QUALITY PARAMETERS OF CERTAIN PRE-RELEASE CULTURES OF RICE DEVELOPED AT REGIONAL AGRICULTURAL RESEARCH STATION, PATTAMBI

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DECLARATION

I hereby declare that this thesis entitled "Quality Parameters of certain pre-release rice cultures developed at Regional Agricultural Research Station (RARS) Pattambi", is a bonafide record of research work done by me during the course of research and that the thesis had not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

Place : Vellayani.

Date : 22-8-92

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CERTIFICATE

Certified that this thesis entitled **"Quality Parameters of certain pre-release ~~rice~~ cultures** of rice **developed at Regional Agricultural Research Station (RARS) Pattambi"** is a record of research work done independently by Kum. NEELOFAR ILLIASKUTTY under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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INTRODUCTION

With the challenges of the twenty first century in mind the need to improve the nutritional value of cereals has been emphasised by farm experts to achieve the twin objectives of food stability and security by the state. In a special report released by FAO the need for improving the quality and quantity of the staple food through farm improvement was stressed.

Rice (Oryza Sativa. L) is the staple food of more than half the world's population. According to Juliano (1985) about 90 percent of the world's rice crop is grown and consumed in Asia. Its importance as a food crop, increases alongwith the increase in human population. Seventy percent of the world's dietary energy is reported to be obtained from this staple food (Juliano 1985).

Although rice is primarily a source of carbohydrate, it also deserves to have the highest digestibility, biological value and protein efficiency ratio among all the cereals (Juliano 1985).

Different ethnic groups prefer various textures of cooked rice. According to Pillaiyar (1979) the cooking and eating characteristics of rice are mostly determined by its composition. Rice quality is determined by four major indices viz. milling quality, grain appearance, cooking and eating quality and grading (Song 1986). As reported by ICAR (1985), the main aspects of rice quality are the size and

shapes of grains, appearance, hulling, milling and cooking quality, nutritional quality and some other special qualities which include scent and linear expansion of the kernel on cooking. Currently work on all these aspects are being carried out in India.

Rice is one of the cereal staples which can be just boiled and cooked without involving complicated preparations. A number of breakfast preparations and main dishes is being prepared and in these preparations widely different quality parameters become determinants in the suitability of a rice variety for a particular preparation. Thus a variety, suitable for one preparation may not be so for another preparation. The characteristics of newly evolved rice cultures are to be initially investigated for various preparationsin comparison with popular varieties. The present study is a relative assessment of major quality parameters of pre-release rice cultures currently under study at Pattambi. The various aspects investigated are;

1. the nutritional composition of the rice cultures selected
2. their physical characteristics
3. their cooking characteristics
4. the effect of parboiling on the above three quality parameters and
5. the suitability of the rice cultures for common rice based preparations popular in Kerala.

REVIEW OF LITERATURE

Rice is the major staple food in Asia and in some countries like Africa and Latin America (Lii and Chang 1986). According to Juliano (1985), about 90 per cent of the world's rice crop is grown and consumed in Asia. Among all the cereals, rice is reported to have the highest digestibility, biological value and protein efficiency ratio (Anonymous 1964).

Rice is the chief source of carbohydrates. According to Grist (1986), being a staple food, rice is reported to provide 80 percent of the calorie requirement of the diet. The calorific value is meant to determine the carbohydrate content of rice which is composed of amylose and amylopectin. Ghosh and Govindaswami (1972) reported that most indica rice varieties had either intermediate or high amylose. They also detected an association between alkali digested value and the iodine value of the rice grains. Raghavendra Rao and Juliano (1970) had indicated that rice with high amylose content (25 percent) showed a drastic drop in peak viscosity upon parboiling as compared with low amylose rice.

As per a report published by All India Co-ordinated Rice Improvement Project (AICRIP) (1970) the indica varieties were observed to contain 25 to 30 percent amylose and japonica varieties 15 to 20 percent. Kumar et al (1976) indicated that the insoluble amylose fraction was the principal factor affecting the rice quality.

Rice is reported to be a moderate source of protein. Prema and Menon (1969) had shown that protein content was higher in exotic rice varieties like Tainan - 3 and IR - 8, compared to local varieties like Kuchuvithu.

According to Srinivasan et al (1969) Indian rice varieties contained protein in the range of 11 to 13 per cent. Mahadevappa and Shankara Gowde (1973) had observed 6 to 11 per cent protein in sixty rice varieties studied. The protein content of rice grain is reported to be negatively correlated with grain yield per plant (Govindaswami et al (1973). The protein content of high yielding rice varieties evolved by Hariyana Agricultural University ranged from 6.88 to 7.43g/100g.

In coarse rice, the protein content and the thickness of the aluerone layer were reported to be greater Webb et al (1968) had found that protein content is influenced by the parboiling and canning stability of rice samples. Okazaki and Oki (1961) had reported that good cooking rice contained considerable amount of protein constituents, amino acids like glutamic acid, aspartic acid and argenine. In polished rice, glutamic acid, aspartic acid and alpha - alenine had formed 60 per cent of the amino acid content of the rice grain.

Rao and Ramasastri (1969) had observed that in the ten varieties evolved in India and Japan the lysine content was negatively correlated with the total protein content.

According to Srinivasan et al (1969) the growth promoting value of the rice was mainly influenced by its total lysine content. Just et al (1976) had reported that the dietary crude fibre had a negative effect on the digestibility of both protein and energy. According to Eggum (1979) low content of tannin and crude fibre in rice had positively influenced the digestibility of rice protein and energy.

According to Dutta and Barua (1978 a), the high yielding varieties contained low amount of protein but distribution of the essential amino acids in their protein was better than those of protein rich rice varieties. All rice varieties were rich in essential amino acids except tryptophan and all amino acid concentration showed an inverse relationship with the protein content of the grain [Dutta and Barua (1978a)].

Rice contains negligible amount of fat. According to Itoh and Kawamura (1987) free-fatty acid values of parboiled rice stored for 25 to 30 days were lower than those of untreated. Storage period favourably influenced the lower fatty acids like palmitic, stearic and linoleic acid and unfavourably affected oleic and linoleic acid.

Rice is reported to have a moderate source of minerals. According to Dutta (1978b) calcium content of rice varieties varied from 15.77 to 29.70 mg/100g. In some of high yielding varieties, higher value of calcium has been reported (Dutta 1978b). Bhat and Rani (1982) reported that

the calcium content of raw rice varied from 8.00 to 16.00 per cent.

Hussain et al (1987) had reported that red grain varieties had higher phosphorus content than white. Miyoshi et al (1987) indicated that phosphorus balance was negative in the brown rice. Dutta (1978a) had reported that iron content of the different rice varieties was lower in Assam in comparison to the varieties grown in other parts of India. Roberts (1978) had estimated the iron content in the different rice varieties and had found a decrease in the milling. According to Damir (1985) puffed rice was also found to contain a high amount of iron. Sood et al (1980) found that rice bran contained maximum calcium, potassium, magnesium and phosphorus, while milled rice contained the lowest level in all the tested rice varieties.

High yielding varieties were reported to be relatively poor sources of vitamins except riboflavin Dutta and Barua (1978b). According to Adoracion et al (1978) low protein rice had lower total ash content than the high protein rice. Experiments conducted by Opadokum and Ikeorah (1981) had shown that moisture content of 34 samples each, of locally produced and imported rice was 6.34 to 15.13 per cent and 6.68 to 12.27per cent respectively.

Quality of rice grains are generally determined by certain physical characteristics of the grain namely thousand grain weight, grain dimension, moisture, head rice yield and gelatinization temperature.

Webb et al (1968) showed significant relationship between kernel length, kernel width and length - width ratio in rice grains. Govindaswami et al (1969) had found that alkali value of rice grains have a significant negative relation with length and length/breadth and a positive relations with breadth in the short bold rice grains. However, in the case of long grains, such significant relationships were not observed.

According to Govindaswamy and Ghosh (1970) rice with high kernel elongation had low intermediate gelatinization temperature and medium to high amylose content (15 to 33%). The varieties having grains with intermediate breadth consisted of both white core and translucent type grains (Bhashyan and Srinivas 1981). The experiment further revealed that white core and grain length or length/breadth ratio appear to be unrelated.

Head rice yield is the percentage yield of whole milled rice obtained on milling of paddy (Rajalekshmi 1984). Sindhu et al (1975) found out that the coarse, variety IR-8, gave the highest yield of brown rice (83%). Sharma and Bains (1979) had observed high variability in refraction, head rice yield and broken rice within and between varieties.

According to the experiment conducted by Sharma and Bains (1979) IR-8 and Jaya had shown higher breakage compared with Basmathi 370 and palmon 579 varieties. Head rice yield was significantly related to hardness and alkali

spreading quality of the rice variety (Goodman & Rao 1983). They also noted the correlation between hardness and area volume ratio of the kernel moisture of rough rice and hardness between alkali spreading and amylose.

According to Ali and Bhattacharya (1980b) the head rice recovery would increase with increase in moisture content, pressure and time of steaming. Itoh and Kawamura (1987) had found out that cracking hardness of brown rice increased with increasing gelatinization temperature. Rao and Juliano (1970) noted ungelatinized opaque core and chalky positions in some varieties whereas in some other varieties dimension was retained. The thousand grain weight of rice varieties varied considerably with the moisture content (Webbs & Stermer 1972) Density and 1000 kernel weight of coarse varieties were higher than those of the fine and medium fine varieties (Sindhu et al 1975).

Gelatinization temperature is defined as the range of temperature at which the gelatinization of starch occurs. Parboiled rice viscograms showed a higher gelatinization temperature when compared to raw rice and when studied at identical slurry concentrations (Ali & Bhattacharya 1980) Nakazava et al (1984) had pointed out that gelatinization on set temperature was significantly affected by starch fraction level in rice suspension. Juliano and Villareal (1987) had reported that high gelatinization temperature of waxy rice starch amylopectin had higher sedimentation coefficient than low gelatinization waxy rice amylopectin.

Consuelo et al (1988) explained that varieties which differed in amylose content and final gelatinization temperature were used to determine the most suitable rice for layer and fermented cakes.

The harvested rice grain is treated with various processing techniques before it reaches the consumer. Generally rice is parboiled and polished and these processes influences the nutritional composition of the grains. Husked hand pounded and parboiled rice are reported to contain about 350 calories per 100g and milled white rice 360 calories. Webb et al (1968) had found that protein content influenced the parboiling-canning stability of rice samples.

According to Houstan et al (1968) the proportion of albumin and globulin in protein is highest in the outer layer of milled rice. They had observed a decrease in this constituent towards the center. Experiments conducted at International Rice Research Institute (1978) had revealed that protein content of rice samples was influenced by milling.

Tara and Bains (1971) had shown a negligible loss of lysine and threonine on cooking rice in plain water. They had also reported that the decrease in lysine content of parboiled rice might be attributed to the longer cooking time. Rice when chemically heated contained maximum amount of thiamine and niacin. Nurunnabi et al (1975) had reported

that thiamine, riboflavin and niacin content of husked rice varied significantly and were found to be influenced by different parboiling methods. Tung et al (1985) had found out that thiamine and niacin content of different rice varieties decreased considerably according to the rate of milling. Grewel et al (1988) had reported that milled and parboiled rice contained more thiamine content in brown rice after parboiling.

Barber (1972) had observed that in commercially milled rice, removal of the outer layers resulted in 40% reduction in total ash and phosphorus, 66% reduction in calcium and a high percentage of loss in iron content of the grain. According to Doesthale et al (1979) changes in nutrient elements in milling were observed among rice varieties. He had further reported that the zinc content of the rice grain was found to be remarkably constant, as it was not affected by the process of milling Damir (1985) had pointed out that the mineral salts of rice were found to have increased as a result of parboiling. According to Pederson and Eggum (1983) the mineral content in different rice varieties decreased considerably during milling and the extent of decrease differed among minerals.

Roberts (1978) had estimated the iron content in the different rice varieties and had found a decrease in the mineral content with different degree of milling. According to Rajalekshmi (1984) the iron content was found to increase

as a result of parboiling when compared to raw rice. Increase in iron content due to parboiling was reported by Damir (1985). The puffed rice was also found to contain a higher amount of iron.

Parboiling of paddy resulted in gelatinization of starch (Raghavendra Rao and Juliano 1970) and retrogradation of gelatinised starch (Ali and Bhattacharya 1976). Performed retrogradation could be partially reversed by closed heat treatment of the paddy (Ali and Bhattacharya 1976). They also reported that concurrent parboiling-cum-drying and sand roasting of paddy had been reported to retard starch retrogradation. Pillaiyar et al (1977) reported that starch could be gelatinised by closed heating of soaked paddy. Starch retrogradation after parboiling reduced expansion as did cracked and broken grains (Chinnaswamy and Bhattacharya 1983a).

