

**Genetic characterization and QTL mapping for grain fructan
in wheat (*Triticum aestivum* L.)**

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By

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Abbreviations

CIMMYT	: International Maize and Wheat Improvement Center
DArT	: Diversity Array Technology™
DH	: Doubled Haploid
HPLC	: High-Performance Liquid Chromatography
MAS	: Marker-Assisted Selection
MPBCRC	: Molecular Plant Breeding Cooperative Research Centre
QTL	: Quantitative Trait Loci
RIL	: Recombinant-Inbred Lines
SARDI	: South Australian Research and Development Institute
SSR	: Simple Sequence Repeats

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Abstract

Fructans are polysaccharides that are made up mainly of fructose. They are non-digestible carbohydrates and act as prebiotics to selectively promote the growth of colonic bifidobacteria, thereby improving human gut health. Fructans are present in the grain of wheat (*Triticum aestivum* L.), a staple food crop. Until now, there has been no research on genetic improvement of the concentration of fructans in wheat grain, partly because it has been difficult to accurately measure. One aim of this research project was to develop a simple and effective method to measure the fructan concentration in wheat grain. This was achieved by modifying a method that involves extraction of fructans from wheat grain followed by enzymatic hydrolysis to break down fructans into monosaccharides and quantification by anion-exchange liquid chromatography coupled with pulsed amperometric detection. The modified procedure is reliable and allows the handling of large numbers of flour samples at a relatively low cost, and can therefore be useful for assessing large numbers of wheat breeding lines. Using this method, grain samples taken from a diverse set of 117 wheat cultivars and breeding lines, including parents of mapping populations, were analysed for grain fructan concentration. There was significant genotypic variation among these materials, with grain fructan concentration ranging from 0.3 to 2.3% of grain dry weight. There was no evidence of strong genotype-by-environment interaction; the fructan concentrations of the same genotypes were positively correlated over different environments in Australia. Genetic mapping was carried out to detect and map loci affecting grain fructan concentration in wheat using a doubled haploid population derived from a cross between Berkut (high fructan) and Krichauff (low fructan). Grain samples were obtained from two field sites in South Australia and one in Kazakhstan. Fructan concentration varied widely within the population (0.6-2.6% of grain dry weight), with heritability estimated as $h^2 = 0.71$. A linkage map of 528 molecular markers covering 21 wheat chromosomes was used for locating quantitative trait loci (QTL). Genetic mapping identified two major QTLs on chromosomes 6D and 7A, with the (high fructan concentration) alleles contributed from Berkut, contributing to a 30-40% increase in wheat grain fructan compared to the Krichauff alleles. Effects of these chromosome regions were validated in additional environments and in another mapping population, Sokoll/Krichauff, with the favourable alleles contributed from Sokoll. The

major QTL on chromosome 7A was in the same region with a reported fructosyltransferase orthologue (*AB029888*), while the major QTL on chromosome 6D seemed to be co-located with a reported gene encoding for a fructan-degrading enzyme 1-exohydrolase (*1-FEHw2*). It is concluded that grain fructan concentration of wheat can be improved by breeding and that molecular markers could be used to select effectively for favourable alleles in two regions of the wheat genome.

Declaration

This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

I give consent to this copy of my thesis, when deposited in the University Library, being made available for loan and photocopying, subject to the provisions of the Copyright Act 1968.

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