FOOD RESEARCH INSTITUTE

QUALITY EVALUATION OF PROMISING RICE VARIETIES

BY

J.T. MANFUL, J. GAYIN AND C. ODURO-YEBOAH

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INTRODUCTION

Rice (*Oryza sativa*) is one of the leading food crops of the world, the staple food of over half the world 's population. It is generally considered a semi-aquatic, annual grass plant (Lu and Chang, 1980). Rice can be grown in several parts of the country profitably provided farming methods and post harvest handling practices are improved (Nelson, 1988). However, inefficient farming and post harvest handling techniques have led to very low quality and high production costs for locally produced rice.

With a large area of Ghana suitable for rice production, the country could be self-sufficient in rice production if the small-scale farmers who have a higher cost-efficiency are encouraged to increase their yields per unit area (Asuming-Brempong, 1989)

Web and Stermer (1972) noted that rice quality is closely related to the quality of its milled whole kernels. Quality evaluation is primarily a matter of determining its suitability for a particular use and whether it meets specific requirements of cleanliness and qualities are important in judging rice, since they vary from country to country.

REVIEW OF LITERATURE

Grain quality denotes different properties to different sectors of the rice industry. The quality or grade of rough rice is determined by a number of aspects that are sometimes interrelated. These aspects are the moisture content of the rough rice, the moisture content of the rough rice, the purity of the discoloured grain, damaged grain, red rice and the varietal purity (Van Ruiten, 1979c). In other words, the quality of rough rice is determined partly by prevailing conditions beyond human control and partly by conditions under control of production and post-production processes. Each of these quality aspect influences the milling potential of the rough rice and it is essential to be aware of their impacts on processing, most of which are negative.

Rice milling is the process of removing the hull and bran from grain paddy in order to produce edible rice. The milling process may be carried out by various kinds of equipment ranging from the simplest pestle and mortar to the large complex modern systems. Since great quantities of paddy are lost during the milling process, the milling of paddy requires precision with properly designed and operated equipment (Esmay *et al*, 1979). The milling potentials of the rough rice largely determine the performance of a rice mill in terms of milled rice recovery and quality. These milling potentials can be of varietal origin, can be related to the quality condition of the rough rice, or can be added through pre-milling processes.

Rough rice has its optimum milling potential at a moisture content of about 14%. Therefore freshly harvested and threshed rough rice must be dried. The drying process is critical, for it determines whether or not fissures and/or full cracks are introduced in the grain structure (Araullo *et al*, 1976).

Rough rice has higher fibre and ash content but lower protein and available carbohydrates than brown rice. The differences are readily explained by the high fibre and ash content and the low content of protein and available carbohydrates in the rice hull. Actually, rough rice has almost the same protein content as milled rice. Minerals are generally present in higher levels in brown than in milled rice. Potassium, magnesium, and silicon are present also in large amounts in brown and milled rice. By contrast, silica is the major element in hull ash (Juliano, 1985).

McCall *et al* (1953), showed that in milled rice, phytin accounts for 40%, nucleic 46%, carbohydrate 10%, inorganic 3% and phoshatide 1% of total phosphorus. Rice contains little or no vitamin A and C. Some of the vitamins such as riboflavin and niacin are not in a completely free form.

Rice is consumed in a different way from other crops. It is usually eaten as the whole grain cooled rice. The eating quality is usually judged by the sensory evaluation, which may seem unscientific and variable according to personal preference. The cooking process consists mainly of gelatinising the starch.

Varieties can be classified according to their gelatinisation temperatures. (Beachell and Stansel 1963). Gel consistency is an important index of the eating quality of rice. Rice with a soft gel consistency is soft and sticky, with an amylose content below 20%. On the other hand a gel length of 26 to 60mm is classified into the hard gel consistency category (Juliano, 1979). Water uptake of the rice grain during cooking is better measured by the swelling power and solubility method.

