

popping quality. CRHP-8 and White Puttu were good poppers, but are agronomically poor. They could be used as donors for good popping gene.

The recommended practice of harvesting at optimum moisture content for high yield and good milling quality also applies to high volume expansion. □

**Effect of variety, harvest moisture, and grain cracking on popping quality of rough rice.<sup>a</sup>**

Variety <sup>b</sup>	Volume (ml) of popped fraction <sup>b</sup>			Cracked grains (%)	
	Fresh rough rice	Stored rough rice	Late harvested and stored	Optimally harvested	Late harvested
				Mean ± SD	Mean ± SD
Inran	970	1300	—	—	—
CRHP-8 (waxy)	900	1040	770	0.4 ± 0.5	6.00 ± 1.2
FT-14 (CS)	870	1000	80	10.2 ± 1.0	50.00 ± 3.1
White Puttu (waxy)	—	965	—	—	—
FT-12 (CR)	55	935	590	0.2 ± 0.4	4.2 ± 0.8
FT-125	880	900	—	—	—
Y-4	—	765	640	0.4 ± 0.5	4.2 ± 0.8
S-701	—	755	—	—	—
ES-18	—	750	—	—	—
IR20	—	715	—	—	—
FT28 (CS)	630	600	170	1.8 ± 1.3	23.0 ± 2.4
Madhu 43	—	600	—	—	—
FT19 (CR)	215	555	320	0.4 ± 0.5	4.0 ± 0.7
Halubbulu	500	530	—	—	—
FT1	320	465	—	—	—
FT2	170	450	—	—	—
Vani	—	410	—	—	—
Bharani	—	345	—	—	—
IET4699	—	390	—	—	—
S199	—	270	—	—	—
Puspha	—	270	—	—	—
Purple Puttu (waxy)	—	230	—	—	—
Pusa 150	—	335	230	1.0 ± 0.7	12.0 ± 1.5
Rajmudi	—	235	—	—	—
Madhu	—	200	—	—	—
Pankaj	90	75	—	—	—
FT199c (completely chalky)	—	20	—	—	—
Sona	—	20	—	—	—

<sup>a</sup> Av of duplicate values. <sup>b</sup> CS =cracking susceptible, CR = cracking resistant.

## Procedures for quality selection of aromatic rice varieties

*R. F. Reinke, L. A. Welsh, J. E. Reece, L. G. Lewin, and A. B. Blakeney, Yanco Agricultural Institute, Yanco, NSW, 2703, Australia*

Aromatic or fragrant rice varieties have an associated flavor. The Basmati rices of Pakistan and India and the jasmine-type rices of Thailand are the aromatic cultivars commonly encountered in world trade.

Changing immigration patterns have created a demand for aromatic rices within the Australian domestic market, presenting the local rice industry with a challenge to breed a temperate climate-adapted aromatic cultivar.

The physicochemical properties of Australian non-aromatic long grain rices are similar to those of some traditional good quality Asian aromatic rice varieties (see table). The fragrant varieties usually have soft to intermediate cooked grain texture and high elongation on cooking.

During the last 8 yr, we have used a number of fragrant lines in our breeding

program. Quality selection has concentrated on subjective odor and taste tests, as well as on normal tests for appearance and for milling and eating quality.

Selection for fragrance has some unique demands. While the major chemical components of fragrance have been identified, we do not use a gas liquid chromatography technique to quantify the active compounds, for fear of selecting against other odor or taste components traditionally associated with high quality, aromatic rices. We believe that taste is as important as aroma, and that these characters vary in type as well as in intensity. Consequently, taste analysis is the most reliable approach for new variety selection.

To ensure selection of pure fragrant lines, the presence of the fragrant character must be subjectively assessed and quantified at each stage of development. Fortunately, the character is present in vegetative material as well as in grain and can be determined by tasting the lower sections of tillers at about the flowering stage. This makes it possible to harvest only those lines with the highest probability of having aromatic grain.

Testing procedures allow experienced taste panels to assess breeding lines for aroma and flavor characteristics. Because of the limited quantity of seed available in early generations, polishing

**Physicochemical properties of some fragrant rices and some Australian nonfragrant varieties.**

Variety	Milled rice property		
	Amylose (% db)	Alkali spreading value	Gel consistency (mm)
Khao Dawk Mali 105 (Thai aromatic)	19	7.0	94
Milagrosa (Filipino aromatic)	24	4.7	60
Seratus malam (Indonesian aromatic)	24	6.0	40
Kulu (Australian nonaromatic)	19	7.0	100
Inga (Australian nonaromatic)	21	6.8	100
Pelde (Australian nonaromatic)	22	6.8	100
Goolarah (Australian aromatic)	21	6.5	100

of the rice is not practical: taste tests are performed on 16 grains of brown rice.

Small quantities of rough rice are dehulled using a hand-turned Kett rice husker. This allows screening of single panicle selections for the presence of the flavor trait and for uniformity within the panicle. When larger quantities are available (10 g or more brown rice), the grain is polished using a Kett "Pearlest" model rice and barley pearler.