Raghavendra Rao and Juliano (1970) had indicated that high amylose (25 per cent) rice showed a drastic drop in peak viscosity upon parboiling as compared with low amylose rice. Sindhu et al (1975) had pointed out that the amylose content of rice increased with the degree of polish to the extent of 5.8 to 8.4 per cent.

Bhattacharya (1979) had reported that rice varieties differed in the equilibrium moisture content attained by the grains when soaked in water at room temperature depending primarily on their amylose content. Sekhon et al

(1980) had estimated that Basmati rice had a high content of amylose. Expansion of parboiled rice correlated strongly with amylose content, expansion being maximum at 27 per cent total amylose content and or at 13.5 per cent hot water insoluble amylose content (Chinnaswamy and Bhattacharya 1983). Parboiling resulted in marked changes in the amylograph properties of rice paste as well as increasing its resistance to alkaline dispersion (Damir 1986).

Sabularse et al (1981) had estimated that cooking time decreased at close level of gama irradiation. He had further pointed out that cooking time was not significantly affected by storage. Vandrasekh and Warthasen (1986) had stated that thermal degradation was slower in brown than in white rice, but the extended cooking period regained for attaining tenderness in brown rice was observed to result in a greater percentage of thiamine loss.

According to Subrahmaniyan et al (1971) parboiling is a pre-milling process for paddy which originated in India and has been practiced from time immemorial. Gariboldi (1974) had reported that 25 per cent of the paddy produced in the world was parboiled. Webb et al (1972) pointed out the significance of research on milling, cooking and processing behaviour of grain since such information would accelerate breeding rate for improved quality.

Different methods are used for parboiling rice grains viz. soaking in cold water (Pillaiyar 1977), Soaking in warm

water (Bhattacharya & Indudharaswamy 1967), soaking in hot water (CFTRI 1960) and pressure steaming methods (Iengar et al 1972) by different institutions. Soakings at 70° or 80°, had also been recommended for parboiling paddy. (Ali and Ohja (1976b) and Bhattacharya and Subha Rao (1966)).

Nurunnabi et al (1975) had standardised two methods of parboiling samples soaked at room temperature for 18 hours, with variation in steaming time and atmospheric pressure applied. Among the cold, warm, hot soaking methods, cold soaking method had the least colour inducing effect on rice and hot soaking had the most colour inducing effect (Pillaiyar and Mohandoss 1981). However they observed no correlation between the parboiling temperature and the degree of milling at constant load and time of milling.

In husked rice the average retention of thiamine and riboflavin was 80 to 83 per cent respectively by the parboiling process (Nurunnabi 1975). Considerable changes in sugars and amino acids were reported during soaking for parboiled rice by Anthoni Raj and Singaravadivel (1980). An average increase of 28.3 per cent in niacin content was reported by Nurunnabi (1975). The second method consists of boiling for 30 minutes without pressure application and at lower temperature. The average retention of thiamine and riboflavin were reported to be 61 and 67 per cent respectively by Nurunnabi et al (1975).

According to Doesthale et al (1978) parboiling process had no effect on composition. They had indicated that parboiling seems to alter the distribution of minerals except zinc, magnesium and copper. Subramanium et al Dekshinamurthy (1977) noted a very high loss of nutrients during parboiling.

Raghavendra Rao et al (1965 and 1967) had observed that the removal of bran colour during polishing is faster in parboiled rice especially from red varieties of rice than in raw rice. Raj et al (1981) improved the conventional parboiling of rice through prevention of husk opening by application of 0.5 to 1.0 per cent of common salt. This ensured husk sealed grains in parboiling. Unnikrishnan et al (1982) described an improved method of parboiling of paddy by simply soaking in hot water, which gave a reasonably good parboiled rice with an acceptable colour.

Narayana Rao et al (1954) reported a marked improvement in the swelling capacity after milling. Sindhu et al (1975) observed the extent of alkali degradation progressed with the increase in the degree of milling in different samples except in Basmathi 370 whereas the kernel was resistant to alkali degradation.

Doesthale et al (1978) had shown the degree of milling and initial content of minerals in grain determined by magnitude of loss on milling. Ali and Bhattacharya (1982) had studied that the milling breakage of pressure parboiled

rice was negligible. According to Chinnaswamy and Bhattacharya (1983) the rate of milling of the rice was influenced by addition of salt and age of paddy after harvest, during parboiling.

Yanase and Ohtsubo (1985) identified three factors controlling the quality of milled rice viz. degree of milling, blending ratio of broken rice grain into milled rice and blending ratio of cracked or checked rice grain into milled rice. Lee (1986) had reported that the recovery rate of milled rice obtainable from paddy varied from about 60 to 70 per cent.

Murugesan and Bhattacharya (1986) showed that puffed rice is traditionally made by subjecting paddy to high temperature heated sand. Lack of maturity to kernels, parboiling and moisture content are reported to influence puffing negatively, while addition of salt and increase in temperature positively influences puffing (Murugesan and Bhattacharya 1986).

Among the harvesting practices, the drying method and the genetic peculiarities had been found to influence puffing (Srinivas and Desikachar 1973). Optimum puffing was obtained by heating milled parboiled rice at a moisture content of 10.5 to 11 per cent (Chinnaswamy and Bhattacharya 1983b). Sharp et al (1984) reported that due to toasting there was water loss and an indication of reduction in total solid with an increase in firmness.

Variation in the extent of swelling of rice kernels was shown to be related to the amylose content, which was highest in varieties having good cooking quality (Sanjiva Rao et al 1952). Prema and Menon (1969) had observed greatest increase in the volume of the cooked rice in Taichung Native 1', whereas the increase was lowest in Tainan 3' in raw rice.

Doesthale et al (1978) had shown that the milling losses for other minerals were lower in parboiled than in raw rice. Bhattacharya (1979) had reported that rice varieties differ in the equilibrium moisture content attained by them when soaked in water at room temperature (EMC-S) depending primarily on their amylose content. Raj and Singaravadivel (1980) had suggested that water soluble constituents formed and present in paddy grains was getting leached out into soaked water.

Juliano (1985) stated that the quality of rice can be improved in terms of cooking properties, nutrient content, colour and flavour by adopting improved practices for processing of paddy. Lee (1986) pointed out that moisture content was of great importance and paddy must be dried to about 14 per cent to avoid great loss due to breakage in milling. Chao (1988) had reported that cracked kernel was an important factor affecting the broken rate of milled rice and hence the marketing value.

According to Webb et al (1968) amylose content, starch-iodine blue values and alkali reaction values were the best indicators for predicting parboiling canning stability. Chalky rice kernels were reported to absorb more water upon soaking than translucent kernel (Bhattacharya 1979). Sekhon et al (1980) showed that Basmati 370 had the best cooking quality since its lowest uptake of water was at 77°C. It showed the greatest grain length, linear expansion and swelling ratio.

The relatively greater expansion of parboiled rice along its breadth after cooking gives it a characteristic short and plump appearance (Mahadevappa and Desikachar (1968). Raw and milled parboiled rice gave minimal expansion which increased with increasing severity of parboiling upto a steam pressure of 1.5 kg/cms. (Chinnaswamy and Bhattacharya 1983) Rice parboiled by heating with sand wax was reported to expand well.

Parboiling is reported to increase the head rice yield (Rajalekshmi 1989). Mecham et al (1961) and Kamura et al (1976) had reported that the harder texture of the endosperm due to parboiling was reflected in the improved head rice yield. Sindhu et al (1975) had observed that coarse varieties had a tendency to break more during milling. According to Singaravadivel and Anthoni (1983) the head rice yield decreased to 55.0% from 98.8% due to moulds and bacteria infection. Sindhu (1975) found out that coarse

variety IR-8 gave the highest yield of brown rice (83 percentage). Sindhu (1975) had further stated that the extent of breakage of rice depended on the variety but increased in all cases with the degree of milling.

Palman 579, a medium fine variety was proved resistant to breakage during milling (Sindhu 1975). Sharma and Bains (1979) had tested the relationship between the physicochemical properties and milling and cooking characteristics. According to the authors the coarse varieties 'IR-8' and 'Jaya' showed higher breakage. Bhattacharya and Sowbhagya (1971) had noted that milled raw rice cracked more readily when put in water than fully vitreous kernels.

Sahay et al (1980) observed that the head rice yield decreased linearly in most cases with the increase in the time of polishing after which there was a sharp fall in all the varieties. Chalkiness score of mature kernels increased in field paddy with the delay in harvest, which perhaps increased the breakage of rice (Indudharaswamy and Bhattacharya 1982). Chao (1988) had reported that cracked kernel was an important factor affecting the cooking quality.

Bhattacharya and Subha Rao (1966b) observed that milled parboiled rice had ungelatinized opaque core while milled raw rice had chalky portion. The dimensions of milled parboiled rice were generally more than that of raw milled

rice (Rao and Juliano 1970). According to these authors parboiling did not alter the 100 kernel weight. Pillaiyar (1983) had reported that after parboiling there was a small reduction in the kernel weight. Damir (1982) had pointed out that parboiled grains were shorter but wider.

According to Fellers and Deissinger (1978) steamed rice milled at 10 per cent moisture gave good head rice yield. Stipe et al (1972) found that with Saturn rice there was considerable decrease in both total and head rice yield when the moisture content was above 18 per cent during shelling. Absorption of water by paddy was related to gelatinization of the starch of the grain (Bandyopadhya and Roy 1976).

Drying and tempering of steam-treated naturally moist paddy had increased the head rice yield (Stipe et al 1977). According to Fellers and Deissinger (1978) steamed rice varieties milled at 10 per cent moisture, gave good head rice yield. Bhattacharya et al (1979) had observed that chalky rice kernels absorbed more water upon soaking than translucent kernels. Inter varietal difference in equilibrium moisture content when soaked was maintained even among fully translucent or fully chalky kernels.

Vandrasekh and Warthesan (1987) showed that thermal degradation was slower than in white rice. Hussain et al (1987) had found that protein content in rice negatively influenced its cooking characteristics and positively influenced grain dimension and phosphorous content.

There was a high loss of thiamine during washing of raw rice than washing of parboiled rice (Swaminathan 1942) Bhattacharya (1979) using calcium salt or phosphate helped to reduce the loss of riboflavin during cooking.

According to Reddy and Salunka (1980) the iddli mixture with 1 per cent salt fermented for 20 hours and then steamed had 1.5 mg/g. of phytate phosphorus. Rajalekshmi (1984) had observed that if the cooked water was discarded the loss of calcium was more significant. Dutta (1978) studied that the starch content was low in too sticky glutinous varieties and amylose was present only in traces. The starch granules absorbed water during soaking and swelled, increasing the volume of paddy by 25 to 30 per cent.

Prema and Menon (1969) had indicated that some high yielding varieties were less acceptable due to poor cooking quality. Rao (1970) had reported that the cooking quality and glutinous nature of rice largely depended upon its amylose and amylopectin ratio of starch. The cooking behaviour of rice was evaluated by determining certain viscoelastic properties after cooking like swelling, firmness, elastic recovery and viscoelastic index using a viscoelastography [International Organisation for Standardisation (1985)].

Tara and Bains (1970) had estimated that the slight decrease of lysine in parboiled rice might be attributed to the large cooking time. Deshpande and Bhattacharya (1982)

showed that consistency value of rice decreased with increase in water to rice ratio. Juliano and Perez (1984) had reported that water-rice ratio for acceptable soft texture increased with increasing amylose content of the sample. The loss of solids in the gruel of raw, soft parboiled and hard parboiled rice was 4.5, 3.5 and 2 per cent respectively.

Removal of the pericarp (bran) layer adhering to the endosperm by appropriate milling, as reported by Sindhu et al (1975) helped to increase amylose content contributing to better cooking quality. Loss of solids on cooking was reported to increase with the proportion of broken rice (Clarke 1982).

The solids in the cooked water of pre-soaked grains were 9.9 per cent for raw and 5.5 per cent for parboiled rice. (Raghavendra Rao and Juliano 1970). According to Priestly (1976) parboiled rice samples needed higher optimum cooking time.

Pillaiyar and Mohandoss (1981) reported that the disappearance of opaque core forms the basis for indicating the completion of cooking. To get as similar a tenderness as their respective cooked raw rice samples, the severely parboiled rice were to be cooked for a prolonged period twice or thrice the time required for raw samples. Rajalekshmi (1984) had indicated a minimum loss of gruel on cooking if parboiled.

Yanase and Ohtsubo (1985) had reported that there was increase in the value of cooking quality parameters including water uptake ratio, expanded volume and total solid content in residual liquid and of textural parameters of cooked rice as in the case of broken rice. The expansion ratio both along the length and breadth of parboiled rice were lower than the ratios of raw rice cooked for the same period. At an equivalent stage of softness, the parboiled rice expanded more along the breadth than raw rice (Pillaiyar 1984). Damir (1985) had observed that parboiled grains had lower water absorption and swelling capacity during cooking than those of raw milled rice. Desikachar and Subrahmanyan (1959) had noted that by directly steaming the freshly harvested paddy, cooking quality can be improved.

