vegetables typically consumed by New Zealand young children is limited. Some evidence can be taken from the Baby-Led Introduction to Solids (BLISS) RCT, which compared effects of a modified version of baby-led weaning (BLW) on infant dietary outcomes, versus traditional spoon-feeding. BLW was defined as infants feeding themselves handheld foods during family mealtimes and modified in the sense that foods offered reduce the risk of iron deficiency, choking and growth faltering. Parents were free to choose which vegetables and fruit to feed their child; broccoli, cabbage, spinach, cauliflower and tomato were the common savoury vegetables offered at 12 months of age in both groups (Morison et al., 2018), bananas were the predominant fruit. At 24 months of age, all infants had been exposed to broccoli, cabbage, carrots, cauliflower, green beans, mushrooms, parsnips, lettuce and tomato; fruits included apples, bananas, oranges, grapes, peaches and strawberries. There was an overall high preference for fruit and a slightly lower preference for vegetables. However, as consumption of specific vegetables/fruits was not the focus of the study and some data restricted by questionnaire items (i.e., nine vegetable items and nine fruit items), an accurate account of which foods were most popular remains limited.

Cross-sectional data suggests that the most popular vegetables consumed by New Zealand children are energy-dense and of sweeter varieties, including potato, kūmara and carrot; popular fruits include banana, apple/pear and orange/mandarin (Mills et al., 2015; Parnell et al., 2003; Szymlek-Gay et al., 2010; Theodore et al., 2006). A survey of 118 children aged 12–23 months found banana, apple, potato and carrot to be the most common fruit and vegetables consumed (Morison et al., 2018; Szymlek-Gay et al., 2010).

More recently, a US cross-sectional study of 6–23 month old children (n = 2359), found dark-green vegetables were the least commonly consumed vegetables (Miles & Siega-Riz, 2017); apple and banana were the most common fruit. Deep-yellow starchy vegetables were most typically eaten by 6- to 11-month-olds, while white potato was more popular amongst 12- to 23-month-olds. In a sample of preschool aged UK children (n = 207), banana and apple were the most consumed fruit, while peas, sweetcorn and carrot were the most consumed vegetables, excluding potato (Cockroft et al., 2005).

The five fruits that were more typically consumed by 6- to 8.9-month-old infants (n = 249) in the US 2008 Feeding Toddlers Study were apple (25.3 %), banana (18.1 %), pear (9.6 %) and peach (6.9 %) in the form of commercial infant food, and fresh banana prepared at home (16.8 %) (Siega-Riz et al., 2010). Common vegetables were sweet potato (16.2 %), mixed/garden vegetables (14.3 %), carrot (11.3 %), peas (9.5 %) and squash (9.0 %), all of which were in the form of commercial infant food. Similarly, an intra-cultural cross-sectional study in Mexican mother-infant dyads (n = 101) found the first most common food given to the majority of infants was fruit (e.g., apple, banana, pear, peach, papaya, mango) and the second most common first food was a sweet/starchy vegetables (e.g., carrot, squash, potato) (Mennella et al., 2005).

Interestingly, 'fruiting vegetables' (e.g., aubergine, cucumber, sweet pepper, tomato, courgette and cabbage) were the most popular amongst young children (2–6 years of age) in the Dutch National Food Consumption Survey 2005/2006 (Ocké et al., 2008), but other leafy greens (e.g., spinach, lettuce) were not well consumed. Therefore, even with some exceptions, it is difficult to ignore children's general preference towards a limited range of fruit and vegetables that are typically sweet in taste.

Barriers for vegetable intake

Taste, texture, energy-density and access.

There may be several reasons for children to under consume vegetables, including a dislike of bitter taste, sensitivity to texture, preferences towards high energy-dense foods or a lack of access (Bailey et al., 2019). Infants are born with a natural preference for sweet taste as breast milk is sweet, and so may find bitter tasting vegetables such as leafy greens more difficult to accept (Forestell, 2017; Mennella & Bobowski, 2015). This is probably a survival tactic, as sweetness usually signals that the food will help meet energy requirements, while bitterness or sourness may warn of harmful toxins (Wardle & Cooke, 2008). It is thought that infants navigate what is safe and nutritious to eat through an interplay of innate preferences and the ability to learn new preferences, particularly within a supportive environment (Dovey et al., 2008; Wardle & Cooke, 2008).

Food neophobia and ‘picky/fussy’ eating are two other naturally occurring psychological barriers that may impact a child’s dietary variety (Cole et al., 2017; Dovey et al., 2008; Johnson et al., 2018). Food neophobia is defined as an unwillingness to eat new or unknown foods, while picky/fussy eating refers to the inadequate consumption of a variety or amount of foods due to the rejection of both familiar and unfamiliar foods (Dovey et al., 2008). A detailed review of these complex food behaviours is beyond the scope of this thesis, especially given the ongoing debate around the definition and developmental trajectory for each. Nevertheless, a relevant concern is that their onset appears to be associated with increased child mobility (i.e., around 20 months of age), may peak at around 5 years and then decline with positive food experiences (Barends et al., 2019; Dovey et al., 2008; Johnson et al., 2018). Factors such as pressure to eat, personality traits and parental style may, similarly, predict the degree to which each food refusal behaviour is experienced during infancy (Dovey et al., 2008). Lastly, both neophobia and ‘picky/fussy’ eating have been associated with a reduced consumption of vegetables during childhood (Galloway et al., 2005; Proserpio et al., 2020; Wolstenholme et al., 2020), and if not handled with care, could lead to a continued lack of dietary variety during adulthood (Dovey et al., 2008).

In addition to natural rejection of vegetables during early childhood, some families face economic pressures that may cause them to forego vegetables that are relatively high cost compared to processed foods that are typically cheaper, high in sugar, fat and sodium, but easily fill up a stomach (Harris et al., 2019). Eurostat data shows that 6.6 % of households with children in the European Union (5.5 % in the UK) cannot afford a meal with meat, fish or a vegetarian alternative every second day (Van Lancker & Parolin, 2020). In a systematic review of the status of food insecurity among children in high-income European countries (Zaçe et al., 2020), prevalence of food insecurity (low and very low) in the UK went from 9 % in one study (Yang et al., 2018), to 100 % in another (Harvey, 2016). Similar data in the US suggests that 14 % of households with children were food insecure in 2018 (United States Department of Agriculture [USDA], 2019). In New Zealand, although most children live in food-secure households, almost one in five (19 %) children experienced severe-to-moderate food insecurity in 2015/16 (Ministry of Health, 2019).

More recently, the GUiNZ study identified that food insecurity, to one degree or another, affected around 72 % of New Zealand infants, and may be associated with poorer health and infant morbidity (Schlichting et al., 2019). Infants at higher odds of being food insecure were from minority ethnic groups, and born to mothers who were young, smoked, and/or lived in a low-income household. Low consumption of fruit and vegetables was one factor underpinning the diet of food insecure infants (Schlichting et al., 2019), which is consistent with available data from other high-income contexts reporting food insecurity as associated with lower fruit and vegetable intake (Tarasuk, 2001).

Regardless of whether families can afford vegetables or not, their choice to consume a variety of vegetables may be simply limited by cultural preferences and by what is available to purchase (Lacy et al., 2019; Ong et al., 2017). Of growing concern, most commercially available infant foods appear to contain more fruit than vegetables (Chambers et al., 2016; Moding et al., 2018; Padarath et al., 2020). A US cross-sectional study found that of 548 vegetable-containing infant and toddler foods available on the market, only 52 single-vegetable products (9.5 %) were identified, none of which contained dark leafy greens, beans or peas. Red and orange vegetables were the most common, and fruits were listed as the most common first ingredient (37.8 %). In New Zealand, Wattie's for Baby® First Tastes Veggie purées are a new range of ready-made infant foods that are composed of either a single fruit (apple or pear) or a starchy/sweet vegetable base (e.g., kūmara, potato, carrot, sweetcorn) (Heinz Wattie's, n.d.). These products contain a very small percentage of bitter-tasting vegetables, for example, the 'Green Veggies' 90 gram pouch contains 30 % pea, 25 % potato, 20 % courgette, and only 2 % spinach. The foods are marketed as tasty nutritious infant foods approved by the Independent Nutrition Advisory Group including Plunket (For Baby, n.d.), which, by encouraging families to offer their infant, may also be inadvertently discouraging vegetable intake.

Conclusion

There is strong evidence to support including vegetables as part of a healthy diet, particularly for the prevention of certain adult chronic diseases. However, further clinical trials are needed to infer causality between vegetable intake and health outcomes during infancy and childhood. RCTs remain challenging to conduct, as it would be unethical for a control group to be denied vegetables given the known nutritive value of vegetables and associated health benefits for other life stages. Data suggesting that sufficient vegetable intake in early life can help to establish protective dietary patterns for adult health seems enough to justify current efforts to increase and promote children's vegetable consumption (Craigie et al., 2011; Hodder et al., 2020).

Such efforts are further justified as dietary intake data across the globe shows that vegetable intake is persistently inadequate in most children. Beyond quantity, vegetable variety may also need promotion if many of the vegetables preferred by children are limited to sweet and starchy varieties, including at the time that solid foods are first introduced. These trends may be an effect of an innate taste preference towards sweet and energy-dense foods, cultural influences, or socioeconomic/environmental factors including food insecurity and the high availability of sweet/starchy vegetable infant foods. Overall, this section has highlighted a rising need for interventions to focus on improving vegetable consumption, rather than fruit, during the early years of life.

2.4. Dietary guidelines for infants and children

With efforts to improve overall health and disease prevention, there has been a shift towards using an evidence-based approach to population dietary guidelines (Baghurst, 2003; HHS, 2015; WHO, 2003b), to the extent that there are now established protocols and tools for guideline development (Dewey & Harrison, 2020; Institute of Medicine [IOM], 2011; Kredo et al., 2016; Qaseem et al., 2012; Schünemann et al., 2014; WHO, 2014c) and quality assessment (Appraisal of Guidelines for Research and Evalulation Enterprise, n.d.; Grimmer et al., 2014). However, these methods have not been adopted universally, and despite progress in early life nutrition research, there is a lack of high-level evidence from clinical trials and systematic reviews to base recommendations on (Dewey & Harrison, 2020). Global collaborative efforts are scant which along with inconsistent review processes and an increased reliance on non-clinical data and narrative reviews, likely contribute to the nuances found across guideline documents (Dewey & Harrison, 2020; Maki et al., 2014).

Existing evidence relating to infant feeding was recently summarised by an ad hoc committee in the US (Dewey & Harrison, 2020). A multipronged targeted systematic search strategy identified 43 guidelines documents that reflected contributions of 26 authoritative entities from Australia, Canada, Europe, Italy, New Zealand, the UK and the US, alongside guidance from the WHO. Overall, it was found that many feeding recommendations (i.e., type of foods, key nutrients including iron) were consistent or generally consistent across guideline documents, with most inconsistencies relating to specific timings and ages. This is likely because of two longstanding evidence gaps on certain areas of infant feeding, namely, timing and content of complementary feeding and duration of breastfeeding (Dewey & Harrison, 2020; Fewtrell et al., 2017; Zalewski et al., 2017).

Although it is reassuring to find some global consensus on important infant feeding topics, harmonisation of current guidelines remains limited. This is because the documents tend to differ widely (i.e., type, scope, level of collaboration, wording, overall methodologies) which makes them difficult to compare. As outlined by the 2020 ad hoc committee, most recommendations have not been graded, and some appear based on little, if any, evidence (Dewey & Harrison, 2020). Furthermore, it is typical for a document to be prepared by a single organisation, thereby procuring cohesive decisions in an informed, cost-effective and timely manner is less possible. This highlights a responsibility to carefully interpret dietary advice (even if consistent across countries) that may be partial, out of date or where clinical data is not available, while also advocating for greater collaboration and more longitudinal RCTs and systematic reviews (Maki et al., 2014; Zalewski et al., 2017).

The review process: New Zealand

New Zealand, like many countries, relies on the collaborative work of the WHO and FAO to review, establish and disseminate information on human nutrition for their dietary guidelines (WHO, n.d.-a). Historically, the infant feeding dietary guideline background papers, developed under the Ministry of Health, summarise the available evidence within the New Zealand context (Ministry of Health, 2008). Issue-based documents provide in-depth reviews beyond what is covered in the background papers (Gerritsen & Wall, 2017). Currently, New Zealand is transitioning towards presenting food and nutrition guidelines in a more user-friendly format that outlines evidence-based eating and physical activity statements, followed by why each is recommended and how these can be put into practice. However, until the transition is complete, the above-mentioned background papers remain the most current infant nutrition advice. Overall, these documents and changes show increasing interest in translating evidence into simple guidance, and the application of a review process that aligns with international best practice, including the use of systematic reviews, food modelling and graded evidence (Baghurst, 2003; Ministry of Health, 2020d; National Health and Medical Research Council [NHMRC], 2013a).

One of the consequences of moving towards an evidenced-based approach is an increased demand on time and resources (Baghurst, 2003), which may delay dissemination of the most up-to-date dietary advice. For example, the update of advice for pregnant and breastfeeding women involved:

- a review of several international guidelines, systematic reviews and existing New Zealand guidelines to draft statements;
- establishment of and then consultation with a technical advisory group who were experts in maternal and child nutrition to further develop draft statements;
- testing of statements with the public and practitioners;
- collating and reviewing stakeholder feedback;
- additional guidance from the technical advisory group, other experts and practitioners on final statements.

This process began in 2019 and was completed at the end of 2020. Since a similar process is needed for each population group, a staggered effect of updating and releasing guidelines has occurred. The Covid-19 pandemic may also have incurred delays. International collaboration may improve human resource and the capacity to update all population groups at the same time (Baghurst, 2003; Magni et al., 2017). In addition, since it is difficult to form guidelines where evidence does not exist, conducting well-funded high-quality trials could facilitate the speed of consensus.

Breastfeeding

Human milk is the safest and most ideal nutrition for infants (Andreas et al., 2015; Ministry of Health, 2008, 2020c). Exclusive breastfeeding (EBF) is typically defined as receiving only breast milk and no other solids or liquids (including infant formula) except medications or supplements (Ministry of Health, 2008; NHMRC, 2013a; World Health Assembly, 2002). Partial, mixed or any breastfeeding refers to a child receiving some breast milk but also receiving other milk and/or solids (Gontijo de Castro et al., 2018). The Ministry of Health recommend EBF to around 6 months of age, then continued breastfeeding up to two years or longer (Ministry of Health, 2020c). All dietary guidelines promote breastfeeding due to convincing evidence of the associated benefits to health (Victora et al., 2016) and the environment (Davidove & Dorsey, 2019). Thus, it makes sense that any complementary feeding intervention advocate for and demonstrate a sound understanding of the importance of breastfeeding.

For infants, the health benefits of breastfeeding may include improved physical and emotional/psychological development (Horta & Victora, 2013; Saini, 2018), protection against mortality and morbidity caused by infectious diseases, reduced hospitalisation (Sankar et al., 2015; Scientific Advisory Committee on Nutrition [SACN], 2018), fewer dental malocclusions, improved intelligence (Horta et al., 2015), and protection against sudden unexplained death in infancy (SUDI) (Hauck et al., 2011; Sankar et al., 2015). Recent reviews suggest that children who are breastfed may be less likely to be overweight or obese in later life (Binns et al., 2016; Patro-Gołąb et al., 2018; Victora et al., 2016), and have a reduced likelihood of developing other health problems, such as type 2 diabetes (Horta & Victora, 2013; Horta et al., 2015; Koletzko et al., 2019).

For mothers, the health benefits of breastfeeding may include improved maternal weight loss after birth, delayed return of menses for improved birth spacing, a reduced risk of breast cancer (Fewtrell et al., 2017; Kramer & Kakuma, 2012; Ministry of Health, 2008; Pan American Health Organization [PAHO], 2003; WHO, 2009) and ovarian cancer (Chowdhury et al., 2015; Victora et al., 2016) and protection against various chronic diseases such as diabetes and cardiovascular disease (Aune et al., 2014; Binns et al., 2016).

Health authorities and providers worldwide have increased efforts to improve breastfeeding rates (WHO, 2010a; WHO, n.d.-b). However, although most infants may be initially breastfed, many do not receive the recommended duration of any or EBF (AIHW, 2011; Castro et al., 2017; United Nations Children's Fund, 2021; Victora et al., 2016). In one meta-analysis on breastfeeding in the 21st century (Victora et al., 2016), about 82 % of infants living in high-income countries were ever breastfed but < 20 % were breastfed for one year or beyond. It was noted that breastfeeding at 12 months was considerably lower in the UK (< 1 %) versus the US (27 %).

From a global perspective, breastfeeding initiation rates in Australia and New Zealand may be relatively higher but the prevalence of continued breastfeeding appears similar to other countries (Australian Institute of Family Studies, 2009; AIHW, 2011; Castro et al., 2017; Heath et al., 2002a; Ministry of Health, 2020b; Newby & Davies, 2015). According to the 2010 National Infant Feeding Survey in Australia, 9 out of 10 (96 %) infants initiated EBF, but less than 2 in 10 (2 %) met the WHO recommendation to EBF to 6 months; only 39 % were EBF to 3 months and 15 % were EBF past 5 months of age (AIHW, 2011). In New Zealand, the 2019/20 National Health Survey found 49.8 % of infants were EBF until 4 + months, and only 7.6 % EBF until 6 + months of age; the latter a significant 3.2 % decrease since 2011/12 (Ministry of Health, 2020b). Other data from Well Child/Tamariki Ora, an infant health service in New Zealand, found 61 % of New Zealand infants were exclusively or fully breastfed at 3 months of age in 2020, with rates lower in highly deprived areas and overall well below the national target of 70 % (Nationwide Service Framework Library, 2020). That said, births are often missed (Castro et al., 2017) and methodologies to assess and definitions used to describe BF initiation and duration differ between countries, thus comparability of data is limited (Heath et al., 2002a; Victora et al., 2016).

Various reasons exist as to why guidelines for breastfeeding and EBF are not being met, including poor self-efficacy, the perception of short milk supply, low intention to breastfeeding, higher maternal BMI (> 25kg/m^2), returning to work and breastfeeding problems (e.g., poor latch, breast discomfort) (Shortis, 2019; Tang et al., 2019). In the UK, mothers living in wealthier areas who are in a managerial and professional occupations, or have previously given birth, may be more likely to initiate breastfeeding (McAndrew et al., 2012). In Australia, one of the most common barriers for breastfeeding is a previously unsuccessful experience (Burns et al., 2020). For New Zealand families, shorter breastfeeding durations may be associated with unplanned pregnancies, younger maternal age (< 20 years old), lower maternal education, lower parity (first pregnancy) and maternal ethnicity (Māori, Pacific or Asian) (Castro et al., 2017).

To address suboptimal breastfeeding rates, the 2016 Lancet Series suggest a multilevel approach which includes legal and policy directives, social support, women's employment conditions, and access to education and healthcare services that help women implement their right to breastfeed (Rollins et al., 2016). The Eating and Activity Guidelines for Adults offer different ways for everyone to play a role in encouraging, supporting and promoting breastfeeding (Ministry of Health, 2020c). For example, fathers, partners and family/whānau can attend antenatal classes or help with housework. According to Gerritsen and Wall (2017), there is Grade A evidence to show that having a supportive partner with positive attitudes and beliefs about breastfeeding improves breastfeeding intention, initiation and duration and a woman's self-efficacy to breastfeed. Meanwhile, a lack of family support (e.g., from a father or grandmother) can be a barrier to breastfeeding

(Shortis, 2019). In view of the importance of breastfeeding and global efforts to improve breastfeeding rates, it is integral for infant feeding trials to include the protection of breastfeeding within the study design.

Complementary feeding

The WHO defines complementary feeding (CF) as ‘the process starting when breast milk alone is no longer sufficient to meet the nutritional requirements of infants, and therefore other foods and liquids are needed, along with breast milk’ (PAHO, 2003). The term weaning is used interchangeably but is less preferred as it may imply breastfeeding cessation (Ministry of Health, 2008; Warren, 2018).

The CF period is an important milestone by which significant changes in dietary intake and increased vulnerability to under or over nutrition could impact a child’s growth, development and later health (Agostoni et al., 2008; Netting & Makrides, 2017). In comparison to breastfeeding, there is relatively less literature describing the CF period, particularly on timing, content and practices (Fewtrell et al., 2017; SACN, 2018).

Timing of introduction of complementary feeding

Starting solids at around 6 months of age is recommended, yet many infants likely start CF earlier.

It is agreed that by 6 months of age it becomes increasingly difficult for an infant to meet nutrient needs from breast milk alone (Ministry of Health, 2008; WHO, 2003a). Iron and zinc stores have declined since birth and breast milk is a poor iron source, thus complementary foods and liquids are needed (Friel et al., 2018; Lapillonne & Becquet, 2017). However, there is ongoing controversy around the optimal duration of EBF and the timing of introducing complementary foods (Borowitz, 2021; Costantini et al., 2019; Dewey & Harrison, 2020).

In 2002, the WHO dietary guidelines were changed from EBF for 4 to 6 months to EBF for the first 6 months of life (World Health Assembly, 2002). Subsequently, the target range for the CF period increased to 6 to 24 months of age, although BF could continue beyond two years if desired by the mother and infant (PAHO, 2003). Following this, the UK, New Zealand and Australia recommend infants start CF at around 6 months of age, alongside breastfeeding, until at least one year of age, or beyond (Ministry of Health, 2008; NHMRC, 2013a; SACN, 2018); but to align with the latest breastfeeding guidelines in New Zealand, upcoming infant feeding guidelines may advise infants are breastfed for up to two years or more (Ministry of Health, 2020c). In contrast, some countries (e.g., Belgium, Spain) continue to recommend starting CF between 4 and 6 months of age (Costantini et al., 2019;

Warren, 2018). Likewise, the European Society for Paediatric Gastroenterology, Hepatology and Nutrition (ESPGHAN) recommend that complementary foods (solids and liquids other than breast milk or infant formula) should not be introduced before 4 months but no later than 6 months (Fewtrell et al., 2017).

International variations across infant feeding guidelines largely derive from limitations within the literature, as previously noted (Agostoni et al., 2008; Dewey & Harrison, 2020; European Food Safety Authority [EFSA], 2013; EFSA Panel on Dietetic Products and Nutrition and Allergies, 2009; Fewtrell et al., 2017). A common critique is that the WHO primarily based EBF guidelines on a systematic review comparing EBF for 6 months to EBF for 3 to 4 months with partial breastfeeding until 6 months, lacking a consideration of the optimal time to introduce solid foods in formula-fed infants (Kramer & Kakuma, 2004). Also, only two RCTs out of 16 eligible studies compared different EBF recommendations, and both were conducted in the low-income setting of Honduras (Cohen et al., 1994; Dewey et al., 1998). From these studies, it was concluded that there were no significant differences in growth nor food allergy risk between infants EBF for 6 months compared to those breastfed for shorter durations. Iron supplementation (Kramer & Kakuma, 2004) and/or delayed cord clamping were considered effective to mitigate the risk of iron deficiency associated with 6 months EBF, rather than early introduction of CF (Blouin et al., 2011; Gyorkos et al., 2012; Pérez-Escamilla et al., 2019; WHO, 2014b).

The WHO recommendation of EBF for 6 months was reaffirmed in 2012 through an updated systematic review, which markedly found no new RCTs and lacked studies that investigated the protective effects of breastfeeding beyond 12 months of age against chronic disease (Kramer & Kakuma, 2012). In view of this, New Zealand adopted the more flexible guidelines of 'around' 6 months, and more attainable recommendation to continue breastfeeding until at least one year of age (Ministry of Health, 2008). It was hoped that this would increase the age in which complementary foods were introduced and avoid the risk of making breastfeeding 'too hard', while considering differences in family circumstances and infant development (Ministry of Health, 2008).

Since the updated WHO review, only one RCT has investigated the effects of the timing of CF on growth and weight outcomes in a high income setting (Wells et al., 2012). In this small (n = 100) trial, infants living in Iceland were randomised to either EBF for 6 months versus receiving complementary foods from 4 months of age in addition to breast milk (Wells et al., 2012). Similar to the findings from the Honduran studies, there were no differences in growth and body composition up to 6 months (Wells et al., 2012) or pre-school age (Jonsdottir et al., 2014). At the end of the intervention, iron stores were higher in those starting solids at 4 months, compared with those of 6 months EBF (Jonsdottir et al., 2012). However, no baseline measures for iron status were collected, which means that those starting at 4 months may have had higher iron stores to begin with. The relatively small sample size, self-selected group and presence of infant characteristics (e.g., high birth weight, mostly formula-fed) that were not typical of most European populations limited generalisability of findings. Nevertheless, this study provided key evidence to inform the ESPHAN position on CF (Fewtrell et al., 2017) and may help to explain why guidelines are not consistent in the recommended age of introduction of iron-rich complementary foods (Dewey & Harrison, 2020).

Despite the controversy, most authorities agree that infants should not start solids before 4 months of age, and that infants should be developmentally ready to start CF (Dewey & Harrison, 2020; Fewtrell et al., 2017; Ministry of Health, 2008; NHMRC, 2013a; SACN, 2018; WHO, 2009). Between 4 and 6 months, infants typically start to show signs that they are developmentally ready to eat solid food safely (**Figure 2.1**) (Arvedson, 2006; Carruth & Skinner, 2002; Ministry of Health, 2008; Naylor & Morrow, 2001). By 4 months, infants are able to digest solid food, with further gastrointestinal maturation being driven by the foods ingested (Naylor & Morrow, 2001).

Figure 2. 1. Signs of developmental readiness to start complementary feeding at around 6 months of age

Note. Created by PhD candidate. Written permission to use images was provided by the infant's mother and content reviewed by a panel of expert nutritionist/dietitians.

In practice, infants in New Zealand and across the world (including in Australia, UK, Italy, Nigeria, Tibet, South Africa) typically begin CF before the age of 6 months (Arora et al., 2020; Costantini et al., 2019; Gontijo de Castro et al., 2018). The GUiNZ study found that while just over half of infants (56.9 %) were introduced to solid foods at around 6 months of age (5 to < 7 months old), 39.9 % were introduced to solid foods early (before 5 months of age) and the rest were introduced late (7 to 9 months of age). The 2019/20 New Zealand Health Survey found 8 % of infants had started solids before 4 months and almost half (47.4 %; a significant 2.3 % decrease since 2011/12) started before 6 months (Ministry of Health, 2020b). Cross-sectional studies among cohorts from Europe, Australia and the UK have found infants starting CF at 4 or 5 months old (Arora et al., 2020; Costantini et al., 2019; McAndrew et al., 2012; Schiess et al., 2010).

Reasons for introducing solids before the recommended time include several factors, including country of residence, young maternal age, lower parental education level and socioeconomic status (Arora et al., 2020; Schiess et al., 2010). In the Australian 'Healthy Smiles Healthy Kids' birth cohort study (n = 934), independently associated risk factors for the very early introduction of solids (< 17 weeks) were: marital status (single mother), decreased maternal age (< 25 years), returning to work late (12 months postpartum), maternal birth place (Australia) and exclusive formula feeding at 4 weeks of age (Agostoni et al., 2008). Mothers' self-reported reasons for introducing solids early included 'baby hungry', 'baby old enough to wean', 'advised by family/friends', 'to settle the baby/assist with sleep' and 'baby interested'. Within GUiNZ, mothers of Māori ethnicity, lower education and those living in deprived neighbourhoods were less likely to adhere to the guideline of introducing solids around 6 months (Gontijo de Castro et al., 2018).

Understanding the determinants of CF remains challenging largely due to the complexity of interacting variables, the presence of information bias (e.g., from convenience sampling and self-reported data) and studies using various definitions or cut-offs for CF timing (e.g., 17 weeks versus 4 months) (Arora et al., 2020; Gontijo de Castro et al., 2018). In addition, the effects of other variables require further investigation such as paid maternal leave, women's workplace support and health care advice (Gontijo de Castro et al., 2018).

Complementary foods for infants

Fruit, vegetables and iron-rich foods are recommended CF foods, which infants typically receive but order/variety varies.

In most countries, recommended first complementary foods include puréed fruit, vegetables and iron-rich foods such as meat and iron-fortified infant cereal (Binns et al., 2018; Dewey & Harrison, 2020; Ministry of Health, 2008; NHMRC, 2013b; PAHO, 2003; SACN, 2018). These foods should complement the energy and nutrients (especially iron and zinc) supplied by breast milk or infant formula for growth and development (Ministry of Health, 2008; SACN, 2018).

Recommended serving sizes per food group are not generally specified for infants likely due to a lack of evidence, natural variation in infant food intake (depending on infants' breast milk intake and growth rate), and a focus on feeding infants according to hunger and satiety cues rather than exact amounts that may encourage pressuring to eat (Ministry of Health, 2008; WHO, 2003a). However, despite some differences in wording, there is some generally consistent advice on meal frequency and amount of food per meal; noting that a 'meal' could include a single fruit or vegetables or be a mix of food groups. Most guidelines recommend that a consistent meal schedule be established and that young children require several eating occasions, both meals and snacks, over the course of the day (Dewey & Harrison, 2020). New Zealand infant feeding guidelines recommend at the start of CF to introduce small amounts of food, ½ to 2 teaspoons at first and then gradually increasing the amount until the infant is having about 3–4 teaspoons or half a cup per meal before increasing the number of meals (Ministry of Health, 2008, 2013). In accordance with WHO guidelines (PAHO, 2003; WHO, 2003a), it is also recommended that meals are provided 2–3 times per day when the infant is 6–8 months of age, progressing to 3–4 times per day with one to two snacks as needed. However, caregivers are reminded that each infant is different, and some may eat more than others.

Evidence to support introducing foods in a specific order is generally lacking, with recommendations often based on infant iron needs, cultural factors and food availability (Fewtrell et al., 2017). For example, infant feeding guidelines for the Asia Pacific region specify infants start with a traditional food (e.g., rice porridge), then after a few days add fruit, vegetables, meat and fish (Binns et al., 2018). WHO guidelines are more broad, stating that meat, poultry, fish or eggs should be eaten daily or as often as possible during the CF period, as well as Vitamin A rich fruit and vegetables (PAHO, 2003; WHO, 2003a). In New Zealand, Australia and the US, a specific order is similarly not well defined but puréed meat/chicken, fruit, vegetables, and iron-fortified infant cereal are recommended as suitable starter foods (Ministry of Health, 2008; NHMRC, 2013b; USDA, 2019). In the UK, following a report by the UK Public Health England and Scientific Advisory Committee on Nutrition's (SACN, 2018), NHS recommendations encourage parents to give a single vegetable and fruit as first foods (NHS, n.d.). This relates to the new interest in prioritising vegetables as first complementary foods (Chambers et al., 2016), which will be discussed further in a later section.

In practice, many families may be providing suitable complementary foods in the broad sense of providing fruit, vegetables, meat and infant cereals, but the order and timing of each can vary (Nicklaus et al., 2015). In FITS 2018, the most commonly consumed complementary food amongst US 4- to 5.9-month-olds was iron-fortified infant cereal (50 %). Commercially available fruit and vegetable infant foods were the second and third most commonly consumed food, respectively (29 % and 27 %). Few consumed meat/other protein food (4.3 %) but this increased (41 %) by the age of 6- to 11.9 months (Roess et al., 2018). Older data from another US large longitudinal birth cohort study found infant cereals were typically introduced first and remained the most common complementary food until around 8 months of age (Grummer-Strawn et al., 2008). The median age for fruit and vegetable introduction was 5 to 6 months, while introduction of meat was around 8 months of age.

In a Norwegian cross-sectional study (n = 715) of CF practices found that the most common food to be first introduced was commercially available porridge. Vegetables and fruit were the next most common, but less than 10 % of infants were introduced to meat/fish at age 5.5 months (Helle et al., 2018). Recent results from a national prospective cohort study (n = 3368) in France showed infant cereals (unclear if these were iron-fortified) and then fruit and vegetables were given as first complementary foods between 4 and 6 months, and less than half (about 30 %) were having meat and fish at 6 months, but this increased to 90 % by one year of age (Boudet-Berquier et al., 2017). Prior to this, a longitudinal survey in France indicated that fruit and vegetables were typically introduced as first foods, and at around seven months, foods were introduced in the order of dairy products, cereal and then meat (Lange et al., 2013).

By contrast, a greater proportion of New Zealand infants may be receiving suitable complementary foods, particularly with regards to meat, but practices could be improved. A recent large, fairly representative internet survey of New Zealand infants (n = 876) explored food fussiness and early feeding characteristics, including first food choices of infants following BLW or traditional-spoon feeding (TSF) (Fu et al., 2018); a comparison of interest as BLW – in which the infant is allowed to entirely self-feed finger foods from the start of CF – is popular but not currently recommended due to insufficient evidence for its nutritional safety and choking risk (Ministry of Health, 2018a). In the total sample, 48 % of 6-month-old infants consumed iron-fortified infant cereals, while 56 % consumed red meat. A greater proportion of TSF infants (57 %) ate cereals compared to BLW infants (40 %), while fewer TSF infants ate red meat (52 %) compared to BLW infants (65 %). Infants following full BLW (most or entirely self-fed) were less likely to consume 'more fruit than vegetables' when solids were first introduced (8 %) compared to TSF infants (19 %; $P = 0.002$). Regardless of feeding method, the highest proportion (47 %) of infants were first introduced to 'half fruits, half vegetables', while some (32 %) received 'mainly vegetables, some fruits', and few received only fruits (1 %) or only vegetables (4 %) (Fu et al., 2018). Meanwhile, the GUiNZ study found the most common first foods to be introduced were baby rice (84.1 % at 5 months), followed soon after by fruit and vegetables (97.9 % and 96.6 % at 6 months, respectively), then meat/chicken and fish slightly later (89.7 % and 54.8 % at 7 months, respectively) (Morton et al., 2012).

Several factors affect the order of first food introduction, including cultural influences (Nicklaus et al., 2015), convenience (i.e., easier to purchase ready-made infant foods that are limited in variety, compared to home-made) (Katiforis et al., 2021; Moding et al., 2018), and poor access to foods (Bailey et al., 2019; Miller et al., 2016). As fruit, vegetables and meat are relatively costly, it is possible that some infants receive cheaper foods such as grains and porridge as a result of living within a low-income household (Miller et al., 2016). It is known that in several West African developing countries (e.g., Ethiopia, Nigeria), where access to a variety of food is often limited, infants receive mostly homemade complementary foods that are plant-based, non-fortified staple cereals or starchy tubers (e.g., maize, rice, potato, yam) as first complementary foods (Abeshu et al., 2016) and a low portion of animal-source foods, fruits and vegetables are provided. In the Asia Pacific region, tradition may be a greater factor, for example, rice-based foods have been reported as culturally the most popular first complementary food, followed by fruit; whereas some countries such as Malaysia (Inoue & Binns, 2014) and Thailand (Jackson et al., 1992) may provide fish or soft meat by 6 months of age.

Safe and positive feeding environment for infants

Feeding to infant hunger/fullness cues is encouraged, but not always practiced.

Creating a safe and positive feeding environment is important for infants learning to eat and accept new foods (Lafraire et al., 2016; Ministry of Health, 2008; Nicklaus, 2016). Mealtime recommendations include sitting the infant in a highchair or similar, removing distractions (e.g., no television or screens) and supervising infants at all times (Ministry of Health, 2008; Pérez-Escamilla et al., 2017). This may foster responsive feeding, by which caregivers pay close attention and appropriately respond to infant hunger and fullness cues (**Table 2.2**) (Hetherington, 2020; Pérez-Escamilla et al., 2017), as recommended by most dietary guidelines (Dewey & Harrison, 2020). This is in contrast to non-responsive feeding that features a lack of reciprocity between caregiver and infant, with the caregiver or infant taking excessive control of the feeding situation, or the caregiver being uninvolved during meals.

Table 2. 2. Hunger and fullness cues during the complementary feeding period: adapted and simplified from Hetherington at al. (2019)

Hunger	Fullness
Agitation	Eating/sucking slows
Fussing	Closes mouth
Crying	Gaze aversion
Excitement in the presence of food	Pushes food away
(e.g., waves arms)	Turns head or body away
Reaches for food	Plays with food/utensils
Points to food	Shakes head to signal ‘no more’
Vocalises and/or gestures an	Gets restless to leave table
interest or need to eat	Specific utterances (e.g., ‘all done’)

Infants who feed in a responsive and positive environment are more likely to enjoy meals and practice self-regulation of food intake, which is further hypothesised to prevent inappropriate weight gain associated with under- or overeating (DiSantis et al., 2011; Gerritsen & Wall, 2017; Hetherington, 2020; Pérez-Escamilla et al., 2017). The *How We Eat* report by Gerritsen et al. (2017) indicated the strength of their dietary advice using the NHMRC grades (A to D) of recommendations (NHMRC, 2009). For example, Grade A was allocated if the body of evidence can be trusted to guide practice, then Grade B if it can be trusted to guide practice in most situations, and so on. The report found Grade B evidence to show that responsive feeding can lead to small improvements in the diet, food preferences and eating behaviours of infants and toddlers, while also being protective against excessive weight gain. There was Grade A evidence to show that coercive practices such as pressure to eat or food restriction can lead to poor dietary behaviours and increased body weight (Gerritsen & Wall, 2017). The supporting evidence for these statements included eight systematic reviews (Cameron et al., 2012; Clark et al., 2007; Fraser et al., 2011; Hurley et al., 2011; Russell et al., 2016; Shloim et al., 2015; Ventura & Birch, 2008) and one RCT (Magarey et al., 2016).

Other papers could be added to the evidence reviewed in the *How We Eat* report. For example, the INSIGHT longitudinal RCT (n = 291) (Hohman et al., 2017) investigated the effects of a responsive feeding intervention on infant dietary patterns. Infants of mothers who received a responsive feeding intervention were less likely to consume diets low in fruits and vegetables, compared to those without responsive feeding exposure. In an experiment by Moding et al. (2014), mother-infant dyads (n = 89) were video-recorded during a novel food (hummus, cottage cheese) feeding task. There was an inverse relationship between maternal responsiveness and acceptance of the new food. In both studies, generalisability of findings remains limited by the use of small demographically homogenous samples, and because the impact of other factors such as genetic influences, early food experiences have not been examined. In a more recent Dutch study involving 246 first-time mothers and their infants, whose feeding interactions were videotaped, maternal behaviour during feeding (e.g., responsiveness to fullness cues) was associated with infant vegetable intake and liking of the very first bites of solid food; but this study was not an experimental design and observations were made over two days only (van Vliet et al., 2021). Addressing the limitations of these studies in future research, ideally through more clinical trials that infer causality, may be needed to better understand the role that responsive feeding plays in vegetable acceptance.

In reality, non-responsive feeding practices including bribing, forcing and pressuring children to eat continue (Daniels, 2019; Haszard et al., 2019). Qualitative research involving six focus groups with Māori, Pacific and low-income first time mothers of infants aged 6 to 23 months found mothers had limited knowledge of responsive feeding and did not find associated benefits immediately obvious (Research New Zealand Limited, 2014). Most had adopted more controlling or structured feeding practices and lacked confidence in reading infant hunger/satiety cues, which appeared related to a desire to establish a routine as soon as possible. Other qualitative and cross-sectional studies in Canada and the US report that while parents have the best intentions to feed their infant responsively, factors such as limited time, societal pressures (including public health messages to eat more fruit and vegetables) and knowledge deficits may make it difficult for them to implement and sustain the practice without adequate support (Almaatani et al., 2017; Bante et al., 2008; Tucker et al., 2006).

Conclusion

With scientific advances, socioeconomic trends and rising concerns about population health, infant feeding guidelines have significantly evolved over time and taken on an evidence-based approach (Dewey & Harrison, 2020). However, vegetables have always been promoted as an important part of a child's diet, including during the CF period (Kleinman & Coletta, 2016). Growing consensus between organisations on a number of infant feeding topics is positive, but important feeding recommendations remain inconsistent. This is partly due to insufficient evidence and/or collaborative effort between expert groups, thus research to fill these gaps is necessary to facilitate the development of cohesive and clear dietary guidelines. Meanwhile, more work is needed to improve low adherence to infant feeding recommendations, particularly with respect to breastfeeding duration, responsive feeding and provision of vegetables and meat during the CF period. Studies investigating the best ways to support young families with their infant feeding needs are required.

2.5. Dietary strategies to improve children's vegetable consumption

Existing reviews on strategies to facilitate vegetable acceptance in children focus on the age of two years and beyond (Evans et al., 2012; Hendrie et al., 2017; Holley et al., 2017). A comprehensive systematic review by Barends et al. (2019) extended the literature by including the period from the start of CF until the age of three years. From 46 papers, six strategies were assessed: repeated exposure; flavour-flavour learning; variety; starting with vegetables/stepwise introduction; and visual exposure/sensory engagement. The most promising of these were repeated exposure to vegetables, giving a different type of vegetable every day (variety) and introducing vegetables at the time that solid foods are first introduced (Barends et al., 2019). Previously, a consensus paper proposed that there is enough evidence to start recommending that infants taste a variety of vegetables from the start of CF in order to improve their acceptance of vegetables, but the need for more longitudinal RCTs was highlighted (Chambers et al., 2016).

Given recent interest in the emerging evidence on introducing vegetables at the beginning of CF to promote vegetable acceptance, the following section will discuss studies on this topic in detail (Bell et al., 2021). The strategies of repeated exposure to a variety of vegetables and early flavour experiences (i.e., as through maternal diet and breast milk) will be covered briefly as these are closely related but more established.

A vegetables first approach to complementary feeding

A vegetables first approach to CF prioritises the introduction of vegetables at the time that CF begins (Barends et al., 2019; Chambers, 2016; Chambers et al., 2016). According to a consensus paper (Chambers et al., 2016), the practice should familiarise infants with a range of vegetables at the earliest opportunity, but also include the provision of iron-rich foods, such as meat and pulses, for infants starting CF at around 6 months of age.

The focus is on vegetables, as these are typically less well accepted and consumed by children, but the introduction of other difficult to accept foods such as sour fruits may be required to improve acceptance of those foods. Offering vegetables first also works to capitalise on infants' particular willingness to try a range of new foods at the start of CF. In a review on sensitive periods for food acceptance, the age of 4–6 months was indicated as a time in which infants find it easier to eat and learn to like novel foods including vegetables (Harris & Mason, 2017). This ability was recently supported by findings from the Good Tastes Study, which showed infants (6 to < 12 months) accepted more tastes and were rated by caregivers as liking plain kale purée more than older toddlers; plain kale was also more likely to be accepted than kale with added sugar or salt (Johnson et al., 2021).

Overall, the goal of a vegetables first approach to CF is to help children establish a lifelong preference and habitual intake of health protective vegetables (Chambers et al., 2016). To date, three key studies have specifically investigated the impact of providing vegetables at the start of CF on children's vegetable acceptance. These interventions are summarised in **Table 2.3**, followed by a detailed review of each.

Table 2. 3. Intervention studies investigating a vegetables first approach to complementary feeding (CF)

Authors (year) country	Sample	Study design	Duration	Outcome variables [a]	Hypotheses
Barends et al. (2013, 2014) Netherlands	N = 101 Mean age 5.4m (range 4-6m) *Follow-up 1:* N = 84 Mean age 12m (±1.4m) *Follow-up 2:* N = 81 Mean age: 23m (±1m)	Longitudinal RCT	19 days ↓ 2 days per follow-up	*Primary:* intake of target vegetables/fruit over time *Secondary:* liking of target vegetables/fruit over time	Repeated exposure to a vegetable or fruit will increase its intake. Starting CF with vegetables only will result in higher vegetable acceptance than starting with fruit; and effects will endure until 24 months of age.
Fildes et al. (2015) UK, Greece, Portugal	N = 139 Mean age 5.2m (±0.6m)	RCT	15 days	*Primary:* intake (grams) of a novel vegetable *Secondary:* liking for the novel vegetable, as rated by mothers and researchers	Parental advice on a vegetables first approach will increase vegetable acceptance in infancy, compared to standard advice.
Hetherington et al. (2015) UK	N = 36 Mean age 4.8m (±0.6m) *Follow-up 1:* N = 31 Age ~12m *Follow-up 2:* N = 14. Age ~24m	Longitudinal RCT	35 days ↓ 1 day per follow-up	*Primary:* intake (grams) and liking of pure vegetables Secondary: acceptability of the intervention among mothers	A gradual introduction to vegetable flavours from the start of CF will increase intake and liking of vegetables (target and novel); and effects will endure until 24 months of age.

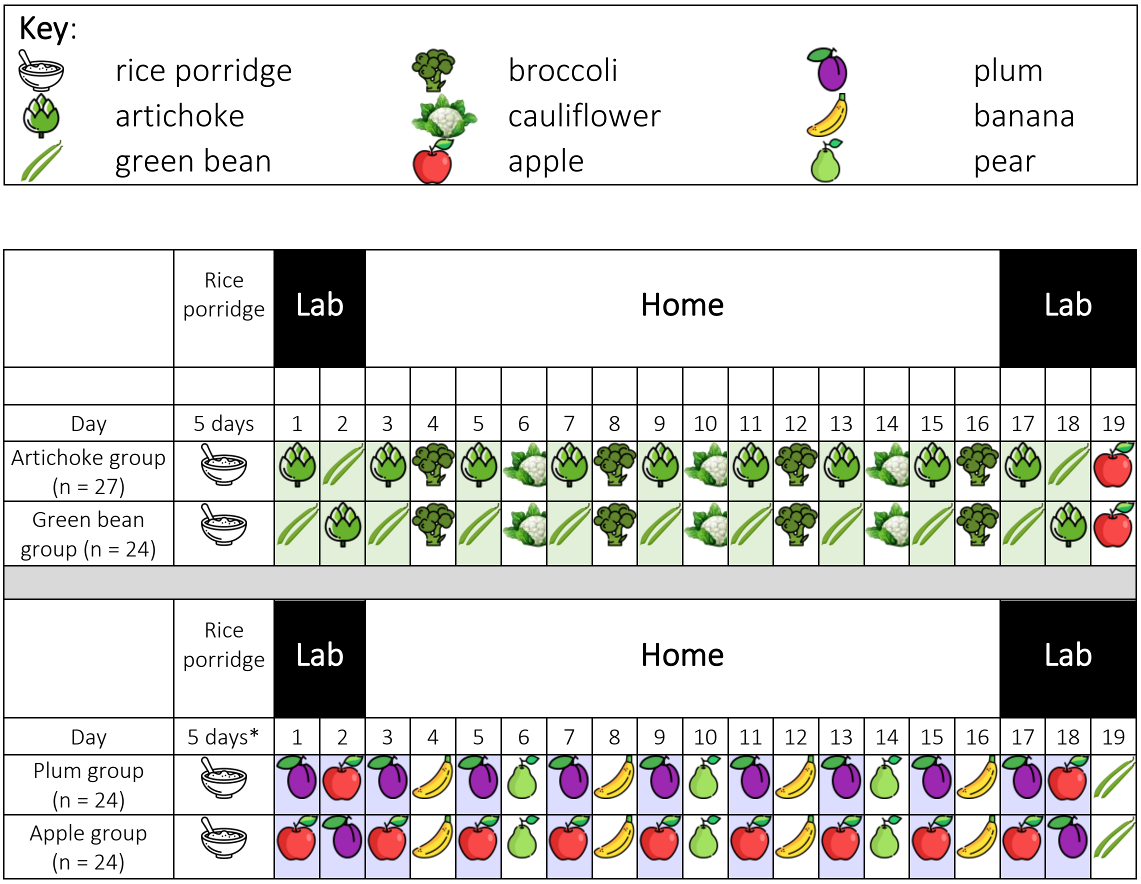
Note. N = sample number of mother-infant dyads, m = months, UK = United Kingdom, RCT = randomised control trial. [a] Assessment tools are detailed in a later section.

Netherlands study: fruit-only versus vegetables-only

Barends et al. (2013, 2014) was one of the first studies to investigate a vegetables first approach to CF. Their RCT investigated the effects of repeated exposure to either vegetables or fruits on infants' acceptance of those foods during the first 18 days of CF. Intake (grams) of foods recorded at the beginning and end of the intervention was the primary outcome measure, and follow-ups conducted about six and 17 months later.

Figure 2.2 shows the feeding schedule for the baseline study and the four possible arms that the healthy Dutch infants (n = 101) aged 4–6 months were randomly assigned to. On day 19, the vegetable groups received their first fruit purée, and the fruit groups received their first vegetable purée. Target vegetables and fruits were chosen based on what was familiar and unfamiliar to the Netherlands population, and infant rice porridge provided to first help infants get accustomed to eating solid food (before the intervention) and then meet additional infant dietary needs (during the intervention).

Figure 2. 2. Feeding schedule used for each treatment group in the baseline study by Barends et al. (2013)



Note. Target purées: artichoke (variety not specified); green bean; apple; plum. Other purées: broccoli; cauliflower; banana; pear; rice porridge. *rice porridge also freely provided throughout intervention. Adapted from Barends et al. (2013).

Their key results are summarised as follows:

- Significant increased intake of target foods (green beans and plums) between day 1 and 18 (P < 0.001 for both foods).
- No effect on artichoke intake in the artichoke group (P = 0.603), which stayed low (< 30 grams).

- No significant increase in apple intake in the fruit groups (apple group, P = 0.103; plum group, P = 0.033), which was already high at the start (> 40 grams).
- Fruit group's intake of vegetables on day 19 was equal to vegetable group's first intake of vegetables on day 1 (P = 0.814).
- Vegetable group's intake of fruit on day 19 was equal to fruit group's first intake of fruit on day 1 (P = 0.842).
- Fruit intake was higher than vegetable intake for all groups.

Such findings were considered to reflect infants' innate preferences for sweet taste and aversion to bitter/sour taste, but also their ability to learn new preferences through repeated exposure. For some vegetables with a markedly sour/less sweet taste (i.e., artichoke, which infants continued to eat in smaller amounts), more exposures might be required to improve acceptance. In summary, authors showed that fruit acceptance is higher than vegetable acceptance at the first exposure, and starting CF with vegetables-only, not fruits, may promote child vegetable acceptance at least in the short-term.

Strengths of their study included the randomisation and standardised protocol with detailed participant instructions. This ensured that potential confounders (i.e., age differences in starting CF), effects of random factors (i.e., infants tired for unknown reasons) and potential bias from mother's beliefs about their child's food preferences were mitigated and evenly spread across groups.

On the other hand, there were important limitations. The primary outcome measure relied on feeding sessions in the laboratory which likely weakened the ecological validity of findings. Ecological validity typically refers to the degree that one can generalise observed behaviour in a study to natural behaviour in the world (Schmuckler, 2001), and is especially important for translational research. Furthermore, providing only fruit for 19 days is not necessarily representative of current advice (e.g., starting CF with fruit, vegetables and iron-rich foods); thus, it remains unknown if starting CF with vegetables-only has any advantage over what is presently recommended. Providing rice porridge during the habituation period and throughout the trial ad libitum may have confounded results, especially as amounts eaten were unreported, not all infants learned to eat equally well, and some mothers found that their infant disliked the porridge. The 3-day weighed food diary used to assess daily intake at the 12 and 23 month required mothers to weigh dinner items only and then use household measures for other foods, which limits accuracy. The intervention period was relatively short, with results limited to very immediate effects (i.e., days 17–19) and to the few target foods selected. Finally, while there may be benefits to convenience sampling (i.e., improved compliance), such sampling is subject to social desirability bias especially without adequate participant blinding.

Follow-up study

The follow-up study occurred when infants were 12 (n = 86) and 23 (n = 81) months of age, and examined whether baseline intervention effects were maintained (Barends et al., 2014). Daily vegetable consumption was recorded by mothers using a 3-day weighed food diary, and intake of green beans and apple purées were measured in the laboratory over two separate days in randomised order. These target foods were selected because all infants had tasted them during the baseline intervention, and additional foods were not tested due to the participant burden. Similar to the baseline study, mothers rated how much their infant liked the foods in the laboratory, but also reported on how often vegetables/fruits were consumed at home and how much their child liked them.

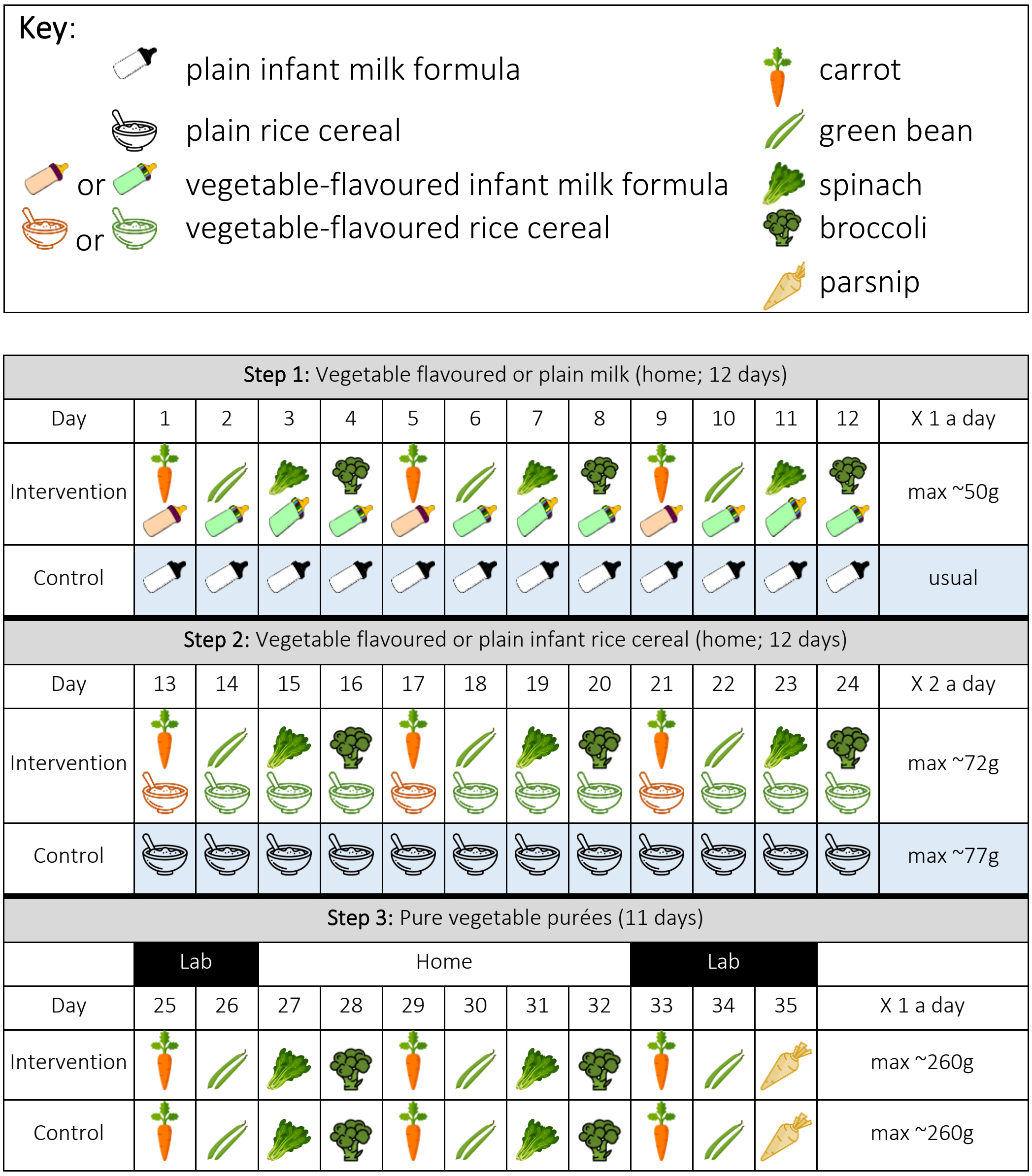
As hypothesised by authors, the infants who had started CF with vegetables continued to eat more vegetables than those who started with fruit. However, this was only true at 12 months of age and for daily vegetable/fruit intake as effects in the vegetable group had disappeared by 23 months of age, and vegetable/fruit intake in the laboratory did not differ by group at either follow-up. That said, vegetable preferences in the laboratory showed some stability over time as intake of green beans correlated between time points (i.e., baseline with 12 months, then 12 months with 23 months).

A possible reason as to why effects were not maintained at 23 months could have been due to an increase in neophobia or pickiness, but this was unclear without the use of a validated tool to assess the influence of such developmental factors. Another limitation was the continued use of purée test meals that were no longer age-appropriate in texture. While this allowed for standardisation between assessments, it is likely that infants rejected the food due to the texture rather than taste. In addition, the results of daily liking of vegetables are not available. Nonetheless, the longitudinal design of this study leads the way in furthering our knowledge of the long-term effects of a vegetables first approach to CF.

A step-by-step vegetables first approach in the UK

The next study to be published was that of Hetherington et al. (2015), which tested the effects of gradually introducing vegetables to infants at the start of CF on intake and liking of vegetables. Infants randomly assigned to the intervention group (n = 18) received a step-by-step exposure to vegetables in milk then rice cereal over 24 days. Those assigned to the control received plain milk and rice cereal. Over the next 11 days, all infants received pure vegetable purées, as illustrated in **Figure 2.3**.

Figure 2. 3. Feeding schedule used by Hetherington et al. (2015) for each treatment group



Note. Target purées: carrot, green bean, spinach, broccoli, parsnip.
Adapted from Hetherington et al. (2015).

The root vegetables and cruciferous/leafy green vegetables were selected based on what was common in the UK and because these are typically liked and disliked by children, respectively. Unlike Barends et al. (2014), this study took additional measures of food acceptance, including liking rated by both a researcher and mother, rate of acceptance, pace of eating, and meal duration. Greater resources were also available to support responsive feeding practices, as demonstrated by mothers receiving a power point presentation on how to feed infants, photos and videos of infant food refusal behaviours and real-time practice feeding their infant with a researcher present, which participants reported as very useful.

During laboratory feeding sessions, two jars (130 ml each, warmed) of the target vegetables were supplied and mothers fed their infant according to infant cues and responsive feeding practices. Similar to Barends et al. (2014), follow-ups were conducted when infants were 12 and 24 months of age to assess stability of intervention effects. At the 12-month follow-up, intake and liking of the same carrot and green bean purées tested at baseline were offered to infants at home during two separate feeding sessions. At 24 months of age, mothers were only asked to rate how often green beans and carrots were offered and how much they were liked by their infant using a questionnaire.

Their main finding was that early and gradual exposure to a rotation of vegetable flavours (added to milk then cereal) increased intake and liking of these vegetables during the first month of CF. This was based on the following results:

- Intake of target vegetables (carrots and green beans) was higher in the intervention than the control, both in the laboratory and home.

- Intake of other vegetables at home (broccoli and spinach) were higher in the intervention than control.
- Liking of carrots and green beans, as rated by researchers, was greater for intervention than control, but mother-rating liking did not differ by group.
- Intervention infants ate carrots and green beans more rapidly than controls.
- Food intake and rate of eating increased with time in both groups.
- For both groups, the order of consumption (most to least) for the four vegetables was carrots, broccoli, spinach then green beans.
- Intake of a new vegetable (parsnip) on day 35 was similar between groups, thus no evidence that effects can be generalised to new foods.
- Mode of milk feeding (breastfeeding vs formula feeding) did not predict vegetable intake; nor did mother's consumption of vegetables.
- At 12 months of age, effects of the intervention were not maintained, and similar quantities of vegetables were consumed between groups. However, intervention infants liked carrots significantly more ($P = 0.05$) and green beans marginally significantly more ($P = 0.07$) than controls. Carrots continued to be eaten more than green beans in both groups.
- At 24 months of age, analysis was not possible due to low response rate.

Like Barends et al. (2013, 2014), findings were attributed to infants being able to accept vegetables relatively well at the start of CF, especially if given a number of exposures early. In addition, pairing vegetables with the sweeter flavour of milk and allowing a smooth transition from a diluted flavour to a strong flavour (i.e., pure vegetable purées) may have improved acceptance in the intervention group (see conditioning strategies below). Reasons as to why effects were not maintained in the long-term were largely attributed to study limitations, including the use of vegetable purées that were not age-appropriate, a small sample size, short intervention duration, feeding in a laboratory and limited detail on foods eaten between the baseline study and follow-up. Also, all infants had received the same vegetable schedule during the final 11 days, thus applying a too-similar condition to both groups could have made it difficult to detect group differences. However, their study had improved on the limitation of Barends et al. (2013, 2014) in that it offered parents more infant feeding support and a longer vegetable exposure period in the home. Furthermore, a number of food acceptance variables were measured to improve accuracy of results and the step-by-step method is similar to a French practice recommended in certain national CF guidelines (Schwartz et al., 2013).

Intervention focused on dietary advice (UK, Greece and Portugal)

About eight months after the publication of the Hetherington et al. (2015) study, findings from an intervention by Fildes et al. (2015) were published. This study was conducted across three countries, namely, the UK, Greece and Portugal, and examined the impact of guiding parents to introduce a variety of single vegetables as first foods on infants' acceptance of a new vegetable. Mothers of infants (4- to 6-month-old) were randomised to receive either advice on a vegetables first approach to CF (intervention, n = 75) or 'usual care' (control, n = 71). Unlike previous studies, it was ensured that breast-fed and formula-fed infants were equally represented per group due to evidence suggesting that breast fed infants accept foods more easily than formula-fed infants.

As shown in **Figure 2.4**, one month after infants had started CF, a follow-up taste test was conducted, in which a novel vegetable (artichoke purée) was offered to infants in their home or paediatrician's office. The primary outcome was weighed intake of that vegetable. Secondary measures included infant liking, measured by mothers and researchers. Mothers were given two 130-gram jars of artichoke purée, and responsive feeding practices were encouraged. Ten minutes after this vegetable had been fed, the same procedure was repeated with a novel fruit (peach purée) for comparative purposes.

Figure 2. 4. Feeding schedule used by Fildes et al. (2015) for each treatment group

Key:
 artichoke purée
 peach purée

	Home																Home or doctor office	
Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	5 days	30	31[b]
Intervention	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	Veg + other food groups		
Control	Feed as they wish according to country-specific CF guidelines [a]. *Example recommended first foods:* • UK = fruits, vegetables and infant rice or cereal • Greece = infant rice/cereals or fruits • Portugal = not prescriptive but likely fruit, vegetables, iron-rich foods + vegetable soups or purées																	

Note. A, B, C, D, E describes rotation of 5 different single vegetables selected in consultation with mothers, but information on specific vegetables not available. Target purées: artichoke (variety not specified); peach. [a] Advice varied according to local health authority and health professional. [b] Follow-up taste tests conducted one month after starting solids, thus a 31-day month assumed but specific testing days may have varied. Created by PhD candidate from Fildes et al. (2015).

The study by Fildes et al. (2015) demonstrated that advice on introducing a variety of vegetables at the start of CF may improve vegetable acceptance among infants living in countries where vegetables are not common first foods. More specifically, results included:

- No significant difference in artichoke intake between groups in the full sample (P = 0.064).
- Researchers rated the intervention to like artichoke more than control in the full sample (P = 0.032), but mothers rated liking similarly (P = 0.052).

- Sub analysis found that the UK intervention infants ate ($P = 0.003$) and liked (researcher and mother rating, both $P < 0.001$) artichoke more than controls.
- Peach intake and liking was similar between groups for all countries, and the full sample.
- Peach was consumed in greater amounts than artichoke in all countries, except for the UK intervention group who appeared to have a low intake of both peach and artichoke.

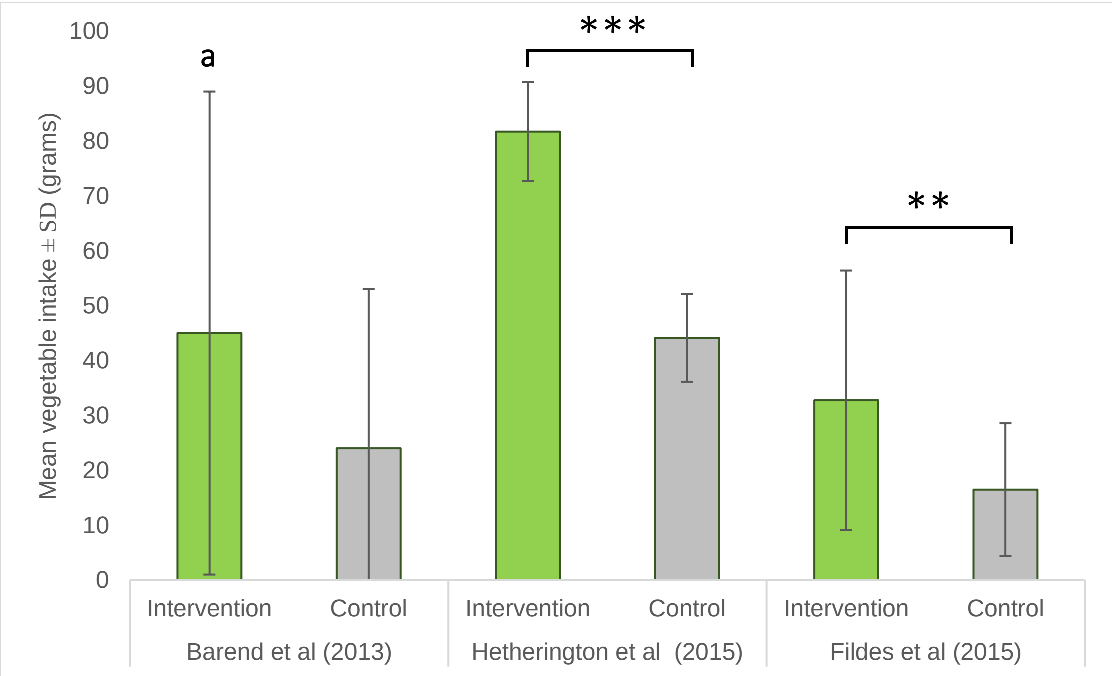
The most convincing explanation for the differences observed in the UK only was the fact that vegetables were not common first foods in that country, but other study limitations may have affected results. For example, they could not standardise the delivery of advice and a larger sample with additional follow-ups were needed to assess long-term effects. However, ecological validity of findings was good, as the entire experiment was conducted at home, advice tailored to region, options to use commercial and home-prepared vegetables were available, and a non-treatment control was included.

Summary and upcoming research on a vegetables first approach to CF

All three studies discussed are well-designed RCTs, with two of these being longitudinal (Barends et al., 2013; Barends et al., 2014; Hetherington et al., 2015). Since RCTs are considered to provide the highest level of evidence (NHMRC, 2009), the small but growing body of evidence supporting a vegetables first approach to CF remains robust and minimally affected by bias (Merlin et al., 2009). Comparability of findings is possible as all studies assess the same outcome parameters for vegetable acceptance (intake, rated liking) using similar methods (weighed food diary, 9-point liking scale). There is also evidence of consistency between feeding protocols, for example, mothers were told to feed their infant at their customary pace and time of day, to feed only the prescribed study foods in addition to their usual milk feed, and to stop feeding after three consecutive spoon refusals. In saying this, major variations in study design including different durations (ranging from 15 to 35 days), types of vegetables and fruit offered, sample sizes (range 36 to 139 participants) and number of treatment groups (range from 2 to 4) may limit comparability and generalisability of findings.

The overall conclusion drawn by all articles is that starting CF with vegetables may improve infants' vegetable acceptance. **Figure 2.5** displays the quantity of vegetables infants were consuming by the end of the intervention for each group and study. While all the articles demonstrate higher vegetable intake among the intervention than controls, it is interesting to note the particularly high vegetable intake among infants following the step-by-step approach examined by Hetherington et al. (2015), and the lower intakes observed in the study by Fildes et al. (2015). This may be due to the intensity of intervention (i.e., following a detailed and prescriptive feeding schedule versus receiving CF advice with fewer resources and support) or other factors such as population group, country, target vegetables explored, etc.

Figure 2. 5. Comparison of vegetable intake post-intervention by group and per study



Note. SD = standard deviation. In Barends et al. (2013), the vegetable treatment groups combined are taken as the intervention, and fruit groups as the control for comparative purposes; and mean day 17 and 18 of vegetable group is compared with day 19 of fruit group due to study design. Hetherington et al. (2015) compares overall vegetable intake from days 25, 26, 33 and 34 in both groups. Fildes et al. (2015) shows vegetable intake post-intervention for the UK sample. a = test for significance not available, but vegetable intake appears double the controls. **P < 0.01, ***P < 0.001.

