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Rice quality

Rachelle Ward

Rice Cereal Chemist, Yanco Agricultural Institute, Yanco

Margrit Martin

Technical Officer, Yanco Agricultural Institute, Yanco

Introduction

Rice is recognised as a source of starch in the diet and is generally consumed as a whole grain or as a flour ingredient. As our diets become varied, so does the selection of rice that consumers demand in the marketplace. Some examples include the chalky rice variety Illabong used for risotto, the soft cooking Opus for sushi, or the long grain, fragrant variety Kyeema as an excellent accompaniment to Asian foods. There are also specific health benefits from eating rice – for example, the variety Doongara is known for its low glycemic index (GI).

Just in describing a selection of grains in the marketplace, many rice grain qualities have been mentioned. Physical grain qualities can include grain shape, translucency and whiteness of the grain, and cooking qualities include texture when hot and cold, cooking time and digestibility. While grain qualities are genetically inherited, environmental conditions, agronomic practices, grain handling and storage affect grain quality.

To survive the harsh Australian environment and the ever-developing demands of rice consumers, it is essential to deliver new and improved varieties for Australian rice growers. To do this NSW DPI supports a Rice Breeding Program and the Quality Evaluation Program to ensure that released varieties are of superior agronomic and grain quality, and therefore commercially viable.

This Primefact explains:

- how new varieties are developed
- physical quality assessments
- cooking quality assessments
- summary of current Australian varieties
- current research directions.

Development of new varieties

Part of the success of the Australian rice industry has been the ability to create a competitive edge in the global marketplace with the supply of high quality grain. For the supply of high-quality Australian produced rice, the rice research community must continue to develop new varieties which meet identified grain quality specifications of changing and new markets.

The Quality Evaluation Program runs parallel to the Rice Breeding Program to provide objective measures of grain quality at various stages of variety development. The first few populations (F_1 to F_4, i.e. first to fourth generation after crossing of the original parent plants) are selected on agronomic features only, with visual assessments and minimal quality tests applied at the F_5 stage. At the F_6 stage the sample size is large enough to test mill and to apply full quality tests.

Physical qualities (F_6 stage)

Physical properties of the grain are those which are recognisable in the marketplace. Each year between 2700 and 5000 breeding lines are assessed for the percentage of grains remaining whole after milling (or millout), grain dimension, chalk and colour. All physical qualities can be affected by the growth conditions of the plant, in particular high temperatures during grain filling, field fertilisation (e.g. N kg per hectare) and harvest moisture.

Millout

Millout is a key determinant of grain quality, as a high millout equates to a high economic return. The process to determine millout is labour intensive and while there is a certain level of automation with use of barcodes and computer programs, millout requires the use of four separate instruments and two experienced staff.

Instruments used in the milling process are pictured in Figure 1. Harvested grain is aspirated to remove debris and the paddy grain is collected. A sample of 150 g of paddy grain is then dehulled to produce brown grain.

Figure 1. Physical quality assessment. From left to right: aspirator, dehuller, mill, Cervitec and the spectrophotometer.

The brown grain is milled, whereby the bran layer is removed to produce white grain. Whole milled, white grain is then separated from the broken grains. The weight of the whole grain is used to calculate the millout percentage. Figure 2 pictures the grain at the three stages of milling: paddy, brown and white rice.

Grain dimension and chalk content

Grain dimension and chalk content are determined with an instrument called Cervitec (see Figure 1) that uses a camera to capture the image of single grains. Image analysis and Artificial Neural Network are then used to determine these physical qualities of the grain.

The length and width ratio is used to describe grain shape, e.g. medium or long grain (see Figure 2). Minimal variation in grain dimension in a sample is desirable. Chalk is defined as the opaque specks in a rice grain desirable only in Arborio and Sake rices (see Figure 2b). Chalk is caused by poorly packed crystalline regions of starch that reflect rather than transmit light. The susceptibility to form high amounts of chalk is a genetic trait, but strongly influenced by high temperature during grain filling.

Colour

A white translucent grain is desired in all markets. A scan of a milled sample by the hand-held spectrophotometer provides information about the lightness/darkness as well as the colour (whiteness/yellowness). A picture of the spectrometer is included in Figure 1.

Cooking qualities (F_5 – F_7 stage)

Cooking qualities of the rice are generally associated with the grain variety. Milled, white rice is composed of ~93% starch (amylose and amylopectin), ~7% protein and ~0.5% lipids. The composition, structure and interaction of these components largely define the cooking qualities of rice.

Most cooking quality assessments are made at the F_6 stage, with tests requiring minimal samples conducted at the F_5 stage. Each year, a selection of 200–400 breeding lines are assessed in the F_5 stage, and 700–1600 lines assessed at the F_6 stage. Images of the variety of instruments that enable subjective analysis of cooking properties are shown in Figure 3.

Gelatinisation temperature (F_5 stage)

Gelatinisation temperature is measured with a Differential Scanning Calorimeter, an instrument that measures energy transfer to and from a sample while it is heated. Rice has a gelatinisation temperature of 65–80°C, and reflects the temperature at which rice starch begins to melt (gelatinise) and take up water.