The whiteness and yellow colour index of cooked rice prepared for rice which underwent different degrees of milling could be measured by using a differential whiteness meter and a calorimeter (Yanase and Ohtsubo 1985).

Kik and Williams (1945) found that well stored rice was more digestible. Narayana Rao et al (1954) observed a loss of 20 to 25 per cent of thiamine in the case of all samples after a storage period of one year. Pushpamma and Reddy (1979) had reported that loss in thiamine was highest followed by niacin when rice was stored for one year. Local samples with a moisture content in excess of 13.0 per cent was accepted for safe storage of rice (Ikeorch 1981).

Drying of paddy before storage did not produce a notable effect on the fatty acid composition except an increase in palmitic acid and decrease in linoleic acid. (Dheliwal et al 1982) storage period favourably influenced the lower fatty acids like palmitic, stearic and linoleic acid. Lysine, aspartic acid and serine decreased markedly with storage, but glutamic acid showed little change (Okazaki and Oki 1961). Desikachar (1956) reported that water imbibing capacity of fresh rice was greater than that of stored rice. Mecham et al (1961) had observed that freshly harvested paddy had a lower rate of water absorption than stored paddy. Schroeder (1965) had reported reduced head rice yield and total yields due to fungi invasion during storage. Choudhary (1970) observed substantial increase in milled head rice yield (4.6 per cent) in the rice stored over a period of 10 months. He also found out that the tensile strength of rice increased during storage.

Aging resulted in less water imbibing rate (Desikachar 1956) but according to Barber (1972) the total water uptake upon cooking was generally more in old rice than in fresh sample. The optimum cooking time decreased from 27 to 25 min. In 11 month storage whereas the swelling index of optimally cooked rice increased from 3.16 to 3.78 (Ali et al 1978). Cold storage effectively retarded the decrease in stickiness of rice (Indudharaswamy et al 1978). The change in texture of milled rice during aging improved with the

increase in amylose content (Villareal et al 1976). Deshpande and Bhattacharya (1982) showed that consistency value of rice increased with storage.

According to Juliano et al (1965) amylose content is the major determinant of the cooking and eating characteristics. For making canned and quick-cooking rice, varieties with high amylose which cook dry and flaky were found suitable (Pillaiyar 1988) Manohar Kumar et al (1976) indicated that insoluble amylose fraction affected the rice quality. Among rice samples of similar amylose content (high, intermediate or low) difference in hardness of cooked rice were related to difference in the gel and amylograph consistency final GT or both the properties (Perez and Juliano 1979).

According to Juliano (1978) volume of expansion, water absorption and resistance to disintegration of milled rice during cooking were directly related to the amylose-amylopectin ratio of the starch (Juliano 1978). Among waxy rice samples, the hardness and stickiness values of cooked rices were related to gelatinization temperature, neutral gel consistency or both the properties. (Perez and Juliano 1979).

According to Ikehashi and Khush (1979) chalkiness and whiteness of milled rice were two of the most conspicuous factors determining its commercial value. They had further stated that visual rating of these traits had been the most common method.

Consumers selected qualities, indirectly through induction, using appearance and sensory assessment. Absansi Duff (1988) had further observed that rice consumers attached economic significance to quality consideration. In a survey conducted among 41 scientists, Juliano (1982) had found that most respondents were interested in co-operate testing of methods including sensory evaluation and instrument evaluation to determine the quality of rice grains. Ho Hsu and Link (1988) had found out that drying condition and moisture content had little effect on eating quality.

Kurien et al (1964) had reported that parboiled rice grains appeared bigger and bolder than cooked raw rice after cooking. Priestly (1976) observed that parboiled rice was fluffy and less cohesive and had better shape after cooking compared to raw rice. Sreedevi (1989) had observed through sensory evaluation studies that the acceptability of the cooked rice samples was influenced by the physical characteristics as well as by the cooking characteristics of the rice grains.

Experiments conducted by CFTRI (1960) had revealed that the colour of polished rice produced under different conditions varied from yellowish to yellowish brown. Time and temperature of soaking had lesser effect on colour development when compared to steaming temperature (Roberts et al (1978)). Jayanarayanan (1965) had found that amylose

activity during soaking influenced considerably the colour formation in parboiled rice. The colour of rice when parboiled, was found to be influenced by enzymatic browning, the husk pigment and the bran, Bhattacharya and Soubhagya (1971a).

According to Gariboldi (1974) the absorbed water during parboiling dissolved the colouring pigments in the hull and the heat applied during parboiling process drove the pigments inward to the endosperm which imparted a darker colour to the grain. Sharp et al (1985) had reported that increasing roasting time in parboiled milled rice resulted in increased redness, but the intensity of the colour change was diminished by hydration. Compared to raw rice samples the parboiled samples were observed to be less acceptable, on the basis of the quality attribute colour (Sreedevi 1989).

Desikachar (1956) had pointed out a suitable wet heated treatment of freshly harvested paddy or an incipient parboiling of the rice reduced the pastiness of the cooked rice. Stickiness was inversely proportional to consistency. Deshpande and Bhattacharya (1982) pointed out that stickiness was not appreciably affected by water to rice ratio used during cooking but was markedly reduced by storage mainly due to starch retrogradation.

Dutta and Barua (1978b) had reported that the scented and sticky rice varieties contained higher amounts of

lipids. According to Yanase and Ohtsubo (1985) values of hardness decreases significantly. Popular local rice varieties in Kerala obtained a higher mean score for adhesiveness when compared to high yielding varieties evolved. The quality parameter "adhesiveness" was also found to be negatively influenced by parboiling (Sreedevi 1989).

Experiments conducted by Pillaiyar and Mohandoss (1981) indicated that the texture of the cooked rice was positively influenced by the length-breadth ratio of uncooked samples. According to Juliano (1985) texture of cooked rice was mainly determined by amylose-amylopectin ratio, gelatinization temperature, gel consistency and viscosity in alkali. Juliano and Perez (1984) also reported that water rice ratio for acceptable soft texture increased with increasing amylose content of the samples.

Cereda et al (1983) graded the cooked rice for taste, smell, colour and overall impression. Tabulated results showed no significant difference between unsoaked control and rice soaked at 60°C while rice soaked at 40°C was rejected because of its unpleasant flavour. Cereda et al (1983) observed that rice soaked at 40°C was rejected by taste panel because of the unpleasant flavour developed.

According to Van Veen et al (1968) fermentation of unhusked rice resulted in an increase in protein and fat even though the final product has brownish yellow colour.

The riboflavin content doubled during fermentation whereas thiamine decreased by 50 per cent (Lee et al 1986). Lee et al (1986) also reported that the average relative nutritive value of protein increased by 11 per cent during fermentation whereas thiamine decreased. Venkatasubbaiah (1985) had found that addition of glucose (1 per cent) in iddli batter did not significantly improve fermentation efficiency. G.L.C. analysis of consistent gases released during batter fermentation by yeast indicated mainly distinct carbondioxide peaks compared to hydrogen produced in batter fermented by Leuconostor mesentroides (Venketasubbaiah 1985). Reddy and Salunka (1980) reported that, fermentation of iddli mixture had no effect on the content of calcium, magnesium, zinc and iron.

During fermentation the pH was reported to fall from 6.0 to 4.3 - 5.3 and acidity increased from 3.2 to 19.0 ml. of 0.1 N lactic acid per 25g. iddli batter. [Desikachar et al (1959), Steinkrans et al (1967)]. Susheela Thirumaran (1976) found that the iddli batter with an initial pH ranging from 6.2 to 6.4 was reduced to 3.9 and a batter with this low pH value was reported to give a good product.

Steinkrans et al (1967) had observed that the batter should raise approximately 50 per cent above its original volume but the batter may rise by as much as three times its original volume. Studies were made by Sarasa and Nath (1985) on the gas retaining capacity of the batter by

measuring its volume for 24 hours at 4 hrs. intervals. They reported that although both batter volume and displaced volume of the test batters increased tremendously at 12 hours of fermentation, they attained a maximum at 16 hours of fermentation and got stabilized thereafter.

Mukherjee et al (1965) reported that the low acid producing L. measenteroides and Streptococcus faecalis appeared early in the fermentation, followed by the high acid producing yeast, namely pedicoccus cereoiseae during the iddli batter fermentation. Venkatasubbaiah et al (1985) also reported that the role of lactic acid bacteria is only to reduce the pH of the iddli batter to a level (4.00 to 4.50)which is optimum for further yeast activity. Gowri (1990) studied on improving the nutritive value of iddli using specific grain of micro organisms.

According to Houstan (1967) and Pillaiyar (1981) the high protein rice flour from the outer layers of the endosperm had been suggested for use in food for infants, the aged and for special diets because of its high concentration of many of its valuable nutrients, especially the B-vitamins and good quality protein. Sodium is concentrated only slightly so rice flour can be useful in low-sodium diets. (Pillaiyar 1988). In addition to increased concentration of many nutrients, flours from the outer layers contained large amount of silicon phytic acid and fibre (Pillaiyar 1988).

Opedokem and Ikeorah (1981) reported that 34 samples each of locally produced and imported rice had any detectable aflatoxin. Sigarawadivel and Anthoni (1983) indicated that when IR-20 parboiled rough rice was not dried for 7 days due to humid weather, molds increased to 24.9 x 10^7/g from 6 x 10^4/g and bacteria increased to 75.9 x 10^6/g from 5.1 x 10^6/g initially. The milled rice yield decreased to 60.1% from 72.2%. Singarawadivel and Anthoni (1983) also pointed out that the infection due to molds and bacteria induced breakdown changes which increased the level of sugars, amino acid and polyphenols in grains which might cause kernel discolouration in the associated heat development during fermentation. (Singarawadivel and Anthoni 1983).

Ramanath and Rao (1987) studied the common Indian snacks and their nutritive value. The nutrient content of 100 common Indian snacks. Pulka, parathas, uppama, idli and dosai was tabulated and five was based on wheet, three on pulse, two on rice and pulse mixture.

Reddy and Selunkha (1980) showed that the mixture with 1% salt fermented for 20 hours gives soft products (iddli) and had phytate phosphorous upto 1.5 mg/g. Vasan and Kausalya (1981) standardised beverages like tea and coffee and sweet preparation of acceptable quality with staple milk prepared from rice germ. They also found that the rice germ could be added upto 20% of rice flour in dosa preparation.

Sharp et al (1985) found that the intensity of the colour change could be diminished by hydrated in parboiled rice. They found that by increasing the roasting time whiteness and yellowness can be decreased and redness can be increased.

MATERIALS AND METHODS

The study on "Quality Parameters of certain pre-release cultures of rice developed at Regional Agricultural Research Station (RARS) Pattambi" is an assessment of different physicochemical properties and nutritional composition of six pre-release rice cultures evolved by Kerala Agricultural University at Pattambi. The influence of processing and cooking was also ascertained on these rice cultures.

MATERIALS

The pre-release cultures selected for the study were Culture 8754, 8755, 8756, 8770, 8772 and 871 with Red Triveni as check.

Different processing methods viz. raw and milling as suggested by Pillaiyar (1988) and parboiling (room temperature method) and milling as suggested by Bhattacharya and Indudharaswamy (1967) were adopted for the study.

Three kilograms each of the six cultures and Red Triveni were processed and the samples obtained after milling were air dried to constant moisture level (14 per cent) and stored in polythene containers.

Different parameters studied on the materials were:

1. Nutritional composition
2. Physical characteristics
3. Cooking characteristics and
4. Suitability for different rice preparations.

3.1 NUTRITIONAL COMPOSITION

Major nutrients analysed in the raw and processed samples are listed below with the methods employed.

3.1.1 Calorific Value

Calorific value was estimated using the Bomb calorimeter as per the method of Swaminathan (1984).

3.1.2 Starch

Starch was estimated by the Ferricyanide method of Aminoff et al (1970).

3.1.3 Protein

The protein content was estimated by Kjeldahl's wet digestion method (Hawk and Oser 1965).

3.1.4 Ash

Ash content was estimated by the method of Raghuramulu et al (1983).

3.1.5 Calcium and iron

The calcium and iron contentS were estimated by wet digestion of the samples using diacid mixture and determined under AAS - PE 3030 (Jackson 1973).

3.1.6 Phosphorus

Phosphorus was estimated by wet digestion with diacid mixture and measuring the yellow colour of vanedomolybdate reagent at 410 mm in spectronic - 2000 (Jackson 1973).