It should be acknowledged that not all data is consistent, for example, researcher's ratings of vegetable liking tend to disagree with that of mothers, and follow-up data from laboratory feeding sessions find a lack of stability of interventions effects. Such inconsistencies are likely due to common limitations already mentioned, including the limited use of validated tools to assess infant liking, small sample sizes, offering test foods that are not age appropriate and using control groups that do not necessarily reflect common practice. Two of the three studies used data derived from laboratory feeding sessions (Barends et al., 2013; Barends et al., 2014; Hetherington et al., 2015), and while this ensured compliance, or may not have differed from home data, one cannot be certain that findings truly show what could be achieved by families in a 'real-life' scenario.

Another question that remains unanswered is whether the success of a vegetables first approach to CF depends on the education given to families. The comprehensive support on responsive feeding practices was valued by participants in the study by Hetherington et al. (2015), but it remains unclear if the education provided by other studies was equally detailed and informative. Without further analysis or a non-treatment control group that receives no advice on responsive feeding, it is difficult to ascertain the relationship between a vegetables first approach to CF, responsive feeding and vegetable acceptance.

From a more positive perspective, the uniqueness of each study may also be viewed as a strength. Each have made a valuable contribution to the literature in the sense that we now have evidence to show:

(1) starting with fruit only does not promote vegetable acceptance;

(2) providing guidance on a vegetables first approach in regions where vegetables are not common first foods could improve child vegetable acceptance;

(3) gradually introducing vegetables to first milk then infant cereal could be a useful and achievable strategy for parents wishing to foster their child's vegetable acceptance.

Together these studies demonstrate that if age-appropriate vegetable purées are offered at the beginning of CF in a responsive manner, then there is a positive impact of vegetable acceptance, at least during infancy. To build on these findings, research in Sweden and the Netherlands investigating aspects of a vegetables first approach to CF is underway (Table 2.4). The OTIS study is measuring the impact of the Nordic diet on infants' acceptance of new and unfamiliar foods including vegetables, compared to regular Swedish diet. The Baby's First Bites RCT will be the first to investigate effects of responsive feeding alongside repeated exposure to vegetables at the start of CF on infants' subsequent vegetable acceptance. In both studies, there are foreseeable limitations including the difficulty for families to adhere to protocols, use of non-validated food acceptance tools and not strictly starting with vegetable-only first complementary foods. However, they are also strong in study design, use large samples and answer unexplored variables thus should further our understanding of the optimal conditions required for a vegetables first approach.

Table 2. 4. Intervention studies in progress investigating aspects of a vegetables first approach to complementary feeding

Author (year) [a] Country Study name	Expected sample	Study design	Intervention duration	Relevant outcome variables	Hypothesis
Lind et al. (2019) Sweden Optimized Complementary feeding study (OTIS)	N = 250, age 6-18m	Longitudinal RCT 2 groups Monthly follow-ups; feeding tests at 12 and 18m	24 days	Acceptance of new and unfamiliar foods at 12 and 18m (secondary)	A complementary diet based on Nordic foods leads to increased acceptance of healthy foods compared to the currently recommended, Swedish complementary diet.
Van der Veek et al. (2019) Netherlands Baby's First Bites	N = 240 (60 per group), age 4-6m	Longitudinal RCT 4 groups Follow-ups at 12, 18, 24 and 36 m	19-day baseline feeding schedule with conditions lasting until 16m	Vegetable consumption and liking (primary)	A combination of repeatedly exposing infants to vegetables and encouraging sensitive feeding leads to improved vegetable acceptance than each of the interventions alone.

[a] Protocol publication.

Repeated exposure to vegetables

Repeated exposure to foods involves experiencing a novel or distinct taste several times without a negative association (Rozin, 1990). For infants, it could take 10 or more exposures to the same vegetable before it is accepted (Barends et al., 2019), and as few as three exposures for younger infants (Ahern et al., 2014; Caton et al., 2014).

Two recent comprehensive systematic reviews found unequivocal evidence that repeated exposure to a single vegetable increased acceptance of that vegetable, while repeated exposure to a variety of vegetables improved acceptance of a new/unfamiliar vegetable (Appleton, Hemingway, et al., 2018; Barends et al., 2019). In the latter, all intervention studies (n = 21) on repeated exposure to a single vegetable and five studies on repeated exposure to a variety (which always involved at least three repeated exposures to the same vegetable) led to increased vegetable intake during and/or directly after the exposure period (Barends et al., 2019). However, limitations to their analyses were acknowledged, including a lack of longitudinal RCTs, variable methodologies used in the experimental papers, small effect sizes, poor ecological validity and low compliance and/or reporting.

Some studies aiming to evaluate the effects of repeated exposure or variety of vegetables on child vegetable acceptance, arguably, have also investigated a vegetables first approach to CF (Coulthard et al., 2014; Gerrish & Mennella, 2001;

Kalhoff et al., 2021; Maier-Nöth et al., 2016; Maier et al., 2008). Maier and colleagues (2008) conducted a 10-day RCT in Germany and France to measure the effects of milk feeding mode and experience with vegetable variety early in the CF period on new food acceptance. Infants (n = 147) received their very first vegetable (carrot purée) on day 1, and then randomised to either: carrot daily; three vegetables changed every three days; or three vegetables changed daily. On day 12 and 23, new vegetable purées (zucchini, tomato, then peas) were offered and then two new foods (turkey, monkfish) several weeks later. They showed that daily changes in vegetables offered early in the CF period, especially in combination with breastfeeding, can facilitate acceptance of new foods for at least up to 2 months. Follow-up at 6 years of age indicated that the group exposed to a high variety of vegetables consumed and liked vegetables more in the laboratory than the no or low variety of vegetable exposure group (Maier-Nöth et al., 2016).

In another study, Gerrish et al. (2001) tested the hypothesis that providing a variety of flavours during the first stages of CF improves acceptance of novel foods amongst formula-fed infants. On day 1, all infants (n = 48) received carrot in the laboratory, and then over the next 9 days at home received either carrots, potato, or a variety of vegetables (peas, potato, squash). On day 11 and 12, carrot and a novel food (puréed chicken) was offered, respectively. It was found that infants fed either carrots or a variety of vegetables, but not potatoes, towards the beginning of CF ate significantly more of the carrots after the exposure period.

Exposure to a variety of vegetables early on in the CF period also improved acceptance of the novel food.

More recently, some of the first outcomes from the OTIS trial (as described in Table 2.3) were published in a paper aiming to investigate the feasibility of systematically introducing taste portions, with repeated exposure of a variety of fruits and vegetables (Johansson et al., 2019). Infants randomised to the Nordic diet were introduced to a variety of fruits and then vegetables at the start of CF, along with other Nordic foods. This was based on an idea that introducing sweet tastes that are inherently familiar to infants first would be easier than starting with bitter and sour tastes. At 6 months of age, fruit and vegetable intake was similar between groups, but at 9 months of age fruit and vegetable intake in the Nordic group was 44 % higher than the control, both separately and combined ($P < 0.001$); at both time points, more fruit than vegetables were consumed. However, accuracy may be questionable given the self-reported 5-day food records (not necessarily weighed), and, due to all the components of the study, it is difficult to determine which factors had the most impact. In their follow-up study, fruit and vegetable intake decreased between the age of 12 and 18 months, but the Nordic group still consumed 32 % more compared to controls (Johansson et al., 2021).

Why studies may not immediately be included as key evidence supporting a vegetables first approach to CF could be due to a number of factors, including the study objectives, date of publication (before a vegetable first approach was coined), or the study design. In some studies (Gerrish & Mennella, 2001; Maier et al., 2008), although it was clear that day 1 of the intervention marked the first day that infants had tried a vegetable, it was either unclear if they had tried other foods (e.g., fruits), or whether infants had already commenced CF (i.e., had already been eating cereal or fruit to various degrees and under uncontrolled conditions); a non-treatment group in which vegetables are not provided as first foods is also missing. In Johansson et al. (2019), a comprehensive account of the foods consumed by the control group was not present, and infants in the Nordic group started with fruit. Overall, these factors make it difficult to assess a vegetables first approach in its most pure form.

Conditioning strategies to improve vegetable acceptance

Conditioning strategies used for improving vegetable consumption typically involve repeated exposure to a novel taste in association with another variable such as a liked taste, nutrient, peer modelling or non-food rewards (i.e., smile, stickers). While modelling or rewards may work for 2–5-year-olds (Holley et al., 2017), this may not be true for 0–3-year-olds, and further research is also needed to assess if mixing or 'masking' vegetables with other foods is an effective method for improving vegetable acceptance in children (Appleton et al., 2016) (Barends et al., 2019). Remy et al. (2013) used artichoke purées (variety not specified) with added oil, salt and sugar to compare learning mechanisms of repeated exposure, flavour-nutrient learning (FNL) and flavour-flavour learning (FFL). FNL is learning to like food based on positive post-ingestive effects of high energy density, while FFL is learning to like foods based on a liked flavour. Results showed repeated exposure was as effective as, and simpler to implement than, FFL and more effective than FNL for increasing vegetable acceptance (Remy et al., 2013). Similarly, in the review by Barends et al. (2019) it was concluded from eight FFL and five FNL studies that repeated exposure and introducing vegetables at the beginning of CF are comparatively more promising strategies (Barends et al., 2019).

Educational approach to promote child vegetable acceptance

Caregivers can play a vital role in helping infants learn to like and eat more vegetables. Yet, evidence suggests that the current support provided to parents and caregivers around infant feeding may be inadequate, with mothers reporting that they receive mixed nutrition messages (Brown, 2020; Murray, 2019). A recent cross-sectional survey of 458 New Zealand women found potentially unreliable sources (e.g., family, friends, internet) to be key sources of dietary information while breastfeeding (Brown, 2020). In New Zealand, free handouts (Ministry of Health, 2012, 2013), online information (Ministry of Health, 2018b; Plunket, n.d.) and community talks from established charities (e.g., Plunket) around starting solids are available. However, advice on how to help children like and eat more vegetables is generally lacking.

Providing education around positive infant feeding practices is helpful to parents (Gibson & Cooke, 2017; Peters et al., 2012) and intervention trials show that an educational approach could improve infant feeding practice (Nicklaus, 2016). However, increasing knowledge alone does not always result in behaviour change (Butler et al., 2020), and additional measures like ongoing in-home reinforcement may be needed (Horodynski et al., 2004). A small New Zealand case study of four first-time mothers participating in an infant feeding programme reported that education around infant feeding cues was the most valuable component (Murray, 2019). Being home-based, offering practical activities and fostering a good relationship with the interventionist were also appreciated. As mentioned, participants involved in the study by Hetherington et al. (2015) found the infant feeding support extremely useful, and similarly, Horodynski and colleagues (2008) found that mothers in their infant feeding programme particularly enjoyed the educational hands-on activities, doing the workbook and watching the DVD.

Alongside the view that education on infant feeding is helpful, there is evidence of parents desiring more contact support; for example, Murray et al. (2019) found mothers want ongoing access to someone to ask questions while introducing solids. In the qualitative research commissioned by the Health Promoting Agency, mothers suggested that in order to make responsive feeding a viable option they would need to be provided a clear and prompt explanation on benefits of the practice, proof that it works and a range of practical resources on how to interpret hunger/satiety cues (Research New Zealand Limited, 2014). Also, it has been recommended that additional support be given to those experiencing a number of socioeconomic stressors, such those addressing limited resources and low food budgets (Tucker et al., 2006).

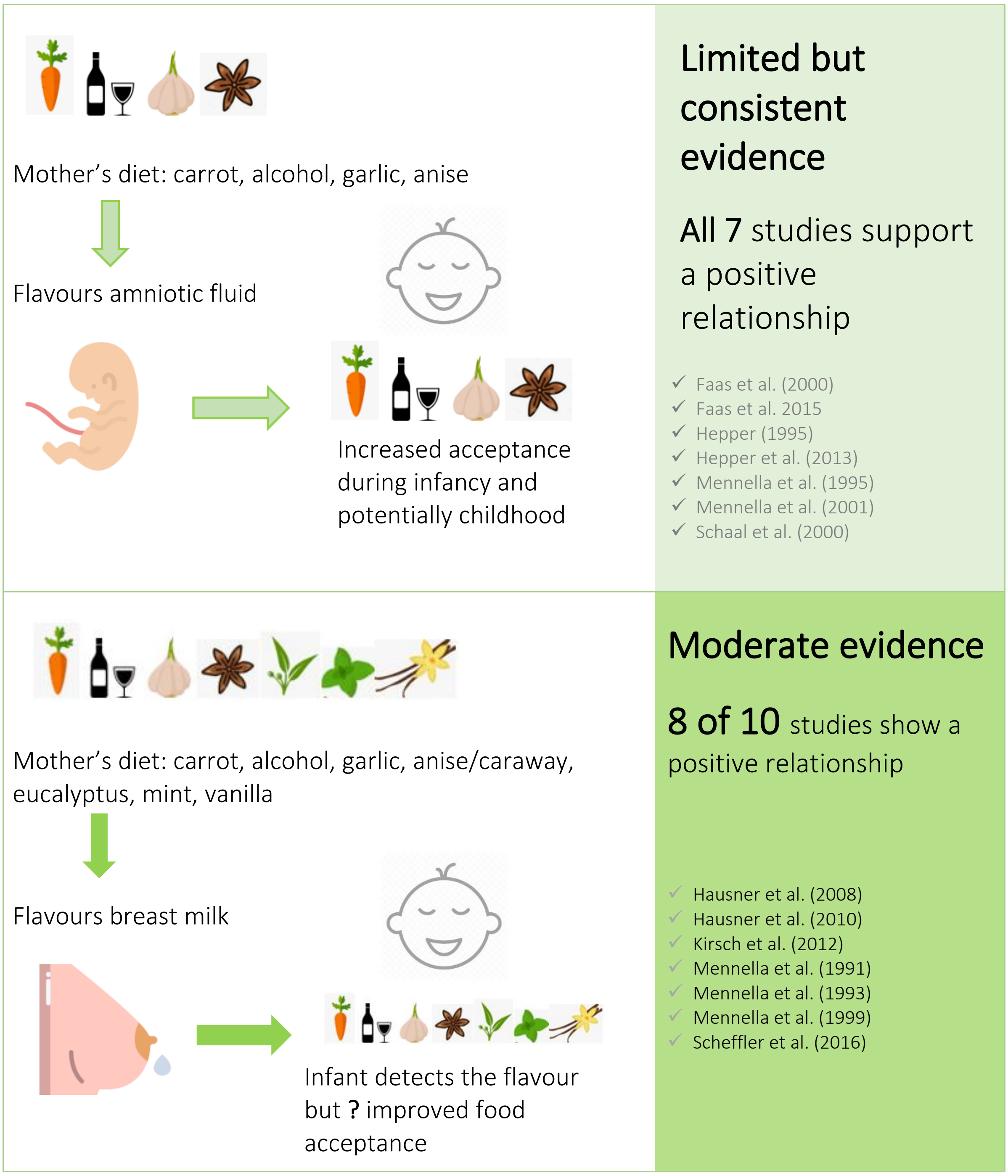
All intervention studies investigating vegetables as first foods include an educational component where participants receive information on various infant feeding topics, including responsive feeding, recognising developmental signs of readiness to start CF and infant cues for food liking (Barends et al., 2013; Barends et al., 2014; Fildes et al., 2015; Hetherington et al., 2015). However, the comprehensiveness of advice needs standardisation, especially in order to assess if education is fundamental to the success and reliability of an intervention. Moreover, if mothers enjoy the education and feel engaged due to learning about topics that they find practical and useful, then confounders (e.g., different feeding practices) and study compliance could be improved.

Modify maternal diet to programme infant food preferences

A mother's diet during pregnancy and lactation may be the earliest opportunity to promote child food acceptance. A growing body of evidence suggests that the development of taste preferences starts in utero with the fetus swallowing amniotic fluid which is flavoured by the mother's diet (Beckerman et al., 2017; De Cosmi et al., 2017; Domínguez, 2021; Forestell, 2017; Nicklaus et al., 2019; Spahn et al., 2019). Taste preferences are then programmed through the flavours present in breast milk and further established with the introduction of solid food (De Cosmi et al., 2017; Nicklaus et al., 2019).

Figure 2.6 presents findings from the most recent systematic review on the relationship between maternal diet and child food preferences (Spahn et al., 2019). Limited but consistent evidence (three RCTs, one non-RCT and three cohort studies) was found for a positive relationship between maternal diet during pregnancy and: (1) amniotic fluid flavour (alcohol, anise, carrot and garlic); and/or (2) children's behavioural response to that flavour. Moderate evidence (five RCTs, five controlled trials, five crossover studies) indicated that flavours (alcohol, anise/caraway, carrot, eucalyptus, garlic, mint, vanilla) derived from the maternal diet during lactation transmit to and flavour breast milk, which infants can detect. Findings were mixed as to whether maternal diet during pregnancy positively impacted child food acceptance and, overall, it was concluded that findings in both pregnancy and lactation could not generalise to all foods and beverages.

Figure 2. 6. Influence of maternal diet on flavour transfer to amniotic fluid and breast milk and children's responses



Note. Created by PhD candidate based on key findings from Spahn et al. (2018).

Key strengths of the review by Spahn et al. (2018) included the comprehensive literature search strategy, evidence appraisal and grading of evidence statements. However, conclusions were limited by the nature of the available studies which, although they were generally strong in study design (e.g., randomisation), often relied on self-reported maternal dietary intake, were limited in the types of foods tested and did not use direct measures of children's preferences (e.g., weighed food intake). Further research areas include effects of a wider variety of foods; how food should be consumed by mothers to elicit an effect (i.e., quantity, number of exposures, timing, duration); and the impact of maternal diet on child dietary intake. Given the current interest in finding ways to improve vegetable consumption in children, studies focusing on the relationship between maternal vegetable intake and child vegetable acceptance would be timely. Indeed, a quasi-experimental, multicentre, controlled and prospective intervention study on this topic is underway in Northern Spain (Urkia-Susin et al., 2021).

Conclusion

It is clear that a vegetables first approach to CF is a promising strategy for improving vegetable acceptance, especially if it entails repeated exposures to a variety of vegetables. Yet, the need for more longitudinal RCTs that address the limitations of previous work is equally apparent, particularly with respect to ecological validity. Such studies may shed light on the long-term benefits of prioritising vegetables as first foods and whether the approach is feasible for families. This should help policy makers decide on whether a vegetables first approach should be adopted by infant feeding dietary guidelines and make it easier to translate findings into simple and practical tips to help children like and eat more vegetables (Appleton, Tuorila, et al., 2018; Chambers et al., 2016).

2.6. Assessment of vegetable acceptance

Various methods for assessing children's food acceptance are available, including weighing food intake (grams), taking behavioural (facial expressions and overt movements) and autonomic measurements (respiration, skin temperature) (Soussignan et al., 1997), recording the duration/pace of eating (Forestell & Mennella, 2007, 2012) and using liking scales. As shown in Table 2.5, all studies investigating a vegetables first approach to CF have used food intake and a liking tool based on a rating scale or coding system to assess infants' vegetable acceptance.

Each method has advantages and disadvantages, for example, the 'Feeding Infants: Behaviour and Facial Expression Coding System (FIBFECS)' is a validated video coding tool that can assess liking independent of subjective ratings from mothers and researchers but is time-consuming, requires extensive training and is difficult to apply in the home setting (Hetherington et al., 2016; Nekitsing et al., 2016). The tool was also validated with only two single vegetables (carrot versus green bean), thus may not be able to detect subtle differences in liking for other foods including vegetable blends. Therefore, it is important to use more than one method to evaluate liking, with most studies using at least intake and liking scales (Barends et al., 2013; Barends et al., 2014; Fildes et al., 2015; Hetherington et al., 2015).

Table 2. 5. Assessment tools used by studies investigating a vegetables first approach to complementary feeding to assess vegetable acceptance and participant characteristics

Tool	Barends et al. (2013)	Barends et al. (2014) [a]	Fildes et al. (2015) [b]	Hetherington et al. (2015) [b, c]
Weighed food diary	Y	Y	Y	Y
Likert scale (1 = dislikes very much, 9 = likes very much)	Y	Y	Y	Y
Meal duration	-	-	-	Y
Pace of eating	-	-	-	Y
BEBQ, CEBQ	-	-	-	Y
Child FFQ	-	-	-	Y
Mother FFQ	-	-	Y	Y
Mother FNQ	Y	Y	-	-
Mother STAI	-	-	-	Y
Video-record of compliance	-	-	-	Y
Other	-	Infant pickiness and openness to new foods (both rated on 4-point scale) Mothers rated how often infant ate a food at home and how much they liked it.	Infant feeding practice questionnaires	De-brief questionnaire (acceptability of intervention) Questionnaire at 24 month asking mothers to report how often green beans and carrot were offered at home and how much they were liked

Note. FFQ = frequency food questionnaire, FNQ = Food Neophobia Questionnaire, STAI = State-Trait Anxiety Inventory, BEBQ = Baby Eating Behaviour Questionnaire, CEBQ = Child Eating Behaviour Questionnaire. All studies collected general demographic data (e.g., infant anthropometry, milk feeding history, ethnicity, mother's education, employment, number of children). Weighed intake, Likert scales, meal duration and pace of eating used to assess infants' acceptance of test meals only. [a] Only mothers rated liking and additional weighed 3-day food diary was used to assess daily vegetable/fruit intake. [b] Mother and researcher rated liking. [c] Likert scale was 1 = dislikes extremely, 9 = likes extremely.

Actual intake

Actual intake (grams) is a primary outcome measure of vegetable acceptance during infancy (Barends et al., 2019). Actual intake was measured by weighing the food before and after consumption using provided digital scales and a food record sheet, and estimated spills or food fallen on the bib were also recorded (Barends et al., 2013; Barends et al., 2014; Fildes et al., 2015; Hetherington et al., 2015). Some studies have collected the remaining jars of uneaten food for weighing in the laboratory (Barends et al., 2013; Remy et al., 2013). However, although intake is often associated with liking (Bere & Klepp, 2005; Gibson et al., 1998; Olsen et al., 2012), direct correlation is not always consistent (Schwartz et al., 2009), which is why other measures of vegetable acceptance are also taken.

Liking scales

Likert-type or hedonic rating scales ask participants and/or researchers to rank how much they think the infant liked a food, for example, on a 9-point scale of ‘1 = extremely like’ to ‘9 = extremely dislike’. While all studies investigating a vegetables first approach to CF have used this type of scale, there are other options. For example, anchor points can be numeric or verbal, labelled or unlabelled and range from 4-points (Schwartz et al., 2011) to 10-points (Madrelle et al., 2017). A 9-point scale is widely used, but 5- and 7-point scales are now considered sensitive measures, with no added benefit of having more points (Coelho & Esteves, 2007). The use of pictorial faces (emojis) to assess liking has grown in popularity in both adults and children (Swaney-Stueve et al., 2018), for example, Carraway-Stage and colleagues (2014) validated a pictorial method to assess liking of familiar fruit and vegetables among preschool children, which uses a non-gendered 5-point face scale (super yummy to super yucky). Meanwhile, a validation study in New Zealand presented promising results for a pictorial scale for use by caregivers to assess fruit and vegetable liking and intake in pre-schoolers (Bodel, 2013). Such a scale could be developed further for intervention studies exploring infants' liking and intake of vegetables.

In the context of child food acceptance, Likert-scale assessments are usually based on interpreting infant behaviours or feeding cues, for example, pushing the food away indicates dislike, or smiling in response to food indicates liking (Hetherington et al., 2016; Hetherington, 2020; Madrelle et al., 2017). Participants (typically the primary caregiver or mother) using these scales may accurately interpret infant behaviours as they know the infant and their unique behavioural subtleties, however, personal traits of the rater (e.g., anxiety level) or preconceptions about their child's preferences may skew results. Meanwhile, an external observer/researcher should offer a more objective and consistent assessment but may not interpret infant behaviours correctly as they do not know the infant (Moding et al., 2014). To limit bias, studies have tried to standardise the feeding protocol as much as possible and obtained both maternal and research ratings, but when these do not agree it becomes difficult to offer conclusive results. It is possible that a Likert-scale alone is not able to accurately assess infant food preferences, and other validated tools are needed; or other factors such as inadequate blinding, using different criteria to assess infant liking and poor compliance need to be addressed to ensure consistency in results.

Food acceptance behaviours in infants

Infants have a diverse repertoire of food acceptance behaviours, including facial expressions and overt body gestures (Hetherington, 2017, 2020; McNally et al., 2016). Examples of facial expressions may include eyebrow raised or lowered, gaping, squinting and lip corners turned up or down. Overt behaviours may include turns head away, arches back, crying/fussing, pushes the food away and leaning forward (Nekitsing et al., 2016). As facial expressions can be subtle and difficult to distinguish, focusing on more obvious and overt behaviours can be helpful. **Table 2.6** shows a list of acceptance and rejection behaviours that may be useful to examine infants' vegetable acceptance. Typically, these behaviours occur as food approaches, but excited body movements, a specific vocalisation, crying/fussing, etc., may be observed on tasting.

Table 2. 6. Examples of overt behaviours used to assess infant food acceptance

Food acceptance behaviours	**Food refusal behaviours**
Leaning forward	Turns head away
Rate of acceptance	Arches back
Early mouth opening	Pushes spoon away
Takes spoon to force it in mouth	Crying/fussing
Excited body movements	Specific vocalisation

Note. Table created by PhD candidate based on the literature (Hetherington, 2020; Madrelle et al., 2017; Nekitsing et al., 2016).

Literature on infant food behaviour responses suggest that facial expressions are indicative of liking, whereas overt behaviours can be used as a more direct measure of wanting. The Incentive Sensitisation Theory proposes that food 'liking' (the pleasure/palatability experienced from eating a food) and 'wanting' (motivation to eat due to appetite) form the basis of food reward, and although interrelated, can be measured separately (Berridge, 1996; Morales & Berridge, 2020). An advantage of assessing wanting as a distinct parameter is that it accounts for the moment before a food has been tasted, providing insight into infant appetite. This is important as it can help to determine whether an infant is rejecting a food due to a lack of appetite and natural increase in satiation from eating or because of a dislike of the taste. In saying this, overt behaviours could be interpreted as liking, thus evaluating other parameters (i.e., facial expressions, duration of meal) are needed for a more complete assessment.

Duration of a meal and pace of eating are considered other objective but indirect measures of food liking and wanting. Duration is measured by recording the start and end time of the meal, whereas pace of eating is calculated by amount eaten divided by duration (Hetherington et al., 2015). As the duration or pace of a meal can be affected by hunger, eating traits and maternal traits/feeding practices (Moding et al., 2014), studies have collected information on such traits using a range of available tools. These include the state-trait anxiety questionnaire, variety-seeking questionnaire, food neophobia questionnaires, infant characteristic questionnaires and the Baby Eating Behaviour Questionnaire (BEBQ) (Barends et al., 2013; Barends et al., 2014; Gerrish & Mennella, 2001; Hetherington et al., 2015; Maier et al., 2007; Maier et al., 2008). Studies examining infant food acceptance are inconsistent in their choice of questionnaires, but the BEBQ is particularly useful as it describes traits directly related to infant appetite and interest/enjoyment of food.

★ New in-home validated tool to assess infant liking

Recently, a new in-home testing method called 'the elaborate method' to assess infant food liking was developed and validated (Madrelle et al., 2017). This tool asks mothers to use a response sheet to record positive and negative behaviours for each spoon offered for the first nine spoons in their home environment. Mothers then rate how much they think their infant likes the food after each triplet of spoons (i.e., 3 x 3 spoons) using a 10-point scale, then again at the end of the meal. As shown in **Figure 2.7**, mothers mark one cross in the appropriate box when a positive or negative behaviour is observed, regardless of how many different behaviours appear. Actions to take when a spoon is refused (i.e., mark a cross as negative) and if infants display a neutral response (i.e., do not mark anything) are provided in the additional feeding instructions, which are available on request from the authors of the tool.

Figure 2. 7. The behaviour chart used in the infant liking tool by Madrelle et al. (2017)

	When the spoon is approaching		**When the food is in mouth**	
	Behaviour		Behaviour	
Spoon number	Positive	Negative	Positive	Negative
1	X	X		X
2		X	X	
3	X		X	

Note. Adapted from information provided by Madrelle et al. (2017) for illustrative purposes; liking scale not included and crosses added as an example of how the tool can be completed.

To validate the tool, Madrelle et al., (2017) compared this elaborate method to a basic method featuring only a global 10-point liking assess at the end of the meal. To standardise procedures, mothers received guidance on feeding environment, feeding style to adopt, when to terminate the meal (3 consecutive refusals) and the list of cues related to liking/disliking. They were also shown a 15-minute video demonstrating example behaviours and given printed instructions to take home. It was found that the elaborate method was more sensitive in detecting liking of carrot and bean purée than the basic method. The tool was also considered to be more ecologically valid as feeding takes place in the infant's usual environment, rather than in a laboratory.

Another advantage of this tool is that it asks mothers to carefully assess infant liking throughout the meal. This can help them make a more accurate overall judgement of infant liking at the end of the meal and also capture real time changes in infant liking, for example, an infant's initial dislike of the food changes to liking by the ninth spoon. In addition, if there is an increase in rejection behaviours over the course of the meal, then effects of satiation can be considered.

Video-coding: rate of vegetable acceptance

Rate of acceptance refers to how readily an infant accepts food and is a measure wanting. Methods for this parameter typically require a trained coder to use a video coding scheme to rate how soon an infant opens their mouth as food approaches. In the study by Hetherington et al. (2016), coders used a 4-point scale to rate food acceptance: 0 = refusal, 1 = enforced, 2 = late acceptance, 3 = early acceptance. Early acceptance occurred when the infant opened their mouth when the spoon was at a distance; late acceptance refers to when the infant opened their mouth when the spoon was close; enforced means the infant opened their mouth when the spoon touched their lips; and refusal occurred when the infant's mouth did not open. Results from a discrimination and correlations analysis suggested that the scale was valid and reliable but limited because it was only tested amongst infants starting CF and by using only two vegetables (Nekitsing et al., 2016). Furthermore, spatial descriptions such as 'at a distance' and 'close' are not easily measurable.

More recently, an abstract by Moding et al. (2020) was published on the development of a live coding scheme to assess food acceptance among infants and toddlers in naturalistic settings. In this study, the 4-point scale differed slightly (0 = refusal, 1 = enforced, 2 = acceptance, 3 = anticipation) but demonstrated excellent reliabilities (Moding et al., 2020). However, validation analyses were based on specialised foods (i.e., small-quantity lipid-based nutrient supplements) and so may not be generalised to vegetable acceptance. Still, rate of acceptance as a parameter using either of the 4-point scales is a potentially simple and short method to measure child food acceptance (Moding et al., 2020; Nekitsing et al., 2016).

Infant foods used to measure liking

Many different types of vegetable purées have been used as target foods to measure vegetable liking, including carrot, green bean, spinach, broccoli, potato, squash, sweet potato, peas, artichoke, eggplant, parsnip and tomato. Several studies considered carrot as a liked vegetable (Coulthard et al., 2014; Gerrish & Mennella, 2001; Hetherington et al., 2015; Maier-Nöth et al., 2016; Maier et al., 2007; Maier et al., 2008; Remy et al., 2013) and green bean as a disliked vegetable (Barends et al., 2013; Barends et al., 2014; Hetherington et al., 2015; Maier-Nöth et al., 2016; Maier et al., 2007). Other disliked or novel foods have included artichoke (Barends et al., 2013; Fildes et al., 2015; Maier et al., 2007; Remy et al., 2013) and parsnip (Hetherington et al., 2015). Target fruits have included peach (Fildes et al., 2015), plum and apple (Barends et al., 2013; Barends et al., 2014).

Across studies, the choice of intervention foods is evidently based on what is known about what vegetables and fruits are liked and familiar/unfamiliar within a specific population or region. For example, green bean and apple purées were chosen as target foods as they were commonly consumed in the Netherlands, whereas artichoke and plum purées were less commonly consumed. Similarly, green beans and cauliflower have been chosen as test foods by the Baby's first bites study, as these are also considered common in the Netherlands. The data sources used for these assumptions are unclear, especially on further investigation such information is difficult to find in national survey results (National Institute for Health and Environment, 2020; Schuurman et al., 2020; van Rossum et al., 2020), but industry statistics, anecdotal or local knowledge could be sources (Statista, n.d.).

Most studies provided ready to eat purées in jars, either bought commercially (Barends et al., 2013; Gerrish & Mennella, 2001; Nekitsing et al., 2016) or specifically manufactured for the study (Fildes et al., 2015; Maier et al., 2007; Remy et al., 2013). As most commercial infant foods undergo high processing techniques (e.g., sterilisation and pasteurisation), nutrient quality and taste may be compromised (Särkkä-Tirkkonen et al., 2010; Seidel et al., 2015), which is problematic for studies focusing on taste. Providing snap frozen infant foods or asking participants to prepare home-made foods are other options that would ensure infants receive true vegetable tastes, but this would require adequate freezer space and cooking facilities in the home, increase participant burden and make it difficult to standardise protocols/control for compliance.

Freeze-dried infant food may be an innovative solution for interventions that require large number of infants to be fed fruit and vegetables that are both convenient and accurate in taste. During the freeze-drying process, foods are snap frozen and then dried at low temperature without damaging their physical structure (Bhandari et al., 2013) or altering the original taste (Pei et al., 2014). These foods do not require food additives, which is increasingly valued by consumers and parents (Roman et al., 2017), and can be made to suit a variety of textures (i.e., whole pieces or milled to a fine powder). In a dried format, the foods have a long shelf-life, do not require refrigeration during storage (i.e., before feeding) and, in a powdered form, are easily reconstituted to a purée by adding water. Overall, using these foods in research may improve trial scalability, standardisation, participant compliance and study design (e.g., using target foods that obtain their original flavour or nutrient profile).

The availability of freeze-dried infant foods remains very limited worldwide, with none commercially available in New Zealand. For this reason, studies wishing to use freeze-dried vegetable/fruit powders must manufacture their own. For example, the freeze-dried kūmara powder used in *Nourish to Flourish* was specifically manufactured for the study, which mothers then mixed into their infant's complementary foods (Australian New Zealand Clinical Trials Registry, 2019).

Conclusion

Infants have a wide range of cues and behaviours to express their nutritional needs and food preferences. These can be difficult to interpret as infants' ability to communicate verbally is limited. For this reason, intake (grams), duration and pace of eating have been used as indirect measures of infant liking and wanting under the assumption that liked food is eaten in greater amounts and more rapidly. Likert-scale ratings have also been used, which rely on the subjective judgement of either a researcher or primary caregiver. With the new availability of validated tools to assess infant food liking, there is an opportunity to improve the reliability of results. Since these tools have been validated in the context of providing vegetables as first foods, they are ideal for research investigating a vegetables first approach to CF. However, as all assessment tools have their own set of limitations, ranging from social desirability bias to being labour intensive, using more than one method to assess infant food preferences is recommended.

2.7. Including iron-rich foods

The consensus paper by Chambers et al (2016) recommends that those wishing to follow a vegetables first approach to CF should also receive advice around the introduction of iron-rich foods. This is because one of the main purposes of complementary feeding is to meet infants' iron requirements, and a diet solely consisting of vegetables is unlikely sufficient to meet these needs, at least for infants starting CF at 6 months of age.

The role of iron in the body

Iron (Fe) is a mineral and essential micronutrient that is central to a spectrum of biological functions including infant growth and brain development, thus is one of the most important nutrients during the CF period (Friel et al., 2018; Ministry of Health, 2008; Y. Wang et al., 2019). Iron exists mainly in its ferrous (Fe 2+) and ferric (Fe3+) oxidation states, which interchange via redox reactions (i.e., electron transfer) in order to facilitate critical biological processes including energy metabolism (Friel et al., 2018; Y. Wang et al., 2019). At birth, most of iron is present as haemoglobin (Hb) in red blood cells, reflecting iron's primary role to transport oxygen from the lungs to other tissues (Domellöf et al., 2014; Friel et al., 2018).

0.2 mg/d

Infant iron requirements

Estimated iron requirements during infancy varies according to physiological state and iron bioavailability, resulting in discrepancies across dietary recommendations. In New Zealand and Australia, the recommended iron requirement from birth to 6 months is 0.2 mg per day (Adequate Intake, AI), increasing to 11 mg per day at 7–12 months (Estimated Average Requirement, EAR) (Ministry of Health, 2008); which is similar to the Institute of Medicine (2001) Dietary Reference Intakes (RDI). In the UK, the Reference Nutrient Intake (RNI) is 1.7 mg/d at 0–3 months old, 4.3 mg/d at 4–6 months, and 7.8 mg at 7–12 months (British Nutrition Foundation, 2019). Meanwhile, the American Academy of Paediatrics recommend that exclusively breastfed, full-term infants receive 1 mg/kg body weight/d of iron supplement from 4 months old (Baker et al., 2010).

Conflicting thoughts on infant iron requirements, particularly in early infancy, are a consequence of insufficient scientific evidence demonstrating iron status in response to dietary intake in young infants. Recommendations for 0–6-month-old infants are thus typically based on observed iron intake of healthy breastfed infants and/or the average concentration of human milk (e.g., average daily milk intake 0.78L/day x milk iron concentration 0.35 mg/L = 0.27 mg iron per day) (IOM, 2001; Ministry of Health, 2008). This is under the assumption that human milk is sufficient to meet dietary requirements for exclusively breastfed infants. The

American Academy of Paediatrics on the other hand reasons that because breast milk iron content varies widely and there is evidence that exclusively breastfed infants are at increased risk of iron deficiency after 4 months of age, then supplementation is routinely needed.

Another source of contention relates to normal physiological shifts in iron compartments during early infancy. At birth, Hb synthesis is halted and then over the next 6 weeks, Hb concentrations fall from an average of 170 g/L to about 120 g/L (Domellöf et al., 2014). Mobilisation of iron stores and Hb concentrations in the blood are high, thus exogenous iron requirements may be practically zero. It is not known when iron stores are fully utilised, except that it is somewhere between 4 and 6 months of age (Friel et al., 2018; IOM, 2001). Furthermore, contrary to what is implied by recommendations, iron needs do not merely jump to 11 mg/day at 7 months of age as the increase is likely more gradual (Baker et al., 2010). Thus, it is has been duly noted that nutrient reference values should be applied with caution (IOM, 2001).

It is agreed that breastfed infants require very little exogenous iron during the first 6 months of life, but that iron needs significantly increase after 6 months (Baker et al., 2010; Domellöf et al., 2014; Friel et al., 2018). At 7 months of age, a factorial approach to calculating iron requirements that involves more certainties can be applied to improve consistency across guidelines (IOM, 2001). Also, it is accepted that these requirements in proportion to body size in the infant are markedly higher than other life stages due to the developmental state already discussed (i.e., rapid growth, relatively immature immune system) (Alles et al., 2014; Dewey, 2013).

Dietary sources of iron

Although iron contained in human breast milk is highly bioavailable (about 50 % absorbed), it contains a low quantity of iron, and so is a poor iron source (Ministry of Health, 2008; Saarinen et al., 1977). For this reason and as mentioned, infants accumulate iron stores in utero, which they primarily rely on during the first few months of life. By 6 months of age, iron stores are assumed to be depleted, and requirements are high, so human milk cannot meet iron requirements alone and complementary foods must be introduced.

A recent systematic review of CF and micronutrient status found strong evidence suggesting that iron-rich complementary foods (e.g., meat, fortified cereal) may help maintain adequate iron status or prevent deficiency in the first year of life, especially amongst at risk infants (Obbagy et al., 2019). Most guidelines reflect this by recommending iron-rich foods as first complementary foods (i.e., meat, poultry, fish and iron-fortified infant cereal) (Dewey & Harrison, 2020; Ministry of Health, 2008; Netting & Makrides, 2017; SACN, 2018; WHO, 2003a). However, more studies are needed to determine if this is necessary for infants starting solids younger than 6 months (Obbagy et al., 2019).

Bioavailability of iron from different dietary sources is also acknowledged by most guidelines, for example, haem iron from meat, poultry and fish is more bio-available (around 25 % absorbed) compared to non-haem iron from plant foods, eggs and fortified foods (around 10–17 %) (Hurrell & Egli, 2010; Institute of Medicine, 2001; Ministry of Health, 2008). Also, healthy infants will absorb less iron than iron deficient infants to achieve iron homeostasis. Suggestions on enhancing non-haem iron absorption usually include adding vitamin C foods (i.e., vegetables and fruit) to a non-haem iron meal; avoiding mixing in iron absorption inhibitors such as calcium in cheese or tannins in tea might also be recommended.

For interest, **Figure 2.8** shows the amount of iron an infant might absorb from one tablespoon of a recommended iron-rich food. From this, for example, if healthy infants consumed at least 2 tablespoons of beef per day they theoretically should meet minimum iron requirements, especially if they are also receiving breast milk and/or iron-fortified infant formula. However, this remains speculative without further studies investigating the effects of dietary intake on infant iron status.

Figure 2. 8. Theoretical amount of iron absorbed from 1 tablespoon (30 g) of iron-rich first foods in healthy infants; a comparison by food type

Note. Calculated within FoodWorks® (version 10, Xyris Software) utilising the New Zealand Food Composition Database (NZ, FOODfiles 2016), and with iron absorption set conservatively to 25 % haem iron sources and 10 % non-haem iron sources. Selected foods for analysis: beef, forequarter and hindquarter assorted cuts, separable lean, cooked; chicken, composite cuts, flesh, cooked; Gurnard, flesh, microwaved (a common white fish in New Zealand); iron content of infant cereal based on Katiforis (2021).

Data on current intakes and sources of iron during the CF period is somewhat low. In the US Infant Feeding and Practices Study II (2005–2007), over half 6 month old infants fell short of the American Academy of Pediatrics (AAP) and WHO recommended two servings per day of iron-rich food sources and did not receive routine oral iron supplements (Dee et al., 2008). However, the sample although relatively large (n = 3033) was not nationally representative and actual food intake not estimated as mothers reported food frequency rather than quantity consumed. That said, similarly poor consumption of iron-rich foods are reported in other more nationally representative US data (Finn et al., 2017; Hamner et al., 2016). FITS found that meat was not a meaningful contributor to young infants (4–8.0 months) total dietary iron intake, with meat varieties consumed being not iron-rich (i.e., chicken, turkey and processed meats) (Finn et al., 2017). Most (74.6 %) 6- to 8.9-month-old infants consumed infant cereal, which declined over time (51.5 % at 9–11.9 months, 14.8 % at 12–17.9 months). A more recent analysis from FITS also showed that the calculated daily iron absorption among 6–12 month old infants was below the recommended amount in over half (54.3 %) of infants, and especially those who were breastfed (full or any) (Abrams et al., 2020). Data was consistent with 2017 findings, with chicken and turkey as the top contributors to iron, and haem iron contributing to total iron absorbed the least (< 12 %) in all infants regardless of milk feeding type.

In New Zealand, secondary analysis from the BLISS study found infants fed traditionally with a spoon had a median dietary iron intake from solid complementary foods of 1.0 mg/day at the age of 7 months, which was similar to those following BLW (1.2 mg/d) (Daniels et al., 2018). Total dietary iron intake including breast/formula milk was similar at both 7 months (2.7 and 3.0 mg/d, respectively) and 12 months of age (5.3 mg/d and 4.7 mg/d, respectively). These intakes are below the recommended 11 mg/d, as was observed in another New Zealand longitudinal study over a decade earlier suggesting a persistent problem

(Heath et al., 2002b). Furthermore, despite education in the BLISS study to feed high iron-foods (red meat, iron-fortified infant cereal), actual intakes were small in both groups. Intake of haem iron appeared almost non-existent at 7 months and minimal at 12 months (Daniels et al., 2018). It is not clear as to why poor dietary iron intake may exist amongst infants, but it is possible that increased popularity of BLW (Brown et al., 2017) and more focus on improving children's fruit and vegetable intake for the prevention of childhood obesity and obesity-related illness could be contributors (Barends et al., 2019). It is clear that further intervention is needed to support increased iron intake during the first year of life (Abrams et al., 2020).

Iron deficiency

Iron deficiency (ID) occurs when there is insufficient iron in the body. Clinically, ID is defined by three stages, ordered from the least to most severity: iron depletion (low storage iron, normal Hb), iron deficient erythropoiesis (storage and functional iron both low, normal Hb), and iron deficiency anaemia (IDA: storage, functional and Hb iron all low) (Coad & Pedley, 2014). Important dietary risk factors include receiving complementary foods earlier or later than recommended, high cow's milk intake (Ziegler, 2011) and low intake of iron-rich complementary foods (Domellöf et al., 2014; Gibson et al., 2014; Ministry of Health, 2008). Other factors include low iron stores at birth, low umbilical cord Hb, lower birth weight (Hirata et al., 2017; Shao et al., 2021), poor socioeconomic status (van der Merwe & Eussen, 2017), and increased iron needs (e.g., rapid growth) (Mattei & Pietrobelli, 2019).

Of concern, observational human studies indicate that early ID is associated with neurodevelopmental impairment and behavioural problems later in life, suggesting irreversibly deleterious effects (Congdon et al., 2012). The longitudinal study in Costa Rica for example examined long-lasting effects on cognitive functioning after chronic ID in infancy, with follow-ups at 5, 11–14, 15–18, 19 and 25 years of age (Lozoff et al., 2006; Lozoff et al., 2000; Lozoff et al., 2013). Despite limitations of the observational method, results showed that by 25 years, those with chronic ID infancy had experienced substantial loss in human potential (i.e., lower education and greater feelings of social detachment) (Lozoff et al., 2013).

Prevalence of iron deficiency

Iron deficiency (ID) is the most common micronutrient deficiency in the world (Domellöf et al., 2014; WHO, 2007) and is prevalent in young New Zealand children (Ministry of Health, 2008). However, the reported prevalence of ID and IDA varies and is difficult to compare between countries, largely due to population difference (e.g., use of iron supplements, formula versus breastfeeding) and inconsistent use of indices and cut-offs to define ID and IDA (Abdullah et al., 2017; Eussen et al., 2015). In addition, nationally representative data for infants aged 12 months or less is lacking (Finn et al., 2017; Pérez-Acosta et al., 2021), resulting in an increased reliance on cross-sectional and intervention studies that report both a low and high prevalence of ID during early infancy (Chen et al., 2020; Clark et al., 2017; Dube et al., 2010; Eussen et al., 2015; Grant et al., 2007; Heath et al., 2002b; Libuda et al., 2018; Lozoff et al., 2016; Shao et al., 2021).

In a systematic review of 44 studies conducted in 19 European countries, the prevalence of ID varied from 2–35 % in infants aged 6–12 months; then 3–48 % in 12- to 36-month-old children (Eussen et al., 2015). The prevalence of IDA in both groups was as high as 50 % in Eastern Europe, and < 5 % in Western Europe. A recent study among 509 Chinese infants revealed that between the age of 6 and 12 months, 20 % and 7 % presented with ID and IDA, respectively (Chen et al., 2020). These rates were concordant with those observed among previous cohorts in China (Clark et al., 2017) and Korea (Hong et al., 2017).

New Zealand data appears equally variable, with one of the few available studies indicating the prevalence of ID in Auckland children (6–23 months old) was 14 % in 2007 (Grant et al., 2007), and higher among Māori (20 %), Pacific (17 %) and other non-New Zealand European ethnicities (27 %). Although the random sampling method allowed for a true population prevalence estimate, the study was insufficiently powered for a comprehensive assessment of ethnic variability. In an earlier cohort of 75 Caucasian infants in Dunedin, 7 % of infants had IDA at 9, 12 and 18 months (Heath et al., 2002b); however, serum ferritin (a sensitive indicator of ID) was not measured, and like the 2007 study, the data is out of date. More recent data from the BLISS study found 5 % of the control and 7 % of the intervention presented with IDA at 12 months of age; 10 % and 13 % had anaemia other than IDA, respectively (Daniels et al., 2018). Robust measures of iron status (plasma ferritin, soluble transferrin receptor, C-reactive protein) were used, but a measurement of iron status before 12 months of age was not possible.

The prevalence of ID was reported in the Iceland RCT by Jonsdottir et al. (2012). When infants were 6 months old, they found that those who started CF at 4 months had higher mean serum ferritin levels ($P = 0.02$) compared to those starting CF at 6 months. Mean dietary iron intake from solid foods had been 0.6 ± 0.5 mg/d among the group starting at 4 months. The biological importance of their findings remained unclear as all infants had serum ferritin values within normal range and were not followed beyond 6 months (Jonsdottir et al., 2014). Also, although there were no group differences in ID with or without anaemia, seven infants in the total sample had depleted iron stores; six of whom also had ID and two had IDA.

Rates of ID are often reported alongside dietary iron intake, which appears similarly variable and suboptimal (Boudet-Berquier et al., 2017; Daniels et al., 2018; Eussen et al., 2015; Heath et al., 2002b; Helle et al., 2018; Roess et al., 2018). For example, the mean value of iron intake in 6–36 month old infants was reported close to the recommended dietary allowance in most countries in Europe (Eussen et al., 2015). Meanwhile, the BLISS study found the prevalence of inadequate iron intake among 7-month-old infants (n = 206) was high at 74 %, but considerably lower by 12 months of age (23 % control, 26 % intervention) (Daniels et al., 2018).

Overall, a potentially high prevalence of ID amongst infants is concerning given the irreversible cognitive impairment and restricted growth that may occur if the deficiency progresses to IDA (Lopez et al., 2016; Mattei & Pietrobelli, 2019). More up-to-date data on infant iron status, especially at the age when complementary feeding starts is needed.

Assessment of iron status

Iron status of children is typically assessed with hematologic tests (e.g., haemoglobin [Hb] concentration) (WHO, 2007). In infants, the 'heel prick' method to obtain a blood sample is considered sufficient and most practical (WHO, 2010b). Acceptable and common biomarkers include Hb, serum ferritin (SF) and soluble transferrin receptor (sTfR) (Ziegler et al., 2014). Cut-offs can vary slightly in the literature (Joo et al., 2016; Ziegler et al., 2014); however, optimal iron status in infants is generally considered as SF > 10 or SF > 12 µg/L, sTfR < 2.4 mg/L, and Hb ≥ 110 g/L (Abdullah et al., 2017; Grant et al., 2016; Gupta et al., 2016; Moor, 2013; Pérez-Acosta et al., 2021; WHO, 2011).

SF increases in the presence of inflammation or infection, thus if a child is unwell then ID may be undiagnosed or underestimated (Baker et al., 2010). The most common biomarker of early inflammation or infection used at a serum level is C-reactive protein (CRP), and thus is useful for iron studies (Brown et al., 2020). A normal concentration is typically < 10 mg/L or < 5 mg/L, depending on the laboratory; a value greater than this is deemed abnormal so SF must be interpreted with caution (Brown et al., 2020; WHO, 2014a).

The importance of monitoring iron status

While providing a variety of vegetable tastes exclusively for the first few weeks of complementary feeding may be suitable for infants aged 4 to 6 months, experts agree that those starting at 6 months will need iron-rich foods to support depleted iron stores (Chambers et al., 2016). Clinical trials investigating a vegetables first approach to complementary feeding have not monitored or reported on infants' iron status. This makes it difficult to comment on the safety of providing vegetables-only at the start of CF, as well as create safe and accurate guidance to mothers choosing vegetables as first foods.

2.8. Summary

Vegetables are very important first foods for infants. Understanding the importance of establishing vegetable acceptance early in life may be the first step to improving vegetable intake later on. This is especially important given the known health benefits of vegetable consumption, and concerningly low vegetable intake amongst children worldwide.

Policy makers, agencies and organisations have been working to ensure that population dietary guidelines promote children's vegetable consumption and are evidence-based. Researchers are also investigating the most effective strategies to facilitate children's vegetable acceptance and subsequent consumption, including the introduction of vegetables early in life. Although there is growing support for a vegetables first approach to CF, more high-quality longitudinal RCT's investigating the feeding practice are needed before it is widely adopted. Learning from the limitations of previous work, future studies could be improved by ensuring that the intervention is entirely home-based, infant iron status is monitored and validated assessment tools used.

It is very difficult for healthcare professionals and policy makers to provide advice on best infant feeding practice where strong evidence does not exist. It becomes further confusing for caregivers wishing to give their infant the best possible start to life without clear guidance. Meanwhile, the specialised skills and resources to conduct high-quality studies and navigate ethical concerns are often beyond the capability of small research teams or single organisations. Greater collaborative effort between expert groups should improve the feasibility of such research, avoid unnecessary repetition of work and help to establish more consistency across guidelines.

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Chapter 3. Study protocol – Paper I

Impact of a 'vegetables first' approach to complementary feeding on later intake and liking of vegetables in infants: a study protocol for a randomised controlled trial.

Following a review of the literature, this chapter describes the methods and study design used to investigate whether a vegetables first approach to complementary feeding improves child vegetable acceptance.

This chapter was accepted for publication in 2021 in *Trials:*

Rapson, J. P., von Hurst, P. R., Hetherington, M. M., & Conlon, C. A. (In press). Impact of a 'vegetables first' approach to complementary feeding on later intake and liking of vegetables in infants: A study protocol for a randomised controlled trial. *Trials*.

This protocol includes information on additional outcome measures that are not relevant to this thesis, namely, Vitamin D in infants and mothers, iron studies in mothers, infant microbiota and infant feeding practices at 24 months of age. These outcomes are included for contextual purposes and will be reported independently at a later date. The prose is in future tense, reflecting time of writing and submission.

3.1. Abstract

Background: Vegetables as first complementary foods for infants may programme taste preferences that lead to improved vegetable intake in children. Yet few studies have investigated the impact of a 'vegetables first' approach to complementary feeding (CF), especially in New Zealand. The purpose of this randomised control trial is to investigate the effect of starting CF with vegetables-only on infants' later intake and liking of vegetables, compared to those starting with fruit and vegetables.

Methods/design: One-hundred and twenty mother-infant dyads living in Auckland, New Zealand, will be randomised to receive either vegetables-only (intervention) or fruit and vegetables (control) for 28 days, starting from the first day of CF at around 4-6 months of age. Infants will be presented with a brassica (broccoli), followed by a green leafy vegetable (spinach) and sweet fruit (pear) at 9 months of age. The primary outcome measures of intake of each food will be assessed using a weighed food diary. Secondary outcome measures of overall intake and liking of vegetables will be assessed using a food frequency questionnaire, liking tool and video coding tool, respectively, at 9, 12 and 24 months of age. Infant growth and iron status will be assessed as part of health screening and monitoring at baseline, post-intervention and 9 months of age. Other biological samples to be collected include infant stool samples, vitamin D (mother and infant), iron status (mother) and mothers' diet.

Discussion: This randomised, controlled trial will be the first to our knowledge to investigate a vegetables first approach to CF on infants' liking and intake of vegetables in New Zealand. Comparison against standard practice (fruit and vegetables as first foods) should complement other trials underway, such as the Baby's First Bites and Nordic OTIS trial. Results may contribute to the evidence supporting CF guidelines in New Zealand and worldwide.

Trial registration: Australian New Zealand Clinical Trial Registry, ACTRN12619000737134. Registered on 16 May 2019, https://anzctr.org.au/Trial/Registration/TrialReview.aspx?ACTRN=12619000737134.

Ethical approval was granted by the Massey University Human Ethics Committee: Southern A, Application SOA 18/56 (see **Appendix A**).

3.2. Background

Children are encouraged to eat plenty of different vegetables daily in order to meet a range of nutrient requirements for growth and development, immune function and digestive health (Appleton et al., 2016; Ministry of Health, 2008). Children with adequate vegetable intake may have a lower risk of obesity (Ledoux et al., 2011) and cardiovascular disease in adulthood (Funtikova et al., 2015; Mellendick et al., 2018), and be more likely to develop healthy eating habits for life (Mikkilä et al., 2005; Reidy et al., 2017). Yet children's vegetable consumption remains low worldwide (Mihrshahi et al., 2019; Miller et al., 2016; Ministry of Health, 2020; National Health Service Digital, 2019; World Health Organization, 2003b). In the UK, only 14 % of children (5-7 years) eat the recommended five or more portions of vegetables and fruit per day (National Health Service Digital, 2019). Vegetable intake in the US is similarly low, with the FITS study finding 30 % of children 12 months or older not consuming any vegetable servings on a given day (Bailey et al., 2019). New Zealand children (2-4 years) are doing better but intakes are still inadequate, with 46.1 % and 71.2 % of children consuming enough vegetables and fruit, respectively (Ministry of Health, 2020).

Reasons for poor vegetable consumption may relate to many factors, including a dislike of bitter taste and poor access (Bailey et al., 2019; Harris et al., 2019; Pearson et al., 2009). Infants have an innate preference for sweetness since breast milk is sweet, and may find bitter taste, such as in dark leafy greens, particularly difficult to accept (Forestell, 2017; Mennella & Bobowski, 2015; Wardle & Cooke, 2008). Meanwhile, children from food insecure households may have an additional challenge of accessing a variety of vegetables (Zaçe et al., 2020). Eurostat data found 5.5 % of UK households with children were unable to afford meat, fish or a vegetarian alternative every second day (Van Lancker & Parolin, 2020). In the US, an estimated 14 % of US families with children experienced food insecurity in 2018 (United States Department of Agriculture). Similarly, although most New Zealand children live in food-secure households, a substantial number do not (19 %) (Ministry of Health, 2019), and so are less likely to have vegetables purchased and offered to them (Schlichting et al., 2019).

It is known that offering infants a variety of vegetables from the start of complementary feeding (CF) may promote liking through familiarisation and facilitate intake throughout childhood (Barends et al., 2019; Chambers et al., 2016; Hendrie et al., 2017). However, many infants receive fruit and sweet tasting vegetables (e.g., pumpkin, sweet potato) as their first foods (Mennella et al., 2005; Miles & Siega-Riz, 2017). Furthermore, most commercial infant foods are largely fruit or sweet/starchy vegetable based (Bakke et al., 2020; Heinz Wattie's, n.d.; Moding et al., 2018). In a sample of traditionally spoon fed New Zealand infants (n = 628), 1 % received ‘only fruits, no vegetables’, 17 % ‘mainly fruits, some vegetables’, 46 % ‘half fruit, half vegetables’, and 4 % ‘only vegetables, no fruits’ when solids were first introduced; just over half were consuming iron-rich foods (meat or infant cereal) at 6 months of age (Fu et al., 2018). A recent systematic review of practices to promote vegetable acceptance in the first three years of life concluded that introducing vegetables at the beginning of CF, giving a different type of vegetable every day and ensuring repeated exposure to the same vegetable following an interval of a few days are the most promising strategies to promote vegetable intake in early childhood (Barends et al., 2019).

The prioritisation of vegetables-only from the start of CF is known as a ‘vegetables first’ approach to CF. Only a handful of studies investigating the effects of this approach have been published, with none in New Zealand (Barends et al., 2013; Barends et al., 2014; Fildes et al., 2015; Gerrish & Mennella, 2001; Hetherington et al., 2015). Barends et al. (2013) compared the effects of repeated exposure and starting CF with vegetables-only across four different treatment groups over 18 days. They found that starting CF with vegetables, but not with fruits, may promote vegetable acceptance, and that liking correlated positively with intake. Their follow-up study (Barends et al., 2014) suggested that starting CF with vegetables-only results in higher daily vegetable consumption until at least 12 months of age, however, further investigation was needed on how to maintain this effect until 24 months of age. Three other studies suggest vegetables as first foods may improve vegetable acceptance later, at least in the short term (Fildes et al., 2015; Gerrish & Mennella, 2001; Hetherington et al., 2015; Maier-Nöth et al., 2016; Maier et al., 2008). However, comparability of findings remains limited due to considerable variability in study designs, small sample sizes and/or poor ecological validity (e.g., conducting trials in the laboratory rather than the home environment). Standardisation across studies could be improved with the use of recent development and validation of tools to assess vegetable liking, such as the Feeding Infants: Behaviour and Facial Expression Coding System (FIBFECS) (Hetherington et al., 2016) or an in-home adapted elaborate method for liking tool (Madrelle et al., 2017).

Historically, most guidelines on CF have included vegetables as first complementary foods but alongside fruit and iron-rich foods without a prescribed sequence (Ministry of Health, 2008). The systematic evidence compiled by the UK Public Health England and Scientific Advisory Committee on Nutrition (SACN) (Scientific Advisory Committee on Nutrition, 2018) however has informed the current NHS recommendations to give a single vegetable and fruit as first foods (National Health Service, n.d.). While there may be enough evidence to start recommending vegetables as first complementary foods, there is still a need for more longitudinal randomised controlled trials (RCTs) (Chambers et al., 2016; Lind et al., 2019; Maier et al., 2008; van der Veek et al., 2019); especially those comparing infants receiving vegetables-only to standard practice. Two other trials examining the effects of providing vegetables as first foods on vegetable acceptance are in progress, including the Baby's First Bites (BFB) trial in the Netherlands and the OTIS Nordic trial. In the BFB, infants are randomised to receiving, with or without a positive feeding programme, either fruits and a sweet vegetable or a variety of vegetables. However, all infants start CF with rice-flour porridge and then vegetables as their first tastes (van der Veek et al., 2019). The Nordic OTIS trial is comparing effects of the recommended, Swedish complementary diet (i.e., starting with infant cereals, commercially available infant foods) to one based on Nordic foods (i.e., increased plant foods including fruit and vegetables and reduced sweets, dairy and meat) on food acceptance (Lind et al., 2019). Infants in the Nordic group are systematically introduced to fruits (e.g., apples, raspberry, buckthorn/lingonberry, cranberry) and vegetables (green peas, cauliflower, turnip, daikon) from the start of the intervention, rather than vegetables-only.

RCTs are one of the most rigorous ways to establish cause-effect relationships between treatment and outcomes (Stang, 2011), and RCT data is a gold standard for translating evidence into practice (Spieth et al., 2016). Our RCT will test the hypothesis that exposure to vegetables-only during the first four weeks of CF increases later intake and liking of vegetables in infants, compared to a control group of fruit and vegetables. If this is supported, our results could contribute to the evidence for recommendations for a 'vegetables first' approach to CF in New Zealand and beyond.

3.3. Hypothesis

Exposure to vegetables-only during the first four weeks of CF increases later intake and liking of vegetables in infants, compared to a control group which includes both fruit and vegetables.

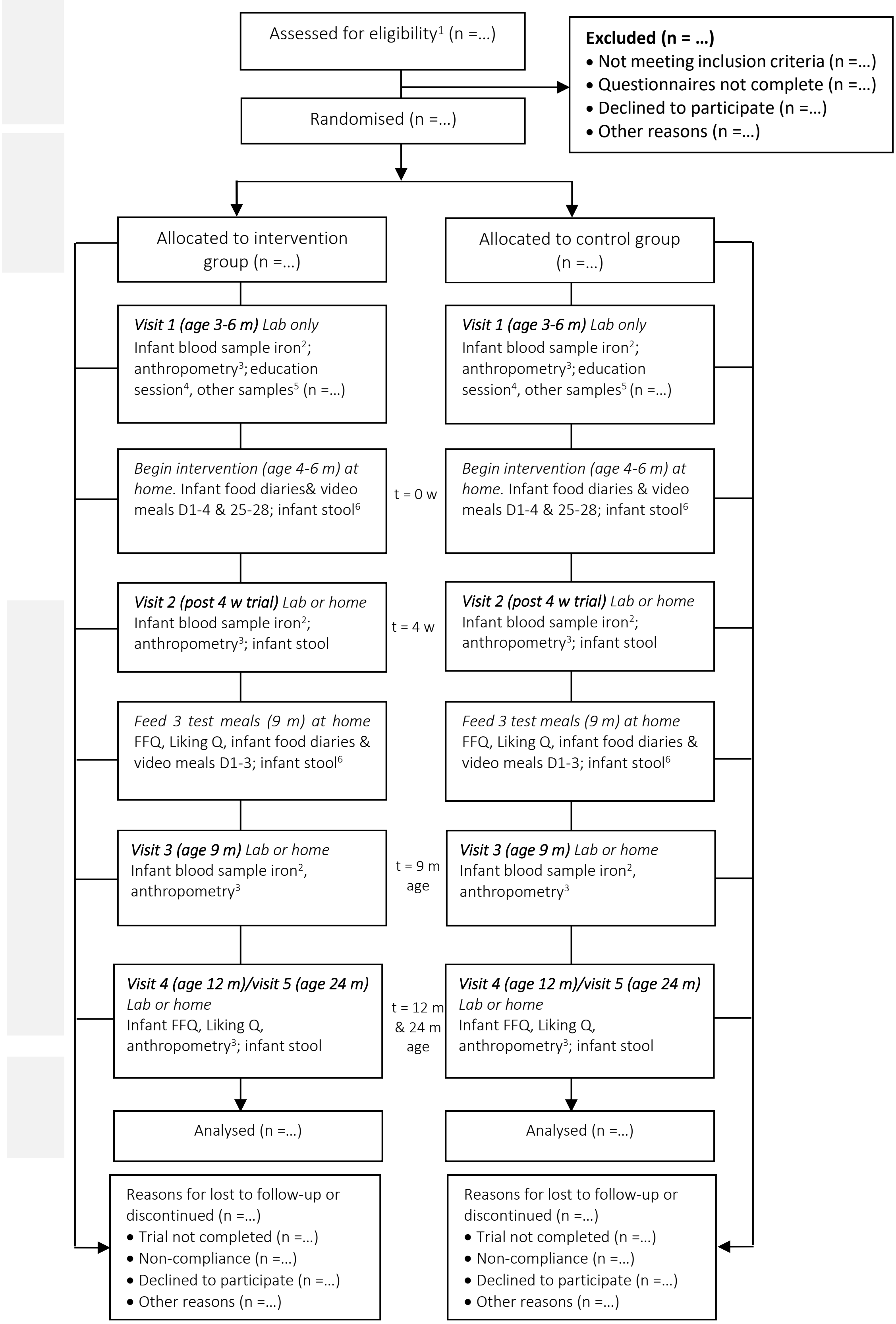
3.4. Aim

The overall aim of this study is to determine whether exposure to vegetables-only during the first four weeks of CF increases later intake and liking of vegetables in infants, compared to a control group which includes both fruit and vegetables.

3.5. Methods/Design

This study is designed as a randomised controlled trial comparing two parallel groups following either a 'vegetables first' approach to CF or standard practice of feeding fruit and vegetables. This involves a 4-week intervention period starting from the beginning of CF (between 4 and 6 months old), with the primary endpoint of vegetable intake at 9 months of age (**Figure 3.1**). The duration of the intervention targets the sensitive period for taste development (Harris & Mason, 2017), is logistically feasible, and allows for a timely progression to other foods and textures (e.g., mashed) that is expected by around 7 months. An endpoint of 9 months old aims to capture effects over time without significant loss to follow-up, and enables the study foods to be retested in an age-appropriate form before infants have transitioned to family foods at 12 months of age.

Figure 3. 1. Schematic diagram of study design



Note. See caption next page.

*Caption for **Figure 3.1.*** Lab = laboratory (Massey University Human Nutrition Research Unit), D = day, w = week, m = month, t = time point, FFQ = food frequency questionnaire, Q = questionnaire. [1]Questionnaires: eligibility, demographics, baby eating behaviours, pregnancy/lactation dietary questionnaires. [2] Blood biomarkers: Serum ferritin, C-reactive protein (CRP) and Haemoglobin. [3] Weight, head circumference and length. [4] Includes delivering all study materials, protocol instructions and information on complementary feeding. [5] Blood samples to assess the status of mother's iron/vitamin D and infant's vitamin D. [6] Infant stool sample collected by mother one week or less before infant receives the first intervention food/test meal. See **Appendix B** for CONSORT template.

Participants

Mother-infant dyads (4 to 6 months old) living in Auckland will be invited to register on the study website (www.vegesfirststudy.co.nz) (Massey University, 2020) advertised on social media, e-mail and community notice boards (see **Appendix C**). Based on the findings of Barends and colleagues (Barends et al., 2014), we calculated that 65 participants (a minimum of 52 participants, and allowing for a 20 % potential dropout rate) would be required for each arm of the trial to demonstrate a clinically significant difference at 80 % power and 5 % statistical significance. Power calculations used a 21-unit difference of vegetable intake (grams) between intervention group and control, and a mean standard deviation of 43 and 29 units, respectively. The sample size was calculated using the formula below (Fox et al., 2009):

$$N = 2\alpha^2K/(\mu_2-\mu_1)^2$$

Where N is the sample size required per group, SD is the pooled standard deviation, α is the SD, K is the constant (7.9 denotes 80 % power and

5 % significance), and (μ_2-μ_1) is the difference in vegetable intake (grams) between groups.

