implementation process will help in capacity building and increase the farmers' sense of ownership in the program.

Farmers are very supportive and cooperative in the project area. However, in some technical matters farmers' had different perceptions and attitudes, which changed along with the time. For example, farmers perceived that plants with short height could not produce good yields, that detasseling leads to total sterility in maize, etc. In the beginning, this made it difficult for researchers to facilitate some of the field activities, such as crossing, demonstrating short-statured varieties, etc. Later, the farmers found that their perceptions were not correct, and their faith in the researchers increased, leading to better understanding, cooperation, and collaboration. Some farmers who were not positive about the program in the beginning are the strongest members of the team now.

Conclusions

Involvement of farmers in the planning process resulted in the development of more specific breeding objectives, which were more focused on the farmers' perceived needs. It has helped to refine the context and process of the participatory plant-breeding program and has given farmers a leading role in the decision-making process.

Bibliography

Kadayat, K.B., R.B. Rana, K.D. Joshi, A. Subedi, and B.R. Sthapit. 1998. *Report on participatory variety selection on food crops in Gulmi district, Nepal: Need assessment and future strategy Gulmi Arghakhanchi Rural Development Project/LI-BIRD, Dec 1998.* Pokhara, Nepal: Local Initiatives for Biodiversity Research and Development.

MoA. 1995. *Agricultural statistics of Nepal.* Kathmandu, Nepal: Ministry of Agriculture, HMGN.

Sthapit, B.R., K.B. Kadayat, A. Vaidya, A. Subedi, K.D. Joshi, and R.B. Rana. 1997. *Report on need assessment for participatory variety selection on food crops in Arghakhanchi district, Nepal. Gulmi Arghakhanchi Rural Development Project/LI-BIRD, May 1997.* Pokhara, Nepal: Local Initiatives for Biodiversity Research and Development.

Subedi, M. and P.K. Shrestha. (Forthcoming). *Site selection report of farmer-led participatory maize breeding program for the Middle Hills of Nepal, 1998.* Pokhara, Nepal: Local Initiatives for Biodiversity Research and Development.

Sensory Evaluation of Upland Rice Varieties with Farmers: A Case Study

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Abstract

As part of a participatory plant-breeding project with methodological objectives to improve rainfed rice in eastern India, an evaluation of sensory characteristics was conducted with farmers in a village of Bihar. Twenty-four farmers (12 women and 12 men) evaluated 15 upland rice varieties as raw rice and parboiled rice for milled and cooked rice appearance, color, odor, texture, stickiness, taste, and overall acceptability. The rice samples were milled and cooked by the women farmers following their ordinary practices. One variety recorded good results with both raw and parboiled modes of preparation. The preferences of women and men farmers did not differ significantly. The rankings based on preferences were compared with the rankings of the varieties for various physico-chemical characteristics measured in the laboratory. Most correlations were not significant, indicating that, for the set of tested varieties, these parameters were poor predictors of farmers' preferences. The rankings based on preferences were compared with farmers' field rankings, and the correlation was positive for raw rice and negative for parboiled rice. Farmers' trade-off between field performance and grain quality is therefore important to assess for at least parboiled rice. The results of this first sensory evaluation experiment will be used to simplify the methodology and to improve varietal evaluation in the formal breeding process.

Introduction

In eastern India, rainfed rice represents a major component in the diet and income of millions of resource-poor people. In these harsh environments, the rate of adoption of modern rice varieties is low. Subsistence agriculture is still quite important, although market integration is slowly progressing (Pingali 1997). In these transition systems, grain quality and taste strongly influence the adoption of modern varieties. The main source of variation in grain quality is the variety, although environment and genotype-x-environment interactions also affect grain quality. Different grain types, and therefore different varieties, are needed for self-consumption, market sale, and various preparations or to pay wages in kind. For plain rice, precooking practices influence the varietal choices. Among the most common is parboiling, which is an age-old practice in some regions of eastern India, where rice is partly cooked before being air-dried and then sun-dried to improve its nutritional, cooking, and storage attributes. Preferences may vary across income levels, various social groups requiring various varieties.

Quality tests for breeding lines are routinely conducted by scientists in the laboratory. In the frame of a participatory plant-breeding project with methodological objectives started in 1997 under the collaborative program with the Indian Council of Agricultural Research (ICAR) and the International Rice Research Institute (IRRI) (Courtois et al. 1999), we developed a methodology to evaluate the grain quality of rice varieties in collaboration with farmers. To test the methodology, the

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sensory evaluation of a set of upland rice varieties was organized in a village of eastern India. The objectives of this study were (1) to document the process of rice preparation at the farm level for raw and parboiled rice, (2) to estimate the influence of the two modes of preparation on rice quality and identify the best varieties in each case, (3) to collect information about quality characteristics that determine varietal acceptability by female and male farmers, and (4) to relate the preferences with the physico-chemical properties of the varieties determined in laboratory.