3.2 PHYSICAL CHARACTERISTICS

The physical characteristics measured in the processed rice samples prior to cooking were thousand grain weight, grain dimensions, moisture, head rice yield and gelatinization temperature.

3.2.1 Thousand grain weight

Thousand grain weight of different rice samples were determined by monitoring the weight of one thousand paddy seeds randomly selected. (Sindhu et al 1975).

3.2.2 Grain dimension

Grain dimension of rice varieties were estimated as per the method of Pillaiyar and Mohandoss (1981).

3.2.3 Moisture

Moisture content was estimated by the method of Indudharaswamy (unpublished).

3.2.4 Head rice yield

The head rice yield was calculated by subtracting the weight of bran, polished and broken rice from the total weight of milled rice and the percentage was worked out. (Rajalekshmi 1984).

3.2.5 Gelatinization temperature

Gelatinization temperature of the rice samples was estimated with brabender Amylograph by the method of Ankar and Yeddes (1944).

3.3.6 **Gruel loss**

Gruel loss was measured by the method of Sanjwa Rao et al (1952).

3.3.7 **Apparent water uptake**

Apparent water uptake was estimated by the method of Bhattacharya and Sowbhagya (1971).

3.3.8 **Volume expansion**

The volume expansion after cooking of milled rice samples was worked out by cooking definite amount of milled rice in uniform sized test tubes and the percentage increase in volume was calculated.

3.3.9 **Amylose content**

The total amylose content was estimated by the method of Mąc Cready and Hassaid (1943).

3.4 **OVERALL QUALITY**

Overall quality of the products was determined using composite scoring test (ISI 1972). Ranking test was used for a comparison among the products (ISI 1972).

3.5 **SUITABILITY OF CULTURES FOR DIFFERENT PREPARATIONS**

Common rice based preparations viz. cooked rice, Iddli, Idiappam, and Puttu were selected to identify the suitability of rice cultures. Recipes standardised at the laboratory level by Thangam Philip (1988) were applied.

3.3 COOKING CHARACTERISTICS

All the samples (raw as well as parboiled) were subjected to studies on different cooking characteristics. The methods employed were optimum cooking time, elongation ratio, gruel loss, apparent water uptake, volume expansion and amylose content. Properties such as batter yield and acidity, rate of fermentation and flour volume were also ascertained.

3.3.1 Batter yield

Batter yield was determined using the method of Sarasa and Nath (1985).

3.3.2 Acidity

Acidity was estimated by the method of Lee (1975).

Fermentation

Rate of fermentation was determined by the method employed by Thilagam (1986).

3.3.3 Optimum cooking time

Optimum cooking time was estimated by the method of Bhattacharya and Sowbhagya (1971).

3.3.4 Elongation ratio

Elongation ratio of milled rice samples was estimated by the method of Pillaiyar and Mohandoss (1981).

3.3.5 Elongation Index

Elongation index of the rice samples was estimated with reference to the method suggested by Sood and Siddiq (1980).

Statistical analysis of Data

The data on the qualities of rice cultures was determined by suitable statistical methods. Assessment of organoleptic quality attributes was done by Kruskal Wallis test (Nagawara Rao 1983).

RESULTS

The study entitled "Quality parameters of certain pre-release ~~rice~~ cultures of rice developed at ~~from~~ Regional Agricultural Research Station (RARS), Pattambi" was conducted to ascertain the following qualities of the raw and processed rice cultures.

i) Nutritional compositon

ii) Physical characteristics

iii) Cooking characteristics

iv) Suitability for different rice preparations

Red Triveni was used as check.

4.1 NUTRITIONAL COMPOSITION OF RICE CULTURES

Calorific value, starch, proteins, ash, calcium, iron and phosphorus, content of the rice cultures were determined to access their nutritional composition and the details are presented in Table 1.

Table I : The Nutritional Composition of differet rice cultures

No.	Culture No.	Calories (Kcal/100g)	Protein (g/100g)	Starch (%)	Ash (mg/100g)	Calcium (mg/100g)	Phos-phrous mg/100g)	Iron (mg/100g)
1.	8754	287.00	8.55	63.80	0.68	10.25	159.30	1.90
2.	8755	343.30	6.12	79.30	0.70	12.54	162.26	2.90
3.	8756	310.00	9.22	66.50	0.72	9.80	157.13	2.80
4.	8770	347.40	7.93	71.03	0.72	8.30	149.00	3.10
5.	8772	333.00	7.20	77.80	0.74	8.10	146.53	3.80
6.	871	313.40	6.35	74.90	0.71	12.16	161.90	3.00
7.	Red Triveni	332.60	6.99	67.20	0.69	7.30	141.60	4.10

As revealed in Table 1, among the seven pre-release cultures, Culture 8770 was found to have the highest calorific value. The calorific value of rice cultures ranged from 287.0 to 347.40 Kcal/100g. Culture 8756 was found to have the highest concentration of protein and the protein content in these cultures varied from 6.12g to 9.22g/100g. Higher concentration of starch was recorded in culture 8755, while culture 8772 depicted a higher concentration in ash content. Minerals such as calcium and phosphorus were found to be higher in culture 8755.

Compared to Red Triveni, Culture 8754 was nutritionally inferior in calories, starch and ash while 871 was nutritionally inferior in calories and protein. Culture 8756 contained less amount of starch and 8755 less amount of protein. Compared to Red Triveni all the pre-release cultures contained higher amount of calcium and phosphorus. While compared to the pre-release cultures analysed, Red-Triveni had the highest iron content.

Parboiling was the only processing method tried on all the rice cultures. Variation in the nutritional composition of raw and parboiled rice culure was studied. The data collected on this aspect were statistically treated and the detailed ANOVA tables are presented in Appendix I. The mean data are presented in Table 2.

Table 2 : Effect of processing on the nutritional composition of different rice cultures

No.	Culture No.	Calories (Kcal/100g)		Starch (percentage)		Protein (g/100g)		Ash (mg/100g)		Calcium (mg/100g)		Phosphorous mg/100g)		Iron (mg/100g)	
		Raw	Par-boiled	Raw	Par-boiled	Raw	Par-boiled	Raw	Par-boiled	Raw	Par-boiled	Raw	Par-boiled	Raw	Par-boiled
1.	8754	287	289	63.80	62.2	8.55	8.50	0.68	0.73	10.25	7.24	159.30	134.0	1.9	2.6
2.	8755	343.3	343	79.30	77.2	6.12	6.10	0.70	0.77	12.54	10.46	162.26	142.20	2.9	3.2
3.	8756	310.0	323	66.50	62.5	9.22	8.58	0.72	0.82	9.80	7.40	157.13	136.36	2.8	3.5
4.	8770	347.4	352.6	71.03	64.9	7.93	7.89	0.72	0.80	8.30	8.20	149.0	142.20	3.1	3.6
5.	8772	333.0	347	77.80	76.1	7.20	7.04	0.74	0.83	8.10	7.60	146.33	140.40	3.8	4.2
6.	871	313.4	322.7	74.90	73.6	6.35	6.09	0.69	0.76	12.16	9.20	161.90	145.50	3.0	3.6
7.	Red Triveni	332.6	342.6	67.20	67.0	6.99	6.16	0.71	0.73	7.30	6.80	141.66	137.53	4.1	4.2
	Mean	323.8	330.2	71.50	69.17	7.48	7.21	0.71	0.78	9.78	8.12	153.97	139.74	3.08	3.56

CD at 5%

Va	3.24	1.96	0.61	2.32	1.31	3.85	0.66
Pr	1.73	1.047	0.33	1.24	0.69	2.06	0.49
Va & Pr	4.59	2.77	0.86	3.28	1.85	5.45	

Effect of Processing on the nutritional Composition of different rice cultures are presented in Table 2.

A significant difference was observed in the calorific value of the different rice cultures after processing. The highest calorific value for processed rice was recorded for culture 8770, while the lowest value was observed for the culture 8754. Culture 8754, 8756 and 871 had lower calorific value when compared to Red Triveni in both raw and parboiled forms. Parboiling had a significant effect on the retention of calories in the rice cultures. Among the various rice cultures the percentage increase in calories was high in culture 8772 (4.2 per cent) and culture 8756 (4.19 per cent). The percentage increase in calories ranged from 0.08 per cent to 4.2 per cent. While considering the calorific value of rice cultures, a significant interaction between the processing methods and rice cultures was also observed.

The starch content in the pre-release rice cultures was found to reduce after parboiling. A significant difference was observed in the starch content, among the different cultures after processing. The highest value of starch content was observed in the culture 8755 followed by 8772 and 871, while the lowest starch content was noted in the culture 8754 in both raw and processed rice cultures compared to other rice cultures, except 8754 and 8756, the starch content of red triveni was low. Due to processing

high percentage decrease was observed in starch contentin culture 8770 and 8756. The decrease ranged from 0.3 per cent to 8.63 per cent.

No significant loss in starch content was observed in the parboiled samples when compared to raw rice samples. The interaction between variety and processing methods was also not found to be significant.

The parboiling of rice samples had negatively influenced the protein content. The Protein retained is more in culture 8756 while there was a considerable loss or decrease in protein content in the cultures 871 and 8755 when compared to their corresponding raw rice samples. Red Triveni also showed similar loss. Percentage decrease in protein content of all the cultures, Red Triveni had high percentage decrease (11.87per cent) in protein content due to processing when compared to all the rice cultures. Variation in protein content after processing however was significant in all the rice samples. The interaction between processing methods and rice cultures was also found to be not significant.

A significant difference in the ash content was observed for the different cultures after processing. The highest ash content was observed for culture 8772, while the lowest value for ash content was observed in Culture 8754 in both raw and parboiled rice. All the cultures studied had

percentage increase in ash when compared to Red Triveni (2.82 per cent). The increase was in the range of 12.16per cent to 2.82per cent. Ash content in the rice samples were affected significantly by processing methods. Higher concentration of ash was noted in the parboiled samples as compared to raw samples.

A significant difference in the calcium content was observed among the different rice cultures after processing. As revealed in Table 2, the calcium content of parboiled rice cultures were in general less than the corresponding raw samples. Rate of loss of calcium content due to processing was varying among the different rice cultures. The highest calcium content for raw rice was observed in the culture 8755, while the lowest was recorded for Red Triveni. Cultures 8770 and 8772 had low percentage decrease in calcium content and cultures 8754, 8756, 871 and 8755 had high percentage decrease. The decrease ranged from 16.11per cent to 29.36per cent.

Processed rice samples negatively affected the calcium content of the rice cultures and a comparison among samples gave significant results. However the variation was negligible in rice samples 8770, 8772 and Red Triveni. No significant interaction between the processing methods and cultures was observed.

A significant difference in the phosphorus content was observed among the different cultures when parboiled. As revealed in Table 2, parboiling rice cultures were found to

influence the phosphorus content negatively, the variation being high in cultures 8755, 8756 and 871. There was a significant difference in the phosphorus content of rice cultures when processed. Parboiling was found to reduce the phosphorus content significantly when compared to raw rice. Phosphorus content was less in Red Triveni when compared to the pre-release cultures. Among the rice cultures, 8755 had highest phosphorus content followed by 871, 8754, 8756, 8770 and 8772 in raw samples. Due to processing the high percentage decrease in phosphorus was detected in cultures 8754, 8756 and 8755. A significant interaction between the processing methods and varieties was also found.

Significant difference was observed in the iron content in the cultures due to processing.

As revealed in Table 2, iron content observed to be the highest in the variety Red Triveni, while the lowest iron content was found in culture 8754. Loss of iron content due to processing was negligible in Red Triveni. A similar trend was observed in rice cultures 8755 and 8772. Cultures 8754 and 8756 had higher percentage increase in iron due to processing. The increase in iron content ranged from 10.34 per cent to 36.84 per cent.

Processing rice samples had influenced the iron content. Iron was found to be retained more in parboiled rice sample when compared to raw rice. The relationship between the cultures and processing methods was found to be not significant.

Table 3: The Physical characteristic of different rice cultures

No.	Culture No.	Thousand grain weight(g)	Grain Dimension ratio	Head rice field percentage	Moisture g/100g	Gelatinization temperature (°C)
1.	8754	18.50	2.40	33.50	13.80	87.00
2.	8755	19.70	2.50	36.50	14.00	86.00
3.	8756	22.60	2.20	40.40	14.32	89.00
4.	8770	22.10	2.60	38.46	14.20	85.05
5.	8772	22.90	2.10	40.03	14.40	87.30
6.	871	21.40	2.90	39.03	14.10	87.00
7.	Red Triveni	18.70	2.70	34.90	13.90	84.00

4.2 PHYSICAL CHARACTERISTICS OF RICE CULTURES

Table 3 presents the physical characteristic of different rice varieties. The major physical characteristics assessed were thousand grain weight, grain dimension ratio, head rice yield, moisture content and gelatinization temperature. Thousand grain weight and moisture content was found to be highest in culture 8772, while highest value for grain dimensions was recorded in culture 871. Head rice yield was highest in 8756 and lowest in 8754. Comparison of the physical characteristics of different rice cultures with Red Triveni revealed higher value for grain dimension ratio and thousand grain weight. Culture 871 obtained the highest value, followed by Red Triveni. Lowest values for head rice yield and moisture were obtained for rice culture 8754, followed by Red Triveni gelatinization temperatute was lowest for Red Triveni.