Inclusion and exclusion criteria

Infants will be eligible for this study if they are born term (37 weeks or greater), of normal growth/weight, and have no known food allergies, chronic diseases or medical conditions. Infants must not have started CF and must live in Auckland. Mother's proficiency in English is needed given the requirement to complete assessment tools as part of the secondary outcomes. Participants will be excluded if they demonstrate repeated non-adherence to key study procedures or are not able to complete the 4-week intervention period.

Setting

The study, data collection and analyses will take place in Auckland, New Zealand from May 2019 to October 2021. Auckland is the major commercial city of New Zealand, with an ethnically diverse population of 1.6 million and around 21 thousand child births recorded in 2018 (Statistics New Zealand, 2019).

Infant foods

Freeze-dried infant foods are specifically developed for the study by the researchers. According to study specifications, these are manufactured by FreshAs° who specialise in the production of high-quality freeze-dried vegetables and fruits and are based in Auckland, New Zealand. Vegetables and fruits are selected based on availability, infant nutrition guidelines, total sugar content per 100 grams and colour. A dietitian and speech language therapist who specialise in child feeding and development will conduct recipe testing in the laboratory. This confirms that to reconstitute the powders into age-appropriate infant purées, each sachet requires the addition of 50 ml of water (except potato and green bean which require 80 ml). The food is then heated in the microwave for three 20 second intervals, stirred in between, and then cooled for 10 minutes until it is at a safe temperature for infants to consume. Final instructions are provided on recipe cards to participants.

The foods provided to the intervention group will be less sweet than controls (< 4 grams total sugar per 100 grams) and made from vegetables-only (**Table 3.1**). The control group receives foods that will be sweeter than intervention (> 4 grams total sugar per 100 grams) and fruit based, resembling commercial infant foods that are currently available on the market; sugar content will be calculated using FoodWorks® (version 10, Xyris Software), entering the variety of vegetable that is freeze-dried (e.g., Crown pumpkin). Following nutrition guidelines, the study will provide a range of different coloured vegetables, including green, purple, white and orange. However, it will not be possible to provide an orange coloured food for the intervention group due to limitations to the freeze-drying method and high sweetness profile of available orange coloured vegetables. Therefore, the intervention group will be offered a second green food, named 'Kākāriki', which is the Māori translation for green and so should resonate with New Zealand families.

At baseline, mothers will receive enough food to provide up to three meals per day for the duration of the intervention and will be able to access additional sachets from the Massey University Human Nutrition Research Unit (HNRU) as required. To ensure infants meet iron intake requirements while participating in the study, mothers with an infant starting CF at 6 months of age will be especially encouraged to provide their own meat (beef, fish or chicken) during the intervention following recipe cards and videos provided.

Table 3. 1. Infant foods allocated to the intervention and control group

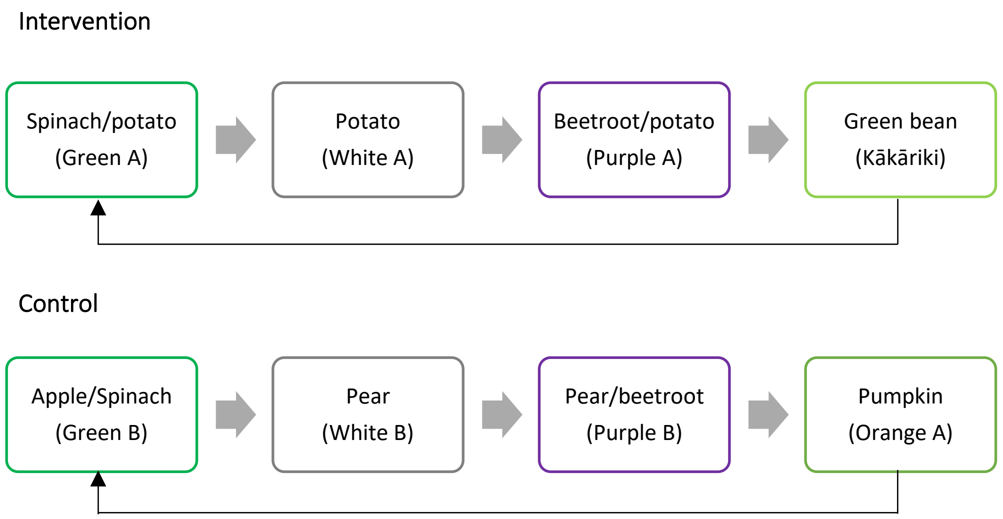
	Food ingredient (%)*	
Food name	**Intervention group**	**Control group**
Green purée	Spinach (80 %), potato (20 %)	Apple (90 %), spinach (10 %)
White purée	Potato (100 %)	Pear (100 %)
Purple purée	Beetroot (70 %), potato (30 %)	Pear (98 %), beetroot (2 %)
Orange purée	Not applicable	Pumpkin (100 %)
Kākāriki purée	Green bean (100 %)	Not applicable

*Total dry weight is 8 grams per sachet; wet weight is 80 grams.

Feeding protocol

Mothers will determine the timing of meals according to their own schedule. However, they will feed the foods according to a prescribed recipe and colour rotation to improve standardisation and ensure infants are exposed to a variety of flavours (**Figure 3.2**). On recording days (the first and last 4 days) mothers must only provide one colour per day, starting with 'Green'. On other days, colours rotate per meal. No meat is provided during the first 4 days to standardise infants' very first tastes. To cater to individual infant needs, mothers can provide as many meals as they need per day.

Figure 3. 2. Food rotations for intervention and control group



Note. Rotation is either per day (recording days) or per meal (other days). Foods will be labelled by colour and none list the ingredients, but mothers are reassured that the foods align with New Zealand infant feeding guidelines. The code A or B act as identifiers for researchers.

The rotation order of foods offered for the intervention group is determined by sugar content, starting with the first food containing the lowest sugar per 100 grams. This should help to expose infants to more bitter flavours first. The order is matched to the intervention group to improve standardisation and ensure vegetables, such as spinach, will be introduced at the same time where possible. Instructions on feeding style and environment will be provided, for example, 'let baby lead', 'use a spoon' and 'choose a quiet time without distractions'. At 9 months of age each group will be offered a brassica (broccoli), green leafy vegetable (spinach) then sweet fruit (pear) over three consecutive days (one per day). These will be labelled Meal A, Meal B and Meal C, respectively. Infants should not have had solid food within one hour prior to trying the meal. Assessment of intake of each food should determine whether a 'vegetables first' approach to CF results in higher intake of a brassica or green leafy vegetable at 9 months of age compared to a control group.

Education session

To standardise the feeding sessions as much as possible, all mothers will receive a 40-minute education session on appropriate infant feeding practices during their first visit, delivered by the primary investigator who is also a New Zealand registered dietitian. Topics include identifying the signs of developmental readiness to start CF, responsive feeding and appropriate breast/formula milk feeding. Instructions for the study protocol and food diary will also be discussed in detail. A series of educational resources, including three infant feeding fridge magnets designed for the study will be provided during the session and mothers will be encouraged to visit the study website to view additional resources (see **Appendix D**). After completion of the 4-week intervention, all mothers receive the Ministry of Health *Eating for Healthy Babies and Toddlers/Ngā kai tōtika mō te hunga kōhungahunga* (Ministry of Health, 2013) and Beef and Lamb New Zealand *Fuelled by Iron* (Beef and Lamb New Zealand, 2018) pamphlets to assist infants' transition to family foods.

Randomisation, blinding and concealed allocation

Eligible and consented mother-infant dyads will be randomly allocated to either the intervention or control group, having been stratified by infant gender and using a random number generator by the HNRU trials manager who is not involved in the study design and outcome analysis (see **Appendix E** for written consent form). In accordance to block randomisation with a 1:1 allocation, for every block of eight participants, four will be allocated to each arm of the trial, with the block size concealed until the primary endpoint is analysed. Allocation concealment will be ensured, as the release of the randomisation code occurs only until the participant has been recruited into the trial, which is after consent and baseline measurements have been completed. After assignment, researchers will not be blinded given their necessary involvement in the food product development and subsequent familiarity with food characteristics (e.g., colour). While participants will be provided with an information sheet that lists all the types of fruit and vegetables included on the study, they will be blinded to the specific foods allocated to them as foods are labelled generically (e.g., 'Green A' rather than 'spinach/potato') (see **Appendix F**). They will also be unaware of the RCT design, so do not know specific differences between feeding regimes. In an emergency where breaking of the study blind is needed, plans are in place for the principal investigator to reveal the treatment assignment for a given participant.

Data collection

Mothers will be emailed the links to the online demographics, infant behaviour and pregnancy/lactation food frequency questionnaires to complete at home before their first visit to the HNRU at which other baseline data (infant anthropometry and blood samples) will be collected. The 4-week intervention and primary data collection (mother reported infant vegetable liking and intake, video-recorded meals) will take place in the infant's home environment from May 2019 to October 2021. Follow-up data (anthropometry and/or blood samples) will be collected at 9, 12 and 24 months of age at the HNRU; home visits will be available as required. In the instance where visits are not possible, mothers will be asked to provide current infant growth measurements (following standardised instructions given by the researcher) and food diaries by email or post (see **Appendix G** for Covid-19 communication). Virtual meetings using Zoom or Skype will be available for additional support. Additional child vegetable/fruit liking, and food frequency questionnaires will be completed by mothers at home when their infant is 9, 12 and 24 months old. To the extent possible, we will continue to collect data for all outcome measures for participants who discontinue or deviate from the intervention protocols, while anticipating and planning for missing data. Given the potential for this cohort to provide valuable data for future early life nutrition research, additional outcome measures will be collected. These include mothers' iron status/vitamin D status (at baseline), infants' vitamin D status (at baseline) and infant stool samples for microbiota analysis (pre- and post-4-week intervention, and all follow-ups). Such data may be useful to assess maternal iron status 6 months post-partum or infant vitamin D status and links to the microbiome. **Table 3.2** outlines the primary study outcome measures and testing methods. **Figure 3.3** provides the schedule of enrolment, intervention and assessment.

Table 3. 2. Summary of the study outcome measures and methods

Variables	Method
Primary outcomes	
Vegetable liking	Liking tool (Appendix A). Completed by mother at home
	Rate of acceptance video coding tool. Mother video-records meals. Independent researcher codes infant behaviours
	Child vegetable and fruit liking questionnaires. Completed online by mother.
Vegetable intake	Weighed food diary. Completed by mothers at home
	FFQ. Completed online by mother
Blood analysis [a]	
Infant iron studies [b]	'Heel prick' test by phlebotomist at Massey University or home
Infant vitamin D	'Heel prick' test by phlebotomist at Massey University or home using *Whatman card*
Mother iron/vitamin D	Venous blood sample collection by phlebotomist at Massey University
Other measures	
Infant anthropometry	Head circumference: Paper measuring tape, widest part of head, three measures, select largest measurement to the nearest 0.1cm; Length: Infant length board; Weight: Infant electronic weighing scales, no nappy; measured by researcher at Massey University or participant home
Demographics	Completed online by mother
Mother diet	Pregnancy and lactation FFQ and FCQ. Completed online by mother
Baby eating behaviour	Baby eating behaviour questionnaire (Llewellyn et al., 2011). Completed online by mother
Compliance	2-minute check-in questionnaires. Completed online by mother

Note. FFQ = food frequency questionnaire, FFQ = food frequency questionnaire, FCQ = food choices questionnaire. [a] Analysed by LabTests, Auckland. [b] Serum ferritin, C-reactive protein (CRP), Haemoglobin.

Figure 3. 3. Schedule of enrolment, interventions, and assessments

	STUDY PERIOD						
	Enrolment	Allocation	Post-allocation				
TIMEPOINT	$-t_1$	0	$t_{baseline}$	t_{4w}	$t_{9m\ age}$	$t_{12m\ age}$	$t_{24m\ age}$
ENROLMENT:							
Eligibility screen	X						
Informed consent	X						
Allocation		X					
INTERVENTIONS:							
Vegetables-only *(intervention)*			◆				◆
Fruit and vegetables *(control)*			◆				◆
ASSESSMENTS							
Primary outcome							
Vegetable intake *Weighed food diary*			◆		◆		
Secondary outcomes							
Vegetable liking *Liking tool*			◆		◆		
Vegetable wanting/liking *Rate of acceptance (video-recording)*			◆		◆		
Total vegetable intake *FFQ*					◆		◆
Total vegetable liking *Child Liking Q*					◆		◆
Other measures							
Demographics			X				
Mothers' diet *Preg/lact FFQ/FCQ**			X				
Baby eating behaviour *BEBQ*			X				
Compliance diary			◆		◆		
Infant iron studies			◆		◆		
Infant vitamin D*			X				
Infant stool sample*			◆				◆
Mother iron/vitamin D*			X				

Note. t = timeline, w = week, FFQ = food frequency questionnaire, preg = pregnancy, lact = lactation, FCQ = food choices questionnaire, Q = questionnaire. *Not relevant to this thesis. Presented according to the SPIRIT statement: Defining Standard Protocol Items for Clinical Trials.

Weighed food diary

Mothers will complete a 4-day weighed food diary during the first and last four days of the 4-week intervention to primarily measure infants' intake of the study foods (grams) (see **Appendix H**). In alignment with other studies (Barends et al., 2013; Barends et al., 2014; Coulthard et al., 2014; Fildes et al., 2015; Gerrish & Mennella, 2001; Hetherington et al., 2015; Maier-Nöth et al., 2016; Maier et al., 2007; Maier et al., 2008; Remy et al., 2013), this will involve weighing the food before and after consumption using provided digital scales and completing the food record sheet. Estimated spills or food fallen on the bib will be recorded. The greater amount of food eaten may indicate a greater preference or acceptance for that food. In addition, the diary collects data for breast/formula milk feeding, meat consumption and medication/supplements. Mothers can report factors that may have affected infant feeding each day (e.g., teething, unwell).

The diary is designed specifically for this study and includes a liking tool to assess the degree that infants like the study foods (see Liking tool). Combining these tools into one booklet should reduce participant burden and improve data collection. Detailed and visually appealing instructions on the feeding environment and protocol, such as food rotation and video-recorded meals, are included. Food diaries for each group differ only by the allocated foods mentioned, for example, instructions for the orange food do not feature for the intervention group diary.

Week one and week four diaries also differ slightly by the removal of irrelevant instructions, for example, the week four diary excludes the instruction 'After the first four days…'. A similar 3-day weighed food diary will be provided at 9 months of age to assess intake of the target foods but includes the option to list any other vegetables or fruits eaten that day.

Weighed food records are considered the best estimate food intake for children aged 0.5 to 4 years (Burrows et al., 2010). The use of 4- and 3-day weighed food diaries should help to reduce participant burden that is typically associated with those of greater durations (e.g., a 7-day food diary) without compromising accuracy (Davies et al., 1994; Thompson & Subar, 2017). These durations also fit well with the protocol, for example, three test meals offered over three consecutive days at 9 months of age is appropriately measured by a 3-day food diary.

☺ Liking tool

The liking tool for our study is adapted from the new in-home validated elaborate method to assess infant liking of vegetables (Madrelle et al., 2017). The tool asks mothers to use a form to report positive and negative behaviours for each spoon offered for the first nine spoons in their home environment, then rate how much they thought their infant liked the food after each triplet of spoons (i.e., 3 x 3 spoons), then again at the end of the meal. After piloting the tool with a small group of New Zealand mothers and with further expert consultation it was agreed that a pictorial 5-point liking scale (1 = dislikes very much to 5 = likes very much), and a list 10 positive and 10 negative behaviours per spoon, which mothers can tick as they occur would reduce participant burden. The greater percentage of positive behaviours recorded may indicate greater liking, while an average score of at least 4 on the liking scale should indicate that the food is liked. It is required that a researcher provides mothers with additional guidance on feeding environment, feeding style to adopt, when to terminate the meal (three consecutive refusals) and the list of cues related to liking/disliking. These are adapted to align with New Zealand infant feeding guidelines (Ministry of Health, 2008), for example, the instruction to minimise verbal communication during feeding is removed as this conflicts with recommendations to interact with and talk to the child at meal times (see **Appendix H**).

Video coding tool

During the intervention, mothers will be asked to video record their infant trying each study food at home for the first time in week one, then again in week four without the researcher present. This provides a total of eight videos. When infants turn 9 months old, mothers will video record their infant at home trying Meal A, B and C. Each participant will be given access to their own secure online shared OneDrive file to upload their videos. To assess rate of acceptance, the videos will be coded using the coding tool described in **Figure 3.4**. Rate of acceptance is the judgement made on how readily the infant accepts the spoon offered and is a measure of wanting. This outcome measure will be included because liking (hedonic drive) and wanting (motivation to eat) are considered interconnected components of food reward and pleasure but can be measured separately (Berridge, 1996; Berridge et al., 2010; Nicklaus, 2016). The coding tool is based on prior studies (Hetherington et al., 2016; Nekitsing et al., 2016), but with further consultation with the researchers, the addition of 'grabs spoon to self-feed' as an indicator of early acceptance, as well measurable spoon distances are included to improve accuracy and standardisation. Coding will be completed by an independent researcher to reduce bias.

Figure 3. 4. Video coding for rate of acceptance

Early acceptance (score 3)

Opens mouth when spoon is at least 1 spoons length away or grabs spoon to self-feed

Late acceptance (score 2)

Opens mouth when spoon is less than a spoons length away

Enforced (score 1)

Opens mouth when spoon touches lips

Refused (score 0)

Did not open mouth, kept mouth shut, turned head away/pushed spoon away

Note. Images provided with written permission from the participating subjects.

Questionnaires

A total of nine online questionnaires specifically developed for this study are to be completed by mothers via the survey software tool Qualtrics™. Researchers will check all answers for completeness.

Eligibility questionnaire: a 5-minute eligibility questionnaire ensures that only infants that meet the inclusion criteria will be included (see Appendix I).

Demographics questionnaire: a 10-minute demographics questionnaire collects information at baseline on mother and infant date of birth, ethnicity, medical history, geographical location, mothers' education level and parity.

Pregnancy/lactation food frequency questionnaire (FFQ) and food choices questionnaire (FCQ): as the mother's diet may predict infant liking and intake of vegetables, a FFQ asking about mothers' intake of vegetables and fruit during pregnancy and lactation is adapted from an existing New Zealand validated FFQ (Beck et al., 2012). An accompanying FCQ gains further insight on other dietary habits, such as foods avoided. These questionnaires are peer-reviewed by three experts in the nutrition and dietetics field and pilot tested with 14 new mothers. Their feedback informed minor wording changes to increase readability and acceptability, thus improving content validity; each questionnaire requires 15-20 minutes to complete at baseline.

Food frequency questionnaire (FFQ): an abbreviated online version of a validated CF food frequency questionnaire (Judd et al., 2019) for mothers to complete in about 15 minutes when infants are 9, 12 and 24 months old collects data on infants' vegetable intake and variety (see Appendix J). The questionnaire is abbreviated because only items relating to vegetables, fruit and meat and alternatives are included to meet study objectives and reduce participant burden. Additional items relating to milk feeding history are added for the purpose of this study. The tool asks mothers to enter the total number of times and typical amount of a specified food (e.g., 'Beans and peas') eaten by the infant in the last four days using free text. Check boxes are used for milk feeding items. The data will be interpreted so that the greater variety and frequency of a vegetable observed, the greater intake of that vegetable. As the tool is validated to assess nutrient intake in infants, this data may be useful for further analysis of nutrient intakes when following a 'vegetables first' approach to CF.

Fruit and vegetable liking questionnaire: an online child vegetable and fruit liking questionnaire for mothers to complete when infants are 9, 12 and 24 months old collects data on vegetables and fruits tried and liked (see Appendix K). It features visually appealing images and the same liking scale used in the adapted infant liking tool. Scores of 4 or above indicate a greater liking for the food. Content validity is confirmed by four experts in the nutrition and dietetic field and five mothers not participating in the study. To improve completion, the questionnaire is divided into two online questionnaires, with one focusing on vegetables and the other on fruit; the estimated completion time is 10 minutes each.

Baby Eating Behaviour Questionnaire (BEBQ): as infant feeding behaviour characteristics could impact results, an online version of the validated BEBQ is to be completed (Llewellyn et al., 2011). This is an 18-item questionnaire with 17 items measuring four aspects of infant feeding behaviour and one item measuring general appetite before starting CF. Response options range from never = 1 to always = 5. Scoring involves calculating mean scores for each subscale with higher mean scores indicating greater presence of the feeding behaviour. The four themes are Enjoyment of food (e.g., 'My baby seems contented while feeding'), Food responsiveness (e.g., 'My baby frequently wants more milk than I provide'), Slowness in eating (e.g., 'My baby takes more than 30 minutes to finish feeding') and Satiety responsiveness (e.g., 'My baby get full up easily'). This questionnaire should take 10 minutes to complete. It is expected that infants who enjoy food less, are less food responsive, eat slower, are less sensitive to internal cues of satiety and have a smaller overall appetite may be more difficult to feed and perhaps less willing to accept vegetables specifically, compared to infants with the opposite traits.

Compliance to study protocol

A 2-minute check-in compliance questionnaire collects data on how many days the intervention food was offered, other food or drink consumed other than provided in the study, medications and factors that may affect infant feeding (e.g., teething) (see **Appendix L**). This will be emailed to participants on the completion of each intervention week. Mothers will be contacted by email or telephone at 9, 12- and 24-month follow-ups and an e-card will be sent on child birthdays to improve sample retention (see **Appendix M**). Mothers will receive a personalised baby bag, kitchen scales, visually appealing infant feeding resources and petrol vouchers at no cost to them in order to improve participation rates. The video footage from mothers' first video recordings will be checked for compliance and quality, with corrections (e.g., lighting, camera angle, environment) administered by the researcher as required.

Website

A study website is designed for participants to use when wishing to register, complete the eligibility questionnaire, learn more about the study, contact the researchers and access exclusive infant resources (see **Appendix N**). The use of a New Zealand website domain, the Massey University logo and a visually appealing study banner may improve credibility and recruitment. The website acts as a platform for distributing participant education and resources, including seven videos, three downloadable fridge magnets, a food safety flyer and three meat purée recipe cards with accompanying videos. These are based on Ministry of Health infant feeding guidelines and created using design software (Canva, Photoshop and Adobe Premier Pro). Images and video content are obtained from a photography/video shoot with written consent from the participating subjects, purchased from Shutterstock® or taken from Creative Commons. Using online surveys, each infant feeding resource is peer-reviewed by six experts in infant nutrition and 20 mothers. Feedback informed revisions, for example, it was recommended to use brighter colours for the recipe cards to improve engagement.

Adverse events

In the rare case that an allergic reaction to the infant foods, participants will be instructed to stop feeding the food and may withdraw from the trial and provided a referral to a doctor. Reports of gastrointestinal symptoms or other side effects will be further investigated by the trial registered Dietitian and the infant's health will be monitored closely for the duration of the intervention. If the adverse event persists, withdrawal from the trial and/or a referral to a doctor for further investigation is expected. All adverse events will be recorded, and mothers offered telephone/email support. If the participant needs to make a claim to Accident

Compensation Corporation (ACC) due to an adverse event and the claim is not accepted, then the researcher will initiate processes to ensure they receive appropriate compensation.

Blood sampling, stool collection and analysis

As part of screening for and monitoring infant health and iron status, capillary blood samples will be taken from infants by a registered phlebotomist using a standard 'heel prick' test at baseline, after the intervention and at the 9-month follow-up. The focus on monitoring iron status reflects concerns for meeting iron requirements during the CF period (Chambers et al., 2016), with iron deficiency having consequences that are more serious and irreversible than in adults (Ministry of Health, 2008; World Health Organization, 2003a). Thus, serum will be used for the analysis of serum ferritin and C-reactive protein (CRP) at LabTests (Auckland). Haemoglobin will be measured using HemoCue in our HNRU laboratory. If Haemoglobin is < 110 g/L, the participant will be notified and given a referral letter to see their doctor.

Additional blood and stool collection will be taken in the interest of future research. At baseline, venous blood samples will be collected from mothers and will be stored for later analysis of iron and vitamin D. Whatman cards will collect infant serum for a future study investigating infant vitamin D at baseline. For microbiome research purposes, mothers will collect a stool sample from their infant before and after the 4-week intervention, then at 9, 12 and 24 months of age.

Dissemination of results

During each visit, mothers will receive their infant's growth measurements and blood Haemoglobin result. The remaining blood results will be provided on request. Once available, participants who completed the intervention will receive a summary of findings in lay language, and whether they were assigned to the intervention or control. Results will be presented at national and international scientific conferences, prepared for publication in peer-reviewed journals, and circulated to the media; and should be of interest to a range of audiences including families, health professionals, district health boards, academics and primary health organisations. Individuals with substantive contributions to the design, conduct, interpretation, and reporting of the study will be recognised by granting authorship on the final relevant report.

Data handling

Name and address details will be kept in a separate Microsoft Excel spreadsheet which will include progress check boxes in order to track and schedule follow-ups. All entries will be cross-checked by another member of the research team. The video content to be stored on the shared storage platform OneDrive will be protected by Citrus Consulting Group Limited, a high security data management and storage company in New Zealand. Only the researcher and the participant have access to the designated video folder labelled by Subject number. All data will be stored safely under confidential conditions and archived for at least five years, and only the researchers will have access and permissions to the final intervention dataset.

Statistical analysis

Statistical analysis will be performed using IBM SPSS version 25.0 (IBM Corp. Released 2017. IBM SPSS Statistics for Windows Version 25.0. Armonk, NY. IBM Corp.). Data will be cleaned and checked for coding errors and completeness. To assess if data is normally distributed, the Kolmogorov-Smirnov, Shapiro-Wilk tests and normality plots will be used. Data that is not normally distributed will be transformed using log transformations to improve normality. Mean (standard deviation) and median (25, 27 percentiles) will be used to report normal and non-normal data, respectively. Transformed data will be reported at geometric mean (95 % CI) following back transformation, and categorical data as frequencies.

For the primary analysis at 9 months, independent t-test or Mann-Whitney test will be used to assess differences in vegetable intake and other food acceptance variables, depending on data distribution. Additional analyses will be performed to investigate if the intake of intervention foods and mothers-rated liking and rate of acceptance after four weeks are correlated (using Pearson's or Spearman's correlations depending on data distribution).

Given the nature of the intervention, per protocol (PP) analyses will be conducted. Although this may compromise the integrity of randomisation and reduce sample size, PP should help address dilution effects of non-compliance/missing data that is associated with intention-to-treat analysis. PP may also provide more information on the efficacy of the treatment. Reasons for excluding patients (e.g., loss to follow-up, major deviations from the protocol) will be fully reported. All statistical tests will be two-tailed with an alpha value of $P < 0.05$, and corrections applied for multiple comparisons where indicated.

3.6. Discussion

Despite the known health benefits of a diet rich in vegetables and fruit (Appleton et al., 2016; Boeing et al., 2012; Wallace et al., 2020), children's vegetable consumption remains lower than recommended worldwide (Mihrshahi et al., 2019; Miller et al., 2016; Ministry of Health, 2020; National Health Service Digital, 2019; World Health Organization, 2003b). Introducing vegetables at the beginning of CF may be a promising strategy to promote vegetable intake in children, both immediately and later in life (Barends et al., 2019). However, the few studies that have investigated this approach vary considerably in methodology and are limited by small sample sizes, short duration and/or poor ecological validity (Barends et al., 2013; Barends et al., 2014; Gerrish & Mennella, 2001; Hetherington et al., 2015; Maier-Nöth et al., 2016; Maier et al., 2008). The main purpose of this randomised controlled trial is to address this research gap by determining whether exposure to vegetables-only during the first four weeks of CF increases later intake and liking of vegetables in infants, compared to a control group which includes both fruit and vegetables.

Strengths of this study include the randomisation of infants, longitudinal design that follows infants until 24 months of age, use of diverse and complementary methods to assess outcome measures, a relatively large sample size, improved ecological validity (e.g., conducted in the home environment for the outcomes of interest), and using a control that mimics current practice. Possible limitations include difficulties for families to adhere to study procedures and remain engaged for up to 24 months of age. Since this is a convenience sample, participants are self-selecting and likely interested in nutrition and health with the potential to generate bias in the participant recruitment. However, extensive measures have been put in place to mitigate these, such as weekly compliance questionnaires, offering home visits/virtual meetings, providing incentives (free infant foods, petrol vouchers) and blinding mothers to the foods. In addition, time has been spent to develop a feeding protocol that is easy to follow (e.g., use of engaging colours, visual aids and clear instructions) and facilitated by evidenced-based infant feeding support.

We anticipate that this trial will provide important insights into the cause-effect relationship between a ‘vegetables first’ approach to CF and vegetable liking and intake in children. To our knowledge, this is the first study to investigate such causality of association in the New Zealand context. If successful, this study may help inform future updates of national and international infant feeding recommendations, and lead to practical advice for caregivers and health professionals wanting to improve vegetable consumption in children.

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Chapter 4. First four weeks – Paper II

Vegetable acceptance and liking at the start of complementary feeding: a randomised controlled trial

This chapter discusses the findings of the 4-week intervention and was recently submitted for publication in the American Journal of Clinical Nutrition, pending acceptance. It addresses a key objective of the study, which is:

To determine whether starting complementary feeding with vegetable-only first foods results in differences between groups in vegetable-only versus fruit and vegetable first food intake and liking in infants at the end of the intervention period.

Results are considered secondary to the primary outcome at 9 months described in the next chapter but reported first to reflect the sequence of events in the trial. The investigation may further our understanding of infants' acceptance of vegetable-only first foods compared to a combination of fruit and vegetables at the start of complementary feeding. Such evidence may support the development of more specific infant feeding advice around the types of vegetables to offer as first foods and give reassurance to new parents and caregivers that adding a sweeter flavour to vegetables is not necessary to promote vegetable acceptance.

4.1. Abstract

Background: Vegetables are recommended complementary foods, but little is known about infants' acceptance of vegetable-only first foods.

Objective: To investigate infants' acceptance of vegetable-only first foods compared to a control of combined fruit and vegetables (FV) at the start of complementary feeding (CF).

Methods: In this randomised, controlled, parallel-group study, 117 mother-infant dyads living in Auckland, New Zealand, received either vegetables-only (veg-only, n = 61) or a combination of FV (control, n = 56) for a duration of four weeks, starting from the first day of CF at around 4–6 months of age. Primary acceptance variables were intake (grams) and mother-rated liking (1–5 Likert scale) of the study foods. Secondary acceptance variables were percentage of reported positive/negative behaviours and rate of eating (grams/min).

Results: Median (25th, 75th percentile) daily vegetable intake in the veg-only group increased significantly from 19.5 (11.4, 28.4) grams in week one to 34.8 (19.4, 66.5) grams in week four ($P < 0.001$). Similarly, FV intake in the control group increased significantly from 19.6 (13.6, 32.1) grams to 31.8 (19.8, 69.2) grams ($P < 0.001$); with no main effect of group on total intake of the study foods [$F(1, 115) = 0.687$, $P = 0.409$]. Overall liking of the study foods significantly increased after four weeks in both groups ($P < 0.001$) from 'neither likes nor dislikes' towards

'likes', with no group differences. Daily intake positively correlated with overall liking. Frequency of negative behaviours in both groups significantly decreased over time (both $P < 0.001$) while positive behaviours did not change (veg-only $P = 0.07$; control $P = 0.147$). Rate of eating was similar and significantly increased for both groups ($P < 0.001$).

Conclusion: Infants accept vegetable-only first foods to the same extent as a combination of FV, demonstrating that adding a sweeter tasting flavour is not needed to promote vegetable acceptance withing a vegetables first approach to CF.

4.2. Introduction

Fruit and vegetables (FV) are a cornerstone of most dietary guidelines including those for complementary feeding (CF) and early life nutrition (Kleinman & Coletta, 2016; Wallace et al., 2020). In children, adequate FV intake may support growth and development, protect against chronic disease (Wallace et al., 2020), and shape healthy eating patterns for life (Barends et al., 2019; Nekitsing et al., 2018). Globally, fruit and vegetable consumption is suboptimal for most children, but vegetable intake remains particularly low (Bailey et al., 2019; Barends et al., 2019; Mihrshahi et al., 2019; National Health Service Digital, 2019; Ocké et al., 2008). The CDC Vital Signs report found only 7 % of US children (2–18 years) had adequate vegetable intake in 2003 with no change in 2010, whereas fruit consumption increased by 67 % (Kim et al., 2014). New Zealand statistics indicate most (71.2 %) children (2–4 years) met fruit recommendations in 2018/19, however, less than half (46.1 %) were eating the recommended two or more servings of vegetables (Ministry of Health, 2020). In Australia, many more children (2–3 years) met recommended fruit intake (96.9 %) than vegetable intake (20.2 %) in 2014/15 (Mihrshahi et al., 2019). This highlights an increasing need to identify strategies that improve vegetable, rather than fruit, consumption in children (Barends et al., 2019; Chambers, 2016).

The types of FV that infants receive as first foods are typically based on sweeter varieties such as apple, pear and carrot, with a small amount of green or cruciferous vegetables (Cockroft et al., 2005; Fu et al., 2018; Mennella et al., 2005; Miles & Siega-Riz, 2017; Siega-Riz et al., 2010). This may reflect commercially available combinations of infant foods (Foterek et al., 2015; Garcia et al., 2016; Mesch et al., 2014; Moding et al., 2018; Padarath et al., 2020), or a strategy to encourage intake of vegetables paired with a sweeter flavour from fruits via flavour-flavour learning (Barends et al., 2019; Remy et al., 2013). Infants are born with an unlearned acceptance of sweet taste, alongside an aversive response to the bitterness that is common to most vegetables (Forestell, 2017; Mennella & Bobowski, 2015; Wardle & Cooke, 2008). Parents are likely to provide foods that are preferred by their child (Savage et al., 2007; Søndergaard & Edelenbos, 2007), which may limit food exposure opportunities that are necessary for the acquisition of new food preferences including for vegetables.

Recent systematic reviews (Barends et al., 2019; Scientific Advisory Committee on Nutrition, 2018) and a consensus paper (Chambers et al., 2016) suggest that starting CF with vegetables is advantageous for later acceptance of vegetables . However, further longitudinal RCTs are needed (Chambers et al., 2016; Lind et al., 2019; Maier et al., 2008; van der Veek et al., 2019) as the few studies examining this approach, although compelling, are limited by factors including short follow-up periods, small samples and the use of control groups that do not necessarily reflect common practices (Barends et al., 2013; Barends et al., 2014; Fildes et al., 2015; Hetherington et al., 2015).

The overall aim of our RCT is to determine whether exposure to vegetables-only during the first four weeks of CF increases later vegetable acceptance in infants, compared to a control group which includes both fruit and vegetables. This paper reports a secondary outcome, which is to investigate infants' acceptance of vegetable-only first foods compared to a combination of control fruit and vegetables over the first four weeks of CF.

4.3. Methods

Trial design

This was a randomised, controlled, parallel-group study conducted in New Zealand. Participants were blinded to the specific foods allocated as these were labelled generically (e.g., 'Green A') and mothers did not know specific differences between feeding regimes. They were assured foods aligned with national infant feeding guidelines. A detailed protocol is reported elsewhere (Rapson et al., 2021) and in chapter 3 of this thesis.

Participants

Mothers with an infant (4–6 months) living in Auckland were recruited to the study between May 2019 and January 2020; and provided data up until July 2020 depending on their start date. Infants were eligible to participate if they were born term (≥ 37 weeks), of normal growth/weight, had not started CF and had no known food allergies, chronic diseases or medical conditions. Caregivers with infants under the age of 4 months could enroll in the study but were required to wait until their infant was developmentally ready (4–6 months) to start solids before beginning the intervention. Each participant completed a first visit (pre-intervention) at the laboratory and second visit (post-intervention) either at the laboratory or home.

Outcomes

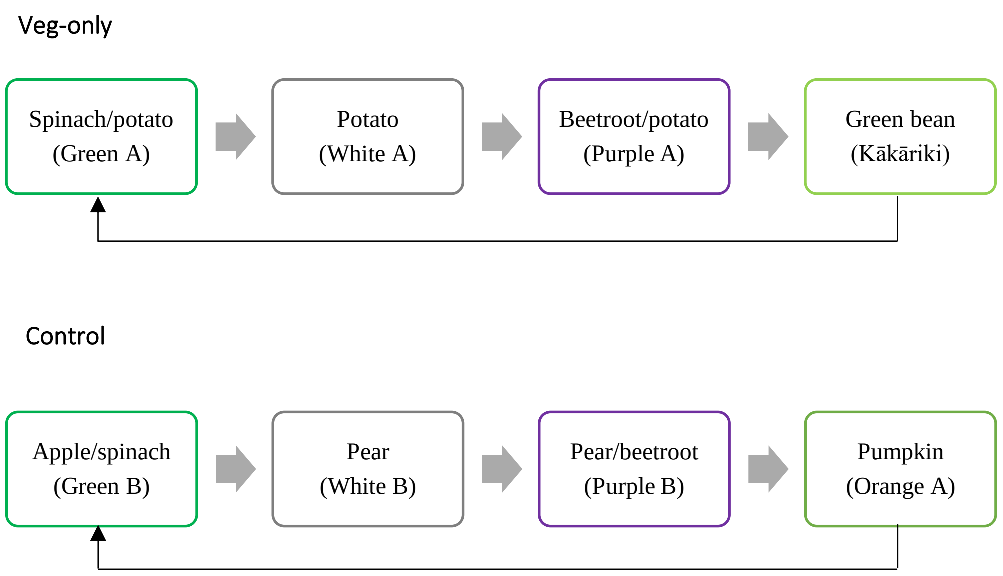
The key outcome measure for this part of the study was intake (grams) of the veg-only and control foods on week one and four, as this offers an objective measure of food acceptance. A secondary measure was liking, as measured by a 5-point mother-rated Likert scale, occurrence of positive/negative behaviours and rate of eating (grams/min).

Intervention

Each group followed a 4-week CF intervention that differed only by the types of foods provided. The veg-only group received daily meals containing only vegetables from the start of CF, while those in the control group received combined fruit and vegetables. Mothers determined the number and timing of meals per day according to their own schedule and infant needs but fed the foods according to a prescribed recipe and colour rotation to improve standardisation

(**Figure 4.1**). During their first visit, mothers received enough infant food to provide up to three meals per day for the duration of the intervention and were able to access additional sachets as required. No meat was allowed during the first four days to standardize infants' very first tastes of solid food but could be introduced thereafter using recipes provided by the researchers. To ensure optimal feeding conditions, a Dietitian delivered a one-on-one 40-minute education session to each mother during their first visit to the laboratory, which covered infant-led feeding practices (e.g., responsive feeding, breastfeeding/formula feeding during the CF period) and the study protocol.

Figure 4. 1. Food rotations for the veg-only and control group



Note. Rotation was either per day (days 1–4 and 24–28) or per meal (days 5–23). Mothers received enough food for two meals per day, allowing for at least 14 exposures to each type of food. Foods were labelled by colour and none listed the ingredients. The codes A or B acted as identifiers for researchers.

Materials - Infant foods

Sachets of freeze-dried infant food powders made from vegetables and/or fruit (**Table 4.1**) specifically developed for the study and produced by a commercial food company were provided to participants. Freeze-drying the foods was preferred for feasibility reasons included easy storage and scalable manufacture. Vegetables and fruits were selected based on availability, infant nutrition guidelines and total sugar content per 100 grams. As there were two green coloured foods given to the veg-only group, to avoid confusion, one was named Kākāriki, which is the Māori translation for green.

Table 4. 1. Infant foods allocated to the veg-only and control group

Food type	Food ingredient (%)	
	Veg-only	Control
Green purée	Spinach (80 %), potato (20 %)	Apple (90 %), spinach (10 %)
White purée	Potato (100 %)	Pear (100 %)
Purple purée	Beetroot (70 %), potato (30 %)	Pear (98 %), beetroot (2 %)
Orange purée	Not applicable	Pumpkin (100 %)
Kākāriki purée	Green bean (100 %)	Not applicable

Note. Total dry weight is 8 grams per sachet; wet weight is approximately 80 grams. Veg-only group foods were less sweet (< 4 grams total sugar per 100 grams) than controls; range of 0.03–3.66 grams per 100 grams and 6.48–10.80 grams per 100 grams, respectively. Average energy content of food was 181 kilojoules per 100 grams for the veg-only and 201 kilojoules per 100 grams for the control.

Mothers followed recipe instructions to rehydrate the powders into age-appropriate infant purées at home. Each sachet required the addition of 50 ml of water (except potato and green bean which required 80 ml). The food was then heated in the microwave for three 20 second intervals, stirred in between, and then cooled for 10 minutes until it was at a safe temperature for infants to consume.

Materials – weighed food diary

Mothers measured and recorded intake of the study foods during the first and last four days of the 4-week intervention using provided digital scales (±1g). Estimated spills or food fallen were recorded. It is assumed that more food eaten indicates liking, acceptance and preference of that food compared to other foods. These two time points allowed for an assessment of effects over time without overburdening the participant. Mothers reported on factors that may have affected infant feeding each day (e.g., teething, unwell) in the diary, as well as information on breast/formula milk feeding, meat consumption and medication/supplements. Instructions on the feeding protocol were included in the weighed food diary.

Materials - Liking tool

The liking tool was adapted from a validated 'elaborate method' to assess infant liking of vegetables (Madrelle et al., 2017) and was included as part of the weighed food diary. Mothers are asked to rate how much their infant liked the food after each trio of spoonfuls (i.e., 3 x 3 spoons), and at the end of the meal (overall liking) using a pictorial 5-point liking scale (1 = dislikes very much to 5 = likes very much).

A list of 10 positive and 10 negative behaviours per spoon was included which mothers ticked as they occurred. The greater percentage of positive behaviours recorded may indicate greater liking, while an average score greater than 3 on the liking scale may show that the food is liked. A dietitian provided mothers with guidance on feeding environment, feeding style to adopt and when to terminate the meal (after three consecutive refusals).

Materials - Questionnaires

Participants were sent a link to an online demographics questionnaire to record information about the mother and infant (e.g., age, ethnicity, parity, education, food availability, infant sex). To assess differences in infants' eating behaviour traits, mothers completed an online version of the Baby Eating Behaviour Questionnaire (BEBQ) retrospectively (Llewellyn et al., 2011). After completion of each week of the intervention, mothers were emailed a brief check-in questionnaire to measure compliance (e.g., number of days that the intervention food was offered, and other food or drink consumed).

Health screening and monitoring

As part of screening for and monitoring infant health and iron status, capillary blood samples were taken from infants by a registered phlebotomist using a standard 'heel prick' test at baseline and after the intervention. If haemoglobin was < 110 g/L, mothers were advised to consult their doctor about their infant but could continue with the study as the provision of plain meat was permissible.

Statistical analysis

On the assumption of a 20 % dropout rate and findings reported by Barends and colleagues (Barends et al., 2014), we calculated a sample size of 52 participants as necessary to detect a clinically significant difference in food intake (grams) with a two-sided 5 % significant level and a power of 80 %. Participant characteristics were described, and significance testing was not performed to align with CONSORT guidelines (de Boer et al., 2015).

Mean daily intakes of the vegetable-only and control foods on week one were calculated as total amount eaten over the first four days divided by four (number of recording days). The same method was applied for week four, and to other variables (i.e., intake of each type of food, overall liking score, liking of each type of food). Mean percentage of positive behaviours was calculated as total positive behaviours over the first nine spoons divided by a maximum score of 90 (as there were 10 positive behaviours per spoon) and then converted to a percentage; mean percentage of negative behaviours was calculated in the same way. Rate of eating (pace) was calculated by dividing daily study food intake by time taken to finish the meal. Log transformations improved normality of daily intake of the study foods and rate of eating only and as geometric means were close to the original medians, the latter has been reported.

To investigate the effect of the intervention on daily food intake of the study foods after four weeks (primary outcome), mixed model analysis (repeated measures analysis) using the interaction terms ‘groups x intervention food intake’, with groups (veg-only vs control) as between subject factors and time (first week and fourth week) as within subject factors. Only exclusive breastfeeding duration was added to the model to avoid overfitting from too many variables. For within and between group comparisons for other variables (e.g., intake of each type of food, overall liking, liking of each food) independent t-tests and paired-sample t-tests were used unless otherwise stated.

Spearman’s rho correlation analysis was used to examine the relationship between food intake and overall liking of the study foods. The same analysis was carried out for other measures of acceptance (i.e., positive/negative behaviours, rate of eating).

All infants who completed the 4-week intervention were included in the analysis; one case did not provide a liking score for one of the meals, thus cell size varied. Outliers, as detected by boxplots, were examined but all remained plausible (i.e., within normal intake for a 4–6-month infant), thus not removed. Also, analysis without outliers did not significantly change results. Statistical analysis was performed using IBM SPSS version 25.0 (IBM Corp. Released 2017, Armonk, NY). All statistical tests were two-tailed with an alpha value of $P < 0.05$.

4.4. Results

Participants

Figure 4.2 provides a flow diagram of participant enrolment. A total of 117 completed the 4-week feeding intervention and provided complete data sets for primary outcomes and so were included in our analyses; these had been randomised to either the veg-only (n = 61) or the control group (n = 56). **Table 4.2** shows baseline demographic characteristics. We had 515 parents indicate interest in the study and 282 completed the screening questionnaire. The primary analysis was per protocol and involved all participants who completed the food diaries. Compliance was high and similar between groups with most mothers reporting that they fed their infant the food every day; median (25^{th}, 75^{th} percentile) number of days for week one and four was 7 days/week (7,7), and other weeks 7 days/week (6,7). However, some compliance data was missing and there were a few instances where infants had consumed food that was outside the study protocol. The first participant recruited was in 2019 and last in 2020, and all 4-week follow-ups were completed by the end of 2020. Normal haemoglobin levels were maintained throughout the 4-week intervention for all infants except three, one of whom had levels that were already below normal (107 g/L) at the start, rising to 109 g/L; a detailed analysis of infants' iron status is beyond the scope of this paper.

Figure 4. 2. Flow diagram of the randomised controlled trial investigating the effects of starting complementary feeding with vegetable-only first foods on vegetable acceptance, compared to combined fruit and vegetables

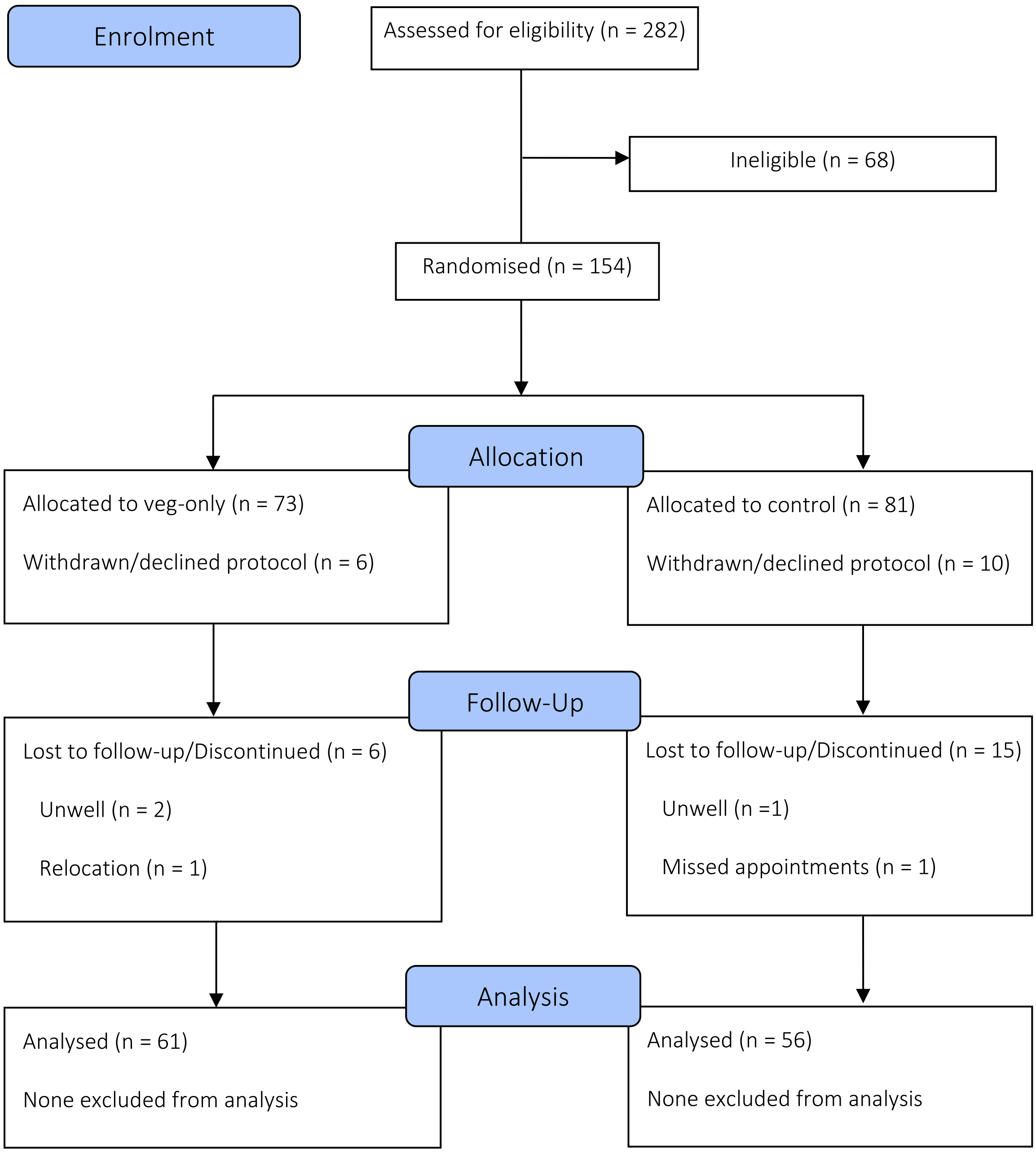


Table 4. 2. Baseline characteristics of mothers and infants by intervention group

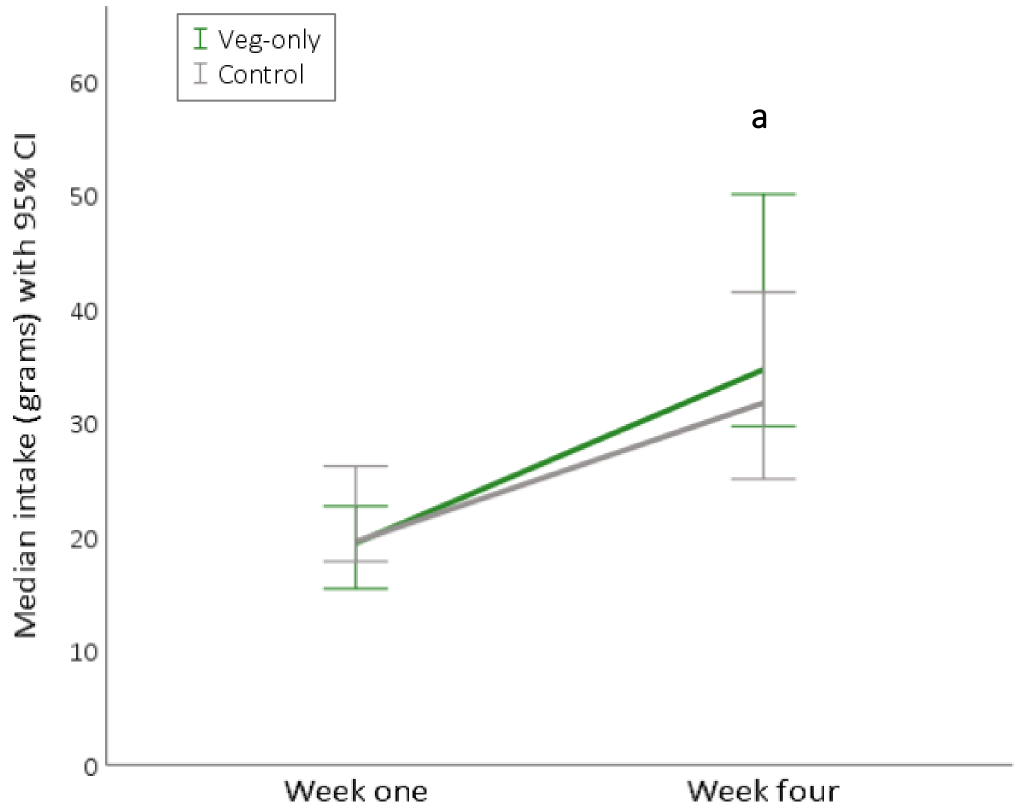
	Veg-only (n = 61)	Control (n = 56)	Total (n = 117)
Infants' characteristics			
Age on day 1 of trial (weeks)	23.5 ± 2.5	23.7 ± 2.7	23.6 ± 2.6
Sex (female), n (%)	33 (54 %)	27 (48 %)	60 (51 %)
Weight (kg)	7.0 ± 0.9	7.0 ± 0.9	7.0 ± 0.9
Length (cm)	64.4 ± 3.1	63.8 ± 3.0	64.1 ± 3.1
Head circumference (cm)	42.6 ± 1.3	42.4 ± 1.5	42.5 ± 1.4
EBF duration (months)	5.0 (2.0, 5.0)	5.0 (1.5, 5.0)	5.0 (2.0, 5.0)
Milk feeding type, n (%) [a]			
Breast milk only	34 (56 %)	30 (54 %)	64 (55 %)
Infant formula only	10 (16 %)	6 (11 %)	16 (14 %)
Both breast/formula milk	17 (28 %)	20 (36 %)	37 (32 %)
Baby eating behaviour questionnaire			
Enjoyment of food	4.24 (0.49)	4.25 (0.48)	4.25 (0.49)
Food responsiveness	2.48 (0.70)	2.54 (0.64)	2.51 (0.67)
Satiety responsiveness	2.61 (0.54)	2.54 (0.61)	2.57 (0.58)
Slowness in eating	2.62 (0.65)	2.63 (0.75)	2.62 (0.70)
General Appetite	3.74 (0.85)	3.75 (0.84)	3.74 (0.84)
Mothers' characteristics			
Age on day 1 of trial (years)	32 ± 4	34 ± 4	33 ± 4
Education, n (%)			
Below university	3 (5 %)	6 (11 %)	9 (8 %)
University or higher	58 (95 %)	50 (89 %)	108 (92 %)
Ethnic origin, n (%) [b]			
NZ European and others	56 (95 %)	48 (91 %)	104 (93 %)
Māori and Pacific Island	4 (7 %)	4 (8 %)	8 (7 %)
Others (e.g., Chinese, Indian)	5 (8 %)	7 (13 %)	12 (11 %)
Primiparous (first time mothers yes), n (%)	44 (72 %)	41 (73 %)	85 (73 %)

Note. EBF = exclusive breastfeeding. Data presented as mean ± SD, number (%) or median (25th, 75th percentile). [a] Describes milk feeding type during the intervention period. [b] Multiple answers were possible.

Daily intake of the study foods

Median (25th, 75th percentile) daily intake of the vegetable-only foods in the veg-only group increased significantly from 19.5 (11.4, 28.4) grams on the first week to 34.8 (19.4, 66.5) grams on the fourth week ($P < 0.001$) (**Figure 4.3**); median change in daily intake of these foods for the veg-only group was 12.0 (-1.4, 33.3) grams. Daily intake of the fruit and vegetable study foods in the control group increased significantly from 19.6 (13.6, 32.1) grams, on the first week to 31.8 (19.8, 69.2) grams on the fourth week ($P < 0.001$); median change in intake of these foods for control infants was 12.1 (-1.8, 38.9) grams, and did not differ from the veg-only group ($P = 0.998$). Daily intake of the assigned foods did not significantly differ between groups at each time point, and there was no main effect of group [$F(1, 115) = 0.687$, $P = 0.409$]; adjusting for the potential covariate of exclusive breastfeeding duration did not change results [$F(1, 115) = 0.662$, $P = 0.418$].

Figure 4. 3. Daily food intake of each group on week one and four of the intervention

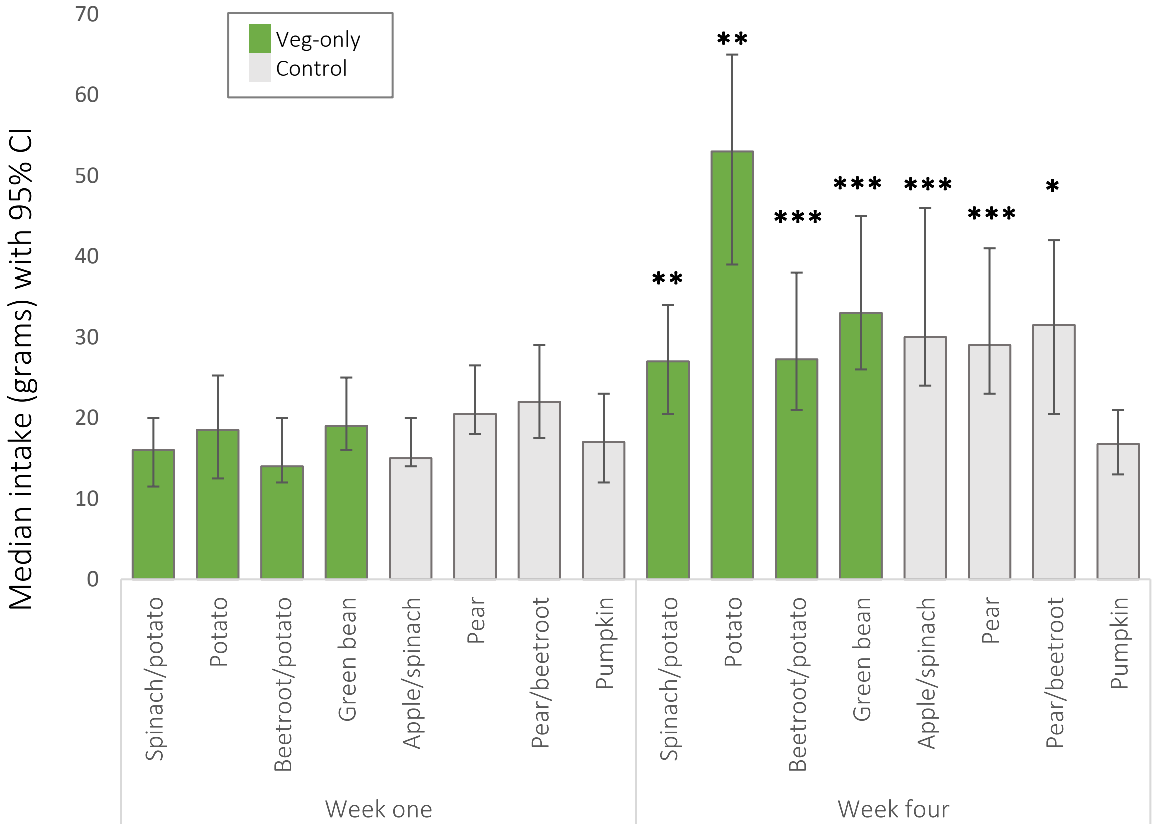


Note. CI = confidence interval. a = significant increase in both groups, P < 0.001; no group differences. Foods consumed were the veg-only or control purées provided by the study.

Intake of each type of food

Median intake of each type of food provided on the study significantly increased after four weeks (P < 0.01), except for pumpkin which was unchanged (P = 0.362) (**Figure 4.4**; see **Supplementary Table O1**). After four weeks, the food with the highest intake belonged to the veg-only group and was potato: median (25th, 75th percentile) 53.0 (23.5, 75.5) grams; the lowest intake belonged to the control and was pumpkin: 16.8 (10.3, 30.1) grams.

Figure 4. 4. Intake of each type of food on week one and four of the intervention

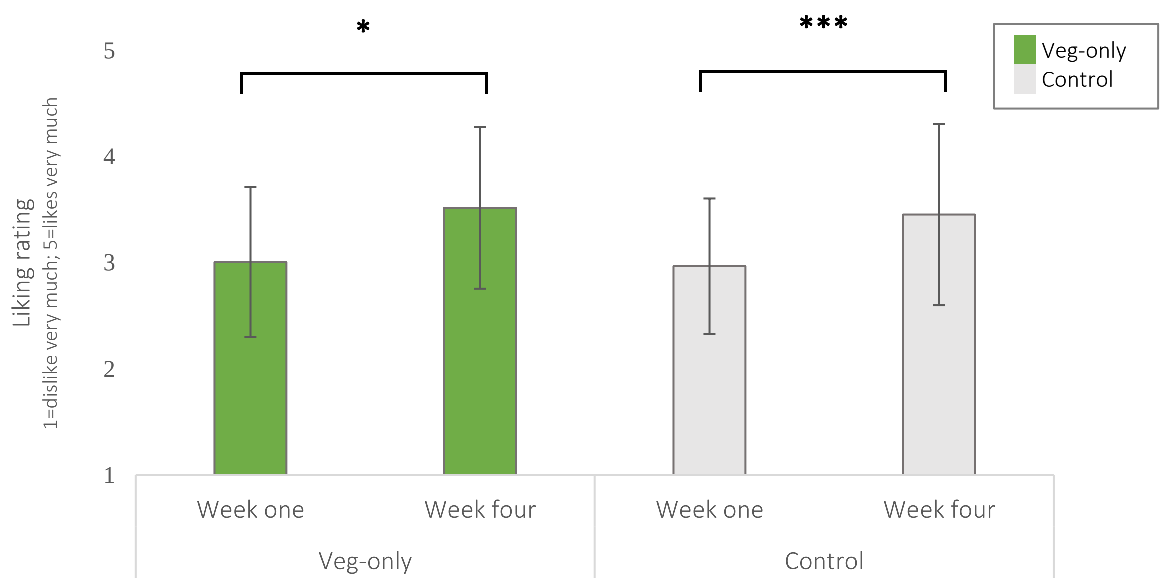


Note. Bars marked with an Asterix indicate a significant increase from week one.
*P < 0.05, **P < 0.01, ***P < 0.001.

Liking – mother rated

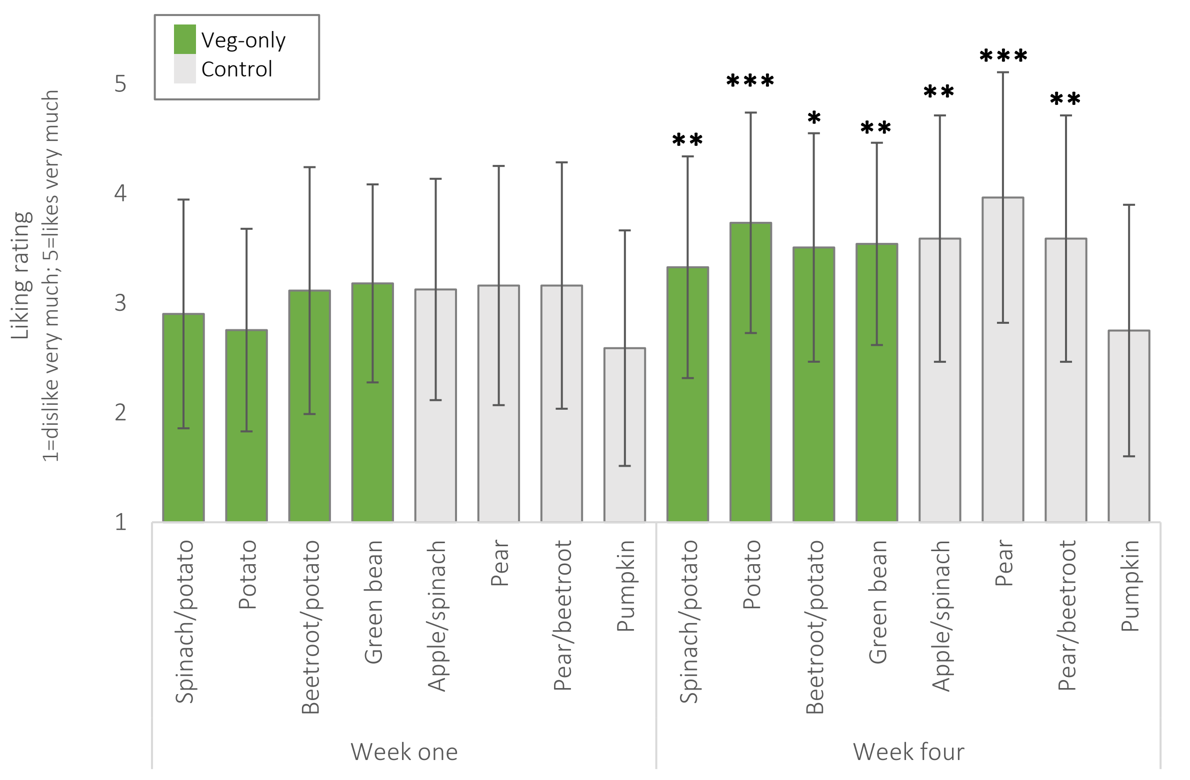
Overall liking of the study foods, as rated by the mothers, significantly increased after the four weeks in both groups ($P < 0.001$) (**Figure 4.5**) but ratings did not differ by group on week one ($P = 0.780$) or by week four ($P = 0.646$). For each type of food, liking significantly increased ($P < 0.05$), except for pumpkin which remained neutral ($P = 0.458$) (**Figure 4.6**; see **Supplementary Table O2**). Eight mothers commented in their weighed food diary that their infant did not like the pumpkin due to its coarser texture or because it made their infant gag more compared to the other foods.

Figure 4. 5. Overall liking of the study foods on week one and four of the intervention for each group



Note. Liking rated by mothers. Paired t-test used to compare within group differences and independent t-test for between group differences. Data presented as mean ± SD.
*P < 0.05, ***P < 0.001.

Figure 4. 6. Liking of each type of food by each group on week one and four of the intervention

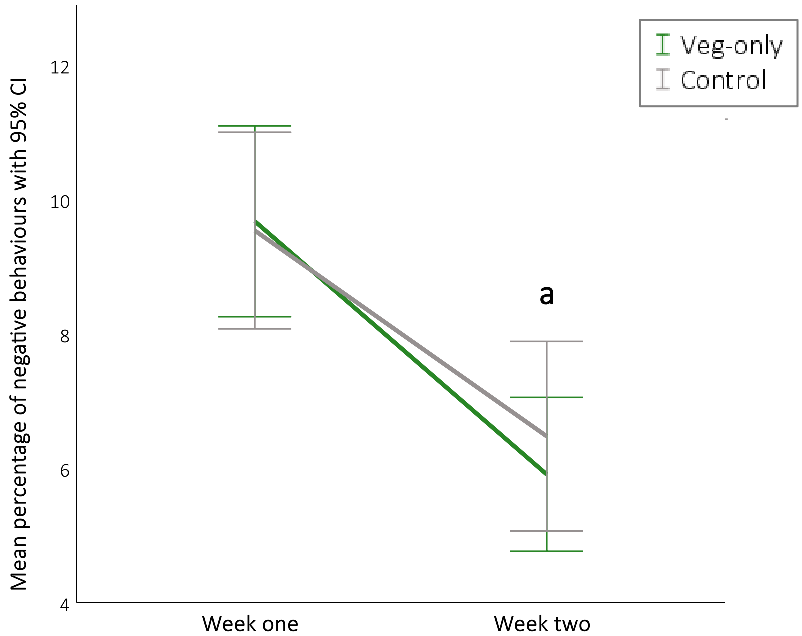


Note. Liking rated by mothers. Bars marked with an Asterix indicate a significant increase from week one. Data presented as mean ± SD. *P < 0.05, **P < 0.01, ***P < 0.001.

Liking – positive and negative behaviours

Mean ± SD percentage of infant positive behaviours as reported by mothers during feeding sessions was similar between groups and did not change over time. For the veg-only group, percentage of positive behaviour was 24.5 ± 14.1 % on the first week and 27.2 ± 14.7 % on the last week (P = 0.07); for the control group, these were 24.5 ± 14.1 % and 27.5 ± 14.4 %, (P = 0.147), respectively. As shown in **Figure 4.7**, the mean ± SD percentage of negative behaviours in the veg-only group significantly decreased from 9.7 ± 5.5 % on the first week to 5.9 ± 4.5 % on the last week (P < 0.001). Similarly, the mean percentage of negative behaviours in the control significantly decreased from 9.5 ± 5.5 % on the first week to 6.5 ± 5.3 % on the last week (P < 0.001); there were no group differences.

Figure 4. 7. Overall mean percentage of negative behaviours during meals in week one and four for each group



Note. CI = confidence interval. a = significant decrease in both groups, P < 0.001; no group differences. Responses recorded by mothers while feeding the veg-only or control purées provided by the study.

