Towards improving rice dietary fibre content and composition for human health

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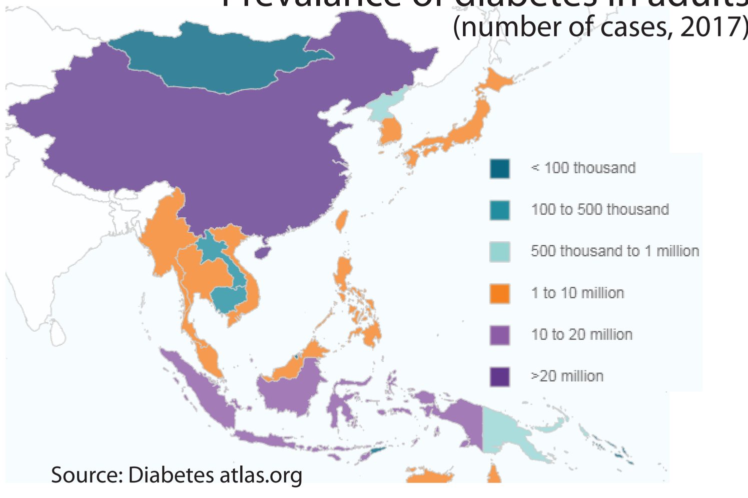
Rice is a major staple food and is consumed as brown rice (produced by removing the hull) or predominantly as white rice (produced by further polishing the dehulled grain to remove the bran and embryo). Polishing removes most of the vitamins, minerals, and up to 80% of dietary fibre. Consequently, white rice comprises of over 90% starch (with 13-18% resistant starch) and low protein, dietary fibre and micronutrient content. It serves as the major source of energy in the diet of most Southeast (SE) Asian countries [1,2].

The **high starch proportion** and **relatively low dietary fibre content** lead to rapid energy release in the human gastrointestinal tract resulting in high glycaemic index (GI). The excessive consumption of high GI foods and adoption of a more sedentary lifestyle are **associated with increased risks for chronic diseases** including type-2 diabetes, cardiovascular diseases (CVD) and some types of cancer. Furthermore, the incidences of these conditions are dramatically increasing in areas where white rice is the staple food, notably Asia, with the prevalence of diabetes in SE Asia alone predicted to reach 120 million by 2030 [3,4]. It is therefore necessary to develop rice lines in which high energy content is combined with low GI. This may be achieved by combining acceptable levels of resistant starch (RS) with an increased content of the cell wall derived-dietary fibre components.

Prevalance of diabetes in adults
(number of cases, 2017)



Source: Diabetes atlas.org

Prevalence of diabetes in adults [%]

China	10.9	Philippines	6.2
Japan	7.7	Singapore	13.7
Korea	8.8	Thailand	8.3
Malaysia	16.9	Vietnam	5.5
Myanmar	4.0	UK	5.6

Source: International Diabetes Federation and Diabetes UK

Our project aims to improve the dietary fibre content in rice by identifying rice lines with high resistant starch and dietary fibre content as well as good organoleptic properties and acceptable palatability to include them in national breeding programmes in SE Asia.

370 rice lines were grown, polished/milled and then ground into white rice flour. Water extractable (WE) and un-extractable (WU) fractions were prepared. WU fraction was destarched (twice) and remaining **dietary fibre** in both fractions was hydrolysed and analysed as **monosaccharides** (Fig.1,2). 96.7-99.6% of all monosaccharides were found in water un-extractable fraction. Principal component analysis (PCA) and hierarchical cluster analysis (HCA) were used to identify lines with low, average and high dietary fibre content (Fig.3).