Grains are placed individually in the wells of a 96-well, polystyrene, "V"-bottom tissue culture plate with lid and 25 µl of distilled water added. The shape of the wells ensures that one end of each grain is positioned in the water droplet. For uniformity of water uptake, the grains are positioned so that the embryo is in the droplet.

The covered plates are enclosed in self-sealing plastic bags and refrigerated at 3 °C overnight to allow the grain to soften. Each grain is tasted and scored for flavor.

Tasting individual seeds allows us to screen panicles for the presence and intensity of aroma, as well as to measure the proportion of flavored seeds/panicle. In early-generation lines segregating for aroma, we can select only those seeds that will produce aromatic plants in the next generation.

To obtain pure seed of fragrant selections, only half of each seed is tested. The embryo halves of seeds found positive for aroma are grown into plants using a sterile agar-culture technique, then transplanted in the glasshouse.

All selections are also tested for amylose, gelatinization temperature, cooked grain elongation, and, in later generations, cooked grain texture.

Taste tests have shown that most fragrant rices traded internationally contain a proportion of nonfragrant grains. By adopting a pure-seed scheme based on single seed descent of taste-tested grains, it is possible to develop pure fragrant varieties.

Fragrant variety Goolarah was developed using this approach. Its locally adapted long-grained parent is Kulu. Goolarah has cooking properties similar to those of many Southeast Asian jasmine-type rices: good milling quality, excellent appearance, and medium-strong fragrance. □

## Relationship of transplanting time to grain quality in Basmati 385

*A. Ali, M. A. Karim, S. S. Ali, L. Ali, and A. Majid, Rice Research Institute, Kala Shah Kaku, Lahore, Punjab, Pakistan*

Normally 30-d-old seedlings of Basmati varieties are transplanted during the first half of Jul. With the release of Basmati 385, we experimented to determine its optimum transplanting time, compared with standard variety Basmati 370. The irrigated trial was laid out in a randomized complete block design with four replications.

Early and late transplanting significantly affected milling recovery and cooking quality (see table). Highest milling recovery and best cooking quality were with samples of Basmati 385 transplanted 16 Jul and Basmati 370 transplanted 1 Jul. This may be due to Basmati 385's short duration: a crop transplanted early matures when the ambient temperature is high.

Aroma in both varieties was also lower in the crop transplanted early. Amylose content and alkali spreading values increased with delay in transplanting, but remained in the intermediate category. The effect of transplanting time on protein content was not significant. □

## Rapid viscometric analysis of rice flour

*L. A. Welsh and A. B. Blakeney, NSW Agriculture and Fisheries, Yanco Agricultural Institute, Yanco, NSW 2703; and D. R. Bannon, Biochemistry Department, La Trobe University, Bundoora, Vic. 3083, Australia*

The Rapid Visco Analyser (R.V.A.) is a new instrument designed in Australia (Newport Scientific, 29 Gondola Road, Narrabeen, NSW 2101) for determining the viscous properties of starches, gels, syrups, shortenings, batters, and foams. The basic instrument has the advantages of small sample size and rapid test time, but it has limited control of heating and cooling.

We modified an R.V.A. to allow the heating and cooling rates of a testing cycle to be precisely controlled. A computer equipped with an additional input/output card is connected to an R.V.A. New software allows the R.V.A. to be fully controlled by signals from the computer (the R.V.A.'s internal control system is disabled).

The instrument has been used for viscometric analysis of rice flour from our breeding program. Viscometric properties had been measured using a Brabender Visco-Amylograph. The

Effect of transplanting date on grain quality attributes of Basmati varieties.<sup>a</sup>

Transplanting date	Total milled rice (%)	Head rice (%)	Cooked grain length (mm)	Bursting upon cooking (%)	Aroma score	Protein content (%)	Amylose content (%)	Alkali spreading score
Basmati 385								
1 Jun	66.1 e	48.3 d	13.0 c	20.0 a	3.4 c	9.5 a	23.7 c	4.1 d
16 Jun	68.1 d	50.0 c	13.6 b	17.0 a	4.0 b	9.1 b	24.1 bc	4.2 cd
1 Jul	70.1 b	54.0 b	14.2 a	12.0 b	4.8 a	9.0 bc	24.5 ab	4.5 bc
16 Jul	70.8 a	55.3 a	14.5 a	10.0 b	5.0 a	8.7 c	24.8 a	4.8 ab
1 Aug	69.2 c	50.0 c	14.0 ab	13.0 b	4.9 a	8.9 bc	25.0 a	5.0 a
Basmati 370								
1 Jun	67.2 c	49.2 c	13.4 c	18.0 a	4.0 c	8.2 a	23.0 c	4.2 a
16 Jun	68.9 b	51.4 b	14.0 ab	14.0 bc	4.4 b	8.0 a	22.9 c	4.4 a
1 Jul	70.6 a	53.4 a	14.4 a	11.0 d	5.0 a	8.1 a	22.9 c	4.5 a
16 Jul	69.0 b	51.7 b	14.2 a	12.0 cd	5.0 a	7.8 a	24.5 b	4.7 a
1 Aug	65.8 d	46.8 d	13.6 bc	16.0 ab	4.6 b	7.9 a	25.3 a	4.8 a

<sup>a</sup>In a column, means for each variety followed by the same letter are not significantly different at the 5% level (DMRT).