Because of the change in texture of cooked rice during cooling and storage, the handling of cooked rice is standardised to reduce further variables to the assessment. Cooked rice characteristics frequently assessed are aroma, flavour or taste, tenderness or hardness cohesiveness or stickiness, appearance, and whiteness or colour (Juliano, 1982a).

MATERIALS AND METHODS

VARIETIES

Ten varieties of rice were received from the Department of Crop Services of the Ministry of Food and Agriculture with request for “Comprehensive Milling and Sensory Analyses”. These were varieties, which were being screened under the Department’s South Western Ghana Rice Development Project in the Western Region. Basic agronomic data on the varieties as well as fertilizer application rates were also received from the Co-ordinator of the project. The tests carried out on the samples were milling and physical quality assessment, nutritional quality, cooking and sensory evaluation.

METHODOLOGY

The rice varieties of rice mainly IET and ITA lines were grown in Kobina Anokrom and Simpa in the Western Region in 1994. However, ITA 306 and IET 6279 were grown in 1995. IET 6279 was nursed on August 20,1995 and transplanted on September 5, 1995. ITA 306 was nursed on August 22, 1995 and transplanted on September 17, 1995. The rest were nursed on July 19, 1994 and transplanted between August 10 - 11,1994 While IET 6279 and ITA 306 were harvested in

December 1995 and January 1996 respectively, the rest were harvested between November and December 1994.

Agro-Chemicals

Fertilizer was applied to the varieties at the following rates:

ITA 306	60:40:40	(N:P:K)
IET6279	125:0:0	(N:P:K)
Others	90:40:40	(N:P:K)

There was no record of either herbicide, insecticide or fungicide application.

Milling

A 200g sample of each cultivar was first de-husked in a Satake (THU-34A) Testing Rice Husker. The brown rice obtained was polished in a BS08A Single Pass Rice Pealer with the degree of whiteness set between "Low" and "Medium" on the equipment.

The level of broken was determined using a TRG 05A Testing Rice Grader.

Other Physical Characteristics

The levels of discoloured grains and chalky grains were determined by hand sorting of 100g of sample of milled grains.

Proximate Analysis

Fat

Extraction thimbles were half filled with samples and the accurate weights of samples (5-7g) were determined. The extraction was carried out in a Soxhlet extraction apparatus with 250ml of petroleum ether (Bp. 40°C - 60°C) for 10 hours. The solvent was evaporated on a water bath, the extracted crude fat weighed, and proportion of fat in the samples determined (Pearson, 1970).

Ash

An accurately weighed 1-2 g samples were weighed and placed into conditioned porcelain crucibles (method 942.05 of AOAC, 1990). The crucibles were placed in a preheated muffle furnace for 2 days at 550°C. The ash content was expressed as a proportion of the original sample weight.

Protein

Protein determination was by AACC method 46 – 10. 2g of finely mixed and ground sample was transferred into a digestion flask and 0.7g HgO, 15g powdered K_2SO_4 and 25 ml H_2SO_4 added. The flask was then placed in an inclined position and heated gently until frothing ceased. This was followed by brisk boiling until solution became clear and then for at least 30 minutes longer. 200ml water was added to cool the solution to below 25°C and then 25ml thiosulphate to precipitate mercury. A few zinc granules were added to prevent bumping. With the flask in a tilted position a layer of NaOH was added without agitation.

Immediately after this the flask was connected to a digesting bulb on the condenser and with the tip of the condenser immersed in standard acid in receiver the flask was rotated to thoroughly mix contents. Heating followed till all ammonia had distilled. The excess standard acid in distillate was titrated with standard alkaline solution, using methyl red indicator.

Crude protein = N x 5.70

Nitrogen (N_2), % = [(B-S) x N x 0.01401 x 100] / W t. Of sample

B= ml alkaline back-titration of blank, S= ml alkaline back-titration of sample, N= normality of alkaline.

Carbohydrates

The percent carbohydrate was obtained by finding the difference between 100 and the sum of the other constituents.