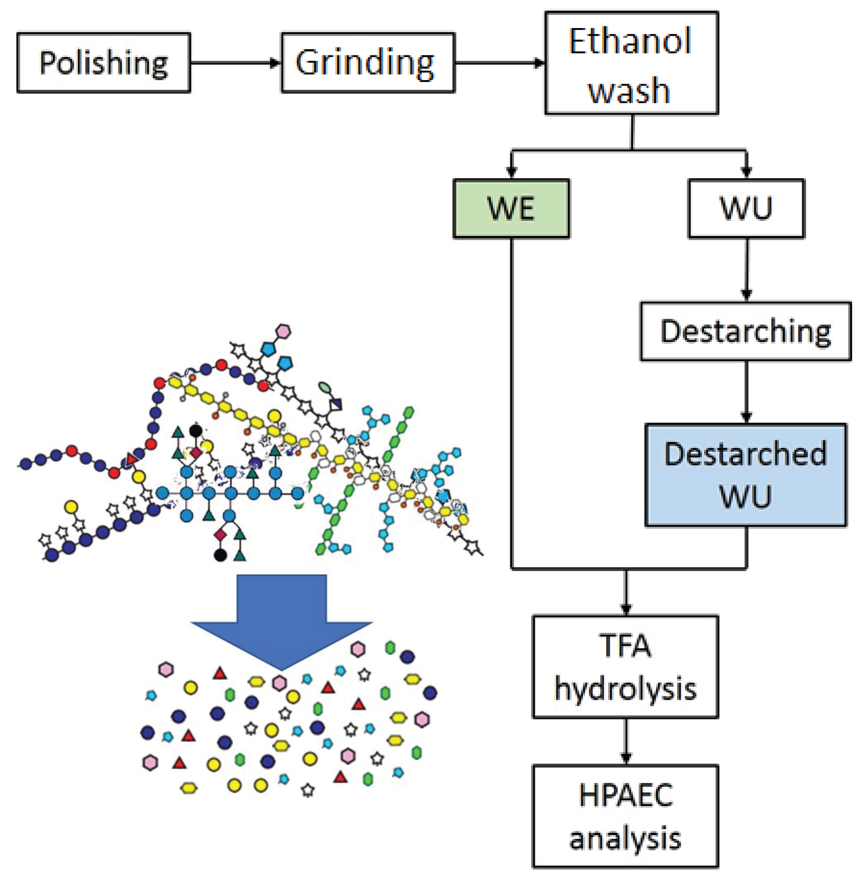


Figure 1: Method developed to analyse dietary fibre in white rice flour.

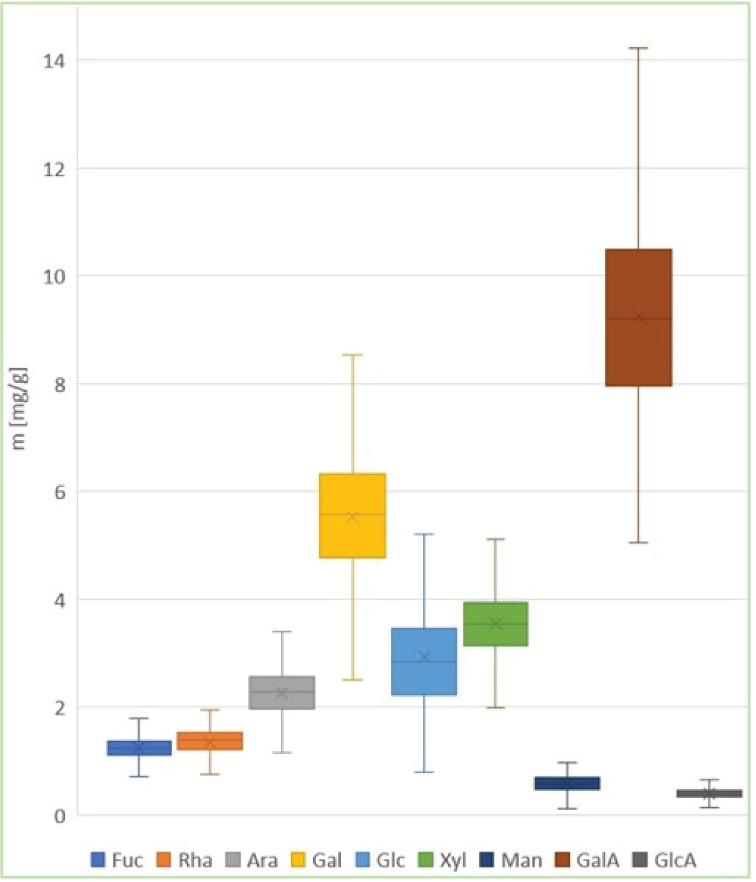


Figure 2: Monosaccharides analysed and their ranges found in white rice flour.

