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Selection of Rice Cooking Characteristics using RVA Paste Viscosity curves

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Abstract

Rice growing began in Australia with successful experimental crops planted near Leeton in 1922. Plant breeding began in 1928, with mainly selection work been carried out in the 1930's, 40's and 50's. Comprehensive quality evaluation began in 1971 using methods mostly developed in the USA. Since 1980 the programme has concentrated on developing objective small scale early generation techniques for quality selection. The major tool developed to assess quality is the Rapid Viscoanalyser. RVA traces are now the major quality selection test used in developing new Australian rice varieties to suit particular market classes.

Keywords

- Rice, paste, viscosity, quality, texture, RVA
- Australia

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Introduction

Since 1997 is the 75th anniversary of the first successful trial of flooded rice growing in NSW, I have decided to write this paper from an historical perspective. Commercial flooded rice growing began in Australia at Leeton in 1924, following successful experiments by John Green and Austin Shepherd in the 1922/23 and 1923/24 seasons. They used both imported varieties and technology from California where growing rice commercially had only began in 1912. The technology used there was itself copied from Louisiana where "prairie" rice growing practices, based on mechanical planting and harvesting of flat lands watered by flood irrigation, developed in the early 1880's. Due to settlers migrating to west Louisiana from northern wheat-growing states realising the potential of their experience in mechanised cropping. With the aid of powerful steam pumps, they irrigated flat prairie land and used wheat growing techniques to grow rice that had until then been hand-planted and irrigated in coastal lowlands.

A rice breeder was appointed to the NSW industry in 1928 and the industry developed rapidly. Only one rice type, short grain, was grown and most rice was a selection of the variety Caloro. Some quality selection work for milling quality was done by the breeder Walter Poggendorf (Poggendorf, 1939). During World War II, the breeding programme lapsed and it was not until 1956 that an effective new programme was established. In the mid-1950's, the medium grain Calrose was introduced from California and a re-selected line, released in 1960, quickly became the industry's major variety. During this period quality work on grain cracking saw the wide-spread adoption of high moisture harvesting (McDonald 1958, 1967). Extensive crossbreeding and selection resulted in the release of these first long grain variety, Kulu, in 1967 and perhaps due to this variety's rather poor qualities, A. Blakeney was appointed Cereal Chemist in 1971. A similar series of events involving the variety Century Patna 231 had led to the US appointing a cereal chemist to a new USDA National Rice Quality Programme located at Beaumont Texts, in 1955 (Webb, 1975).

Early Generation Quality Testing

Until the 1980's, the breeding programme at Yanco Agricultural Institute used quality evaluation procedures developed mainly in the USA (Beachell and Stinsel, 1963; Webb, 1975). The amylograph method was found to be potentially useful, but it was too slow and used too much sample. An international survey of methods used conducted by Ben Juliano 1981 (Juliano, 1982) showed a similar picture for rice breeding programmes throughout the world. However the need to evaluate a greater number of lines and the emergence of increasingly discriminating world markets encouraged the development of both new tests and more efficient versions of the old tests.

Over the past 15 years the range of tests used to evaluate the quality of NSW rice lines within the breeding programme has been extensively automated. New methods using small samples have allowed some tests to be transferred to earlier generations and wherever possible instrument-based, objective tests to be substituted for subjective assessments.

A high whole grain milling return is essential for all potential varieties. In very early generations it is subjectively judged by hulling and inspection. Later, panicle rows are evaluated in the brush mill developed in California (Tseng and Nguyen, 1988). For later generations, the small scale (150g paddy) McGill mills are used in conjunction with Satake huskers and locally made indent cylinders. Late generation material is prepared for other assessments in the larger McGill (1000g paddy) and with flow through Satake polishers.

The grain appearance following milling is evaluated by both subjective observation and objective tests. Grain size and shape were measured using dissecting microscopes until last harvest when an image analyser method became a routine component of the testing (Martin et al, 1997).