Materials and methods

Fifteen modern upland rice varieties and a local check (Brown Gora, widely grown by upland farmers) were tested. The test was conducted in 1998 in the village of the Korahar district of Hazaribagh, Bihar, India. These varieties had been previously tested for their agronomic values in a participatory varietal trial conducted in the same village (Courtois et al., *submitted*).

Raw rice

For each variety, two kilos of sun-dried paddy of good quality were used. The paddy was dehulled and milled using a *dhenki*, a big wooden bar moving up and down around an axis. The *dhenki* was operated by two women, one of them moving the *dhenki* with her leg, the other shuffling the paddy grain after every stroke of the *dhenki*. All the varieties were dehulled and milled by the same two persons under the same conditions. The times necessary for completion of dehulling and milling, and the milling recovery (percentage of milled rice weight on rough rice weight) were recorded. The head rice recovery (unbroken grains) was not quantified but estimated visually (milled rice appearance).

Before cooking, one kilo of cleaned rice was washed with water. Aluminum vessels called *bhudeli* were used to cook each variety separately. All *bhudeli* were of the same capacity. The women suggested using 3 liters of water to cook 1 kg of raw rice. The *bhudeli* with water was kept on the fire up to the boiling point, when the washed rice was added. The cooking test was done by pressing the cooked rice between thumb and index finger. The same woman did the cooking test for all varieties. The cooking time of each variety was recorded. The excess water was drained and the cooked rice was displayed on a *pattal* (leaf mat) for sensory evaluation.

Parboiled rice

As decided by the women, 2.5 kg of paddy were soaked in 3 liters of water in a tin container for 18 hours. A common belief is that the soaking of paddy should be done in the evening rather than during daytime, with the excess water drained in the morning, to avoid the heat of the day. A temperature that is too high would induce the soaked paddy to ferment, leading to poor rice quality, high breakage, and bad odor (Bhattacharya 1985). The soaking of paddy in water started at 4:00 p.m. and the water was drained at 10:00 am the next day. After decanting the water, the soaked paddy was steamed on the fire. During the steaming process, the tin containing the soaked paddy was covered with a gunny bag to avoid loss of heat. When the husks of the paddy started cracking, the container was taken off the fire. The steamed paddy was spread in the shade on a mud floor for drying. The paddy was dried in the shade for 48 hours with intermittent mixing. It was then exposed to the sun for complete drying. An indigenous technique was used to test the proper drying of paddy. Twenty to 30 grains of paddy were dropped on a hard floor. The grains were crushed underfoot by rotating the heel. If this removed the grain husk, the rice was considered to be well dried and ready for

dehulling. For dehulling and milling, 2 kg of cleaned paddy were used and the same process as for raw rice was followed.

More water is needed to cook parboiled rice than to cook raw rice. The women suggested adding 7 liters of water to cook 1 kg of parboiled rice. For the subsequent operations, the same process was followed as for raw rice.

Sensorial evaluation

A protocol for the practical organization of the sensory evaluation was designed following the recommendations of Amerine, Pangborn, and Roessler (1965) and Del Mundo (1991) and adapting them to the realities of an eastern Indian village.

Twenty-four farmers (12 women and 12 men) participated in the sensory evaluation. A hedonic scale was used. The farmers were asked to indicate whether they liked (score 1) or disliked (score 0) the varieties for milled grain appearance, cooked rice appearance, odor, color, texture (soft/hard), stickiness, taste, and overall acceptability. The samples were numbered and randomized to limit the "first-sample bias." The raw rice and parboiled rice were evaluated on different days to limit the testers' fatigue.

Physico-chemical characterization of the samples under laboratory conditions

The tests were performed at the technology laboratory of the Central Rice Research Institute, Cuttack, India, for raw rice and in N.D. University of Agriculture and Technology, Masodha, Faizabad, India, for parboiled rice. The parameters measured for raw rice were milling recovery, head rice recovery, grain length and width, alkali value, volume-expansion ratio, kernel-elongation ratio, and amylase content. For parboiled rice, hulling and milling recovery and grain shape were measured.

Statistical analysis

For rank comparison, Spearman's coefficient of correlation was used when only two rankings were compared. A Kendall coefficient of concordance was used, as described in Siegel (1956), when more than two rankers were involved. The mean comparisons were performed using a Student's *t*-test.