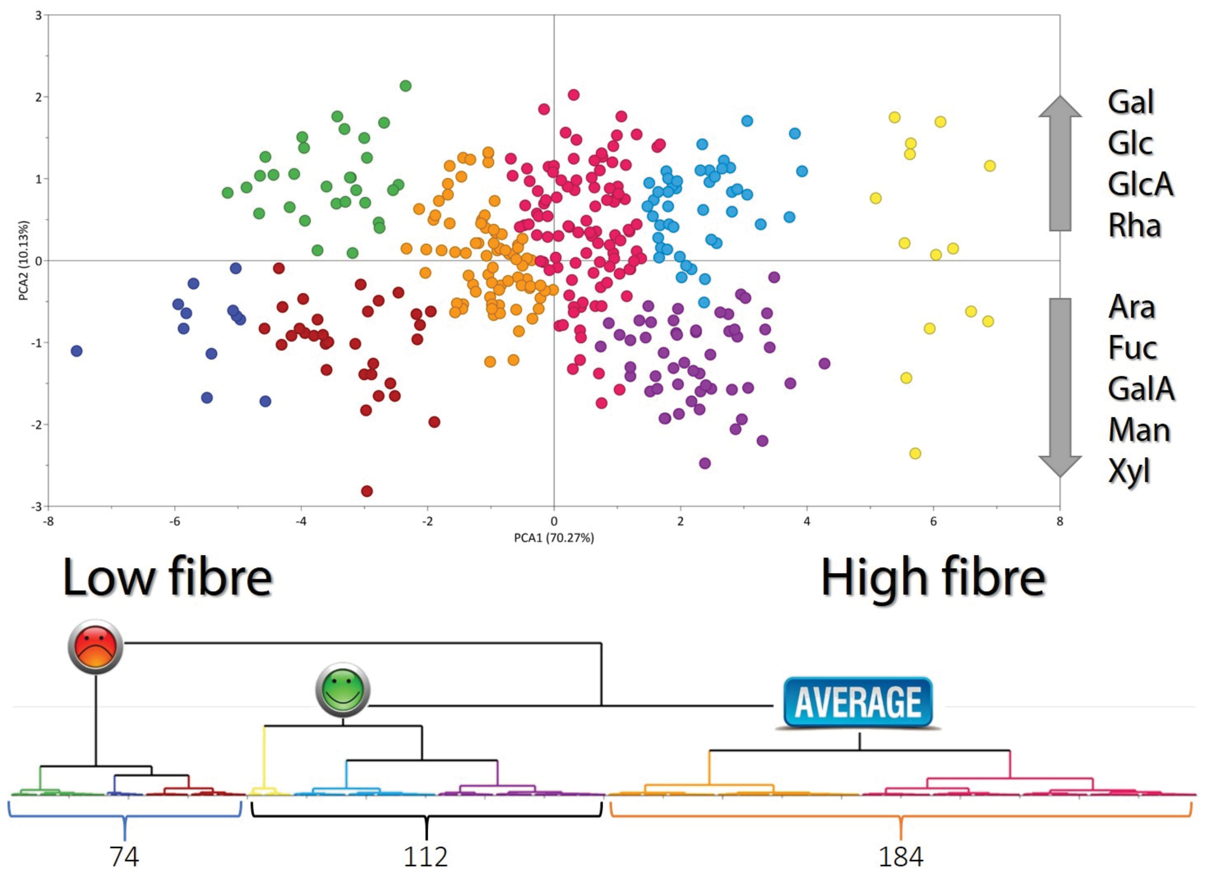


Figure 3: PCA (top) and HCA (bottom) were used to analyse and visualise lines low, average and high in dietary fibre content.

