# Varietal Differences in Quality Characteristics of Rice Layer Cakes and Fermented Cakes

CONSUELO M. PEREZ and BIENVENIDO O. JULIANO[1]

Cereal Chem. 65(1):40–43

**ABSTRACT**

Varieties differing in amylose content (AC) and final gelatinization temperature (GT) were used to determine the most suitable rices for layer and fermented cakes. Using the layer cake formula of Bean et al (1983), acceptable cakes were obtained with nonwaxy low-GT rice flours; increasing the amount of water in the batter based on AC improved cake height. Collapsed cakes were obtained with intermediate-high GT nonwaxy flours; slightly improved cake volume but coarser texture was obtained by reducing sucrose in the batter to ensure starch gelatinization. Fermented rice cakes (*puto*) without starter showed optimum texture for intermediate-AC rices measured by double-bite technique and a laboratory panel, but cake height also correlated positively with AC.

The study of properties of processed rice products provides a means of obtaining information on indicators of varietal differences in grain quality that may not be apparent from the study of cooked rice. Bean et al (1983) showed that acceptable layer cakes are obtainable only from low-amylose, low-gelatinization temperature (GT) U.S. rices but not from intermediate-amylose, intermediate-GT rices. Hydration with intense mixing, wet milling of rice flour, or holding the hydrated flour for 6 hr at room temperature improved the texture and volume of the cake.

For traditional Philippine fermented rice cake, *puto*, aged intermediate-amylose rices showed optimum cake properties (Perdon and Juliano 1975, Sanchez 1975). Wet-milled rice flour is traditionally used in fermented cakes; this was simulated in the laboratory by homogenization of dry-milled rice flour in water (Perdon and Juliano 1975). Both layer cake and steamed fermented rice cake are prepared without eggs or milk and have mainly starch as the structural component.

The effect of variety on the properties of these two contrasting types of rice cakes was studied using rices differing in amylose content (AC) and GT.

## MATERIALS AND METHODS

Rice samples differing in amylose content (AC) and gelatinization temperature (GT) were obtained from crops grown on the International Rice Research Institute (IRRI) farm and aged for at least three months (Table I). The variety Inga was obtained from the Agricultural Research Institute, Yanco, New South Wales, Australia. Century Patna 231 was obtained from USDA, ARS Rice Research, Beaumont, TX.

Dehulling was done with a Satake THU-35A type testing dehusker, and milling of brown rice was performed either with a Satake TM-05 testing mill or McGill miller to 10% bran-polish removal. Flours from milled rice for cake making and for analysis were prepared using a Udy cyclone mill with 40- or 60-mesh sieve.

Milled rices were analyzed for AC (Juliano et al 1981), alkali spreading value (Little et al 1958), gel consistency (Cagampang et al 1973) of 100 mg of flour for nonwaxy and 170 mg of flour for waxy rices in 2 ml of 0.2*N* KOH, and protein by micro-Kjeldahl, using the factor 5.95. Viscosity of gel consistency sample was measured at 25° C with a Wells-Brookfield RVT-C/P cone-plate microviscometer using a 1.565° cone at 2.5 rpm. Alkali spreading value was used as the index of starch GT because these two properties are significantly negatively correlated (Juliano et al 1964).

### Layer Cake

The basic layer cake formula consisted of 150 g of rice flour (100-mesh), 120 g of sucrose, 10.5 g of baking powder (double-acting), 22.5 g of vegetable oil, and 120 g of water (Bean et al 1983). The rice flour and formula water were mixed at 440 rpm (setting of 8) for 3 min in a 3-L bowl of a Hobart Kitchen-Aid household mixer (model 4C) and allowed to set for 15 hr at 20–25° C. Other ingredients were added and mixed at 300 rpm (setting of 4) for 2 min. The batter was poured into greased 75 × 205 × 70 mm high aluminum pans and baked at 177° C for 32 min in a Precision Scientific model 104 gravity convection oven. Baked cakes were removed and allowed to cool in the pan for 2 hr. A sample of low-AC IR43 batter was further sheeted 20 times through an Ampia model 150 pasta maker immediately after high-speed mixing to develop the dough to simulate a dough brake (Bean 1976).

### Fermented Cake

Rice flour (100 g, 60–100 mesh) was soaked in 140 ml of water for 1 hr and homogenized at 1,700 rpm for 4 min in a 1,250-ml jar in a Waring Blendor model 5012. The batter was then allowed to stand covered overnight at 37–40° C. No starter was added. Before and after standing overnight, batter viscosity was measured at 12 rpm and 30° C with a Brookfield LVTD digital viscometer using an

[1]Cereal Chemistry Department, The International Rice Research Institute, Los Baños, Laguna, Philippines. Mail address: P.O. Box 933, Manila 2801, Philippines.