Results and discussion

Milling

No difference between the two modes of preparation was observed for milling time (table 1). Raw rice took significantly less time to cook as compared to parboiled rice. Milling recovery was significantly higher for parboiled rice in comparison to raw rice. There was no significant difference between farmers' practices and laboratory method for raw rice but recovery was higher with farmers' practices for parboiled rice. The lower coefficients of variation in the case of parboiled rice indicated a buffering effect of parboiling across varieties for recovery, which explains why parboiling is considered an excellent means to recover poor-quality samples.

Sensory evaluation

The method of rice preparation had a great impact on the ranking of the rice varieties for all traits, as shown by the nonsignificant and sometimes negative rank correlations between the two sets of

Table 1. Comparison of the Milling Properties and Cooking Time of Raw and Parboiled Upland Varieties Prepared by Farmers, Korahar, Bihar, India, 1998

Variety	Milling time (minutes)		Recovery farmers' practices (%)		Recovery laboratory (%)		Cooking time farmers' practices (minutes)	
	Raw	Parboiled	Raw	Parboiled	Raw	Parboiled	Raw	Parboiled
Brown Gora	19	30	70	71	58.5	75.0	11.0	23.0
RR139-1	16	17	63	77	62.3	80.0	8.5	33.5
RR151-3	18	19	69	72	67.3	75.0	10.0	17.0
RR151-4	22	19	57	74	67.5	80.0	8.0	20.5
RR166-645	15	23	65	74	59.5	76.3	11.0	23.0
RR203-16	15	17	63	73	56.0	76.3	11.0	22.0
RR2-6	27	18	70	72	60.5	76.3	13.0	33.0
RR265-1	20	15	70	72	76.5	77.5	8.5	22.0
RR347-166	20	17	66	74	73.5	7.38	15.5	23.0
RR348-5	30	17	71	72	66.3	78.8	9.0	23.0
RR348-7	13	16	69	74	51.0	77.8	13.0	32.0
RR352-1	16	24	66	72	64.0	76.3	14.0	27.0
RR354-1	20	23	59	75	69.8	77.5	16.0	29.0
RR50-5	18	20	67	71	67.8	80.0	13.0	34.0
RR51-1	19	18	66	72	58.8	75.0	10.0	26.0
Vandana	17	19	74	70	72.0	76.3	13.5	25.0
Mean	19.1	19.5	66.6	72.8	64.4	77.0	11.4	25.8
SD	4.4	3.8	4.5	1.8	6.9	1.9	2.5	5.1
t raw/parboiled	0.28ns		7.11**		4.29**		12.04**	

Note: ** = significant at the 1% level; ns = not significant.

scores (table 2). The preferred varieties in terms of acceptability were RR151-3, RR352-1, and RR354-1 for raw rice, and RR50-5, RR352-1, and RR354-1 for parboiled rice. For breeding purposes, it was interesting to identify varieties that could perform well under both preparations. RR352-1 and RR354-1 scored quite well in this respect.

The farmers were also asked to indicate the four varieties they liked the most (high score indicated high preference) and the four varieties they liked the least (this time high scores indicated high dislike). By this means, only one variety, RR354-1 recorded a good score for both raw and parboiled rice (table 3), being liked by 67% of the farmers as parboiled rice and 58% of the farmers as raw rice. RR151-3 and RR352-1 were appreciated by the farmers as raw rice but not as parboiled rice. Inversely, RR2-6, RR166-645, and RR265-1 were liked by the farmers as parboiled rice but not as raw rice.

For raw rice as well as parboiled rice, the rank correlations among characteristics scored by farmers were very strong and positive (table 4) except for stickiness, for which they were also positive but more seldom significant. This means that there is probably no need to ask the farmers to score all these traits. The acceptability or the choice of the three or four most preferred varieties should be enough to represent the group of traits. A simplification of the testing procedure an important in order to facilitate the integration of participatory approaches in the formal breeding system and to sustain farmers' participation.