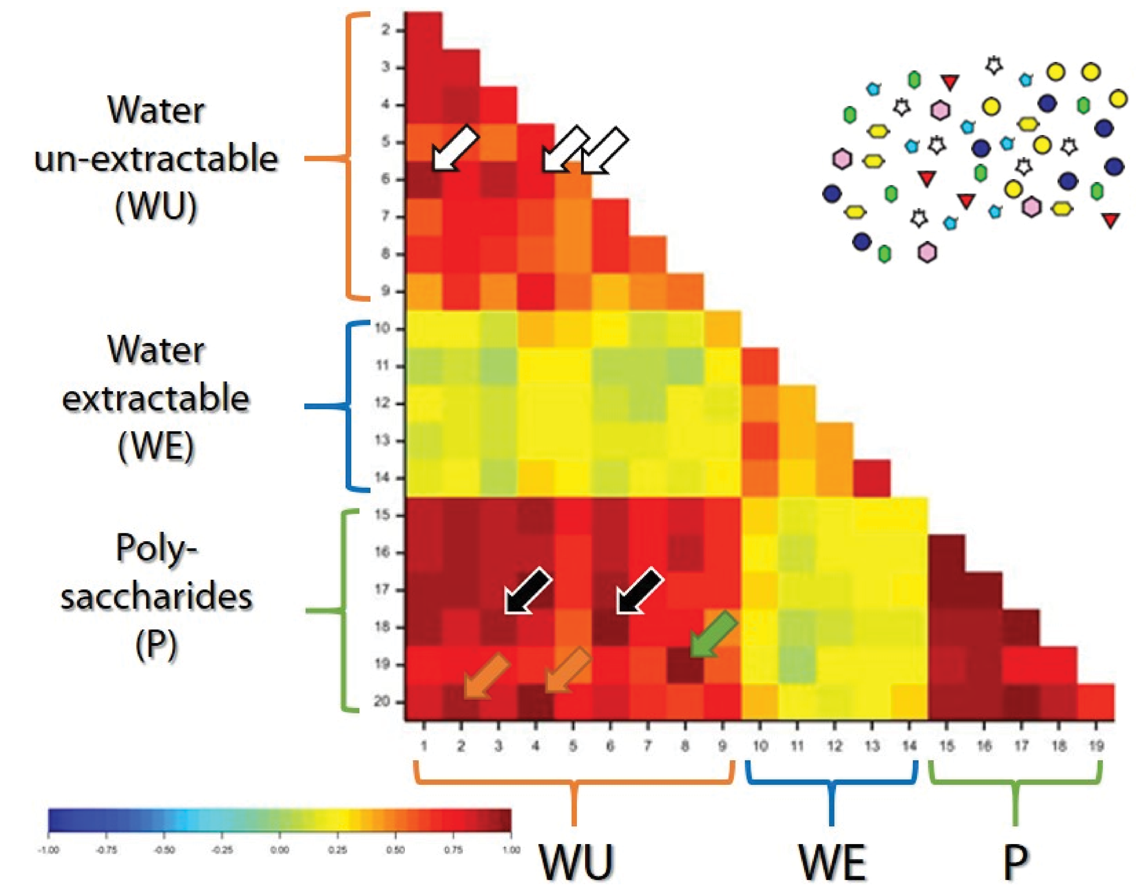


Figure 4: Shade plot showing correlations between water extractables, water un-extractables and polysaccharides based on monosaccharides data.