Parboiling was only the procesing method applied on the rice culture samples. The abstract of ANOVA related to the effect of processing on the physical characteristic of different rice cultures are presented in Appendix II.

Table 4 : Effect of Processing on the Physical characteristics of different rice cultures

No.	Culture No.	Thousand grain weight(g)		Grain Dimension ratio		Head rice yield (percentage)		Moisture g/100g		Geletinization temperature (^{o}C)	
		Raw	Parboiled	Raw	Parboiled	Raw	Parboiled	Raw	Parboiled	Raw	Parboiled
1.	8754	18.50	20.10	2.4	2.4	33.5	55.9	13.8	13.4	87.00	88.0
2.	8755	19.70	20.40	2.5	2.5	36.5	60.5	14.0	13.6	86.00	87.33
3.	8756	22.60	21.70	2.2	2.2	40.4	66.5	14.32	14.1	89.00	91.31
4.	8770	22.10	23.20	2.6	2.6	38.46	77.5	14.2	13.8	85.05	91.00
5.	8772	22.90	24.20	2.1	2.01	40.03	77.9	14.4	14.1	87.30	90.33
6.	871	21.40	23.10	2.9	2.7	39.03	70.2	14.1	13.1	87.00	93.00
7.	Red Triveni	18.70	19.20	2.7	2.5	34.90	54.07	13.9	13.5	84.0	93.00
	Mean	20.84	21.70	2.48	2.42	37.54	66.08	14.1	13.74	86.48	90.56
	CD at 5%										
	Va	1.048		2.194		2.199		0.199		1.46	
	Pr	0.560		2.103		1.757		0.106		0.78	
	Va & Pr	1.480		2.748		3.110		0.281		2.07	

The effect of processing on the physical characteristics of different rice cultures are presented in Table 4.

The thousand grain weight was found to vary significantly among the different cultures after processing. Values for thousand grain weight was recorded high for the culture 8772 in raw and parboiled forms while the lowest value was observed for the culture 8754 in raw samples. Thousand grain weight was low for Red Triveni. High percentage increase in thousand grain weight was seen in culture 8754 (8.65%) and low percentage increase was observed in Red Triveni (2.67%).

A significant difference in the thousand grain weight was observed among the different varieties of rice. The parboiled samples generally had higher value for thousands grain weight than the raw rice except culture 8756. Thus parboiling significantly influences thousand grain weight. Interaction between rice cultures and processing method found to be not significant.

Among the different rice cultures no significant difference was observed for grain dimension ratio after processing. As revealed in Table 4, the highest value for grain dimension among the different cultures of rice was seen in culture 871 in raw form as well as in parboiled form, while the lowest value was recorded for culture 8772 both in parboiled or in raw forms. Red Triveni revealed high value for grain dimension. No percentage decrease in

grain dimension was observed in pre-release rice culture like 8754, 8755 8756 and 8770. Red Triveni had highest percentage decrease (7.41%) when compared to 871 (6.89%) and 8772 (4.2%). No significant difference among rice cultures was observed when processed. Not much variation in the grain dimension ratio was observed between parboiled and raw samples in most of the cases.

The interaction among cultures and processing methods was also found to be not significant. A significant difference in the percentage head rice yield was observed among the varieties. The highest percentage of head rice yield was observed for the culture 8756, while the lowest percentage was seen in the culture 8754 for raw samples. The head rice yield was better for all rice cultures except culture 8754, when compared to Red Triveni. In parboiled rice Red Triveni had lowest percentage of head rice yield and 8772 had highest percentage of head rice yield. All the pre-release cultures had high percentage increase in head rice yield when compared to Red Triveni. It ranged from 101.50 to 54.92%

Parboiling as a processing method significantly increase ~~by~~ the percentage head rice yield of all the rice cultures. A significant difference was observed in the interaction between the various rice cultures and parboiling as a processing method.

There was a significant difference in the moisture content among the different rice cultures after processing.

The moisture content was highest in the culture 8772, where as low value for moisture content was observed in culture 8754. Red Triveni had low value for moisture. Highest percentage decrease in moisture was seen in culture 871 (7.07%). All the other cultures had low percentage decrease including Red Triveni (2.88%). A significant loss in moisture content was observed in the parboiled samples when compared to the raw samples.

The interaction between the cultures and processing methods was found to be not significant.

As revealed in Table 4, a significant difference was observed in the gelatinization temperature among the different cultures. the highest gelatinization temperature before processing was recorded for culture 8756 while the lowest gelatinization temperature was recorded for the variety Red Triveni. After processing the gelatinization temperature was high for culture 871 and Red Triveni and lowest for culture 8755. Percentage increase in gelatinization temperature was higher for Red Triveni. It ranged from 1071% to 1.149%.

There was a significant difference between the processing methods also. A significant higher gelatinization temperature was seen in the parboiled rice cultures when compared to raw samples. A significant interaction was also observed among the cultures and the processing methods.

Table 5 : The cooking qualities of different rice cultures

No.	Culture No.	Optimum cooking time (minutes)	Elongation ratio	Elongation index (ratio)	Volume of expansion (percentage)	Water uptake g/g	Total amylose percentage	Gruel loss (percentage)
1.	8754	25	1.6	1.03	325.03	2.3	21.5	3.08
2.	8755	22.45	1.6	1.00	276.16	2.4	31.7	5.8
3.	8756	25	1.4	0.90	284.73	2.2	22.9	3.9
4.	8770	30	1.5	1.16	337.11	2.5	25.3	4.2
5.	8772	29.05	1.6	1.01	276.76	2.13	29.2	4.9
6.	871	30	1.4	0.8	376.83	2.73	26.5	4.4
7.	Red Triveni	27	1.76	1.02	349.9	2.6	22.5	3.7

4.3 COOKING CHARACTERISTIC OF DIFFERENT RICE CULTURES

The cooking characteristics of the rice cultures were assessed by determining the optimum cooking time, elongation ratio, elongation index, volume of expansion, water uptake, total amylose and gruel loss.

As revealed in Table 5, the optimum cooking time of seven rice cultures were found to be in a range of 22.45 to 30 minutes. Among these cultures 8770 and 871 were found to take maximum and culture 8755 less time. During cooking, volume of expansion was highest for culture 871 and this culture was found to absorb more water during cooking and was well comparable with variety Red Triveni the standard check. Gruel loss as well as amylose content were found to be highest in culture 8755.

Comparison of cooking qualities of different rice cultures with Red Triveni showed that all the rice cultures had lower value for elongation ratio than Red Triveni. Culture 871 and Red Triveni were observed to have higher rate of water uptake than all the rice cultures studied. Culture 8755 had low optimum cooking time but high total amylose percentage and gruel loss when compared to Red Triveni.

The abstract of ANOVA related to the effect of processing on the cooking characteristics of different rice cultures are presented in Appendix 3.

Table 6 : Effect of Processing on the cooking characteristic of different rice cultures

No.	Culture No.	Optimum cooking time (minutes)		Elongation (Ratio)		Elongation Index (Ratio)		Volume of Expansion (Percentage)		Water uptake g/g		Total amylose (percentage)		Gruel loss (percentage)	
		Raw	Par-boiled	Raw	Par-boiled	Raw	Par-boiled	Raw	Par-boiled	Raw	Par-boiled	Raw	Par-boiled	Raw	Par-boiled
1.	8754	25.00	33.35	1.60	1.50	1.03	1.06	325.03	210.53	1.9	2.3	21.5	21.56	3.08	2.9
2.	8755	22.45	33.00	1.60	1.60	1.00	1.07	276.76	221.93	2.03	2.4	31.7	27.4	5.8	4.0
3.	8756	25.00	35.00	1.40	1.46	0.90	1.00	284.73	180.76	1.9	2.2	22.9	19.05	3.9	2.8
4.	8770	30.00	39.10	1.50	1.40	1.16	1.20	337.11	250.33	2.08	2.5	25.3	21.5	4.2	3.2
5.	8772	29.05	40.00	1.60	1.66	1.09	1.00	276.76	167.00	1.73	2.13	29.2	27.5	4.9	4.3
6.	871	30.00	40.00	1.40	1.30	0.80	0.90	376.83	272.00	2.3	2.73	26.5	24.6	4.4	3.8
7.	Red Triveni	27.00	34.20	1.76	1.70	1.02	1.05	349.9	263.13	2.1	2.6	22.5	21.5	3.7	3.0
	Mean	26.92	36.09	1.55	1.52	1.001	1.041	318.16	223.6	2.0	2.4	25.65	23.3	4.28	3.43
CD at 5%															
	Va		1.17		7.06		0.075		3.364		0.194		1.57		0.322
	Pr		0.628		3.77		0.04		1.798		0.103		0.84		0.172
	Va & Pr		1.66		9.99		0.128		4.578		0.274		2.23		0.46

Effect of processing on the cooking characteristics of different rice cultures are presented in Table 6.

From the table 6 it is evident that the optimum cooking time for each rice cultures is different. Among the six cultures 8755 required least time for cooking, followed by cultures 8754, 8756 and Red Triveni. Compared to parboiled rice cultures, raw rice cultures needed lesser time to cook to an optimum level. In case of rice cultures, least time was required for culture 8755. This was followed by cultures 8754 Red Triveni and 8756. Red Triveni required lesser time than cultures 8770, 8772 and 871 in raw form and cultures 8756, 8770, 8772 and 871 in parboiled form needed more time than Red Triveni. Highest percentage increase in optimum cooking time was seen in culture 8755 (46.99%) and lowest in Red Triveni (26.66%).

Interaction between the cultures and processing methods were also found to be significant.

The elongation ratio was observed to decrease as a result of parboiling. A significant difference was observed in the elongation ratio of different rice cultures after processing. Compared to pre-release rice cultures the highest elongation ratio after cooking was observed for Red Triveni while the lowest was observed in the cultures 871 and 8756 in raw form and in culture 871 and 8770 in parboiled rice. All the pre-release cultures observed a high percentage decrease in elongation ratio when compared

to Red Triveni except culture 8755 (19.81%). Increase was observed to be the highest in culture 8772 (39.66%). Processing methods had a significant effect on the elongation ratio of different cultures.

The interaction between different rice cultures and the processing methods are also found to be significant.

Among the different varieties, a significant difference was observed in the elongation index after processing. The elongation index was highest for culture 8770 and lowest for culture 871. Red Triveni had lower value than 8770 and 8754 in raw rice and 8770 and 8755 in parboiled. Highest percentage increase in elongation index was observed in culture 871 (12.5%). All the cultures except 8754 (2.9%) had high percentage increase in elongation index when compared to Red Triveni (2.94%). Parboiling was not found to be significantly affecting the elongation index of different rice cultures. Interaction between the processing method and cultures was not significant.

From Table 6 highest value was observed for culture 871 and the lowest value obtained for 8772 and 8755 in raw samples culture 8772 and 8756 in parboiled rice. Cultures 8772, 8756 and 8754 had obtained high percentage decrease in volume of expansion whereas other cultures had lower percentage decrease including Red Triveni. It ranged from 19.81% to 39.66%.

There was significant interaction between the cultures and the processing methods. Cultures 871 had high volume of expansion than Red Triveni in the parboiled and raw rice.

A significant difference was observed in the water uptake after processing the rice varieties. The highest water uptake was recorded in 871 and Red Triveni while the lowest was observed in culture 8772 in both raw and parboiled form. The water uptake by the rice cultures found to be not significant as a result of processing. Red Triveni had highest percentage increase in water uptake ratio (23.8%) followed by culture 8772 and 8754. Least percentage increase in water uptake was observed in culture 8756 (15.79%). Thus the water uptake were not significant after parboiling compared to raw rice. The interaction among the cultures and between processing methods was not found to be significant.

Values for total amylose varied significantly among the different rice cultures, after processing. The highest value for amylose was recorded for culture 8755 and the lowest value 8754 in raw samples. Culture 8772 had high amylose and culture 8756 had low amylose content. Red Triveni had low amylose content. All the cultures had highest percentage decrease in total amylose content when compared to Red Triveni (4.44%) except culture 8754 (0.28%). The highest percentage decrease is seen in culture 8756 (16.81%). There was a significant difference in the total

Table 7: Effect of processing on flour yield from various rice cultures

		Raw		Paraboiled	
Sl.No.	Culture No.	Mean	% increase	Mean	% increase
1.	8754	215	7.5	210	5.0
2.	8755	217	8.5	212	6.0
3.	8756	219	9.5	211	5.5
4.	8770	214	7.00	56	2.8
5.	8772	225	12.50	219	9.5
6	871	212	6	204	2
7.	Red Triveni	207	3.5	204	2

Significance : Cd at 5%

Between varieties (Va)* - 3.721

Between processing method (Pr)* - 4.208

amylose content obtained for rice cultures after processing. The amylose content decreases significantly in the parboiled samples when compared to the raw samples. A significant iteraction was observed between the cultures and the processing methods in respect of the amylose content.