Grain colour is determined using a (Instrumental Colour Systems, Newbury Bks,UK) Micromatch 2000 reflectance spectrophotometer using the 10 degree observer and DL65 with the UV component and the specular excluded in CIE (Commission international de l'Eclairage) 1976 L*a*b* colour space (Blakeney and Welsh, 1986). Grain samples (75ml) are packed into 75mm diameter cylindrical cells fitted with a silica glass window. Grain is held in place with a plastic sponge fitted between the samples and the rear cell cap. For routine reporting on breeding lines the ASTM D1925 yellowness index (ATSM, 1991) is used, which was found to correlate with subjective assessment of milled grain colour.

The presence of chalk (opaque areas within the endosperm) in grain has traditionally been measured by counting or by subjective assessment. Image analysis methods have been developed for the estimation of chalk that correlate well with the manual counting method. The presence of grain cracks is also visually determined by counting (McDonald, 1958). Research on developing an image analysis method is well advanced. The image analyser used is a simple instrument that is attached to personal computer and programmable for specific tasks (Reece and Blakeney, 1993).

Cooking qualities are usually assessed by reference to the gelatinisation temperature, amylose content and paste viscosity profiles of rice flours. The most common way of assessing gelatinisation temperature within breeding programmes is to use the alkali spreading and clearing test which is based on early Indian research (F.J. Warth and D.B. Darabsett, 1914). The method used is modified by the use of multi-compartmented square plastic petri dishes with only 1 grain per compartment (Blakeney et al, 1985) and both 1.1% (w/v) and 1.4% (w/v) potassium hydroxide for medium grain and 1.4% (w/v) and 1.7% (w/v) for long grain.

Apparent amylose content is determined on finely ball milled rice flour using ISO method 6647 (International Organization for Standardization, 1987) and approved in 1997 as an AACC standard method. This method is still slow and tedious and represents a bottleneck in the quality evaluation process. We are currently working on an NIR method for white rice amylose content using an NIRsystems 6500 scanning spectrometer (NIRSystems, Inc., Silver Spring, MD, USA). Using the partial least squares option of the NSAS software calibrations have been developed which have standard errors of prediction suitable for use in the rice breeding programme. However, data from more seasons will be collected and added to the calibrations before they are put into routine use.

Cooked grain texture is assessed on samples cooked by rapid boil, absorption to 75% wet weight or in domestic rice cookers. The availability of domestic rice cookers has allowed standard methods to be developed for both texture and taste tests that relate to domestic practice and has achieved some uniformity between rice cooking practices around the world. Rice grain texture is assessed using a Kramer shear cell and an Instron Model 1140 Universal testing machine (Blakeney, 1979).

