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**Development of bread products containing *Chordaria  
cladosiphon* (Mozuku) and its bioactive extract fucoidan**

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## Abstract

Many seaweeds such as *Chordaria cladosiphon*, commonly known as mozuku, have been shown to contain several health promoting components such as dietary fibres, antioxidants, and a range of bioactive compounds. Mozuku is an edible brown seaweed which constitutes an important part of the diet of native Okinawans who enjoy long lives and consume the seaweed mixed with various seafoods and vegetables. Brown seaweeds and their isolated compounds, specifically a long-chain polysaccharide known as fucoidan, are reported to retard the formation and growth of various cancer cells in humans as well as having anticoagulation, antiviral and immunological activities. The present study developed wheat and gluten-free bread formulations containing mozuku powder in order to introduce its potential health effects into a staple food product thus making it more accessible to a wider range of consumers.

Nutritional analysis of mozuku powder was determined by proximate analysis, fatty acid analysis and amino acid analysis, particle size distribution of the powder was also determined. Mozuku powder was added to modified wheat bread and developed gluten-free bread formulations with adjustments in levels of added salt. The effects of mozuku powder inclusion on bread quality were assessed by measuring changes in bread quality parameters, with standard methods being used to determine texture characteristics, crust and crumb colour, specific volume and water activity. Samples of gluten-free and wheat bread were evaluated by consumer sensory panellists for appearance, texture, aroma, taste, and overall acceptability using the 9-point hedonic scale. Microbial stability of wheat bread was determined by enumeration of total aerobic plate counts and, yeast and mould counts over the course of 3 days.

Particle size distribution of mozuku powder showed that 90% of particle by weight were less than 500µm in diameter and that only 10% were less than 90µm. At these particle sizes, mozuku flakes were observable in the finished loaves. Nutritional analysis of mozuku powder contained (w/w, wet basis) 46.9% ash, 30.4% dietary fibre, 19.0% sodium, 5.4% protein, 4.7% available carbohydrates, 1.0% fat, 0.13% sugar and an overall energy content of 209.1 kJ/100 g. The most prevalent amino acids in mozuku powder were aspartate (0.59 mg/100 mg), glutamate (0.55 mg/100 mg), and leucine (0.42 mg/100 mg). Of the fatty acids, palmitic (69%) and oleic acid (13%) were present in highest concentrations however due to the total fat content of 1% they are unlikely to contribute to overall health.

Addition of mozuku powder to both gluten-free and wheat bread formulations with adjusted salt levels, reduced specific volume and breadcrumb lightness of the products without affecting water activity. However, inclusion of the seaweed powder in formulations increased redness/yellowness in the bread crumb. There were no significant differences ( $P<0.05$ ) in textural changes between wheat bread containing 1 and 2 % mozuku powder. However, wheat bread containing 2 % mozuku powder was characterised by decreased cohesiveness with no perceived changes in hardness, chewiness, resilience and springiness. Wheat bread containing 1% and 2% mozuku powder were well accepted by consumer sensory panellists receiving mean scores of 6.8 and 6.4 in overall acceptability on the 9-point hedonic scale. The addition of mozuku powder to wheat bread at 1% and 2% did not affect the microbial stability of the loaves during storage at 20°C for 3 days. With respect to gluten-free bread formulations, mozuku powder (up to 3%) did not affect texture ( $P<0.05$ ), however, the inclusion of 4% mozuku powder in gluten-free bread increased hardness, chewiness and resilience. The gluten-free formulation containing a concentration of 2.5% mozuku powder was selected for consumer sensory trials due to its favourable quality results and received a mean score of 6.4 in overall acceptability on the 9-point hedonic scale thus indicating the product was well-liked by consumer sensory panellists.

In this study, wheat bread and gluten-free bread containing variable levels of mozuku powder were successfully developed. Wheat bread containing 1% and 2% mozuku powder and gluten-free bread containing 2.5% mozuku powder had desirable textural characteristics, were well liked by consumer sensory panellists, and would be suitable for use in clinical trials.

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## **List of Abbreviations**

1% M	Wheat Bread With 1% Mozuku Powder
1% RSM	Wheat Bread With 1% Mozuku Powder And Reduced Salt
2% M	Wheat Bread With 2% Mozuku Powder
2% RSM	Wheat Bread With 2% Mozuku Powder And Reduced Salt
$a^*$	Red-Green Axis
AACC	American Association Of Cereal Chemists
ANOVA	Analysis Of Variance
$a_w$	Water Activity
$b^*$	Blue-Yellow Axis
CD	Celiac Disease
CFU	Colony Forming Unit
CIE	Commission Internationale De L'éclairage
CMC	Carboxymethyl Cellulose
CMYK	Cyan, Magenta, Yellow, Black Model
EPA	Eicosapentaenoic Acid
FFA	Free Fatty Acids
FSANZ	Food Standards Australia New Zealand
GCF	Grade Colour Figure
GFB	Gluten Free Bread
HPLC	High-Performance Liquid Chromatography
HPMC	Hydroxypropyl Methylcellulose
$L^*$	Lightness (Value) Axis
M	Mozuku
NaCl	Table Salt
PCA	Plate Count Agar
RDI	Recommended Daily Intake
RGB	Red, Green, Blue Colour Profile
SV	Specific Volume
U.S. FDA	United States Food And Drug Administration
YGC	Yeast Glucose Chloramphenicol