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The influence of habitual dietary intake on the responsiveness of the gut microbiota to a dietary intervention

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

Doctor of Philosophy

in

Nutritional Science

at Massey University, Manawatu, New Zealand

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2017
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Abstract

Preliminary evidence suggests that inter-individual variability in gut microbiota response to a dietary intervention is influenced by baseline gut microbiota composition. Differing habitual dietary intakes lead to distinctions in baseline gut microbiota composition making it plausible that habitual dietary intake may also influence gut microbiota response. Prior to conducting this research no studies had been undertaken to determine whether habitual dietary intake has an impact on gut microbiota responsiveness. Therefore, the aim of this research was to investigate the influence habitual dietary intake has on gut microbiota response to a dietary intervention.

Initially, secondary data analysis was conducted to determine whether there was any support for the hypothesis that individuals with differing habitual dietary intakes would have gut microbiota that respond in a distinctive manner to a dietary intervention. The secondary data analysis results demonstrated that dietary groups rich in dietary fibre had the greatest impact on gut microbiota responsiveness. An *in vitro* three-stage colonic model system study was conducted to determine whether media with differing fermentable carbohydrate (i.e. dietary fibre) contents influenced gut microbiota response to an inulin-type fructan prebiotic. It was demonstrated that differing prebiotic driven changes in organic acids and bacterial taxa occurred between the low (LFC) and high fermentable carbohydrate (HFC) content media. The results of the secondary data analysis and *in vitro* study provided evidence to suggest that a human intervention study was warranted. A randomised, double-blind, placebo-controlled, cross-over, human intervention study in 34 healthy participants was undertaken to determine whether habitual dietary fibre intake influenced gut microbiota response to an inulin-type fructan prebiotic. The results of the human intervention study demonstrated that the low habitual
dietary fibre (LDF) group harboured gut microbiota that were less responsive to the
inulin-type fructan prebiotic than the high habitual dietary fibre (HDF) group.

Future studies which aim to modulate the gut microbiota via dietary change or to
determine the prebiotic potential of a novel fermentable substrate should take habitual
dietary fibre intakes into consideration when recruiting participants or analysing the data.
This will help reduce the confounding influence of inter-individual variability in gut
microbiota responsiveness and ensure the true efficacy of a dietary intervention is
demonstrated.
Acknowledgements

I would like to take the opportunity to thank the following individuals and organisations who contributed to making the completion of this thesis possible:

- My PhD supervisors, Professor Jane Coad, Associate Professor Rinki Murphy, Dr Louise Brough and Dr Chrissie Butts for the greatly appreciated guidance and continued support provided throughout my PhD;
- Professor Kevin Whelan for providing expertise relating to the fructan food frequency questionnaire and feedback on the study protocol and human intervention study manuscripts;
- Dr Paul Blatchford and Dr Doug Rosendale for providing microbiological support and expertise, particularly during the in vitro three-stage colonic model system study. Dr Paul Blatchford also provided much appreciated bioinformatic support during my PhD;
- Halina Stoklosinski for undertaking all the organic acid analysis;
- Duncan Hedderley for his statistical expertise and support;
- Anne Broomfield for her much appreciated help during the human intervention study and Ying Jin for being available to take blood samples from my study participants;
- My husband David, who constantly helped, supported and encouraged me throughout my PhD. I am truly grateful for his love and belief in me.
- My family, friends and colleagues at The New Zealand institute for Plant & Food Research Limited who were always there to support me and provide advice and encouragement when needed;
• The validation and human intervention study participants for their time and commitment;

• Massey University and The New Zealand institute for Plant & Food Research Limited for providing financial and resource support throughout my PhD;

• Ministry of Business, Innovation and Employment for providing financial support to The New Zealand institute for Plant & Food Research Limited which was used in part to fund my PhD research.
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<td>AA</td>
<td>African Americans</td>
</tr>
<tr>
<td>AC</td>
<td>African children</td>
</tr>
<tr>
<td>AMER</td>
<td>Typical American style dietary pattern</td>
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<tr>
<td>ANOVA</td>
<td>Analysis of variance</td>
</tr>
<tr>
<td>BMI</td>
<td>Body mass index</td>
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<tr>
<td>BodPod</td>
<td>Air displacement plethysmography</td>
</tr>
<tr>
<td>CD</td>
<td>Crohn’s disease</td>
</tr>
<tr>
<td>CHO</td>
<td>Carbohydrate</td>
</tr>
<tr>
<td>CNAQ</td>
<td>Comprehensive nutrition assessment questionnaire</td>
</tr>
<tr>
<td>CRON</td>
<td>Plant-rich, calorie-restricted diet with optimal nutrient composition</td>
</tr>
<tr>
<td>D</td>
<td>Donor</td>
</tr>
<tr>
<td>DFI-FFQ</td>
<td>Dietary fibre intake short food frequency questionnaire</td>
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<tr>
<td>DNA</td>
<td>Deoxyribonucleic acid</td>
</tr>
<tr>
<td>EC</td>
<td>European children</td>
</tr>
<tr>
<td>EI:BMR</td>
<td>Energy intake: basal metabolic rate</td>
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<tr>
<td>FFQ</td>
<td>Food frequency questionnaire</td>
</tr>
<tr>
<td>FI-FFQ</td>
<td>Fructan intake food frequency questionnaire</td>
</tr>
<tr>
<td>FISH</td>
<td>Fluorescence <em>in situ</em> hybridisation</td>
</tr>
<tr>
<td>FMP</td>
<td>Fermented milk product</td>
</tr>
<tr>
<td>FODMAP</td>
<td>Fermentable Oligosaccharides, Disaccharides, Monosaccharides and Polyols</td>
</tr>
<tr>
<td>GC</td>
<td>Gas chromatography</td>
</tr>
<tr>
<td>GI</td>
<td>Gastrointestinal</td>
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<tr>
<td>GLP-1</td>
<td>Glucagon-like peptide-1</td>
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<tr>
<td>HFC</td>
<td>High fermentable carbohydrate medium</td>
</tr>
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<td>HDF</td>
<td>High habitual dietary fibre</td>
</tr>
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<td>HMP</td>
<td>Human Microbiome Project</td>
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<tr>
<td>HNRU</td>
<td>Human Nutrition Research Unit</td>
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<tr>
<td>IBD</td>
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<td>Irritable bowel syndrome</td>
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