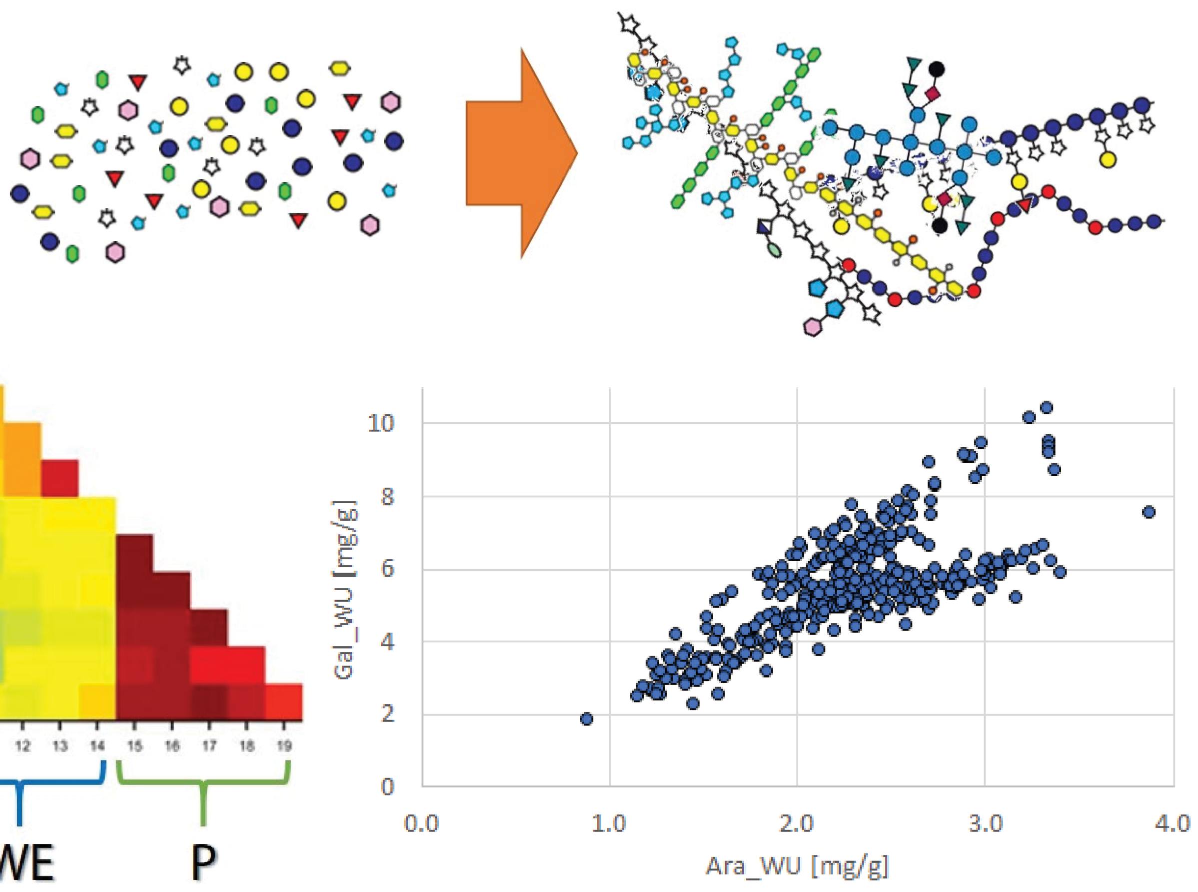


Figure 5: Response between WU galactose and arabinose suggesting the presence of two population of polysaccharides.