Liking – rate of eating

On week one, infants in the veg-only group consumed the vegetable-only foods at a similar rate to the fruit-based controls, with a median of 2.0 (1.2, 2.8) grams/min and 2.1 (1.3, 3.3) grams/min, respectively. On week four, rates between the veg-only (3.8 (1.8, 6.2) grams/min) and control groups (3.4 (2.0, 5.8) grams/min) were also similar. Rate of eating significantly increased over time for both groups (P < 0.001). For each type of food on week one, the rate of eating only differed by group in two instances: controls consumed apple/beetroot at a faster rate than veg-only infants consumed beetroot/potato; controls consumed pumpkin at a slower rate the veg-only infants consumed green bean (all P < 0.05). On week four, rates significantly differed between potato and pear, then green bean and pumpkin (all P < 0.05); with the veg-only group consuming potato and green bean faster than the controls consumed pear and pumpkin. However, differences only just reached significance in all cases, except for green bean and pumpkin on week four (see **Supplementary Table O3**). Infant food consumption rate of each food significantly increased over time in both groups, except for the control pear where rate of eating did not change (P = 0.055).

Correlations between liking and intake

Overall liking positively correlated with daily food intake at each time point for both groups (**Table 4.3**). Similar relationships were observed between other measures of liking and intake. On week one, occurrence of positive behaviour was positively correlated to daily food intake for the veg-only (r_s = .59, P < 0.001) and controls (r_s = 61, P < 0.001); there was an inverse correlation between negative behaviour and intake for the controls (r_s = -.30, P < 0.05) but not the veg-only group (r_s = -.12, P = 0.34). On week four, positive behaviour was positively correlated to daily food intake for both groups (veg-only, r_s = .36, P < 0.01; control r_s = .47, P < 0.001); negative behaviours inversely correlated with intake (veg-only,

r_s = -.29, $P < 0.05$; control, r_s = -.44, $P < 0.01$). Rate of eating was significantly related to daily food intake for both groups on week one (both r_s = .83, $P < 0.001$) and week four (veg-only, r_s = .88, $P < 0.001$; control r_s = .90, $P < 0.001$), with a greater pace related to greater amount eaten.

Table 4. 3. Spearman's rho (r_s) correlations for daily intake and overall liking

Variable	Daily intake w 1	Daily intake w 4	Overall liking w 1	Overall liking w 4
Veg-only (n = 61)				
Daily intake w 1	–			
Daily intake w 4	.18	–		
Overall liking w 1	.51**	.04	–	
Overall liking w 4	.19	.40**	.35**	
Control (n = 59)				
Daily intake w 1	–			
Daily intake w 4	.43**	–		
Overall liking w 1	.51**	.31*	–	
Overall liking w 4	0.12	.37**	.42**	–

Note. w = week. *P < 0.05, **P < 0.01.

4.5. Discussion

The purpose of this trial was to investigate infants' acceptance of vegetable only first foods compared to a combination of control fruit and vegetables at the start of CF; thus, reporting the secondary outcome measures of a prospective study examining a vegetables first approach to CF. The study showed that infants ate and liked vegetable only first foods as much as of the combined fruit and vegetable first foods. Occurrence of acceptance behaviours (e.g., opens mouth, turns head away) and rate of eating were also equivalent. By week four, infants continued to eat and like the foods similarly, but in greater amounts. This was further supported by fewer negative behaviours and eating the foods more rapidly.

These findings contrast to a previous study by Barends et al. (Barends et al., 2013) which showed overall fruit intake was significantly higher than vegetable intake from the start of CF, demonstrating that from the first exposure fruit acceptance is higher than vegetable acceptance. These results are likely driven by the sweeter flavour of fruit which enhances the intake of fruit based complementary foods. However, the present study adds to the literature by indicating that using fruits added to vegetables is not necessary to encourage infants to accept vegetables as a first food.

An infant's ability to accept vegetable only first foods relatively easily from the start of CF has been reported elsewhere (Caton et al., 2014; Harris & Mason, 2017;

Hetherington, 2020; Hetherington et al., 2015; Johnson et al., 2021; Maier et al., 2008). In the UK, Hetherington et al. (2015) found that providing infants with vegetable tastes as early as possible in the CF period was effective for improving vegetable acceptance. Like our study, all mothers received detailed instructions and support on infant-led feeding practices, so this may be important to help infants accept vegetables (Hetherington et al., 2015). Even so, findings support evidence from a systematic review on sensitive periods for food acceptance and taste, which showed that infants can easily accept all new foods including vegetables at the beginning the CF period (4–6 months of age) (Harris & Mason, 2017).

The parallel and significant increase in daily intake of the study foods over time could simply be an effect of learning how to like and eat solid foods, particularly as infants had daily opportunities to taste and practice eating. It is well documented in two recent systematic reviews that several exposures to a particular food during infancy improves acceptance of that food (Appleton et al., 2018; Barends et al., 2019), suggesting that the more an infant experiences the smell, texture and taste of a food, the more likely they will learn to like it. This is supported by the positive correlation between daily intake and overall liking observed in our study and others (Barends et al., 2013; Forestell & Mennella, 2007, 2012; Maier et al., 2007; Mennella et al., 2009).

An interesting observation was the particularly high intake and liking of potato among infants assigned to the vegetables-only group, as was the low intake and liking of pumpkin among the control. Infants in the veg-only group received many more exposures to potato. This was both in pure form (at least four times) and combined with spinach and beetroot (at least eight times). It is possible that infants liked potato for other reasons, including relatively bland flavour, higher energy density, carbohydrate content or smoother texture. It has been hypothesised that infants seek out energy-dense foods as part of an adaptive mechanism to ensure adequate nutrition (Wardle & Cooke, 2008), and that children prefer fruit and vegetables that contain the most energy per gram such as banana and potato, rather than melon and marrow/courgetti which have higher water contents (Gibson & Wardle, 2003). Similarly, pumpkin may have been accepted least because it had the lowest energy density, or because it was the only food offered which had a coarse texture. Indeed, due to the season and variety of pumpkin used, a very smooth consistency was not achieved during the manufacturing process.

It is important to acknowledge that some infants consumed only a few tastes at the beginning and end of the intervention, while others finished the whole meal. Such wide variation is common (Barends et al., 2013; Forestell & Mennella, 2017; Hetherington et al., 2015) and could reflect the age of starting CF or that infants develop at different rates (Ministry of Health, 2008). Nevertheless, our findings illustrate that vegetables tend to be well accepted at the beginning of CF, which should offer encouragement to caregivers and new parents who are apprehensive about offering vegetables as first foods (Søndergaard & Edelenbos, 2007).

A major strength of this study is that it is the first to investigate acceptance of vegetable only first foods compared to a combination of fruit and vegetables at the beginning of CF. The sample size was adequately powered and baseline characteristics similar between groups, thus observed outcomes were likely an effect of the intervention, rather than confounding factors. By conducting the entire intervention in the home environment in alignment with recommended infant feeding practices (i.e., responsive feeding) and in a way that parents found easy to achieve, our findings can be easily translated into practical guidelines (e.g., SACN, 2018).

Limitations of the present study relate to aspects of social desirability and convenience sampling which can weaken generalisability of findings. The study may have attracted highly motivated mothers interested in health and a vegetables first approach, which may have yielded good compliance and influenced infant intakes. However, mothers received a detailed protocol, completed weekly compliance questionnaires, and video-recorded meals so that adherence could be checked. Although completing the intervention at home was favorable in terms of improving ecological validity, we could not rule out all breaches of protocol, especially as there was some data missing from the compliance questionnaires. Other random factors could have skewed findings including infants being upset or tired due to teething or unknown reasons, but these were documented, and the use of several food acceptance measures likely reduced bias.

4.6. Conclusion

Vegetable only first foods were consumed and liked to the same extent as a combination of fruit and vegetables, demonstrating that adding a sweeter fruit flavour to vegetables is unnecessary during first food exposures. These findings reassure caregivers that offering infants vegetables first will not result in substantial food refusal and food waste. Given the infant feeding education component of this intervention, it would seem beneficial for those wishing to prioritise vegetables over fruit at the start of CF to receive practical advice on infant-led feeding practices and the introduction of iron-rich foods. A reminder that not all infants will accept food in the same way is important but other research may be needed to investigate the best ways to help parents in knowing when to seek tailored advice from a health professional. While our study supports a current movement towards a variety of vegetables as first foods, additional follow-ups are necessary to identify if adopting a vegetables first approach to CF has a long-term benefit, including improved vegetable acceptance later in life.

4.7. References

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Chapter 5. Primary outcome – Paper III

Starting complementary feeding with vegetables only increases vegetable acceptance at nine months: a randomised controlled trial

The previous chapter demonstrated that infants could accept and eat vegetable-only foods at the start of complementary feeding, which may be of encouragement to new parents. Participants were then recalled for measurement of the primary objective – assessment of vegetable intake at 9 months of age. Their participation allowed us to meet the study's primary objective, which was:

To determine whether starting complementary feeding with vegetable only first foods results in higher intake of vegetables (target: broccoli, spinach) at 9 months of age compared to a control group.

The following chapter should be of interest to anyone, including policy makers, parents/caregivers and health professionals, seeking simple but effective ways to improve vegetable consumption in early life. This manuscript has been submitted to the American Journal of Clinical Nutrition for publication, pending acceptance.

5.1. Abstract

Background: Starting complementary feeding (CF) with vegetables-only may improve vegetable acceptance throughout childhood. Most dietary guidelines recommend fruit, vegetables and meat or iron-fortified infant cereals as first complementary foods.

Objective: To examine whether exposure to vegetables-only during the first four weeks of CF increases later vegetable acceptance, compared to a control group receiving fruit and vegetables.

Design: In this randomised, controlled, parallel-group study, 108 Auckland mother-infant dyads, received either vegetables-only (veg-only, n = 56) or a combination of fruit and vegetables (control, n = 52) for a duration of four weeks, starting from the first day of CF at around 4–6 months of age. At 9 months of age all infants were offered broccoli (day 1), spinach (day 2) and pear (day 3) at home. The primary outcome measure was intake (grams) of vegetables at 9 months of age. Additional food acceptance variables were mother-rated liking (5-point Likert Scale), frequency of positive/negative behaviours (%), rate of eating (grams/min), rate of acceptance (video coding) and intake/preferences of fruit and vegetable (food frequency/liking questionnaires).

Results: Intake of the target vegetables per day was significantly higher among veg-only infants than controls: median (25th, 75th percentile) for broccoli was 47.0 (27.0, 72.0) vs 30.0 (16.0, 62.0) grams, $P = 0.024$, respectively; spinach was 37.0 (19.0, 55.0) vs 24.0 (12.0, 41.0) grams, $P = 0.028$, respectively. Daily total vegetable intake as derived from the food frequency questionnaire was significantly higher in the veg-only group: 86.3 (52.5, 146.3) grams vs control 67.5 (37.5, 101.3) grams, $P = 0.042$. Veg-only infants consumed the target vegetables at a faster rate (broccoli, $P < 0.001$; spinach, $P = 0.004$) and showed greater acceptance than controls (both vegetables $P = 0.018$). Fruit intake (target and daily) was similar across groups, as were all other acceptance variables.

Conclusion: Providing vegetables as first foods increased vegetable intake at 9 months of age, and may be an effective strategy for improving child vegetable consumption and developing preferences for vegetables in infancy.

5.2. Introduction

Vegetables are an important part of a child's diet as they provide nutrients needed for growth, development, and overall health (Boeing et al., 2012; Kleinman & Coletta, 2016). Yet, according to the latest UNICEF flagship report, 44 % of children aged 6 to 23 months are not offered fruit or vegetables, with the percentage increasing to 52 % for the poorest children (UNICEF, 2019). Growing Up in New Zealand found low adherence to eating fruit (37 %) and lower adherence to eating vegetables (33 %) twice or more times daily at 9 months old; some children (12 %) consumed vegetables less than daily or never (Gontijo de Castro et al., 2018). Other studies report more children eating fruit, compared to vegetables (Bailey et al., 2019; Barends et al., 2019; Mihrshahi et al., 2019; Ministry of Health, 2020). In the US, children's consumption of fruit but not vegetables has increased (Kim et al., 2014), and the Feeding Infants and Toddlers Study (FITS) study showed that consumption of dark green vegetables is particularly low among infants (Reidy et al., 2018). Reasons for poor vegetable intake are many and range from infant preferences for sweet/energy dense foods over more bitter tasting, low energy density vegetables to simple lack of access, maternal dislike or cultural practices. Indeed, many families are accustomed to providing fruit and sweet/starchy vegetables to infants as first foods (Cockroft et al., 2005; Fu et al., 2018; Mennella et al., 2005; Miles & Siega-Riz, 2017; Siega-Riz et al., 2010). A focus on improving vegetable consumption (quantity and variety) as early as possible is desirable (Barends et al., 2019; Hodder et al., 2020), especially as eating habits, including vegetable preferences, track into adulthood (Caton et al., 2014; Mikkilä et al., 2005; Rose et al., 2017).

On May 2016, the British Nutrition Foundation met with leading infant feeding experts to discuss a ‘vegetables first’ approach (Chambers et al., 2016) to complementary feeding (CF), which refers to the prioritisation of vegetable-only first foods from the moment solid food starts to complement breast milk and/or infant formula. The evidence base was considered sufficient to start recommending the approach as a strategy to improve vegetable acceptance throughout childhood, which some authorities such as the NHS (National Health Service, n.d.) and ESPGHAN (Fewtrell et al., 2017) now reflect in their current messaging. Yet, the sparsity of studies and the need for more longitudinal randomised controlled trials (RCTs) (Bell et al., 2021) is acknowledged and perhaps the reason why others, including the WHO (World Health Organization, 2003), New Zealand (Ministry of Health, 2008) and Australia (National Health and Medical Research Council, 2013) continue to recommend fruit, vegetables, meat and iron-rich infant cereals as first complementary foods.

This RCT investigates the effects of starting CF with vegetables-only on vegetable acceptance, compared to a combination of fruit and vegetables. We hypothesised that introducing vegetable-only first foods at the start of CF would result in greater vegetable acceptance at 9 months of age compared to introducing combined fruit and vegetables.

5.3. Methods

Experimental design

This study was a randomised controlled trial comprising a 4-week intervention at the start of CF with the primary endpoint assessed at 9 months of age. A detailed protocol has been published (Rapson et al., 2021) and described in chapter 3 of this thesis.

Outcomes

The primary outcome measure was intake (grams) of vegetables at 9 months of age. A secondary measure was liking of vegetables, as measured by a 5-point mother-rated Likert scale, frequency of positive/negative behaviours as reported by mothers, rate of eating (grams/min), rate of acceptance (video coding), and daily vegetable intake reported via a food frequency questionnaire. Additional analyses of intake and liking of fruit were conducted for comparative purposes.

Participants

Mother-infant dyads (N = 117) participated in the 4-week intervention (between May 2019 and May 2020, depending on their start date) in Auckland, New Zealand, and were randomly assigned to start CF with vegetables-only (veg-only = 61) or a combination of fruit and vegetable purées (control = 56). Of these, 108 completed provided target food intake data (grams) for the primary analysis at 9 months of age, thus is the total sample. Loss to follow-up was due to family time constraints (n = 5) and one infant was excluded from all analysis as they had started taking PediaSure® due to feeding issues. The first participant to complete this study was in September 2019 and last in July 2020. Informed, written consent to participate was obtained during recruitment. Ethical approval was granted by the Massey University Human Ethics Committee: Southern A, Application SOA 18/56.

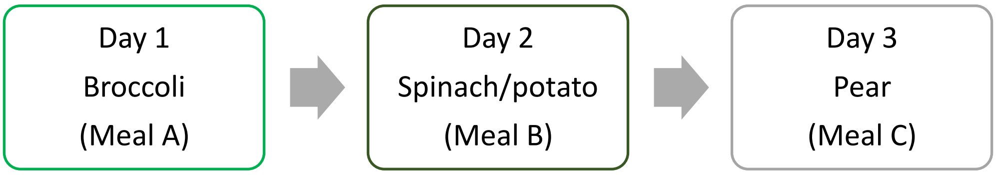
Procedure

The procedure for the 4-week intervention is reported in detail elsewhere (Rapson et al., 2021) and in chapter 3 of this thesis, but a brief description is below:

At the start of CF (4–6 months), infants were randomly assigned to receiving either vegetables-only (veg-only) or combined fruit and vegetables (control). Infants had not been fed any other complementary foods before commencing the trial. During the four weeks, the veg-only group received a daily meal rotation of vegetable purées: spinach, potato, beetroot and green bean (natural sugars ranging from 0.03–3.66 grams per 100 grams). Infants in the control group received a mix of fruit and vegetables which were sweet in taste and largely apple and pear based (natural sugars ranging from 6.48–10.80 grams pers 100 grams). Mothers fed their infant at home following detailed protocol instructions and were offered support around preparing additional iron-rich meat foods. After the four weeks, parents were given general advice about infant feeding during the first year of life and were free to feed their infant as they wished.

At 9 months of age, mothers were given three foods for their infant to try at home including a brassica (broccoli), green leafy vegetable (spinach) then sweet fruit (pear) over three consecutive days (Figure 5.1).

Figure 5. 1. Order of foods given over three consecutive days at 9 months of age



Note. None of the foods listed the ingredients, but mothers were reassured that the foods aligned with New Zealand infant feeding guidelines. The labels Meal A, Meal B and Meal C acted as identifiers for researchers and helped mothers feed the foods in the correct order of feeding. Spinach contained 20 % potato to improve feasibility of manufacture. Dry weight of each food 8 grams; wet weight 80 grams.

Mothers were asked to choose the same time each day to provide the meal, making sure that no other solid food had been consumed within one-hour prior. Infants could consume their usual foods and drinks during the rest of the day. Feeding guidelines were similar to those given during the 4-week intervention. A researcher contacted mothers before the experiment to ensure they understood the guidelines, and mothers were reminded to stop feeding after three consecutive spoon refusals. Mothers weighed the pre- and post-weight of the bowl containing food using digital scales (±1 gram) and estimated the amount spilt in teaspoons/tablespoons, recording these in a weighed food diary. Only intake of the target foods was weighed, but other vegetables and fruit consumed that day were noted, as well as anything else that may have affected feeding (e.g., infant feeling unwell, teething).

During the feed, mothers rated how much they thought their infant liked the food using the same liking tool as during the 4-week intervention, which comprised a pictorial 5-point liking scale (1 = dislikes very much to 5 = likes very much), and a list of 10 positive and 10 negative behaviours per spoon that mothers ticked as they occurred. Greater liking was indicated by a greater score on the liking scale, higher percentage of positive behaviours and/or lower percentage of negative behaviours.

Target foods

Vegetables and fruits used in the study for the veg-only and control foods were selected based on availability, infant nutrition guidelines and sugar content. The target vegetables (broccoli and spinach) at 9 months were chosen as these are typically disliked and eaten less frequently than sweet vegetables such as carrots, whereas fruit (pear) is typically consumed and liked by children. In addition, the spinach was the same food provided to the veg-only and the pear was the same as was given to the control group at during the 4-week intervention. These foods were considered familiar within the respective groups but neither group had tasted broccoli within the first four weeks of CF. Only three foods were tested at 9 months to reduce participant burden. Throughout this study, parents were unaware as to which group that they had been originally assigned (since foods were named for their colour not their content).

All foods provided by the study were freeze-dried powders which rehydrated with the addition of water to an age-appropriate texture, i.e., mashed or puréed. Recipe instructions asked mothers to add 50 ml water, heat the food in the microwave for three 20 second intervals, stir in between, and then cool for 10 minutes until it was at a safe temperature for infants to consume. Freeze-drying the foods was preferred as these were easy to store and manufacture within the study time frame.

Video-recorded meals

Mothers video recorded each meal using a personal video camera or mobile phone following detailed instructions on where to position the camera (Figure 5.2) and how to upload videos to a secure database. These instructions were the same as given during the 4-week intervention and thus familiar to mothers.

Figure 5. 2. Example images used to instruct mothers on how to video record the meals

Note. Permission to use infant image provided by mother.

The videos captured the moment when infants opened their mouth as food approached, which has been established to reflect the degree or rate of food acceptance (Hetherington et al., 2016). To assess rate of acceptance, an independent research assistant who was blinded to the originally assigned groups was trained to score the videos according to a set of coding rules: early acceptance = 3; late acceptance = 2; enforced = 1; and refused = 0. The first nine spoons were coded, and an average score was calculated by dividing the sum of scores by nine spoons. A complete nine spoons could not be coded for some videos due to the feeding session ending following infant cues (19 videos) or because the video was cut short for technical or unknown reasons (10 videos). In these instances, the average scores were calculated by the number of available spoons offered and coded. When the visibility was obscured or obstructed (e.g., by the mother's hand), the spoon was not counted in the analysis. To assess reliability, a second coder who was considered a gold standard coded a randomly selected 20 % of the videos (30 videos from each group); randomisation was conducted by the HNRU trials manager using a random number generator.

Clinic and home visits

After infants had been offered the target foods at home, a researcher met with participants at the laboratory or at home to collect their weighed food diary and measure infants' weight, height and length. Due to restrictions caused by the Covid-19 pandemic, 36 (33 %) in-person-visits were not possible, and mothers were required to measure their infant's anthropometry at home without a researcher present. However, detailed instructions and phone/Zoom support were given to improve accuracy. Food acceptance measures and sample retention seemed minimally impacted.

Questionnaires

Mothers completed an infant food frequency questionnaire (FFQ) and fruit/vegetable preference questionnaire online. The FFQ was an abbreviated version of a validated questionnaire and measured infants' daily vegetable and fruit intake (Judd et al., 2020). The total grams consumed over four days was divided by four to obtain an average daily intake. To assess how often vegetables/fruit were typically offered per day, the sum of frequency was divided by four days. Greater frequency and amount eaten of a vegetable reflected greater daily intake of that vegetable. The fruit/vegetable preference questionnaire asked about which vegetables and fruits infants had tried and liked (1 = dislike very much, 5 = like very much) over the last three months. The overall liking scores, as calculated by the sum of liking divided by the number of vegetables or fruit tried, were used to assess daily liking of vegetables and fruit. The frequency categories that mothers had selected were coded based on the lower value of the range as follows: 'never' = 0; 'tried 1–3 times' = 1; 'tried 4–6 times' = 4; 'tried 7–9 times' = 7; and 'tried 10+ times' = 10. The sum of scores indicated the minimum number of occasions that infants had tried vegetables/fruit since completing the 4-week intervention.

Statistical analysis

We calculated a sample size of 52 participants as necessary to detect a clinically significant difference in food intake (grams) with a two-sided 5 % significant level and a power of 80 % as shown in chapter 3 of this this thesis. For the primary analysis, group differences for the average intake of target foods (broccoli, spinach and pear) were compared using independent t-tests or Mann-Whitney tests, depending on data distribution. The same method was applied for all secondary outcome variables. To assess if a particular target food was consumed or liked more than others, Wilcoxon signed-rank test was used. Log transformations improved normality of target food intake (pear only), rate of eating (all target foods), daily vegetable intake, number of occasions vegetables were offered per day, and number of times fruit was tried over the previous 3 months. The original medians are reported as these were close to the geometric means. Spearman's rho correlations were used to examine the relationship between food intake and secondary measures of food acceptance. Interclass correlation coefficient (ICC) estimates and their 95 % confident intervals for rate of acceptance for each meal type were calculated using single-rating, absolute-agreement, 2-way mixed-effects model. The average score given per participant was used for the reliability analysis, rather than the scores of each spoon. ICC values < 0.5, 0.5–0.75, 0.75–0.90, and > 0.90 were considered poor, moderate, good and excellent reliability, respectively (Koo & Li, 2016).

The primary analysis was per protocol and involved all participants who provided data on target food intake at 9 months of age. Infant data from the feeding sessions were excluded from analysis if they were unwell on the day of testing with evidence of affected appetite, e.g., mother reported 'has a cold so not keen on solids' (n = 4). Outliers, as detected by boxplots, were examined but remained plausible, thus not removed. Statistical analysis was performed using IBM SPSS version 25.0 (IBM Corp. Released 2017, Armonk, NY). All statistical tests were two-tailed with an alpha value of $P < 0.05$.

5.4. Results

Participants

Mother and infant characteristics at the start of the trial and 9-month time point are presented in **Table 5.1** (see also **Supplementary Table P1**).

Table 5. 1. Characteristics of mothers and infants by originally assigned group

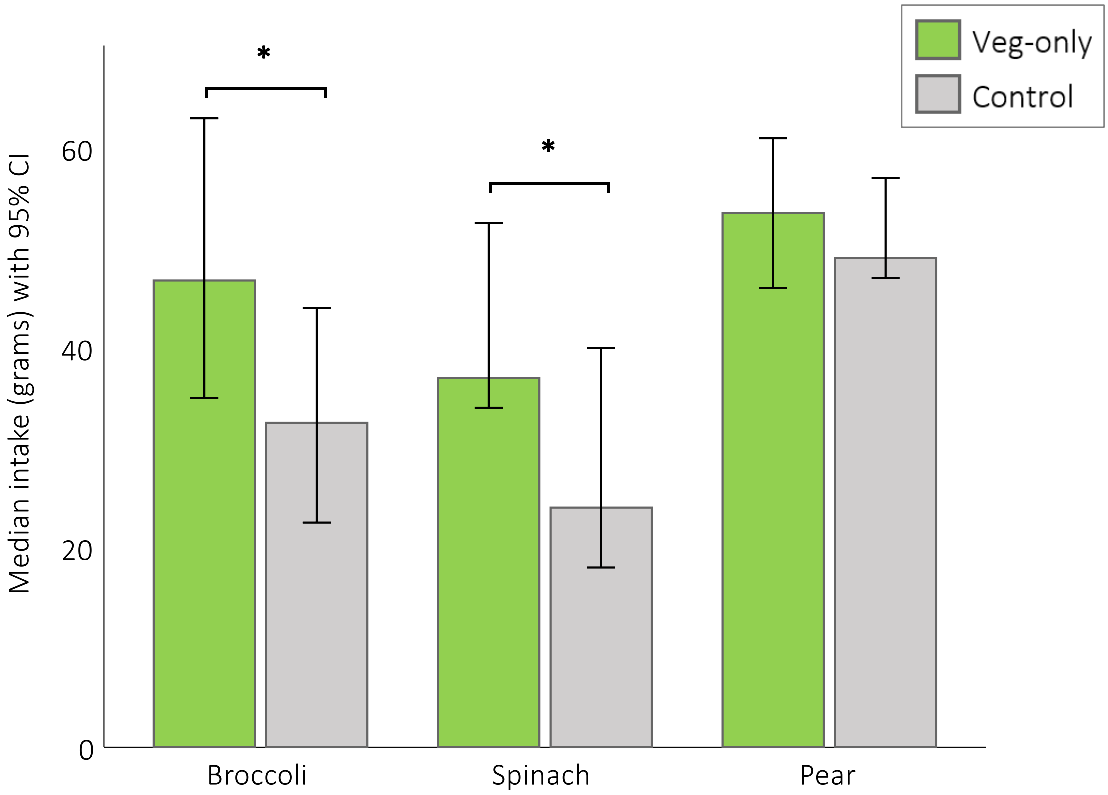
	Veg-only	Control	Total
Baseline, n	61	56	117
Infants' age (weeks)	23.5 ± 2.5	23.7 ± 2.7	23.6 ± 2.6
Sex (female)	33 (54 %)	27 (48 %)	60 (51 %)
9 months of age, n	56	52	108
Infants			
Sex (female)	29 (52 %)	26 (50 %)	55 (51 %)
Age (months)	9 (8, 9)	9 (9, 9)	9 (8, 9)
Weight (kg) [a]	8.9 ± 1.0	9.0 ± 0.9	9.0 ± 1.0
Length (cm) [a]	72.8 ± 3.1	71.9 ± 2.8	72.4 ± 2.9
Head circumference (cm) [a]	45.7 ± 1.5	45.7 ± 1.5	45.7 ± 1.5
EBF duration (months) [a]	5.0 (2.5, 5.0)	5.0 (1.5, 5.0)	5.0 (2.0, 5.0)
Milk feeding type [b]			
Breast milk only	22 (39 %)	26 (50 %)	48 (44 %)
Infant formula only	19 (34 %)	12 (23 %)	31 (29 %)
Both breast/formula milk	15 (27 %)	14 (27 %)	29 (27 %)
Mothers			
Age (y)	33 ± 4	34 ± 5	33 ± 4
Education, n (%) [c]			
Below university	2 (4 %)	6 (12 %)	8 (7 %)
University or higher	54 (96 %)	46 (88 %)	100 (93 %)
Ethnic origin, n (%) [d]			
NZ European and others	53 (95 %)	45 (87 %)	98 (91 %)
Māori and Pacific Island	3 (5 %)	3 (6 %)	6 (6 %)
Others (e.g., Chinese, Indian)	4 (7 %)	5 (10 %)	9 (8 %)
Primiparous (first time mothers yes), n (%)	43 (77%)	38 (73%)	81 (75%)

Note. EBF = Exclusive breastfeeding. Data presented as mean ± SD, numbers (%) or median (25th, 75th percentile). [a] Weight (veg-only, n = 51; control, n = 51), length (veg-only, n = 47; control, n = 49), head circumference (veg-only, n = 47; control, n = 49); missing data due to Covid-19 restrictions. [b] Describes milk feeding type over the three days of feeding the study foods at 9 months of age. [c] Multiple answers were possible. [d] Multiple answers were possible.

Intake – target foods

Intake of broccoli (Meal A) was significantly higher among infants originally assigned to the veg-only group, compared to the control group: median (25th, 75th percentile) for veg-only group, 47.0 (27.0, 72.0) grams; control, 30.0 (16.0, 62.0) grams; P = 0.024. Intake of spinach (Meal B) was also significantly higher amongst the veg-only group compared to controls: 37.0 (19.0, 55.0) grams; 24.0 (12.0, 41.0) grams, respectively; P = 0.028) (**Figure 5.3**). Pear (Meal C) intake did not significantly differ by group: veg-only 53.5 (44.0, 65.0) grams; control, 49.0 (39.0, 57.8) grams; P = 0.353. Intake of spinach and broccoli did not significantly differ from intake of pear among the veg-only group (spinach vs pear P = 1.00; broccoli vs pear 0.095); whereas controls consumed significantly more pear than broccoli and spinach (P = 0.038 and P < 0.001, respectively).

Figure 5. 3. Intake of the target foods at 9 months of age

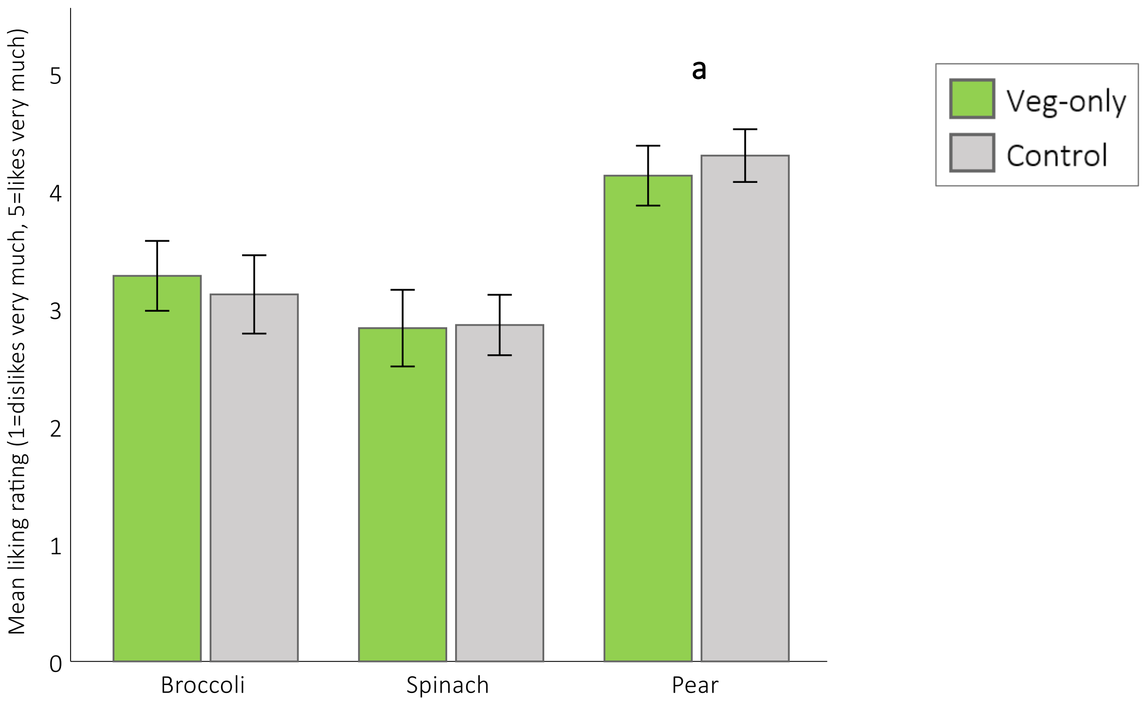


Note. CI = confidence interval. Target foods: broccoli (Meal A), spinach (Meal B), pear (Meal C). Mann-Whitney test used to assess group differences in broccoli and spinach intake. Independent t-test used to assess differences in pear intake. Median reported to improve comparability.
*P < 0.05.

Mother-rated liking – study foods

Overall liking of the broccoli, spinach and pear foods, as rated by mothers, did not differ by group ($P = 0.478$, $P = 0.962$ and $P = 0.378$, respectively) (**Figure 5.4**). Fifteen mothers commented that their infant did not like being spoon-fed and preferred self-feeding/finger foods. In both groups, pear was rated as significantly more liked than broccoli and spinach (all $P < 0.001$).

Figure 5. 4. Overall liking of target foods as rated by mothers



Note. Target foods: broccoli (Meal A), spinach (Meal B) and pear (Meal C). Independent t-test found no group differences. Error bars are 95 % confidence interval. a = pear liking was significantly higher than broccoli and spinach in both groups ($P < 0.001$).

Behaviour and rate of eating

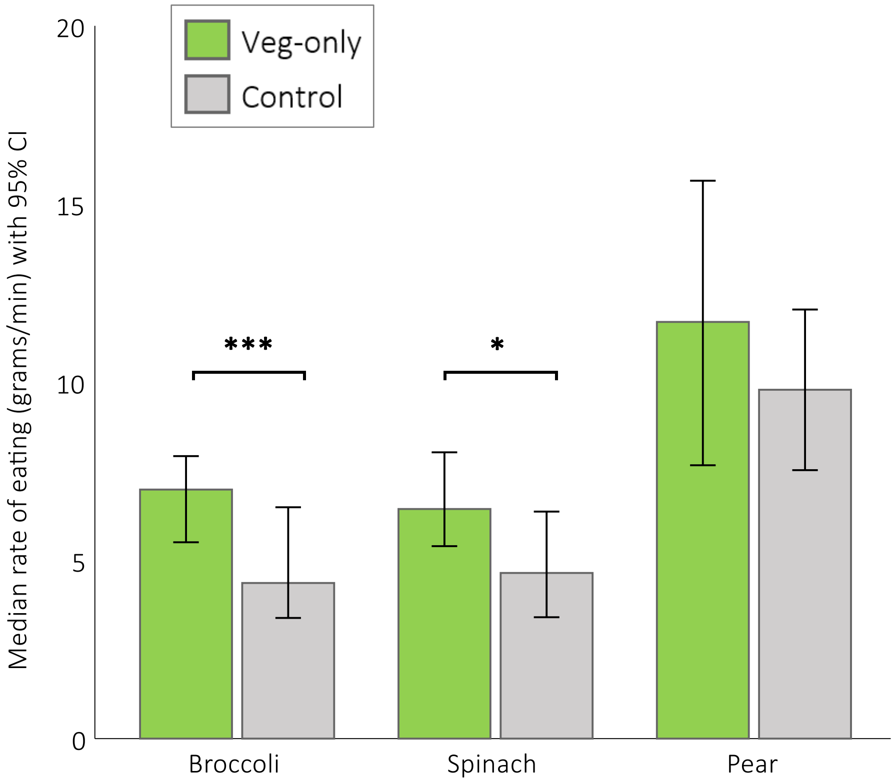
Frequency of positive and negative behaviours recorded during the meals did not differ between groups (**Table 5.2**). Infants in the veg-only group consumed broccoli and spinach at a significantly faster rate than infants in the control group, but rate of eating did not differ by group for pear (**Figure 5.5**). Overall, pear received fewer negative behaviours and was eaten at a faster rate compared to broccoli and spinach.

Table 5. 2. Percentage of positive and negative behaviours towards the target foods

	Veg-only	Control	Total	P-value*
Broccoli	n = 53	n = 50	n = 103	
Positive, %	23.7 ± 14.2	25.67 ± 15.9	24.6 ± 15.0	0.503
Negative, %	6.5 ± 6.4	6.7 ± 6.6	6.6 ± 6.5	0.944
Spinach	n = 52	n = 51	n = 103	
Positive, %	22.2 ± 14.9	20.4 ± 12.3	21.3 ± 13.6	0.508
Negative, %	6.8 ± 6.7	6.4 ± 6.1	6.6 ± 6.4	0.793
Pear	n = 54	n = 51	n = 105	
Positive, %	30.5 ± 15.7	32.4 ± 14.3	31.4 ± 15.0	0.519
Negative, %	2.4 ± 3.3	3.0 ± 5.1	2.7 ± 4.2	0.514

Note. Target foods: broccoli (Meal A), spinach (Meal B) and pear (Meal C). Independent-t test and Mann-Whitney test performed for positive behaviours and negative behaviours, respectively. Data reported as mean ± SD for consistency. Cell size varies due to missing data or infants' being unwell.
*Significant at the P < 0.05 level.

Figure 5. 5. Rate of eating for each target food

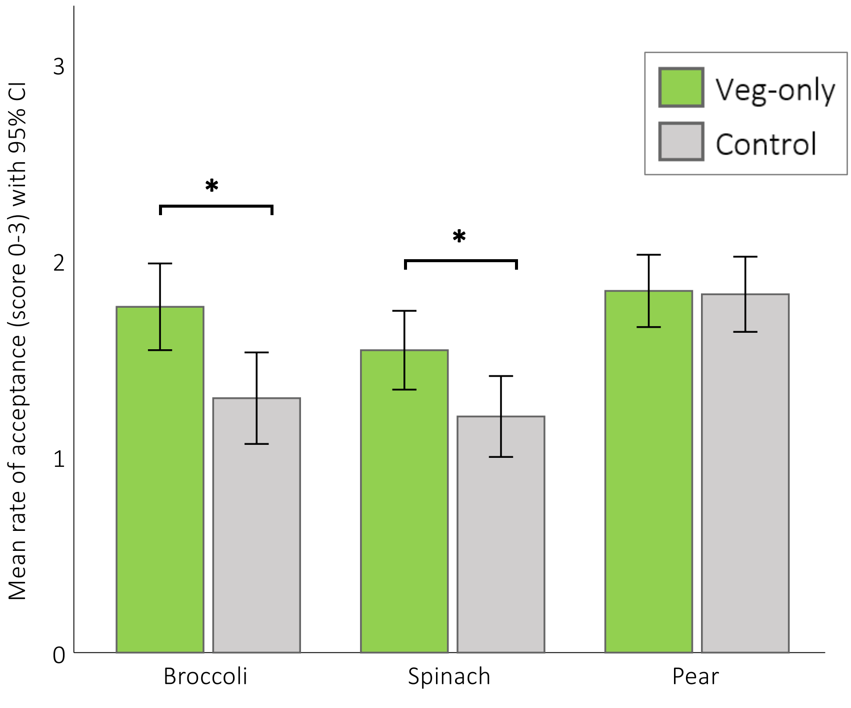


Note. CI = confidence interval. Target foods: broccoli (Meal A), spinach (Meal B) and pear (Meal C). Cell sizes: broccoli (veg-only, n = 48; control, n = 48); spinach (veg-only, n = 50; control, n = 46); pear (veg-only, n = 51; control, n = 46). Independent t-test performed following log transformation. Data presented as original median with 95th confidence interval. *$P < 0.05$, ***$P < 0.001$.

Rate of acceptance – video coding

Figure 5.6 shows that rate of acceptance of broccoli and spinach was significantly faster in the veg-only group compared to the controls (both foods P = 0.018). Rate of acceptance for pear did not differ between groups (P = 0.708). The ICC (95 % CI) for broccoli, spinach and pear was 0.97 (0.92–0.99), 0.99 (0.97–0.10) and 0.99 (0.97–0.10), respectively.

Figure 5. 6. Rate of acceptance for each target food



Note. CI = confidence interval. Rate of acceptance coded by researcher: 0 = refusal; 1 = enforced; 2 = late acceptance; 3 = early acceptance. Target foods: broccoli (Meal A), spinach (Meal B) and pear (Meal C). Cell sizes: broccoli (veg-only, n = 47; control, n = 48), spinach (veg-only, n = 48; control, n = 48) and pear (veg-only, n = 48; control, n = 49). Independent t-tests performed for broccoli and spinach, and Mann-Whitney test for pear. Mean with 95 % confidence interval presented for consistency. *P < 0.05.

Correlation between intake and liking

Intake significantly correlated with mother-rated liking; and rate of acceptance (**Table 5.3**). Intake was significantly correlated with percentage of positive/negative behaviours, degree of acceptance and rate of eating; although intake of pear did not correlate with negative behaviour among the veg-only group (see **Supplementary Table P2**).

Table 5. 3. Spearman's rho (r_s) correlations between intake and liking of target foods

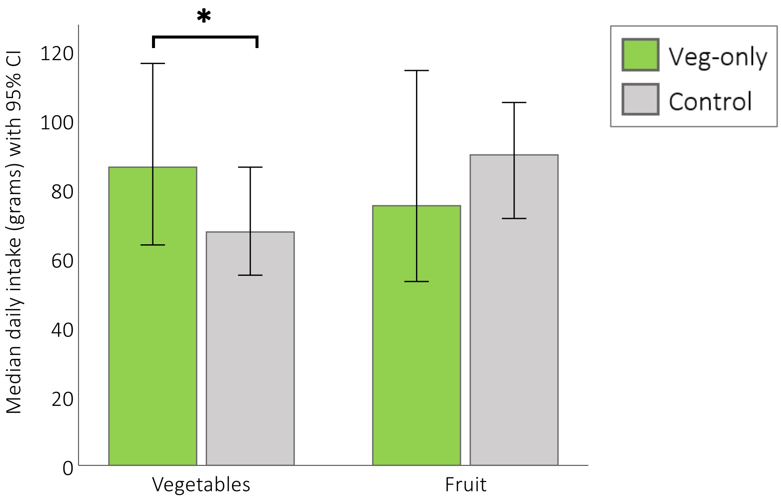
	Veg-only		Control	
Variable	Intake	Mother-rated liking	Intake	Mother-rated liking
Broccoli				
Intake	–		–	
Mother-rated liking	.46**	–	.67**	–
Rate of acceptance	.33*	.49**	.64**	.68**
Spinach				
Intake	–		–	
Mother-rated liking	.53**	–	.39**	–
Rate of acceptance	.71**	.36*	.56**	.41**
Pear				
Intake	–		–	
Mother-rated liking	.31*	–	.34*	–
Rate of acceptance	.39**	.44**	.34*	.28*

*P < 0.05, **P < 0.01.

Daily vegetable intake

Daily intake of vegetables as derived from the FFQ was significantly higher among infants in the veg-only group compared to controls: 86.3 (52.5, 146.3) vs 67.5 (37.5, 101.3) grams, P = 0.043, respectively (**Figure 5.7**). Daily intake of fruit did not differ between groups: veg-only, 75.1 (35.0, 159.4); control, 86.3 (33.7, 128.8) grams, P = 0.770. There was no difference in the number of occasions that vegetables had been tried over the previous 3 months between groups: veg-only 98 ± 37 occasions; control 96 ± 38 occasions (mean ± SD), P = 0.710. Fruit had also been tried to the same frequency between groups: veg-only 64 ± 35 occasions; control 68 ± 33 occasions, P = 0.923.

Figure 5. 7. Daily intake of vegetables and fruit at 9 months of age

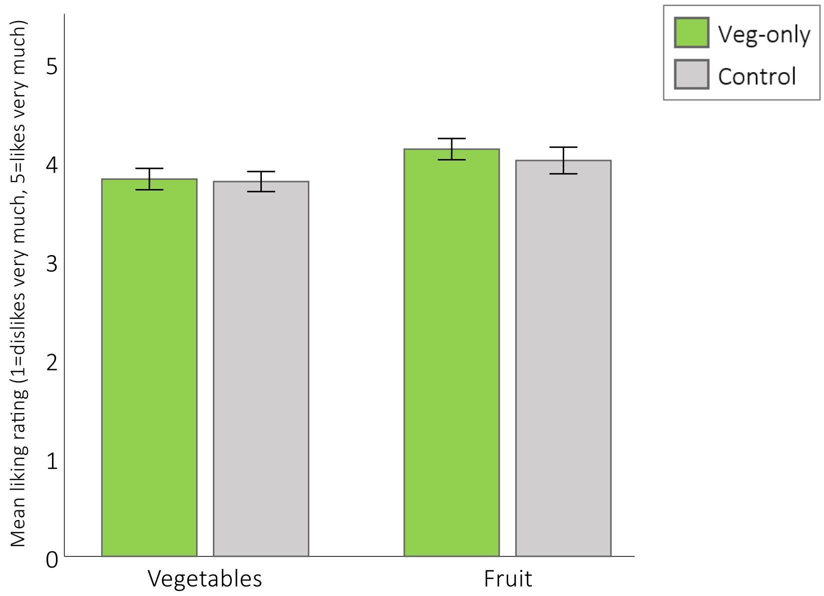


Note. CI = confidence interval. Daily vegetable and fruit intake reported by mothers using a food frequency questionnaire. Independent t-test performed on log transformed vegetable intake data (veg-only, n = 53; control, n = 49). Mann-Whitney test used for fruit intake data (veg-only = 53; control = 51). Median presented for comparability. *P < 0.05.

Daily liking of vegetables

Figure 5.8 shows daily liking of the vegetables and fruits infants had tried since completing the 4-week intervention, as reported by mothers using the food preference questionnaire. There was no significant difference in liking of the overall category of vegetables (P = 0.734) or fruit (P = 0.178) between groups. The number of times that fruit was tried was also similar between groups: median (25^{th}, 75^{th} percentile) veg-only, 64.0 (39.0, 90.0); control, 58.0 (46.0, 84.0), P = 0.937. The number of different types of vegetables that infants had tried over the previous 3 months did not differ between the veg-only (16 ± 4 types) and controls (15 ± 4 types); number of different fruits tried also did not differ by group (veg-only, 13 ± 5; control, 14 ± 5 types). Two infants in the veg-only group and one infant in the control had not tried any green vegetables (broccoli, cabbage, green bean, kale, lettuce, green leafy salad, spinach, sprouted beans) since the 4-week intervention. Six infants (three per group) had not tried broccoli, nineteen had not tried spinach (eight of these were controls) and none had tried artichoke.

Figure 5. 8. Daily liking of vegetables and fruit at 9 months of age



Note. CI = confidence interval. Liking of vegetables and fruit tried over the previous three months, as rated by mothers using a vegetables and fruit preferences questionnaire. Independent t-test performed. No significant group differences found.

Intervention-related adverse events

There were no reported harms or serious adverse events observed in either group.

5.5. Discussion

The present study showed that infants who received vegetable-only first foods during the first four weeks of CF consumed more vegetables at 9 months of age, compared to a control group who received a combination of vegetables and fruit. Intake of the target vegetables (broccoli, spinach) was double that of the controls, and daily vegetable consumption at home 28 % higher. The veg-only group consumed the target vegetables more rapidly and accepted the foods at a greater rate than controls, but according to mothers' ratings, infants liked vegetables similarly. Of the target foods, pear was consumed in significantly greater amounts than broccoli and spinach by controls, whereas the veg-only group ate just as much vegetables as fruit.

These findings complement earlier results of three key RCTs investigating a vegetables first approach to CF. Barends et al. (2013) showed that 19 days of repeated exposure to only vegetable purées at the beginning of CF resulted in a significant increase in vegetable intake at the end of the intervention, compared to exposure to only fruit purées. Fildes et al. (2015) found UK infants who received a variety of single vegetables as first foods during the first 15 days of CF ate twice as much of a new vegetable (artichoke purée) one month post-intervention as infants who started with fruit, vegetables and infant rice or cereal. In the two-arm RCT by Hetherington et al. (2015), infants received either a stepwise introduction to vegetable purées added to milk then rice cereal, or plain milk and rice cereal during the first 24 days of CF. When pure vegetable purées were offered to both groups over the next 11 days, the infants who were introduced to vegetable tastes gradually and earlier showed greater intake, pace of eating, duration and liking of vegetables, compared to those introduced to plain milk/rice cereal before vegetables. Altogether, it seems that making the most of infants' willingness to try new foods at the start of CF and when infants are most sensitive to taste (4–6 months) (Harris & Mason, 2017) has been effective for training infants to eat more vegetables.

Infants assigned to the veg-only group in our study had tried four different types of vegetable-only first foods several times during the 4-week intervention, thus mechanisms of repeated exposure were likely present. There is unequivocal evidence to show that giving the same vegetable multiple times increases vegetable acceptance (Barends et al., 2019; Bell et al., 2021). Furthermore, mothers in our study were encouraged to follow responsive feeding practices, as this is recommended to foster healthy food preferences and eating behaviours (Gerritsen & Wall, 2017). More research is needed to determine the optimal feeding conditions for a vegetables first approach (i.e., parenting style, number/type of vegetable exposures) (Bell et al., 2021), but our findings have shown that giving infants the opportunity to taste vegetable-only foods more than once at the start of CF, and in a responsive manner, is beneficial for increasing vegetable acceptance.

Despite differences in vegetable intake, it was interesting to find that mothers in each group perceived their infant to like vegetables equally. Lack of agreement between mothers' ratings of liking and other food acceptance measures (i.e., intake, researcher ratings) is often observed and attributed to response bias or the difficulty of interpreting infant cues (Fildes et al., 2015; Hetherington, 2020; Hetherington et al., 2015). Indeed, expressions of surprise can easily be interpreted as disgust (Hetherington, 2020). Such bias might be true for this study, and it is possible that the adapted liking tool that featured a 5-point scale was not sensitive enough to assess group differences. Nonetheless, mothers' ratings of liking significantly correlated with all other vegetable acceptance measures. This suggests that infants with greater liking, earlier rate of acceptance, longer duration of eating and quicker pace of eating consumed more vegetables. Furthermore, the higher rate of acceptance among the veg-only group might be a more objective and reliable result since the parameter relied on spatial rather than temporal criteria, was obtained by a trained researcher who was blinded to assignment and demonstrated excellent reliability.

Meanwhile, the similar fruit intake and liking observed in this study suggests that offering vegetables without fruit for the first four weeks of CF has no effect on fruit acceptance in young infants. This might be expected given infants' innate preferences for sweet taste and familiarity with sweet taste via breast or formula milk (Nicklaus et al., 2019; Ventura & Worobey, 2013; Wardle & Cooke, 2008). Comparable results have been observed elsewhere (Barends et al., 2013; Barends et al., 2014; Birch et al., 1998; Mennella et al., 2008), for example, the study by Fildes et al. (2015) found the infants who had started CF feeding with vegetables-only ate and liked a novel fruit (peach purée) later and to the same extent as the controls who had previous fruit exposure. Barends et al. (2013) found infants' very first intake of fruit was the same for all infants (around 45 grams) regardless of their previous vegetable or fruit experiences. Such findings are reassuring since consumption of fruit is as important as vegetables during childhood, but needs little encouragement compared with vegetables.

A strength of the study was the randomisation and retention of a relatively large and adequately powered sample. This is also the first study to examine the effects of starting CF with vegetable-only first foods on vegetable acceptance at 9 months, compared to starting with a combination of fruit and vegetables. Previous studies examined effects at 4–6 months, 12, 24 and/or 36 months of age, with loss to follow-up often limiting the analysis (Barends et al., 2013; Barends et al., 2014; Fildes et al., 2015; Hetherington et al., 2015). Our study is also unique in that all feeding sessions were conducted at home following detailed but easy to apply feeding instructions, improving the ecological validity of findings. Lastly, vegetable intake was an important measure because low vegetable intake among young children is widespread.

One limitation of this study is that although mothers were randomised and blinded to group assignment, it was a convenience sample and had potential for social desirability bias. The study was advertised as the 'Veges First Study', which likely attracted families who were motivated to feed their infant vegetables. Consequently, fixed ideas about their infant's food preferences or a desire to report more socially acceptable information could have skewed results. However, there was no significant difference in the number of different types of or number of occasions vegetables had been tried since the 4-week intervention, thus the influence of mothers was likely equal. In addition, the use of a validated FFQ and several other measures of vegetable acceptance improved assessment accuracy, while convenience sampling improved compliance. A second limitation is that some mothers reported that their infant preferred self-feeding over being spoon fed, and/or had become accustomed to finger foods. This could have made it challenging to know whether infants were rejecting the food due to a dislike of taste or due to feeding mode. Nonetheless foods were deemed age appropriate, and 'grabs spoon to feed self' was included as food acceptance criteria. It might be further argued that one cannot know whether the higher intake of vegetables at 9 months is attributable to the CF intervention or due to eating more vegetables daily after the intervention. While possible, this does not take away from the fact that those who started CF with only vegetables went on to eat more vegetables daily; and as mentioned, the degree of vegetable variety was similar between groups since the 4-week intervention. Another limitation is the potential impact of the Covid-19 pandemic. The change in daily routines and stress of lockdowns may have influenced responses and led to missing data (e.g., video recordings, difficulty in remembering food intake). However, 92 % of the original sample returned completed study diaries, thus it is probable that being restricted to the home gave mothers more time to complete the study tasks, especially if they had the support of a spouse. A de-brief questionnaire or stress assessment could have been valuable to confirm this. Last, while the broccoli food was considered novel in the sense that none had tried this during the intervention, most had tried it during the intervening period, hence it was not novel by the age of 9 months. Perhaps offering artichoke which none had experienced would have been of value to determine whether the intervention improved acceptance of novel vegetables.

5.6. Conclusion

This study showed that introducing vegetable-only first foods, rather than a combination of fruit and vegetables, at the start of CF increases vegetable intake by 9 months of age. Fruit acceptance was not compromised, and it seems that the intervention built upon the ‘window of opportunity’ for flavour learning and acceptance during solid food introduction. In this, there is a simple and practical message for caregivers to offer a variety of vegetable tastes in the early days of CF for improving child vegetable acceptance. Such a message complements and could extend, rather than amend, current infant feeding guidelines that recommend fruit, vegetables, and iron-rich meat/infant cereals as complementary foods. This is because iron remains an essential nutrient for infants at around 6 months of age and because fruit is a nutritious food, however, offering vegetables first before these foods enhances familiarity and increases acceptance. Also, it is still unknown whether introducing fruits with more complex flavors (sour, less sweet) early is also important for subsequent acceptance. Translating this evidence into practice is promising as the intervention was achieved within the home, but access to vegetables and resources (e.g., videos, leaflets, education sessions) as used in the study might be required to replicate results in a wider population. On-going follow-up is necessary to examine sustainability of intervention effects.

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Chapter 6. Follow-up study – Paper IV

Higher vegetable consumption maintained at 12 months of age when infants start complementary feeding with vegetables-only: follow-up of a randomised controlled trial

Chapter 5 showed that starting complementary feeding with vegetable-only foods increased vegetable intake at 9 months of age, suggesting infants had begun to accept vegetables as a habitual part of their diet. Since the goal of focusing on vegetables as first foods is to encourage infants to establish a life-long preference and subsequent intake of vegetables, it was important for the study to conduct further follow-up. All participants, except one, were available for follow-up, thus we have met another key objective, which was:

To determine whether starting complementary feeding with vegetables-only first foods results in increased intake of vegetables at 12 months, compared to a control group starting with a combination of fruit and vegetables.

This chapter addresses the need for longitudinal RCTs investigating the long-term value of introducing vegetables as first foods. These findings have not been submitted for publication as the wider team intends to include results from the 24-month follow-up; data collection is due to complete in October 2021.

6.1. Abstract

Background: Introducing vegetables as first complementary foods may promote a lifelong preference for vegetables. In a previous paper reporting the first outcomes of this randomised controlled trial, we found starting CF with vegetables-only increased vegetable intake at 9 months of age. The current study is a follow-up of these infants at the age of 12 months, with the aim to examine whether intervention effects were maintained.

Methods: Participants were randomly allocated to receive vegetables-only (veg-only, n = 56) or a combination of fruit and vegetables (control, n = 52) for the first month of CF. At 12 months of age, infants' daily vegetable intake was reported by mothers using an online validated food frequency questionnaire; and was the primary outcome for this analysis. Typical liking of vegetables/fruit (5-point Likert Scale) and daily fruit intake were also reported.

Results: Of the original 108 participants, 107 were available for follow-up at 12 months of age. Median (25^{th}, 75^{th} percentile) daily vegetable intake was 20 % higher in the veg-only group (84.4 (67.5, 160.6) grams), than the controls (67.5 (33.8, 120.0) grams), P = 0.021. Daily fruit intake was similar: veg-only, 133.8 (75.0, 206.9) grams; control, 138.6 (63.8, 203.4) grams, P = 0.689, P = 0.770. Mother-

rated liking of vegetables and fruit did not differ by group. Intake and liking did not significantly correlate at this follow-up, but intake at 9 months of age significantly correlated with intake at 12 months of age, as did liking.

Conclusion: A vegetables first approach to CF improved infant vegetable consumption until the age of 12 months. Additional measures of infant liking may be required in future studies, as well as ongoing follow-up of infants' vegetable acceptance.

6.2. Introduction

Daily vegetable and fruit consumption during childhood offers several known health benefits (Boeing et al., 2012; Kleinman & Coletta, 2016), yet intake is still below recommendations, particularly for vegetables (Bailey et al., 2019; Gontijo de Castro et al., 2018; Mihrshahi et al., 2019; Ocké et al., 2008; United Nations Children's Fund, 2021). The first year of life is a sensitive period for the acquisition of food preferences (Harris & Mason, 2017), which become more difficult to influence as food neophobia (i.e., 'fear' of new food) reaches a peak between the age of 2 and 6 years (Birch, 1998; Byrne et al., 2018; Cole et al., 2017; Dovey et al., 2008; Johnson, 2016; Johnson et al., 2018). This suggests a window of opportunity to capitalise on infants' willingness to try new foods and train them to habitually eat plenty of different vegetables from a young age. Since eating habits often track from childhood into later years (Nicklaus & Remy, 2013), then such training may serve to improve diet-related health throughout the lifecycle and reduce future disease burden (Hodder et al., 2020).

A recent umbrella review synthesised evidence from eleven systematic reviews on strategies to improve child vegetable acceptance (Bell et al., 2021). Consistent with recent consensus between infant feeding experts (Chambers, 2016), familiarizing infants with vegetables at the start of CF, also known as a ‘vegetables first’ approach to complementary feeding (CF), showed promise and warranted further research. This is largely because the approach has consistently increased vegetable intake in the short-term (i.e., immediately or soon after the intervention) (Barends et al., 2013; Fildes et al., 2015; Hetherington et al., 2015), but perhaps due to the small evidence-base and a lack of robust long-term follow-up, lasting effects remain unclear (Barends et al., 2014; Hetherington et al., 2015).

We previously reported a 4-week randomised controlled trial (RCT) at the start of CF, which showed commencing CF with vegetable-only first foods increased vegetable intake at 9 months of age, compared to a combination of fruit and vegetables (see chapter 5). This current report concerns the follow-up at 12 months of age and assesses whether intervention effects are maintained. We hypothesised that the infants who started CF with vegetables-only would continue to eat more vegetables until at least the age 12 months, than infants who started with fruit and vegetables. Such evidence could help policy makers and caregivers prioritise which strategies are the easiest and most effective for improving vegetable intake throughout childhood.

6.3. Methods

Experimental design

This was a follow-up of infants (12 months of age) who participated in a two-arm RCT, which included a 4-week intervention at the start of CF and a primary endpoint at 9 months of age.

Outcomes

The follow-up measure of key interest was daily vegetable intake (grams) at 12 months of age as reported by mothers using a validated food frequency questionnaire. Other measures included mother-rated liking (1 = dislike very much, 5 = likes very much) of vegetables and fruit, and daily intake (grams) of fruit.

Participants

Mother-infant dyads (n = 108) living in Auckland had completed the 4-week intervention and primary endpoint at 9 months of age between May 2019 and May 2020, depending on recruitment date. All but one participated in this follow-up study, thus the total sample was 107. Reason for loss to follow-up was unknown as the participant could not be reached. The first participant to complete this follow-up was in December 2019 and the last in October 2020. Consent to participate was obtained and ethical approval granted by the Massey University Human Ethics Committee: Southern A, Application SOA 18/56.

Procedure

The 4-week intervention and 9-month methods are reported in chapters 3–5. To summarise: infants were randomly allocated to receive either vegetable-only first foods (veg-only) or a combination of fruit and vegetables (control) for a duration of 4-weeks, starting from the first day of CF. At 9 months of age, all infants received three target foods: broccoli, spinach and pear. Mothers conducted feeding sessions at home following a detailed feeding protocol and were blinded to group assignment. Intake (grams) and liking of the study foods were recorded by mothers using a weighed food diary and a liking tool, respectively. An additional measure at 9 months included daily vegetable and fruit intake/liking. Infants were fed according to their usual family diet in the interim of each time point.

For this follow-up study, mothers were emailed links to an online food frequency questionnaire (FFQ) and vegetable/fruit preference questionnaire on their infants' first birthday; each took 10 minutes to complete. Due to Covid-19 precautions, they were given the options to measure and report their infant's weight, length, and head circumference at home following detailed instructions, provide measurements from a recent infant health check, or visit the clinic to have these measured by a researcher.

12-month questionnaires

The online dietary questionnaires administered at 12 months were the same as given at 9 months of age. The validated FFQ measured infants' daily vegetable and fruit intake and asked how many times vegetables were eaten over the last 4 days and how much per feed in grams or household metric measures. The average daily vegetable intake was the total amount eaten divided by 4 days, and the greater amount eaten suggested greater daily intake. This method was applied to the fruit category.

The vegetable/fruit preference questionnaire was designed specifically for the study and asked about which vegetables and fruits infants had tried and liked (1 = dislike very much, 5 = like very much) over the last three months. To improve completion rates, this questionnaire was divided into two 10-minute online questionnaires, with one focusing on vegetable preferences, and the other on fruit preferences. A total of 28 vegetables and 32 fruit types could be reported and daily liking of vegetables was calculated by the sum of liking scores divided by the number of vegetables or fruit tried. Frequency categories were coded based on the lower value of the range ('never tried' = 0, 'tried 1-3 times' = 1, 'tried 4-6 times' = 4, 'tried 7-9 times' = 7 and '10+ times' = 10). The sum of frequencies (i.e., asparagus x 1 + beetroot x 4 + broccoli x 10, etc.) indicated the number of occasions that infants had tried vegetables/fruits over the previous three months.

Statistical analysis

Participant characteristics were described according to CONSORT guidelines (de Boer et al., 2015). Group differences for daily intake and liking of vegetables and fruit were compared using independent t-test or Mann-Whitney test, depending on data distribution. Log transformations improved normality of daily vegetable intake only, and original medians reported as these were close to the geometric means. Wilcoxon signed-rank test was used to assess differences between daily vegetable intake and daily fruit intake; and between vegetable liking and fruit liking. Spearman's rho correlation analysis was used to examine the relationship between intake and liking at this follow-up, and then between the 9-month and 12-month time points since assessment tools were the same.

Participants were included in this analysis if they had completed both the 4-week intervention and 9-month endpoint as per protocol, and at least one of the 12-

month questionnaires. Outliers as detected by boxplots were examined but remained plausible, thus not removed; exclusion did not significantly change results. Statistical analysis was performed using IBM SPSS version 25.0 (IBM Corp. Released 2017, Armonk, NY). All statistical tests were two-tailed with an alpha value of $P < 0.05$.

6.4. Results

Participants

Infants (n = 107) were 50 % female, 91 % European ethnicity and had started CF at the age of 23.6 ± 2.6 weeks. Most mothers (93 %) had a university degree or higher, had no other children (75 %), considered themselves to have adequate access to food (95 %) and were aged 33.6 ± 4.3 years at the 12-month follow-up. **Table 6.1** presents infants' age, anthropometry and milk feeding history only as other demographic data was almost identical to what has previously been reported in chapter 5.

Table 6. 1. Characteristics of infants at the 12-month follow-up

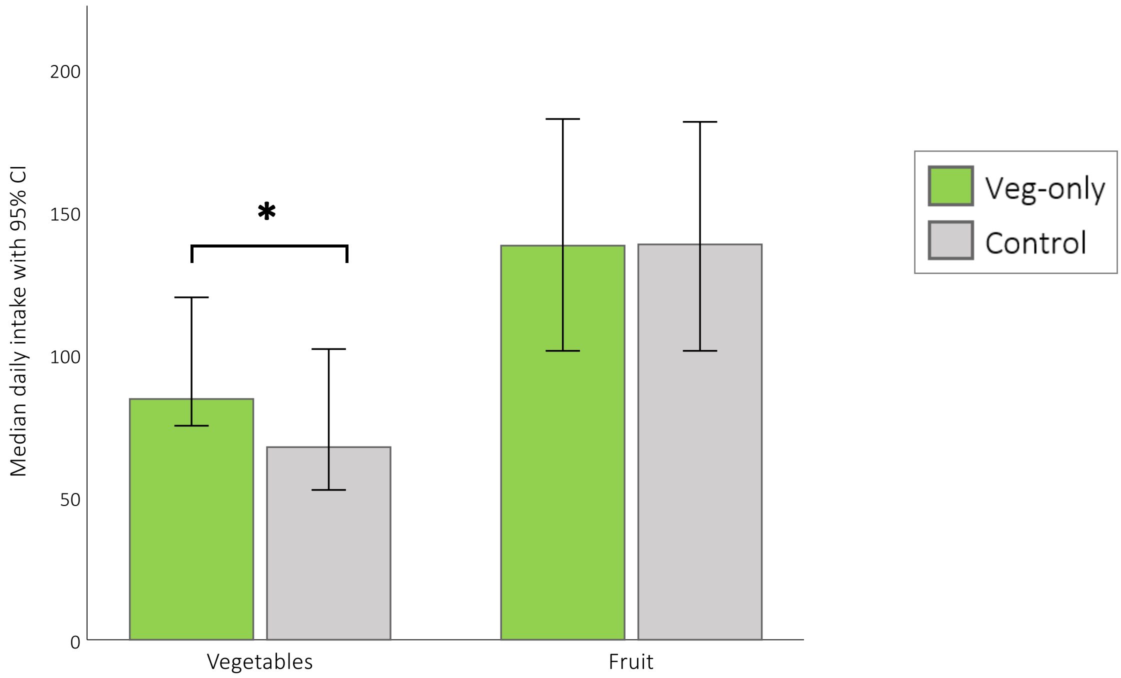
	Veg-only	Control	Total
Infants (n)	56	51	107
Age (months)	12.0 (12.0, 12.0)	12.0 (12.0, 12.0)	12.0 (12.0, 12.0)
Weight (kg) [a]	10.0 ± 1.2	10.2 ± 1.1	10.1 ± 1.2
Length (cm) [a]	77.0 ± 3.8	75.9 ± 3.1	76.5 ± 3.5
Head circumference (cm) [a]	46.6 ± 1.5	47.0 ± 1.7	46.8 ± 1.6
Duration of BF (months) [b]	12.0 (7.5, 12.0)	12.0 (11.0, 12.0)	12.0 (9.0, 12.0)
Milk feeding type at 12 m			
Breast milk only	16 (30 %)	20 (43 %)	36 (36 %)
Infant formula only	29 (54 %)	18 (39 %)	47 (47 %)
Both Breast/formula milk	8 (15 %)	7 (15 %)	15 (15 %)
No longer milk feeding	2 (4 %)	0 (0 %)	2 (2 %)

Note. CF = complementary feeding; BF = breastfeeding; m = months. Data presented as mean ± SD, numbers (%) or median (25th, 75th percentile). [a] Sample sizes: weight (veg-only, n = 44; control, n = 45), length (veg-only, n = 46; control, n = 45), head circumference (veg-only, n = 44; control, n = 41); missing data due to Covid-19 restrictions. [b] 35 mothers had stopped breastfeeding before 12 months of age; 6 stopped at 12 months of age; the remaining were still breastfeeding at the time of follow-up.