SC4 small sample adapter and 34/13R spindle. The batter was transferred into the 3-L bowl of a Kitchen-Aid mixer. Sucrose (40 g) was added and mixed 2 min at 200 rpm (setting of 2). Then 4.5 g of double-acting baking powder was added and mixed 40 sec. Batter (40 g) was poured into ungreased round aluminum pans (diameter 40 mm at the bottom, 67 mm at the top, and 25 mm high) and steamed immediately for 30 min in Toshiba RC-4B electric cookers with platforms to hold the pans. After steaming, the cakes were allowed to cool for 5 min in the open and then covered with aluminum foil for further cooling. Samples stored for 1 day at 25°C were sealed with polyethylene film.

**Instron Texture Measurements**

The hardness of layer cake was determined using an Instron model 1140 food tester with a 35-mm-diameter plunger at a crosshead speed of 10 cm/min and chart speed of 20 cm/min on duplicate 3 × 3 × 2 cm thick pieces of cake. Hardness was the maximum force required up to 50% compression.

Texture profile analysis of 2-cm-thick bottom slices of steamed fermented cake was performed by the double-bite technique using 50% compression and with the 35-mm-diameter plunger at a crosshead speed of 10 cm/min (Okabe 1979) (Fig. 1). Hardness was the maximum force of the first bite in kilograms. Adhesiveness was the work required in g·cm to lift the plunger after the first bite ($A_3$ in Fig. 1). Cohesiveness was the ratio $A_2/A_1$ of the compression area of the second ($A_2$) and first ($A_1$) bites. Elasticity or deformation recovery was the ratio of recovery distance, a, to deformation (compression) distance, b, for the first-bite peak.

The products were also assessed for comments and overall preference by an untrained laboratory panel composed of six female and six male staff members of the cereal chemistry department (25–54 years old).

All analyses were done in duplicate. Raw data were subjected to analysis of variance and correlation coefficients were calculated (Snedecor and Cochran 1980). Cohesiveness data were subjected to separation of means by Duncan's (1955) multiple range test.

## RESULTS AND DISCUSSION

**Rice Layer Cake**

Varietal differences of rices were evident in the properties of layer cake even among samples with similar AC and GT (Table I). IR24 was similar to U.S. low-AC, low-GT rices (Bean et al 1983). However, IR43, with starch properties similar to IR24, produced a thicker batter, and additional water was required to allow efficient mixing of the batter. Further sheeting of the IR43 batter 20 times through a pasta maker further improved cake height. Sheeting did not affect aged-cake hardness, although laboratory tasters observed slightly better texture.

Additional water had to be added to intermediate- and high-AC rice flours to reduce batter thickness; this resulted in increased cake height (Table I). Among the low-GT samples, volume expansion during baking as indexed by cake height increased with the increase in AC ($r = 0.95^{**}$, $n = 6$ including two additional IR43 samples). Good quality crumb was obtained for all low-GT rices. IR24 and IR43 made the most acceptable cake in terms of softness and moistness. The low hardness value of IR42 cake may be attributable to its being more crumbly because of greater cake volume. Although hardness and AC were not significantly correlated, hardness and height were ($r = 0.91^{*}$, $n = 6$).

Intermediate-GT samples such as Inga, IR36, and IR32 collapsed during baking when prepared using the regular formula. This supports the observations of Bean et al (1983). The panel described the cake as "grainy." In addition, the batter was less viscous than those of low-GT rice flours. Reducing sucrose to 40 or 45 g per 100 g of flour prevented cake collapse, but cake height was even less than that of IR24 and IR43 (Table I). Also, the cake was harder, particularly the one made from IR36 rice. Bean et al (1983) demonstrated that 50% sucrose in water increased the GT of rice starch in the batter to about 80°C for a low-GT rice. The 50% sucrose increased GT to about 92°C for an intermediate-GT rice

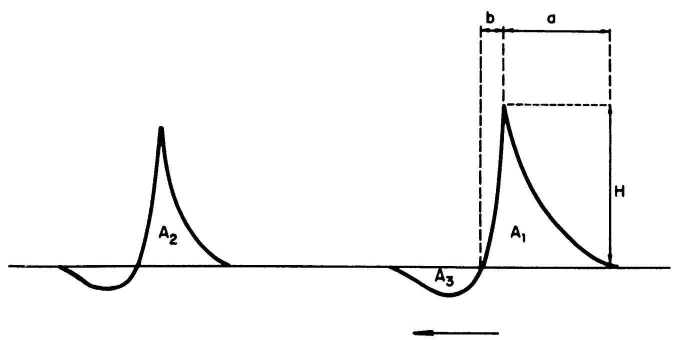


**Fig. 1.** Texture parameters used in the texture profile of steamed fermented rice cake with the Instron 1140 double-bite technique after Okabe (1979). **H** = hardness, $\mathbf{A_3}$ = adhesiveness, $\mathbf{A_2/A_1}$ = cohesiveness and **b/a** = deformation recovery.