Table 2. Sum of Scores Given by 24 Farmers for Cooking Quality Characteristics of Upland Rice Varieties, Korahar, Bihar, India, 1998

Variety	Milled rice appearance		Cooked rice appearance		Odor		Color		Texture (soft/hard)		Stickiness		Taste/ flavor		Accept.	
	Raw	Par.	Raw	Par.	Raw	Par.	Raw	Par.	Raw	Par.	Raw	Par.	Raw	Par.	Raw	Par.
Brown Gora	1	11	5	13	2	11	2	7	2	10	8	12	10	13	4	9
RR139-1	4	10	18	19	13	18	17	21	13	17	11	20	15	20	12	16
RR151-3	17	1	20	9	18	10	20	9	18	8	16	10	17	9	18	6
RR151-4	17	16	16	19	12	23	17	19	13	15	10	22	18	18	16	19
RR166-645	4	11	11	18	11	17	6	8	12	10	9	13	11	16	9	18
RR203-16	8	6	13	14	9	16	14	15	5	12	8	15	13	15	13	11
RR2-6	8	13	9	21	8	23	12	23	6	17	8	19	9	20	8	20
RR265-1	19	18	13	18	10	16	13	21	12	18	9	19	13	16	9	18
RR347-166	21	6	20	17	17	17	21	17	14	14	12	16	14	13	12	12
RR348-5	1	22	19	20	13	17	16	20	15	16	15	15	17	14	15	16
RR348-7	1	13	7	16	6	16	4	19	5	14	11	13	8	14	6	13
RR352-1	22	10	20	21	20	20	18	20	17	17	16	21	21	20	17	22
RR354-1	12	23	15	24	14	23	19	23	16	20	7	22	18	22	17	24
RR50-5	21	16	14	24	15	21	15	22	10	22	11	19	14	22	14	21
RR51-1	9	7	11	14	12	12	16	10	7	13	13	15	13	11	11	13
Vandana	12	2	15	9	15	11	19	5	16	8	11	8	12	9	12	6
Rank correl. raw/parboiled	-0.12		0.10		0.12		0.20		0.06		-0.19		0.26		0.23	

Notes: Par. = Parboiled rice; Accept. = Acceptability; Varieties with high scores are the preferred ones.

Table 3. Preferences of Farmers for the Various Varieties in the Sensory Evaluation Conducted in Korahar, Bihar, India, 1998

Variety	Most liked*		Least liked*	
	Raw	Parboiled	Raw	Parboiled
Brown Gora	0	0	13	5
RR139-1	4	0	2	8
RR151-3	16	0	1	15
RR151-4	8	6	2	2
RR166-645	1	10	10	1
RR203-16	3	9	4	0
RR2-6	1	11	14	0
RR265-1	2	10	3	0
RR347-166	8	2	1	7
RR348-5	7	6	2	3
RR348-7	3	2	15	11
RR352-1	14	0	1	7
RR354-1	14	16	2	1
RR50-5	4	4	4	4
RR51-1	3	3	1	3
Vandana	0	0	1	13

*Farmers were asked to give the codes of the four varieties they liked most and the four varieties they liked lease. However, some of them gave only 1 or 2 scores.

Table 4. Correlations between Farmers' Ranks for Quality Traits of Raw and Parboiled Upland Rice Varieties (Women's and Men's Rankings Pooled Together), Korahar, Bihar, India, 1998

Trait		Milled rice app.	Cooked rice app.	Odor	Color	Texture	Stickiness	Taste
Milled rice app.	Raw Parboiled							
Cooked rice app.	Raw Parboiled	0.59* 0.55*						
Odor	Raw Parboiled	0.72** 0.68**	0.85** 0.88**					
Color	Raw Parboiled	0.60* 0.60*	0.84** 0.87**	0.88** 0.88**				
Texture	Raw Parboiled	0.46 0.50*	0.76** 0.87**	0.80** 0.87**	0.83** 0.85**			
Stickiness	Raw Parboiled	0.18 0.29	0.47 0.62*	0.45 0.66**	0.29 0.48	0.20 0.52*		
Taste	Raw Parboiled	0.58* 0.53*	0.87** 0.83**	0.71** 0.72**	0.72** 0.71**	0.72** 0.74**	0.28 0.39	
Acceptability	Raw Parboiled	0.67* 0.52	0.81** 0.81**	0.82** 0.87**	0.79** 0.75**	0.75** 0.77**	0.23 0.39	0.90** 0.91

Opinions of women and men farmers were similar, with significant to highly significant correlations between their rankings for milled rice appearance, cooked rice appearance, texture, color, and taste (table 5). The only traits for which their agreement was weaker was stickiness and, to lower

Table 5. Correlations between Women and Men Farmers' Mean Ranks for Cooking Characteristics of Raw Rice, Korahar, Bihar, India, 1998

Trait	Spearman rank coefficient of correlation
Milled rice appearance	0.97**
Cooked rice appearance	0.57*
Odor	0.45
Color	0.75**
Texture	0.55*
Stickiness	0.22
Taste/flavor	0.54*
Acceptability	0.83**
Most liked	0.88**
Least liked	0.95**

Note: Sample size was 12 women and 12 men.
* = Significant at 5% level.
** = Significant at 1%.

extent, odor. In terms of overall acceptability, there was no difference in women and men farmers' opinions on the tested varieties nor in their final choices of the varieties they liked most and least.