Daily vegetable intake

Median (25th, 75th percentile) daily intake of vegetables was significantly higher among the veg-only group (84.4 (67.5, 160.6) grams) than controls (67.5 (33.8, 120.0) grams), P = 0.021. Daily intake of fruit was similar between groups: veg-only, 133.8 (75.0, 206.9) grams; control, 138.6 (63.8, 203.4) grams, P = 0.689 (**Figure 6.1**). Fruit was consumed more than vegetables in both groups (veg-only, P = 0.022; control, P < 0.001).

Figure 6. 1. Daily intake of vegetables and fruit at 12 months of age

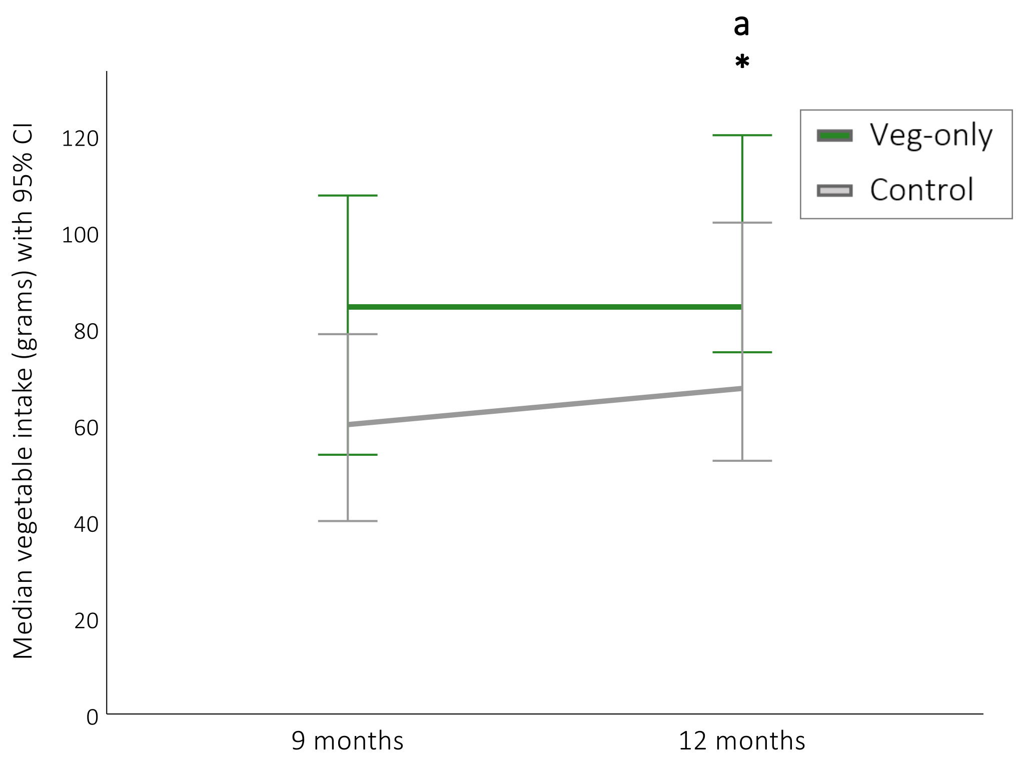


Note. CI = confidence interval. Medians presented for consistency.
*P < 0.05.

9 month versus 12 month vegetable intake

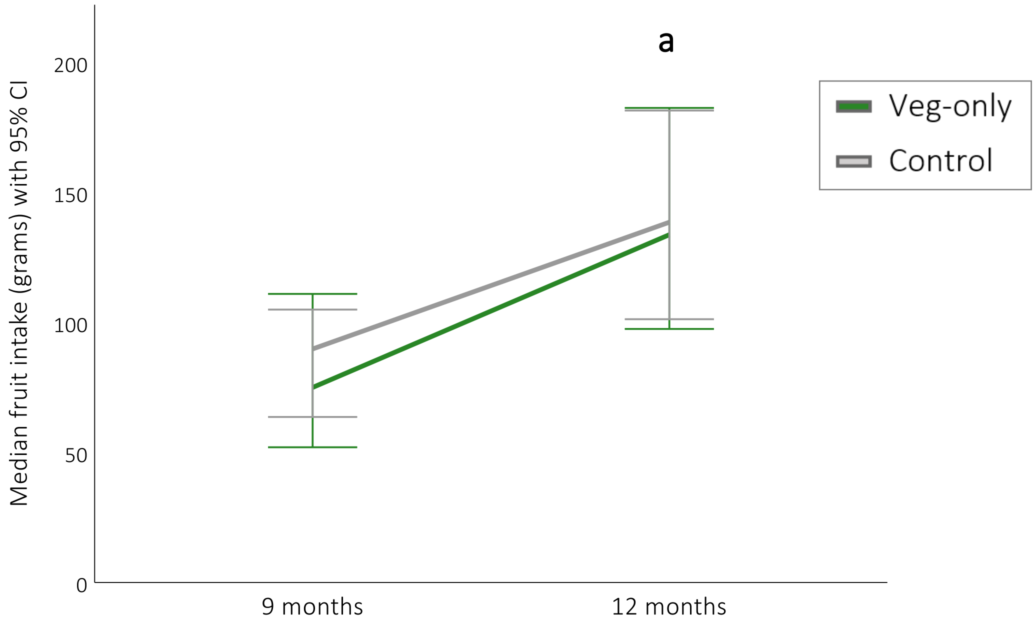
Daily vegetable intake at 9 months was similar to vegetable intake at 12 months in both groups: veg-only, P = 0.361; control, P = 0.365 (**Figure 6.2**). Meanwhile, daily fruit intake had significantly increased: veg-only, P < 0.001; control, P = 0.003 (**Figure 6.3**).

Figure 6. 2. Comparison of daily vegetable intake between 9 and 12 months of age by group



Note. CI = confidence interval. Medians presented for consistency. a = no differences over time but veg-only group intake significantly higher than controls at both 9 months (P = 0.043) and 12 months (P = 0.021). *P < 0.05.

Figure 6. 3. Comparison of daily fruit intake between 9 and 12 months of age by group



Note. CI = confidence interval. a = significant increase over time for veg-only ($P < 0.001$) and controls ($P < 0.01$), with no group differences.

Vegetable variety and frequency

There was no difference in the number of different types of vegetables that infants had tried over the previous three months between groups: veg-only, 18 ± 4 (mean ± SD); control 18 ± 4, P = 0.574. Number of fruits tried were also similar: veg-only, 18 ± 5; control 18 ± 4, P = 0.832. The frequency to which vegetables had been tried over the previous three months did not differ by group: veg-only group 121 ± 27 occasions vs controls 120 ± 39 occasions, P = 0.949. There were no group differences in the number of occasions fruit had been tried: veg-only 109 ± 38 occasions; control 103 ± 36 occasions, P = 0.906.

Across the sample, the most frequently tried vegetables (7 times or more) since the 9-month time point were carrot, potato, broccoli, kūmara, pumpkin, green bean and corn; most frequently tried fruits were banana, avocado, apple, pear and blueberries (ordered most to least). All infants had tried some type of green leafy vegetable since the 9-month time point, but twelve had not tried spinach (seven of these were controls). Vegetables that were tried the least were artichoke (n = 2), sprouted beans (n = 7) and radish (n = 10).

Vegetable liking

Median (25th, 75th percentile) liking of vegetables, as rated by mothers, was similar among infants: veg-only, 3.7 (3.4, 3.9); control, 3.8 (3.5, 4.0), P = 0.384. Median (25th, 75th percentile) liking of fruit was also similar: veg-only, 4.1 (3.9, 4.4); control, 4.1 (3.7, 4.3), P = 0.598. Fruit was liked more than vegetables in both groups (veg-only, P < 0.001; control, P = 0.001).

Correlations

In both groups, daily intake of vegetables did not significantly correlate with mother-rated liking of vegetables at 12 months of age; nor did daily intake and liking of fruit correlate. Daily vegetable intake at 9 months significantly correlated with daily intake at 12 months (veg-only group, $r_s = .28$, $P < 0.05$; control, $r_s = .48$, $P < 0.01$); as did vegetable liking between time-points (veg-only, $r_s = .59$, $P < 0.01$; control, $r_s = .60$, $P < 0.01$). Daily fruit intake at 9 months also correlated with fruit intake at 12 months (veg-only, $r_s = .48$, $P < 0.01$; control, $r_s = .47$, $P < 0.01$); as did liking (vegetable, $r_s = .60$, $P < 0.01$; control, $r_s = .63$, $P < 0.01$).

Intervention-related adverse events

There were no reported harms or serious adverse events observed in either group.

6.5. Discussion

This longitudinal RCT demonstrated that starting CF with vegetable-only first foods resulted in a 20 % higher daily vegetable intake at 12 months of age than starting with a combination of fruit and vegetables. These findings paralleled those at 9 months, thus intervention effects were maintained. There were no group differences in daily fruit intake over time, and according to mothers, daily liking of vegetables and fruit did not differ.

Two other intervention studies investigating a vegetables first approach to CF have reported effects at 12 months of age. Consistent with our findings, Barends et al. (2014) demonstrated that commencing CF with vegetables-only led to a 38 % higher daily vegetable intake at 12 months of age, compared to commencing with fruit-only. They also showed intervention effects had proven stable over time, with no apparent negative impact on daily fruit intake.

In contrast, Hetherington et al. (2015) observed no effect of early introduction of vegetables on vegetable intake at 12 months of age. This is probably due to differences in study design. First, while the intervention group was introduced to vegetables earlier and gradually (first added to milk then cereal), all infants received the same vegetable purées, and no fruit, during the last 11 days of the CF intervention. Second, daily vegetable intake was assessed using an adapted FFQ which had not been validated in young infants, and a detailed account of foods consumed between follow-ups was not available. Last, differences in vegetable consumption were largely assessed from intake of purées (green beans and apple) in the laboratory that may have been too smooth to be well accepted at 12 months of age. Indeed, Barends et al. (2014) found that intake of green bean purée in the laboratory at this age did not differ by group likely due to the unfamiliar feeding environment and use of age-inappropriate textured purées.

No difference in mother-rated liking of vegetables and fruit observed in this study is likely due to the subjective nature of analysis, especially as liking was measured by a single 5-point Likert scale within a non-validated online food preferences questionnaire. However, previous reports on infant vegetable liking are mixed and most relate to liking of a particular vegetable immediately after a feeding session, rather than daily vegetable liking (Barends et al., 2013; Barends et al., 2014; Fildes et al., 2015; Hetherington et al., 2015). Thus, more research examining the relationship between liking and intake of vegetables during infancy seem warranted.

Despite improvements in vegetable intake, fruit was still consumed in greater amounts across both groups, which is consistent with global vegetable and fruit consumption trends (Barends et al., 2019). This may not be of concern since recommended servings are not specified for infants (Dewey & Harrison, 2020; Ministry of Health, 2008), but could become a problem if these dietary habits track into later life (Nicklaus & Remy, 2013). This is because a greater number of servings of vegetables than fruit is recommended (Ministry of Health, 2012, 2020). Thus, further intervention might be required to see vegetable intake surpass that of fruit.

Trajectories of vegetable and fruit intake between the 9-month and 12-month time points showed that while daily vegetable intake did not reduce or increase, fruit intake significantly increased and was overall higher. These results are difficult to explain without further data, but perhaps as infants progressed to finger foods, fruit was perceived by parents as a particularly convenient healthy option (Boak et al., 2016; Damen et al., 2019). Changes to the food environment may have contributed, for example, attending child care (Boak et al., 2016) or if the difficulties imposed by Covid-19 lead to poorer family eating habits (Litton & Beavers, 2021). Maybe there were early signs of food neophobia that increased food refusal, leading to higher provision of well-accepted foods like sweet fruits (Cole et al., 2017). Regardless of the reasons, it’s likely that parents need more support and specific guidelines on introduction of fruit after an initial focus on vegetables during early CF, but this remains challenging with limited evidence on the optimal timing and method of fruit introduction (Bell et al., 2021; Johnson, 2016). Furthermore, our results reaffirm the need to focus on promoting vegetable intake, rather than fruit.

The high sample retention and the use of a validated FFQ that mothers were familiar with are key strengths of this study, as is the overall longitudinal RCT design. This is the third study to follow-up infants at 12 months of age, and the second to show that higher vegetable consumption is maintained to at least one year of age when following a vegetables first approach to CF.

The limitations of using self-reported data and a convenience sample are noted. Mothers may have reported more socially desirable information or incorrectly assessed food intake, especially if their infant spent part of the day in childcare. A weighed food diary may have provided more accurate results, however, our choice of using a simple validated FFQ likely improved data quality and participant response rates. Furthermore, mothers were still blinded to assignment and were encouraged that there were no ‘right’ or ‘wrong’ answers to alleviate social pressures to over or under report food intake. We did not conduct a feeding experiment at 12 months largely for feasible and practical reasons, especially as changes in the food format (i.e., purée to finger foods) would be necessary. In addition, many mothers return to work by this time and may have found it difficult to commit to the study (Peterson et al., 2018). Another potential limitation is that we were unable to control the foods offered between the 9- and 12-month time points, and while no group differences were found in the frequency or number of types of vegetables/fruit tried over the previous three months, the veg-only group had eaten a greater amount of vegetables than controls. Thus, greater vegetable exposure among the veg-only group during the previous three months may have been more responsible for higher vegetable intake at 12 months, rather than the baseline intervention. Also, possible effects of neophobia and/or pickiness were not examined, which although do not typically set in until around 20 months of age, may start earlier (Cole et al., 2017; Dovey et al., 2008; Johnson, 2016; Johnson et al., 2018) and so cannot be ruled out. Further data on these potential confounders may have strengthened the analysis, but it remains clear that infants who started CF with only vegetables achieved favourable vegetable consumption later.

6.6. Conclusion

At this follow-up, introducing infants to vegetable-only first foods, rather than fruit-based foods, from the moment they started CF has proven to encourage higher consumption of vegetables until at least 12 months of age. Given that only a brief exposure period was required (i.e., four weeks) and that the entire intervention was completed at home, these findings confirm that a vegetables first approach to CF could be a simple but effective strategy that families can follow in order to improve their child's vegetable intake.

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Chapter 7. Iron results - Paper V

Iron status of infants participating in a 'vegetables first' complementary feeding intervention

The previous three chapters have addressed the primary objectives of the Veges First Study, which focused on vegetable acceptance and in turn increasing our knowledge base for introducing vegetables as first foods. A unique aspect to the study design was the consideration of recommendations for iron-rich complementary foods, and the iron status of infants participating in the trial. By collecting infant blood samples at each clinic visit, we have been able to meet our last objective, which was:

To describe the iron status of the infants from baseline to 9 months of age.

This chapter should be of value to anyone interested in the iron status of infants at 9 months of age, but especially those seeking insight within the context of infants participating in a 'vegetables first' complementary feeding intervention. This manuscript has been submitted to the American Journal of Clinical Nutrition for publication, pending acceptance.

7.1. Abstract

Background: Focusing on vegetables as first complementary foods may improve child vegetable acceptance, but maintaining adequate infant iron status is equally important.

Objective: To describe the iron status of infants at 9 months of age who participated in a 'vegetables first' complementary feeding (CF) intervention.

Methods: The Veges First Study included 117 infants, randomised to receive either vegetables-only (veg-only) or a combination of vegetables and fruit (control) at the start of CF. Advice on introducing iron-rich foods (meat, fish, poultry) was given to all mothers. Indicators of iron status (haemoglobin, Hb; serum ferritin, SF; C-reactive protein, CRP) were examined at baseline, post-intervention and at 9 months of age via capillary blood samples. Milk feeding type and meat consumption were collected via questionnaire items (during intervention) and food frequency questionnaire (9 months). Infant iron status at 9 months of age was the primary outcome of this analysis, but secondary to the wider study.

Results: Seventy-five infants were included in this analysis. Most (92 %) infants were iron sufficient at 9 months of age; mean ± SD Hb: 126 ± 14 g/L, median (25^{th},

75th percentile) SF: 40 (29, 59) μg/L. Most (93 %) infants consumed iron-rich foods (meat, fish, poultry) by 9 months, and half (53 %) were introduced to these foods within the first month of CF. Higher baseline SF (*B*-coefficient ± s.e. 4.1 ± 0.5, $P < 0.001$), later age at the start of CF (1.1 ± 0.5, $P = 0.017$), receiving formula only during initial stages of CF (-1.1 ± 0.5, $P = 0.042$), and later introduction of meat (1.2 ± 0.4, $P = 0.001$) were associated with higher SF at 9 months. Introducing vegetables as the first food was not associated with 9-month SF.

Conclusion: The majority of infants recruited to a vegetables first approach for CF trial who had good iron status prior to starting solids maintained their status; this was in the context of mothers receiving iron-rich food advice as well.

7.2. Introduction

Iron deficiency (ID) is a global public health concern and infants are at particular risk (Berglund & Domellöf, 2021; Domellöf et al., 2014; World Health Organization, 2007). Rapid growth and brain development during infancy demands high iron requirements (Friel et al., 2018; Institute of Medicine, 2001; Ministry of Health, 2008), and if not met and ID occurs then there may be irreversible negative consequences on neurodevelopment and behaviour (Baker et al., 2010; Congdon et al., 2012; Lozoff et al., 2006; Lozoff et al., 2000; Lozoff et al., 2013; Radlowski & Johnson, 2013). US national statistics estimate 14 % of children (1-2 years) were iron deficient in 2007-2010 (Gupta et al., 2016). Among infants aged 12 months or less, several cross-sectional and experimental studies report poor iron status (Chen et al., 2020; Clark et al., 2017; Dube et al., 2010; Eussen et al., 2015; Grant et al., 2007; Heath et al., 2002; Libuda et al., 2018; Lozoff et al., 2016; Shao et al., 2021). For example, a recent New Zealand study (n = 119) examining the iron status of infants participating in a baby-led weaning (BLW) intervention found 17 % had suboptimal iron status (using cut-offs: body iron ≥ 0 mg/kg, Haemoglobin ≥ 11 g/dL, plasma ferritin ≥ 15 ug/L, CRP > 5 mg/L) at 12 months of age (Daniels et al., 2018).

Risk factors for developing ID during infancy are many, but those relating to diet include inadequate iron or iron-rich food intake and milk feeding type (i.e., prolonged breastfeeding, receiving no infant formula) (Berglund & Domellöf, 2021; Grant et al., 2007; Grmt et al., 2019; Hong et al., 2017). To prevent ID in infancy, dietary guidelines stress the importance of introducing iron-rich foods at around 6 months of age as iron stores have depleted and breast milk alone is insufficient (Dewey & Harrison, 2020). Recommended iron-rich foods include iron-fortified infant cereals, age-appropriate meats (puréed cooked beef, lamb, pork, chicken or fish) and vegetarian alternatives (puréed cooked legumes, tofu) (Binns et al., 2018; Dewey & Harrison, 2020; Ministry of Health, 2008; National Health and Medical Research Council, 2013; Scientific Advisory Committee on Nutrition, 2018; World Health Organization, 2003). Meanwhile, there is growing interest in a 'vegetable first' approach to complementary feeding (CF) which focuses on vegetables as first foods (Barends et al., 2019; Bell et al., 2021; Chambers, 2016; Chambers et al., 2016). While this feeding practice may improve child vegetable acceptance, there are concerns that the approach may compromise infants' consumption of iron-rich foods and iron status (Chambers et al., 2016).

No intervention studies investigating a vegetables first approach to CF have reported infants' iron status (Barends et al., 2013; Barends et al., 2014; Fildes et al., 2015; Hetherington et al., 2015), which is problematic given the high risk of ID (Chambers et al., 2016). The primary aim of our previously reported randomised controlled trial (RCT) was to determine whether starting CF with vegetables-only increases infants' vegetable intake later (see chapter 5). This paper reports the predetermined secondary outcome of iron status of these infants at 9 months of age.

7.3. Methods

Experimental design

This was an RCT with a primary outcome of vegetable intake at 9 months of age, and a secondary objective to describe infant iron status, as reported here.

Outcomes

The outcome measure of this study was infant iron status at 9 months of age through assessment of haemoglobin (Hb) on a capillary blood sample, and serum ferritin (SF) and C-reactive protein (CRP), as measured by standard blood capillary analysis.

Time point definitions

Baseline: infants provided their first blood sample; they were required to be 3 months or older for this visit, and must not have started CF.

Post-intervention: second blood sample collection, immediately after (within three weeks) of completing the last day of the 4-week feeding intervention.

9-months: third blood sample, when infants were 9 months of age.

Participants

Mother-infant dyads (n = 117) participated in the 4-week CF intervention and 76 provided data for the present analysis. Eligibility criteria included: born ≥ 37 weeks, completed the 4-week intervention per protocol and normal CRP levels at 9 months. After exclusion of one infant with inflammation/infection at 9 months (n = 1), a final sample of 75 (veg-only, n = 33; control, n = 42) was obtained for this analysis. Blood collection took place between May 2019 and August 2020, depending on recruitment date. Government restrictions implemented in March 2020 in response to the novel coronavirus disease (Covid-19) caused missed appointments (baseline = 1, post-intervention = 15, and 9 months = 33), explaining fewer data than anticipated. Other loss to follow-up related to mothers becoming too busy (n = 8). Participants provided consent to use all data including blood samples for research, and ethical approval was provided by the Massey University Human Ethics Committee: Southern A, Application SOA 18/56.

Procedure

The study protocol of the Veges First Study is detailed elsewhere (Rapson et al., 2021) and in chapter 3 of this dissertation but relevant information included here. All infants in this study received either vegetable-only first foods (veg-only) or a combination of fruit and vegetables (control) for a period of four weeks, starting from the first day of CF. These foods were provided by the study and contained only vegetables or a combination of fruit and vegetables, and no meat or other ingredients added. Mothers freely fed their infant home-made puréed meat, chicken or fish according to recipe instructions, except for the first four days to standardise the protocol and satisfy primary objectives. Before the intervention, a dietitian provided education on appropriate CF practices, including when to start solids and the importance of iron for infants. Recipe cards with videos on how to prepare appropriate 'high' or iron-rich foods (meat, fish, poultry) were provided at baseline and all mothers encouraged to feed these foods, particularly if starting the intervention at 6 months of age. After the 4-week intervention, mothers received standard infant feeding advice, including the *Fuelled for Iron* (Beef and Lamb New Zealand, 2018) booklet that gives practical tips and easy iron-rich meal ideas for infants and toddlers; which the dietitian explained in detail. Infants then continued with their usual family diet. Mothers were asked to attend three clinic/home visits (baseline, post-intervention and 9 months of age), at which time point infants' weight, height and head circumference were measured, diet/feeding practices assessed, and blood samples taken. Information about infants' demographics were also collected at baseline.

Biochemical assessment

Non-fasting capillary blood samples were taken from infants by a registered phlebotomist using a standard 'heel prick' test as part of health screening at each visit (baseline, post-intervention and at 9 months). Indicators of iron status were: Hb, SF and CRP. The phlebotomist assessed Hb using a HemoCue ® Hb 201+ Analyzer immediately as blood was drawn at Massey University (Auckland, New Zealand), and if outside the normal range, the mother was notified and given a referral letter to see their general practitioner (baseline, n = 5; post-intervention, n = 2; 9 months, n = 4). Aliquots of serum were stored at -80°C until subsequent analysis of SF and CRP at LabTests (Auckland) by their Biochemistry department via particle-enhanced immunoturbidimetric assay; this laboratory undergoes regular quality assurance testing by an external agency known as International Accreditation New Zealand (IANZ). We used established cut-offs of Hb < 110 g/L and SF < 10 µg/L to assess the presence of ID and IDA (Baker et al., 2010; Grant et al., 2016; Vendt, Talvik, et al., 2007); a cut-off of ≥ 10 mg/L CRP suggested the presence of infection or inflammation (Brown et al., 2020; Domellöf et al., 2001; Libuda et al., 2018; Newborn Services Clinical Practice Committee, 2019).

Dietary assessment

During the last four days of the feeding intervention, mothers were required to answer questionnaire items to report on their infant's meat consumption (i.e., if and when meat had been introduced), milk feeding (type, number of feeds per day, minutes per breastfeed/milliliters per formula feed), and iron supplementation (yes/no). These questions were included as part of the weighed food diary that mothers used to report intake of the vegetable-only or fruit and vegetable purées provided by the study, as reported in chapter 4 and 5 of this thesis (see **Appendix H** for more information). A validated food frequency questionnaire (FFQ) (Judd et al., 2020) administered at 9 months asked mothers to report how often their infant ate beef, lamb, pork, ham, chicken/poultry and fish in the last four days, and typical quantity at each feed. A free text option was available to capture information on other meat (e.g., rabbit, turkey). Milk feeding history was collected at 9 months of age, which included breast milk/formula milk introduction/cessation, number of feeds per day and amount of milk per feed. Throughout the study however an accurate assessment of milk intake, such as weighing infants before and after a breastfeed, was not feasible.

Statistical analysis

Descriptive statistics were used for participant characteristics and other variables of interest (indicators of iron status and its potential determinants). Group differences (e.g., veg-only vs control, milk feeding type, age started CF) were explored using independent t-test or Mann-Whitney test for continuous variables, depending on normality; and chi-square test used for categorical variables. Paired samples t-test were used to compare changes in SF and Hb between baseline and 9 months only since fewer blood samples (n = 50) were available post-intervention (25 missing due to Covid-19 restrictions). SF at baseline and 9 months were not normally distributed, but log transformation and square root transformation improved normality, respectively. Outliers identified through boxplots were examined but considered plausible (Larsson et al., 2019) so not removed. Infants with CRP levels ≥ 10 µg/L at 9 months were excluded from the entire analysis (n = 1, due to being the primary outcome). Infants with CRP levels ≥ 10 µg/L at baseline (n = 2) and post-intervention (n = 1) were excluded from analyses relating to that time point.

Linear regression was used to determine predictors of square root transformed infant SF at 9 months from independent variables: square root infant SF at baseline, age started CF, meat introduced during the first month of CF (yes/no), formula-fed only during the first month of CF (yes/no), and sex (female/male). These variables largely reflect our interest in early dietary factors during CF on later iron status; however, sex was included due to significant differences in SF observed in this study and others (Domellöf et al., 2002; Emond et al., 1996; Larsson et al., 2019; Pérez-Acosta et al., 2021; Ziegler et al., 2014). Serum ferritin was used as the dependent variable as it is the most widely used biomarker of iron status in young children (Abdullah et al., 2017). All assumptions for regression analysis were met (i.e., multicollinearity, independence of variables, normally distributed residuals, Cook's distance < 1, linear relationship between dependent and independent variable and homoscedasticity). Statistical analysis was performed using IBM SPSS version 25.0 (IBM Corp. Released 2017, Armonk, NY). All statistical tests were two-tailed with an alpha value of $P < 0.05$.

7.4. Results

Participants

Table 7.1 shows demographic data for the participants included in this analysis. No infants were taking iron supplements, except one in the control group at the start of CF. Infants' and mothers' characteristics for the veg-only and control groups, and those included and not included in this study are presented in Supplementary Table Q1.

Table 7. 1. Characteristics of participants included in the analysis of iron status at 9 months of age

Infants' characteristics	Total sample (n = 75)
Age at 9-month blood test (months) [a]	9 (9, 10)
Sex (female), n (%)	42 (56 %)
Weight (kg) [b]	9.2 ± 1.0
Length (cm) [b]	72.5 ± 2.6
Head circumference (cm) [b]	45.9 ± 1.3
Age started CF	
3–4 months	14 (19 %)
5–6 months	61 (81 %)
EBF duration (months) [c]	5 (2, 5)
Milk feeding type at start of CF, n (%)	
BM only	33 (44 %)
IF only	19 (25 %)
Both IF and BM	23 (31 %)
Mothers' characteristics	n = 75
Age on day 1 of intervention (years)	33 ± 4
Education, n (%)	
Below university	4 (44 %)
University or higher	72 (95 %)
Ethnic origin, n (%) [d]	
NZ European and others	66 (88 %)
Māori and Pacific Island	6 (8 %)
Others (e.g., Chinese, Indian)	7 (9 %)
Primiparous (first time mothers yes), n (%)	56 (75 %)

Note. CF = complementary feeding, EBF = exclusive breastfeeding, BM = breast milk, IF = infant formula. Data presented as mean ± SD, numbers (%) or median (25th, 75th percentile), unless otherwise stated.
[a] Median (25th, 75th percentile) age at baseline and post-intervention blood test was 4 (5, 5) months and 6 (6, 7) months, respectively. [b] Measured by a researcher on day of blood test at 9 months. [c] EBF defined as having had only breast milk and no other substance except prescribed medicines since birth (Ministry of Health, 2008). [d] Multiple answers were possible.

Iron status

The majority of infants (92 %) were iron sufficient at 9 months of age (**Table 7.2**). At this age, three had ID (n = 2) and IDA (n = 1), of whom one received vegetables as the first complementary food, and all received breast milk during early stages of CF (fully breastfed, n = 2; both breast and formula-fed, n = 1). Most (94 %) were iron sufficient post-intervention (iron depleted, n = 2; ID, n = 1). Overall, those who developed ID or IDA post-intervention and/or at 9 months had lower SF and Hb at baseline, compared to those who maintained sufficient iron status (both $P < 0.001$).

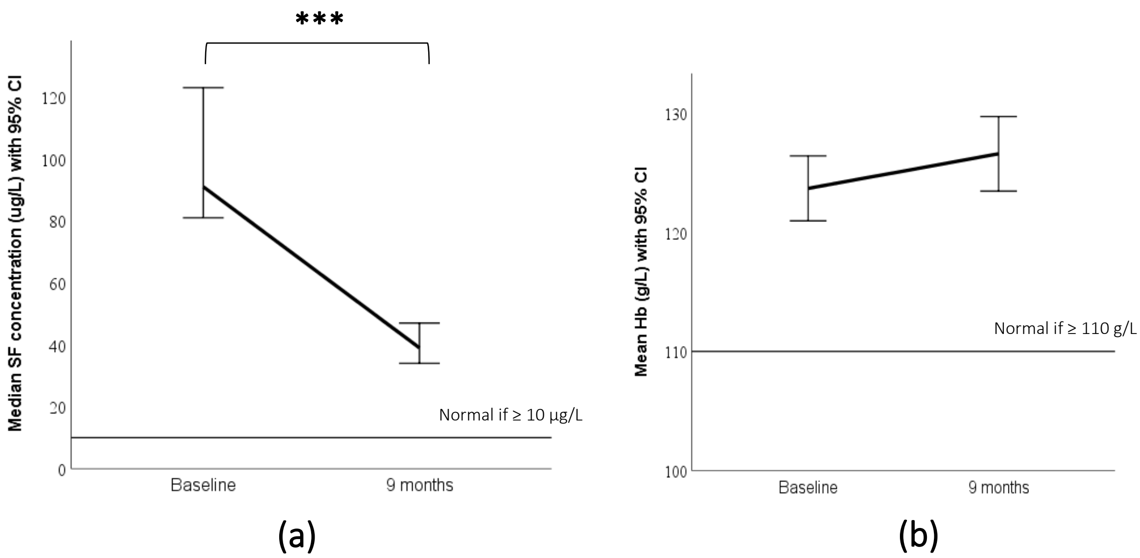
Table 7. 2. Iron status categories at baseline, post-intervention and 9 months of age

	Iron sufficient	Iron depleted	ID/IDA
Baseline (n = 72) [a]	67 (93 %)	5 (7 %)	0 (0 %)
Post-intervention (n = 49) [b]	46 (94 %)	1 (2 %)	0 (0 %)
9-months (n = 75)	69 (92 %)	3 (4 %)	3 (4 %) [c]

Note. ID = iron deficiency, IDA = iron deficiency anemia. Iron sufficient = haemoglobin ≥ 110 g/L and serum ferritin ≥ 10 µg/L; Iron depleted = haemoglobin < 110g/L and serum ferritin ≥ 10 µg/L; ID = serum ferritin < 10 µg/L, in the absence of iron deficiency anemia; IDA = serum ferritin < 10 µg/L with haemoglobin < 110g/L. Data presented as numbers (%). [a] 2 excluded due to ≥ 10 CRP; 1 missing due to Covid-19 restrictions. [b] 1 excluded due to ≥ 10 CRP; 13 missing from each group due to Covid-19 restrictions. [c] ID, n = 2; IDA, n = 1.

Median (25th, 75th percentiles) SF decreased between baseline and 9 months of age, 91 (58, 262) µg/L at baseline vs 40 (29, 59) µg/L at 9 months, P < 0.001 (**Figure 7.1**). However, mean ± SD Hb remained stable over time, 124 ± 12 g/L at baseline vs 126 ± 14 g/L at 9 months, P = 0.106 (**Figure 7.1**).

Figure 7. 1. Change in serum ferritin and haemoglobin concentration between baseline and 9 months (n = 72)



Note. SF = serum ferritin, Hb = haemoglobin, CI = confidence interval. (a) Serum ferritin significantly decreased; median of untransformed data reported as these were similar to geometric mean. (b) Haemoglobin did not change; mean with 95 % confidence interval reported as data normal for the primary outcome. ***P < 0.001.

There were no significant differences in iron status indicators categories between the veg-only and control groups. Higher SF concentrations were observed among females (51 ± 27 µg/L), than males (38 ± 22 µg/L) at 9 months, P = 0.034.

Meat intake

Table 7.3 shows information on meat consumption at two different time points (during the first four weeks of CF and 9 months). Most (93 %) consumed meat, fish and/or poultry at 9 months of age, with a median (25^{th}, 75^{th} percentiles) daily intake of 30 (15, 60) grams. There was no difference in meat intake at 9 months of age between the veg-only and control groups. Meat intake was also similar between those who had been fully breastfed, formula-fed only or both breast and formula-fed (during early CF or at 9 months); and between those who had been introduced to meat during the first four weeks of CF and those who had not. However, those who had started CF earlier (3–4 months) were eating less meat than those who started later (5–6 months): 14 (8, 45) grams vs 34 (17, 64) grams, respectively, $P = 0.024$. All females were consuming meat at 9 months of age, compared to 84 % males, $P = 0.008$; there were no other sex differences with respect to meat consumption and other complementary feeding practices (milk feeding type, introduced meat during the first month of CF).

Table 7. 3. Meat consumption at 9 months of age

Variable	Total sample (n = 75)
First four weeks of CF	
Introduced meat (yes, %)	38 (53 %)
Age meat introduced (weeks) [a]	27 (26, 28)
9 months of age [b]	
Consuming meat (yes, %)	69 (93 %)
Meat, fish, poultry intake (g/day)	30 (15, 60)
Dietary iron (mg/day) [c]	0.6 (0.3, 1.1)

Note. CF = complementary feeding. Data presented as numbers (%) or median (25th, 75th percentile). [a] Of the 38 infants who were introduced to meat. [b] One case missing. [c] From meat, fish and/or poultry.

Approximately half of infants were introduced to meat during the first four weeks of CF: week one, n = 6 (16 %); week two, n = 9 (24 %); week three, n = 11 (29 %); week four, n = 12 (32 %). A larger proportion who started CF at the age of 5–6 months than < 5 months (59 % vs 23 %, P = 0.02) and were fully breastfed than receiving some formula (67 % vs 39 %, P = 0.02) were introduced to meat during the first month of CF.

Factors associated with iron status at 9 months

Baseline SF was the strongest predictor of SF at 9 months of age, followed by formula-fed only, then meat introduction at the start of CF (**Table 7.4**). These variables accounted for 56 % of the variance in SF concentrations. Higher SF at baseline, being formula-fed only during the first four weeks of CF and starting CF at 5–6 months of age was associated with higher SF concentrations, whereas having had meat introduced during this time was associated with lower SF concentrations.

Table 7. 4. Factors associated with serum ferritin concentrations at 9 months of age

Sqrt SF at 9 m model [a]	*Coefficient (B)*	*s.e. (B)*	*95 % CI B*	*Standardised B*	*R^2*	*P-value*
Model					0.560 [b]	< 0.001
Intercept	-3.5	2.3	-8.1, 1.1			
Baseline log SF [c]	4.1	0.5	3.0, 5.2	0.7		< 0.001
Meat introduced [d]	1.2	0.4	0.5, 1.9	0.3		0.001
Age started CF [e]	1.1	0.5	0.2, 2.0	0.2		0.017
Formula only [f]	-1.1	0.5	-2.2, -0.04	-0.2		0.042

Note. SF = serum ferritin, CF = complementary feeding, CI = confidence interval, sqrt = square root. Regression equation: sqrt SF at 9 months of age (µg/L) = -3.5 + 4.1 × log baseline SF (µg/L) + 1.2 × meat introduced during first month of CF + 1.1 × age started CF — 1.1 x infant formula only during first month of CF. Continuous variables were transformed using square root (SF at 9 months) and log transformation (baseline SF) to improve normality. Categorical variables were coded as Yes = 1, No = 2, or female = 1, male = 2. [a] Enter method. Variables included in the model were baseline log SF, formula feeding only during first month of CF, age started CF, sex and meat introduced during first month of CF. Valid number of participants: 69. [b] F (5, 63) = 16.0, P < 0.001. [c] For each increase of one unit in baseline log SF concentration, sqrt SF at 9 months is expected to increase by 4.1 µg/L. [d] Introducing meat during the first month of CF was associated with a 0.9 µg/L decrease in sqrt SF at 9 months of age. [e] Starting CF at 5–6 months was associated with a 1.1 µg/L increase in sqrt SF at 9 months of age. [f] Formula feeding only during the first month of CF was associated with a 1.1 µg/L increase in sqrt SF at 9 months of age.

Intervention-related adverse events

There were no reported harms or serious adverse events observed in either group.

7.5. Discussion

This is the first study to report the iron status of infants participating in a 'vegetables first' CF intervention. Most infants in this study were iron sufficient at 9 months of age and consumed iron-rich foods (meat, fish and/or poultry). During initial stages of CF, approximately half of infants were introduced to meat, of whom the majority were fully breastfed. Higher SF at 9 months was associated with higher SF prior to starting solids, being formula-fed during initial stages of CF, starting CF later (5-6 months of age) or not being introduced to meat during the first month of CF. However, it was not associated with being introduced to vegetable-only first foods.

In the context of a vegetables first CF trial, other data related to iron is not available; however, a number of studies have reported the iron status of 9-month-old infants with similar characteristics to our cohort (i.e., mostly breastfed, iron sufficient before starting CF and receiving no iron supplements) (Chen et al., 2020; Domellof et al., 2002; Georgieff et al., 2002; Krebs et al., 2013; Lozoff et al., 2016; Ziegler et al., 2014). Across these studies, infants' SF ranged from 5.2–27.5 µg/L and Hb 92–124 g/L, thus by comparison, infants on our trial had relatively high SF (median 40 µg/L) and Hb (mean 126 g/L). These levels were within normal limits

(Cormack, 2013; Larsson et al., 2019; Pérez-Acosta et al., 2021) and interestingly similar to those observed among infants receiving some iron-fortified cereal or iron supplementation (i.e., SF ranging ~41–55 µg/L) (Domellöf et al., 2001; Georgieff et al., 2002; Pasricha et al., 2013; Shao et al., 2021).

It is difficult to compare rates of ID and IDA between studies due to different study conditions, sample sizes and methodologies (e.g., different indices and cut-offs used for deficiency diagnosis). Nonetheless, the rate of suboptimal iron status at 9 months (4 %, excluding iron depleted) was lower than observed in an earlier New Zealand study (7 %) (Daniels et al., 2018; Grant et al., 2007; Heath et al., 2002) and cohorts overseas, including China (ID and IDA combined ranging 14 % – 69 % at 9 months) (Chen et al., 2020; Clark et al., 2017; Lozoff et al., 2016; Shao et al., 2021), Estonia (34 % at 9–12 months, mean age ~10 months) (Vendt, Grünberg, et al., 2007), US (12 % at 9 months) (Ziegler et al., 2014) and Germany (ranging 23 % – 34 % at 10 months) (Dube et al., 2010; Libuda et al., 2018).

The timely introduction of complementary foods including those that are iron-rich was promoted to all mothers on this study, which may partly explain why most infants were iron sufficient and consumed meat by 9 months of age. A similar observation was made in the BLISS study examining BLW, a different practice in which low in iron foods (vegetables and fruit) are self-fed and tend to be predominant first foods (Daniels et al., 2018). In their study, a BLW approach that had been modified to include advice on introducing 'high' iron foods (red meat, iron-fortified infant cereal) did not seem to increase the risk of ID among infants or reduce the presence of meat in the diet, compared to traditional spoon-feeding.

Another explanation for the low prevalence of ID was infants' relatively high SF and adequate Hb at baseline. As shown in the regression analysis, higher baseline SF concentrations were associated with higher SF concentrations at 9 months of age. Similar findings have been observed elsewhere (Ashish et al., 2017; Georgieff et al., 2002; Michaelsen et al., 1995; Moreno-Fernandez et al., 2019; Shao et al., 2021; Ziegler et al., 2014), with a recent study in China showing that iron stores at birth independently related to iron status at 9 months (Shao et al., 2021). In our study, being fully on formula at the start of CF and introducing complementary foods at 5–6 months of age were other factors associated with higher SF. The positive effects of receiving formula on iron status was expected based on prior evidence (Berglund & Domellöf, 2021; Grant et al., 2007; Grmt et al., 2019) and because formula is typically iron-fortified to reduce the risk of ID (Björmsjö et al., 2021; Chen et al., 2020). It is less clear as to why starting CF closer to the age of 6 months appeared protective. Two other RCTs have found ferritin concentrations improve with starting CF at 4 months, but most of these infants received iron-rich first foods (Dewey et al., 1998; Jonsdottir et al., 2012). Therefore, perhaps our findings occurred because more infants who started CF at 5–6 months received meat soon after commencing solids, compared to those who started CF earlier. This could also reflect the advice given to mothers to introduce meat as a first food, especially if starting CF at 6 months of age.

An interesting and possibly contradictory finding was that introduction of meat during the early weeks of CF was inversely related to iron status at 9 months. This was unexpected as meat is an important source of bioavailable haem iron, and because higher meat intake has been associated with improved iron status indicators in early life (Hong et al., 2017; Olaya et al., 2013; Szymlek-Gay et al., 2009). Perhaps our results relate to the fact that a larger proportion of infants who were introduced to meat during the first month of CF were fully breastfed, and breast milk is a poor iron source. Furthermore, without disputing the benefits of breastfeeding, two large cross-sectional studies recently reported the odds of ID and IDA at 9 months increased in breastfed infants (Chen et al., 2020; Clark et al., 2017); which is consistent with evidence from ten other studies mentioned in Clark

(2017). This brings forward the question as to whether breastfed infants require different CF guidelines to those who are formula-fed, in which case further research is warranted. Tailored advice may also need to consider sex differences as we observed lower SF concentrations among males than females, as have others (Domellöf et al., 2002; Emond et al., 1996; Larsson et al., 2019; Pérez-Acosta et al., 2021; Ziegler et al., 2014). However, according to our regression analysis, no association was found between sex and SF at 9 months of age. The unadjusted sex differences seen in SF at 9 months may, in part, be attributed to higher baseline SF among females (P = 0.006), or other dietary factors such as more females eating meat at 9 months, compared to males.

This analysis was more interested in the presence of ID and IDA due to their associated deleterious health effects, but some (< 5 %) infants were found to be iron depleted. As the conditions that typically cause iron depletion (e.g., malaria, hookworm, folate/B_{12} deficiency, thalassemia) are rare in New Zealand and infants were reported as generally healthy, then maybe the Hb cut-off of < 110 g/L exaggerated occurrence. This Hb cut-off is well accepted but supported by negligible evidence in young infants (Abdullah et al., 2017; Garcia-Casal et al., 2019), and a lower cut-off may be more suitable (Domellof et al., 2002).

Interestingly, while Hb remained stable for the majority of infants over time, SF significantly decreased without reaching ID. This may reflect normal physiological shifts of iron compartments during the first year of life (Ashish et al., 2017), but importantly, highlights the need to obtain adequate iron stores from the beginning of life, as well as introducing exogenous dietary iron sources as stores become depleted by 6 months of age.

Infants were consuming around two tablespoons of meat, fish and/or poultry per day at 9 months of age, making a small contribution (e.g., ~0.8 mg per day if consuming minced beef) to the recommended daily intake of 11 mg iron per day (National Health and Medical Research Council, 2006). Furthermore, although serving sizes are not generally prescribed by infant feeding guidelines, the observed intakes are lower than recommended by the American Academy of Pediatrics (i.e., two servings or around four tablespoons of dry cereal per serving of iron-rich complementary foods per day during the early stages of CF (Duryea et al.; Powers & Mahoney, 2021). Other studies have reported relatively low intakes of iron-rich first foods, including red meat (Boudet-Berquier et al., 2017; Daniels et al., 2018; Heath et al., 2002; Helle et al., 2018; Roess et al., 2018). More studies may be needed to identify ways to help parents feed more of these important foods, especially if other foods such as vegetables become the focus.

At first glance, it might be disappointing to see that only around half of mothers introduced meat to their infant at the start of CF. However, instructions provided to mothers noted that the introduction of meat was optional during the first few weeks of CF, but strongly recommended if starting at 6 months of age. Perhaps as most started CF at 5 months, mothers were less inclined to offer meat. However, 87 % of those who were introduced to meat during the first months of CF were aged 4–5 months, demonstrating a certain willingness of mothers to feed iron-rich foods despite knowing this was optional. Furthermore, as most mothers who introduced meat were fully breastfeeding, then perhaps there was appreciable awareness of the importance of introducing iron-rich foods to infants who are fully breastfed. This would be encouraging but without further data remains speculative.

Strengths and limitations

The major strength of this study is that it is the first to monitor and report the iron status of infants following a vegetables first approach to CF. Important indicators of iron status (SF and Hb) were assessed at baseline, post-intervention and at 9 months of age. This not only ensured the safety of infants enrolled but has begun to address concerns as to whether an emphasis on vegetables as first foods increases risk of ID. Also, as mothers fed their infant at home following practical CF advice including the introduction of iron-rich foods, results demonstrate favorable ecological validity.

However, this study was secondary to meeting the RCT's primary objectives (vegetable intake) and impacted by Covid-19, so had some limitations. The small convenience sample was likely not representative of a wider population (e.g., of different socioeconomic status and ethnicities). Stratification of infant demographics (e.g., starting at 4 months vs 6 months; milk feeding type) or a no treatment group could (i.e., receiving 'usual care' without additional education) have established if and how advice on iron-rich foods should be tailored; but this was not feasible given the wider study design. Data for dietary iron intake was limited, for example, iron intakes from all dietary sources (breads, cereals, breast milk/formula) were not assessed, nor effects of iron inhibitors (phytates)/enhancers (vitamin C). In the interest of reducing participant burden and obtaining sufficient data for the primary outcome, we focused on meat, especially as meat is a source of haem iron, and is a poorly consumed first food (Boudet-Berquier et al., 2017; Fu et al., 2018; Helle et al., 2018; Morton et al., 2012; Roess et al., 2018). Finally, it is possible that a cut-off of < 10 for SF and CRP underestimated the prevalence of ID, but these cut-offs are commonly used by others in New Zealand (Grant et al., 2016).

7.6. Conclusion

The majority of infants on the Veges First Study were able to maintain iron sufficiency, and most were consuming iron-rich foods by 9 months of age. These infants had good iron stores prior to starting solids and mothers had received practical advice and resources (i.e., recipes cards and videos) on introducing iron-rich foods, emphasising the importance of iron endowment from birth and supporting parents during the CF period. However, the sample was small and findings not generalisable to those introducing vegetables exclusively without meat, or at different ages. It is also unclear as to whether a more intensive intervention is needed to improve iron intake. Nonetheless, findings show that a vegetable-only first approach to CF in conjunction with advice on introducing iron-rich foods did not result in decreased iron-status.

7.7. References

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Chapter 8. Discussion, research impact & conclusion

This chapter summarises the findings of the Veges First Study and discusses the implications of those findings. The chapter ends with suggested future research directions and concluding remarks.

8.1. Main findings and discussion

This randomised, controlled, parallel-group study showed that infants who received vegetable-only first foods (veg-only group, n = 56) during the first four weeks of complementary feeding (CF) consumed more vegetables at 9 months of age, compared to the group who started CF with a combination of vegetables and fruit (controls, n = 52). Intake of the target vegetables (broccoli and spinach) was double that of the controls (P = 0.028, P = 0.024, respectively), and daily vegetable consumption at home was 28 % higher (P = 0.042). These effects were maintained until 12 months of age, with the veg-only group having a 20 % higher daily vegetable intake than controls (P = 0.021). Thus, our hypothesis is supported: starting CF with only vegetables increases infants' vegetable consumption later.

Secondary measures of food acceptance at 9 months of age indicated that the veg-only group consumed the target vegetables more rapidly and accepted the foods at a greater rate, but according to mothers' ratings, infants liked vegetables equally. Food preference questionnaires completed by mothers at 9 and 12 months of age revealed no group difference in daily vegetable liking.

When vegetables were first introduced (week one of the intervention), the veg-only infants ate and liked vegetable-only first foods to the same extent as the controls ate and liked fruit-based vegetable foods. Occurrence of acceptance behaviours (e.g., opens mouth, turns head away) and rate of eating did not differ by group. By week four, infants continued to eat and like the foods similarly, but in greater amounts. This was supported by fewer negative behaviours and eating the foods more rapidly.

Throughout the study infants ate and liked fruit equally, with no indication that starting CF with vegetables-only negatively impacts fruit consumption. In fact, the veg-only group ate as much of the target fruit as they did the target vegetables at 9 months of age. Whereas the control group consumed significantly more of the target fruit than target vegetables.

Almost all (92 %) of infants who participated in the trial were able to maintain adequate iron status at 9 months, by which time most (93 %) were also consuming iron-rich foods (meat, fish, poultry). Higher SF at 9 months was associated with higher SF prior to starting solids, being formula-fed during initial stages of CF, starting CF later (5–6 months of age) or not being introduced to meat during the first month of CF. Starting CF with vegetables-only or a combination of fruit and vegetables had no effect on infants' iron status, demonstrating that the intervention caused no apparent harm.

Comparison with relevant findings from other published studies

Our finding of an increased vegetable intake at 9 and 12 months of age after receiving vegetable-only first foods is consistent with those of similar studies, which all show that early exposure to vegetables improved child vegetable acceptance within the first year of life (Barends et al., 2013; Barends et al., 2014; Fildes et al., 2015; Hetherington et al., 2015).

There were three instances where our results differed from previous research, but these relate to secondary objectives. First, the intervention appeared to have no effect on vegetable liking. While Hetherington et al. (2015) also found mothers' ratings were not sensitive to group assignment, according to researchers' ratings, vegetables were liked more by infants exposed to vegetables early. In Fildes et al. (2015), liking results were inconclusive, and only in the UK intervention did both mothers' and researchers' ratings indicate that vegetables were more liked after following a vegetables first approach, compared to traditional practice (fruit, vegetables, cereals). Limited data which are inconsistent and derived from different methodologies suggest a need for more studies using validated and objective measures to assess infant liking.

The second finding that differed from previous work is the similar acceptance of vegetable-only first foods and fruit-based foods during the 4-week trial. In Barends et al. (2013), single fruit purées were accepted to a higher degree than single vegetable purées at the start of CF. Non-identical results likely reflect differences in the study design, particularly as our fruit-based foods contained a small quantity of vegetables.

Third, while increased vegetable intake at 12 months supports the findings of Barends et al. (2014), this finding is inconsistent with Hetherington et al. (2015) who found no improvement in vegetable acceptance among infants with early vegetable exposure. However, this is likely because by the end of the intervention, all infants had received 11 days of the same rotation of vegetables, which perhaps diluted effects. Also, at the 12-month follow-up, their study tested infant purées that were smooth in texture and may not have been well accepted by infants who had progressed to eating more finger and family foods at 1 year of age.

Overall, the few data available and heterogeneity between studies might limit comparability of results and be viewed as a weakness. However, comparisons remain possible as the feeding strategy investigated by each study was the same (starting CF with vegetables), as were the outcome measures (vegetables intake and liking). The uniqueness of these interventions has offered new knowledge to the literature. From Barends et al. (2013, 2014) we have evidence to show no benefit in starting CF with only fruit to improve vegetable acceptance. Meanwhile, Hetherington et al. (2015) showed that gradually introducing vegetable flavours to milk then cereal can encourage infants to accept and consume vegetables. Our study has extended these conclusions by demonstrating that starting CF with vegetables-only has an advantage over starting with fruit and vegetables with respect to vegetable intake. These studies could be repeated or tailored for larger cohorts, in different countries and over longer periods in order to improve generalisability and assess reliability of effects.

Consideration of possible mechanisms and explanations

Infants' willingness to accept new foods and their ability to establish new and lasting food preferences from a young age (Chambers et al., 2016; Nicklaus & Remy, 2013) may explain why starting CF with vegetables-only has been effective in improving vegetable acceptance. According to a systematic review on sensitive periods for taste, infants can learn to accept and eat vegetables relatively easily and early on in the CF period (4–6 months), suggesting the early weeks of CF as a sensitive window for flavour learning or 'taste training' (Harris & Mason, 2017).

Exposure to vegetable-only first foods was a driving factor for study findings, but mechanisms of repeated exposure and responsive feeding were likely present as infants were offered vegetables (or fruit-based foods) on more than one occasion according to their hunger/satiety cues. Both of these other feeding practices have been shown to improve child food acceptance (Barends et al., 2019; Gerritsen & Wall, 2017; Scientific Advisory Committee on Nutrition, 2018), with effects of repeated exposure often limited within food categories (i.e., exposure to vegetables improves acceptance of the vegetable category, but not the fruit category). This could explain why starting CF with vegetable had no effect on fruit acceptance, and *vice versa.* Potential synergies between feeding strategies may require further investigation, but it seems that incorporating well established and recommended infant feeding practices into a vegetables first approach has proven beneficial.

Innate preference for sweet taste is another common theory discussed in the context of infant vegetable acceptance. In our study, if infants had an inbuilt preference for sweet taste, this did not seem to dictate their ability to accept more savoury vegetables during the early weeks of CF. Instead, preferences for sweeter flavours may be responsible for fruit being well accepted in both groups. This underscores a greater need to encourage infants to learn to like more difficult-to-accept flavours and foods, such as bitter-tasting green-leafy vegetables, rather than those that are immediately enjoyable.

The mechanistic relationship between food intake and liking is complex but it is often thought that children will eat more of a food they like (Bell et al., 2021; Shehan, 2014). Thus, it was interesting to find that mothers rated vegetable liking similarly between groups despite difference in vegetable intake. As mentioned, this is not uncommon to observe (Fildes et al., 2015; Hetherington et al., 2015) and is likely due to the subjective nature of assessment. That said, based on the correlations between intake and liking, as well as data on other food acceptance variables supporting improved vegetable intake, this present study suggests a possibility that the more infants ate vegetables, the more they liked them.

What about infant iron status?

Although a vegetables first approach to CF may improve child vegetable acceptance, there are concerns that an emphasis on vegetables may lead to the unintended neglect of other important first foods (i.e., those that are iron-rich), increasing the risk of iron deficiency. For this reason, a recent consensus paper stressed that any focus on vegetables during early CF should be in the context of a healthy, varied diet, and the timely introduction of iron-rich foods (Chambers et al., 2016).

Our intervention did not appear to have a negative impact on infants' iron status; however, it is important to note that all participating mothers were given support and advice on when and how to introduce iron-rich foods. Furthermore, infants had relatively high iron stores on enrolment. Higher iron stores emerged as the strongest predictor of iron status, that is, higher serum ferritin at baseline was associated with higher serum ferritin at 9 months. Although these findings offer some reassurance, there were a number of limitations related to the preliminary nature of the analysis, including the small sample, incomplete dietary iron data and a lack of a non-treatment group (e.g., no iron-rich foods introduced).

A further study designed to examine a causal relationship between starting CF with vegetables-only and infant iron status is needed, as well as the specific conditions and advice needed to reduce ID risk while following a vegetables first approach to CF. Such research may consider stratifying for age (e.g., starting CF at 4 months vs 6 month), collecting more comprehensive dietary iron data and/or using different comparison groups as far as is practically and ethically possible (e.g., comprehensive advice on iron-rich foods vs standard care; iron fortified infant rice cereal vs no cereal). In the meantime, it remains sensible to adhere to current infant feeding guidelines which promote both iron-rich foods and vegetables as important first complementary foods (Dewey & Harrison, 2020; Ministry of Health, 2008).

8.2. Strengths and limitations

RCTs are considered a gold standard for establishing causal conclusions of an intervention and are needed to demonstrate the actual outcome if it were implemented (Hariton & Locascio, 2018; Moher et al., 2012). There is a significant need for longitudinal RCTs for the evaluation of long-term efficiency and impact of a vegetables first approach to CF (Bell et al., 2021; Chambers et al., 2016). Thus, our longitudinal RCT study design was a major strength of this research. In acknowledging that RCTs still need to be well designed and properly executed to obtain reliable evidence, **Figure 8.1** highlights key elements of our intervention that improved study quality, as well as inherent limitations that need consideration when interpreting results.

Figure 8. 1. Important strengths and limitations of the Veges First Study

Strengths

	Longitudinal, randomised controlled trial (RCT)
	Adequately powered
1st	First to use control foods that contain fruit and vegetables
	Conducted in the home
	Participant blinding

Limitations

	Social desirability bias
	Covid-19 restrictions
	Limited generalisability

Study strengths

Beyond the robust study design, the use of a relatively large sample that was adequately powered suggest findings for the primary outcome were minimally affected by bias and that the estimate of random error, typical of human trials, was improved (Chow, 2017; Moher et al., 2012). As participant characteristics were similar between groups and participants did not know which group they had been assigned to, effects were likely due to the intervention, rather than other factors. Feeding sessions were conducted in the infants' familiar home environment and the control group was considered representative of common practice (starting CF with fruit-based foods), improving ecological validity of findings and the ability to translate the science into a practical setting.

Other strengths included high response rates and compliance, with 92 % of the original sample providing sufficient data for the primary analysis. These successes reflect the benefits of convenience sampling, efforts taken to minimise participant burden (e.g., home visits, easy to follow instructions, simple online dietary questionnaires), the provision of comprehensive infant feeding support (e.g., visually appealing resources, dietetic consultation) and rapport building between the researcher and participant (e.g., infant birthday cards, face-to-face contact).

This scaffolding of support for parents to successfully adhere to the study protocol may indicate the care and guidance that parents require to following infant feeding guidelines. This thesis is also the first to present results on the iron status of infants following a vegetables first approach to CF, thus has made a valuable contribution in addressing concerns regarding intervention safety.

These study characteristics are considered improvements on the limitations of previous research, which were shorter in duration, featured smaller samples, used controls that did not necessarily reflect current practice, did not monitor or report infant iron status, experienced significant loss to follow-up and/or were partly conducted in a laboratory setting. Finally, guidelines for the Consolidated Standards of Report Trials (CONSORT) were followed to improve transparency and quality of reporting.

Study limitations

The limitations of this study relate to factors and circumstances that were difficult to control, including Covid-19 restrictions introduced after the study had commenced, family practices between follow-ups and the characteristics of the population sampled.

Social desirability bias and non-compliance

Participants had to be living in Auckland and able to commute to the clinic for at least the first visit, thus data is not nationally representative, especially as most mothers were well-educated, of European ethnicity and had reported having adequate access to food. Being a convenience sample, the study likely attracted mothers highly motivated to feed their infant vegetables. Thus, personal food preferences, predetermined ideas about their infants' food preferences or a desire to report more socially desirable information may have skewed data, especially where subjective responses or self-reported information was required (e.g., liking scales, food recalls). Some mothers reported that by 9 months of age their infant preferred and had become accustomed to baby-led weaning (BLW) which made it difficult to know if their infant disliked the food or the feeding method. Meanwhile, as the intervention was conducted at home without the presence of a researcher, we cannot rule out all breaches of protocol, particularly with some missing compliance data. This included mothers tasting the foods and trying to guess what they were. We also had no control over infant feeding and dietary practices between the baseline study and later outcomes.

To mitigate these potential sources of bias, we provided:

(1) detailed feeding instructions;

(2) feedback on the first few videos submitted by each participant;

(3) weekly compliance questionnaires;

(4) additional support to those who had started BLW (e.g., ‘allow your baby to hold a second empty spoon’, ‘avoid a power struggle’);

(5) follow-up phone calls/e-mails to confirm mothers understood the protocol;

(6) foods that were labelled generically (e.g., Meal A) with no ingredient list alongside instructions for mothers to not taste the foods themselves.

Overall, a motivated group was advantageous for compliance and several measures of food preferences were taken to improve accuracy of assessment, including daily vegetable/fruit intake (validated FFQ) and intake (grams) of target vegetables. At 9 and 12 months of age, there was no difference in the number of types of vegetables that infants had tried, suggesting that food experiences and the influence of mothers was likely equal.

Covid-19 restrictions

Auckland's first Covid-19 lockdown occurred on 23 March, which restricted mothers from leaving their home for non-essential purposes. At this time, 30 participants had yet to complete the 9 month feeding sessions but as these were always intended to be conducted at home, it was possible to continue with the intervention. However, some clinic/home visits were missed, and mothers were asked to measure infant weight, height and head circumference themselves, which led to missing data (e.g., weight if no scales were available, blood samples) and/or inaccurate data. Changes in routine and additional family stress during this period may have influenced responses (i.e., difficulty in remembering food intake or completing video recordings). While a de-brief questionnaire may have given more insight, > 90 % of the original sample returned completed food diaries, suggesting that mothers were able to complete the tasks sufficiently.

Foods selected and other sources of bias

The findings are likely limited to the target foods selected and effects may not be generalised to other foods. Firstly, at baseline, the fruit-based purées contained more natural sugars than the vegetable-only purées and are distinctly sweeter. However, two control foods contained a small quantity of vegetables ('green food' = 90 % apple + 10 % spinach; 'purple food' = 98 % pear + 2 % beetroot), thus group differences may have diminished. Conducting sensory analysis could have confirmed this, but these are often performed using adult taste panels, which are not representative of the sensory world of infants, especially if children are more sensitive to bitter taste than adults (Mennella et al., 2014). Furthermore, our choice to add some vegetables to the control improved blinding (e.g., both groups started with a green colour food) and reflected current recommendation to feed both fruit and vegetables as first foods.

Secondly, it is unknown whether a similar result of improved vegetable intake would have been achieved if a different combination of vegetable and/or fruits were provided. Also, as it was difficult to identify a suitable unfamiliar vegetable in this cohort, we could not test whether the vegetables first approach improved acceptance of a novel vegetable. Broccoli was considered novel in the sense that none of the infants had tried it during the first month of CF, yet most had tried it after this time, so were familiar by 9 months of age. None had tried artichoke either but using this as a target food was considered less meaningful given its obscurity in New Zealand. Perhaps the choice of vegetables could have been chosen according to what was novel to the individual infant, but this was beyond study resource and time constraints. For similar reasons, we could not conduct a food experiment at 12 months of age, thus relied on self-reported data.

As expected, when conducting research in humans, other random factors may have affected results, including infants being upset or tired due to teething or other unknown reasons; these were documented and used to assess outliers. Finally, we adapted a validated infant liking tool which might have changed validity of results. Using a second-rater (i.e., researcher) may have confirmed findings and provided a more objective measure, but as they do not know the infant, bias is not resolved, especially as the liking tool was specifically designed to be used by mothers (Madrelle et al., 2017). Such problems suggest a need for further development and validation of tools to assess infant food acceptance.

8.3. Research impact

It is important to consider the potential impact of this research including how it will have an effect, benefit, or contribution to the economy, society or environment, beyond contribution to academic research (Fort et al., 2017; Ministry of Business Innovation and Employment, 2019). As illustrated in Figure 8.2, the key implications of this research relate to policy/guideline development, providing educational tools to support caregivers' confidence about feeding infants, and improving the diet and health of New Zealand children and beyond.

Figure 8. 2. Potential implications of the results of the Veges First Study

Infant feeding guideline development

e.g., guideline documents may include additional information on a vegetables first approach to CF.

Simple tips for parents

e.g., focus on offering vegetable-only first foods at the start of CF; no need to sweeten first foods with fruit to encourage vegetable acceptance in young infants.

Resource development

e.g., videos, mobile apps and visual flyers covering practice tips on starting CF.

Improved vegetable intake

e.g., children's vegetable consumption may improve among infants with early vegetable exposure.

Obesity prevention

e.g., if a vegetables first approach to CF improves vegetable acceptance later and improves child weight trajectories, then the approach could be one effective strategy to reduce disease burden and associated economic cost.

Social and population health benefits

At an individual or community level, the infants who participated in this trial, or those following a vegetables first approach to CF in the future, may develop a lifelong dietary habit of eating vegetables and experience the associated health benefits. For parents, results may help to prioritise which strategies are the most effective for improving their child's vegetable intake, especially if authorities are able to translate the evidence into a few simple key messages. For example, the National Health Service (NHS) in the UK now recommend to 'Include vegetables that aren't so sweet, such as broccoli, cauliflower and spinach – this will help your baby get used to a range of flavours (rather than just the sweeter ones like carrots and sweet potato)' (NHS, n.d.). Indeed, there is a need to improve the use and communication of evidence-based dietary information to New Zealand mothers (Brown, 2020), and perhaps alleviate parental pressures to 'get it right' through several recommended feeding strategies (Bell et al., 2021).

These outcomes support the global strategic goal of increasing vegetable intake to help reduce the global burden of disease (Cammock et al., 2021; World Health Organization, 2021). With vegetable consumption persistently low, and 1 in 10 New Zealand children (aged 2–14 years) still obese in 2019/20 (Ministry of Health, 2020), there is an urgent need to find simple preventative strategies for immediate implementation, especially as obesity and related chronic illness is the leading cause of death in New Zealand adults (89 % of overall deaths) (World Health Organization, 2018). That said, given the limited evidence of a link between increased vegetable acceptance and child weight trajectories (Barends et al., 2019; Boeing et al., 2012; Ledoux et al., 2011), it would be somewhat premature to suggest that the outcomes of this study have the potential to impact on obesity prevention.

$ Economic benefits

The economic impact of this type of health research, if translated into better health outcomes, largely relates to a reduction in the financial cost of diet-related diseases including obesity, which has accounted for 4.4 % of New Zealand's total health care expenditure (Lal et al., 2012), and as high as $2.0 trillion in other countries such as the US (Dobbs et al., 2014). Furthermore, improving population health is needed to alleviate over-burdened healthcare systems, which is timely given the additional pressure from the Covid-19 pandemic (Bartsch et al., 2020).

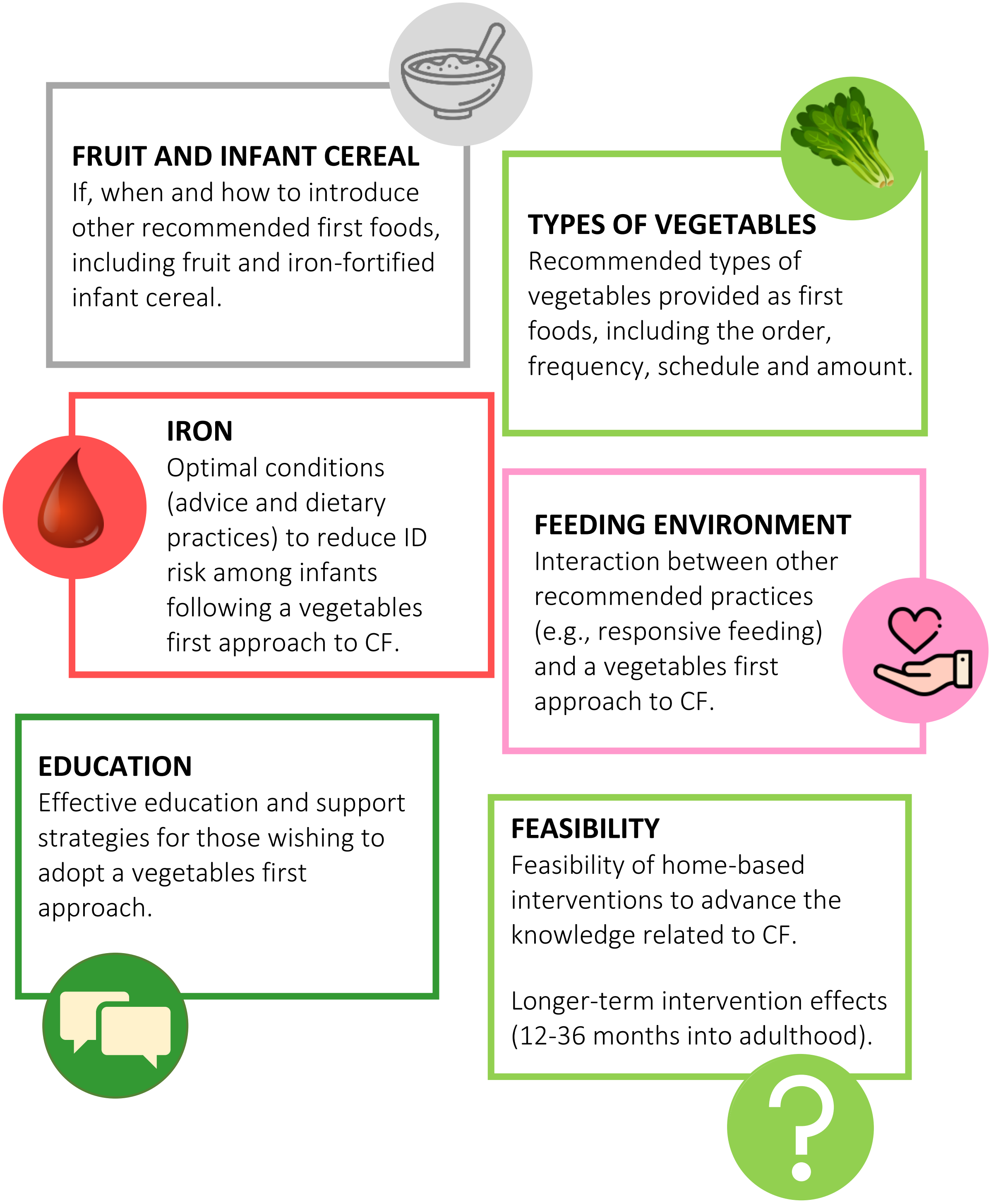
Environmental benefits

At an environmental level, there are complex dimensions that were beyond the scope of this thesis (i.e., the impact on sustainable food systems), but one implication of evidence demonstrating the importance of vegetables as first foods could be changes in food regulations or market trends that demand the availability of more vegetables for children. These trends may drive industry to support local vegetable growers and develop commercially available infant foods featuring more vegetable varieties, including single dark green vegetable products that are currently lacking (Bakke et al., 2020).

