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Rice quality for the future

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Abstract

With increasing knowledge of the structure of starch granule and the starch fractions, new screening methods to evaluate properties such as amylopectin staling will evolve. Methods to determine amylose and aqueous gel consistency to reflect amylopectin staling will be simplified and made more reproducible and will be supplemented by non-destructive instrument methods. Breeding for high and stable head rice yield will intensify. Distinctions between indica and japonica rices will decrease and DNA methods for variety identification of milled rice will improve. Biotechnology may see the production of functional foods through transgenic rices containing less allergenic globulin, less phytin, more protein, Fe, Zn, Vitamin A and Â-amylase, etc. All these and other transgenic rices with resistance genes should be tested for residual antinutrients in the scutellum of milled rice and in bran and germ.

The adoption of GATT-WTO and the policy of encouraging value-added rice products to compensate for the downward trend in boiled rice consumption in Asia auger well for the development and improvement of quality and shelflife of rice food products and rice-based ready-to-eat convenience foods. Rice flours from dry/semi-wet process will replace wet-milled flour in most traditional rice food and use of rice in food formulations will increase.

Keywords

- Chemical characteristics, technology.
- World.

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Introduction

The Rice Processing Working Group Meeting of the FAO-Mediterranean Rice Research Network, Alexandria, Egypt, 13-16 Jan. 1992 reported the preferred variety types as :

- Short-medium grain rice (mainly japonica) with low (15-20%) apparent amylose content (AC), low gelatinization temperature (GT) and soft gel consistency (GC); and
.
- Long-grain rice (mainly indica) with intermediate (20-25%) AC, soft GC and intermediate-low GT. Increased production of long-grain indica rice in 1988-92 in France, Italy, Greece, etc. was triggered by the 5-yr EEC support for such rice.

An IRRI survey of world rices (Juliano and Villareal 1993) showed that European-grown rices have low-intermediate AC, low GT and soft GC (Table 1). Most of the intermediate/high-GT samples were low-AC. The hard-GC samples were mainly high- and intermediate-AC rices.

Screening methods

Grain quality is an important breeding objective in national rice programs (Juliano and Duff 1991a,b). The problem of reproducibility of the quality tests, particularly amylose was noted in the 1992 Alexandria meeting. Phan and Mercier (1984) demonstrated that organic acids, including acetic acid, complex with amylose in the traditional African meal "foufou". Chrastil (1987) reported improved colorimetric determination of amylose through the use of trichloroacetic acid, which also precipitates rice protein, in place of acetic acid. The application of trichloroacetic acid or formic acid (in place of acetic acid) to remove amylose complexing and the reduction of iodine to obtain blue instead of a greenish color due to excess iodine are being explored. Instrument methods (Kohlwey 1994, Blakeney 1996, Juliano 1996, Ohtsubo et al 1996), particularly those based on near-infrared transmission and reflectance, will surely improve, but they still depend on the wet method for calibration.

Gel consistency has been shown to be mainly due to amylopectin (Juliano and Perdon 1975). Hard GC corresponds mainly to longer chain length amylopectin common in low-GT high-AC rices (Villareal et al 1997). Charge repulsion among starch molecules in 0.2N KOH prevents amylose retrogradation in the GC test. Advances in our knowledge of granule structure and fine structure of amylopectin and amylose should facilitate the development of simple tests that measure varietal difference in amylopectin staling. Amylopectin staling of cooked rice has been measured in aqueous gels by differential scanning calorimetry and low-angle oscillating viscometry, and in cooked rice by Instron cooked rice hardness. A screening method based on aqueous GC for waxy, low-AC and intermediate-AC rices would be helpful in the breeding program. High-AC aqueous gels are unstable. Low-GT cooked rices show less amylopectin staling than intermediate-high-GT rices in each of the AC types. In addition, differences in glycemic index seem to be evident when high-AC rices differing in GT were cooked to optimum water uptake, but not in excess water to minimum cooking time (Panlasigui et al 1991).

The 1995 meeting of this EEC rice group (Mourzelas 1996) showed concern for the variable head rice yield in experiments. Our studies showed that reproducible screening is only possible with a consistent moisture adsorption stress method, soaking rough rice 1-3 hr in 30°C water (Juliano et al 1993). Stress methods at lower relative humidity (rh) are subject to variation with changes in the number of samples treated (Ibabao et al 1987). Evidently soaking the rough rice ensures a 100% rh environment to the grain before free water diffuses through the hull. Resistant varieties have a critical moisture content (CMC) of 11-14%, whereas susceptible varieties have a CMC of 15-16% (Juliano and Perez 1993). Thus all varieties are crack-resistant at 16% moisture, but susceptible rices crack at 14% moisture, the ideal moisture content for the test (Juliano et al 1993). Satake Corporation (1991) has utilized this observation in their high-moisture milling of brown rice at 15% moisture and in cooking milled rice at 15% moisture also, thus minimizing grain breakage during milling and cooking. Crack resistance will become more important in the future because of the increasing premium being given to head rice. Random arrangement of cells in crosssection in Kulu contributes to crack resistance as contrasted to radial pattern in Caloro (Blakeney 1996).

