Evidence for effects of oat [beta]-glucan on satiety and weight control

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Evidence for effects of oat β-glucan on satiety and weight control

A thesis submitted in fulfilment of the requirements for the award of the degree

**Doctor of Philosophy**

from

University of Wollongong

by

**Eleanor Jane Beck**

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Honours I (University of Queensland)
Grad. Dip. Nutr. & Diet. (Queensland University of Technology)
Advanced Accredited Practising Dietitian

School of Health Sciences

2009
DECLARATION

I hereby declare that this thesis, submitted in fulfilment of the requirements for the award of Doctor of Philosophy, in the School of Health Sciences, University of Wollongong, is my own work unless otherwise referenced or acknowledged. This document has not been submitted in whole, or in part, for qualifications at any other academic institution.

__________________

Eleanor J. Beck

Date:
DEDICATION

To

Mum, Dad and Craig
ACKNOWLEDGEMENTS

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friendship and work in beautiful surroundings. Similarly, Ruedi Duss has been at all
times helpful in advice on β-glucan, oats and regulations and I appreciate his support,
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Most importantly I wish to thank my family for their unwaivering support. This starts
with my parents who told me at a young age that I should be so excited to have the
opportunity to learn new things. I did not appreciate this back then, but my PhD has
given me many opportunities to learn and I am fully appreciative of this. My husband
Craig told me I could do this when the children were still aged 2, 4 and 6 and I
thought it ridiculous. He told me it would be fine and I should do it. His support,
encouragement, love and friendship never waivers, and for this I will always
appreciate how lucky I am. Kennedy, Lewis and Finlay are 9, 7 and 5 now and their
ability to constantly distract me from my work has made me appreciate them even
more. This thesis may not be perfect but it has been enjoyed and nurtured along with
my three beautiful cherubs as we have all learned and grown in the last three years.
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<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>AACC</td>
<td>American Association of Cereal Chemists</td>
</tr>
<tr>
<td>ANOVA</td>
<td>Analysis of Variance</td>
</tr>
<tr>
<td>AOAC</td>
<td>Association of Official Analytical Chemists</td>
</tr>
<tr>
<td>AUC</td>
<td>Area Under the Curve</td>
</tr>
<tr>
<td>β-glucan</td>
<td>$(1\rightarrow3)(1\rightarrow4)$ Beta-D-glucan</td>
</tr>
<tr>
<td>BMI</td>
<td>Body Mass Index</td>
</tr>
<tr>
<td>CCK</td>
<td>Cholecystokinin</td>
</tr>
<tr>
<td>DPPIV</td>
<td>Dipeptidyl peptidase IV</td>
</tr>
<tr>
<td>EDTA</td>
<td>Ethylenediaminetetraacetic acid</td>
</tr>
<tr>
<td>ES1</td>
<td>Excellent Source of fibre under current regulation</td>
</tr>
<tr>
<td>ES2</td>
<td>Excellent Source of fibre under proposed regulation</td>
</tr>
<tr>
<td>FDA</td>
<td>Food and Drug Administration</td>
</tr>
<tr>
<td>FSANZ</td>
<td>Food Standards Australia New Zealand</td>
</tr>
<tr>
<td>GI</td>
<td>Glycaemic Index</td>
</tr>
<tr>
<td>GIT</td>
<td>Gastrointestinal Tract</td>
</tr>
<tr>
<td>GLP-1</td>
<td>Glucagon-like-peptide-1</td>
</tr>
<tr>
<td>GS1</td>
<td>Good Source of fibre under current regulation</td>
</tr>
<tr>
<td>GS2</td>
<td>Good Source of fibre under proposed regulation</td>
</tr>
<tr>
<td>HBG</td>
<td>High β-glucan</td>
</tr>
<tr>
<td>HBGO</td>
<td>High β-glucan oat bran ingredient</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Description</td>
</tr>
<tr>
<td>--------------</td>
<td>-------------</td>
</tr>
<tr>
<td>HBGX</td>
<td>High β-glucan extracted ingredient</td>
</tr>
<tr>
<td>HDL</td>
<td>High Density Lipoprotein</td>
</tr>
<tr>
<td>LBG</td>
<td>Low β-glucan</td>
</tr>
<tr>
<td>LDL</td>
<td>Low Density Lipoprotein</td>
</tr>
<tr>
<td>MBG</td>
<td>Medium β-glucan</td>
</tr>
<tr>
<td>MW</td>
<td>Molecular Weight</td>
</tr>
<tr>
<td>NPY</td>
<td>Neuropeptide Y</td>
</tr>
<tr>
<td>P293</td>
<td>Proposal 293</td>
</tr>
<tr>
<td>PASSCLAIM</td>
<td>Process for the Assessment of Scientific Support of Health Claims on Food</td>
</tr>
<tr>
<td>PYY</td>
<td>Peptide Y-Y</td>
</tr>
<tr>
<td>PYY3-36</td>
<td>Peptide Y-Y 3-36</td>
</tr>
<tr>
<td>RCT</td>
<td>Randomised Controlled Trial</td>
</tr>
<tr>
<td>RMANOVA</td>
<td>Repeated Measures Analysis of Variance</td>
</tr>
<tr>
<td>RTE</td>
<td>Ready-To-Eat</td>
</tr>
<tr>
<td>S1</td>
<td>Source of fibre under current regulation</td>
</tr>
<tr>
<td>S2</td>
<td>Source of fibre under proposed regulation</td>
</tr>
<tr>
<td>SD</td>
<td>Standard Deviation</td>
</tr>
<tr>
<td>TFEQ</td>
<td>Three Factor Eating Questionnaire</td>
</tr>
<tr>
<td>TG</td>
<td>Triglycerides</td>
</tr>
<tr>
<td>TIU</td>
<td>Trypsin Inhibitor Units</td>
</tr>
<tr>
<td>VAS</td>
<td>Visual Analogue Scales</td>
</tr>
</tbody>
</table>
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Accepted Papers