Phosphorus

Phosphorus was determined by the photometeric method number 965.12 of AOAC (1990). Samples (1 – 2 g) were ashed at 600°C for 4 hours or until white. The residue was dissolved in 40 ml HCl (1: 3 v/v: 3 parts de-ionised water) adding several drops of conc. HNO_3. The solution was brought to boil, cooled and diluted to 200ml with de-ionised water. After filtration, aliquots containing 0.5mg to 1.5mg P were placed in 100ml volumetric flasks to which 20ml molybdovanadate reagent was added, and diluted to the mark. After allowing the solutions to stand for 10 minutes, the absorbance was read at 400nm against a 0.5mg standard set at 100%T. Phosphorus was determined from a standard curve of 0.5, 0.8, 1.0 and 1.5mg P standard solutions prepared from a working solution of 0.1mg P / ml. The working solution was obtained from a 50ml stock solution (8.788g KH_2PO_4 in 1L) diluted to 1L. From the standard curve, % P = mg P in aliquot /g sample in aliquot x 10).

Calcium

About 4g sample was ashed and then dissolved in water. 20ml of this solution was pipetted into a 150ml beaker, 10ml hydrochloric acid solution added and topped with distilled water to produce 50ml. This was followed by the addition of 2 drops of methyl red indicator. The solution was then boiled for some few minutes. To the hot solution, 15ml of saturated ammonium oxalate solution and 5g of urea were added and boiled for another 10 minutes. Dilute ammonia was added drop-wise to the hot solution (70°C - 80°C) with continuous stirring until the liquid was neutral or faintly alkaline (colour change from red to yellow). The solution was then left to stand overnight.

On the next day, the solution was filtered using coarse filter paper (Whatman no. 1) with the addition of small volume of water until chloride free. The precipitate was next dissolved with 30ml to 50ml of hot 2N sulphuric acid and immediately titrated with standard N/50 potassium permanganate. The temperature of the solution was maintained at 60°C.

mg Ca / 100g sample was calculated thus: $\frac{\text{Titre} \times 0.4 \times 5 \times 100}{\text{Weight of sample}}$

1ml of N/50 $KmnO_4$ = 0.4 mg of calcium

Iron

20ml of digested sample solution was pipetted into a 50ml volumetric flask, 40mg of crystalline ascorbic acid added and the neck of the flask rinsed with a small volume of water. About 10 minutes was allowed for complete reduction of the iron to the ferrous state.

10ml of ammonium acetate solution was next added and the pH of the solution tested with indicator paper to ensure a pH value of 4 to 5. 2ml of dipyridyl solution was added and the volume made up to the mark. 60 minutes was allowed for full development of colour at room temperature. The optical density was then measured at 500nm and for the setting of the colourimeter a blank solution was used.

In exactly the same way 0.5,1.0, 2.0, 5.0, 10.0ml of the standard solution was treated and measured and the resulting calibration curve was used for the determination of the iron in the sample solution.

mg iron / 100g sample was calculated thus:

$$\frac{\text{mg/100g} \times 25}{\text{Weight of sample}}$$

Moisture

Moisture was determined by the AOAC (1990) method number 934.01. Accurately weighed uniformly blended 1 – 2g samples were introduced into pre weighed aluminiuum dishes (75mm diameter, 25mm deep) and dried in a vacuum oven at 70°C and 100 mmHg for a period of 9 to 12 hours. The moisture content was reported as loss in weight of samples after drying.

Sensory Evaluation

Cooking qualities and consumer acceptance of the rice cultivars were investigated. Imported American Grade 5 and imported perfumed rice were used as controls. The samples were cooked with salt to taste. Using Preference Test questionnaire sheets judges carried out sensory evaluation. Qualities investigated were Colour, Aroma,Texture and Taste. Panelists were requested to give numerical values to each sensory characteristic assessed using the nine point hedonic scale namely, 9=like extremely and 1=dislike extremely.

The questionnaires were then statistically analysed. The mean scores for the sensory characteristics of the rice samples and the over-all acceptance were determined. Other qualities investigated were swelling capacity and local dishes that each sample would be suitable for.