The liberalization of agricultural trade under the GATT will cause market prices to increase, more for japonica rice than for indica rice, and more in the short run than in the long run (Hossain 1996). Quality differences between indica and japonica rices will decrease in the future with continuous crossbreeding. The basis of texture differences between these two types will be elucidated and quality then will be described in terms of physicochemical properties, particularly of starch. The failure to breed japonica quality into indica x japonica Korean rice (Tongil), despite the similarities in AC and GT, is an example.

With the increased international trade in rice due to the GATT-WTO, methods for differentiating local and imported rice and identifying varieties will be necessary. DNA methods using milled rice will be used for variety identification (Ohtsubo et al 1997). Demand for aromatic rice will increase as consumers become accustomed with its aroma (Mourzelas 1996, Setboonsarng 1996), which is similar to that of popcorn. The demand for "organic" rice without added agrochemicals (Hossain 1996) will increase even in developing countries.

Transgenic rices

Transgenic rices incorporating genes for resistance to diseases and pests need to be checked for antinutrition factors in the residual maternal tissue of brown and milled rice. However, the problem is less severe in monocots (with triploid endosperm storage tissue than in dicots (with diploid cotyledon storage tissue).

The nutritional quality of the rice grain will also be improved by incorporating wheat glutenin genes to increase the protein content and by removing the allergenic globulin gene (Matsuda et al 1993) which is responsible for atopic dermatitis in certain persons. Spherical protein body (PB) I is mainly prolamin and crystalline, segmented PB II (Harris and Juliano 1977, Bechtel and Juliano 1980) is mainly glutelin in the rice endosperm (Tanaka et al 1980). Although the poorly digested protein of cooked rice is the core of PB I (Tanaka et al 1978, Resurreccion et al 1993), storage protein mutants with more prolamin subunits (Esp-4, LGC 1) were not less digestible in growing rats than the parents and glutelin-rich mutants (Eggum et al 1994, Eggum and Juliano 1997)(Table 2).

Improvement of micronutrient density of rice through breeding and biotechnology, with emphasis on Vit. A, Zn, and Fe (Graham and Welch 1996), has been under way with the support of the Rockefeller Foundation and other donors. A complementary approach is the use of low-phytate rice mutant of Raboy (1996) to improve mineral bioavailability in brown and milled rice. Consumer acceptability of high-vitamin A rice needs to be verified in view of the partiality of consumers to white rice. Filipino consumers also prefer white corn to yellow corn.

Rice products

The widespread adoption of GATT-WTO and the policy of encouraging value-added rice products to compensate for the downward trend in boiled rice consumption in Asia auger well for the development and improvement of the quality and shelflife of rice food products and rice-based, ready-to-eat convenience foods (Juliano 1997). These would be based on the rice quality type (AC-GT) preferred in each country (Juliano and Gonzales 1989). Nonconventional food uses for rice are being sought in the United States (Champagne 1994, 1995).

There is much interest in parboiled rice in Europe (Mourzelas 1996). Usually, tests for quality are done on parboiled rice. The degree of parboiling is difficult to maintain uniformly among rices that differ in GT and AC. However, Biswas and Juliano (1988) demonstrated that the quality of parboiled rice may be more conveniently determined on raw rice, because of the predictability of parboiled rice quality from raw rice quality.

Ready-to-eat convenience rice foods that take a few minutes to prepare will be increasingly popular as is the case with instant noodles (Juliano 1997). During calamities and emergency situations, wet precooked rice has been very useful. Wet products should be able to maintain their cooked rice texture during shelf storage. In Japan, frozen cooked rice packed in airtight plastic pouches in an instant freezer is popular. Deep freezing without dehydration is most effective in keeping cooked rice from retrograding. It is readily heated in microwave ovens in chain restaurants and served to customers. For dry pregelatinized rice in Japan, cooked rice is quickly dried by heated air to fix the starch in the amorphous state at about 8% moisture. It has good shelflife and light weight. It is consumed after rehydration, cooking or warming for about 10 min and standing for about 15 min.

Our 1988 study of rice products in the Bonn markets showed a preference for head rice, processing level, lot size, and type of packaging (Kaosa-ard and Juliano 1991). The United States has the advantage in supplying this market since U.S. producers have a domestic market focused on physical quality and attractive packaging (Unnevehr et al 1992). A corresponding study of the Rome markets showed a preference for raw and parboiled chalky bold-grain Arborio type japonica rice. Similar results were obtained by Chataigner (1991) and Mourzelas (1996).