As revealed in Table 6, the gruel loss was found to vary significantly among the different rice samples after processing. The minimum loss in the gruel after cooking was observed for culture 8754 and maximum loss was recorded in culture 8755, Red Triveni had low gruel loss except culture 8754 in raw samples. In parboiled rice samples minimum loss in gruel after cooking was observed in culture 8756 and maximum loss in culture 8772, Red Triveni had low gruel loss except for culture 8754 and 8756. Cultures 8754, 8770 and 8772 had low percentage decrease in gruel loss than Red Triveni, whereas all the cultures had high percentage decrease in gruel loss due to processing. It ranged from 5.84% to 31.03%. A significant difference was observed in the gruel loss among the processing methods also. There was significant decrease in the gruel loss in the parboiled rice samples when compared to raw rice samples. The interaction among the cultures and the processing methods was also found to be significant.

Table 7 presents the percentage increase in flour volume of different rice cultures. Raw rice cultures had obtained more flour, compared to parboiled rice samples. Among pre-release cultures, culture 8772 and 8756 had obtained more flour in raw samples. However from parboiled sample of culture 8756 the flour yielded was less.

Table 8 : Relation between physical characteristics and cooking characteristics for pre-release rice cultures

	TGW	HRY	GT	OCT	P	GL	GD	V E
WU	-0.3184*	-0.5236**	-0.7625**	-0.5800**			0.5796*	0.8457
VE		-0.4622**	-0.6332**	-0.4882**		0.3437*	0.5351**	
GL		-0.4327**	-0.3405**	-0.3782**	0.4417**			
OCT	-0.5119**	-0.6517**	0.8999**					
TA		-0.3380*			-0.5540**	0.8813**		
GT	-0.5105**	-0.7081**						
ER	-0.4769**							
GD					-0.3126*			
HRY	0.3198*							

TGW - Thousand grain weight

HRY - Head rice yield

GT - Gelatinization temperature

OCT - Optimum cooking time

P - Protein

GL - Gruel loss

GD - Grain dimension

VE - Volume of expansion

TA - Total amylose

WU - Water uptake

ER - Elongation ratio

The relationship among the physical and cooking characteristics of the pre-release rice cultures were statistically tested and the results are presented in Table 8 and the correlation matrix worked out is presented in Appendix 4.

Head rice yield had a significant positive correlation with gelatinization temperature and optimum cooking time and significant negative correlation with gruel loss, volume of expansion, water uptake and amylose content.

Thousand grain weight of the cultures became a significant positive factor determining the head rice yield, gelatinization temperature and optimum cooking time of the cultures while the same quality was observed to be negatively associated with elongation ratio and water uptake of the cultures.

A significant positive correlation was obtained for gelatinization temperature with optimum cooking time and negatively correlated with gruel loss, volume of expansion and water uptake.

As revealed in table, significant negative association was observed between factors like grain dimension, gruel loss, and amylose content with the protein content of the cultures.

A significant positive correlation for grain dimension was obtained with volume of expansion and water uptake. Optimum cooking time was found to be significantly

correlated negatively with gruel loss, volume of expansion and water uptake.

A significant positive correlation was observed for gruel loss with volume of expansion and amylose content. A significant positive correlation was obtained for volume of expansion with water uptake.

Amylose content was found to be significantly correlated negatively with protein and head rice yield and positive correlation was observed with gruel loss.

4.4 SUITABILITY OF PRE-RELEASED RICE CULTURES FOR DIFFERENT PREPARATIONS

The suitability of pre-release rice cultures for different preparations were determined by conducting detailed sensory evaluation studies on common rice based preparations. Preparation selected for the study were cooked rice (raw and parboiled) iddli, puttu and idiappam. Experiments for each preparations were repeated three times. Mean score obtained for the three experiments were worked out. Major quality attributes studied were appearance, colour, flavour, texture, taste and doneness.

Table 9 : Mean score obtained for cooked rice (raw) in sensory evaluation tests

Number of panel members : 10

Sl. No.	Culture No.	QUALITY ATTRIBUTES											
		Appearance		Colour		Flavour		Texture		Taste		Doneness	
		Mean Score	Ranking	Mean Score	Ranking	Mean Score	Ranking	Mean Score	Ranking	Mean Score	Ranking	Mean Score	Ranking
1.	8754	4.9	1	4.9	1	4.9	1	4.7	1	4.3	3	4.8	2
2.	8755	4.3	3	4.4	2	4.8	2	4.7	1	3.5	4	4.9	1
3.	8756	4.8	2	4.9	1	4.6	3	4	4	4.3	3	4.7	3
4.	8770	2.9	4	3.1	3	4.3	5	4.5	3	3.5	4	4.8	2
5.	8772	2.8	5	2.9	4	4.4	4	4.5	3	4.3	3	4.8	2
6.	871	1.9	7	1.8	6	4.8	2	4.6	2	4.7	1	4.8	2
7.	Red Triveni	2.1	6	2.2	5	4.8	2	4.5	3	4.6	2	4.8	2
8.	Kruskal Wallis Test X_2	57.682**		57.707**		31.46**		24.002**		46.378**		4.2764*	

Table X_2 = 12.592

** Significant at 1% level

* Significant at 5% level

4.4.1 Cooked rice (raw)

Mean scores obtained for various quality attributes for cooked rice (raw) of different rice cultures are presented in Table 9.

Mean score obtained for appearance of cooked rice (raw) was found to be significantly different for different rice cultures. Highest mean score was observed for culture 8754 and 8756. Culture 871 had obtained the lowest value followed by Red Triveni.

There was a significant difference among the cultures on the mean scores obtained for colour. Among the pre-release rice cultures, culture 8754 and 8756 had obtained highest score for colour while culture 871 and Red Triveni had obtained lower scores.

A significant difference was observed in the mean scores obtained for flavour among different cultures of rice. Among the cultures, 8754, 8755, 871 and Red Triveni had secured higher score for flavour while culture 8770 and 8772 had secured lower score.

A significant difference was observed in the mean score for texture also. All the rice cultures had obtained a mean score above four. Higher score was obtained for culture 8754 and 8755 and lowest score for 8756.

Significant cultural difference was observed for taste. Among the pre-release rice cultures, Culture 871 and Red

Fig. 1. Triangle Test

Fig. 2. Suitability of pre-release rice cultures for cooked rice (raw)

Triveni had obtained the higher score and lower scores was obtained for culture 8770 and 8755 for taste.

A significant difference was observed among the rice cultures for the quality attribute "doneness". Except culture 8756, all the remaining pre-release cultures and Red Triveni has obtained the higher mean score.

Fig. 3. Suitability of rice cultures for cooked rice (parboiled)

Fig. 4. Suitability of cultures for 'iddli'

4.4.2 Cooked rice (Parboiled)

Mean scores obtained for the quality attributes for cooked rice (parboiled) of different cultures are presented in Table 10.

A significant varietel difference was observed in the mean scores for appearance of parboiled rice samples. Culture 8756 and 8754 had obtained the higher mean scores and culture 871 had obtained the lowest. Mean score ranged from 2.1 and 3.9. Red Triveni had a mean score of 2.9.

Data on the mean scores of different rice cultures obtained for colour showed a significant difference. Cultures 8754 and 8756 had obtained the high mean scores. Culture 871 had obtained lowest mean score followed by Red Triveni. When the flavour of parboiled rice of the different rice cultures was taken into consideration, there was significant difference. Among the different pre-release cultures, cultures 8756, 871 and Red Triveni had obtained the higher scores and cultures 8754 and 8755 had obtained the lower scores.

The texture of different cooked rice samples also varied significantly. Culture 8756 had obtained the highest score and the lowest score was obtained for cultures 8770 and 8754. Moderate and similar scores were obtained for Red Triveni, Cultures 8755 and 8772.

Table 10 : Mean score obtained for cooked rice (Parboiled)in sensory evaluation tests

Number of panel members : 10

Sl. No.	Culture No.	QUALITY ATTRIBUTES											
		Appearance		Colour		Flavour		Texture		Taste		Doneness	
		Mean Score	Ranking	Mean Score	Ranking	Mean Score	Ranking	Mean Score	Ranking	Mean Score	Ranking	Mean Score	Ranking
1.	8754	3.8	2	3.9	1	3.8	6	4.1	2	4.1	5	4.7	3
2.	8755	2.8	4	2.9	3	3.9	5	3.8	3	3.6	6	4.8	2
3.	8756	3.9	1	3.8	2	4.9	1	4.6	1	4.3	4	4.9	1
4.	8770	2.9	3	2.7	5	4.2	4	3.6	4	3.5	7	4.8	2
5.	8772	2.9	3	2.8	4	4.4	3	3.8	3	4.5	3	4.7	3
6.	871	2.1	5	2.0	7	4.9	1	4.1	2	4.8	1	4.9	3
7.	Red Triveni	2.9	3	2.4	6	4.8	2	3.8	3	4.7	2	4.8	2
8.	Kruskal Wallis Test X_2	45.593**		51.899**		48.348**		37.169**		50.570**		7.111*	

Table X_2 = 12.592

** Significant at 1% level

* Significant at 5% level

Triveni had obtained the higher score and lower scores was obtained for culture 8770 and 8755 for taste.

A significant difference was observed among the rice cultures for the quality attribute "doneness". Except culture 8756, all the remaining pre-release cultures and Red Triveni has obtained the higher mean score.

A significant difference was observed for taste of different pre-release cultures. Culture 871 and Red Triveni had obtained the highest score and culture 8770 had obtained the lowest. Data on the mean score obtained for doneness of different cultures showed a significant difference among the culture. The mean values were above four. High mean scores were obtained for culture 871 and 8756 followed by 8755 Red Triveni and 8770 and lower score was obtained for culture 8754 and 8772.

4.4.3 Iddli

Iddli a breakfast dish in most parts of India especially popular in South India, is expected to be soft and spongy and of desirable sour taste and flavour. Iddli is prepared by steaming the natural fermented batter made of rice and black gram. The organoleptic quality of iddli was measured by determining the batter yield, porosity and by conducting sensory evaluation studies.

For the food item iddli the mean scores of quality attributes for the different rice cultures are presented in Table 11. The batter yield is increase in volume of 20ml of batter, kept at room temperature for 12 hours was measured and the details are presented in Table 12.

A significant difference was observed for quality attribute, 'appearance' among different rice cultures. All the rice cultures were not acceptable for appearance. The highest score had been obtained for rice culture 8754. 8770

Table 11 : Mean score obtained for Iddli in sensory evaluation tests

Number of panel members : 10

Sl. No.	Culture No.	QUALITY ATTRIBUTES											
		Appearance		Colour		Flavour		Texture		Taste		Doneness	
		Mean Score	Ranking	Mean Score	Ranking	Mean Score	Ranking	Mean Score	Ranking	Mean Score	Ranking	Mean Score	Ranking
1.	8754	3.7	1	3.3	1	4.7	3	3.8	4	3.1	3	4.6	4
2.	8755	2.9	3	1.9	5	4.1	5	3.3	5	2.9	4	4.7	3
3.	8756	3.6	2	3.2	2	4.8	2	2.9	7	3.2	2	4.9	1
4.	8770	1.7	7	2.7	4	4.2	4	3.2	6	3.1	3	4.8	2
5.	8772	2.7	5	1.8	6	4.1	5	3.9	3	3.2	2	4.9	1
6.	871	1.9	6	1.7	7	4.9	1	4.3	1	3.3	1	4.7	3
7.	Red Triveni	2.8	4	2.9	3	4.8	2	4.2	2	3.3	1	4.8	2
8.	Kruskal Wallis Test X_2	55.172**		50.132**		45.305**		46.541**		14.158**		16.776**	

Table X_2 = 12.592

** Significant at 1% level

* Significant at 5% level

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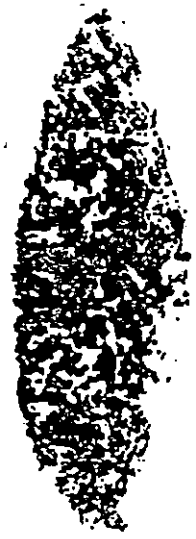

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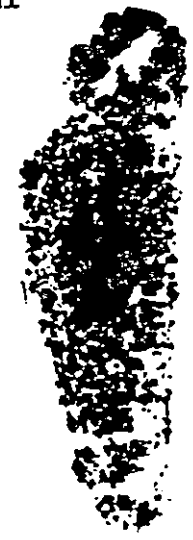

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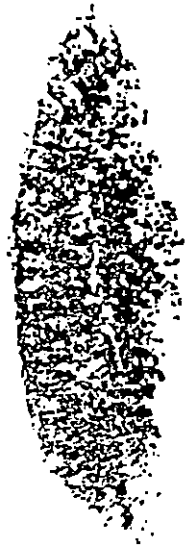
8772



871

RED TRIVENI

had lower scores followed by cultures 871, 8772 and Red Triveni. Iddli prepared from these seven rice cultures were not acceptable because of their pinkish red colour. Highest score for colour was obtained for culture 8754 and the lowest score for culture 871. There was significant difference among the cultures. The mean score ranged from 1.7 to 3.3.