8.4. Research gaps

Despite the valuable contribution of our study and others discussed, many questions remain about commencing CF with vegetables-only, with those of some urgency summarised in **Figure 8.3**. A future research possibility includes conducting a larger intervention by which parents purchase/grow, cook and prepare their own vegetables at home to feed their infant rather than relying on the study foods that were supplied. Focus groups may be needed to identify the best format and information needed for resource development in order to develop a sustainable way to support parents from a range of socioeconomic and cultural backgrounds. In the meantime, our study has offered compelling results and supports current efforts to promote the consumption of a variety of vegetables from an early age.

Figure 8. 3. Suggested research gaps within the topic of a vegetables first approach to complementary feeding



8.5. Concluding remarks

This thesis began by highlighting a major public health concern, which is poor vegetable consumption amongst children. By no means does the study claim to have solved this problem, however, it has shown that introducing vegetables at the start of CF is a prospective part of the solution. As the intervention was conducted in the home environment using commonly available vegetables, it shows promise as a simple and achievable way for parents wishing to foster their child's vegetable acceptance. A key public health message could be to 'introduce a variety of vegetables alongside iron-rich foods as first foods for your baby.'

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Appendices

The following section provides supplementary information to this thesis, including ethics approval, study materials and additional tables to support research findings.

Appendix A: Research ethics approval

MASSEY UNIVERSITY
TE KUNENGA KI PŪREHUROA
UNIVERSITY OF NEW ZEALAND

Date: 27 September 2018

Dear Jeanette Rapson

Re: Ethics Notification - **SOA 18/56 - Vegetables as first food for babies: a randomised controlled trial**

Thank you for the above application that was considered by the Massey University Human Ethics Committee: **Human Ethics Southern A Committee** at their meeting held on **Thursday, 27**

Approval is for three years. If this project has not been completed within three years from the date of this letter, reapproval must be requested.

If the nature, content, location, procedures or personnel of your approved application change, please advise the Secretary of the Committee.

Yours sincerely

C Johnson

Professor Craig Johnson
Chair, Human Ethics Chairs' Committee and Director (Research Ethics)

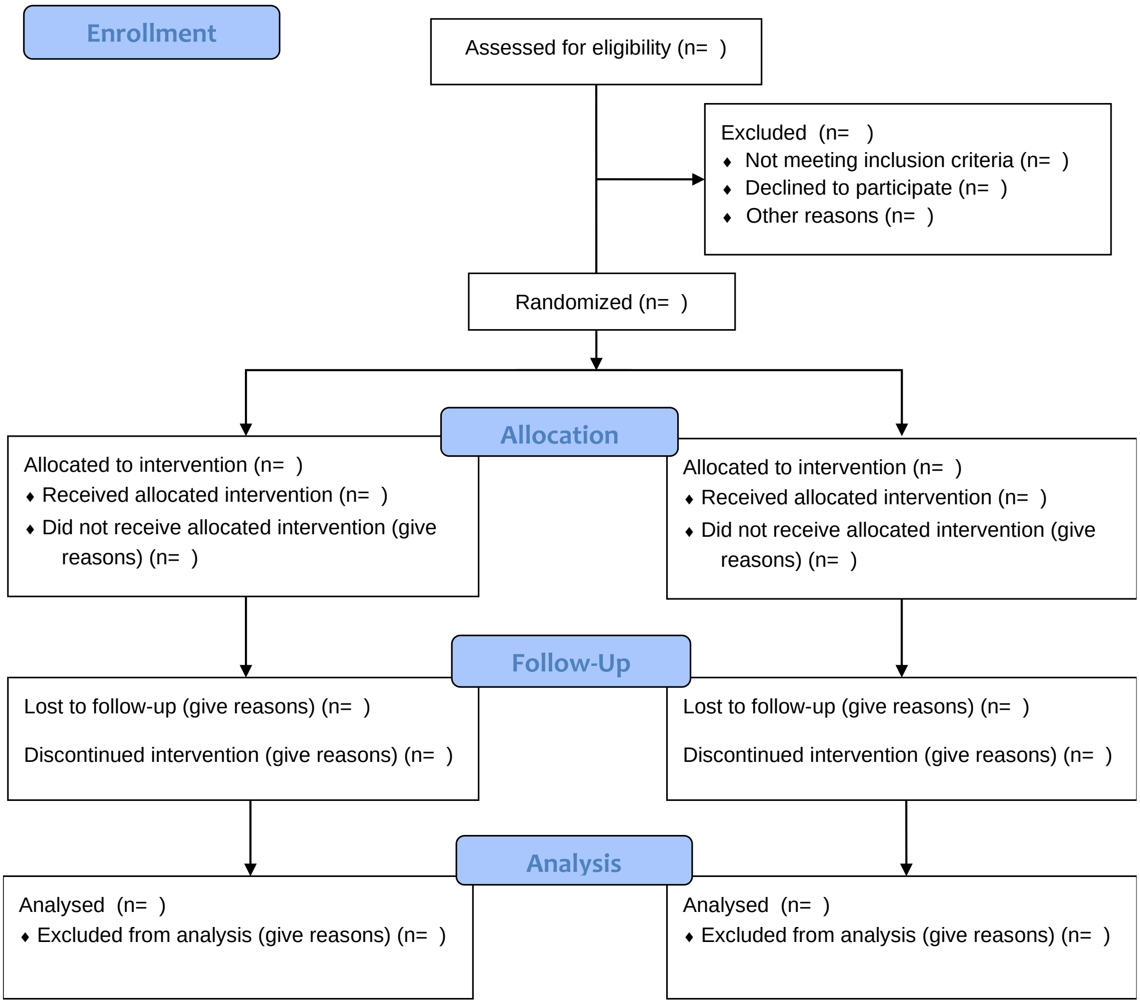
Research Ethics Office, Research and Enterprise
Massey University, Private Bag 11 222, Palmerston North, 4442, New Zealand T 06 350 5573; 06 350 5575 F 06 355 7973
E humanethics@massey.ac.nz W http://humanethics.massey.ac.nz

Note. Comments from approver following first application were: I'm happy for you to submit this application. Please just complete the missing section on how many hours the participant will need to commit. Very minor wording changes suggested for the flyer. These were addressed accordingly before final approval.

Appendix B: CONSORT diagram outline

CONSORT
TRANSPARENT REPORTING of TRIALS

CONSORT 2010 Flow Diagram



Appendix C: Recruitment material

Is your baby getting ready to start solids?

We want to invite you to participate in our study!

You will need to:

- Live in Auckland and have a baby 4-6 months of age
- Feed your baby recommended infant foods for 4 weeks
- Fill in simple questionnaires and baby food diary
- Provide blood and stool samples, and child growth measurements
- Video record your baby trying foods for the first time

You will receive FREE:

- Infant feeding and nutrition support from an **NZ registered dietitian**
- **Nutritious baby foods** during the 4-week trial
- **Iron** and **Vitamin D** status assessments for you and your baby
- Infant growth assessments
- **Fun DVD** of your baby's first food experiences

INTERESTED? Please contact:

Jeanette Rapson
0210773419 | vegesfirst@massey.ac.nz
www.vegesfirststudy.co.nz

MASSEY UNIVERSITY TE KUNENGA KI PŪREHUROA UNIVERSITY OF NEW ZEALAND | COLLEGE OF HEALTH TE KURA HAUORA TANGATA

Jeanette Rapson

MUHEC: Southern A, Application SOA 18/56.

Note. Poster/flyer. This material was distributed via e-mail, social media (i.e., Facebook groups) and community notice boards with permission from respective persons of each channel.

https://www.massey.ac.nz/massey/about-massey/news/article.cfm?mnarticle_uuid=7F89673A-BDE4-43CC-A26C-ED4E809006B7

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Developing healthy eating habits early on

Researchers are looking for 120 Auckland-based mothers and babies to take part in a new study which will evaluate whether exposing babies to vegetables when they first move to solids, could improve their chances of enjoying eating vegetables later in life.

Taste preferences start to develop early in life and can influence food choices in the future. Now, a new Massey University study is investigating how exposing babies to a variety of fruit and vegetables when they first move to solids, could help form better eating habits in the future.

Jeanette Rapson, PhD candidate and registered dietitian.

The study is being led by PhD candidate and registered dietitian Jeanette Rapson, who wants to know if early exposure to vegetables during complementary feeding (when babies begin to progress from breast milk or formula) will improve the chances of children liking vegetables.

"In New Zealand, suggested first foods for babies include vegetables, fruits, meat and commercial infant foods like baby rice," Ms Rapson says. "During this critical window, repeated exposure to a variety of tastes may be a successful strategy to promote vegetable intake amongst children. It is important that children eat plenty of different vegetables and fruits to ensure they are getting the vitamins, minerals and dietary fibre needed for growth and development."

Few studies have investigated vegetables during complementary feeding, especially in New Zealand. "The aim of our study is to compare two different feeding regimes which differ in the types of vegetables and fruits they provide. We will also examine the mother's diet during pregnancy and breast feeding, as these may have some impact on the taste preference of their child," she says.

"The results of our study may contribute to recommendations around first foods for babies in New Zealand, and worldwide."

Researchers are looking for 120 Auckland-based mothers and their babies to participate in the study.

"As soon as you think your baby is ready to start solids, we will ask you to feed them age-appropriate vegetable and fruit baby foods that we provide to you for free for four weeks. We would also like you to take a few video recordings of your baby trying the foods and keep a weighed infant food diary."

Participants will need to visit the Human Nutrition Research Unit at Massey's Auckland campus in Albany, when their baby is four months old. "We can visit mums and babies at home for follow-ups at the end of the four-week trial, then again when the baby is nine months and 12 months of age," Ms Rapson says.

All mothers will have the opportunity to meet with a New Zealand registered dietitian, who can offer support with infant feeding and nutrition. Mothers will also have access to free nutrition information throughout the study. This study, entitled 'Vegetables as first foods for babies', is being supervised by Dr Cath Conlon and Associate Professor Pam von Hurst from the School of Sport, Exercise and Nutrition.

For more information about the study or to register your interest, please click here.

Related articles

New mums needed for study on babies' best start

Created: 18/07/2019 | Last updated: 18/07/2019

Note. Massey University press release to promote recruitment.

Appendix D: Infant feeding resources

The following resources were created by the PhD candidate using Canva. Images were purchased from Shutterstock ® or used with permission from the photographed subject. Illustration (i.e., cooking utensils) created by the PhD candidate using Adobe illustrator.

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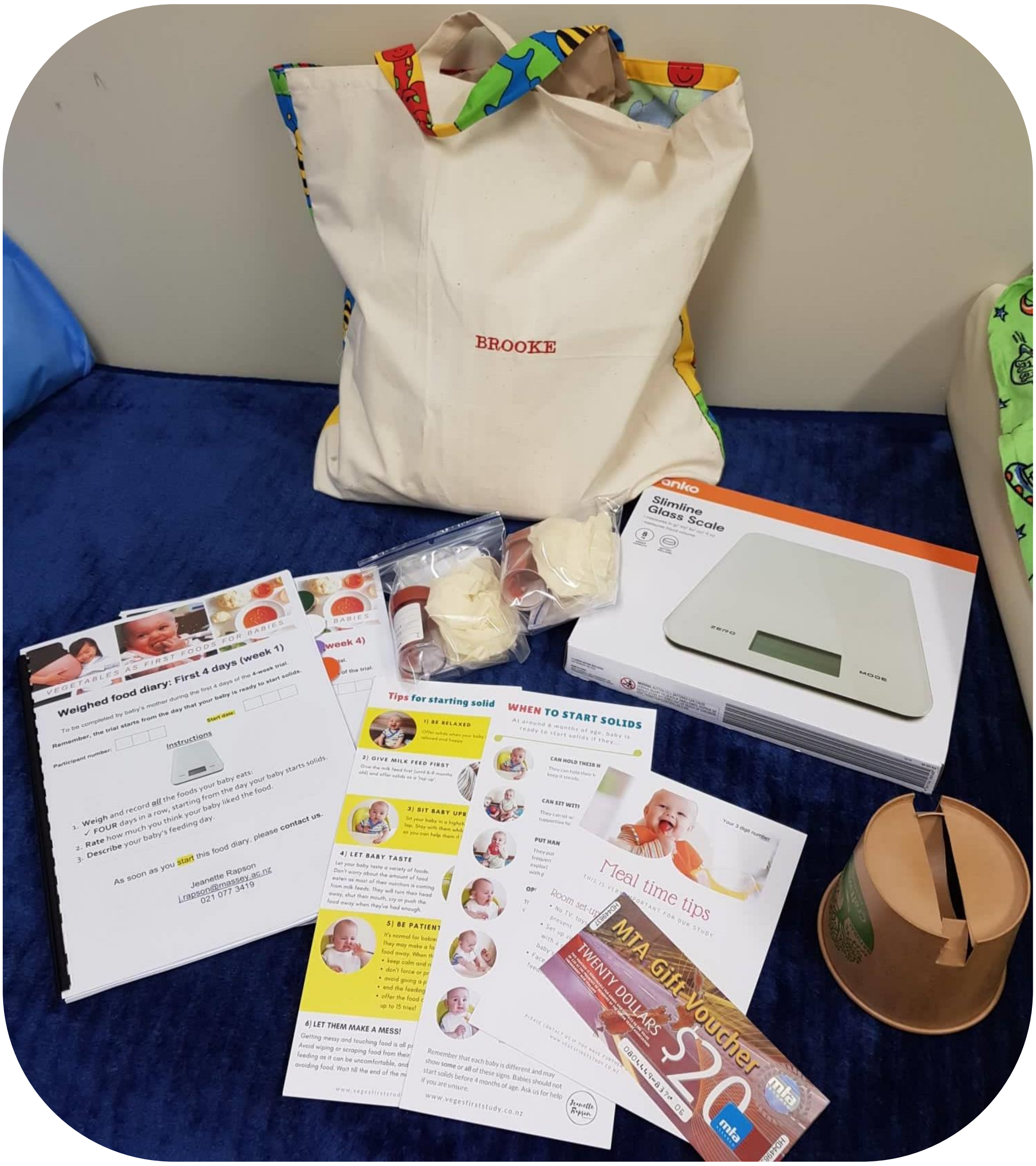
Infant feeding participant study pack



Note. Items include: weighed food diaries, stool collection kit (for wider study), infant feeding resources, petrol voucher, mobile phone tripod cup, kitchen scales, personalised fabric bag and all infant foods.

Meal time tips – A5 fridge magnet

Meal time tips

THIS IS VERY IMPORTANT FOR OUR STUDY

Room set-up

- No TV, toys or siblings present
- Set up video camera with a clear view of baby's face and arms
- Face your baby while feeding

Feeding style

- Baby-led pace
- Stop after 3 spoon refusals in a row
- Approach your baby's lips horizontally with spoon while they are focused on the meal (don't play airplane/train)
- Don't try your baby's food - this will change the accuracy of our measurements

PLEASE CONTACT US IF YOU HAVE FURTHER QUESTIONS
WWW.VEGESFIRSTSTUDY.CO.NZ

When to start solids – A4 narrow fridge magnet

WHEN TO START SOLIDS

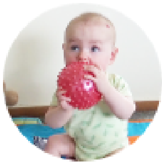
At around 6 months of age, baby is ready to start solids if they...

CAN HOLD THEIR HEAD UP

They can hold their head up and keep it steady.

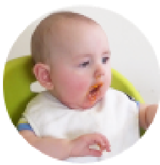
CAN SIT WITH LESS HELP

They can sit with less help, e.g. in a supportive high chair.



PUT HANDS TO MOUTH OFTEN

They put their hands and toys frequently in their mouth, exploring fingers, thumbs and fists with great interest.



OPEN THEIR MOUTH EASILY

They open their mouth easily when a spoon touches their lip or as food approaches; and they do not stick their tongue out.

REACH OUT FOR FOOD OR MAKE CHEWING MOVEMENTS

They reach out for food/toys, seem hungry after milk feeds, or show signs of chewing movements.

CAN KEEP FOOD IN THEIR MOUTH

They keep some food in their mouth and swallow it, instead of spitting it all out.

Remember that each baby is different and may show **some** or **all** of these signs. Babies should not start solids before 4 months of age. Ask us for help if you are unsure.

Jeanette Rapson

www.vegesfirststudy.co.nz

Tips for starting solids – A4 narrow fridge magnet

Tips for starting solids

1) BE RELAXED

Offer solids when your baby is most relaxed and happy.

2) GIVE MILK FEED FIRST

Give the milk feed first (until 8-9 months old) and offer solids as a 'top up'.

3) SIT BABY UPRIGHT

Sit your baby in a highchair or on your lap. Stay with them while they're eating so you can help them if they need it.

4) LET BABY TASTE

Let your baby taste a variety of foods. Don't worry about the amount of food eaten as most of their nutrition is coming from milk feeds. They will turn their head away, shut their mouth, cry or push the food away when they've had enough.

5) BE PATIENT

It's normal for babies to reject new foods. They may make a face, cry or push the food away. When this happens:

- keep calm and relaxed
- don't force or pressure them to eat
- avoid giving a preferred food instead
- end the feeding session
- offer the food another day. It may take up to 15 tries!

6) LET THEM MAKE A MESS!

Getting messy and touching food is all part of learning. Avoid wiping or scraping food from their face and hands while feeding as it can be uncomfortable, and may lead to babies avoiding food. Wait till the end of the meal to clean up.

Jeanette Rapson

www.vegesfirststudy.co.nz

Preparing and storing meat safely – A5 booklet

Preparing and storing meat booklet | Page 1/7 (cover)

Prepare

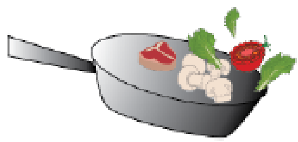
- Wash your hands with soap and water before preparing food.
- Use clean surfaces, utensils and cookware (washed with soap and water, rinsed with clean water).
- Use different chopping boards for meat and fruit/vegetables.
- Don't let raw meat come into contact with fresh fruit/vegetables or cooked food.

Cooking methods

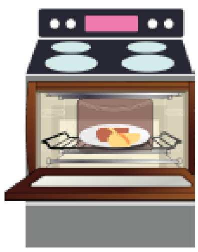
Cook baby's meat using any of these methods.

Steam

Poach / boil



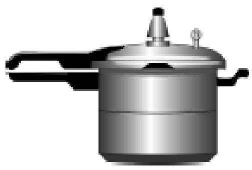
Stir-fry
(use oil if needed)



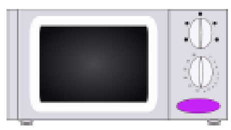
Roast / Bake

Grill

If barbecuing, avoid giving charred, blackened bits to your baby.



Slow cook / pressure cook



Microwave

Do not add salt, soy sauce, sugar, honey, cream, butter, margarine, or artificial sweeteners to baby foods. Even though it may taste bland to adults, the food will be attractive to babies.

Purée meat

Puree baby's meat using any of the following equipment.

If you don't have suitable equipment, please contact us for help!

Blender

Food processor

Stick blender

- Use a blender, food processor or stick blender to ensure the purée is smooth with no lumps or hard bits. If struggling with lumps, push the food through a sieve after blending.
- During early weeks of introducing solids, the consistency should be like runny, smooth yoghurt.
- Adding extra water will make it more runny, while adding less will thicken the purée (water from a tank or bore should be boiled and cooled before use).

During the 4-week trial of this study, **please do not** add breast milk or formula to the meat purée. This is for the purpose of the study.

Storage

- Once you've prepared a batch of purées, allow to cool and then put it straight into the fridge or freezer.
- You can freeze portions using ice trays.
- Transfer the cubes into a freezer proof bag with the date you made it.
- Food can be kept in the fridge for 2 days.
- Food can be frozen for up to 1 month.
- Don't freeze foods more than once.
- Don't keep half finished purées. If your baby doesn't eat all of their meal, throw the rest away to avoid bacteria that can cause illness.

Reheating

- Hot food can burn your baby's mouth. When heating frozen food, make sure it's piping hot, then let it cool down before giving it to your baby.
- Test the temperature of the food by stirring the food with a spoon and then testing the purée on the inside of your wrist. It should not feel hot.
- If using a microwave to reheat, remember to stir the baby food at 10-15 second intervals to avoid hot spots that could burn your baby.
- Don't reheat your baby's food more than once.

Serving

- It's not necessary to sterilise your baby's spoons, bowls, or containers after they are 3 months old. Washing them in very hot soapy water or in a hot dishwasher is fine.

Get messy!

- Mealtimes can get messy. Babies enjoy playing with and exploring food with their hands as part of learning. Avoid constantly wiping or scraping food off their face and hands while feeding as many find this sensation uncomfortable, leading to food avoidances. Gently clean up after the meal.
- You can use some newspaper or plastic under their highchair to contain the mess.

Infant feeding videos (available on request)

Duration: 1 min 13 sec

Duration: 1 min 29 sec

Duration: 1min 39 sec

Meat purée preparation videos (available on request)

Duration: 1 min 15 sec

Chicken

Duration: 42 sec

Fish

Duration: 47 sec

Baby's first beef - recipe card

Baby's first beef

RED MEAT PROVIDES AN EXCELLENT SOURCE OF IRON WHICH IS ESSENTIAL FOR A GROWING BABY!

You will need:

250 grams lean steak
1 cup water

MAKES ABOUT 1 ½ CUPS

Tips:

- This meat purée can be frozen into portions using an ice tray.
- You can also try this recipe with lean beef mince, lamb, pork or venison.
- Don't add salt, fat, sugar or sweeteners.
- See our food safety resource.

Method

1. Trim all fat off the steak and cut into small cubes.
2. Place steak into a shallow pan and cover with the water.
3. Bring water to boil, then reduce to simmer and cover with a lid.
4. Cook steak until tender and no longer pink, then remove from heat.
5. Allow steak to cool, then blend the meat with the cooking water in a food processor or stick blender. You may need to add extra water as you go or push through a sieve to create a smooth purée.

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Jeanette Rapson

Baby's first chicken - recipe card

First chicken purée

CHICKEN PROVIDES AN EXCELLENT SOURCE OF IRON WHICH IS ESSENTIAL FOR A GROWING BABY!

You will need:

1 skinless chicken breast, diced

1 cup water

MAKES ABOUT 1 ½ CUPS

Tips:

- This chicken purée can be frozen into portions using an ice tray.
- You can also use oven baked or steamed chicken.
- Don't add salt, fat, sugar or sweeteners.
- See our food safety resource.

Method

1. Place chicken into a shallow pan and cover with the water.
2. Bring water to boil, then reduce to simmer and cover with a lid.
3. Cook until tender and no longer pink in the middle, then remove from heat.
4. Allow to cool, then blend the chicken with it's cooking water in a food processor or stick blender. You may need to add extra water or push through a sieve to create a smooth purée.

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Jeanette Rapson

Baby's first fish - recipe card

First fish purée

FISH PROVIDES AN EXCELLENT SOURCE OF IRON WHICH IS ESSENTIAL FOR A GROWING BABY!

You will need:

2 fillets of fish

1 cup water

MAKES ABOUT 1 ½ CUPS

Tips:

- This fish purée can be frozen into portions using an ice tray.
- You can also use oven baked or steamed fish.
- Don't add salt, fat, sugar or sweeteners.
- See our food safety resource.

Method

1. Remove all fish bones and scales.
2. Place fish into a shallow pan and cover with the water.
3. Bring water to boil, then reduce to simmer and cover with a lid.
4. Cook until opaque and not translucent, then remove from heat.
5. Allow to cool, then blend the fish with some of the cooking water in a food processor or stick blender. You may need to add extra water or push through a sieve to create a smooth purée.

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Example of specified consistency of study foods - video

Duration: 27 sec

Appendix E: Consent form

Participant Consent Form

I have read the Information Sheet and have had the details of the study explained to me.

My questions have been answered to my satisfaction, and I understand that I may ask further questions at any time.

I agree for my baby and I to participate in the study under the conditions set out in the Information Sheet.

○ Agree

Parent/Caregiver

First name

Last name

Baby

First name

Last name

Date of consent:

	Day	Month	Year
Please Select:			

Are you willing to be contacted regarding future research projects within the School of Sport Exercise and Nutrition? Your name and email address will be saved in a secure location. You will be sent periodic newsletters regarding research studies within the School. You can opt out of this newsletter at any time.

○ Yes

○ No

Note. Created by PhD candidate using Qualtrics Survey Software.

Appendix F: Information sheet

School of Sport, Exercise and Nutrition
Massey University, Albany
Gate 4, Building 80, Turitea Place
Albany, 0632
Auckland

Vegetables as first foods for babies study

INFORMATION SHEET

You are invited to take part in the *Vegetables as first foods for babies study* which is looking at the impact of a vegetables first approach to complementary feeding on infant food preferences.

The researchers are as follows:

Lead researcher

Supervisor

Supervisor

Jeanette Rapson
PhD candidate, registered dietitian
School of Sport, Exercise and Nutrition
0210773419
vegesfirst@massey.ac.nz

Dr Cath Conlon
Senior Lecturer
School of Sport, Exercise and Nutrition
09 414 0800 ext. 43658
C.Conlon@massey.ac.nz

Dr Pam von Hurst
Associate Professor
School of Sport, Exercise and Nutrition
09 414 0800 ext. 43657
P.R.vonHurst@massey.ac.nz

Whether or not you take part is your choice. If you do not want to take part, you do not have to give a reason. If you do want to take part now, but change your mind later, you can pull out of the study at any time.

This Participant Information Sheet will help you decide if you would like to take part. It sets out why we are doing the study, what your participation would involve, what the benefits and risks to you might be, and what would happen after the study ends. We will go through this information with you and answer any questions you may have. You do not have to decide today whether or not you will participate in this study.

Before you decide you may want to talk about the study with other people, such as family, whānau, friends, or healthcare providers. Feel free to do this.

If you agree to take part in this study, you will be asked to sign the Consent Form. You will be given a copy of both the Participant Information Sheet and the Consent Form to keep.

This document is seven pages long. Please make sure you have read and understood all the pages.

If you have any further question, concerns or complaints about the study at any stage, please do not hesitate to contact our lead researcher:

Jeanette Rapson
Lead researcher

Tel: 0210773419
email: vegesfirst@massey.ac.nz
Website: www.vegesfirststudy.com

What is the study about?

In New Zealand, complementary feeding is recommended to start at around 6 months. Suggested first foods include vegetables, fruits, meat, and commercial infant foods including baby rice.

Introducing vegetables early in life may help children like and eat more vegetables later. It is important that children eat plenty of different vegetables and fruits to provide the vitamins, minerals and dietary fibre needed for their growth and development.

Few studies have investigated different combinations of vegetables and fruits during complementary feeding, especially in New Zealand. The aim of this study is to compare two different feeding regimes which differ in the types of vegetables and fruits they provide. We will also examine the mother's diet during pregnancy and lactation as this may have some impact on the taste preference of their child.

Our results may better inform current infant feeding recommendations in New Zealand and worldwide.

Who can take part?

We are looking for 120 mothers and their baby to volunteer to participate in this study.

To take part in all parts of this study, your baby should be:

- 4-6 months of age
- healthy and born at term gestation (37+ weeks)
- with no known allergies
- with no chronic diseases or medical conditions that may affect abilities to participate in the study
- at a stage where they have not started eating solids
- living in the Auckland region

What will my participation involve?

Your participation involves visiting our Human and Nutrition Research Unit, giving a blood sample, having measurements taken for your baby (growth, heel prick blood sample and faecal) completing dietary and lifestyle questionnaires, and video-recording your infant trying foods for the first time.

If you decide to take part in this study after you have read and had time to consider this information sheet, you will be asked to complete a screening questionnaire to ensure that you meet the study's eligibility criteria. If eligible, you will be invited to take part in the study and asked to sign a consent form. You will then be sent a series of dietary and lifestyle questionnaires to complete at home.

Total time involved for this study is **10 hours over a period of 12 months.** This time is divided as follows:

Each visit takes about 1 hour (total of 4 hours). Questionnaires each take about 10-30 minutes to complete (total of 2.5 hours). It is not anticipated that infant feeding will take any longer than what is usual for you, however, additional time will be needed to complete infant feeding diaries and video recordings (5-10 minutes per day).

When your baby is 4 months old

A researcher will make an appointment with you and your baby to visit the Human Nutrition Research Unit at Massey University in Albany at a time that suits. We will provide reserved free parking, appropriate bathroom facilities and private spaces for feeding. This visit will take about **1 hour.**

During this visit, we will ask you to:

- Meet with a New Zealand registered dietitian to discuss any questions you may have about the study and infant feeding.
- Tell us more information about your diet and lifestyle.
- Have a small blood sample taken from yourself by a qualified phlebotomist (about 20 ml which is equivalent to 4 teaspoons) to measure your iron and vitamin D levels.
- Have a small blood sample taken from your baby by qualified phlebotomist using a 'heel prick' test to measure their iron and vitamin D levels (please see what does a heel prick involve?)
- Have your baby's length, weight and head circumference measured.
- Provide a small faecal sample from your baby to assess their faecal microbiota composition (please see what does a faecal sample involve?)
- Collect your infant feeding pack, which includes the foods, equipment and instructions needed during the 4-week trial.
- Discuss with a researcher about video recording your baby's feeding sessions using a device of your choice, e.g., mobile phone, video camera.

You and your baby will be randomly allocated one of two infant feeding regimes that differ by the types of vegetables and fruits they provide. You will not be told which feeding regime you have been assigned to; however, the feeding regimes include vegetables and fruits that are recommended for babies starting solids. All babies will receive approved age-appropriate foods that enable them to meet recommended dietary guidelines (please see 'what will the foods be like?').

During the 4-week trial

When your baby is ready to start solids (around 4-6 months of age), we will ask you to:

- Notify the researcher that you have started/ready to start complementary feeding.
- Feed the allocated foods to your baby for a period of 4-weeks alongside breast milk or infant formula. You will also be asked to please not provide any other foods or beverages except water and meat (please see what will the foods be like?)
- Video record the first time you feed the allocated foods to your baby, and then at least two additional feeding sessions during the 4-weeks.
- Complete a daily weighed food diary (please see what does a weighed food diary involve?)
- Each week you will be asked to compete an online 2-minute check-in questionnaire to see how you are going.

After the 4-week trial

You will no longer need to feed the allocated foods and can resume your normal family diet. A researcher will contact you to arrange a time to meet you and your baby at the research unit at Massey University Albany (home visits available on request). This visit will take about **30 minutes.**

During this visit, we will ask you to:

- Have a small blood sample taken from your baby by qualified phlebotomist using a 'heel prick' test to measure their iron levels.
- Have your baby's length, weight and head circumference measured.
- Provide a small faecal sample from your baby to assess their faecal microbiota composition.
- Provide your baby's infant feeding diary, videos and return any borrowed equipment.

When your baby is 9 months old

When your baby is 9 months of age, a researcher will contact you to arrange a time to meet you and your baby at the research unit at Massey University Albany (home visits available on request). This visit will take about **30 minutes.**

During this visit, we will ask you to:

- Have a small blood sample taken from your baby by qualified phlebotomist using a 'heel prick' test to measure their iron levels.
- Have your baby's length, weight and head circumference measured.
- Provide a small faecal sample from your baby to assess their faecal microbiota composition.
- Video record your baby trying a vegetable food that we will provide.
- Complete dietary questionnaires for your baby.

When your baby is 12 months old

When your baby is 12 months of age, a researcher will send you online questionnaires to complete then arrange a time to meet you and your baby at the research unit at Massey University Albany (home visits available on request). This visit will take about **30 minutes.**

During the visit, we will ask you to:

- Have your baby's length, weight and head circumference measured.
- Provide a small faecal sample from your baby to assess their faecal microbiota composition.

FAQ

What does the 'heel prick' test involve?

Iron is extremely important for infant brain development and growth. Iron deficiency can also cause taste disturbances, which may affect your baby's liking and intake of foods. It is vital that your baby has good iron status for the study outcomes and their health. Babies also need good levels of vitamin D for growth and development.

The common way to measure and assess iron and vitamin D status in babies is to do a 'heel prick' test. This involves making a pinprick puncture in one heel of your baby to collect a small blood sample. This is completed by a qualified phlebotomist and is then sent to a laboratory to be analysed.

You can ease any distress for your baby by cuddling and feeding them and making sure they are warm and comfortable. Your baby's foot will also be warmed by a sock prior to the heel prick test to minimise discomfort. There is a small risk of infection at the puncture site, however strict hygiene and safety procedures will be followed to minimise this risk.

What does a faecal sample involve?

The human microbiota consists of a wide variety of microorganisms such as bacteria, viruses and fungi. The common way to measure the composition of an infant's microbiota is to collect a small faecal (stool) sample and then analyse it in a laboratory. We will ask you to use a collection kit that we provide with easy to follow instructions.

What will the foods be like?

You will receive freeze-dried vegetables and fruit powders that are conveniently made into a smooth purée by adding water. These have been commercially prepared, packaged, and developed especially for this study by a food manufacturer. There are no preservatives, gluten, dairy or nuts added to these foods. They are easy to store and travel with. All foods meet recommended guidelines and safe for baby.

The types of vegetables include: spinach, beetroot, green bean, broccoli, pumpkin and potato. The types of fruits include: apple and pear.

Foods do not contain meat. However, meat is encouraged as an iron-rich food during the study. Support will be given on how to prepare and provide meat foods.

What does a weighed food diary involve?

It is important for us to understand how much of the foods your child eats and their liking of it. An easy way to do this is to weigh (in grams) the amount of leftover food using food kitchen scales, then record this in the diary. We will provide a set to use during the trial. Alternatively, you can freeze the leftover foods and we will collect this from you to complete the measurement.

In this diary, you will need to rate your baby's liking of the given food using a simple rating scale (1 = likes very much to 9 = dislikes very much), then describe anything that might have affected you baby's feeding that day. You will be given training and support on how to complete this.

What are the possible benefits and risks of this study?

Direct benefits of participating in this study include:

- Free infant nutrition and feeding support from a registered dietitian throughout the study period.
- Free nutritious infant foods during the 4-week trial.
- You will receive feedback on you and your baby's individual blood results, and your baby's growth measurements. You will be advised if any of the blood results are outside of a normal range and advised to seek advice from your general medical practitioner (GP). We will provide you with a copy of your results to give to your GP.
- An increased awareness and knowledge of the processes involved in research by actively participating in it, and a satisfaction in knowing that you are contributing to nutrition knowledge in the community.
- At the end of the study you will receive a DVD with memorable video clips of your child that were made during the research.
- You will receive a brief report summarising the main findings of the project via mail or email.

Foreseeable risks, adverse-effects and discomforts that you may encounter by taking part in this study are minimal but could include possible infection from the site in which blood is drawn and there may be some minor bruising at this site as well. Your baby may also feel some discomfort from the heel prick test. These discomforts will be managed by the presence of a qualified phlebotomist who will be available to assist you should you require it. While all foods provided by the study will be safe, age-appropriate and approved first foods for babies, it is possible that your baby may not like or tolerate the food. A record of all adverse events will be monitored and maintained throughout the course of the study.

Unless otherwise arrange, all follow-up visits will be conducted at your home with consent and if deemed safe for the researcher and participant. We will ask if you have any cultural issues or concerns around taking these measurements before they are taken. For example, if you are Māori and consider the head as tapu (sacred), we will ask for your permission before touching the infant's head.

Does it cost money to participate?

There is no monetary cost to you, the participant, for taking part in this study. You will be reimbursed for travelling costs with a $20 voucher following your first visit to the Massey University Human and Nutrition Research Unit (Albany). If you choose to visit our research unit for the follow-up visits, you will be given a $20 voucher following each visit.

What are my rights?

You are under no obligation to accept this invitation. If you decide to participate, you have the right to:

- decline to answer any particular question;
- withdraw from the study (specify timeframe);
- ask any questions about the study at any time during participation;
- provide information on the understanding that your name will not be used unless you give permission to the researcher;
- be given access to a summary of the project findings when it is concluded;
- ask for the recorder or video to be turned off at any time during the interviews or video recordings.

What if something goes wrong?

If physical injury results from your participation in this study, you should visit a treatment provider to make a claim to ACC as soon as possible. ACC cover and entitlements are not automatic and your claim will be assessed by ACC in accordance with the Accident Compensation Act 2001. If your claim is accepted, ACC must inform you of your entitlements, and must help you access those entitlements. Entitlements may include, but not be limited to, treatment costs, travel costs for rehabilitation, loss of earnings, and/or lump sum for permanent impairment. Compensation for mental trauma may also be included, but only if this is incurred as a result of physical injury.

If your ACC claim is not accepted you should immediately contact the researcher. The researcher will initiate processes to ensure you receive compensation equivalent to that to which you would have been entitled had ACC accepted your claim.

Data management

The data will be used only for the purposes of this project and no individual will be identified. Only the investigators and administrators of the study will have access to personal information and this will be kept secure and strictly confidential. Participants will be identified only by a study identification number.

Results of this project may be published or presented at conferences or seminars. No individual will be able to be identified.

At the end of this study the list of participants and their study identification number will be disposed of. Any raw data on which the results of the project depend will be retained in secure storage for 16 years, after which it will be destroyed.

Samples will be stored separately and only Dr Cath Conlon, Owen Mugridge and Jeanette Rapson will have access to these records. You will be given the option for samples donated by yourself or your child to be stored for use in future research studies.

What happens if I change my mind?

You are able to stop participating in the study at any time and will be compensated accordingly for your time. Further you are welcome to discuss any concerns you have with the research team at any time, and you have free access to your data. If you withdraw from the study all of the data that was related to you will be destroyed.

The foods and support from a dietitian will not be available to any participant after the study. The outcomes of this study may inform future recommendations enable further investigation in a long-term intervention study.

The study data will be stored at a secure location at Massey University Albany Campus. Electronic data and records will be the responsibility of the Principal investigator. All data will be kept for 10 years, at which point it will be destroyed using University Security methods for removal of confidential material. At the completion of the study all biological samples collected will be disposed of using established methods for discarding biological waste. Any participant can request to have their remaining blood sample returned to them.

You may hold beliefs about a sacred and shared value of all or any tissue samples removed. The cultural issues associated with storing your tissue should be discussed with your family/whānau as appropriate. There are a range of views held by Māori around these issues; some iwi disagrees with storage of samples citing whakapapa and advise their people to consult prior to participation in research where this occurs. However, it is acknowledged that individuals have the right to choose.

We anticipate that the results of this study will be published in a peer-reviewed journal within 12 months of completing the study. Participants are welcome to discuss the findings of this study with the researchers at any time.

Who do I contact for more information or if I have concerns?

If you have any questions, concerns or complaints about the study at any stage, you can contact researchers in the study.

You can contact the following researchers:

> Jeanette Rapson, Dr Cath Conlon or Associate Professor Pam von Hurst. Contact details are at the beginning of this information sheet.

Committee Approval Statement

This project has been reviewed and approved by the Massey University Human Ethics Committee: Southern A, *Application SOA 18/56. If you have any concerns about the conduct of this research, please contact Dr Lesley Batten, Chair, Massey University Human Ethics Committee: Southern A, telephone + 64 6 356 9099 x 85094, email humanethicsoutha@massey.ac.nz .*

Appendix G: Covid-19 response and communication

Rapson, Jeanette

From: Rapson, Jeanette
Sent: Thursday, 26 March 2020 8:37 AM
Subject: Veges First Study - Update

Dear mums and families,

Firstly, thank you so much for all your ongoing support for the Veges First Study. Our community of families in the study have been amazing and we want to reach out to you at this time to tell you about how we are going keep the study going and make sure we keep you all safe as well.

Changes to the study:

1. There will be no face-to- face visits. This means that we will not be taking any blood samples at this stage. However, a phone call or virtual skype/zoom catch up is available if you have any questions about the study or feeding your baby.
2. Where possible, we will ask you to please send us your baby's growth measurements. This will be at the end of the 4 week trial, at 9 months and 12 months of age – but we will email you when the time comes. This can be done with a tape measure and scale, however, if you don't have these, don't worry! We understand that we may not be able to get these measurements.

What stays the same?

1. Please still complete the **online questionnaires.**
2. Please still **provide the baby foods** (whether it is your 4 week trial or 9 month time point), complete the **food diaries** and **video** the meals.
3. If you are comfortable, please still **collect the stool samples** for now and store these in your freezer until things go back to normal. However, this is completely optional and we totally understand if you prefer not to.

At this point, we can't tell for how long we will have to work remotely but rest assured we will do anything we can to help you continue to enjoy your experience on our study. This is a measure we need to take to protect our health but also minimise the risk of further spreading the virus.

Thank you!

We understand that this is a very anxious time and we do not want you to feel any extra pressure or stress from the study. Rather, we would like to support you where we can. We want to send a huge thank you again for all your support so far and for your ongoing participation. We could not do this without you. If you have any questions or concerns, please contact me.

Warm regards,

Jeanette Rapson
NZ Registered Dietitian and Lead Researcher

Mobile: 021 0773419 | www.vegesfirststudy.co.nz

Dear [insert mother's name]

As we cannot see you in clinic, if possible, we would love your help by sending us some baby measurements. However, we understand that this is a stressful time, so please don't worry if you prefer not to. Please let me know.

If you are able, we need the following:

1. Baby weight (kg)
2. Head circumference (cm)
3. Length (cm)

Instructions on how to measure baby:

Baby weight (kg)

Step 1: Weigh yourself (you do not need to give us this measurement)

Step 2: Weigh yourself holding your naked baby.

Step 3: Subtract your single weight from your combined weight. The result is your baby's weight.
For example: if you alone weigh 70kg and the weight of you and your baby combined is 79kg, then your baby's weight is 9 kg on their own. Please send us this weight.

Head circumference (cm)

- Use a flexible tape measure.
- Wrap the tape snugly around the widest possible circumference - from the most prominent part of the forehead (often 1-2 fingers above the eyebrow) around to the widest part of the back of the head.
- **Try to find the widest way around the head.**
- Remeasure 2 times, if possible.

Baby length (cm)

Lay your baby down and stretch a measuring tape from the top of the head to the bottom of the heel. It's easiest if you have someone help because you'll need to gently stretch your baby's leg straight to do this. This can be tricky so please don't worry if you feel that it's a ballpark figure. Please just do your best!

Thanks again for all your help. Please let me know if I can clarify anything – I am more than happy to give you a call or Zoom.

Kind regards,

Jeanette Rapson
NZ Registered Dietitian and Lead Researcher

Mobile: 021 0773419 | www.vegesfirststudy.co.nz

Appendix H: Weighed food diaries

The weighed food diaries collected data specific to the study outcomes, including infants' intake and liking of the study foods/target foods, meat consumption and milk feeding. The diaries completed in week one and four of the four-week intervention were identical except for minor changes in words (e.g., 'first 4 days' vs 'last 4 day', different coloured foods as relevant to group assignment, additional meat questions). All pages from the diary for week four has been included first because it contained the additional meat questions. Following this, only pages from week one that differed notably from week four are provided; these pages also capture how the food diary given to the control group differed from that of the vege-only group. The 9-month weighed food diary is then included (both treatment groups received this diary). These were A4 in size and ring bound. All diaries and content (including images and illustrations) were created by the PhD candidate. Permission to use photographs of infant was provided by the mother.

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Week four weighed food diary (veg-only group)

Weighed food diary: Last 4 days (week 4)

To be completed by baby's mother **during the last 4 days** (in a row) of **week 4.**

Participant number: | | | |

Start date of this diary in week 4: | | | |

Instructions

1. **Weigh** and record ***all*** the foods your baby eats:
   - ✓ **Last FOUR** days in a row in week 4 of the trial.
2. **Rate** how much you think your baby liked the food.
3. **Describe** your baby's feeding day.

As soon as you've completed this food diary, please **contact us.**

Jeanette Rapson
j.rapson@massey.ac.nz
021 077 3419

Participant number:

Important!

During your **4-week trial**, please only feed your baby:

- ✓ Breastmilk or formula
- ✓ Baby food we provide
- ✓ Meat or fish (especially if 6 months old as this is a good source of iron)

These are very important conditions for helping our study be the best that it can be.

BUT…we understand that some days don't always go to plan. You may forget or be unable to feed our baby food for various reasons.

If this happens while you are completing this diary, don't worry. **Please still weigh and report everything that your baby had to eat or drink.**

If it happens at any other stage during the 4-week trial, simply report this in our weekly email check-ins.

We really appreciate your time and effort.

We are here to help any time!

Participant number:

The last four days…

Please offer your baby the foods in the following order for the last four days of the trial.

This is very important for the purpose of our study.

Day 1 — Green A

↓

Day 2 — White A

↓

Day 3 — Purple A

↓

Day 4 — Kākāriki

Remember to video record **each colour** **<u>once</u> in week 4.**

Participant number:

Offering meat?

Babies need a lot of iron because they are growing so rapidly, especially if they are 6 months old.

Beef, chicken and fish are good sources of iron and are suitable first foods.

If your baby is 6 months old, we encourage you to please offer your baby plain meat puree AFTER the first four days of the trial **using the recipes provided for this study on the website.**

Please offer meat at a <u>different</u> time of day to the baby food we provide. This is for the purpose of the study.

Steps to find online resources:

1. Visit the website www.vegesfirststudy.co.nz
2. Click the resources tab
3. Enter the **password**: vegesfirst

Participant number:

Steps per feeding session:

1. **PREPARE** baby food
2. **WEIGH & RECORD** baby food
3. **FEED** baby food
4. **WEIGH & RECORD** baby food

1

Empty all of the food from the pouch into a microwave safe bowl

Add water to desired consistency and stir. Use recipe cards.

Heat baby food in the microwave on HIGH for 20 seconds, stir to remove hot spots, then repeat twice more. **Allow to cool for 10 minutes.**

2

Weigh the bowl with food (**BEFORE** feeding)

3

Offer baby the food and complete the behaviour form. Test the food temperature on the inside of your wrist, it <u>should not be hot.</u>

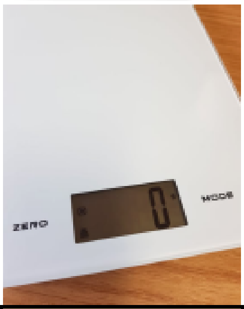
4

Weigh and record food (**AFTER** feeding). Discard leftover food.

Participant number:

Instructions for using food scales

Weigh <u>leftover baby foods</u> in gram (g) amounts using digital scales.



Step 1: Turn on the scales

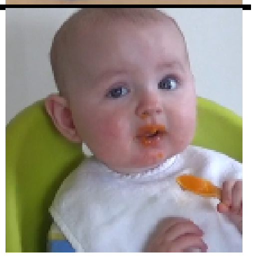
- Firstly, set scales up on a flat surface such as kitchen bench.
- Push the ON/ZERO key.
- Ensure the display screen then appears with “0g”.
- If the unit is in “oz”, change to “g” by pressing the UNIT button.

Step 2: Weigh the bowl with puree (**BEFORE** eating)

- Add puree sachet and water to the bowl.
- Place the bowl with mixed puree on the scales.
- Record the weight in the *“Amount (before eating) column”.*

Step 4: Weigh the leftover food (**AFTER** eating)

- Scoop up as much spilt food as possible and place it back in the bowl.
- Place the bowl with left over puree on the scales.
- Record the weight in the *“Weight of food leftover column”.*



Step 5: Estimate the leftovers unable to be weighed and record this in the *“Estimation of food spilt (e.g. on floor, infant or bib)”*

- For any foods that may have been spilt on the floor, or on the infant that you could not scoop back into the bowl, estimate as accurately as possible amounts and record in *“spilt leftovers column” (e.g. 2 tsp Green A)*

Participant number:

Video recording baby's first tastes

We would like you to please video record you baby trying **each food colour**. You can use a video camera, mobile phone or smart device of your choice. We will send you a link to upload your videos.

Please show a clear view of your baby's face and arms. We also need to be able to see the bowl and spoon.

Camera zoom

This picture is a good example:

- Medium zoom - not too close, not too far away
- We can see the spoon approaching
- Clear view of baby's face and arms
- Camera is opposite to mum's feeding hand (see next page)

Participant number:

Camera setup

The camera should be set up like this:

Please position the camera to the opposite side of your feeding hand.

For example, if you are holding the spoon with your **right hand**, then place the camera to your left (see picture). This stops your hand from blocking the camera view of your baby's face. If left handed, then place the camera to the right.

Use the tripod cup provided (for mobile phones) or your own tripod/stand. Alternatively, your partner or whanau could video record you feeding your baby.

Participant number:

EXAMPLE: How to record infant foods

Date: 22/11/18

1. Weigh and **record** all the food your baby eats today.

Please feed your baby according to **times and amounts** that **suit you and your baby**. Each baby is different and some will eat more than others. The below is only an example.

Start time	Food name	Amount (**before** eating)	Leftovers (after eating)		**Heated then cooled** before serving	End time
			Weight of food **left over**	Estimation of **food spilt** (e.g. on floor or bib)		
10:00am	Green A	99g	85g	1 tablespoon	✓	10:12am
6:00pm	Beef	50g	33g	1 teaspoon	✓	6:10pm

Please also record any **meat** eaten.
Serve at a different time to our food.

2. What else did your baby have today? *Please **tick** all that apply.*

Milk today:
- ☑ Breastmilk
- ☐ Infant formula

Supplements:
- ☐ Iron
- ☑ Vitadol C
- ☐ Probiotics
- ☐ None
- ☐ Other: ………………………………

Medications:
- ☐ Antibiotics
- ☑ None
- ☐ Other: ……………………

Participant number:

EXAMPLE *(continued)*

3. How many milk feeds today?

Please count all feeds for **today's calendar day**. For example, feeds at 2am, 7am, 11am, 2pm, 4pm and 11:30pm would be 6 feeds.

Breastmilk: __6__

Infant formula: ____

4. Which of the following applies to your baby **today**? *Please **tick** all that apply.*

- [x] My baby was unwell
- [ ] My baby was feeling upset, grizzly or tired
- [ ] Teething
- [ ] Baby fussiness
- [ ] My baby was distracted (e.g. by noise, people or television)
- [ ] My baby wasn't hungry
- [x] Feeding away from home
- [ ] Not sure
- [ ] None of the above

5. Is there anything else that you would like to tell us about feeding baby today? *If **yes**, please explain.*

She seemed less interested in food today and just wanted her milk feeds.

Participant number:

A few things to remember while feeding…

Regular mealtime

Ideally, **all the study feeding occasions** should be more or less **the same time of day.** Choose a time when your baby is usually hungry but not starving. They should not have been fed solid food during the past hour and a half. You can offer sips of water after the meal or at least 30 minutes before feeding.

Quiet environment, without distraction

- We want your baby to focus on what he/she is eating.
- Choose a quiet time, **without being disturbed** – if possible – by others (e.g. siblings, pets), without **TV or music**, with **toys out of sight.** If your baby is used to having a specific object, and without it, he/she will not eat, you can leave the object.

Your position while feeding

- **Sit facing your child**, with you face at about the same height as his/hers so that you can respond to their requests.
- Keep the behaviour form in front of you to avoid turning your head too much while recording behaviours.

Amount served per spoonful

- An overfilled spoon may be the cause your baby to reject the food.
- Fill the spoon with a **moderate amount.**

Let your baby "lead"

- Baby is **free to interact with you and the spoon.**
- **Follow his/her movements and cues** – this allows baby to "decide" the pace of eating.
- **Keep minimum of control of the spoon.** Once the spoon is accepted or rejected, regain full control of the spoon to refill it with the food.
- **Wait until your baby has finished the bite of food** in his/her mouth before offering the food again.
- For each spoon accepted (even partially) or not, **always put the spoon back in the bowl**, then make sure your baby is ready again before offering a new one.
- If the spoon is offered at an inappropriate time (mouth still full, baby not ready), they may reject the spoon. **Take your time observing their reactions.**

Participant number:

Let's get started!

Please remember to follow these **steps in order:**

1. Make the food
2. Weigh food BEFORE feeding
3. Complete the behaviour form WHILE feeding
4. Weigh food AFTER feeding

Day 1 – Green A

Please start with Green A today. You can serve as many meals as you like, as long as they are all Green!

Date: ______________

1. Weigh and **record** all the food your baby eats today.

Start time	Food name	Amount (**before** eating)	Leftovers (after eating)		**Heated then cooled** before serving	End time
			Weight of food **left over**	Estimation of **food spilt** (e.g. on floor or bib)		
	Green A					

2. What else did your baby have today? *Please **tick** all that apply.*

Milk today:
- ☐ Breastmilk
- ☐ Infant formula

Supplements:
- ☐ Iron
- ☐ Vitadol C
- ☐ Probiotics
- ☐ None
- ☐ Other: ………………………………

Medications:
- ☐ Antibiotics
- ☐ None
- ☐ Other: ………………………

Behaviour form: first 3 spoons

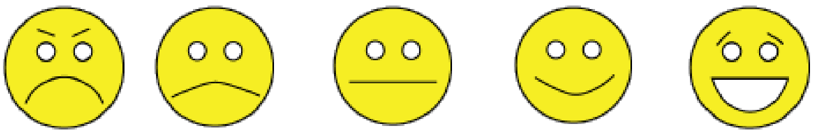
If they **refuse** the spoon 3 times in a row, please stop feeding.

Please complete this **WHILE feeding** Green A.

For **each spoon,** which behaviours did your baby show? *Tick all that apply*

	When the spoon is approaching		When the food is in the mouth		Refused
Spoon number	**Positive**	**Negative**	**Positive**	**Negative**	
1	☐ Opened mouth ☐ Leaned forward ☐ Reached out for food ☐ Looked interested ☐ Took spoon to feed self	☐ Closed mouth ☐ Turned head away ☐ Looked away ☐ Arched back/pulled body away ☐ Pushed spoon away	☐ Smiled ☐ Happy sound, e.g. giggles, Mmm, oohs ☐ Excited, e.g. waves arms, kicks legs ☐ Swallowed food ☐ Licked lips	☐ Frowned/nose wrinkled ☐ Shivered/stiffened ☐ Spat food out ☐ Cried/fussed ☐ Pushed spoon away	☐
2	☐ Opened mouth ☐ Leaned forward ☐ Reached out for food ☐ Looked interested ☐ Took spoon to feed self	☐ Closed mouth ☐ Turned head away ☐ Looked away ☐ Arched back/pulled body away ☐ Pushed spoon away	☐ Smiled ☐ Happy sound, e.g. giggles, Mmm, oohs ☐ Excited, e.g. waves arms, kicks legs ☐ Swallowed food ☐ Licked lips	☐ Frowned/nose wrinkled ☐ Shivered/stiffened ☐ Spat food out ☐ Cried/fussed ☐ Pushed spoon away	☐
3	☐ Opened mouth ☐ Leaned forward ☐ Reached out for food ☐ Looked interested ☐ Took spoon to feed self	☐ Closed mouth ☐ Turned head away ☐ Looked away ☐ Arched back/pulled body away ☐ Pushed spoon away	☐ Smiled ☐ Happy sound, e.g. giggles, Mmm, oohs ☐ Excited, e.g. waves arms, kicks legs ☐ Swallowed food ☐ Licked lips	☐ Frowned/nose wrinkled ☐ Shivered/stiffened ☐ Spat food out ☐ Cried/fussed ☐ Pushed spoon away	☐

Please **rate** how much baby likes Green A? *Please tick one*



Dislikes very much	Dislikes	Neither like nor dislike	Likes	Likes very much
☐	☐	☐	☐	☐

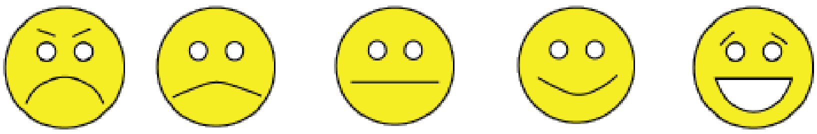
…next 3 spoons

If they **refuse** the spoon 3 times in a row, please stop feeding.

For **each spoon,** which behaviours did your baby show? *Tick all that apply*

	When the spoon is approaching		**When the food is in the mouth**		**Refused**
Spoon number	**Positive**	**Negative**	**Positive**	**Negative**	
4	☐ Opened mouth ☐ Leaned forward ☐ Reached out for food ☐ Looked interested ☐ Took spoon to feed self	☐ Closed mouth ☐ Turned head away ☐ Looked away ☐ Arched back/pulled body away ☐ Pushed spoon away	☐ Smiled ☐ Happy sound, e.g. giggles, Mmm, oohs ☐ Excited, e.g. waves arms, kicks legs ☐ Swallowed food ☐ Licked lips	☐ Frowned/nose wrinkled ☐ Shivered/stiffened ☐ Spat food out ☐ Cried/fussed ☐ Pushed spoon away	☐
5	☐ Opened mouth ☐ Leaned forward ☐ Reached out for food ☐ Looked interested ☐ Took spoon to feed self	☐ Closed mouth ☐ Turned head away ☐ Looked away ☐ Arched back/pulled body away ☐ Pushed spoon away	☐ Smiled ☐ Happy sound, e.g. giggles, Mmm, oohs ☐ Excited, e.g. waves arms, kicks legs ☐ Swallowed food ☐ Licked lips	☐ Frowned/nose wrinkled ☐ Shivered/stiffened ☐ Spat food out ☐ Cried/fussed ☐ Pushed spoon away	☐
6	☐ Opened mouth ☐ Leaned forward ☐ Reached out for food ☐ Looked interested ☐ Took spoon to feed self	☐ Closed mouth ☐ Turned head away ☐ Looked away ☐ Arched back/pulled body away ☐ Pushed spoon away	☐ Smiled ☐ Happy sound, e.g. giggles, Mmm, oohs ☐ Excited, e.g. waves arms, kicks legs ☐ Swallowed food ☐ Licked lips	☐ Frowned/nose wrinkled ☐ Shivered/stiffened ☐ Spat food out ☐ Cried/fussed ☐ Pushed spoon away	☐

Please **rate** how much baby likes **Green A**? *Please tick one*



Dislikes very much	Dislikes	Neither like nor dislike	Likes	Likes very much
☐	☐	☐	☐	☐

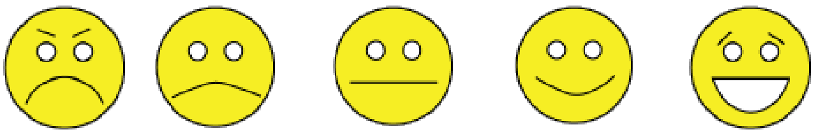
If they **refuse** the spoon 3 times in a row, please stop feeding.

…next 3 spoons

For **each spoon,** which behaviours did your baby show? *Tick all that apply*

	When the spoon is approaching		When the food is in the mouth		Refused
Spoon number	Positive	Negative	Positive	Negative	
7	☐ Opened mouth ☐ Leaned forward ☐ Reached out for food ☐ Looked interested ☐ Took spoon to feed self	☐ Closed mouth ☐ Turned head away ☐ Looked away ☐ Arched back/pulled body away ☐ Pushed spoon away	☐ Smiled ☐ Happy sound, e.g. giggles, Mmm, oohs ☐ Excited, e.g. waves arms, kicks legs ☐ Swallowed food ☐ Licked lips	☐ Frowned/nose wrinkled ☐ Shivered/stiffened ☐ Spat food out ☐ Cried/fussed ☐ Pushed spoon away	☐
8	☐ Opened mouth ☐ Leaned forward ☐ Reached out for food ☐ Looked interested ☐ Took spoon to feed self	☐ Closed mouth ☐ Turned head away ☐ Looked away ☐ Arched back/pulled body away ☐ Pushed spoon away	☐ Smiled ☐ Happy sound, e.g. giggles, Mmm, oohs ☐ Excited, e.g. waves arms, kicks legs ☐ Swallowed food ☐ Licked lips	☐ Frowned/nose wrinkled ☐ Shivered/stiffened ☐ Spat food out ☐ Cried/fussed ☐ Pushed spoon away	☐
9	☐ Opened mouth ☐ Leaned forward ☐ Reached out for food ☐ Looked interested ☐ Took spoon to feed self	☐ Closed mouth ☐ Turned head away ☐ Looked away ☐ Arched back/pulled body away ☐ Pushed spoon away	☐ Smiled ☐ Happy sound, e.g. giggles, Mmm, oohs ☐ Excited, e.g. waves arms, kicks legs ☐ Swallowed food ☐ Licked lips	☐ Frowned/nose wrinkled ☐ Shivered/stiffened ☐ Spat food out ☐ Cried/fussed ☐ Pushed spoon away	☐

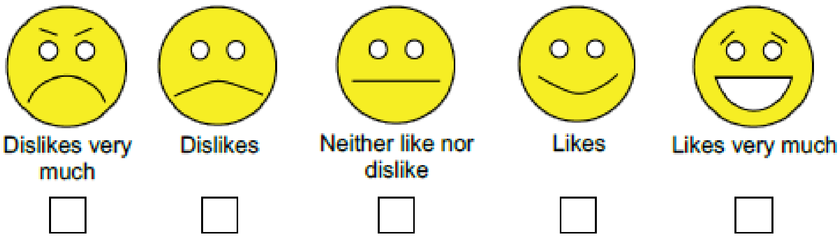
Please **rate** how much baby likes **Green A**? *Please tick one*



Dislikes very much	Dislikes	Neither like nor dislike	Likes	Likes very much
☐	☐	☐	☐	☐

How much did your baby like Green A?

Please rate **at the END of the meal**.



Please don’t forget to record how much your baby ate in the weighed food table.

Day 1 – questions

1. How many milk feeds today?

Please count all feeds for **today's calendar day**. For example, feeds at 2am, 7am, 11am, 2pm, 4pm and 11:30pm would be 6 feeds.

Breastmilk: ____

Infant formula: ____

2. Which of the following applies to your baby **today**? *Please **tick** all that apply.*

- ☐ My baby was unwell
- ☐ My baby was feeling upset, grizzly or tired
- ☐ Teething
- ☐ Baby fussiness
- ☐ My baby was distracted (e.g. by noise, people or television)
- ☐ My baby wasn't hungry
- ☐ Feeding away from home
- ☐ Not sure
- ☐ None of the above

3. Is there anything else that you would like to tell us about feeding baby today? *If **yes**, please explain.*

Day 2 – White A

Date: ______________

Please provide White A today. You can serve as many meals as you like, as long as they are all White!

1. Weigh and **record** all the food your baby eats today.

Start time	Food name	Amount (**before** eating)	Leftovers (after eating)		**Heated then cooled** before serving	End time
			Weight of food **left over**	Estimation of **food spilt** (e.g. on floor or bib)		
	White A					

2. What else did your baby have today? *Please **tick** all that apply.*

Milk today:
- ☐ Breastmilk
- ☐ Infant formula

Supplements:
- ☐ Iron
- ☐ Vitadol C
- ☐ Probiotics
- ☐ None
- ☐ Other: ....

Medications:
- ☐ Antibiotics
- ☐ None
- ☐ Other: ....

If they **refuse** the spoon 3 times in a row, please stop feeding.

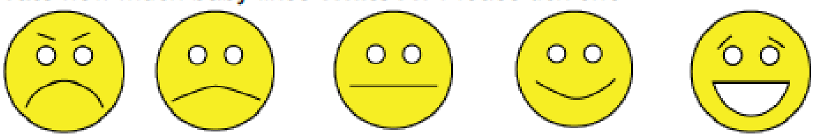
Behaviour form: first 3 spoons

Please complete this **WHILE feeding White A.**

For **each spoon,** which behaviours did your baby show? *Tick all that apply*

	When the spoon is approaching		**When the food is in the mouth**		**Refused**
Spoon number	**Positive**	**Negative**	**Positive**	**Negative**	
1	☐ Opened mouth ☐ Leaned forward ☐ Reached out for food ☐ Looked interested ☐ Took spoon to feed self	☐ Closed mouth ☐ Turned head away ☐ Looked away ☐ Arched back/pulled body away ☐ Pushed spoon away	☐ Smiled ☐ Happy sound, e.g. giggles, Mmm, oohs ☐ Excited, e.g. waves arms, kicks legs ☐ Swallowed food ☐ Licked lips	☐ Frowned/nose wrinkled ☐ Shivered/stiffened ☐ Spat food out ☐ Cried/fussed ☐ Pushed spoon away	☐
2	☐ Opened mouth ☐ Leaned forward ☐ Reached out for food ☐ Looked interested ☐ Took spoon to feed self	☐ Closed mouth ☐ Turned head away ☐ Looked away ☐ Arched back/pulled body away ☐ Pushed spoon away	☐ Smiled ☐ Happy sound, e.g. giggles, Mmm, oohs ☐ Excited, e.g. waves arms, kicks legs ☐ Swallowed food ☐ Licked lips	☐ Frowned/nose wrinkled ☐ Shivered/stiffened ☐ Spat food out ☐ Cried/fussed ☐ Pushed spoon away	☐
3	☐ Opened mouth ☐ Leaned forward ☐ Reached out for food ☐ Looked interested ☐ Took spoon to feed self	☐ Closed mouth ☐ Turned head away ☐ Looked away ☐ Arched back/pulled body away ☐ Pushed spoon away	☐ Smiled ☐ Happy sound, e.g. giggles, Mmm, oohs ☐ Excited, e.g. waves arms, kicks legs ☐ Swallowed food ☐ Licked lips	☐ Frowned/nose wrinkled ☐ Shivered/stiffened ☐ Spat food out ☐ Cried/fussed ☐ Pushed spoon away	☐

Please **rate** how much baby likes **White A**? *Please tick one*



Dislikes very much	Dislikes	Neither like nor dislike	Likes	Likes very much
☐	☐	☐	☐	☐

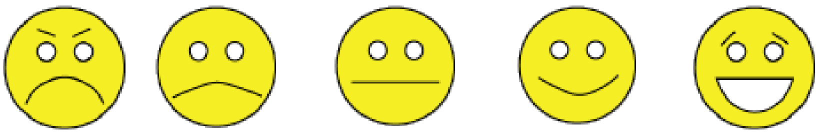
If they **refuse** the spoon 3 times in a row, please stop feeding.