RESULTS AND DISCUSSION

Agronomic data on the cultivars are shown in Table 1. The mean yield for the cultivars was 5.84 t/ha. Varieties ITA 304, ITA 324 and ITA 222 had yields of over 6t/ha. The lowest yielding variety was ITA 306 with a yield of 5.20 t/ha.

The mean number of days to 50% flowering was 102 days with ITA 306 having the shortest duration of 96 days and ITA 336, the longest of 112 days. ITA 92 was the tallest with a plant height of 140 cm while ITA 306 was the shortest with a height of 117 cm.

There was little variation in the 1000-grain weights of the varieties, which is indicative of the fact that the grain sizes of the varieties were almost the same (Table 1).

There were considerable differences in the physical quality of the varieties.

The most important determinants of white rice yield under the circumstances were the husk content of the variety and the degree of hardness of the grains. IET 6279 had a Brown Rice percentage of 78.8 indicating a low percentage of husks in the paddy. On the other hand, ITA 324 and IET 1996 had a Brown Rice yield of 72.5% (Table 2). While IET 6279 had a White Rice yield of 68.3%, ITA 324 had a very low White Rice yield of 57.5%. The level of broken grains on milling also showed wide variations among the varieties. IET 6279 had a brokens percentage of 18.5 while the level of brokens for ITA 222 and ITA 338 were 39.0% and 44.0% respectively. Variety IET 6279 had a very high chalky white belly level of 72.0%, which calls for a closer investigation of this attribute. ITA 338 had the highest level of both discoloured and mouldy grains of 1.41% and 0.95% respectively (Table 2).

The nutritional compositions of the rice varieties are shown in Table 3. These compare favourably with other locally grown and imported rice cultivars, which have been analysed by The Food Research Institute in recent times.

In the sensory evaluation of the varieties, ITA 92, ITA 332, ITA 222 and IET 6279 had over-all acceptability ratings higher than the U.S. #5 rice which was one the control samples. The least acceptable variety organoleptically was ITA 304 with acceptability rating of 6.5 (Table 4). Of the varieties tested ITA 336 and ITA 222 were judged to be sticky while the others were not. ITA 304 had the highest swelling capacity of 107.1% and that of ITA 336 was 61.1% which in turn was higher than that of Control Perfumed Rice of 52.8% (Table 5).

Table 6 shows the suitability of the various rice varieties for different local dishes. Most of the varieties passed the minimum requirements needed for the various local dishes.

CONCLUSION AND RECOMMENDATION

Most of the varieties had good eating qualities with ITA 92, ITA 222 and IET 6279 being the best.

The nutritional qualities of all the samples were good with IET 6279 having the best milling characteristics. However this variety needs to be further investigated due to the high percentage of white bellies.

It is recommended that this exercise be carried out at the end of each trial season of The Department's South Western Ghana Rice Development Project in the Western Region to keep track of processing and food characteristics of the varieties on trail.

Table 1. Agronomic Characteristics of Rice Cultivars.

Variety	Days to 50% Flowering	Plant Height (cm)	Tiller No	Grain Yeild (t/ha)	Panicles/m^2	Spiklets/ Panicle	1000 GW (gm)
ITA 92	102	140	10	6.00	191	210	21
ITA 304	102	136	10	6.35	168	215	20
ITA 306	96	117	9	5.20	220	176	N/A*
ITA 324	104	126	12	6.70	201	208	19
ITA 332	105	138	12	5.80	213	213	20
ITA 336	112	138	11	5.30	221	208	20
ITA 338	101	139	12	5.45	224	210	21
IET6279	100	136	9	5.70	196	237	19
IET 1996	102	128	11	5.55	223	185	20
ITA 222	100	130	9	6.53	170	215	20
Mean	**102**	**133**	**11**	**5.84**	**203**	**208**	**20**
L.S.D.	**3**	**5**	**1**	**0.37**	**15**	**11**	**1**

*Not Available

Table 2. Physical Quality Evaluation of Rice Cultivars.