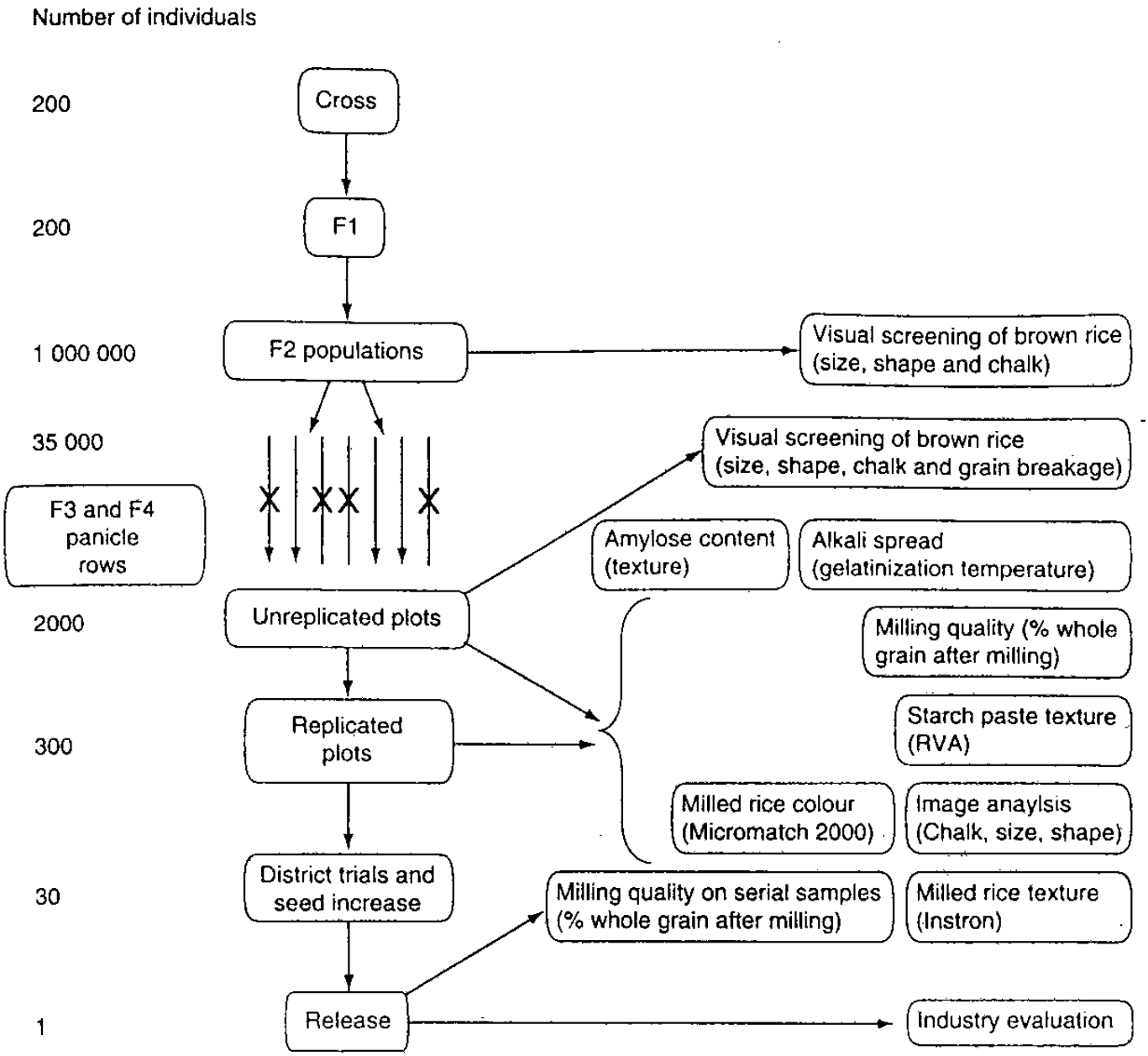
Rapid Viscoanalysis (RVA)

Currently the most useful test available to the breeding programme for assessing rice cooking properties is the RVA paste profile that is performed using the Newport Scientific Rapid ViscoAnalyser Model 3D (Newport Scientific Pty Ltd, Warriewood NSW, Australia) (Welsh et al, 1990; Blakeney et al, 1992; Blakeney and Welsh, 1993,Blakeney et al, 1996). This test produces similar information to the Brabender amylograph method that was used on late generation material but uses only 2.5g instead of 50g and takes 12.5 minutes instead of 90 minutes. The RVA method is now widely used and has progressed through the standard methods committees to become a standard method for both the American Association of Cereal Chemists (AACC) and the International Association for Cereal Science and Technology (ICC). It was accepted as a standard method by the Royal Australian Chemical Institute Cereal Chemistry Division in 1994. A standard Japanese method using an extended cooking period has been developed and ring tested (Toyoshima et al 1997). This method holds the rice surry at 50 degrees for one minute, heats to 93 degrees in 4 minutes, holds at 93 degrees for 7 minutes, then cools back to 50 degrees in 4 minutes where it holds the paste for a further 3 minutes. This gives a total test time of 19 minutes, still a substantial saving over a conventional amylograph.

Each year our rice breeding programme his about 200 new crosses that result in 200 F, plants. These are grown up to produce of the order of a million F2 plants that are selected for quality by visual screening of grain for size, shape and chalk. From these selections, usually about 35,000 F3 and F4 short rows are grown that are again visually screened for size, shape chalk and grain breakage. Amylose content and alkali spread are often run on F4 grain. Lines with suitable characteristics pass into unreplicated plots (2000/year), replicated plots (300/year) and then pass successively into district trials, seed increase and release. At present we release an average of one new variety each year. The number of varietal types we currently grow (Blakeney, 1992) means that varietal replacement within a type still occurs only at 5 - 10 year intervals (Figure 1).