A significant difference was observed in the mean scores of "flavour" among the different cultures. Culture 871 had obtained the highest score and cultures 8755 and 8772 had obtained the lowest scores. Mean scores ranged from 4.1 to 4.9.

Texture of the iddli was evaluated by taking the impression of an iddli slice using the rubber stamp pad, the details are presented in Figure 1. Iddli prepared from cultures 8772 and 871 were found to be more porous and the iddli was soft when compared to other pre-release cultures. Iddli made from Red Triveni was also porous.

A significant difference was observed among the different rice cultures in the mean score for "texture". Texture of most of the iddli prepared from this rice cultures were not soft, fluffy and not acceptable. Culture 871 had obtained the highest value followed by Red Triveni cultures 8772 and 8756 had obtained the last score.

A significant difference was observed in the mean score among the different rice cultures for the quality attribute

Table 12 : Percentage increase in Iddli batter yield and acidity after fermentation

Sl. No.	Cultures No.	Volume increase (ml)		Acidity gm/Litre/100ml.
		Mean	Percentage increase	Mean
1.	8754	64	32	0.156
2.	8755	56	28	0.153
3.	8756	50	25	0.149
4.	8770	50	25	0.155
5.	8772	75	37.5	0.174
6.	871	68	34	0.181
7.	Red Triveni	70	35.0	0.172

CD Value 5% = 3.3033** CD Value 5% - 0.01265**

"taste". Highest mean scores were obtained for culture 871 and Red Triveni, followed by cultures 8756 and 8772. The lowest mean score was obtained for culture 8755 and 8770.

A significant cultural difference was observed in the mean scores obtained for the quality attribute "doneness". Highest scores were observed for cultures 8756 and 8772 and the lowest score for culture 8754. Red Triveni had a moderate value for doneness.

A comparison of iddli preparation among pre-release cultures, revealed that the cultures were not suitable for this preparation with reference to the appearance, colour and texture.

As revealed in Table12 culture 8772 and Red Triveni had obtained high batter yield when compared to other cultures. Batter yield of cultures 8756 and 8770 was low. Fermentation efficiency was determined by increase in volume and acidity level.

Fig. 5, 6. Batter volume before and after fermentation

4.4.4 Puttu

Puttu is made of roasted and coarsely powdered rice flour. The flour was moistened before steaming for 2 to 3 minutes.

Table 13 presents the mean scores for different quality attributes obtained for the preparation "Puttu" made of pre-release rice cultures and Red Triveni.

A significant difference among the pre-release rice cultures was observed in the mean scores obtained for "appearance". Culture 8756 was more preferred in appearance than other cultures. Culture 871 had obtained the lowest scores followed by cultures 8754 and 8755. Red Triveni had obtained a moderate mean score.

Colour preference was found to be significantly affected among different rice cultures. Culture 8754 and culture 8756 had obtained the highest mean scores for this quality followed by culture 8755 and Red Triveni. Cultures 8770, 8772 and 871 had obtained the lowest scores. Mean score ranged from 4.3 to 4.7.

A significant difference was revealed among the different pre-release rice cultures and Red Triveni for the quality attribute "flavour". Culture 871, 8754 and Red Triveni had obtained the highest scores and cultures 8770 and 8772 were less preferred.

Table 13 : Mean score obtained for Puttu in sensory evaluation tests

Number of panel members : 10

Sl. No.	Culture No.	QUALITY ATTRIBUTES											
		Appearance		Colour		Flavour		Texture		Taste		Doneness	
		Mean Score	Ranking	Mean Score	Ranking	Mean Score	Ranking	Mean Score	Ranking	Mean Score	Ranking	Mean Score	Ranking
1.	8754	4.3	4	4.7	1	4.6	2	4.4	3	5.0	1	4.9	1
2.	8755	4.3	4	4.5	3	3.9	4	4.5	2	4.7	4	4.7	3
3.	8756	4.9	1	4.6	2	4.4	3	3.9	4	4.8	3	4.8	2
4.	8770	4.5	2	4.3	5	3.8	5	3.9	4	4.6	5	4.6	4
5.	8772	4.4	3	4.3	5	3.8	5	4.4	3	4.6	5	4.7	3
6.	871	4.3	4	4.3	5	4.7	1	4.6	1	4.9	2	4.8	2
7.	Red Triveni	4.4	3	4.4	4	4.6	2	4.5	2	4.9	2	4.8	2
8.	Kruskal Wallis Test X_2	39.514**		43.018**		45.209**		33.508**		29.147**		11.842*	

Table X_2 = 12.592

** Significant at 1% level

* Significant at 5% level

Texture of Puttu prepared from different pre-release rice cultures were found to be significantly different. Texture preference was higher for culture 871 followed by Red Triveni and 8755. Low preference was observed for culture 8756 because of its stickiness and for culture 8770 because of hardness of the product.

A significant cultural difference was observed for taste. Highest score was observed for culture 8754 followed by culture 871 and Red Triveni. Lowest score for taste was observed for cultures 8770 and 8772.

A significant difference was observed in the different rice cultures. All the cultures had obtained high score for doneness. The score ranged from 4.6 to 4.9. Highest score was obtained for culture 8754 followed by cultures 8756, 871 and Red Triveni.

Table 14 : Mean score obtained for Idiappam in sensory evaluation tests

Number of panel members : 10

Sl. No.	Culture No.	QUALITY ATTRIBUTES											
		Appearance		Colour		Flavour		Texture		Taste		Doneness	
		Mean Score	Ranking	Mean Score	Ranking	Mean Score	Ranking	Mean Score	Ranking	Mean Score	Ranking	Mean Score	Ranking
1.	8754	4.7	1	4.9	1	4.7	3	4.5	2	4.7	2	4.7	2
2.	8755	4.4	2	4.7	2	4.5	4	4.4	3	4.9	1	4.9	1
3.	8756	4.7	1	4.9	1	4.7	3	4.1	4	4.6	3	4.7	2
4.	8770	3.9	5	4.3	4	4.1	6	4.4	3	4.3	4	4.7	2
5.	8772	4.2	3	4.2	5	4.4	5	4.5	2	4.3	4	4.6	3
6.	871	4.1	4	4.1	6	4.9	1	4.7	1	4.7	2	4.9	1
7.	Red Triveni	4.2	3	4.4	3	4.8	2	4.7	1	4.9	1	4.7	2
8.	Kruskal Wallis Test X_2	38.092**		40.341**		30.531**		19.962**		48.099**		16.415**	

Table X_2 = 12.592

** Significance at 1% level

* Significance at 5% level

4.4.5 Idiappam

Idiappam is a festive dish of Kerala. It is also used as a breakfast item. It is usually made out of refined raw rice flour. The product is steamed and garnished with coconut.

Table 14 presents the mean scores obtained for Idiappam preparation using pre-release rice cultures and Red Triveni.

A significant difference was observed in the mean scores obtained for appearance of the Idiappam prepared using different cultures. Culture 8754 and culture 8756 had obtained the highest score for appearance. While culture 8770 had obtained the lowest score, mean score range from 4.1 to 4.7. Red Triveni had mean score of 4.2.

A significant difference was observed in the mean scores obtained for the quality attribute colour of idiappam prepared with different rice cultures. Idiappam prepared with rice cultures 8754 and 8756 was highly preferred for colour compared to the preparation of other cultures. Among the different cultures, culture 871 had the lowest score. Red Triveni had obtained a moderate score for colour. Idiappam made with cultures 871, 8772 and 8770 had obtained lower values than the one made with Red Triveni.

A significant difference was observed in the mean scores obtained for flavour for Idiapam made with different rice cultures. Red Triveni had the higher score for flavour

Fig. 7. Suitability of pre-release rice cultures for 'puttu'

Fig. 8. Suitability of pre-release rice cultures for 'idiappam'

when compared to other cultures except culture 871. Among the pre-release cultures, culture 871 had the highest score and culture 8770 had obtained the lowest score.

Significant variatal difference was obtained for Idiappam for the quality attribute "texture". The culture 871 and Red Triveni had obtained the highest score and culture 8756 observed the lowest.

A significant difference was observed in the mean score obtained for taste among different rice cultures for the preparation of "Idiappam". The rice culture 8755 and Red Triveni had obtained the highest mean score for taste and cultures 8770 and 8772 had obtained the lowest scores among the different rice cultures.

A significant difference was observed in the mean score for doneness, among the different cultures for Idiappam. The highest score was for cultures 8755 and 871. Red Triveni had moderate mean score followed by cultures 8754, 8756 and 8770.

Table 15 : Overall acceptability of different rice preparations

Sl. No.	Cultures No.	Cooked rice (Raw)		Cooked Rice (Parboiled)		Iddli		Puttu		Idiappam		Overall Average	
		Average Score	Rank	Average Score	Rank	Average Score	Rank	Average Score	Rank	Average Score	Rank Score	Average	Rank
1.	8754	4.75	1	4.1	4	3.9	5	4.6	3	4.7	2	4.41	1
2.	8755	4.4	2	3.6	3	3.3	4	4.4	2	4.5	1	4.04	4
3.	8756	4.6	1	4.4	3	3.7	4	4.56	2	4.6	1	4.37	2
4.	8770	3.85	3	3.6	4	3.28	5	4.28	1	4.2	1	3.84	6
5.	8772	3.95	3	3.85	4	3.4	5	4.38	1	4.36	2	3.98	5
6.	871	3.76	4	3.8	3	3.48	5	4.56	2	4.6	1	4.04	4
7.	Red Triveni	3.8	4	3.9	3	3.66	5	4.6	1	4.58	2	4.1	3
8.	Kruskal Wallis X_2	11.785		39.977**		37.969**		47.27**		22.076**			

Overall acceptability of different rice preparation carried through ranking test are presented in Table 15.

Cultures 8754 and 8756 were highly acceptable for popular Kerala rice preparations viz. Cooked rice (raw) Idiappam and Puttu. Culture 8755 was highly acceptable for Idiappam and culture 871 was accepted for both Idiappam and Puttu. Parboiled cultures were found not so suitable for preparing iddli and cooked rice. For Idiappam and Puttu all the cultures had high scores above 4.

For all the preparations, cultures 8755, 8770, 8772 and 871 were found to be inferior to Red Triveni. A comparison among the cultures gave significant results for all the preparations except cooked rice (raw).

DISCUSSION

The present study on the "Quality parameters of certain pre-release ~~rice~~ cultures rice developed at from Regional Agricultural Research Station (RARS) Pattambi" was carried out by assess in the nutritional composition, physical and cooking characteristics as well as the organoleptic qualities of seven different rice cultures with local variety Red Triveni.

Rice is the major source of calories and protein for the majority of the population in Asia. The changes in the constituents of rice - amylose, amylopectin, protein, fat, minerals and vitamins are governed not only by their genetic make-up, but also by various environment factors. Though the cooking and eating characteristics of rice are mostly determined by the composition, they are by and large, modified by the storage and processing conditions (Pillaiyar 1979). A knowledge of rice culture and composition is necessary to understand the various changes that occur during its processing.

5.1 NUTRITIONAL COMPOSITION

Rice is the most extensively cultivated grain crop in Kerala. The harvested grain, paddy is processed in different ways to yield easy to cook foods like raw rice and parboiled rice. In raw rice the rice is dehusked in rice mills and most of the brown layer is generally removed to give a white polished appearance. The parboiled rice is lightly coloured and is harder than the original grain.

A comparison of nutrient content of raw rice samples revealed that parboiled grains are richer in calories, ash and iron content and deficient in protein, starch, calcium and phosphorus.

Rice provides more calories per hectare than any other cereal crop (Pillaiyar 1988). The calorific value of a few pre-release rice cultures evolved at RARS Pattambi were comparable with Red Triveni. All the parboiled rice samples were found to have higher calorific values compared to raw rice sample. This might be due to the passing of rice bran oil into the endosperm at the time of parboiling. According to Raghavendra Rao et al (1967) the bran from parboiled rice had higher fat and lower starch contents than that for raw rice for the same degree of milling.

