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Development of Gluten-Free Wrap Bread

A Thesis

submitted in partial fulfilment of the requirements

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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 CO₂ 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, carboxymethyl 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 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
<i>ca</i>	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 stearyl 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)