Laboratory analysis versus sensory evaluation

The ranks given by farmers for the various quality traits were compared with the ranks of the same varieties for the main chemical properties of raw rice measured in the laboratory: alkali value, volume expansion, amylase content, and elongation ratio. Elongation ability was negatively correlated with stickiness $r = -0.55$, significant at the 5% level) but that was the only significant case. In the samples tested, amylase content did not seem to have any link to farmers preferences for texture $r = -0.14$) or stickiness $r = 0.04$).

It is unexpected to see so few relationships between consumer preferences and measurable chemical properties, since these are standard parameters used by all chemistry laboratories. However, for the varieties included in the evaluation, the variability for some traits was limited and therefore consumers had difficulty assessing differences.

Field performance versus grain quality

There was little relationship between farmers' field ranking and grain quality for parboiled rice, as shown by the very low coefficients of correlation for rank and a negative one for the ranking based on yield (table 6). The relationship was stronger and positive for raw rice. There was no particular reason why the rankings should be correlated, but a strong negative correlation would complicate the breeding work. These results confirm that participatory varietal selection should not stop after harvest. Since a compromise might be necessary, at least for parboiled rice, the trade-off between criteria for agronomic performance and cooking quality applied by farmers has to be assessed.

Table 6. Correlation Between Field Ranking and Yield, and Farmers Preferences based on Grain Quality, Korahar, Bihar, India, 1998

Variety	Farmers field ranking	Ranks based on observed yield	Most liked *		Acceptability ***	
	(1)	(2)	Raw	Parboiled	Raw	Parboiled
Brown Gora	15.0	10.5	15.5	14.0	16.0	14.0
RR139-1	12.0	16.0	7.5	14.0	9.0	8.5
RR151-3	4.0	2.0	1.0	14.0	1.0	15.5
RR151-4	2.0	10.5	4.5	6.5	4.0	5.0
RR166-645	6.0	8.0	13.5	3.5	12.5	6.5
RR203-16	10.0	12.0	10.0	5.0	7.0	13.0
RR2-6	8.0	13.5	13.5	2.0	14.0	4.0
RR265-1	13.0	13.5	12.0	3.5	12.5	6.5
RR347-166	3.0	3.0	4.5	10.5	9.0	12.0
RR348-5	11.0	6.5	6.0	6.5	5.0	8.5
RR348-7	16.0	15.0	10.0	10.5	15.0	10.5
RR352-1	7.0	5.0	2.5	14.0	2.5	2.0
RR354-1	5.0	9.0	2.5	1.0	2.5	1.0
RR50-5	9.0	6.5	7.5	8.0	6.0	3.0
RR51-1	14.0	4.0	10.5	9.0	11.0	10.5
Vandana	1.0	1.0	15.5	14.0	9.0	15.5
Rank correlation with (1)			0.35	0.03	0.57*	0.06
Rank correlation with (2)			.027	-.034	0.45	-0.28

* Ranked from 1 (most liked) to 16 (least liked); results of a participatory varietal trial conducted in Korahar in 1998 wet season.
** Ranked from 1 (highest yield) to 16 (lowest yield).
*** Ranked from (most acceptable) to 16 (least acceptable).

Conclusions and recommendations

Grain quality is an important selection criterion (Juliano and Villareal 1993). Sensory evaluation with farmers allows us to assess varietal preferences under conditions of food preparation very close to that of the final consumer. For the set of varieties tested, men and women seemed to share the same opinions. The physico-chemical analysis did not indicate much power to predict the results of farmers' rankings. The methodology was satisfactory although quite costly in terms of organization time. It is important to define which of the two modes of preparation (raw rice or parboiling) is most prevalent in the target area, since they lead to different varietal choices. A simplification of the ranking system by reducing the number of ranked traits is possible.

References

Amarine, M.A., R.M. Pangborn, and E.B. Roessler. 1965. *Principles of sensory evaluation of food.* New York and London: Academic Press.

Bhattacharya, K.R. 1985. Parboiling of rice. In *Rice chemistry and technology*, edited by B.O. Juliano. St Paul, Minnesota: American Association of Cereal Chemists.

Courtois, B., R.K. Singh, S. Pandey, C. Piggin, T. Paris, S. Sarkarung, V.P. Singh, G. McLaren, S.S. Baghel, R.K. Sahu, V.N. Sahu, S.K. Sharma, S. Singh, H.N. Singh, A. Singh, O.N. Singh, B.V.S. Sisodia, C.H. Mishra, J.K.