The Australian rice breeding programme now uses RVA paste viscosity testing at all stages, from F4 grain, onwards to estimate cooking quality and class. From the traces we measure paste gel temperature, peak viscosity, breakdown after peak, setback and viscosity on cooling to 50 degrees C. Although these measurements are useful, the major use of RVA traces is for direct comparison with class standard varieties. Where the trace of a new line very nearly matches that of the class standard, it can be progressed with the confidence that it will have similar cooking qualities to the standard. The results are computer compatible and a trial of 10 or 20 lines can be superimposed in colour for visual appraisal. A black and white presentation, in which closely related lines are compared to in Amaroo, is shown in Figure 2. This does not do justice to the discrimination which can be achieved on a colour screen or with a colour printer.

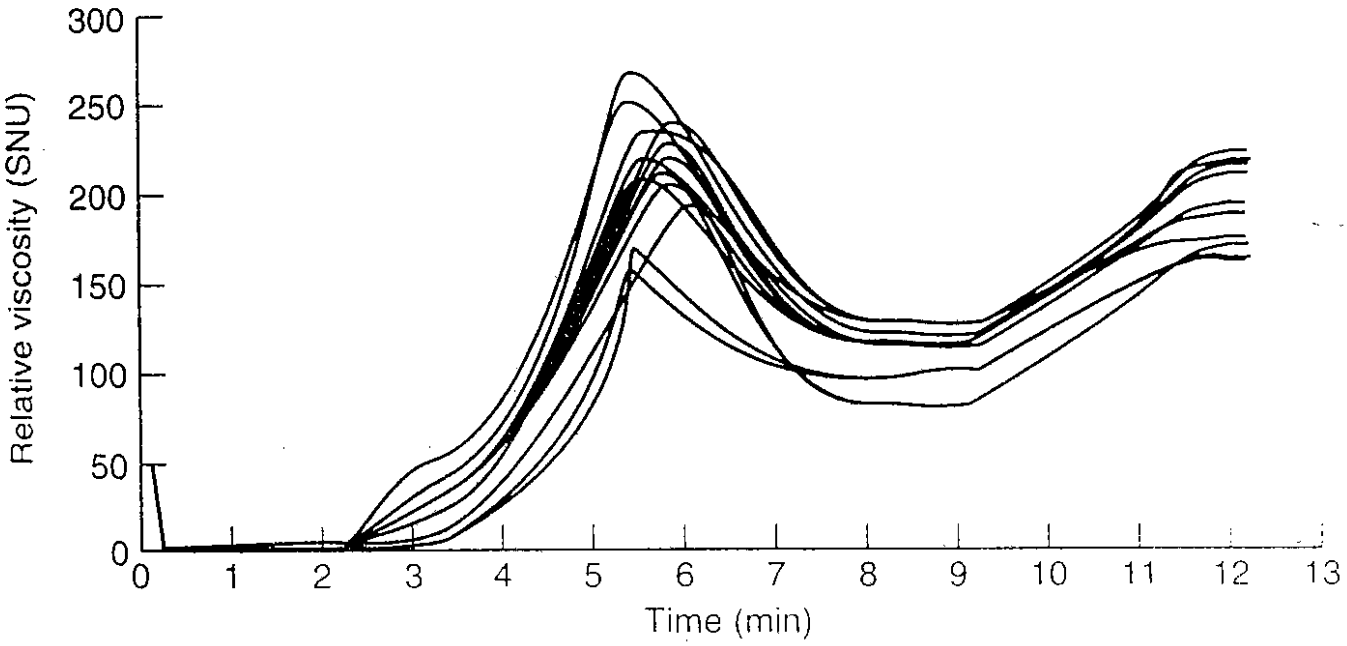
Figure 1 : Selection for grain quality used in the rice breeding programme at Yanco Agricultural Institute, Yanco, NSW, Australia.



Recently the use of pattern recognition programmes to allocate the RVA profiles into families commenced as a further step in automating quality analysis. The hierarchical cluster analysis with nearest neighbour clustering technique is currently being used (Pirouette software programme from Infometrix Inc, Woodinville WA, USA).

By using two RVAS, one technician can evaluate over 50 lines per day and quality selection can easily be completed between harvest and sowing. The approach has greatly improved the throughput and efficiency of the Yanco Agricultural Institute breeding programme.

Figure 2 : RVA traces of rices from the Yanco breeding programme superimposed to allow classification and selection.



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Figures and tables summary

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