Wheat flour and corn starch have been replacing wet-milled rice flour in traditional rice food products because of convenience and the pollution problem inherent with wet milling plus the poor shelflife of the wet-milled flour due to fermentation. The production of rice flour with minimal starch damage at lower moisture content should reverse this trend, particularly if the flours will be labelled in terms of products for which they are suitable as raw material. The Tropical Products Institute in the UK reported that sorghum and millet grain may be roller-milled using a semiwet process; 8-14% added water for millet (to 17-21% water content) and 20-30% added water to sorghum (to 26-32% water content)(Cecil 1986). In Japan, milled waxy and nonwaxy rices for rice crackers are washed with water and steeped (32% moisture content) prior to roller milling and further processing, instead of the traditional cooking and handpounding of cooked rice (Juliano and Sakurai 1985). Thus, we are exploring, with food scientists at the University of the Philippines Los Baños Institute of Food Science and Technology, the feasibility of using a roller mill on washed and steeped waxy and nonwaxy milled rice for flour production. The flour can then be readily dried and stored before use and this can substitute for wet-milled flour, wheat flour and corn starch in rice products.

Moreover, rice flour will find more applications in formulations, where intermediate-AC rice improves the crispness/crunchiness of fried batters and chips (Kohlwey et al 1995). Waxy rice flour can reduce chip hardness and breakage during packaging and can produce a "melt-in-the mouth" texture usually achieved with extra fat (Sheng 1995). One important use of rice in the United States is as a thickener (Kohlwey et al 1995). Waxy and low-AC rice flours are preferred because syneresis (retrogradation) is minimized. Waxy rice is preferred when a smoother, more fat-like texture is intended.

Ultimately, progress in rice quality will depend on how effective is the linkage and feedback from consumers and processing industry to the rice breeders, chemists and food scientists, to ensure a market driven research set-up, particularly in developing countries.

Table 1. Protein Content and Classification of Milled Rices Grown from Europe and Egypt Based on Apparent Amylose Content (AC), Final Gelatinization Temperature (GT), and Gel Consistency (GC).

IRRI, 1965-91 (Juliano and Villareal 1993).

Source	Sample (no.)	Protein (%wb) Range	Mean	AC[a] L	I	H	GT[b] L	I	HI/H	GC[c] S	M	H
Bulgaria	23	6-10	7.4	14	8	1	23	0	0	17	4	0
France	50	5-12	7.1	31	17	2	50	0	0	29	12	5
Greece	10	5- 8	6.4	3	5	2	8	2	0	4	4	2
Hungary	42	6-11	7.2	15	26	1	38	4	0	10	22	7
Italy	40	5- 8	6.9	14	25	1	39	1	0	20	7	5
Portugal	31	5- 8	6.8	17	13	1	30	1	0	26	4	1
Russia	25	5- 7	6.4	16	9	0	17	4	4	22	3	0
Spain	12	6-13	8.2	9	3	0	12	0	0	9	0	0
Total	233	5-13	7.0	119	106	8	217	12	4	137	56	20
Egypt	44	5-19	6.7	29	8	7	42	2	0	30	2	9

[a]L = low (12-20%), I = intermediate (20-25%), H = high (>25%).
[b]Indexed by alkali spreading value: L = low (6-7), I = intermediate (4-5), HI = high intermediate (3), H = high (2).
[c]Only samples analyzed from mid-1991 have GC values: S = soft (61-100 mm), M = medium (41-60 mm), H = hard (25-40 mm).

Table 2. True Digestibility (TD) in Growing Rats of Protein of Cooked Milled Rice of Various Japonica Storage Protein Mutants (Eggum et al 1994, Eggum and Juliano 1997)

Mutant/Parent	Mutation[a]	N x 6.25 (%)	TD (%)
esp-1 (CM21)	Prolamin 13b-	7.3±0.0	94.6±0.6d
esp-2 (CM1787)	Glutelin 57+	6.6±0.0	99.9±0.4a
esp-3 (CM1675)	Prolamin 10/13a-	7.5±0.2	97.2±0.9b
Esp-4 (CM1834)	Prolamin 10/16+	7.2±0.0	97.1±0.8b
Kinmaze	None	6.8±0.2	95.5±0.8c
LGC 1 (NM67)	Glutelin 22/37-	5.6±0.3	99.7±0.6a
Nihonmasari	None	5.8±0.1	99.8±0.6a

[a]Numbers refer to protein subunit MW in kiloDaltons; - = lower; + = higher.

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