Variety	Moisture (%)	Brown Rice(%)	White Rice(%)	Whole Grain(%)	Brokens (%)	Chalky Grains(%)	Mouldy Grains(%)	Discoloured Grains(%)	Other Varieties(%)	Paddy(%)	Insects
ITA 92	14.4	75.0	64.5	63.0	37.0	6.06	0.20	0.34	+	-	-
ITA 304	14.6	75.5	59.5	65.0	35.0	5.90	0.32	0.21	-	-	-
ITA 306	16.3	77.0	60.0	65.5	34.5	11.76	0.08	0.45	+	+	-
ITA 324	14.4	72.5	57.5	72.0	28.0	0.85	0.51	0.22	0.18	-	-
ITA 332	14.7	75.0	62.5	62.0	38.0	0.73	0.19	0.75	0.17	+	-
ITA 336	14.5	74.0	65.0	70.5	29.5	0.50	0.35	0.55	+	-	-
ITA 338	14.5	75.0	62.5	56.0	44.0	1.05	0.95	1.41	+	-	-
IET 6279	16.2	78.8	68.3	81.5	18.5	72.0	0.35	0.20	-	-	-
IET 1996	14.1	72.5	62.5	65.5	34.0	0.22	0.65	0.29	+	-	-
ITA 222	14.4	77.5	63.5	61.0	39.0	6.68	0.16	0.37	-	-	-
Mean	**14.8**	**75.3**	**62.6**	**66.2**	**33.8**	**10.6**	**0.38**	**0.48**			
L.S.D	**0.55**	**1.46**	**2.20**	**5.04**	**5.04**	**15.7**	**0.19**	**0.25**			

Table 3. Nutritional Composition of Rice Varieties.

Variety	Moisture (%)	Ash (%)	Protein (%)	Fat (%)	Carbohydrate (%)	Energy (Kcal/100g)	Calcium (mg/100g)	Iron (mg/100g)	Phosphorus (mg/100g)
ITA 92	13.1	0.6	7.2	0.9	78.2	350	9.9	1.2	27
ITA 222	12.6	0.5	6.8	0.9	79.2	352	6.1	1.1	92
ITA 304	12.6	0.6	6.8	0.8	79.1	350	5.8	0.5	108
ITA 306	13.4	0.4	7.7	0.8	78.5	352	10.7	1.8	83
ITA 324	13.2	0.6	7.2	0.8	78.2	349	9.2	1.3	86
ITA 332	13.5	0.6	7.3	0.8	77.8	348	8.9	1.2	56
ITA 336	13.4	0.6	6.6	0.7	78.7	348	12.9	0.6	201
ITA 338	13.0	0.5	7.5	1.1	77.9	352	12.0	1.2	145
IET 1996	13.2	0.6	7.1	0.9	78.2	349	8.5	0.5	187
IET 6279	13.9	0.6	7.6	1.0	76.9	347	13.6	1.4	208
Mean	**13.2**	**0.6**	**7.2**	**0.9**	**78.3**	**350**	**9.8**	**1.1**	**119**
L.S.D	**0.3**	**0.1**	**0.3**	**0.1**	**0.5**	**1.3**	**1.9**	**0.3**	**45**

Table 4. Mean Scores for Sensory Characteristics and Over-all Acceptability of Rice Cultivars.

Variety	Colour	Aroma	Texture	Taste	Over-all Acceptability
Control 1. (Perfumed Rice)	8.5	8.2	7.8	8.1	8.1
Control 2. (U.S. #5)	6.9	7.1	7.1	6.8	6.9
ITA 336	7.4	7.0	6.9	6.4	6.6
ITA 306	8.0	7.1	6.7	6.8	6.9
ITA 92	7.9	7.4	6.9	6.9	7.1
ITA 338	6.9	6.9	6.6	6.6	6.6
ITA 332	7.1	7.1	7.0	7.1	7.0
ITA 304	6.8	6.7	6.4	6.7	6.5
ITA 222	7.8	7.6	7.0	7.1	7.2
IET 1996	6.7	6.6	6.5	6.5	6.6
ITA 324	7.1	6.3	6.7	6.5	6.7
IET 6279	7.8	7.0	7.0	7.1	7.1
Mean	**7.4**	**7.1**	**6.9**	**6.9**	**6.9**
LSD	**0.4**	**0.3**	**0.2**	**0.3**	**0.3**

Table 5. Majority Comments on Stickiness and Swelling Capacities of Rice Cultivars.