Molecular markers (F_5 stage)

From young rice leaves, DNA can be extracted and then screened for several quality traits. Use of molecular markers in the Quality Evaluation Program allows quality trait information to be delivered to the Breeding Program at earlier generations. This has the potential to reduce the number of breeding lines that require the more labour intensive quality assessment, and provides an opportunity to screen more breeding lines.

A marker (known as the CT repeat) is used to predict cooking class and amylose content, and two markers to predict gelatinisation temperature are used in the Quality Evaluation Program.

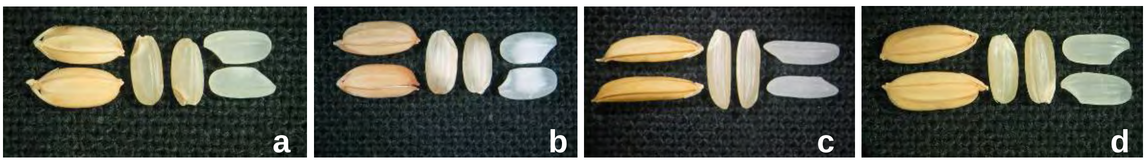

Figure 2. Each picture shows the paddy, brown and milled grain of a medium grain (a), a chalky medium grain (b), a typical long grain (c) and a larger, medium grain (d).

Figure 3. Cooking quality assessment. From left to right: calorimeter, molecular marker, UV-vis spectrometer, viscometer and texture analyser.

Amylose content

The amount of amylose is the key factor for how rice cooks and can range from 15–30%. Low amylose content produces a soft cooking rice where high amylose usually produces a firm and fluffy rice. Amylose binds with iodine and produces a blue colour which is measured with a spectrophotometer to determine the amylose content.

Nitrogen content

The nitrogen content of milled grain can be predicted by NIR (near infrared). Protein content in milled rice is generally around 7%, but can reach up to 12% if the soil has a high nitrogen load.

Viscosity

Viscosity is a measure of the energy required to stir a sample of rice flour and water as it is heated and cooled. Each variety has a different viscosity profile depending on how the temperature causes the starch to gelatinise, proteins to denature, lipids to alter and water to interact with the flour. Different inflection points of the resultant viscosity curve provide information about the cooking properties of the grain.

Texture / retrogradation

Cooked rice and re-heated rice can have very different textures. This difference between the two textures is known as retrogradation. Testing the firmness of a stored gel made of rice flour and water gives an indication of how the cooked rice behaves when refrigerated.

Elongation

Some rice types become longer when they are cooked. Basmati rice should at least double in length when cooked. The rice grains are measured before and after cooking to test whether they elongate.

Australian rice varieties

Rice varieties developed through the Rice Breeding Program and Quality Evaluation Program are summarised in Table 1. The released varieties reflect agronomic benefits such as increased yield or tolerance to cold and their quality characteristics have been selected to meet specific market requirements.

Current research

Current RIRDC funded research is directed at the improvement of the Quality Evaluation Program to continually improve the efficiency, scope, delivery time, cost and objective nature of the program.

Physical qualities

Between 2700 and 5000 breeding lines are assessed for millout each year. As the process is labour intensive and thus costly, options to reduce the number of samples that require milling and options to predict millout are being explored.

Examples of current research avenues are:

- At the F_5 stage, grain is visually assessed for grain dimension, chalk and cracks, with promising breeding lines entered into the Quality Evaluation Program for gelatinisation temperature and molecular marker assessment, followed in the subsequent year by millout. To replace this subjective screening, an objective measure will be explored. This will ensure that breeding lines entering the Quality Evaluation Program align with breeding goals, and the data can be used to ensure unbiased selection.
- Exploring options to improve millout through improved sample handling.

Cooking qualities

Options to improve the assessment of cooking qualities are targeted towards the evaluation and implementation of molecular markers to predict cooking qualities at early stage generations. This will allow the Quality Evaluation Program to expand the number of breeding lines with molecular analysis while reducing the number of samples that require wet chemistry.

Table 1. A summary of physical and cooking quality attributes of Australian rice varieties.

Variety	Release Year	Length (mm)	Width (mm)	Chalk	Amylose (%)	Gelatinisation Temp. (º C)	Cooking-type
Amaroo	1987	5.7	2.7	low	18	70	soft
Doongara	1989	6.7	2.0	low	24	75	firm
Illabong	1993	6.0	3.2	high	18	69	soft
Kyeema	1994	6.9	2.0	low	18	79	soft, fragrant
Langi	1994	7.0	2.0	low	18	77	soft
Millin	1995	5.5	2.7	low	17	69	soft
Opus	1999	5.0	2.8	low	18	70	soft
Paragon	2003	5.7	2.7	low	18	68	soft
Quest	2003	6.0	2.7	low	17	70	soft
Reiziq	2005	6.3	2.7	low	17	69	soft

Further reading

Further information is available from other rice Primefacts:

- Primefact 256 *Rice crop protection guide*
- Primefact 261 *Choosing a rice variety for 2007*
- Primefact 406 *Have I enough water to finish my rice crop?*
- Primefact 701 *Rice production using groundwater.*

Final research reports are available from the RIRDC website

www.rirdc.gov.au/programs/rice.html

For any further information contact Rachelle Ward at rachelle.ward@dpi.nsw.gov.au.

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