…next 3 spoons

For **each spoon,** which behaviours did your baby show? *Tick all that apply*

	When the spoon is approaching		When the food is in the mouth		Refused
Spoon number	Positive	Negative	Positive	Negative	
4	☐ Opened mouth ☐ Leaned forward ☐ Reached out for food ☐ Looked interested ☐ Took spoon to feed self	☐ Closed mouth ☐ Turned head away ☐ Looked away ☐ Arched back/pulled body away ☐ Pushed spoon away	☐ Smiled ☐ Happy sound, e.g. giggles, Mmm, oohs ☐ Excited, e.g. waves arms, kicks legs ☐ Swallowed food ☐ Licked lips	☐ Frowned/nose wrinkled ☐ Shivered/stiffened ☐ Spat food out ☐ Cried/fussed ☐ Pushed spoon away	☐
5	☐ Opened mouth ☐ Leaned forward ☐ Reached out for food ☐ Looked interested ☐ Took spoon to feed self	☐ Closed mouth ☐ Turned head away ☐ Looked away ☐ Arched back/pulled body away ☐ Pushed spoon away	☐ Smiled ☐ Happy sound, e.g. giggles, Mmm, oohs ☐ Excited, e.g. waves arms, kicks legs ☐ Swallowed food ☐ Licked lips	☐ Frowned/nose wrinkled ☐ Shivered/stiffened ☐ Spat food out ☐ Cried/fussed ☐ Pushed spoon away	☐
6	☐ Opened mouth ☐ Leaned forward ☐ Reached out for food ☐ Looked interested ☐ Took spoon to feed self	☐ Closed mouth ☐ Turned head away ☐ Looked away ☐ Arched back/pulled body away ☐ Pushed spoon away	☐ Smiled ☐ Happy sound, e.g. giggles, Mmm, oohs ☐ Excited, e.g. waves arms, kicks legs ☐ Swallowed food ☐ Licked lips	☐ Frowned/nose wrinkled ☐ Shivered/stiffened ☐ Spat food out ☐ Cried/fussed ☐ Pushed spoon away	☐

Please **rate** how much baby likes **White A**? *Please tick one*



Dislikes very much	Dislikes	Neither like nor dislike	Likes	Likes very much
☐	☐	☐	☐	☐

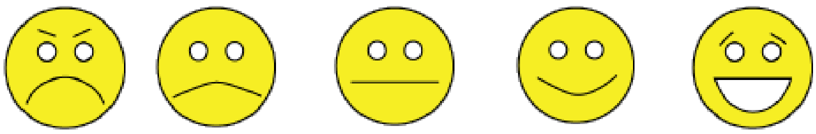
…next 3 spoons

If they **refuse** the spoon 3 times in a row, please stop feeding.

For **each spoon,** which behaviours did your baby show? *Tick all that apply*

Spoon number	When the spoon is approaching		When the food is in the mouth		Refused
	Positive	**Negative**	**Positive**	**Negative**	
7	☐ Opened mouth ☐ Leaned forward ☐ Reached out for food ☐ Looked interested ☐ Took spoon to feed self	☐ Closed mouth ☐ Turned head away ☐ Looked away ☐ Arched back/pulled body away ☐ Pushed spoon away	☐ Smiled ☐ Happy sound, e.g. giggles, Mmm, oohs ☐ Excited, e.g. waves arms, kicks legs ☐ Swallowed food ☐ Licked lips	☐ Frowned/nose wrinkled ☐ Shivered/stiffened ☐ Spat food out ☐ Cried/fussed ☐ Pushed spoon away	☐
8	☐ Opened mouth ☐ Leaned forward ☐ Reached out for food ☐ Looked interested ☐ Took spoon to feed self	☐ Closed mouth ☐ Turned head away ☐ Looked away ☐ Arched back/pulled body away ☐ Pushed spoon away	☐ Smiled ☐ Happy sound, e.g. giggles, Mmm, oohs ☐ Excited, e.g. waves arms, kicks legs ☐ Swallowed food ☐ Licked lips	☐ Frowned/nose wrinkled ☐ Shivered/stiffened ☐ Spat food out ☐ Cried/fussed ☐ Pushed spoon away	☐
9	☐ Opened mouth ☐ Leaned forward ☐ Reached out for food ☐ Looked interested ☐ Took spoon to feed self	☐ Closed mouth ☐ Turned head away ☐ Looked away ☐ Arched back/pulled body away ☐ Pushed spoon away	☐ Smiled ☐ Happy sound, e.g. giggles, Mmm, oohs ☐ Excited, e.g. waves arms, kicks legs ☐ Swallowed food ☐ Licked lips	☐ Frowned/nose wrinkled ☐ Shivered/stiffened ☐ Spat food out ☐ Cried/fussed ☐ Pushed spoon away	☐

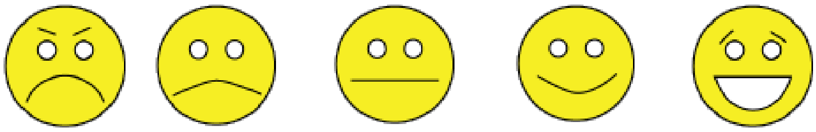
Please **rate** how much baby likes **White A**? *Please tick one*



Dislikes very much	Dislikes	Neither like nor dislike	Likes	Likes very much
☐	☐	☐	☐	☐

How much did your baby like White A?

Please rate **at the END of the meal.**



Dislikes very much	Dislikes	Neither like nor dislike	Likes	Likes very much
☐	☐	☐	☐	☐

Please don’t forget to record how much your baby ate in the weighed food table.

Day 2 - questions

1. How many milk feeds today?

Please count all feeds for **today's calendar day**. For example, feeds at 2am, 7am, 11am, 2pm, 4pm and 11:30pm would be 6 feeds.

Breastmilk: ____

Infant formula: ____

2. Which of the following applies to your baby **today**? *Please* ***tick*** *all that apply.*

☐ My baby was unwell
☐ My baby was feeling upset, grizzly or tired
☐ Teething
☐ Baby fussiness
☐ My baby was distracted (e.g. by noise, people or television)
☐ My baby wasn't hungry
☐ Feeding away from home
☐ Not sure
☐ None of the above

3. Is there anything else that you would like to tell us about feeding baby today? *If* ***yes****, please explain.*

Day 3 – Purple A

Please provide Purple A today. You can serve as many meals as you like, as long as they are all Purple!

Date: ______________

1. Weigh and **record** all the food your baby eats today.

Start time	Food name	Amount (**before** eating)	Leftovers (after eating)		**Heated then cooled** before serving	End time
			Weight of food **left over**	Estimation of **food spilt** (e.g. on floor or bib)		
	Purple A					

2. What else did your baby have today? *Please **tick** all that apply.*

Milk today:
- ☐ Breastmilk
- ☐ Infant formula

Supplements:
- ☐ Iron
- ☐ Vitadol C
- ☐ Probiotics
- ☐ None
- ☐ Other: ………………………………

Medications:
- ☐ Antibiotics
- ☐ None
- ☐ Other: ………………………

Behaviour form: first 3 spoons

If they **refuse** the spoon 3 times in a row, please stop feeding.

Please complete this **WHILE feeding** **Purple A.**

For **each spoon,** which behaviours did your baby show? *Tick all that apply*

	When the spoon is approaching		When the food is in the mouth		Refused
Spoon number	**Positive**	**Negative**	**Positive**	**Negative**	
1	☐ Opened mouth ☐ Leaned forward ☐ Reached out for food ☐ Looked interested ☐ Took spoon to feed self	☐ Closed mouth ☐ Turned head away ☐ Looked away ☐ Arched back/pulled body away ☐ Pushed spoon away	☐ Smiled ☐ Happy sound, e.g. giggles, Mmm, oohs ☐ Excited, e.g. waves arms, kicks legs ☐ Swallowed food ☐ Licked lips	☐ Frowned/nose wrinkled ☐ Shivered/stiffened ☐ Spat food out ☐ Cried/fussed ☐ Pushed spoon away	☐
2	☐ Opened mouth ☐ Leaned forward ☐ Reached out for food ☐ Looked interested ☐ Took spoon to feed self	☐ Closed mouth ☐ Turned head away ☐ Looked away ☐ Arched back/pulled body away ☐ Pushed spoon away	☐ Smiled ☐ Happy sound, e.g. giggles, Mmm, oohs ☐ Excited, e.g. waves arms, kicks legs ☐ Swallowed food ☐ Licked lips	☐ Frowned/nose wrinkled ☐ Shivered/stiffened ☐ Spat food out ☐ Cried/fussed ☐ Pushed spoon away	☐
3	☐ Opened mouth ☐ Leaned forward ☐ Reached out for food ☐ Looked interested ☐ Took spoon to feed self	☐ Closed mouth ☐ Turned head away ☐ Looked away ☐ Arched back/pulled body away ☐ Pushed spoon away	☐ Smiled ☐ Happy sound, e.g. giggles, Mmm, oohs ☐ Excited, e.g. waves arms, kicks legs ☐ Swallowed food ☐ Licked lips	☐ Frowned/nose wrinkled ☐ Shivered/stiffened ☐ Spat food out ☐ Cried/fussed ☐ Pushed spoon away	☐

Please **rate** how much baby likes **Purple A**? *Please tick one*

Dislikes very much	Dislikes	Neither like nor dislike	Likes	Likes very much
☐	☐	☐	☐	☐

…next 3 spoons

If they **refuse** the spoon 3 times in a row, please stop feeding.

For **each spoon,** which behaviours did your baby show? *Tick all that apply*

	When the spoon is approaching		When the food is in the mouth		Refused
Spoon number	Positive	Negative	Positive	Negative	
4	☐ Opened mouth ☐ Leaned forward ☐ Reached out for food ☐ Looked interested ☐ Took spoon to feed self	☐ Closed mouth ☐ Turned head away ☐ Looked away ☐ Arched back/pulled body away ☐ Pushed spoon away	☐ Smiled ☐ Happy sound, e.g. giggles, Mmm, oohs ☐ Excited, e.g. waves arms, kicks legs ☐ Swallowed food ☐ Licked lips	☐ Frowned/nose wrinkled ☐ Shivered/stiffened ☐ Spat food out ☐ Cried/fussed ☐ Pushed spoon away	☐
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6	☐ Opened mouth ☐ Leaned forward ☐ Reached out for food ☐ Looked interested ☐ Took spoon to feed self	☐ Closed mouth ☐ Turned head away ☐ Looked away ☐ Arched back/pulled body away ☐ Pushed spoon away	☐ Smiled ☐ Happy sound, e.g. giggles, Mmm, oohs ☐ Excited, e.g. waves arms, kicks legs ☐ Swallowed food ☐ Licked lips	☐ Frowned/nose wrinkled ☐ Shivered/stiffened ☐ Spat food out ☐ Cried/fussed ☐ Pushed spoon away	☐

Please **rate** how much baby likes **Purple A**? *Please tick one*

Dislikes very much	Dislikes	Neither like nor dislike	Likes	Likes very much
☐	☐	☐	☐	☐

…next 3 spoons

If they **refuse** the spoon 3 times in a row, please stop feeding.

For **each spoon,** which behaviours did your baby show? *Tick all that apply*

	When the spoon is approaching		When the food is in the mouth		Refused
Spoon number	**Positive**	**Negative**	**Positive**	**Negative**	
7	☐ Opened mouth ☐ Leaned forward ☐ Reached out for food ☐ Looked interested ☐ Took spoon to feed self	☐ Closed mouth ☐ Turned head away ☐ Looked away ☐ Arched back/pulled body away ☐ Pushed spoon away	☐ Smiled ☐ Happy sound, e.g. giggles, Mmm, oohs ☐ Excited, e.g. waves arms, kicks legs ☐ Swallowed food ☐ Licked lips	☐ Frowned/nose wrinkled ☐ Shivered/stiffened ☐ Spat food out ☐ Cried/fussed ☐ Pushed spoon away	☐
8	☐ Opened mouth ☐ Leaned forward ☐ Reached out for food ☐ Looked interested ☐ Took spoon to feed self	☐ Closed mouth ☐ Turned head away ☐ Looked away ☐ Arched back/pulled body away ☐ Pushed spoon away	☐ Smiled ☐ Happy sound, e.g. giggles, Mmm, oohs ☐ Excited, e.g. waves arms, kicks legs ☐ Swallowed food ☐ Licked lips	☐ Frowned/nose wrinkled ☐ Shivered/stiffened ☐ Spat food out ☐ Cried/fussed ☐ Pushed spoon away	☐
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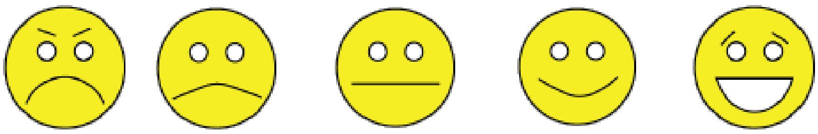
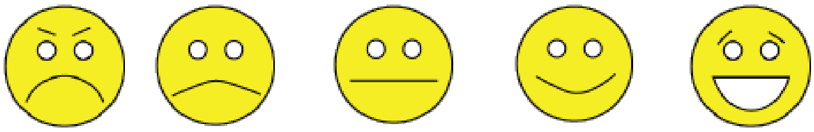
Please **rate** how much baby likes **Purple A**? *Please tick one*



Dislikes very much	Dislikes	Neither like nor dislike	Likes	Likes very much
☐	☐	☐	☐	☐

How much did your baby like Purple A?

Please rate **at the END of the meal.**



Dislikes very much	Dislikes	Neither like nor dislike	Likes	Likes very much
☐	☐	☐	☐	☐

Please don't forget to record how much your baby ate in the weighed food table.

Day 3 - questions

1. How many milk feeds today?

Please count all feeds for **today's calendar day**. For example, feeds at 2am, 7am, 11am, 2pm, 4pm and 11:30pm would be 6 feeds.

Breastmilk: ____

Infant formula: ____

2. Which of the following applies to your baby **today**? *Please **tick** all that apply.*

☐ My baby was unwell
☐ My baby was feeling upset, grizzly or tired
☐ Teething
☐ Baby fussiness
☐ My baby was distracted (e.g. by noise, people or television)
☐ My baby wasn't hungry
☐ Feeding away from home
☐ Not sure
☐ None of the above

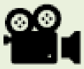
3. Is there anything else that you would like to tell us about feeding baby today? *If **yes**, please explain.*

Day 4 – Kākāriki

Please provide Kākāriki today. You can serve as many meals as you like, as long as they are all Kākāriki.

Date: ______________

1. Weigh and **record** all the food your baby eats today.

Start time	Food name	Amount (**before** eating)	Leftovers (after eating)		**Heated then cooled** before serving	End time
			Weight of food **left over**	Estimation of **food spilt** (e.g. on floor or bib)		
	Kākāriki 					

2. What else did your baby have today? *Please **tick** all that apply.*

Milk today:
- ☐ Breastmilk
- ☐ Infant formula

Supplements:
- ☐ Iron
- ☐ Vitadol C
- ☐ Probiotics
- ☐ None
- ☐ Other: ………………………………

Medications:
- ☐ Antibiotics
- ☐ None
- ☐ Other: ………………………

If they **refuse** the spoon 3 times in a row, please stop feeding.

Behaviour form: first 3 spoons

Please complete this **WHILE feeding** Kākāriki.

For **each spoon,** which behaviours did your baby show? *Tick all that apply*

	When the spoon is approaching		When the food is in the mouth		Refused
Spoon number	**Positive**	**Negative**	**Positive**	**Negative**	
1	☐ Opened mouth ☐ Leaned forward ☐ Reached out for food ☐ Looked interested ☐ Took spoon to feed self	☐ Closed mouth ☐ Turned head away ☐ Looked away ☐ Arched back/pulled body away ☐ Pushed spoon away	☐ Smiled ☐ Happy sound, e.g. giggles, Mmm, oohs ☐ Excited, e.g. waves arms, kicks legs ☐ Swallowed food ☐ Licked lips	☐ Frowned/nose wrinkled ☐ Shivered/stiffened ☐ Spat food out ☐ Cried/fussed ☐ Pushed spoon away	☐
2	☐ Opened mouth ☐ Leaned forward ☐ Reached out for food ☐ Looked interested ☐ Took spoon to feed self	☐ Closed mouth ☐ Turned head away ☐ Looked away ☐ Arched back/pulled body away ☐ Pushed spoon away	☐ Smiled ☐ Happy sound, e.g. giggles, Mmm, oohs ☐ Excited, e.g. waves arms, kicks legs ☐ Swallowed food ☐ Licked lips	☐ Frowned/nose wrinkled ☐ Shivered/stiffened ☐ Spat food out ☐ Cried/fussed ☐ Pushed spoon away	☐
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Please **rate** how much baby likes **Kākāriki**? *Please tick one*

Dislikes very much	Dislikes	Neither like nor dislike	Likes	Likes very much
☐	☐	☐	☐	☐

If they **refuse** the spoon 3 times in a row, please stop feeding.

…next 3 spoons

For **each spoon,** which behaviours did your baby show? *Tick all that apply*

	When the spoon is approaching		When the food is in the mouth		Refused
Spoon number	**Positive**	**Negative**	**Positive**	**Negative**	
4	☐ Opened mouth ☐ Leaned forward ☐ Reached out for food ☐ Looked interested ☐ Took spoon to feed self	☐ Closed mouth ☐ Turned head away ☐ Looked away ☐ Arched back/pulled body away ☐ Pushed spoon away	☐ Smiled ☐ Happy sound, e.g. giggles, Mmm, oohs ☐ Excited, e.g. waves arms, kicks legs ☐ Swallowed food ☐ Licked lips	☐ Frowned/nose wrinkled ☐ Shivered/stiffened ☐ Spat food out ☐ Cried/fussed ☐ Pushed spoon away	☐
5	☐ Opened mouth ☐ Leaned forward ☐ Reached out for food ☐ Looked interested ☐ Took spoon to feed self	☐ Closed mouth ☐ Turned head away ☐ Looked away ☐ Arched back/pulled body away ☐ Pushed spoon away	☐ Smiled ☐ Happy sound, e.g. giggles, Mmm, oohs ☐ Excited, e.g. waves arms, kicks legs ☐ Swallowed food ☐ Licked lips	☐ Frowned/nose wrinkled ☐ Shivered/stiffened ☐ Spat food out ☐ Cried/fussed ☐ Pushed spoon away	☐
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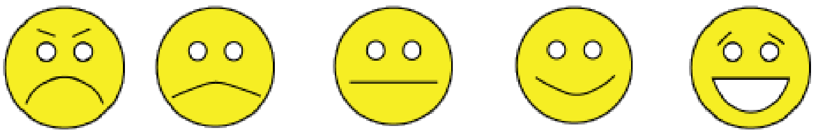
Please **rate** how much baby likes **Kākāriki**? *Please tick one*



Dislikes very much	Dislikes	Neither like nor dislike	Likes	Likes very much
☐	☐	☐	☐	☐

If they **refuse** the spoon 3 times in a row, please stop feeding.

…next 3 spoons

For **each spoon,** which behaviours did your baby show? *Tick all that apply*

	When the spoon is approaching		When the food is in the mouth		Refused
Spoon number	Positive	Negative	Positive	Negative	
7	☐ Opened mouth ☐ Leaned forward ☐ Reached out for food ☐ Looked interested ☐ Took spoon to feed self	☐ Closed mouth ☐ Turned head away ☐ Looked away ☐ Arched back/pulled body away ☐ Pushed spoon away	☐ Smiled ☐ Happy sound, e.g. giggles, Mmm, oohs ☐ Excited, e.g. waves arms, kicks legs ☐ Swallowed food ☐ Licked lips	☐ Frowned/nose wrinkled ☐ Shivered/stiffened ☐ Spat food out ☐ Cried/fussed ☐ Pushed spoon away	☐
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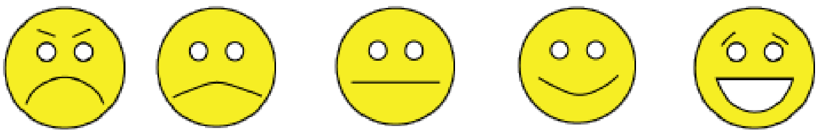
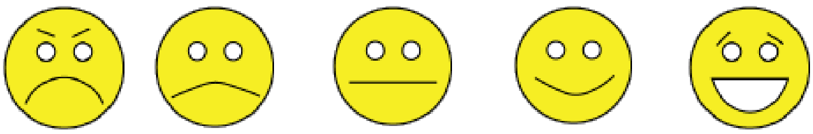
Please **rate** how much baby likes **Kākāriki**? *Please tick one*



Dislikes very much	Dislikes	Neither like nor dislike	Likes	Likes very much
☐	☐	☐	☐	☐

How much did your baby like Kākāriki?

Please rate **at the END of the meal**.



Dislikes very much	Dislikes	Neither like nor dislike	Likes	Likes very much
☐	☐	☐	☐	☐

Please don't forget to record how much your baby ate in the weighed food table.

Day 4 - questions

1. How many milk feeds today?

Please count all feeds for **today's calendar day**. For example, feeds at 2am, 7am, 11am, 2pm, 4pm and 11:30pm would be 6 feeds.

Breastmilk: ____

Infant formula: ____

2. Which of the following applies to your baby **today**? *Please **tick** all that apply.*

- ☐ My baby was unwell
- ☐ My baby was feeling upset, grizzly or tired
- ☐ Teething
- ☐ Baby fussiness
- ☐ My baby was distracted (e.g. by noise, people or television)
- ☐ My baby wasn't hungry
- ☐ Feeding away from home
- ☐ Not sure
- ☐ None of the above

3. Is there anything else that you would like to tell us about feeding baby today? *If **yes**, please explain.*

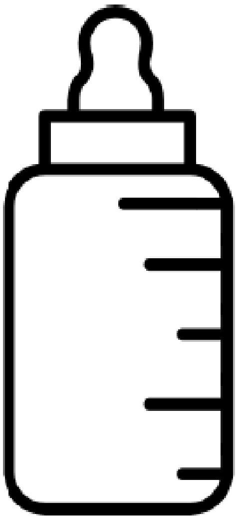
A few more questions…

We would like to know more about your baby's milk feeding

1. If breastfeeding, how many minutes has baby usually sucked at **each feed** in the last 4 days?

_____________ minutes

2. If providing bottle feeds (breastmilk or formula), how much has baby usually been drinking at **each feed** in the last 4 days?



☐ 250 ml
☐ 200 ml
☐ 150 ml
☐ 100 ml
☐ 50 ml

☐ More than 250ml
☐ Fully breastfed
☐ Other, please specify:

____

3. When feeding baby, which do you give first?

☐ Milk before solids
☐ Solids before milk
☐ I don't usually give milk near the time my baby eats solids

We would like to ask about baby's meat consumption

4 Has baby started eating meat (e.g. beef, chicken, fish or pork)?

- ☐ Yes
- ☐ No
- ☐ Other (please specify): ______________________

5 During the 4-week trial, when was meat or fish first introduced?

- ☐ Week 1
- ☐ Week 2
- ☐ Week 3
- ☐ Week 4
- ☐ I have not introduced my baby to meat or fish

MASSEY UNIVERSITY
COLLEGE OF HEALTH
TE KURA HAUORA TANGATA

THANK YOU!

If you have any questions, please email or call us and we will get back to you ☺

Jeanette Rapson, *Lead researcher*
School of Sport, Exercise and Nutrition
Massey University, Albany
Email – vegesfirst@massey.ac.nz
Phone: 0210773419

Selected pages from week one weighed food diary (controls)

Weighed food diary: First 4 days (week 1)

To be completed by baby's mother during the first 4 days of the **4-week trial.**

Remember, the trial starts from the day that your baby is ready to start solids.

Participant number: | | | | **Start date:** | | | |

Instructions

1. **Weigh** and record ***all*** the foods your baby eats:
   - ✓ **FOUR** days in a row, starting from the day your baby starts solids.
2. **Rate** how much you think your baby liked the food.
3. **Describe** your baby's feeding day.

As soon as you start this food diary, please **contact us.**

Jeanette Rapson
j.rapson@massey.ac.nz
021 077 3419

Participant number:

The first four days…

Please offer your baby the foods in the following order for the first four days of the trial.

This is very important for the purpose of our study.

Day 1 — Green B

↓

Day 2 — White B

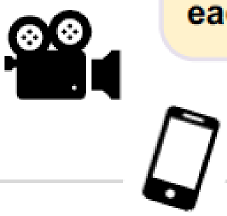
↓

Day 3 — Purple B

↓

Day 4 — Orange A

Remember to video record the **first time** your baby tries **each colour**!



Participant number:

Steps per feeding session:

1 **PREPARE** baby food

2 **WEIGH & RECORD** baby food

3 **FEED** baby food

4 **WEIGH & RECORD** baby food

1

Empty all of the food from the pouch into a microwave safe bowl

Add water to desired consistency and stir. Use recipe cards.

Heat baby food in the microwave on HIGH for 20 seconds, stir to remove hot spots, then repeat twice more. **Allow to cool for 10 minutes.**

2

Weigh the bowl with food (**BEFORE** feeding)

3

Offer baby the food and complete the behaviour form. Test the food temperature on the inside of your wrist, it <u>should not be hot.</u>

4

Weigh and record food (**AFTER** feeding). Discard leftover food.

Participant number:

Instructions for using food scales

Weigh <u>leftover baby foods</u> in gram (g) amounts using digital scales.

Step 1: Turn on the scales

- Firstly, set scales up on a flat surface such as kitchen bench.
- Push the ON/ZERO key.
- Ensure the display screen then appears with "0g".
- If the unit is in "oz", change to "g" by pressing the UNIT button.

Step 2: Weigh the bowl with puree (**BEFORE** eating)

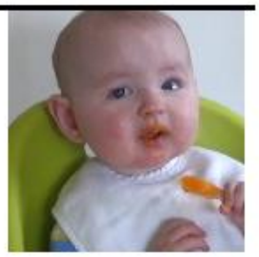
- Add puree sachet and water to the bowl.
- Place the bowl with mixed puree on the scales.
- Record the weight in the *"Amount (before eating) column".*

Step 4: Weigh the leftover food (**AFTER** eating)

- Scoop up as much spilt food as possible and place it back in the bowl.
- Place the bowl with left over puree on the scales.
- Record the weight in the *"Weight of food leftover column".*

Step 5: Estimate the leftovers unable to be weighed and record this in the *"Estimation of food spilt (e.g. on floor, infant or bib)"*

- For any foods that may have been spilt on the floor, or on the infant that you could not scoop back into the bowl, estimate as accurately as possible amounts and record in *"spilt leftovers column" (e.g. 2 tsp Orange A)*



Day 4 – Orange A

Please provide Orange A today. You can serve as many meals as you like, as long as they are all Orange!

Date: ______________

1. Weigh and **record** all the food your baby eats today.

Start time	Food name	Amount (**before** eating)	Leftovers (after eating)		**Heated then cooled** before serving	End time
			Weight of food **left over**	Estimation of **food spilt** (e.g. on floor or bib)		
	Orange B					

2. What else did your baby have today? *Please **tick** all that apply.*

Milk today:
- ☐ Breastmilk
- ☐ Infant formula

Supplements:
- ☐ Iron
- ☐ Vitadol C
- ☐ Probiotics
- ☐ None
- ☐ Other: ……………………………………

Medications:
- ☐ Antibiotics
- ☐ None
- ☐ Other: ………………………

Behaviour form: first 3 spoons

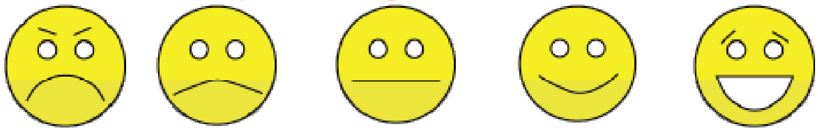
If they **refuse** the spoon 3 times in a row, please stop feeding.

Please complete this **WHILE feeding** Orange A.

For **each spoon,** which behaviours did your baby show? *Tick all that apply*

Spoon number	When the spoon is approaching: Positive	When the spoon is approaching: Negative	When the food is in the mouth: Positive	When the food is in the mouth: Negative	Refused
1	☐ Opened mouth ☐ Leaned forward ☐ Reached out for food ☐ Looked interested ☐ Took spoon to feed self	☐ Closed mouth ☐ Turned head away ☐ Looked away ☐ Arched back/pulled body away ☐ Pushed spoon away	☐ Smiled ☐ Happy sound, e.g. giggles, Mmm, oohs ☐ Excited, e.g. waves arms, kicks legs ☐ Swallowed food ☐ Licked lips	☐ Frowned/nose wrinkled ☐ Shivered/stiffened ☐ Spat food out ☐ Cried/fussed ☐ Pushed spoon away	☐
2	☐ Opened mouth ☐ Leaned forward ☐ Reached out for food ☐ Looked interested ☐ Took spoon to feed self	☐ Closed mouth ☐ Turned head away ☐ Looked away ☐ Arched back/pulled body away ☐ Pushed spoon away	☐ Smiled ☐ Happy sound, e.g. giggles, Mmm, oohs ☐ Excited, e.g. waves arms, kicks legs ☐ Swallowed food ☐ Licked lips	☐ Frowned/nose wrinkled ☐ Shivered/stiffened ☐ Spat food out ☐ Cried/fussed ☐ Pushed spoon away	☐
3	☐ Opened mouth ☐ Leaned forward ☐ Reached out for food ☐ Looked interested ☐ Took spoon to feed self	☐ Closed mouth ☐ Turned head away ☐ Looked away ☐ Arched back/pulled body away ☐ Pushed spoon away	☐ Smiled ☐ Happy sound, e.g. giggles, Mmm, oohs ☐ Excited, e.g. waves arms, kicks legs ☐ Swallowed food ☐ Licked lips	☐ Frowned/nose wrinkled ☐ Shivered/stiffened ☐ Spat food out ☐ Cried/fussed ☐ Pushed spoon away	☐

Please **rate** how much baby likes Orange A? *Please tick one*



Dislikes very much	Dislikes	Neither like nor dislike	Likes	Likes very much
☐	☐	☐	☐	☐

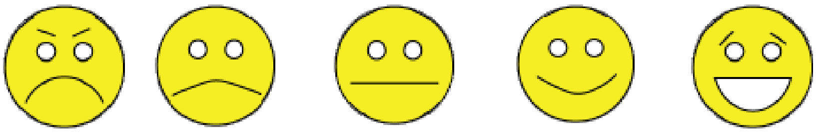
…next 3 spoons

If they **refuse** the spoon 3 times in a row, please stop feeding.

For **each spoon,** which behaviours did your baby show? *Tick all that apply*

Spoon number	When the spoon is approaching		When the food is in the mouth		Refused
	Positive	**Negative**	**Positive**	**Negative**	
4	☐ Opened mouth ☐ Leaned forward ☐ Reached out for food ☐ Looked interested ☐ Took spoon to feed self	☐ Closed mouth ☐ Turned head away ☐ Looked away ☐ Arched back/pulled body away ☐ Pushed spoon away	☐ Smiled ☐ Happy sound, e.g. giggles, Mmm, oohs ☐ Excited, e.g. waves arms, kicks legs ☐ Swallowed food ☐ Licked lips	☐ Frowned/nose wrinkled ☐ Shivered/stiffened ☐ Spat food out ☐ Cried/fussed ☐ Pushed spoon away	☐
5	☐ Opened mouth ☐ Leaned forward ☐ Reached out for food ☐ Looked interested ☐ Took spoon to feed self	☐ Closed mouth ☐ Turned head away ☐ Looked away ☐ Arched back/pulled body away ☐ Pushed spoon away	☐ Smiled ☐ Happy sound, e.g. giggles, Mmm, oohs ☐ Excited, e.g. waves arms, kicks legs ☐ Swallowed food ☐ Licked lips	☐ Frowned/nose wrinkled ☐ Shivered/stiffened ☐ Spat food out ☐ Cried/fussed ☐ Pushed spoon away	☐
6	☐ Opened mouth ☐ Leaned forward ☐ Reached out for food ☐ Looked interested ☐ Took spoon to feed self	☐ Closed mouth ☐ Turned head away ☐ Looked away ☐ Arched back/pulled body away ☐ Pushed spoon away	☐ Smiled ☐ Happy sound, e.g. giggles, Mmm, oohs ☐ Excited, e.g. waves arms, kicks legs ☐ Swallowed food ☐ Licked lips	☐ Frowned/nose wrinkled ☐ Shivered/stiffened ☐ Spat food out ☐ Cried/fussed ☐ Pushed spoon away	☐

Please **rate** how much baby likes **Orange A**? *Please tick one*



Dislikes very much	Dislikes	Neither like nor dislike	Likes	Likes very much
☐	☐	☐	☐	☐

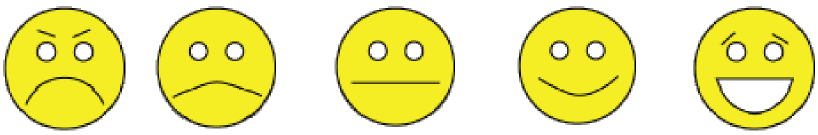
…next 3 spoons

If they **refuse** the spoon 3 times in a row, please stop feeding.

For **each spoon,** which behaviours did your baby show? *Tick all that apply*

	When the spoon is approaching		**When the food is in the mouth**		**Refused**
Spoon number	**Positive**	**Negative**	**Positive**	**Negative**	
7	☐ Opened mouth ☐ Leaned forward ☐ Reached out for food ☐ Looked interested ☐ Took spoon to feed self	☐ Closed mouth ☐ Turned head away ☐ Looked away ☐ Arched back/pulled body away ☐ Pushed spoon away	☐ Smiled ☐ Happy sound, e.g. giggles, Mmm, oohs ☐ Excited, e.g. waves arms, kicks legs ☐ Swallowed food ☐ Licked lips	☐ Frowned/nose wrinkled ☐ Shivered/stiffened ☐ Spat food out ☐ Cried/fussed ☐ Pushed spoon away	☐
8	☐ Opened mouth ☐ Leaned forward ☐ Reached out for food ☐ Looked interested ☐ Took spoon to feed self	☐ Closed mouth ☐ Turned head away ☐ Looked away ☐ Arched back/pulled body away ☐ Pushed spoon away	☐ Smiled ☐ Happy sound, e.g. giggles, Mmm, oohs ☐ Excited, e.g. waves arms, kicks legs ☐ Swallowed food ☐ Licked lips	☐ Frowned/nose wrinkled ☐ Shivered/stiffened ☐ Spat food out ☐ Cried/fussed ☐ Pushed spoon away	☐
9	☐ Opened mouth ☐ Leaned forward ☐ Reached out for food ☐ Looked interested ☐ Took spoon to feed self	☐ Closed mouth ☐ Turned head away ☐ Looked away ☐ Arched back/pulled body away ☐ Pushed spoon away	☐ Smiled ☐ Happy sound, e.g. giggles, Mmm, oohs ☐ Excited, e.g. waves arms, kicks legs ☐ Swallowed food ☐ Licked lips	☐ Frowned/nose wrinkled ☐ Shivered/stiffened ☐ Spat food out ☐ Cried/fussed ☐ Pushed spoon away	☐

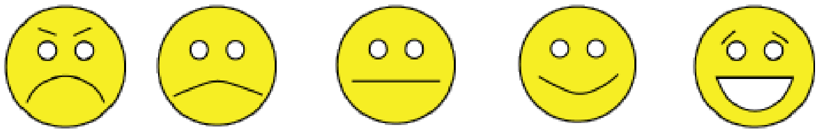
Please **rate** how much baby likes **Orange A**? *Please tick one*



Dislikes very much	Dislikes	Neither like nor dislike	Likes	Likes very much
☐	☐	☐	☐	☐

How much did your baby like Orange A?

Please rate **at the END of the meal.**



Dislikes very much	Dislikes	Neither like nor dislike	Likes	Likes very much
☐	☐	☐	☐	☐

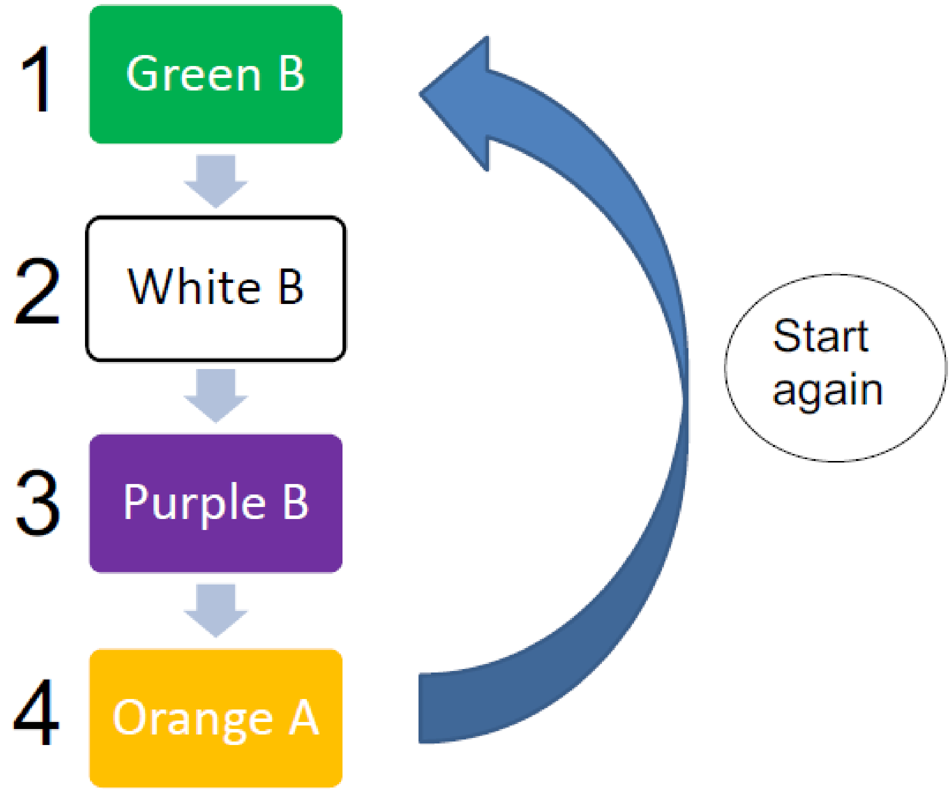
Please don't forget to record how much your baby ate in the weighed food table.

AFTER the first four days of starting solids....

To make sure that your baby eats a variety of foods, please rotate the foods as shown below for the remaining 4-weeks of the trial.

Each time your baby has a meal, please provide a different food. This means that baby can have up to four different colours in one day if they wish!

This is very important for the purpose of our study.



Sachet mixing instructions

How to prepare Green A	How to prepare Green B
1 x sachet *80 ml water*	*2 x sachets* *50 ml water*
1. Pour 1 x sachet of dried powder into a microwave safe bowl. 2. Add **80 ml** cold water, then stir. 3. Microwave on high for 20 seconds, then stir. Repeat this step two more times. 4. Set aside to cool for 10 minutes, then serve to your baby. **Tip:** As your baby gets more used to solid food, you can thicken the purée by adding less water.	1. Pour 2 x sachets of dried powder into a microwave safe bowl. 2. Add **50 ml** cold water, then stir. 3. Microwave on high for 20 seconds, then stir. Repeat this step two more times. 4. Set aside to cool for 10 minutes, then serve to your baby. **Tip:** As your baby gets more used to solid food, you can thicken the purée by adding less water.
How to prepare White A	How to prepare White B
1 x sachet *80 ml water*	*2 x sachets* *50 ml water*
1. Pour 1 x sachet of dried powder into a microwave safe bowl. 2. Add **80 ml** cold water, then stir. 3. Microwave on high for 20 seconds, then stir. Repeat this step two more times. 4. Set aside to cool for 10 minutes, then serve to your baby. **Tip:** As your baby gets more used to solid food, you can thicken the purée by adding less water.	1. Pour 2 x sachets of dried powder into a microwave safe bowl. 2. Add **50 ml** cold water, then stir. 3. Microwave on high for 20 seconds, then stir. Repeat this step two more times. 4. Set aside to cool for 10 minutes, then serve to your baby. **Tip:** As your baby gets more used to solid food, you can thicken the purée by adding less water.

How to prepare Purple A	How to prepare Purple B
1 x sachet *50 ml water*	*2 x sachets* *50 ml water*
1. Pour 1 x sachet of dried powder into a microwave safe bowl. 2. Add **50 ml** cold water, then stir. 3. Microwave on high for 20 seconds, then stir. Repeat this step two more times. 4. Set aside to cool for 10 minutes, then serve to your baby. **Tip:** As your baby gets more used to solid food, you can thicken the purée by adding less water.	1. Pour 2 x sachets of dried powder into a microwave safe bowl. 2. Add **50 ml** cold water, then stir. 3. Microwave on high for 20 seconds, then stir. Repeat this step two more times. 4. Set aside to cool for 10 minutes, then serve to your baby. **Tip:** As your baby gets more used to solid food, you may wish to thicken the purée by adding less water.
How to prepare Kākāriki	How to prepare Orange B
1 x sachet *70 ml water*	*1 x sachet* *50 ml water*
1. Pour 1 x sachet of dried powder into a microwave safe bowl. 2. Add **70 ml** cold water, then stir. 3. Microwave on high for 20 seconds, then stir. Repeat this step two more times. 4. Set aside to cool for 10 minutes, then serve to your baby. **Tip:** As your baby gets more used to solid food, you can thicken the purée by adding less water.	1. Pour 1 x sachet of dried powder into a microwave safe bowl. 2. Add **50 ml** cold water, then stir. 3. Microwave on high for 20 seconds, then stir. Repeat this step two more times. 4. Set aside to cool for 10 minutes, then serve to your baby. **Tip:** As your baby gets more used to solid food, you can thicken the purée by adding less water.

9 month weighed food diary

3-day weighed food diary: 9 months old

To be completed by baby's mother over **three days** in a row
when baby is 9 months old.

Participant number: ☐☐☐ **Start date:** ☐☐☐

Instructions

1. **Feed your baby** three different meals that we provide.
2. **Weigh** and record how much baby eats.
3. **Rate** how much you think your baby liked the food.
4. **Describe** your baby's feeding day.

As soon as you start, please **contact us.**

Jeanette Rapson
j.rapson@massey.ac.nz
021 077 3419

Participant number:

Instructions

- **Choose three days** in a row that you can offer the foods.
- Offer your baby the foods on the **allocated days** (please see next page).
- Choose **any time of day** (preferably the same time each day). However, baby should **not have** eaten any solid food for at least 1 hour before trying our food.
- Provide your usual breast/formula milk feeds.
- Provide any other food you like at other times of the day.

Tip
Try choose the same time every day and when baby is happy and relaxed.

Participant number:

Three days...

Please offer your baby the foods in the following order.

This is very important for the purpose of our study.

Meal A
Day 1

↓

Meal B
Day 2

↓

Meal C
Day 3

Remember to video record **each meal.**

Participant number:

Steps per feeding session:

1. **PREPARE** baby food
2. **WEIGH & RECORD** baby food
3. **FEED** baby food
4. **WEIGH & RECORD** baby food

1

Empty all of the food from the pouch into a microwave safe bowl

Add water to desired consistency and stir. Use recipe cards.

Heat baby food in the microwave on HIGH for 20 seconds, stir to remove hot spots, then repeat twice more. **Allow to cool for 10 minutes.**

2

Weigh the bowl with food (**BEFORE** feeding)

3

Offer baby the food and complete the behaviour form. Test the food temperature on the inside of your wrist, it should not be hot.

4

Weigh and record food (**AFTER** feeding). Discard leftover food.

Participant number:

Instructions for using food scales

Weigh leftover baby foods in gram (g) amounts using digital scales.

Step 1: Turn on the scales

- Firstly, set scales up on a flat surface such as kitchen bench.
- Push the ON/ZERO key.
- Ensure the display screen then appears with “0g”.
- If the unit is in “oz”, change to “g” by pressing the UNIT button.

Step 2: Weigh the bowl with puree (**BEFORE** eating)

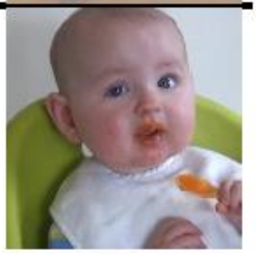
- Add puree sachet and water to the bowl.
- Place the bowl with mixed puree on the scales.
- Record the weight in the *“Amount (before eating) column”.*

Step 4: Weigh the leftover food (**AFTER** eating)

- Scoop up as much spilt food as possible and place it back in the bowl.
- Place the bowl with left over puree on the scales.
- Record the weight in the *“Weight of food leftover column”.*

Step 5: Estimate the leftovers unable to be weighed and record this in the *“Estimation of food spilt (e.g. on floor, infant or bib)”*

- For any foods that may have been spilt on the floor, or on the infant that you could not scoop back into the bowl, estimate as accurately as possible amounts and record in *“spilt leftovers column” (e.g. 2 tsp Meal A)*



Participant number:

Video recording baby's first tastes

We would like you to please video record you baby trying **each meal we have provided**. You can use a video camera, mobile phone or smart device of your choice. We will send you a link to upload your videos.

Please show a clear view of your baby's face and arms. We also need to be able to see the bowl and spoon.

<u>Camera zoom</u>

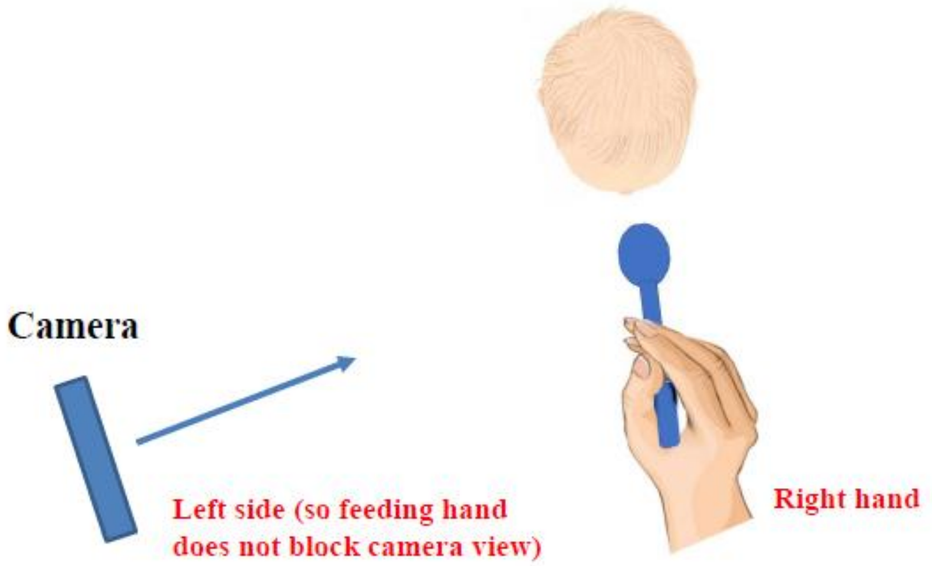
This picture is a good example:

- Medium zoom - not too close, not too far away
- We can see the spoon approaching
- Clear view of baby's face and arms
- Camera is opposite to mum's feeding hand (see next page)

Participant number:

Camera setup

The camera should be set up like this:



Please position the camera to the opposite side of your feeding hand.

For example, if you are holding the spoon with your **right hand**, then place the camera to your left (see picture). This stops your hand from blocking the camera view of your baby's face. If left handed, then place the camera to the right.

Use the tripod cup provided (for mobile phones) or your own tripod/stand. Alternatively, your partner or whanau could video record you feeding your baby.

Participant number:

EXAMPLE: How to record infant foods

Date: 22/11/19

1. Weigh and **record** how much of the meal your baby eats today.

Please choose a **time that suits you.** Each baby is different and some will eat more than others. The below is only an example.

Start time	Food name	Amount (**before** eating)	Leftovers (after eating)		**Heated then cooled** before serving	End time
			Weight of food **left over**	Estimation of **food spilt** (e.g. on floor or bib)		
10:00am	Meal A	99g	85g	1 tablespoon	✓	10:12am

2. What other **vegetables and fruits** did your baby eat today? *You do not need to record the amounts.*

- Apple
- Kūmara
- Banana

3. What else did your baby have today? *Please **tick** all that apply.*

Milk today:	Supplements:	Medications:
☑ Breastmilk	☐ Iron	☐ Antibiotics
☐ Infant formula	☑ Vitadol C	☑ None
	☐ Probiotics	☐ Other: ....
	☐ None	
	☐ Other:	

Participant number:

EXAMPLE *(continued)*

4. How many milk feeds today?

Please count all feeds for **today's calendar day**. For example, feeds at 2am, 7am, 11am, 2pm, 4pm and 11:30pm would be 6 feeds.

Breastmilk: __6__

Infant formula: ____

5. Which of the following applies to your baby **today**? *Please **tick** all that apply.*

- [x] My baby was unwell
- [ ] My baby was feeling upset, grizzly or tired
- [ ] Teething
- [ ] Baby fussiness
- [ ] My baby was distracted (e.g. by noise, people or television)
- [ ] My baby wasn't hungry
- [x] Feeding away from home
- [ ] Not sure
- [ ] None of the above

6. Is there anything else that you would like to tell us about feeding baby today? *If **yes**, please explain.*

She seemed less interested in food today and just wanted her milk feeds.

Participant number:

A few things to remember while feeding…

Regular mealtime

Ideally, **all the study feeding occasions** should be more or less **the same time of day.** Choose a time when your baby is usually hungry but not starving. They should not have been fed solid food during the past hour and a half. You can offer sips of water after the meal or at least 30 minutes before feeding.

Quiet environment, without distraction

- We want your baby to focus on what he/she is eating.
- Choose a quiet time, **without being disturbed** – if possible – by others (e.g. siblings, pets), without **TV or music**, with **toys out of sight.** If your baby is used to having a specific object, and without it, he/she will not eat, you can leave the object.

Your position while feeding

- **Sit facing your child**, with you face at about the same height as his/hers so that you can respond to their requests.
- Keep the behaviour form in front of you to avoid turning your head too much while recording behaviours.

Amount served per spoonful

- An overfilled spoon may be the cause your baby to reject the food.
- Fill the spoon with a **moderate amount.**

Let your baby "lead"

- Baby is **free to interact with you and the spoon.**
- **Follow his/her movements and cues** – this allows baby to "decide" the pace of eating.
- **Keep minimum of control of the spoon.** Once the spoon is accepted or rejected, regain full control of the spoon to refill it with the food.
- **Wait until your baby has finished the bite of food** in his/her mouth before offering the food again.
- For each spoon accepted (even partially) or not, **always put the spoon back in the bowl**, then make sure your baby is ready again before offering a new one.
- If the spoon is offered at an inappropriate time (mouth still full, baby not ready), they may reject the spoon. **Take your time observing their reactions.**

Participant number:

Let's get started!

Please remember to follow these **steps in order:**

1. Make the food
2. Weigh food BEFORE feeding
3. Complete the behaviour form WHILE feeding
4. Weigh food AFTER feeding

Day 1 – Meal A

Recipe (mashed texture)

1 x sachet
80ml water

1. Pour 1 x sachet of dried powder into a microwave safe bowl.
2. Add **80ml** cold water, then stir.
3. Microwave on high for 20 seconds, then stir. Repeat this step two more times.
4. Set aside to cool for 10 minutes, then serve to your baby.

Tip: The above recipe make a mashed texture. However, you can adjust the texture to suit your baby.

- To make a thin puree, add extra water.
- To thicken the puree, microwave for longer or adding less water.

Day 1 – Meal A

Date: ____________

1. Weigh and **record** how much of the meal that your baby eats today.

Start time	Food name	Amount (**before** eating)	Leftovers (after eating)		**Heated then cooled** before serving	End time
			Weight of food **left over**	Estimation of **food spilt** (e.g. on floor or bib)		
	Meal A 					

2. What other **vegetables and fruits** did your baby eat today? *You do not need to record the amounts.*

3. What else did your baby have today? *Please* ***tick*** *all that apply.*

Milk today:	**Supplements**:	**Medications**:
☑ Breastmilk	☐ Iron	☐ Antibiotics
☐ Infant formula	☑ Vitadol C	☑ None
	☐ Probiotics	☐ Other: ....
	☐ None	
	☐ Other:	

Behaviour form: first 3 spoons

If they **refuse** the spoon 3 times in a row, please stop feeding.

Please complete this **WHILE feeding Meal A.**

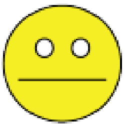
For **each spoon**, which behaviours did your baby show? *Tick all that apply*

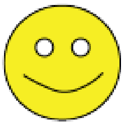
	When the spoon is approaching		When the food is in the mouth		Refused
Spoon number	**Positive**	**Negative**	**Positive**	**Negative**	
1	☐ Opened mouth ☐ Leaned forward ☐ Reached out for food ☐ Looked interested ☐ Took spoon to feed self	☐ Closed mouth ☐ Turned head away ☐ Looked away ☐ Arched back/pulled body away ☐ Pushed spoon away	☐ Smiled ☐ Happy sound, e.g. giggles, Mmm, oohs ☐ Excited, e.g. waves arms, kicks legs ☐ Swallowed food ☐ Licked lips	☐ Frowned/nose wrinkled ☐ Shivered/stiffened ☐ Spat food out ☐ Cried/fussed ☐ Pushed spoon away	☐
2	☐ Opened mouth ☐ Leaned forward ☐ Reached out for food ☐ Looked interested ☐ Took spoon to feed self	☐ Closed mouth ☐ Turned head away ☐ Looked away ☐ Arched back/pulled body away ☐ Pushed spoon away	☐ Smiled ☐ Happy sound, e.g. giggles, Mmm, oohs ☐ Excited, e.g. waves arms, kicks legs ☐ Swallowed food ☐ Licked lips	☐ Frowned/nose wrinkled ☐ Shivered/stiffened ☐ Spat food out ☐ Cried/fussed ☐ Pushed spoon away	☐
3	☐ Opened mouth ☐ Leaned forward ☐ Reached out for food ☐ Looked interested ☐ Took spoon to feed self	☐ Closed mouth ☐ Turned head away ☐ Looked away ☐ Arched back/pulled body away ☐ Pushed spoon away	☐ Smiled ☐ Happy sound, e.g. giggles, Mmm, oohs ☐ Excited, e.g. waves arms, kicks legs ☐ Swallowed food ☐ Licked lips	☐ Frowned/nose wrinkled ☐ Shivered/stiffened ☐ Spat food out ☐ Cried/fussed ☐ Pushed spoon away	☐

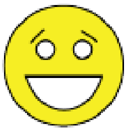
Please **rate** how much baby likes **Meal A**? *Please tick one*


Dislikes very much ☐


Dislikes ☐


Neither like nor dislike ☐


Likes ☐


Likes very much ☐

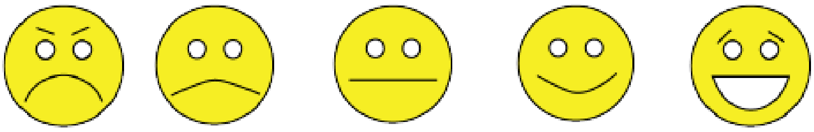
If they **refuse** the spoon 3 times in a row, please stop feeding.

…next 3 spoons

For **each spoon**, which behaviours did your baby show? *Tick all that apply*

Spoon number	When the spoon is approaching		When the food is in the mouth		Refused
	Positive	**Negative**	**Positive**	**Negative**	
4	☐ Opened mouth ☐ Leaned forward ☐ Reached out for food ☐ Looked interested ☐ Took spoon to feed self	☐ Closed mouth ☐ Turned head away ☐ Looked away ☐ Arched back/pulled body away ☐ Pushed spoon away	☐ Smiled ☐ Happy sound, e.g. giggles, Mmm, oohs ☐ Excited, e.g. waves arms, kicks legs ☐ Swallowed food ☐ Licked lips	☐ Frowned/nose wrinkled ☐ Shivered/stiffened ☐ Spat food out ☐ Cried/fussed ☐ Pushed spoon away	☐
5	☐ Opened mouth ☐ Leaned forward ☐ Reached out for food ☐ Looked interested ☐ Took spoon to feed self	☐ Closed mouth ☐ Turned head away ☐ Looked away ☐ Arched back/pulled body away ☐ Pushed spoon away	☐ Smiled ☐ Happy sound, e.g. giggles, Mmm, oohs ☐ Excited, e.g. waves arms, kicks legs ☐ Swallowed food ☐ Licked lips	☐ Frowned/nose wrinkled ☐ Shivered/stiffened ☐ Spat food out ☐ Cried/fussed ☐ Pushed spoon away	☐
6	☐ Opened mouth ☐ Leaned forward ☐ Reached out for food ☐ Looked interested ☐ Took spoon to feed self	☐ Closed mouth ☐ Turned head away ☐ Looked away ☐ Arched back/pulled body away ☐ Pushed spoon away	☐ Smiled ☐ Happy sound, e.g. giggles, Mmm, oohs ☐ Excited, e.g. waves arms, kicks legs ☐ Swallowed food ☐ Licked lips	☐ Frowned/nose wrinkled ☐ Shivered/stiffened ☐ Spat food out ☐ Cried/fussed ☐ Pushed spoon away	☐

Please **rate** how much baby likes **Meal A**? *Please tick one*



Dislikes very much	Dislikes	Neither like nor dislike	Likes	Likes very much
☐	☐	☐	☐	☐

…next 3 spoons

> If they **refuse** the spoon 3 times in a row, please stop feeding.

For **each spoon**, which behaviours did your baby show? *Tick all that apply*

	When the spoon is approaching		**When the food is in the mouth**		**Refused**
Spoon number	**Positive**	**Negative**	**Positive**	**Negative**	
7	☐ Opened mouth ☐ Leaned forward ☐ Reached out for food ☐ Looked interested ☐ Took spoon to feed self	☐ Closed mouth ☐ Turned head away ☐ Looked away ☐ Arched back/pulled body away ☐ Pushed spoon away	☐ Smiled ☐ Happy sound, e.g. giggles, Mmm, oohs ☐ Excited, e.g. waves arms, kicks legs ☐ Swallowed food ☐ Licked lips	☐ Frowned/nose wrinkled ☐ Shivered/stiffened ☐ Spat food out ☐ Cried/fussed ☐ Pushed spoon away	☐
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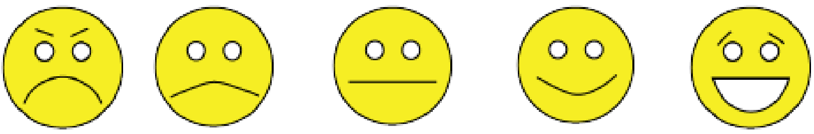
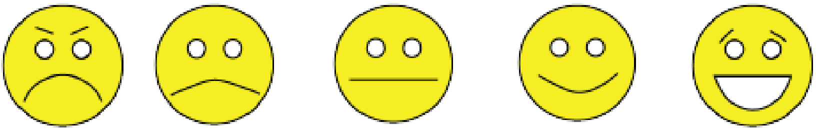
Please **rate** how much baby likes **Meal A**? *Please tick one*



Dislikes very much	Dislikes	Neither like nor dislike	Likes	Likes very much
☐	☐	☐	☐	☐

How much did your baby like Meal A?

Please rate **at the END of the meal.**



Dislikes very much	Dislikes	Neither like nor dislike	Likes	Likes very much
☐	☐	☐	☐	☐

Please don't forget to record how much your baby ate in the weighed food table.

Day 1 – questions

1. How many milk feeds today?

Please count all feeds for **today's calendar day**. For example, feeds at 2am, 7am, 11am, 2pm, 4pm and 11:30pm would be 6 feeds.

Breastmilk: _____

Infant formula: _____

2. Which of the following applies to your baby **today**? *Please **tick** all that apply.*

- ☐ My baby was unwell
- ☐ My baby was feeling upset, grizzly or tired
- ☐ Teething
- ☐ Baby fussiness
- ☐ My baby was distracted (e.g. by noise, people or television)
- ☐ My baby wasn't hungry
- ☐ Feeding away from home
- ☐ Not sure
- ☐ None of the above

3. Is there anything else that you would like to tell us about feeding baby today? *If **yes**, please explain.*

Day 2 – Meal B

Recipe (puree texture)

1 x sachet
80ml water

5. Pour 1 x sachet of dried powder into a microwave safe bowl.
6. Add **80ml** cold water, then stir.
7. Microwave on high for 20 seconds, then stir. Repeat this step two more times.
8. Set aside to cool for 10 minutes, then serve to your baby.

Tip: The above recipe make a puree texture. However, you can adjust the texture to suit your baby.

- To make a thin puree, add extra water.
- To thicken the puree, microwave for longer or adding less water.

Day 2 – Meal B

Date: ____________

1. **Weigh** and **record** how much of the meal that your baby eats today.

Start time	Food name	Amount (**before** eating)	Leftovers (after eating)		**Heated then cooled** before serving	End time
			Weight of food **left over**	Estimation of **food spilt** (e.g. on floor or bib)		
	Meal B					

2. What other **vegetables and fruits** did your baby eat today? *You do not need to record the amounts.*

3. What else did your baby have today? *Please **tick** all that apply.*

Milk today:	**Supplements**:	**Medications**:
☑ Breastmilk	☐ Iron	☐ Antibiotics
☐ Infant formula	☑ Vitadol C	☑ None
	☐ Probiotics	☐ Other: ....
	☐ None	
	☐ Other:	

Behaviour form: first 3 spoons

If they **refuse** the spoon 3 times in a row, please stop feeding.

Please complete this **WHILE feeding Meal B.**

For **each spoon,** which behaviours did your baby show? *Tick all that apply*

	When the spoon is approaching		When the food is in the mouth		Refused
Spoon number	Positive	Negative	Positive	Negative	
1	☐ Opened mouth ☐ Leaned forward ☐ Reached out for food ☐ Looked interested ☐ Took spoon to feed self	☐ Closed mouth ☐ Turned head away ☐ Looked away ☐ Arched back/pulled body away ☐ Pushed spoon away	☐ Smiled ☐ Happy sound, e.g. giggles, Mmm, oohs ☐ Excited, e.g. waves arms, kicks legs ☐ Swallowed food ☐ Licked lips	☐ Frowned/nose wrinkled ☐ Shivered/stiffened ☐ Spat food out ☐ Cried/fussed ☐ Pushed spoon away	☐
2	☐ Opened mouth ☐ Leaned forward ☐ Reached out for food ☐ Looked interested ☐ Took spoon to feed self	☐ Closed mouth ☐ Turned head away ☐ Looked away ☐ Arched back/pulled body away ☐ Pushed spoon away	☐ Smiled ☐ Happy sound, e.g. giggles, Mmm, oohs ☐ Excited, e.g. waves arms, kicks legs ☐ Swallowed food ☐ Licked lips	☐ Frowned/nose wrinkled ☐ Shivered/stiffened ☐ Spat food out ☐ Cried/fussed ☐ Pushed spoon away	☐
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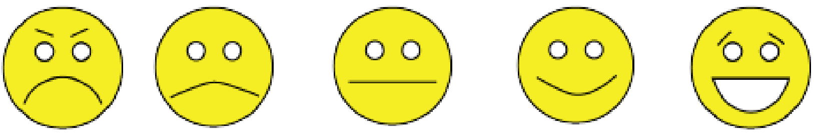
Please **rate** how much baby likes **Meal B**? *Please tick one*



Dislikes very much	Dislikes	Neither like nor dislike	Likes	Likes very much
☐	☐	☐	☐	☐

…next 3 spoons

If they **refuse** the spoon 3 times in a row, please stop feeding.

For **each spoon**, which behaviours did your baby show? *Tick all that apply*

Spoon number	When the spoon is approaching		When the food is in the mouth		Refused
	Positive	**Negative**	**Positive**	**Negative**	
4	☐ Opened mouth ☐ Leaned forward ☐ Reached out for food ☐ Looked interested ☐ Took spoon to feed self	☐ Closed mouth ☐ Turned head away ☐ Looked away ☐ Arched back/pulled body away ☐ Pushed spoon away	☐ Smiled ☐ Happy sound, e.g. giggles, Mmm, oohs ☐ Excited, e.g. waves arms, kicks legs ☐ Swallowed food ☐ Licked lips	☐ Frowned/nose wrinkled ☐ Shivered/stiffened ☐ Spat food out ☐ Cried/fussed ☐ Pushed spoon away	☐
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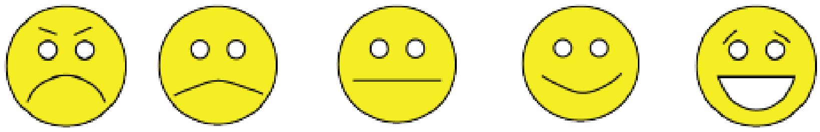
Please **rate** how much baby likes **Meal B**? *Please tick one*



Dislikes very much	Dislikes	Neither like nor dislike	Likes	Likes very much
☐	☐	☐	☐	☐

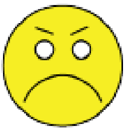
If they **refuse** the spoon 3 times in a row, please stop feeding.

…next 3 spoons

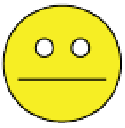
For **each spoon**, which behaviours did your baby show? *Tick all that apply*

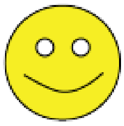
	When the spoon is approaching		When the food is in the mouth		Refused
Spoon number	Positive	Negative	Positive	Negative	
7	☐ Opened mouth ☐ Leaned forward ☐ Reached out for food ☐ Looked interested ☐ Took spoon to feed self	☐ Closed mouth ☐ Turned head away ☐ Looked away ☐ Arched back/pulled body away ☐ Pushed spoon away	☐ Smiled ☐ Happy sound, e.g. giggles, Mmm, oohs ☐ Excited, e.g. waves arms, kicks legs ☐ Swallowed food ☐ Licked lips	☐ Frowned/nose wrinkled ☐ Shivered/stiffened ☐ Spat food out ☐ Cried/fussed ☐ Pushed spoon away	☐
8	☐ Opened mouth ☐ Leaned forward ☐ Reached out for food ☐ Looked interested ☐ Took spoon to feed self	☐ Closed mouth ☐ Turned head away ☐ Looked away ☐ Arched back/pulled body away ☐ Pushed spoon away	☐ Smiled ☐ Happy sound, e.g. giggles, Mmm, oohs ☐ Excited, e.g. waves arms, kicks legs ☐ Swallowed food ☐ Licked lips	☐ Frowned/nose wrinkled ☐ Shivered/stiffened ☐ Spat food out ☐ Cried/fussed ☐ Pushed spoon away	☐
9	☐ Opened mouth ☐ Leaned forward ☐ Reached out for food ☐ Looked interested ☐ Took spoon to feed self	☐ Closed mouth ☐ Turned head away ☐ Looked away ☐ Arched back/pulled body away ☐ Pushed spoon away	☐ Smiled ☐ Happy sound, e.g. giggles, Mmm, oohs ☐ Excited, e.g. waves arms, kicks legs ☐ Swallowed food ☐ Licked lips	☐ Frowned/nose wrinkled ☐ Shivered/stiffened ☐ Spat food out ☐ Cried/fussed ☐ Pushed spoon away	☐

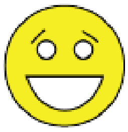
Please **rate** how much baby likes **Meal B**? *Please tick one*


Dislikes very much ☐


Dislikes ☐

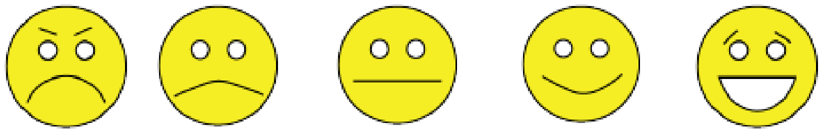

Neither like nor dislike ☐


Likes ☐


Likes very much ☐

How much did your baby like Meal B?

Please rate **at the END of the meal**.



Dislikes very much	Dislikes	Neither like nor dislike	Likes	Likes very much
☐	☐	☐	☐	☐

Please don't forget to record how much your baby ate in the weighed food table.

Day 2 - questions

Please count all feeds for **today's calendar day**. For example, feeds at 2am, 7am, 11am, 2pm, 4pm and 11:30pm would be 6 feeds.

1. How many milk feeds today?

Breastmilk: ____

Infant formula: ____

2. Which of the following applies to your baby **today**? *Please **tick** all that apply.*

- ☐ My baby was unwell
- ☐ My baby was feeling upset, grizzly or tired
- ☐ Teething
- ☐ Baby fussiness
- ☐ My baby was distracted (e.g. by noise, people or television)
- ☐ My baby wasn't hungry
- ☐ Feeding away from home
- ☐ Not sure
- ☐ None of the above

3. Is there anything else that you would like to tell us about feeding baby today? *If **yes**, please explain.*

Day 3 – Meal C

Recipe (puree texture)

2 x sachet
50ml water

9. Pour 1 x sachet of dried powder into a microwave safe bowl.
10. Add **50ml** cold water, then stir.
11. Microwave on high for 20 seconds, then stir. Repeat this step two more times.
12. Set aside to cool for 10 minutes, then serve to your baby.

Tip: The above recipe make a puree texture. However, you can adjust the texture to suit your baby.

- To make a thin puree, add extra water.
- To thicken the puree, microwave for longer or adding less water.

Day 3 – Meal C

Date: ____________

1. **Weigh** and **record** how much of the meal that your baby eats today.

