DEVELOPMENT OF A FUNCTIONAL FOOD INGREDIENT USING EXTRUSION PROCESSING TECHNOLOGY

A THESIS
PRESENTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

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ABSTRACT

This project aimed to develop a puffed “functional food” cereal ingredient that could subsequently be used in muesli bar products and potentially be on sold to breakfast cereal manufacturers. This ingredient was to contain nutrients that provided heart health benefits and also to possess good textural properties and to have an acceptable taste. Extrusion processing was used to produce the ingredient; extrusion processing transformed the raw materials used into a more palatable and texturally acceptable form and changed the nutritional quality.

The decision as to which nutrients to include in the ingredient required consideration of efficacy, regulatory and consumer and market factors. A literature review was undertaken to identify potential nutrients that would have heart health efficacy, meet regulatory guidelines and still be acceptable to consumers. A qualitative consumer study was conducted to gauge consumer awareness of the nutrients investigated and the desirability for these ingredients to be included in a bar benefiting heart health.

The main heart health nutrient selected for use in the puffed muesli ingredient, based on the results of screening, was soluble fibre. The source of soluble fibre selected was oat. The total, soluble and β-glucan (a particular form of soluble fibre) dietary fibre contents and the physical properties were of interest due to their influence on heart health benefits, product claims and sensory characteristics.

The effect of formulation (starch level, starch type), enzyme treatment and extruder processing settings on the fibre content and physical properties of the puffed ingredient was investigated. It was found that soluble fibre increased during the extrusion process, partially at the expense of insoluble dietary fibre. However, β-glucan was found to decrease during processing. The level of starch in the formulation was found to have the most significant effect on both the physical and nutritional properties. Increasing the level of starch had a positive effect on the physical properties, but decreased dietary fibre levels.
The puffed extrusion product contained a low level of β-glucan and a moderate level of total and soluble dietary fibre. A number of recommendations are presented concerning the feasibility of commercialisation, ingredient supplementation requirements and further research associated with the optimisation of the formulation and extrusion processing conditions.
ACKNOWLEDGEMENTS

Firstly, I would like to thank Nice and Natural Ltd. (the project sponsor) for the opportunity to work on such an interesting project. Functional food is an area of great market and research potential, and to be exposed to the numerous issues involved in the development and marketing of such products, I am privileged. This project has been a great learning experience, both interesting and challenging. I only hope that the information and learning from this project can go on to be successfully commercialised.

There have been many people who have contributed significantly to the completion and achievements in this project, I would like to take this opportunity to thank them.

First and foremost, I would like to thank my chief supervisor Ms. Carol Ma for all of the time and effort she has dedicated to this project and for the continuous support and encouragement she has provided. Her academic guidance and knowledge of extrusion technology has been of great assistance.

I would like to thank my co-supervisors, Dr. Janet Weber and Dr. Brian Wilkinson. I would like to thank Janet for her assistance with nutritional issues and interpretation of clinical studies, and guidance throughout the consumer research process, particularly ethics approval. Many thanks to Brian for his expert opinion on product development issues throughout the project and for reviewing my work, despite his extremely busy schedule. I would also like to thank Brian and Janet for their on-going encouragement, motivation and support.

I would like to thank everyone at Nice and Natural who contributed to this project, but in particular I would like to make a special thanks to Juli Mercer (Technical Manager) for her direction, perspective and on-going support. I would like to thank both Allen Peters (Managing Director) and Lawrie McColl (Marketing Manager) and Nimma Sherpa (Food Technologist) for their support, understanding and encouragement.

I would like to thank Dr. Chris Baldi and Dean Fourie from the University of Auckland Cardiac Rehabilitation Clinic for assistance in the recruitment of focus group
participants, particularly to Dean for going beyond expectations and conducting a postal request to past members on my behalf. Thanks are also due to Klaus Borges and Laurie Holloway of the Rotary Club of Auckland City West for their assistance in recruiting club members to participate in focus groups and organising a venue for focus group sessions to be held. The contribution of all focus group participants is greatly appreciated. I regret that your names can not appear here for sake of anonymity.

There are a great number of people that I would like to thank for making trials and product testing happen more easily, both in Palmerston North and Albany.

At Massey University in Palmerston North, I would like to thank Garry Radford for his assistance with the operation of the extruder, Byron Killop for his help and ideas in the modification of the extruder hopper, and Steve Glasgow and Gheeda Reid for their help in the lab.

I would like to thank the Massey University Nutrition Laboratory staff, particularly Felicity Jackson (Nutrition Lab Manager) for arranging training and testing and Hian and Roshela, who demonstrated the dietary fibre testing procedures. Thanks are due to all technicians who conducted testing and responded to urgency.

At Massey University in Albany, I would like to thank Marie Wong for organising access to the lab facilities, Lisa Duizer for her assistance with texture analysis and a big thanks to the technicians Dushi Bigwood and Raschna Parmar who were a tremendous help organising equipment and space in a territory that was new to me.

Others have contributed advice, and information.

Many thanks to David Roberts (Dietician) and Dave Monroe (Industry Settings Manager) from the National Heart Foundation for their willingness to assist and contribute information.

Thanks to Professor Harsharnjit Gill from Massey University in Palmerston North for the provision of conference material on the subject of functional foods that I would not have been able to access otherwise.
I would also like to thank Allan Hardacre and Rebecca Harding from Crop and Food Research for their guidance in the early stages of this project.