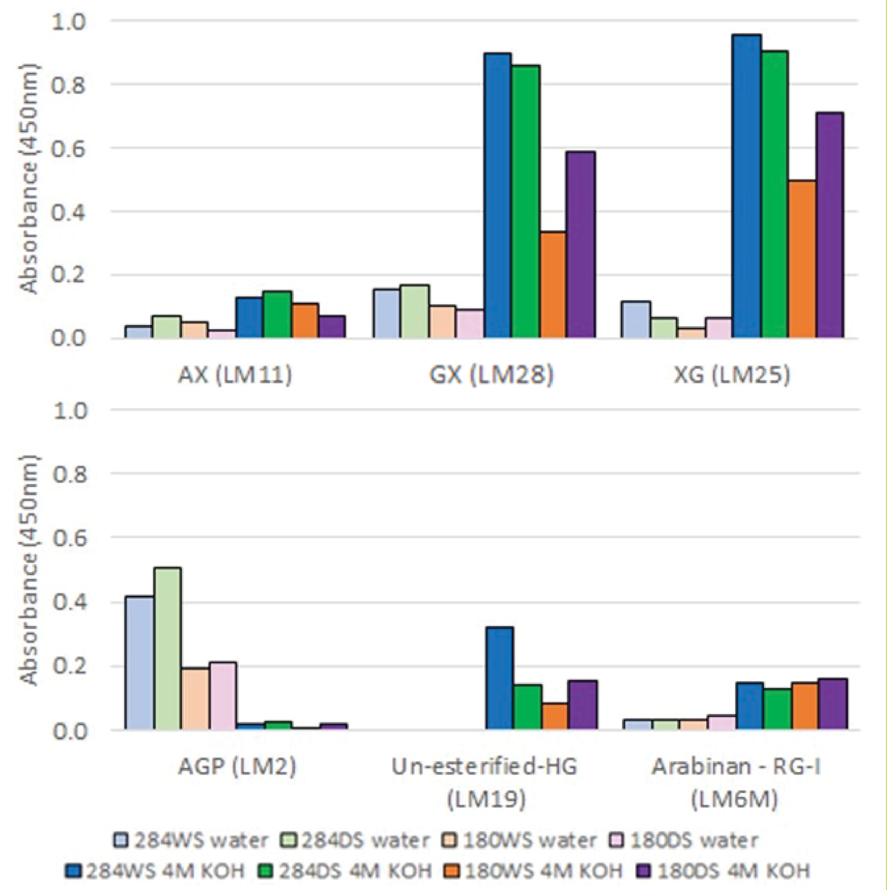


Figure 6: mAbs ELISA data showing the presence of various polysaccharides from white rice flour in water and 4M KOH fraction.

Monosaccharides data together with literature-based knowledge were used to **predict** the **polysaccharides present in rice endosperm** by correlations. Correlations highlighted in Fig. 4 suggest the presence of AG (orange arrows), pectins (green), AX/GX (black) and XG (white). Fig. 5 showing the possible presence of two polysaccharides made of arabinose and/or galactose. ELISA based assays were used to analyse for the **presence of different polysaccharides epitopes** in water and 4M KOH extract of rice endosperm. Fig. 6 showing the existence of **AG** in water fraction and presence of **AX, GX, XG and pectins** predominantly in 4M KOH fraction.

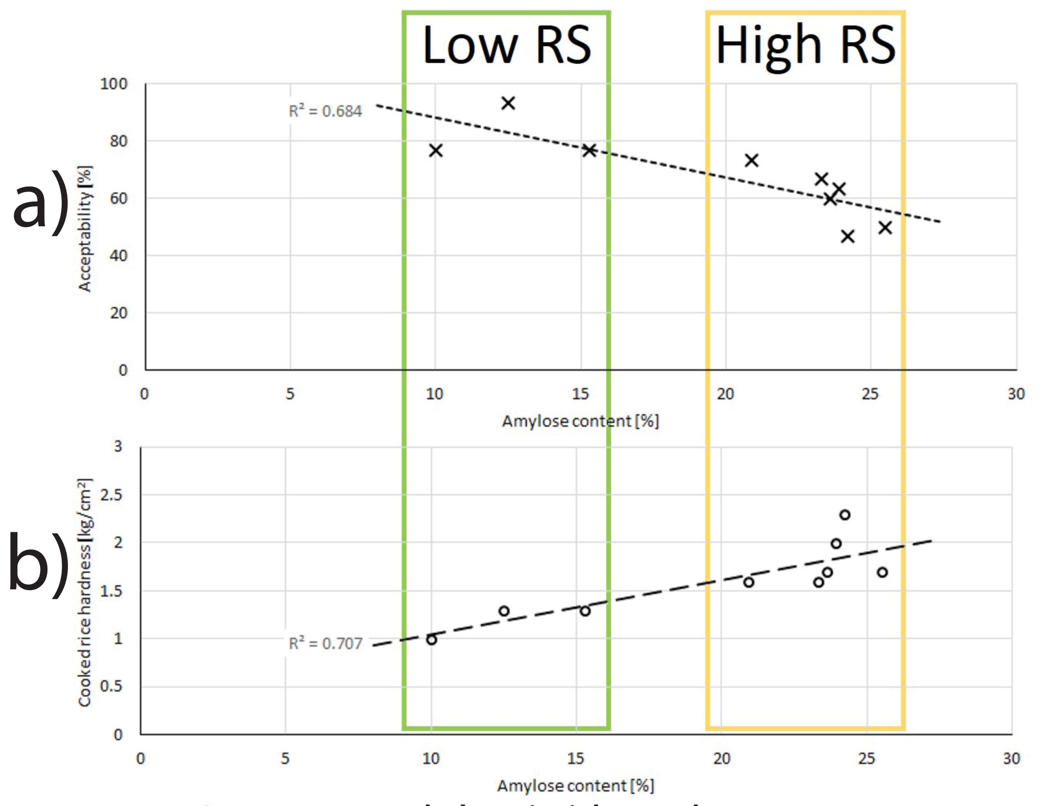


Figure 7a: Rice acceptability (%) based upon sensory test scores (including texture, smoothness, tenderness, cohesiveness) vs amylose content (%). Figure 7b: Cooked rice hardness (kg/cm^2) vs amylose content (%).
Low RS lines 10-15.5%, high RS lines 20-25.5% amylose.

