# Development of Gluten-Free Wrap Bread

A Thesis
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# Dedication

*To my mother and father, Xiangdong and Xiaofang.*

*For their love, support and kindness.*

# Abstract


Gluten, the storage protein in wheat, barley and rye is associated with coeliac disease, wheat allergy and non-coeliac gluten sensitivity. The clinical symptoms include diarrhoea, anaemia, nausea, mouth sore and psychological symptoms and in some cases a gluten free diet may reduce the severity of irritable bowel disease (IBD). Gluten-related disorders can be prevented by the omission of gluten from the diet. Currently, there is an increasing demand for gluten-free foods due to consumer awareness of gluten-related disorders as well as people seeking to reduce possible dietary risks. New Zealand's market for gluten-free foods is presently estimated at nearly four million US dollars.

The development and production of gluten-free bread presents major technological challenges due to the role of gluten in developing the characteristic structure of both the raw dough and subsequent loaf texture. The main ingredients of bread are water and cereal flours which provide the primary structure to the baked product. Wheat grain is a traditional and common cereal that is milled into bread flour. When wheat flour is hydrated with water, gluten, the protein component hydrates to become a continuous cohesive viscoelastic network entrapping starch granules. This highly elastic network retains $CO_2$ gas produced by yeast and sugar during leavening, thus forming the foam structure of bread. Gluten replacements that mimic the viscoelastic properties of gluten have been widely investigated for gluten free baked products including flatbread. Flatbread is popular for use in ready-to-eat convenient foods due to its large crust to crumb ratio. Wrap bread is a typical flatbread that can be rolled to hold various fillings. The manufacture of gluten-free wrap breads mainly suffers from poor rollability which is an essential property of the product. Thus, the present study investigated the development of gluten-free wrap bread (GFW) using xanthan gum, guar gum, carboxmethyl cellulose (CMC) as possible replacers for gluten, coconut oil was also added to improve flexibility of the bread. The formulations were investigated and optimised in four integrated phases.

In phase 1, guar and xanthan gums were studied as possible gluten replacers during the development of GFWs. GFW samples (n = 16) made from four formulations under four baking conditions (200°C/2 min, 200°C/4 min, 220°C/2 min, 220°C/4 min) were analysed for baking weight loss and rollability. Baking weight loss was determined as moisture loss during baking, while rollability was measured as the ability of the freshly cooked bread to conform to shape (1-5 scale) as it was rolled around a 3-cm diameter wooden dowel (rod). A mixture of guar and xanthan gums (1:1) produced GFWs with better rollability and less baking weight loss than either gum alone. GFW samples baked at the higher temperature for the longer time generally had higher rollability. The highest average rollability score (3) obtained for this phase was considered low for wrap breads developed in phase 2.

In phase 2, GFWs (n = 20) made from five formulations containing both xanthan and guar gums (1:1), CMC, and coconut oil were baked at 230°C for 2 or 4 min or at 240°C for 2 or 4 min. Freshly baked GFWs were analysed for baking weight loss, water activity, and colour. Rollability using 1 1-cm diameter dowel and visible mould growth of the GFWs were determined during storage for 28 days (4°C). Products produced in phase 2 had no visible mould growth during storage for 3 weeks (4°C). The inclusion of xanthan-guar gum, CMC and coconut oil into GFWs baked at 240°C/2 min may have contributed to high rollability and low baking weight loss. The effect of each test ingredient (xanthan-guar, CMC, and coconut oil) on the properties of GFWs was the subject of phase 3.

In phase 3, a basic formulation made with three levels (9 formulations) each of coconut oil, CMC and xanthan-gum gum were optimized using the Taguchi method to test the effect

of each ingredient in the basic formulation. GFWs made using the 9 formulations were analysed by physical and sensory tests over three weeks storage at 4°C during which mould growth was assessed visually. Products in phase 3 had no visible mould growth during storage for three weeks (4°C). GFWs with high level of coconut oil (12%) were characterised by high baking weight loss, high whiteness index and a shorter firmer texture (high rupture force and low rupture distance). CMC (0.3%) and xanthan-guar gum (1%) may have contributed to low water activity, high rollability, high rupture distance and high rupture force during storage. Results indicated that 0.3% CMC and 1% xanthan-guar gum were the optimum levels for these ingredients. As the optimized levels of coconut oil could not be confirmed in this phase, three promising formulations with different levels of coconut oil (8, 10, 12%) were evaluated in phase 4.

In phase 4, three products were produced using 3 optimised formulations from phase 3 and were analysed by physical tests and sensory evaluation during storage for two weeks (4°C). The 3 optimised formulations selected from phase 3 were: (1) base formulation plus 8% coconut oil, 0.3% CMC and 1% xanthan-guar gum; (2) base formulation plus 10% coconut oil, 0.3% CMC and 1% xanthan-guar gum; (3) base formulation plus 12% coconut oil, 0.3% CMC and 1% xanthan-guar gum. Among the three formulations, samples containing 12% coconut oil, 0.3% CMC and 1% xanthan-guar gum had the highest consumer sensory acceptability and were characterised by high rollability, and a more flexible texture (moderate rupture force and greater rupture distance) and low baking weight loss.

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# List of Abbreviations

| | |
|---|---|
| AACC | American Association for Clinical Chemistry |
| ANOVA | analysis of variance |
| AOAC | Association of Official Agricultural Chemists |
| B.C. | Before Christ |
| BWL | baking weight loss |
| *ca* | circa |
| CD | coeliac disease |
| CFU | colony forming units |
| CIE | International Commission on Illumination |
| cm | centimetre |
| CMC | carboxymethyl cellulose |
| DATEM | diacetyl tartaric acid ester of mono- and diglycerides |
| ERH | equilibrium relative humidity |
| FAO | Food and Agriculture Organization of the United Nations |
| FSANZ | Food Standards Australia New Zealand |
| GFW | gluten-free wrap bread |
| GLM | General linear model |
| HDP | hydroxypropyl distarch phosphate |
| Hi-Maize | high amylose maize resistant starch |
| HPMC | hydroxypropyl methycellose |
| IBD | Irritable bowel disease |
| L | litre |
| LDL | low density lipoprotein |
| M | molar, mole/litre |
| MCTs | medium chain triglycerides |
| min | minute |
| mL | millilitre |
| mm | millimetre |
| NaCl | sodium chloride |
| NCGS | non-coeliac gluten sensitivity |
| NMR | Nuclear Magnetic Resonance |
| No. | number |
| PA | Commonwealth of Pennsylvania |
| RS | resistant starch |
| SD | standard deviation of mean |
| SEM | standard error of mean |
| sec | second |
| SSL | sodium and calcium stearoyl lactylate |
| temp. | temperature |
| TPA | texture profile analysis |
| UK | United Kingdom of Great Britain and Northern Ireland |
| USA/US | United States of America |
| WHO | World Health Organization |
| xanthan-guar gum | mixture of xanthan gum and guar gum (1:1) |