Start time	Food name	Amount (**before** eating)	Leftovers (after eating)		**Heated then cooled** before serving	End time
			Weight of food **left over**	Estimation of **food spilt** (e.g. on floor or bib)		
	Meal C					

2. What other **vegetables and fruits** did your baby eat today? *You do not need to record the amounts.*

3. What else did your baby have today? *Please **tick** all that apply.*

Milk today:	**Supplements**:	**Medications**:
☑ Breastmilk	☐ Iron	☐ Antibiotics
☐ Infant formula	☑ Vitadol C	☑ None
	☐ Probiotics	☐ Other: ....
	☐ None	
	☐ Other:	

If they **refuse** the spoon 3 times in a row, please stop feeding.

Behaviour form: first 3 spoons

Please complete this **WHILE feeding Meal C.**

For **each spoon**, which behaviours did your baby show? *Tick all that apply*

	When the spoon is approaching		When the food is in the mouth		Refused
Spoon number	**Positive**	**Negative**	**Positive**	**Negative**	
1	☐ Opened mouth ☐ Leaned forward ☐ Reached out for food ☐ Looked interested ☐ Took spoon to feed self	☐ Closed mouth ☐ Turned head away ☐ Looked away ☐ Arched back/pulled body away ☐ Pushed spoon away	☐ Smiled ☐ Happy sound, e.g. giggles, Mmm, oohs ☐ Excited, e.g. waves arms, kicks legs ☐ Swallowed food ☐ Licked lips	☐ Frowned/nose wrinkled ☐ Shivered/stiffened ☐ Spat food out ☐ Cried/fussed ☐ Pushed spoon away	☐
2	☐ Opened mouth ☐ Leaned forward ☐ Reached out for food ☐ Looked interested ☐ Took spoon to feed self	☐ Closed mouth ☐ Turned head away ☐ Looked away ☐ Arched back/pulled body away ☐ Pushed spoon away	☐ Smiled ☐ Happy sound, e.g. giggles, Mmm, oohs ☐ Excited, e.g. waves arms, kicks legs ☐ Swallowed food ☐ Licked lips	☐ Frowned/nose wrinkled ☐ Shivered/stiffened ☐ Spat food out ☐ Cried/fussed ☐ Pushed spoon away	☐
3	☐ Opened mouth ☐ Leaned forward ☐ Reached out for food ☐ Looked interested ☐ Took spoon to feed self	☐ Closed mouth ☐ Turned head away ☐ Looked away ☐ Arched back/pulled body away ☐ Pushed spoon away	☐ Smiled ☐ Happy sound, e.g. giggles, Mmm, oohs ☐ Excited, e.g. waves arms, kicks legs ☐ Swallowed food ☐ Licked lips	☐ Frowned/nose wrinkled ☐ Shivered/stiffened ☐ Spat food out ☐ Cried/fussed ☐ Pushed spoon away	☐

Please **rate** how much baby likes **Meal C**? *Please tick one*

Dislikes very much	Dislikes	Neither like nor dislike	Likes	Likes very much
☐	☐	☐	☐	☐

…next 3 spoons

If they **refuse** the spoon 3 times in a row, please stop feeding.

For **each spoon**, which behaviours did your baby show? *Tick all that apply*

	When the spoon is approaching		When the food is in the mouth		Refused
Spoon number	Positive	Negative	Positive	Negative	
4	☐ Opened mouth ☐ Leaned forward ☐ Reached out for food ☐ Looked interested ☐ Took spoon to feed self	☐ Closed mouth ☐ Turned head away ☐ Looked away ☐ Arched back/pulled body away ☐ Pushed spoon away	☐ Smiled ☐ Happy sound, e.g. giggles, Mmm, oohs ☐ Excited, e.g. waves arms, kicks legs ☐ Swallowed food ☐ Licked lips	☐ Frowned/nose wrinkled ☐ Shivered/stiffened ☐ Spat food out ☐ Cried/fussed ☐ Pushed spoon away	☐
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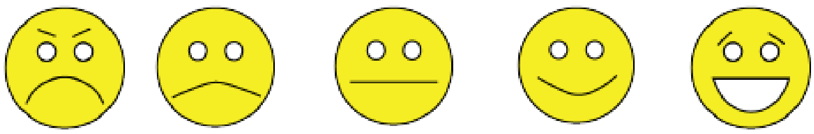
Please **rate** how much baby likes **Meal C**? *Please tick one*



Dislikes very much	Dislikes	Neither like nor dislike	Likes	Likes very much
☐	☐	☐	☐	☐

…next 3 spoons

If they **refuse** the spoon 3 times in a row, please stop feeding.

For **each spoon**, which behaviours did your baby show? *Tick all that apply*

	When the spoon is approaching		When the food is in the mouth		Refused
Spoon number	Positive	Negative	Positive	Negative	
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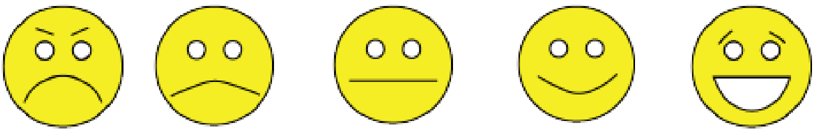
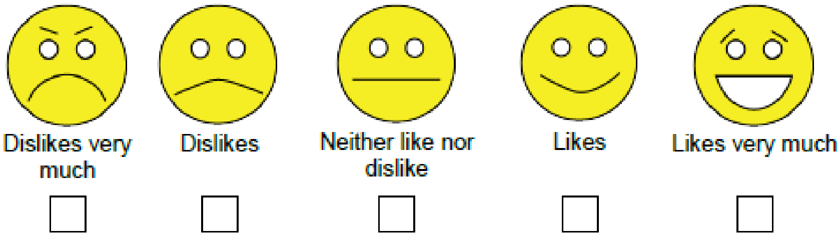
Please **rate** how much baby likes **Meal C**? *Please tick one*



Dislikes very much	Dislikes	Neither like nor dislike	Likes	Likes very much
☐	☐	☐	☐	☐

How much did your baby like Meal C?

Please rate **at the END of the meal.**



Please don’t forget to record how much your baby ate in the weighed food table.

Day 3 - questions

1. How many milk feeds today?

Please count all feeds for **today's calendar day**. For example, feeds at 2am, 7am, 11am, 2pm, 4pm and 11:30pm would be 6 feeds.

Breastmilk: ____

Infant formula: ____

2. Which of the following applies to your baby **today**? *Please **tick** all that apply.*

- ☐ My baby was unwell
- ☐ My baby was feeling upset, grizzly or tired
- ☐ Teething
- ☐ Baby fussiness
- ☐ My baby was distracted (e.g. by noise, people or television)
- ☐ My baby wasn't hungry
- ☐ Feeding away from home
- ☐ Not sure
- ☐ None of the above

3. Is there anything else that you would like to tell us about feeding baby today? *If **yes**, please explain.*

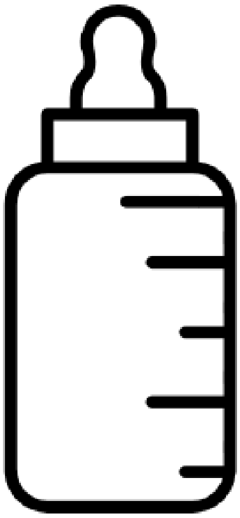
A few more questions…

We would like to know more about your baby's milk feeding

1 If breastfeeding, how many minutes has baby usually sucked at **each feed** in the last 3 days?

____________ minutes

2 If providing bottle feeds (breastmilk or formula), how much has baby usually been drinking at **each feed** in the last 3 days?



☐ 250 ml
☐ 200 ml
☐ 150 ml
☐ 100 ml
☐ 50 ml

☐ More than 250ml
☐ Fully breastfed
☐ Other, please specify:

____

3 When feeding baby, which do you give first?

☐ Milk before solids
☐ Solids before milk
☐ I don't usually give milk near the time my baby eats solids

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COLLEGE OF HEALTH
TE KURA HAUORA TANGATA

THANK YOU!

If you have any questions, please email or call us and we will get back to you ☺

Jeanette Rapson, *Lead researcher*
School of Sport, Exercise and Nutrition
Massey University, Albany
Email – vegesfirst@massey.ac.nz
Phone: 0210773419

Appendix I: Eligibility questionnaire

Eligibility Screening Questionnaire

Thank you for taking the time to complete this 2-5 minute questionnaire.

Your answers will help us identify if you are eligible to participate in the study.
All information that you provide will be kept confidential.

If you have any questions, please contact:

Jeanette Rapson, Lead Researcher
0210773419 | vegesfirst@massey.ac.nz

Website: www.vegesfirststudy.co.nz

Committee Approval Statement

This project has been reviewed and approved by the Massey University Human Ethics Committee: Southern A, Application SOA 18/56. If you have any concerns about the conduct of this research, please contact Dr Lesley Batten, Chair, Massey University Human Ethics Committee: Southern A, telephone + 64 6 356 9099 x 85094, email humanethicsoutha@massey.ac.nz

Mother with newborn baby

I am a mother with a baby 6 months of age or less

- ○ Yes
- ○ No

When was your baby born? *Please choose a date.*

	Day	Month	Year
Please Select:			

At how many weeks gestation was your baby born?

- ○ Less than 37 weeks
- ○ 37 or more weeks

Does **your baby** have any known allergies or family history of allergies?

- ○ Yes, please specify:
- ○ No

Does **your baby** have any medical conditions?

- ○ Yes, please specify:
- ○ No

Do **you** have any current medical conditions?

- ○ Yes, please specify:
- ○ No

Has your baby started complementary feeding (ie. started eating solids alongside breast and/or formula milk)?

- ○ Yes
- ○ No

Do you live in Auckland?

- ○ Yes
- ○ No

What is your postcode? *Please write in the text box.*

If you do not know your postcode, please click here.

Will you be able to offer your baby infant foods that we provide for a duration of 4 weeks, starting from when your baby first starts solids?

- ○ Yes
- ○ No

Registration

Please provide the following details so that a researcher can contact you about the study.

First name*

Last name*

E-mail*

Phone

Note. Created by PhD candidate using Qualtrics Survey Software.

Appendix J: Child food frequency questionnaire

Baby Food Frequency Questionnaire

Thank you for taking the time to complete this questionnaire.
It should take approximately **10 minutes** to complete.

This questionnaire asks about how your baby has been fed over the last 4 days. There are no "right" or "wrong" answers.

If you have any questions, please contact:
Jeanette Rapson on 0210773419 | vegesfirst@massey.ac.nz
or Dr Cath Conlon on 09 4140800 ext 43658 | C.Conlon@massey.ac.nz

Website: www.vegesfirststudy.co.nz

All information in this questionnaire will be kept confidential.

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Please enter your **three digit** participant number:

Note: this number was given to you by email, as well as a fridge magnet. It will be used to match up data sets, **not** to personally identify you.

What is your child's date of birth? *Please choose a date.*

	Month	Day	Year
Please Select:			

In the last 4 days, how often did your baby eat **vegetables and fruit**?

Note: If your baby has not had the food, please enter 0.

	Click to write Column 1 Total number of times in last 4 days	Click to write Column 2 Typical amount at each feed
Starchy (e.g. potato, kumara) e.g. 15g mashed potato = 1 TBSP		
Cruciferous (e.g. broccoli, cauliflower, cabbage)		

Leafy green (e.g. spinach, silverbeet)		
Red and orange (e.g. carrot, pumpkin, capsicum)		
Beans and peas		
Citrus (e.g. orange, mandarin)		
Berries (e.g. blueberry, strawberry)		
Melon (e.g. watermelon, honeydew)		
Stone fruit (e.g. apricot, peach)		
Tropical (e.g. banana, mango)		
Cucumber		
Avocado		
Apple (e.g. 1/2 small apple = 45g = 3 TBSP)		
Grapes		
Other fruit (e.g. pears)		

Other fruits and vegetables (please specify total number of times in the last 4 days and typical amount at each feed)

	Total number of times in last 4 days	Typical amount at each feed
Beef (e.g. 15g mince = 1TBSP)		
Lamb		
Pork		
Ham (e.g. 1 slice ham = 15g or 1 TBSP)		
Chicken and poultry		
Fish		
Eggs (e.g. 1 medium egg = 3 TBSP)		
Beans/Lentils		
Chickpeas		
Tofu		

Other meat and alternative foods (please specify total number of times in the last 4 days and typical amount at each feed)

We would like to learn more about your baby's **milk feeds.**

Was your baby ever breastfed?

- ○ Yes
- ○ No

Skip to 11 IF 'Was our baby ever breastfed?' = No

Are you still breastfeeding?

- ○ Yes
- ○ No

Skip to 10 IF 'Are you still breastfeeding?' = Yes

If no longer breastfeeding, how old was your baby when you stopped?

- ○ Less than 1 week
- ○ 1 week
- ○ 2 weeks
- ○ 3 weeks
- ○ 1 month
- ○ 2 months
- ○ 3 months
- ○ 4 months
- ○ 5 months
- ○ 6 months
- ○ 7 months
- ○ 8 months
- ○ 9 months
- ○ Still breastfeeding

Display next question IF 'Are you still breastfeeding?' = Yes

OR 'If no longer breastfeeding, how old was your baby when you stopped?' = Still breastfeeding

If breastfeeding, how many minutes has baby usually sucked at **each feed** in the last 4 days?

- ○ Less than 1 minute
- ○ 1 minute
- ○ 2 minutes
- ○ 3 minutes
- ○ 4 minutes
- ○ 5 minutes
- ○ 6 minutes
- ○ 7 minutes
- ○ 8 minutes
- ○ 9 minutes
- ○ 10 minutes
- ○ More than 10 minutes

Has your baby had infant formula at any stage?

- ○ Yes
- ○ No

Skip to 14 IF 'Has your baby had infant formula at any stage?' = No

How old was your baby when formula was first introduced?

- ○ Less than 1 week
- ○ 1 week
- ○ 2 weeks
- ○ 3 weeks
- ○ 1 month
- ○ 2 months
- ○ 3 months
- ○ 4 months
- ○ 5 months
- ○ 6 months
- ○ 7 months
- ○ 8 months
- ○ 9 months
- ○ No formula introduced

Skip to 14 IF 'How old was your baby when formula was first introduced?' = No formula introduced

Is your baby still having infant formula?

- Yes
- No

For bottle/cup feeds (any milk or formula), how much does baby usually drink at **each feed** in the last 4 days?

- 50 ml
- 100 ml
- 150 ml
- 200 ml
- 250 ml
- More than 250 ml
- Fully breastfed
- Other, please specify amount: ______

Question 14:

Regardless of the type of milk you provide, which do you give first?

- Milks before solids
- Solids before milk
- I don't usually give milk near the time my baby eats solids
- My baby is not having any breastmilk or formula

What else is your child drinking?

- Water
- Standard cow's milk
- Juice
- Nothing other than breast milk or formula
- Other, please specify: ______

Note. Created using Qualtrics Survey Software by the PhD candidate. Images were sourced from www.pixabay.com with no attribution required. Broccoli image sourced from www.vegetables.co.nz with permission.

Appendix K: Fruit and vegetable liking questionnaire

Vegetables - 9 months old

Thank you for taking the time to complete this questionnaire.
It should take approximately **15 minutes** to complete.

This is **not a test.** Your answers will help us learn about the **vegetables** that your child likes and dislikes.

Questions will ask about what vegetables your baby has tried over the last 3 months (starting from after completing the 4 week trial).

If you have any questions, please contact:
Jeanette Rapson on 0210773419 | vegesfirst@massey.ac.nz
or Dr Cath Conlon on 09 4140800 ext 43658 | C.Conlon@massey.ac.nz

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Please enter your **three digit** participant number:

***Note:** this number was sent to you by email. It will be used to match up data sets, **not** to personally identify you.*

How many times has your child tried **artichokes**?

Remember: questions ask about what vegetables your baby has tried over the last 3 months (starting from <u>after</u> completing the 4 week trial).

- Never tried
- Tried 1-3 times
- Tried 4-6 times
- Tried 7-9 times
- Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **artichokes**?

Dislike very much	Dislike	Neither dislike or like	Like	Like very much

How many times has your child tried **asparagus**?

- Never tried
- Tried 1-3 times
- Tried 4-6 times
- Tried 7-9 times
- Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **asparagus**?

Dislike very much	Dislike	Neither dislike or like	Like	Like very much

How many times has your child tried **beetroot**?

- Never tried
- Tried 1-3 times
- Tried 4-6 times
- Tried 7-9 times
- Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **beetroot**?

Dislike very much | Dislike | Neither dislike or like | Like | Like very much

How many times has your child tried **broccoli**?

- Never tried
- Tried 1-3 times
- Tried 4-6 times
- Tried 7-9 times
- Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **broccoli**?

Dislike very much | Dislike | Neither dislike or like | Like | Like very much

How many times has your child tried **brussel sprouts**?

- Never tried
- Tried 1-3 times
- Tried 4-6 times
- Tried 7-9 times
- Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **brussel sprouts**?

Dislike very much	Dislike	Neither dislike or like	Like	Like very much

How many times has your child tried **cabbage**?

- Never tried
- Tried 1-3 times
- Tried 4-6 times
- Tried 7-9 times
- Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **cabbage**?

Dislike very much	Dislike	Neither dislike or like	Like	Like very much

How many times has your child tried **capsicum**?

- ○ Never tried
- ○ Tried 1-3 times
- ○ Tried 4-6 times
- ○ Tried 7-9 times
- ○ Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **capsicum**?

Dislike very much	Dislike	Neither dislike or like	Like	Like very much
○	○	○	○	○

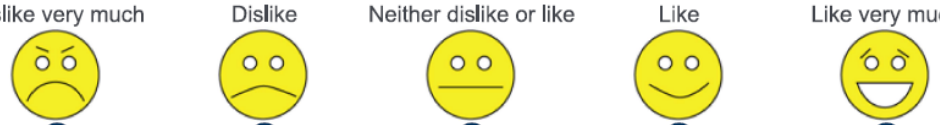
How many times has your child tried **carrots**?

- ○ Never tried
- ○ Tried 1-3 times
- ○ Tried 4-6 times
- ○ Tried 7-9 times
- ○ Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **carrots**?

Dislike very much	Dislike	Neither dislike or like	Like	Like very much
○	○	○	○	○



How many times has your child tried **cauliflower**?

- ○ Never tried
- ○ Tried 1-3 times
- ○ Tried 4-6 times
- ○ Tried 7-9 times
- ○ Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **cauliflower**?

Dislike very much	Dislike	Neither dislike or like	Like	Like very much
○	○	○	○	○

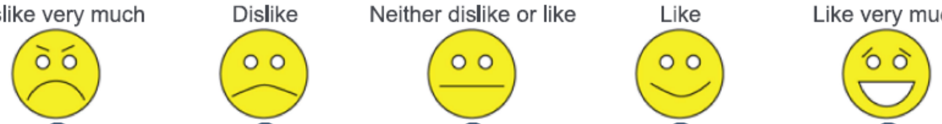
How many times has your child tried **corn**?

- ○ Never tried
- ○ Tried 1-3 times
- ○ Tried 4-6 times
- ○ Tried 7-9 times
- ○ Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **corn**?

Dislike very much	Dislike	Neither dislike or like	Like	Like very much
○	○	○	○	○



How many times has your child tried **courgette, zucchini or marrow**?

- Never tried
- Tried 1-3 times
- Tried 4-6 times
- Tried 7-9 times
- Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **courgette, zucchini or marrow**?

Dislike very much	Dislike	Neither dislike or like	Like	Like very much

How many times has your child tried **green beans or broad beans**?

- Never tried
- Tried 1-3 times
- Tried 4-6 times
- Tried 7-9 times
- Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **green beans or broad beans**?

Dislike very much	Dislike	Neither dislike or like	Like	Like very much

How many times has your child tried **kale**?

- Never tried
- Tried 1-3 times
- Tried 4-6 times
- Tried 7-9 times
- Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **kale**?

Dislike very much	Dislike	Neither dislike or like	Like	Like very much

How many times has your child tried **kumara**?

- Never tried
- Tried 1-3 times
- Tried 4-6 times
- Tried 7-9 times
- Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **kumara**?

Dislike very much	Dislike	Neither dislike or like	Like	Like very much

How many times has your child tried **lettuce**?

- Never tried
- Tried 1-3 times
- Tried 4-6 times
- Tried 7-9 times
- Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **lettuce**?

Dislike very much	Dislike	Neither dislike or like	Like	Like very much

How many times has your child tried **cucumber**?

- Never tried
- Tried 1-3 times
- Tried 4-6 times
- Tried 7-9 times
- Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **cucumber**?

Dislike very much	Dislike	Neither dislike or like	Like	Like very much

How many times has your child tried **mushrooms**?

- ○ Never tried
- ○ Tried 1-3 times
- ○ Tried 4-6 times
- ○ Tried 7-9 times
- ○ Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **mushrooms**?

Dislike very much	Dislike	Neither dislike or like	Like	Like very much

How many times has your child tried **onions**?

- ○ Never tried
- ○ Tried 1-3 times
- ○ Tried 4-6 times
- ○ Tried 7-9 times
- ○ Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **onions**?

Dislike very much	Dislike	Neither dislike or like	Like	Like very much

How many times has your child tried **celery**?

- ○ Never tried
- ○ Tried 1-3 times
- ○ Tried 4-6 times
- ○ Tried 7-9 times
- ○ Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **celery**?

Dislike very much	Dislike	Neither dislike or like	Like	Like very much
○	○	○	○	○

How many times has your child tried **green leafy vegetables (e.g. watercress, puha, salad greens)**?

- ○ Never tried
- ○ Tried 1-3 times
- ○ Tried 4-6 times
- ○ Tried 7-9 times
- ○ Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **green leafy vegetables (e.g. watercress, puha, salad greens)**?

Dislike very much	Dislike	Neither dislike or like	Like	Like very much
○	○	○	○	○

How many times has your child tried **green peas**?

- ○ Never tried
- ○ Tried 1-3 times
- ○ Tried 4-6 times
- ○ Tried 7-9 times
- ○ Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **green peas**?

Dislike very much	Dislike	Neither dislike or like	Like	Like very much

How many times has your child tried **potato (baked, mashed, boiled or roasted)**?

Note: **excludes** store bought potato crisps.

- ○ Never tried
- ○ Tried 1-3 times
- ○ Tried 4-6 times
- ○ Tried 7-9 times
- ○ Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

*How much does your child like **potato (baked, mashed, boiled, roasted)**?*

Note: ***excludes*** store bought potato crisps.

Dislike very much	Dislike	Neither dislike or like	Like	Like very much

How many times has your child tried **pumpkin**?

- ○ Never tried
- ○ Tried 1-3 times
- ○ Tried 4-6 times
- ○ Tried 7-9 times
- ○ Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **pumpkin**?

Dislike very much	Dislike	Neither dislike or like	Like	Like very much

How many times has your child tried **yams**?

- ○ Never tried
- ○ Tried 1-3 times
- ○ Tried 4-6 times
- ○ Tried 7-9 times
- ○ Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **yams**?

Dislike very much	Dislike	Neither dislike or like	Like	Like very much

How many times has your child tried **radishes**?

- ○ Never tried
- ○ Tried 1-3 times
- ○ Tried 4-6 times
- ○ Tried 7-9 times
- ○ Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **radishes**?

Dislike very much	Dislike	Neither dislike or like	Like	Like very much

How many times has your child tried **spinach or silverbeet**?

- ○ Never tried
- ○ Tried 1-3 times
- ○ Tried 4-6 times
- ○ Tried 7-9 times
- ○ Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **spinach or silverbeet**?

Dislike very much	Dislike	Neither dislike or like	Like	Like very much

How many times has your child tried **sprouted beans and seeds**?

- Never tried
- Tried 1-3 times
- Tried 4-6 times
- Tried 7-9 times
- Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **sprouted beans and seeds**?

Dislike very much	Dislike	Neither dislike or like	Like	Like very much

How many times has your child tried **tomatoes**?

- Never tried
- Tried 1-3 times
- Tried 4-6 times
- Tried 7-9 times
- Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **tomatoes**?

Dislike very much	Dislike	Neither dislike or like	Like	Like very much

Fruit - 9 months old

Thank you for taking the time to complete this questionnaire.
It should take approximately **15 minutes** to complete.

This is **not a test.** Your answers will help us learn about the **fruits** that your child likes and dislikes.

Questions will ask about what fruits your baby has tried over the last 3 months (starting from after completing the 4 week trial).

If you have any questions, please contact:
Jeanette Rapson on 0210773419 | vegesfirst@massey.ac.nz
or Dr Cath Conlon on 09 4140800 ext 43658 | C.Conlon@massey.ac.nz

Website: www.vegesfirststudy.co.nz

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Please enter your **three digit** participant number:

Note: *this number was sent to you by email. It will be used to match up data sets,* ***not*** *to personally identify you.*

How many times has your child tried **apple**?

Remember: all questions ask about what fruits your baby has tried over the last 3 months (starting from <u>after</u> competing the 4 week trial).

- ○ Never tried
- ○ Tried 1–3 times
- ○ Tried 4–6 times
- ○ Tried 7–9 times
- ○ Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **apple**?

Dislike very much | Dislike | Neither dislike or like | Like | Like very much

How many times has your child tried **banana**?

- ○ Never tried
- ○ Tried 1–3 times
- ○ Tried 4–6 times
- ○ Tried 7–9 times
- ○ Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **banana**?

Dislike very much | Dislike | Neither dislike or like | Like | Like very much

How many times has your child tried **kiwifruit**?

- Never tried
- Tried 1-3 times
- Tried 4-6 times
- Tried 7-9 times
- Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **kiwifruit**?

Dislike very much | Dislike | Neither dislike or like | Like | Like very much

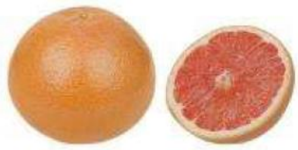
How many times has your child tried **cherries**?

- Never tried
- Tried 1-3 times
- Tried 4-6 times
- Tried 7-9 times
- Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **cherries**?

Dislike very much | Dislike | Neither dislike or like | Like | Like very much



How many times has your child tried **grapefruit**?

- Never tried
- Tried 1-3 times
- Tried 4-6 times
- Tried 7-9 times
- Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **grapefruit**?

Dislike very much | Dislike | Neither dislike or like | Like | Like very much

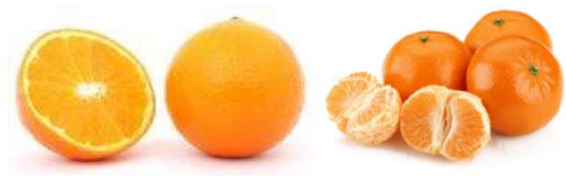
How many times has your child tried **lemon**?

- Never tried
- Tried 1-3 times
- Tried 4-6 times
- Tried 7-9 times
- Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **lemon**?

Dislike very much | Dislike | Neither dislike or like | Like | Like very much



How many times has your child tried **oranges or mandarins**?

- Never tried
- Tried 1-3 times
- Tried 4-6 times
- Tried 7-9 times
- Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **oranges or mandarins**?

Dislike very much	Dislike	Neither dislike or like	Like	Like very much

How many times has your child tried **feijoa**?

- Never tried
- Tried 1-3 times
- Tried 4-6 times
- Tried 7-9 times
- Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **feijoa**?

Dislike very much	Dislike	Neither dislike or like	Like	Like very much

How many times has your child tried **grapes**?

- Never tried
- Tried 1-3 times
- Tried 4-6 times
- Tried 7-9 times
- Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **grapes**?

Dislike very much | Dislike | Neither dislike or like | Like | Like very much

How many times has your child tried **mango**?

- Never tried
- Tried 1-3 times
- Tried 4-6 times
- Tried 7-9 times
- Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **mango**?

Dislike very much | Dislike | Neither dislike or like | Like | Like very much

How many times has your child tried **melon (e.g. honeydew, rock melon)**?

- ○ Never tried
- ○ Tried 1-3 times
- ○ Tried 4-6 times
- ○ Tried 7-9 times
- ○ Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **melon (e.g. honeydew, rock melon)**?

Dislike very much | Dislike | Neither dislike or like | Like | Like very much

How many times has your child tried **pear**?

- ○ Never tried
- ○ Tried 1-3 times
- ○ Tried 4-6 times
- ○ Tried 7-9 times
- ○ Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **pear**?

Dislike very much | Dislike | Neither dislike or like | Like | Like very much

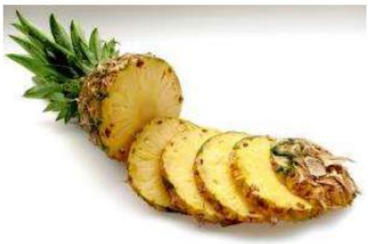
How many times has your child tried **nashi pear (Chinese pear)**?

- Never tried
- Tried 1–3 times
- Tried 4–6 times
- Tried 7–9 times
- Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **nashi pear (Chinese pear)**?

Dislike very much	Dislike	Neither dislike or like	Like	Like very much



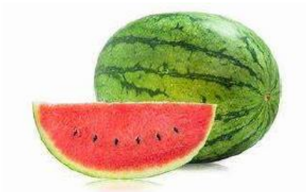
How many times has your child tried **pineapple**?

- Never tried
- Tried 1–3 times
- Tried 4–6 times
- Tried 7–9 times
- Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **pineapple**?

Dislike very much	Dislike	Neither dislike or like	Like	Like very much



How many times has your child tried **watermelon**?

- Never tried
- Tried 1-3 times
- Tried 4-6 times
- Tried 7-9 times
- Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **watermelon**?

Dislike very much	Dislike	Neither dislike or like	Like	Like very much

How many times has your child tried **apricot**?

- Never tried
- Tried 1-3 times
- Tried 4-6 times
- Tried 7-9 times
- Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **apricot**?

Dislike very much	Dislike	Neither dislike or like	Like	Like very much

How many times has your child tried **nectarine**?

- ◯ Never tried
- ◯ Tried 1-3 times
- ◯ Tried 4-6 times
- ◯ Tried 7-9 times
- ◯ Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **nectarine**?

Dislike very much	Dislike	Neither dislike or like	Like	Like very much
◯	◯	◯	◯	◯

How many times has your child tried **pawpaw (papaya)**?

- ◯ Never tried
- ◯ Tried 1-3 times
- ◯ Tried 4-6 times
- ◯ Tried 7-9 times
- ◯ Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **pawpaw (papaya)**?

Dislike very much	Dislike	Neither dislike or like	Like	Like very much
◯	◯	◯	◯	◯

How many times has your child tried **peach**?

- ○ Never tried
- ○ Tried 1-3 times
- ○ Tried 4-6 times
- ○ Tried 7-9 times
- ○ Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **peach**?

Dislike very much	Dislike	Neither dislike or like	Like	Like very much

How many times has your child tried **persimmon**?

- ○ Never tried
- ○ Tried 1-3 times
- ○ Tried 4-6 times
- ○ Tried 7-9 times
- ○ Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **persimmon**?

Dislike very much	Dislike	Neither dislike or like	Like	Like very much

How many times has your child tried **plum**?

- Never tried
- Tried 1-3 times
- Tried 4-6 times
- Tried 7-9 times
- Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **plum**?

Dislike very much	Dislike	Neither dislike or like	Like	Like very much

How many times has your child tried **lychee**?

- Never tried
- Tried 1-3 times
- Tried 4-6 times
- Tried 7-9 times
- Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **lychee**?

Dislike very much	Dislike	Neither dislike or like	Like	Like very much

How many times has your child tried **avocado**?

- ◯ Never tried
- ◯ Tried 1-3 times
- ◯ Tried 4-6 times
- ◯ Tried 7-9 times
- ◯ Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **avocado**?

Dislike very much	Dislike	Neither dislike or like	Like	Like very much

How many times has your child tried **olives**?

- ◯ Never tried
- ◯ Tried 1-3 times
- ◯ Tried 4-6 times
- ◯ Tried 7-9 times
- ◯ Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **olives**?

Dislike very much	Dislike	Neither dislike or like	Like	Like very much

How many times has your child tried **rhubarb (cooked)**?

- Never tried
- Tried 1-3 times
- Tried 4-6 times
- Tried 7-9 times
- Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **rhubarb (cooked)**?

Dislike very much	Dislike	Neither dislike or like	Like	Like very much

How many times has your child tried **tamarillo**?

- Never tried
- Tried 1-3 times
- Tried 4-6 times
- Tried 7-9 times
- Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **tamarillo**?

Dislike very much	Dislike	Neither dislike or like	Like	Like very much

How many times has your child tried **canned fruit, e.g. peaches, pear, fruit salad**?

- ○ Never tried
- ○ Tried 1-3 times
- ○ Tried 4-6 times
- ○ Tried 7-9 times
- ○ Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **canned fruit, e.g. peaches, pear, fruit salad**?

Dislike very much	Dislike	Neither dislike or like	Like	Like very much

○	○	○	○	○

Which of the following does your child usually eat? *You may tick more than one.*

- ☐ Canned fruit in juice
- ☐ Canned fruit in light syrup
- ☐ Canned fruit in syrup

How many times has your child tried **blueberries**?

- Never tried
- Tried 1-3 times
- Tried 4-6 times
- Tried 7-9 times
- Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **blueberries**?

Dislike very much	Dislike	Neither dislike or like	Like	Like very much

How many times has your child tried **strawberries**?

- Never tried
- Tried 1-3 times
- Tried 4-6 times
- Tried 7-9 times
- Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **strawberries**?

Dislike very much	Dislike	Neither dislike or like	Like	Like very much

How many times has your child tried **other berries, e.g. raspberries, blackberries**?

- Never tried
- Tried 1-3 times
- Tried 4-6 times
- Tried 7-9 times
- Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **other berries, e.g. raspberries, blackberries**?

Dislike very much	Dislike	Neither dislike or like	Like	Like very much

How many times has your child tried **sultanas, raisins, dried currants or figs**?

- Never tried
- Tried 1-3 times
- Tried 4-6 times
- Tried 7-9 times
- Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **sultanas, raisins, dried currents or figs**?

Dislike very much	Dislike	Neither dislike or like	Like	Like very much

How many times has your child tried **dried apricots, prunes, dates or mixed dried fruit**?

- Never tried
- Tried 1-3 times
- Tried 4-6 times
- Tried 7-9 times
- Tried 10+ times

Display next question IF NOT 'Never tried' answered in previous question

How much does your child like **dried apricots, prunes, dates or mixed fruit**?

Dislike very much | Dislike | Neither dislike or like | Like | Like very much

Note. Created using Qualtrics Survey Software by the PhD candidate. The same questionnaire was used at 12 months of age with the introduction page adjusted accordingly. Vegetable images from www.Vegetables.co.nz with permission. Likert scale faces created by PhD candidate using Adobe illustrator. Fruit images sourced from www.pixabay.com without attribution required, or were found online through google images using 'free to share and use' filter. Likert scale faces created by PhD candidate using Adobe illustrator.

Appendix L: Compliance questionnaire

2-minute check in!

We would love to check in with you and see how you are going.

Please enter your **three digit** participant number:

Note: this number was sent to you by email. It will be used to match up data sets, **not** to personally identify you.

How many **days** did you offer the baby food that we provided **in the last 7 days**?

- 0
- 1
- 2
- 3
- 4
- 5
- 6
- 7 (every day)

Display next question IF 'How many days did you offer the baby food that we provided in the last 7 days?' ! = 7 (every day)

On days that you **did not** provide our baby food, please tick the reason(s) below.
There is no right or wrong answer.

- ☐ I didn't have time
- ☐ I was unwell
- ☐ Baby was unwell
- ☐ I forgot
- ☐ Not sure
- ☐ Other, please specify: ______

Which of the following applies to your baby's feeding **in the last 7 days**? *You may tick more than one.*

Helpful hint: If your baby was unwell one day, yet was distracted on a different day, please tick both.

- ☐ My baby was unwell
- ☐ My baby was feeling upset, grizzly or tired
- ☐ Teething
- ☐ Baby fussiness
- ☐ My baby was distracted (e.g. by noise, people or television)
- ☐ My baby wasn't hungry
- ☐ Feeding away from home
- ☐ Not sure
- ☐ No, nothing affected my baby's feeding
- ☐ Other, please specify: ______

Has your baby had any of the following **in the last 7 days**?

- ☐ Antibiotics

☐ Probiotics

☐ None of the above

Did you offer any other **food or drink** (other than breastmilk, infant formula or water) to your baby **in the last 7 days**?

○ No

○ Yes, please specify:

Is there anything else that you would like to tell us about feeding your baby **in the last 7 days**?

Note. if 'choose not to answer', 'not sure' or 'no nothing affected my baby's feeding' were selected, other selected items for that question would automatically deselect. A compliance questionnaire was sent to participants via email at the end of each week during the four-week intervention. Created on Qualtrics Survey Software by the PhD candidate.

Appendix M: E-cards and invites

Effort was taken to build rapport with participants to improve sample retention. This section provides examples of the correspondence between the research team and participants.

Rapson, Jeanette

From:	Rapson, Jeanette
Sent:	Saturday, 15 June 2019 2:27 PM
To:	Rapson, Jeanette
Subject:	Veges First Study - success!

Dear

Congratulations on your baby! We are pleased to inform you that you are eligible for the Veges First Study.

Your participant number is:

To get started, please complete the following questionnaires.

Consent form - 2 min

About you - 10 min

Baby eating behaviour questionnaire (before solids) - 5 min

Pregnancy - survey 1 - 15 min

Pregnancy - survey 2 - 20 min

Lactation - survey 1 - 15 min

Lactation - survey 2 - 20 min

Please let me know once you have completed all the questionnaires. We can then arrange your first visit to our Research Unit in Albany where you will be able to meet with a NZ Registered dietitian, receive free resources, nutritious baby foods and health assessments.

Kind regards,

Jeanette Rapson
NZ Registered Dietitian and Lead Researcher

Mobile: 021 0773419 | www.vegesfirststudy.co.nz

Rapson, Jeanette

From:	Rapson, Jeanette
Sent:	Saturday, 1 June 2019 8:01 AM
To:	Rapson, Jeanette
Subject:	Veges First Study - Week 1 complete!

Congratulations! You have completed your first week of starting solids. We hope you and your baby have enjoyed it.

Please click the link and complete a 2-minute survey below. You will receive these weekly until the end of the 4-week trial.

2-minute survey

We really appreciate your time and effort. If you have any questions, please let me know.

Thanks,

Jeanette Rapson
NZ Registered Dietitian and Lead Researcher

Mobile: 021 0773419 | www.vegesfirststudy.co.nz

From: Rapson, Jeanette <J.Rapson@massey.ac.nz>
Sent: Wednesday, 22 January 2020 3:33 PM
To: Rapson, Jeanette <J.Rapson@massey.ac.nz>
Subject: Happy birthday

We just wanted to wish [insert baby name] a happy 1st birthday! We hope that you have a lovely day and enjoy this special milestone!

We have really appreciated all your help on the study. I will send you details for the 12 month online questionnaires.

Kind regards,

Jeanette Rapson
NZ Registered Dietitian and Lead Researcher

Mobile: 021 0773419 | www.vegesfirststudy.co.nz

Rapson, Jeanette

From: Rapson, Jeanette
Sent: Sunday, 10 May 2020 9:33 AM
Subject: Happy Mother's Day! Veges First Study

Dear Mums,

We just wanting to wish you a Happy Mother's day! We hope that you enjoy this special day with your family and little one. Thank you again for all your ongoing support with the Veges First Study. Your babies have brought so many smiles to the team and always brighten our day!

Kind regards,

Jeanette Rapson
NZ Registered Dietitian and Lead Researcher

Mobile: 021 0773419 | www.vegesfirststudy.co.nz

Rapson, Jeanette

From: Rapson, Jeanette
Sent: Saturday, 21 December 2019 9:53 AM
Cc: Mugridge, Owen
Subject: MERRY CHRISTMAS! Veges First Study

Hi there!

We just wanted to thank you for all your amazing support and participation in the Veges first study this year! We have thoroughly enjoyed meeting you and thanks to you, our research is becoming a great success. We are still recruiting up until the end of January. So if you know of any other mums who would like to participate, it's not too late!

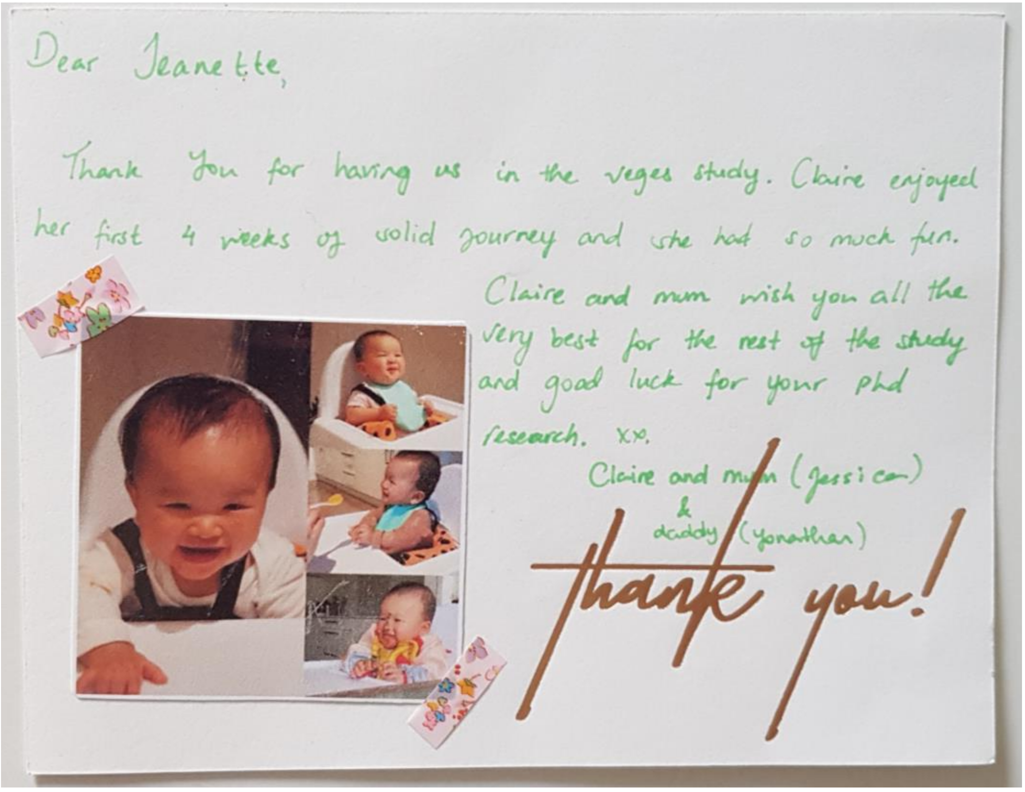
We wish you a safe and happy holiday!! Merry Christmas and a great New Year!

We will be out of office until 6th January 2020. However, please still email or text us if you start your trial over the holiday period. For other matters or questions, please contact Jeanette 0210773419.

Thanks again – we really couldn't be doing this study without you.

Kind regards,
Jeanette Rapson and the Veges First team.

Mobile: 021 0773419 | www.vegesfirststudy.co.nz



Thank you card from a participant. Included in thesis with permission from mother.

Appendix N: Study website

Welcome page (screenshot)

Home Update Team Contact Resources Share

Welcome!

Taste preferences start to develop early in life and can influence food choices. As you may know it can be difficult to get children to eat their veggies! We want to explore how feeding babies a variety of vegetables and fruit as first foods can help.

By participating in the research, you can help provide evidence for infant feeding and nutrition guidelines. If children learn to like vegetables, they may be more likely to practice healthy eating habits later in life.

What happens in the study?

Feeding regime

As soon as you think your baby is ready to start solids, we will ask you to feed them age appropriate infant foods that we provide FREE for 4-weeks. We would also like you to take a few video recordings of your baby trying the foods and keep a weighed infant food diary.

Clinic visits and questionnaires

You will need to visit our Massey University Human Nutrition Research Unit in Albany, Auckland before you baby starts solids. Follow-up visits are at the end of the 4-week trial, when your baby is 9 months and 12 months of age.
Each visit takes about 1 hour.

During these visits we will ask, for example, to provide a heel prick blood spot and a stool sample using a simple collection kit. In addition to home visits, we will ask you, via online questionnaires, about your diet, exercise, and health; as well as how much you think your baby liked the foods. Questionnaires vary in length from 10 to 20 minutes.

Note. Website and banner created by PhD candidate using Wix.com (premium plan), Shutterstock® images and Canva.

Registration page (screenshot)

Home Register Team Contact Resources Share

Do you have a **baby getting ready to start solids?**
We want to invite you to participate in our study.

What you'll need to do:

- Be living in Auckland
- Feed your baby recommended infant foods for 4 weeks
- Fill in simple questionnaires and baby food diary
- Provide blood and stool samples, and child growth measurements
- Video record your baby trying foods for the first time

You will receive FREE:

- Infant feeding and **nutrition support** from an NZ registered dietitian
- **Nutritious baby foods** during the 4-week trial
- **Iron** and **vitamin D** status assessments for you and your baby
- Infant **growth assessments**
- **Fun DVD** of your baby's first food experiences

Information sheet (pdf) Check if you are eligible

Interested?
Please register for further information.

Name

Email Address

Register your interest

Share

Contact

MASSEY UNIVERSITY
TE KUNENGA KI PŪREHUROA
UNIVERSITY OF NEW ZEALAND
COLLEGE OF HEALTH
TE KURA HAUORA TANGATA

Update page (screenshot)

Home Update Team Contact Resources Share

Thank you to all the mums and babies who have signed up and taken part in our study. We have now met our target number and will no longer be recruiting any new babies.

We are now in the process of analysing results - so please stay tuned.

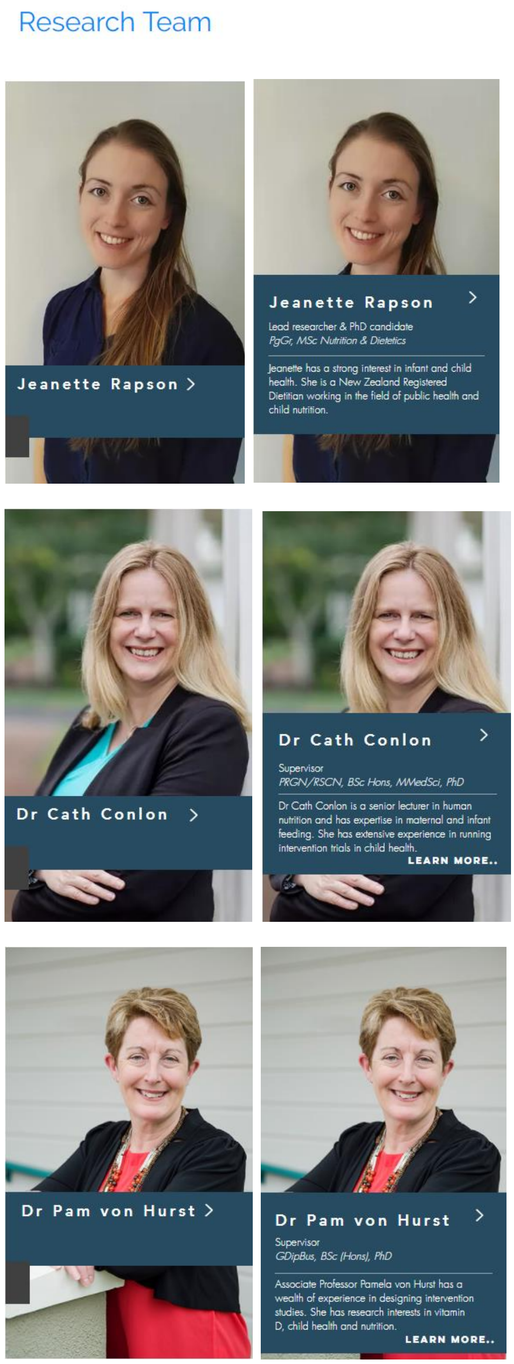
We have been overwhelmed by your community support. We could not do this without you! So thank you again.

Contact

Share

Note. Once recruitment was complete, the registration page was hidden and replaced with an update on the study's progress.

Team page (screenshot)



Note. Visitor hovers mouse/curser over the researcher's name (left) to view qualifications and expertise (right).

Contact page (screenshot)

Home Update Team Contact Resources Share

Get in touch

Jeanette Rapson - Lead Researcher

021 0773419

vegesfirst@massey.ac.nz

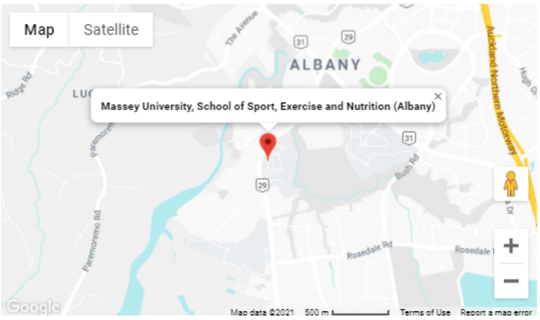
Location
Massey University, Albany
Oteha Rohe Campus (not the main campus)
Gate 4, Turitea Place
Albany 0632
Auckland

Postal address
Massey University
Private Bag 102904
North Shore City
Auckland 0745
New Zealand

Reception - Building 80

Human and Nutrition Research Unit - Building 27

Download map



Contact form

First name *

Last name *

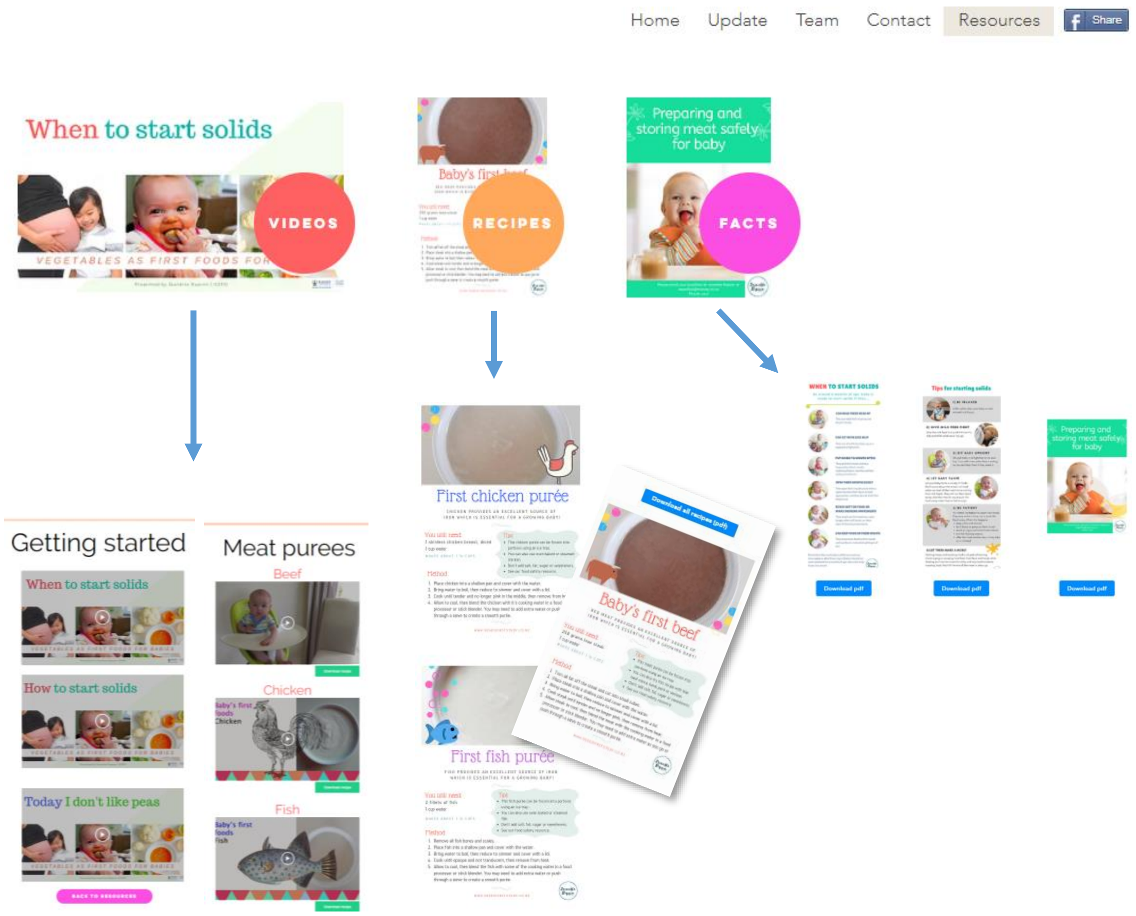
Email *

Subject

Message

Send

Resources section (screenshot)



Note. Study participants were given a password to obtain exclusive access to this section for the duration of the study. Clicking on each topic redirected participants to free downloadable infant feeding resources specifically designed to support the study. See **Appendix D** for details on each resource.

Appendix O: Supplementary material (chapter 4)

Table O1. Intake of each food, on the first week compared to the last week for veg-only and control groups

	Week one	Week four	P-value*
Veg-only (n = 61)			
Spinach/potato	16.0 (7.25, 25.50)	27.0 (13.00, 43.50)	0.001
Potato	18.5 (8.50, 35.50)	53.0 (23.50, 75.50)	0.001
Beetroot/potato	14.0 (8.75, 27.75)	27.3 (14.00, 45.00)	< 0.001
Green bean	19.0 (11.13, 31.00)	33.0 (17.50, 53.25)	< 0.001
Control (n = 59)			
Apple/spinach	15.0 (10.0, 22.4)	30.0 (12.8, 55.1)	< 0.001
Pear	20.5 (12.3, 32.6)	29.0 (15.1, 50.4)	< 0.001
Pear/beetroot	22.0 (10.5, 35.5)	31.5 (15.5, 50.5)	0.012
Pumpkin	17.0 (6.6, 29.5)	16.8 (10.3, 30.1)	0.603

Note. Data presented as median (25th, 75th percentile). Wilcoxon signed-rank test performed.
*Significant at the P < 0.05 level.

Table O2. Liking of each food, on the first week compared to the last week for veg-only and control groups

	Week one	Week four	P-Value*
Veg-only (n = 61)			
Spinach/potato	2.90 (1.04)	3.33 (1.01)	0.007
Potato [a]	2.75 (0.92)	3.73 (1.01)	< 0.001
Beetroot/potato	3.11 (1.13)	3.51 (1.04)	0.018
Green bean	3.18 (0.90)	3.54 (0.92)	0.008
Control (n = 59)			
Apple/spinach	3.13 (1.01)	3.59 (1.12)	0.005
Pear	3.16 (1.09)	3.96 (1.14)	< 0.001
Pear/beetroot	3.16 (1.12)	3.59 (1.12)	0.004
Pumpkin	2.59 (1.07)	2.75 (1.15)	0.402

Note. Data presented as mean ± SD. Wilcoxon signed-rank test performed. [a] One case missing as a liking score was not provided in week four. *Significant at the P < 0.05 level.

Table O3. Rate of intake of each food, on the first week compared to the last week for veg-only and control groups

	Week one	Week four	P-Value*
Veg-only (n = 61)			
Spinach/potato	1.6 (0.8, 2.1)	2.4 (1.3, 4.3)	0.001
Potato	2.1 (1.1, 3.3)	4.4 (2.2, 6.7)	< 0.001
Beetroot/potato	1.6 (1.0, 2.9)	2.4 (1.5, 4.2)	< 0.001
Green bean	1.9 (1.2, 3.4)	2.9 (1.5, 5.3)	0.001
Control (n = 59)			
Apple/spinach	1.6 (1.1, 2.4)	2.6 (1.5, 3.8)	< 0.001
Pear	2.4 (1.4, 3.3)	3.1 (1.5, 4.4)	0.055
Pear/beetroot	2.0 (1.5, 3.1)	2.9 (2.0, 4.8)	0.001
Pumpkin	1.7 (0.9, 2.4)	2.0 (1.0, 3.2)	0.016

Note. Log transformation improved day normality; original medians reported were close to the geometric means. Paired samples t-test performed. *Significant at the P < 0.05 level.

Appendix P: Supplementary material (chapter 5)

Table P1. Baseline characteristics of infants and mothers were completed the study at 9 months (n = 108) and those who were lost to follow-up (n = 9)

	Completers	Non-completers
Treatment groups		
Veg-only	56 (52 %)	5 (8 %)
Controls (fruit + veg)	52 (48 %)	4 (44 %)
Infants' characteristics		
Age on day 1 of trial (weeks)	23.5 ± 2.6	24.2 ± 2.6
Sex (female)	55 (51 %)	5 (56 %)
Weight (kg)	7.0 ± 0.9	7.2 ± 0.9
Length (cm)	64.1 ± 2.9	64.5 ± 4.8
Head circumference (cm)	42.5 ± 1.4	42.8 ± 1.1
EBF duration (months)	5.0 (2.0, 5.0)	4.0 (0.8, 5.0)
Milk feeding type [a]		
Breast milk only	60 (56 %)	4 (44 %)
Infant formula only	14 (13 %)	2 (22 %)
Both breast/formula milk	34 (32 %)	3 (33 %)
Baby eating behaviour questionnaire		
Enjoyment of food	4.24 (0.49)	4.33 (0.41)
Food responsiveness	2.50 (0.66)	2.59 (0.75)
Satiety responsiveness	2.56 (0.57)	2.78 (0.62)
Slowness in eating	2.60 (0.71)	2.92 (0.41)
General Appetite	3.71 (0.84)	4.11 (0.78)
Mothers' characteristics		
Age on day 1 of trial (years)	33 ± 4	33 ± 5
Education		
Below university	8 (7 %)	1 (11 %)
University or higher	100 (93 %)	8 (89 %)
Ethnic origin [b]		

	Completers	Non-completers
NZ European and others	97 (90 %)	7 (78 %)
Māori and Pacific Island	6 (6 %)	2 (22 %)
Others (e.g., Chinese, Indian)	10 (9 %)	1 (11 %)
Primiparous (first time mothers yes, %)	81 (75 %)	4 (44 %)

Note. EBF = exclusive breastfeeding. Data presented as mean ± SD, numbers (%) or median (25^{th}, 75^{th} percentile), unless otherwise stated. [a] Describes milk feeding type during the 4-week trial. [b] Multiple answers were possible.

Table P2

Spearman's rho (r_s) Correlations for Study Food Intake and Overall Liking

Variable	Intake	Positive behaviour	Negative behaviour	Rate of eating
Veg-only				
Broccoli				
Intake				
Positive behaviour	.43**			
Negative behaviour	-.55**	-.49**		
Rate of acceptance	.33*	.61**	-.60**	
Rate of eating	.67**	.13	-.31*	
Spinach				
Intake				
Positive behaviour	.55**			
Negative behaviour	-.56**	-.38**		
Rate of acceptance	.71**	.61**	-.53**	
Rate of eating	.53**	.89*	-.32*	
Pear				
Intake				
Positive behaviour	.29*			
Negative behaviour	-.22	-.60**		
Rate of acceptance	.39**	.49**	-.52**	
Rate of eating	.39**	.20	-.44**	
Control				
Broccoli				
Intake				
Positive behaviour	.68**			
Negative behaviour	-.55**	-.74**		
Rate of acceptance	.64**	.73**	-.66**	
Rate of eating	.84**	.58**	-.63**	
Spinach				

Variable	Intake	Positive behaviour	Negative behaviour	Rate of eating
Intake				
Positive behaviour	.53**			
Negative behaviour	-.49**	-.42**		
Rate of acceptance	.56**	.71**	-.81**	
Rate of eating	.56**	.10	-.26	
Pear				
Intake				
Positive behaviour	.41**			
Negative behaviour	-.39**	-.47**		
Rate of acceptance	.34*	.48**	-.66**	
Rate of eating	.54**	.44**	-.41**	

*P < 0.05, **P < 0.01.

Appendix Q: Supplementary material (chapter 7)

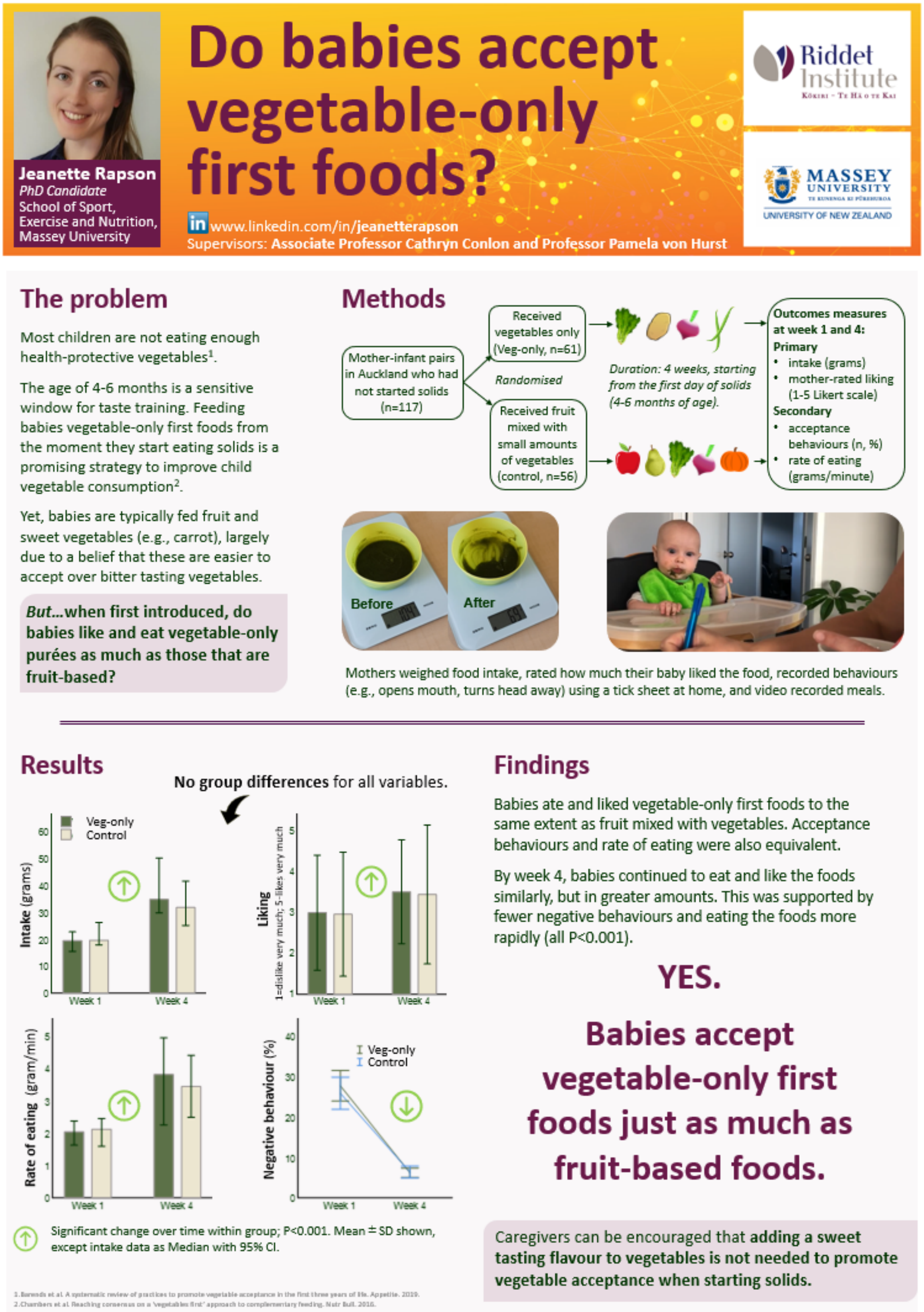
Table Q1. Baseline characteristics of infants and mothers who were included in the analysis of iron status at 9 months (n = 75) and those who were excluded (n = 42)

	Completers	Non-completers
Treatment groups		
Veg-only	33 (44 %)	28 (67 %)
Controls	42 (75 %)	14 (33 %)
Infants' characteristics		
Age on day 1 of trial (weeks)	23.3 ± 2.3	24.2 ± 3.0
Sex (female)	42 (56 %)	18 (43 %)
Weight (kg)	7.0 ± 0.9	7.0 ± 0.8
Length (cm)	64.0 ± 2.9	64.3 ± 3.4
Head circumference (cm)	42.5 ± 1.4	42.6 ± 1.4
EBF duration (months)	5.0 (2.0, 5.0)	4.0 (0.8, 5.0)
Milk feeding type [a]		
Breast milk only	42 (56 %)	22 (52 %)
Infant formula only	10 (13 %)	6 (14 %)
Both breast/formula milk	23 (31 %)	14 (33 %)
Baby eating behaviour questionnaire		
Enjoyment of food	4.26 (0.50)	4.23 (0.47)
Food responsiveness	2.52 (0.70)	2.49 (0.60)
Satiety responsiveness	2.56 (0.61)	2.60 (0.52)
Slowness in eating	2.51 (0.71)	2.83 (0.63)
General Appetite	3.71 (0.84)	3.81 (0.86)
Mothers' characteristics		
Age on day 1 of trial (years)	33 ± 4	34 ± 5
Education		
Below university	4 (44 %)	5 (56 %)
University or higher	72 (95 %)	37 (88 %)

	Completers	Non-completers
Ethnic origin [b]		
NZ European and others	66 (88 %)	38 (91 %)
Māori and Pacific Island	6 (8 %)	2 (5 %)
Others (e.g., Chinese, Indian)	7 (9 %)	4 (10 %)
Primiparous (first time mothers yes, %)	56 (75 %)	29 (69 %)

Note. EBF = exclusive breastfeeding. Data presented as mean ± SD, numbers (%) or median (25^{th}, 75^{th} percentile), unless otherwise stated. [a] Describes milk feeding type during the 4-week trial. [b] Multiple answers were possible.

Appendix R: Poster presentation



Note. Poster presentation of findings from the 4-week intervention. Presented at the Riddet Institute Student Colloquium, March 2020, Wellington, New Zealand.

Appendix S: Image and icon attributions

Images, photographs and icons were sourced online (i.e., www.pixabay.com, Clipart Library), created by the PhD candidate, or purchased from Shutterstock®. This section provides the attributions required for the images/icons that require attribution.

Graphical abstract

‘New Zealand’ image by Yohann Berger from the Noun Project.

Section 2.3

‘Vitamin’ image, ‘baby growth’ image, ‘intestine’ image, ‘immunity’ image: Flaticon.com. These have been used under a CC BY-SA 4.0 International license.

‘Barriers to vegetable intake’ image (cropped) by Sorina Răsteanu CC BY-NC 2.0.

Figure 2.2 – 2.6, 2.8

Vegetables/fruit (‘parsnip’, ‘artichoke’, ‘broccoli’, ‘green bean’, ‘apple’, ‘plum’, ‘banana’, ‘pear’, ‘peach’) images, ‘cereal’ image, ‘head with lightening’ image, ‘milk bottle’ image, ‘heart in hand’ image: Flaticon.com. Figures were created using resources from Flaticon.com. These have been used under a CC BY-SA 4.0 International license.

Appendix T: Contribution forms

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We, the candidate and the candidate's Primary Supervisor, certify that all co-authors have consented to their work being included in the thesis and they have accepted the candidate's contribution as indicated below in the *Statement of Originality*.

Name of candidate:	Jeanette Rapson
Name/title of Primary Supervisor:	Associate Professor Cathryn Conlon
Name of Research Output and full reference:	
Rapson, P. J., von Hurst, P. R., Hetherington, M. M., Conlon, A. C. (in press). Impact of a 'vegetables first' approach to complementary feeding on later intake and liking of vegetables in infants: A study protocol for a randomised controlled trial. *Trials.*	
In which Chapter is the Manuscript /Published work:	Chapter 3
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Date:	22/07/2021
Primary Supervisor's Signature:	
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Name of candidate:	Jeanette Rapson
Name/title of Primary Supervisor:	Associate Professor Cathryn Conlon
Name of Research Output and full reference:	
Rapson, J. P., Conlon, A. C., Hetherington, M. M., von Hurst, P. R. Vegetable acceptance and liking at the start of complementary feeding: a randomized controlled trial.	
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Name/title of Primary Supervisor:	Associate Professor Cathryn Conlon
Name of Research Output and full reference:	
Rapson, J. P., von Hurst, P. R., Hetherington, M. M., Conlon, A. C. Starting complementary feeding with vegetables only increases vegetable acceptance at nine months: a randomized controlled trial.	
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Rapson, J. P., von Hurst, P. R., Hetherington, M. M., Conlon, A. C. Higher vegetable consumption maintained at 12 months of age when infants start complementary feeding with vegetables-only: follow-up of a randomised controlled trial.	
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Rapson, J. P., Conlon, A. C., Mazahery, H., von Hurst, P. R. Iron status of infants participating in a 'vegetables first' complementary feeding intervention.	
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For manuscripts intended for publication please indicate target journal:	
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