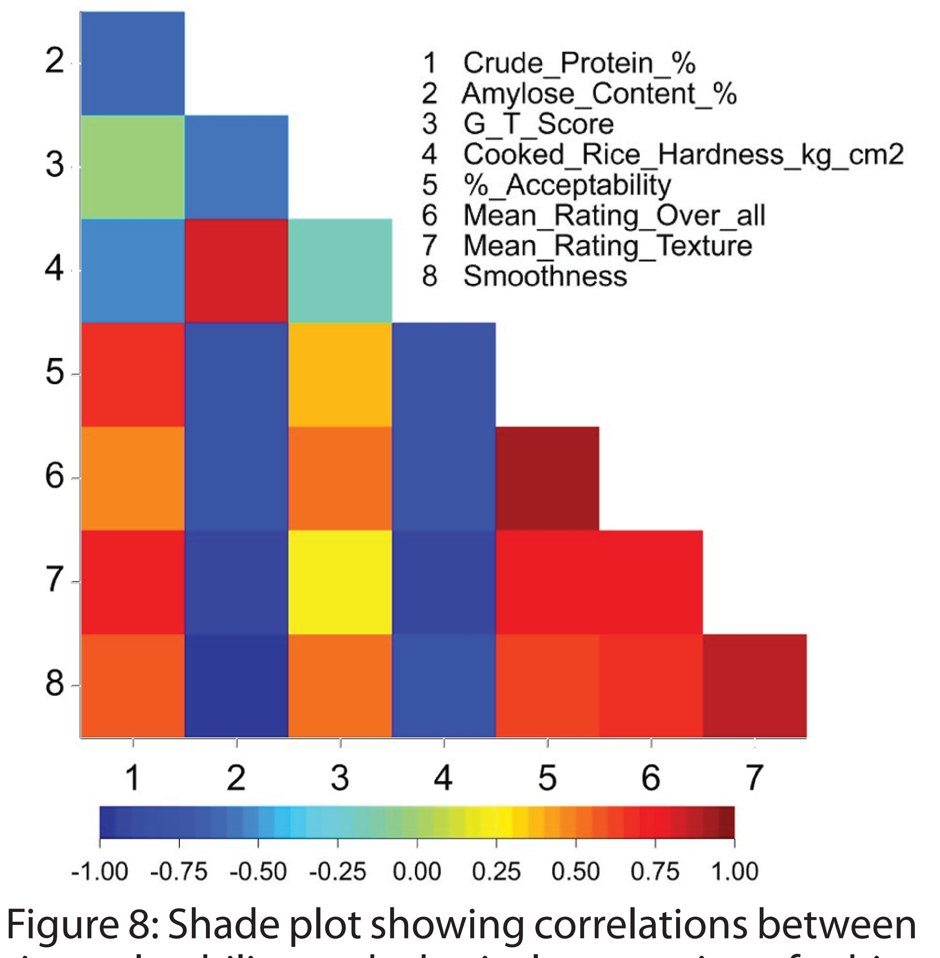


Figure 8: Shade plot showing correlations between rice palatability and physical properties of white rice.

Conclusions and future prospects:

- We have screened 370 rice genotypes for cell wall-derived dietary fibre (DF) and resistant starch (RS) in white rice.
- Rice lines with diverse levels of DF and RS have been identified.
- The quantity and relative proportions of these components contribute to the glycaemic index (GI) of these lines.
- Selected lines have been used in G X E studies to determine the stability of these lines.
- Rice lines with diverse levels of DF and RS have been assessed for palatability.
- Selected lines are being assessed for GI.
- Lines with improved DF and RS content, combined with good palatability characteristics, need to be pyramided to produce low GI rice lines that will deliver healthy white rice.

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References: [1] ASEAN Food Consumption Database (2014). [2] http://www.fao.org/faostat/en/#data/FBS [3] Carbohydrates and Health, SACN London (2015). [4] http://www.who.int/diabetes/facts