**TABLE I**
**Relative Effect of Amylose Content and Gelatinization Temperature on Height and Hardness of Rice Layer Cake**

| Variety | Crude Protein (% N×5.95, wb) | Amylose Content (% db) | Alkali Spreading Value | Gel Consistency (mm) | Layer Cake: Water-Rice Ratio | Layer Cake: Height (mm) | Layer Cake: Hardness[a] (kg/9.6 cm$^2$) |
|---|---|---|---|---|---|---|---|
| Low gelatinization temperature | | | | | | | |
| IR24 | 8.3 | 17.6 | 7.0 | 80 | 0.80 | 49 | 0.48 |
| IR43 | 7.2 | 16.5 | 6.8 | 72 | 0.80 | 48 | 0.68 |
| IR43 | 7.2 | 16.5 | 6.8 | 72 | 0.93 | 50 | 0.50 |
| IR43 (sheeted) | 7.2 | 16.5 | 6.8 | 72 | 0.93 | 52 | 0.50 |
| IR48 | 7.7 | 23.4 | 7.0 | 46 | 1.00 | 53 | 0.58 |
| IR42 | 8.5 | 29.5 | 7.0 | 32 | 1.13 | 60 | 0.40 |
| Intermediate gelatinization temperature | | | | | | | |
| Inga | 5.8 | 19.0 | 3.6 | 90 | 0.87 | "51"[d] | ··· |
| IR36 | 10.4 | 28.1 | 5.0 | 36 | 0.80[b] | 42 | 1.10 |
| IR32 | 8.6 | 31.4 | 5.0 | 92 | 0.80 | "55"[d] | 0.40 |
| IR32 | 8.6 | 31.4 | 5.0 | 92 | 0.80[c] | 42 | 0.50 |
| LSD (5%) | ··· | ··· | ··· | ··· | ··· | 4 | 0.24 |

[a] Aged for three days.
[b] Sucrose reduced from 80 g to 40 g/100 g of rice flour.
[c] Sucrose reduced from 80 g to 45 g/100 g of rice flour.
[d] Height measured at edge because center collapsed.

(Bean and Nishita 1985). Reducing sucrose in intermediate-GT rices to adjust GT close to 80°C also resulted in acceptable cake volume, but the sandy texture remained.

The study confirmed that complete starch gelatinization was critical for successful development of rice layer cake. Low GT of starch is required for the formula of Bean et al (1983), because intermediate-GT flours are not gelatinized. Additional work on the batter, as evident from sheeting in a pasta maker, resulted in improved cake volume. Fifteen passes through a dough brake is used for dough development of bread flours in the Philippines (Bean 1976). Intense mixing of hydrated flour, wet milling, sheeting, and holding of hydrated dry-milled flour all improved cake volume and texture. Such processes result in the breakdown of the flour particles into discrete starch granules and protein bodies. Discrete starch granules would hydrate and gelatinize more uniformly than flour particles. However, "gel" protein (Graveland et al 1979) has been noted to be produced from kneading rice flour as a dough even though rice does not have gluten-like protein (Bean 1986). Nonstarch polysaccharides (Mod et al 1981) and nonstarch lipids would also be better dispersed by these developing processes.

Our preliminary experiments on IR24 and IR64 rice flours showed that pronase-treated starch produced slightly reduced cake height but a harder cake for IR24 and a softer cake for IR64. Cakes made from starch were more translucent than those from milled rice. Addition of 7 and 14% protein or *Aspergillus oryzae* α-amylase-destarched milled rice (Resurreccion et al 1978) to the starch resulted in cake with poor volume, brittle crust, and dull appearance. The use of washed wet-milled flour in place of unwashed wet-milled flour did not adversely affect cake properties, suggesting that water-soluble polysaccharides, proteins, and nonstarch lipids are not major factors to layer cake quality because they are discarded together with damaged starch during the filtration of wet-milled rice flour. Further experiments are needed to verify the role of starch and protein on volume expansion of layer cake.

