Potential impact of temperature and carbon dioxide levels on rice quality

A thesis submitted in fulfilment of the requirements for admission to the degree of Doctor of Philosophy

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Abstract

A rice grain is composed of 90% starch, and amylose contributes to up 30% of the starch with the remainder as amylopectin. The structure of starch largely defines the quality of rice, yet the methods to characterise starch have not been reviewed recently. This thesis begins by using the simplest form of starch, debranched amylopectin, to detail and apply the principles of molecular weight theory using Size Exclusion Chromatography (SEC) to illustrate that without correct calibration the molecular weight distribution of starch has been underestimated. In contrast to amylopectin, amylose is difficult to isolate from flour without causing irrevocable damage, is unstable in an aqueous system and is believed to be impossible to debranch with isoamylase. Here an amylose-rich fraction was extracted directly from flour using hot water to avoid the structural–damaging isolation techniques used previously. The ability of isoamylase to debranch the amylose was shown through traditional methods of controlled enzyme degradation of the starch, ensuring that association of chains did not hinder access to the enzyme activation site, and through the contrast of 1H NMR spectra before and after the debranching event. Further, it was shown that 20% of carbohydrate was not recoverable from the SEC, and the unrecoverable carbohydrate is likely to be of high molecular weight and with long chains.

High temperatures during the grain filling period are known to impede on the rice quality of one classification of non-waxy varieties. That hypothesis was rigorously examined by growing rice from a wide genetic background in three temperature regimes, followed by analysis of amylose at a functional, structural and synthesis level. From that phenotypic data, the rice varieties could be divided into three distinct groups – two of poorer quality in an increasingly warmer climate. Candidate single nucleotide polymorphisms (SNPs) have been identified, and a mechanism proposed, to explain the phenotypes. Linking a phenotype to a SNP allows the opportunity for wide scale screening of varieties to predict the quality of rice in an increasing warmer environment.

Rice quality has the potential to change with elevated carbon dioxide levels, both alone and with increased temperature. Here, the quality traits of varieties grown in four combinations of temperature and carbon dioxide levels were assessed. The negative impact of temperature on grain quality was unable to be overcome by an increase in carbon dioxide in all but one quality. Chalk is the undesirable opaque belly of a grain that defines the market price of the grain. In elevated carbon dioxide, the proportion of grains containing a high amount of chalk per grain which will increase the market value of the grain and may help to alleviate the burden of climate change on rice farmers.

Declaration

I hereby declare that this thesis is my own work and that, to the best of my knowledge, it contains no material previously published or written by another person except where due acknowledgement is given in the text of this thesis.

Rachelle Ward

Thank You

It's often said that it is the journey, and not the end result that is important – my journey was touched by many people and experiences because it spanned four laboratories, two supervisors, two countries, one love and the support of my family.

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