



Linking starch structure to rice cooking quality

Rosa Paula Cuevas^{1,2} & Melissa Fitzgerald²

¹University of Queensland, Brisbane, ²International Rice Research Institute (IRRI), Philippines

in a rice hull

- The use of rice in cooking and industry depends on its cooking qualities, in particular the structure and characteristics of the starch in rice
- Understanding starch structure will ultimately lead to the development of designer rice varieties to meet specific markets and end uses
- Research over the course of this project suggests that a particular component of one of the starches in rice grain (the hot water soluble fraction of amylopectin), may be contributing to peak viscosity, texture of the cooked rice and glycaemic index

Rice is the most important cereal on the globe, being the main source of energy and income for the majority of the world's human population. Aside from being the staple food, or a carbohydrate component of a meal, rice is also used in numerous industrial applications. Its use in the diet and in industry depends on its cooking properties.

To predict the cooking quality of rice, it is essential to understand the structure of the starch that composes it. Relating starch structure to mechanisms involved in its production will aid rice breeders in targeting genes for developing genetic markers. In turn, these will further hasten the development of new designer varieties that can meet specific and newly emerging niche markets.

The composition of rice grain is 90% starch and approximately 2% lipids, 6% proteins and 1% minerals.

Two types of starch

There are two types of starch in the rice grain: amylose and amylopectin. The proportions and structures of the two types of starch are the main factors that affect the cooking quality of rice. Previous studies have shown that amylose has a huge impact in the cooking quality of a rice variety but it cannot be used as a sole predictor. It is therefore important to determine the effects of the other grain components on the cooking quality.

Amylose & grain quality

Amylose is mainly a linear form of starch. The amount of amylose in the grain determines how sticky the rice will be when cooked. As amylose content increases, the rice grains become less sticky and more firm.

Some varieties do not have amylose in them because of a mutation in a gene called *Waxy* gene. These varieties, called

waxy or glutinous rice, are sticky when cooked, and are eaten mainly in south east Asia.

Amylopectin & grain quality

Amylopectin is a highly branched form of starch. Its structure is organised into different levels, with each level contributing to the overall effect of amylopectin on cooking properties. The effect of amylopectin on cooking qualities has been investigated in this project year.

Predicting cooking quality

One of the quickest ways to predict for cooking quality is by obtaining viscosity curves from the Rapid Visco-Analyser (RVA). As rice flour is cooked, the flour-and-water mixture becomes a thick paste, which is increasingly difficult to stir. This difficulty in stirring is measured by the RVA as viscosity. The viscosity curve shows the time it takes and temperature at which flour transforms from a raw powder to a cooked paste, and the behaviour of the paste as it is cooled.

It was consistently observed that waxy rice reached peak viscosity at lower temperatures (hence, earlier in the cooking process) than non-waxy rice, ie those varieties with amylose. The causes of variations in peak viscosity are presently poorly understood.

To simplify the process of determining the effects of grain components on peak viscosity, waxy rice varieties were used. These varieties do not have amylose but they do contain amylopectin.

Pasting properties of waxy rice

The viscosity profiles (Figure 1), which indicate pasting properties, show that the waxy varieties tested have either high or low viscosity. In addition, the shape of the viscosity curves for high and low samples are similar. It is the



variations in peak viscosity that determine whether the varieties are of high or low viscosity.

When the pastes of rice flour of waxy varieties were cooked on the dynamic rheometer, high-viscosity samples had firm pastes (Figure 2). On the other hand, low-viscosity samples had weaker pastes (Figure 3). In addition, phase separation into an insoluble paste and a clear liquid was observed in low-viscosity samples (Figure 4). These observations suggest that factors other than amylose content contribute to the variations in pasting properties.

There are a number of different ways of cooking a rice grain, and we have found that cooking a waxy variety by steaming in particular conditions leads to a cooked rice grain with significantly lower glycaemic index than standard varieties, even Doongara. Peak viscosity relates to the ability of the starch granule to swell, so it is highly likely that factors determining peak viscosity are likely to affect the way the rice cooks in this steaming process.

Proteins & pasting properties

Proteins, despite their small proportion in the grain, are the grain's major water absorbers. They increase viscosity significantly. When these were removed, the viscosity curves of the waxy varieties were greatly reduced. But, the high and low viscosity groupings were retained. Thus, proteins are not causing the variations in peak viscosity.

Amylopectin structure

Amylopectin was the only component left unconsidered, so it was characterised to determine if there were differences in structure of amylopectin among the high and the low viscosity groups.

At IRRI, amylose is effectively leached out of rice flour by heating the flour in excess hot water. In this same manner, some amylopectin is also leached out, called hot-water soluble (HWS) amylopectin. High-viscosity samples had less HWS amylopectin while low-viscosity samples had more HWS amylopectin. The HWS amylopectin in low-viscosity samples started leaching out at 50°C; in contrast, the HWS amylopectin in high-viscosity samples started leaching out at 60°C.

These results indicate that the amylopectin structure of the low-viscosity samples is more easily damaged due to heat, while that of high-viscosity samples are more resistant to heat.

Why the difference in resistance to heat?

The first difference is the presence of long chains of amylopectin in the high-viscosity sample. This indicates that the strength of the pastes could be attributed to the presence of long chains that enhance interactions between chains. The other difference is the subtle change in the ratio of chain growth and chain stoppage rates, in chains that are 18–22 units long. These suggest that the high-viscosity sample may have a more organised starch structure than the low-viscosity sample.

Future work

The contribution of this hot water soluble component of amylopectin to peak viscosity, texture of the cooked rice and glycaemic index will be determined in more detail in the next and final year of this project. 🌾

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Melissa Fitzgerald

Head Grain Quality, Nutrition and Postharvest Centre
IRRI, The Philippines

E: M.FITZGERALD@CGIAR.ORG

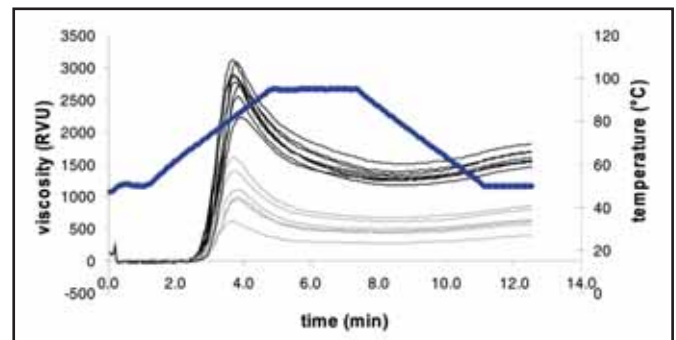


Figure 1: RVA viscosity profiles of flour from a collection of waxy rice varieties. Black lines are high-viscosity samples while grey lines are low-viscosity samples. The blue line shows the cooking temperature during the test.



Figure 2: High-viscosity sample with a firm paste.



Figure 3: Low-viscosity sample with a weak paste.



Figure 4: Phase separation of the low-viscosity sample into a soluble liquid and an insoluble paste.