**Fermented Rice Cakes**

Letting the rice batter stand overnight to age or ferment resulted in increased batter viscosity for all samples (Table II). However, IR64 batter showed the highest viscosity. Volume expansion of fermented rice cakes, as indexed by cake height, was highest for those made from high-amylose rice and least for that from waxy rice. The waxy rice cake collapsed during steaming. Considering the 10 nonwaxy rices, cake height and AC were significantly correlated ($r = 0.84^{**}$), but cake height and alkali spreading value were not ($r$ = 0.05). Expansion ratio of fermented cakes was correlated with AC (Sanchez 1975). Perdon and Juliano (1975) observed maximum volume for intermediate-amylose cakes, but they used a lower water-rice ratio of 1.0 and a sugar-water ratio of 0.125. The present recipe had a water-rice ratio of 1.4 and a sugar-water ratio of 0.286. The use of more water in the batter in the present study may have allowed the high-AC rice batters to expand further during steaming.

The consensus of the sensory panel was that the fermented cakes from high- and intermediate-amylose rices were satisfactory in overall properties, but it preferred intermediate-amylose rice cakes. Low-amylose rice cakes were less acceptable because they were too sticky and mushy. Texture profile analysis of freshly steamed cakes revealed overlapping hardness values among the amylose types but more adhesiveness for waxy and low-amylose cakes, except for Century Patna 231 (Table III). Cohesiveness values also overlapped among amylose types, but deformation recovery was lowest for low-amylose rices. The high deformation recovery of IR65 waxy rice cake was due to its collapsed or unexpanded state. Amylose content significantly correlated negatively with adhesiveness and positively with cohesiveness and deformation recovery. Alkali spreading value did not significantly correlate with fresh cake texture. The fermented rice cakes had higher hardness values than the layer cakes (Table I).

One-day storage of rice cakes at room temperature increased the hardness values of some high-amylose samples (Table III). The soft gel, intermediate-GT, high-amylose rices IR32 and IR62 had the greatest increases in cake hardness. IR24, IR43, and IR65 cakes had the highest adhesiveness values. No trend was shown for cohesiveness, but deformation recovery increased for C4-63G cake. Amylose content correlated significantly with hardness, adhesiveness, and deformation recovery but not with cohesiveness. Again, alkali spreading value did not correlate with aged-cake texture.

The sensory panel rated IR36 as the most preferred high-amylose rice cake, followed by IR42, then IR32, and IR62, consistent with the relative softness of cake as indexed by hardness values (Table III). Among the intermediate-amylose cakes, IR64 was most preferred, followed by C4-63G and then IR48, again consistent with the relative softness of the cakes.

These results confirmed earlier results that intermediate-amylose rice produces the preferred fermented rice cakes (Perdon and Juliano 1975). General acceptability of fermented rice cakes had been correlated with AC (Sanchez 1975). Starch gelatinization temperature was a less important factor in cake texture for steamed fermented cake than in layer cake, probably because of lower sucrose-water ratio (0.286 vs. 1.00), rice-water ratio (0.71 vs. 1.25) and wet steaming of the fermented cake.

Gas retention of the fermented batter must involve cohesion among the hydrated rice starch granules. Waxy rice IR65 showed the greatest batter volume before steaming, but collapsed during steaming (Table II). Because the solubilized exudate during gelatinization forms a network that connects the individual granules (Lee and Osman 1986), amylose probably forms a stronger network than amylopectin and explains the positive correlation between cake height and AC. By contrast, the rice

**TABLE II**
**Physicochemical Properties of Aged Milled Rices Used for Steamed Fermented Rice Cakes, Batter Viscosity, and Height of Cake**

| Variety | Crude Protein (% N×5.95, wb) | Amylose Content (% db) | Alkali Spreading Value | Gel Consistency (mm) | Batter Viscosity (cP) Before Aging | Batter Viscosity (cP) After Aging | Maximum Height of Cake (mm) |
|---|---|---|---|---|---|---|---|
| IR32 | 8.6 | 28.4 | 5.0 | 92 | 382 | 472 | 42.0 |
| IR62 | 9.3 | 27.5 | 5.0 | 73 | ... | ... | 42.0 |
| IR36 | 10.4 | 26.6 | 5.0 | 36 | 352 | 732 | 44.5 |
| IR42 | 8.5 | 27.9 | 7.0 | 32 | 528 | 785 | 42.0 |
| IR48 | 7.7 | 22.9 | 7.0 | 46 | 445 | 700 | 29.5 |
| IR64 | 7.1 | 23.5 | 4.0 | 98 | 3,130 | 11,560 | 36.5 |
| C4-63G | 6.5 | 23.2 | 3.0 | 56 | 492 | 922 | 36.5 |
| Century Patna 231 | 8.6 | 14.3 | 3.0 | 60 | 470 | 1,270 | 35.0 |
| IR24 | 8.3 | 15.4 | 7.0 | 80 | 492 | 575 | 30.5 |
| IR43 | 7.2 | 15.2 | 6.8 | 72 | 338 | 772 | 27.5 |
| IR65 | 9.0 | 3.0 | 6.2 | 100 | 515 | 615 | <20 |
| LSD (5%) | ... | ... | ... | ... | 354 | 224 | 2.5 |