Variety	Swelling Capacity (%)	Majority Comment on Stickiness
Control 1 (Perfumed Rice)	52.8	Sticky
Control 2 (U.S. #5)	89.3	Sticky
ITA 336	61.1	Sticky
ITA 306	88.9	Non-Sticky
ITA 92	81.3	Non-Sticky
ITA 338	87.5	Non-Sticky
ITA 332	85.7	Non-Sticky
ITA 304	107.1	Non-Sticky
ITA 222	92.9	Sticky
IET 1996	78.6	Non-Sticky
ITA 324	89.2	Non-Sticky
IET 6279	89.3	Non-Sticky
Mean	**83.6**	
L.S.D.	**9.1**	

Table 6. Suitability of Rice Cultivars for Various Local Dishes.

Variety	Suitable Dishes
ITA 336	Best for Plain rice and Jollof rice. May also be good for Rice porridge and Omotuo.
ITA 306	Best for Plain rice and Jollof rice
ITA 92	Best for Plain rice and Jollof rice
ITA 338	Best for Waakye. May also be good for Plain rice and Jollof rice
ITA 304	Best for Plain rice and Jollof rice but may also be good for Waakye, Rice porridge and Omotuo.
ITA 222	Best for Plain rice and Jollof rice but be used for waakye Rice porridge and Omotuo.
IET 1996	Best for Plain rice and Jollof; can also be used for Rice porridge and Waakye.
ITA 324	Best for Plain rice and Jollof rice
ITA 332	Best for Jollof rice and Plain rice; can also be used for porridge and Waakye
IET 6279	Best for Plain rice and Jollof. May also be used for Waakye and Rice porridge.

REFERENCE

Araullo, E.V. De Padua, D.B., and Graham M. eds (1976). Rice Post harvest Technology Publ. 053e. International Development Research Centre, Ottawa, Canada. 394pp.

Asuming – Brempong, S (1989) – rice self-sufficiency in Ghana. Paper presented at workshop on Effective post harvest of cereals and legumes. Univ. of Ghana, Dept. of Nutr. and Fd. Sc.

Beachell. H.M. and Stansel, J.W. (1963) Selection rice for specific cookjing characteristics in a breeding program. Internatl. Rice comm. Newsletter, spec. Issue pp-25 – 40.

Juliano, B.O. (1979). The Chemical Basis of Rice Grain Quality. Proceedings of the Workshop on chemical Aspects of Rice Grain Quality. International Rice Research Institute L.S. Banos, Laguna.

Juliano, B.O. compiler, 1982a. An international survey of methods used for evaluation of the cooking and eating qualities of milled rice. IRRI Res. Paper ser. 77. Int. rice Res. Inst., Los Banos, Laguna Philippines 28pp.

Juliano,. BO (1985). Rice chemistry and Technology, United States of America.

McCall. E.R. Jurgens, Hoffpauir, D.L. Pons, W.A., Jr Stack S.M. Jr. Cucullu, A.F. Heurzelman D.C. Cirino, V.O. and Murray M.D. (1953). Composition of rice. Inffluence of variety and environment of physical and chemical composition. J. Agric. Food chem. 1;988 – 993.

Merle, E. Soemangat, Eriyatno, Phillips A. (1979) Rice post production Technology on the Tropics. East west Center.

Pearson, D. (1970). The chemical analysis of foods. 6th ed. J and A, Churchill, London.

Van Ruiten, H.T.L. (1979c) The Quality of Paddy Related to the Performance of Rice mills Southeast Asia co-operative Post Harvest Res. Dev. Programme, SEARCA, Los Banos, Philippines