Submitted Papers


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ABSTRACT

Making claims on the health effects of foods currently presents major challenges to nutrition science. As a case in point, oat β-glucan has been shown to deliver a number of health benefits, including an ability to lower cholesterol levels as well as reducing glucose and insulin responses to a meal. These physiological functions are related to the viscosity and solubility of the β-glucan, with the viscosity a function of concentration and molecular weight. Further, despite epidemiological evidence that high fibre diets are associated with lower levels of overweight and obesity in populations, and experimental evidence that fibre will “make you feel fuller for longer”, there is little evidence linking specific fibres with weight control. Changes to regulations governing health claims in Australia and New Zealand are currently under review, and while they reflect European and other regional positions in allowing claims for β-glucan and cholesterol, they do not address other health benefits such as weight loss. This thesis provides a novel approach to evidence based research in food by combining studies in food science, acute meal tests and longer term dietary interventions. The hypothesis examined in this thesis is that overweight individuals following a nutritionally-balanced, energy-restricted diet including oat β-glucan will experience increased satiety and lose more weight than if they followed the same diet without the added β-glucan.

Product development studies examined the effects of extrusion on the important physical attributes of β-glucan included in a ready-to-eat cereal product. It did not prove difficult to produce a cereal that maintained β-glucan at high molecular weight (>1 million) and was viscous at high concentration (up to 5g β-glucan/cereal serve). Extrusion improved solubility which means the effects of downstream processing in this manner are likely to improve the physiological effects of β-glucan in cereals.

Results of a meal-test study with fourteen subjects found that increasing doses of β-glucan up to 5.5 g, decreased insulin levels (P=0.011) and increased subjective satiety measured by visual analogue scales (P=0.039). Increasing doses of β-glucan were correlated with increased plasma concentrations of cholecystokinin (CCK) and peptide Y-Y (PYY) (R²=0.970 and 0.994 respectively). Food intake at a subsequent meal was decreased with inclusion of β-glucan in the earlier test meal, although the differences were not statistically significant.
A 3-month randomised controlled trial of 66 overweight women was then conducted to investigate the effects of two different doses of β-glucan (5-6g or 8-9g) on weight loss within an energy-restricted regimen. Outcome measures included weight loss and markers of appetite regulation (hormones) as well as changes in metabolic variables related to cardiovascular disease. All groups lost weight (approximately 5% of body weight) and showed a reduced waist circumference (P<0.001 for both). The study sample also showed reductions in total cholesterol, LDL, HDL, leptin, PYY, glucagon-like-peptide-1 (GLP-1) values and an increase in CCK levels. No significant differences were noted between the groups for all outcome values except fasting PYY levels (P=0.018) but levels did not correlate with increasing dose.

Thus, the addition of oat β-glucan did not enhance the effect of energy restriction on weight loss in mildly overweight women, although large standard deviations in observed results, suggested that individual responsiveness makes elucidation of significant changes difficult. Adding these results to the body of evidence, it seems that some evidence exists relating to β-glucan and satiety with the most likely mechanisms relating to changes in absorption of nutrients and resultant release of anorexigenic hormones. There appears to be insufficient evidence to suggest the validity of a claim related to β-glucan and weight control. Further research of this nature would build on the knowledge of the mechanisms of satiety elucidated here, and this would further investigate how β-glucan and other soluble fibres may help weight control over longer time frames.