TABLE III
Textural Properties of Fresh and Day-Old Steamed Fermented Rice Cakes and Their Correlation with Amylose Content and Alkali Spreading Value[a]

| | Fresh Cake | | | | Day-Old Cake | | | |
|---|---|---|---|---|---|---|---|---|
| Variety | Hardness (kg) | Adhesiveness (g·cm) | Cohesiveness[b] | Deformation Recovery | Hardness (kg) | Adhesiveness (g·cm) | Cohesiveness[b] | Deformation Recovery |
| IR32 | 2.0 | 10 | 0.80 ab | 0.75 | 4.5 | 0 | 0.62 a | 0.82 |
| IR62 | 2.0 | 0 | 0.76 ab | 0 58 | 3.2 | 0 | 0.81 a | 0.80 |
| IR36 | 1.2 | 5 | 0.86 a | 0.68 | 1.8 | 0 | 0.66 a | 0.70 |
| IR42 | 1.7 | 15 | 0.85 a | 0.66 | 2.1 | 17 | 0.67 a | 0.69 |
| IR48 | 2.9 | 164 | 0.66 ab | 0.33 | 2.5 | 62 | 0.74 a | 0.54 |
| IR64 | 1.1 | 111 | 0.72 ab | 0.52 | 1.7 | 23 | 0.82 a | 0.73 |
| C4-63G | 1.5 | 128 | 0.80 ab | 0.42 | 2.0 | 5 | 0.78 a | 0.71 |
| Century Patna 231 | 0.9 | 110 | 0.71 ab | 0.18 | 1.0 | 56 | 0.64 a | 0.35 |
| IR24 | 1.7 | 359 | 0.49 b | 0.16 | 1.3 | 359 | 0.63 a | 0.30 |
| IR43 | 1.7 | 605 | 0.50 b | 0.14 | 1.4 | 456 | 0.56 a | 0.25 |
| IR65 | 0.9 | 328 | 0.67 ab | 0.42 | 0.9 | 287 | 0.62 a | 0.48 |
| LSD (5%) | 0.6 | 297 | ns | 0.24 | 0.8 | 235 | ns | 0.20 |
| Correlation coefficient with | | | | | | | | |
| Amylose | 0.26 | −0.77**[c] | 0.79** | 0.96** | 0.73* | −0.74* | 0.34 | 0.78** |
| Alkali spreading value | 0.62 | 0.41 | −0.47 | −0.12 | 0.04 | 0.53 | −0.34 | −0.58 |

[a] Significant $r = 0.632$ at the 5% level and 0.765 at the 1% level, excluding IR65 ($n = 10$).
[b] Means followed by a common letter are not significantly different at the 5% level by Duncan's (1955) multiple range test.
[c] Significant at the ** 1% and * 5% level.

component of *idli* (black gram rice pudding) is considered a less important factor than the black gram component in the gas retention and volume expansion of steamed *idli* (Susheelamma and Rao 1979), probably because the milled rice commonly used in India is high in amylose and parboiled (Ghose et al 1960). Low-amylose and waxy raw rices are considered unsuitable for *idli* (Ghose et al 1960).

Water-soluble hemicelluloses, protein, and nonstarch lipids are probably minor factors in fermented rice cake quality, because the wet-milled flour is collected by filtration and the water phase discarded. Thus, use of washed wet-milled IR64 flour resulted in cake heights identical to those made with unwashed wet-milled flour (IRRI, *unpublished data*). Freshly harvested IR64 flour resulted in less cake height increase and slightly harder cake than six-month-old flour (IRRI, *unpublished data*), confirming that fermented rice cakes are also subject to aging effects (Perdon and Juliano 1975) as is boiled rice (Villareal et al 1976). A detailed study of processing factors and rice constituents important in determining the quality of layer cake and fermented rice cake would be desirable.


## ACKNOWLEDGMENTS

The Inga sample was supplied by A. B. Blakeney and Century Patna 231 by B. D. Webb.


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[Received March 31, 1987. Revision received July 10, 1987. Accepted July 10, 1987.]