On a personal level, I would like to make a very special thanks to my family and friends who have been so supportive towards the completion of this project. Your support, encouragement, and patience has been crucial to the achievements in this project, it means a great deal to me.

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<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>AA</td>
<td>Arachidonic acid</td>
</tr>
<tr>
<td>ALA</td>
<td>Alpha-linolenic acid</td>
</tr>
<tr>
<td>ANZFA</td>
<td>Australia New Zealand Food Safety Authority (renamed FSANZ)</td>
</tr>
<tr>
<td>CHD</td>
<td>Coronary Heart Disease</td>
</tr>
<tr>
<td>CIAA</td>
<td>Confederation of Food and Drink Industries of the European Union</td>
</tr>
<tr>
<td>CMC</td>
<td>Carboxymethyl cellulose</td>
</tr>
<tr>
<td>DHA</td>
<td>Docosahexanoic acid</td>
</tr>
<tr>
<td>Dwrb</td>
<td>Dry Weight Basis</td>
</tr>
<tr>
<td>EPA</td>
<td>Eicopentaenoic acid</td>
</tr>
<tr>
<td>EU</td>
<td>European Union</td>
</tr>
<tr>
<td>FA</td>
<td>Fatty acid</td>
</tr>
<tr>
<td>FDA</td>
<td>Food and Drug Administration (food regulatory authority in the United States)</td>
</tr>
<tr>
<td>FDAMA</td>
<td>Food and Drug Modernisation Act (in the United States)</td>
</tr>
<tr>
<td>rpm</td>
<td>Feed rate rpm is the number of revolutions of the feed conveying screws per minute</td>
</tr>
<tr>
<td>FOSHU</td>
<td>Foods for Specified Health Use (a regulatory framework in Japan)</td>
</tr>
<tr>
<td>FSANZ</td>
<td>Food Safety Australia New Zealand, (New Zealand and Australian Food Regulation Authority) formerly ANZFA</td>
</tr>
<tr>
<td>GE</td>
<td>Genetic Engineering</td>
</tr>
<tr>
<td>GM</td>
<td>Genetic Modification</td>
</tr>
<tr>
<td>GI</td>
<td>Glycaemic Index</td>
</tr>
<tr>
<td>HDL</td>
<td>High density lipoprotein (cholesterol)</td>
</tr>
<tr>
<td>ISSFAL</td>
<td>The International Society for the Study of Fatty Acids and Lipids</td>
</tr>
<tr>
<td>LA</td>
<td>Linoleic acid</td>
</tr>
<tr>
<td>LDL</td>
<td>Low density lipoprotein (cholesterol)</td>
</tr>
<tr>
<td>LFRA</td>
<td>Leatherhead Food Research Association</td>
</tr>
<tr>
<td>mm</td>
<td>Millimetres</td>
</tr>
<tr>
<td>mmolL⁻¹</td>
<td>units for blood cholesterol concentration</td>
</tr>
<tr>
<td>MUFA</td>
<td>Monounsaturated fatty acid</td>
</tr>
<tr>
<td>MUHEC</td>
<td>Massey University Human Ethics Committee</td>
</tr>
<tr>
<td>n-3</td>
<td>Omega-3 (polyunsaturated fatty acid)</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Definition</td>
</tr>
<tr>
<td>--------------</td>
<td>------------</td>
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<tr>
<td>n-6</td>
<td>Omega-6 (polyunsaturated fatty acid)</td>
</tr>
<tr>
<td>NHF Tick</td>
<td>National Heart Foundation approved Tick symbol</td>
</tr>
<tr>
<td>NHF</td>
<td>National Heart Foundation</td>
</tr>
<tr>
<td>N.I.P</td>
<td>Nutrition Information Panel</td>
</tr>
<tr>
<td>NLEA</td>
<td>Nutrition Labelling and Education Act (in the United States)</td>
</tr>
<tr>
<td>NZHIS</td>
<td>New Zealand Health Information Service</td>
</tr>
<tr>
<td>PUFA</td>
<td>Polyunsaturated fatty acid</td>
</tr>
<tr>
<td>rpm</td>
<td>Number of rotations of the screw per minute.</td>
</tr>
<tr>
<td>RS</td>
<td>Resistant Starch</td>
</tr>
<tr>
<td>RS1</td>
<td>Physically inaccessible starch (a classification of resistant starch)</td>
</tr>
<tr>
<td>RS2</td>
<td>Resistant Starch granules (a classification of resistant starch)</td>
</tr>
<tr>
<td>RS3</td>
<td>Retrograded Starch</td>
</tr>
<tr>
<td>SFA</td>
<td>Saturated fatty acid</td>
</tr>
<tr>
<td>TFA</td>
<td>Trans Fatty Acids</td>
</tr>
<tr>
<td>TG</td>
<td>Triglyceride (generally referred to as plasma triglycerides)</td>
</tr>
<tr>
<td>UK</td>
<td>United Kingdom</td>
</tr>
<tr>
<td>US</td>
<td>United States of America</td>
</tr>
<tr>
<td>β-glucan</td>
<td>(1-3)(1-4)β-D-glucan (a form of soluble dietary fibre present in oats)</td>
</tr>
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