Volume of expansion, water absorption and resistance to disintegration of milled rice during cooking were directly related to the amylose - amylopectin ratio of the starch (Juliano, 1978). Rao (1970) had reported that cooking quality and glutinous nature of rice largely depended upon its amylose/amylopectin content. The rice samples processed by parboiling were found to have a loss in starch content. Similar findings were observed by Kuzimine and Torzhinskaya (1973). All the varieties had high variation in starch content which ranged from 63.8 to 79.3 per cent.

Protein is the second most abundant constituent of rice. Rice protein has one of the highest nutritional value

among cereal proteins because of its higher lysine content. According to Srinivasan et al (1969) Indian rice varieties contain protein in the range of 11 to 13g/100g. The pre-release rice cultures of RARS Pattambi were found to contain protein in the range of 6.2 - 9.2g/100g. Parboiling resulted in a decrease in the protein content of the rice cultures. A decrease in the protein value of rice may be due to decrease in total free amino acid contents as a result of parboiling (Schrodar 1965). According to Kuzmina and Torzhinskaya (1973) the protein content got reduced during parboiling, probably, because of leaching out of non-protein nitrogen.

No wide variation was observed in ash content of the different cultures of rice. More ash was retained as a result of parboiling. According to Sreedevi (1989) the rice varieties evolved by KAU are nutritionally superior to local varieties. On comparing with pre-release cultures from Pattambi they are equal in nutrient content with the rice varieties of KAU except iron content which is higher for the pre-release rice cultures.

The calcium content in pre-release rice cultures were estimated to range from 7.3 to 12.54 mg/100g. The high yielding rice varieties of KAU was reported to contain calcium content ranging from 8.2 - 10.9 mg/100g (Sreedevi 1989). Calcium content of rice varieties varied from 15.77 to 29.70 mg/100g (Dutta 1978). Among the different

processing methods tried, parboiled rice samples were reported to have lower calcium content than raw rice. This may be due to the leaching of calcium during the process of parboiling.

A comparatively higher amount of phosphorus was seen in pre-release rice cultures from RARS Pattambi. There was not much difference in the phosphorus content of pre-release cultures. But according to Pillaiyar (1988), the phosphorus content of parboiled rice samples was higher compared with that of raw milled rice when subjected to the same degree of milling. However the findings of the present study had indicated that parboiling had negatively influenced the phosphorus content.

The iron content of pre-release rice cultures varied from 1.9 - 4.1 mg/100g. The assessment of the iron content of the rice cultures after processing indicated that there was an increase in iron content after parboiling when compared to raw rice. According to Deesthale et al (1979) mineral elements migrated deep into the grain during parboiling, resulting in a greater retention of these nutrients in milled parboiled grain.

5.2 PHYSICAL CHARACTERISTICS

While assessing the characteristics of different rice cultures the major physical characteristics assessed were thousand grain weight, moisture content, grain dimension, head rice yield and gelatinization temperature.

The thousand grain weight of rice varieties were reported to vary considerably with moisture content (Webb and Stermer(1972). According to Das et al (1983) parboiling had the effect of reducing the length and increasing the dorso - ventral diameter in both rough and brown rice and Kurien et al (1964) had reported that the dimension of milled parboiled rice were generally more than that of raw milled rice. In the present study there was no variation in grain dimension between raw and parboiled rice grain. The highest value of length/breadth ratio was observed for culture 871 and Red Triveni.

Moisture content of rice grains are expected to be 13.7g/100g for raw rice and 13.3g/100g for parboiled rice (ICMR, 1987). Moisture content of grain is reported to effect the head rice yield, milling breakage and also water uptake ratio.

In the present study it was found to be ranging from 13.8 to 14.40g/100g in raw rice and 13.4 to 14.10g/100g in parboiled rice. A slight decrease in the moisture content was observed after parboiling. According to Pillaiyar (1988) the extent of retrogradation was dependent on the temperature of storage as well as the moisture content of parboiled paddy.

Head rice yield is the yield of whole milled rice obtained on milling of paddy. Environmental factors such as time of harvesting and moisture content was reported to be

major factors influencing the milling recovery of rice (Tomar 1981). After studying 49 samples of paddy comprising Basmati 390 (14); Palman 579 (16), IR-8 (8) and Jaya (11) collected from different markets and tested for physico-chemical, milling and cooking characteristics, high variability in head rice yield were observed within and among varieties (Sharma and Bains 1979). Sindhu et al (1975) had reported varietal variation in head rice yield. In the present study the percentage head rice yield was found to be higher in pre-release rice cultures evolved by RARS when compared to Red Triveni except for culture 8754. Parboiling was found to increase the head rice yield. This is in accordance with the results of Rajalekshmi (1984). Sahay et al (1980) observed that the head rice yield decreased linearly in most cases with the increase in the time of polishing. Head rice yield depends on moisture content. At a moisture of 10 to 14 per cent head rice and total yields increased approximately by 3 and 0.7 per cent respectively, for each in 1 per cent decrease in rice moisture.

The range of temperature at which the gelatinization of starch occurs is called the gelatinization temperature. Nakazava et al (1984) reported that the gelatinization onset temperature was significantly affected by starch fraction level in the rice suspension. The gelatinization temperature was found to be negatively influenced by the

total amylose content and water uptake ratio. The gelatinization temperature of pre-release rice cultures from Pattambi varied from 84 to 87.3 in raw samples. Highest gelatinization temperature was obtained for culture 8772 in raw rice and culture 871 and Red Triveni in parboiled sample. According to Ali and Bhattacharya (1980) parboiled rice viscograms showed a high gelatinization tempeature when compared to raw rice and when studied at identical slurry concentrations. These results agreed with the present findings on rice cultures from RARS Pattambi.

5.3 COOKING CHARACTERISTICS

Prema & Menon (1969) had indicated that some exotic high yielding varieties were less acceptable due to poor cooking quality. The cooking quality and glutinous nature of rice largely depend on its amylose/amylopectin(Rao 1970).

Major cooking characteristic of the rice grains assessed were optimum cooking time, elongation ratio, elongation index, gruel loss, volume of expansion, water uptake and amylose content.

Bhattacharya and Subba Rao (1966) had reported, that parboiling affected colour and cooking qualtiy of rice. According to the authors, besides non-enzymatic browning the husk pigment and the bran appeared to contribute to the colour of the parboiled rice. Amylose content in rice was considered as a single most important characteristic used in describing and predicting rice cooking and eating qualities.

Water absorption and volume expansion during cooking were directly affected by amylose content.

Juliano and Perez (1984) indicated that the cooking rate was mainly influenced by the reactivity of the grain constituents with water. In the present study on pre-release rice cultures from RARS the optimum cooking time did not vary much among different varieties evolved. However the higher optimum time was recorded for parboiled rice (Sekhon and Anand (1983)). Priestly (1976), had observed that parboiled low amylose samples cooked a little faster than raw kernels.

Elongation ratio is the ratio between the length of cooked grain and length of raw grain. Higher values in elongation ratio of cooked rice is a positive and desirable trait. It was studied that increase in milling to 8 per cent and parboiling, normally increased the elongation ratio. Basmati 370 rice, when cooked individual grains showed maximum elongation and it was observed to increase with the degree of milling. Among the rice cultures studied Red Triveni had higher elongation ratio. A slight decrease in the elongation ratio of all the rice cultures was observed after parboiling. Temperature of parboiling influenced the linear elongation of the rice kernel after cooking. According to Pillaiyar and Mohandoss (1981), the expansion ratio both along the length and breadth of parboiled rice were lower than the ratio for raw, cooked for the same period.

Elongation index is the ratio between the length-width of cooked grain and length-width of uncooked grain. Elongation index is related to grain dimension. The elongation index will give an idea of the percentage increase in grain dimension after cooking which is a desirable trait while estimating the acceptibility of the varieties. The elongation index ranged from 0.8 to 1.2 (ratio). The highest value for elongation ratio was seen in culture 8770. As a result of parboiling there is a slight increase in the elongation index. This can be observed by the findings of Mahadevappa and Desikachari (1968).

Apparent water uptake is the weight of moisture absorbed by the grain during cooking. According to a study by Deshpande, and Bhattacharya (1982) the water uptake ratio increase with the degree of polish. The author showed that consistency value of rice decreased with increased water to rice ratio and increased with storage. In the present study, all the pre-release rice cultures had shown similar trends. Parboiled rice samples were found to absorb a lesser amount of water during cooking. According to Sekhon et al (1980), Basmati 370 had the lowest uptake of water at $77^{o}C$.

Volume of expansion depend on the water uptake ratio. Higher the water uptake ratio, greater will be the volume of expansion in rice after cooking. According to Sanjiva Rao et al (1952) variation in the extent of the milling of rice

kernels were shown to be related to the amylose content when parboiled rice cooked for the same period. (Mahadevappa and Desikechari 1968). The swelling ratio was significantly lower for parboiled rice than for raw rice. This result is in accordance with the findings of the present study on pre-release rice cultures. According to Pillaiyar (1988) expanded volume was correlated to the temperature of parboiling.

Amylose is the linear molecular component of rice starch which determines the texture of cooked rice. According to Kaul (1970) high amylose containing rice cooked dry and fluffy while high amylopectin containing rice resulted in a moist and sticky mass. According to Ali and Bhattacharya (1976) on extending at 80^{o}C, soluble amylose content remained more or less constant (10-12 per cent of total amylose) in all the raw and parboiled samples. In the present study there was no difference in the total amylose content among the pre-release rice cultures. The highest amylose content was for culture 8755. The parboiled rice samples gave lower values for total amylose when compared to raw rice samples.

High amylose rice cooked, moist and tender did not harden after cooking. Amylose content is the most important criterion on grain quality of milled rice and is an indicator of amylose - amylopectin ratio. Amylose content

of rice classifies rice into waxy and non-waxy. Juliano et al (1964) had emphasised that amylose content was the principle determinant of cooking characteristics. Water absorption rate of the grain of rice is also directly proportional to the amylose content. The correlation coefficient between water uptake and amylose were statistically highly significant. In the present study, it was shown that there was no correlation coefficient between the water uptake ratio and amylose content.

Higher the gruel loss, greater will be the nutrients loss. Though the rate for loss of solids in the gruel followed the pattern of water uptake, the precision of this determination was rather low. The loss of solids in the gruel of raw, soft parboiled and hard parboiled rice was 4.5, 3.5 and 2 per cent respectively (Bhattacharya and Subba Rao 1966a). The solids lost through the cooking water included the water soluble vitamins, minerals, carbohydrates and protein. The gruel loss was found to be higher for pre-release cultures than Red Triveni. Culture 8754 was an exception. Rajalekshmi (1984) indicated a minimum loss of gruel in cooking when parboiled. This finding is in agreement with the findings of the present study.

Flour yield was also more in raw rice samples than parboiled rice cultures. Culture 8772 was found to yield more flour than any other cultures in both the forms.

5.4 SUITABILITY FOR DIFFERENT RICE PREPARATIONS

Quality has been defined as degree of excellence and is the composite of characteristics determining acceptibility. Sensory evaluation of food is assumed increasing significance as this provides information which may be utilized for product improvement and new product development. According to Kramer and Twigg (1970) food quality detectable by our senses can be broken down into three main categories - appearance factors, textural factors and flavour factors.

Rice is the only major cereal in the world and is consumed commonly as a whole cooked kernel. The main aspects of rice quality are the size and shape of grain, appearance; hulling, and milling and cooking quality; nutritional quality and some other special qualities which included scent and linear expansion of the kernel on cooking. White and translucent rice is preferred by people in most parts of the world though in places such as Kerala (India) rice with red colour (red pericarp) is preferred.

Sreedevi (1989) observed through sensory evaluation studies, that the acceptability of a cooked rice sample was influenced by the physical characteristics of individual samples. In many South Indian rice preparations like puttu, idiappam and iddli, rice flour functions as a binding additive. In the present study, quality attributes such as appearance, colour, flavour, texture, taste and doneness were the parameters selected to determine the overall

acceptibility of the rice cultures for selected rice preparations like cooked rice, iddli, puttu and idiappam.

Highest scores were obtained for cultures 8754 and 8756 followed by 8755. All the pr-release cultures had obtained higher scores for appearance than Red Triveni. Variations in mean scores for this quality were also observed to be significant at 1% level. However the same rice cultures when parboiled, only moderate scores were obtained, especially for culture 8755 probably because of the change in colour and size after parboiling. However, in this context also variation in scores among the rice cultures were found to be significant.

According to Priestly (1976) for appearance, parboiled rice was fluffy and less cohesive and have better shape after cooking. When data on the mean scores obtained for appearance, for each preparation was analysed, it revealed that pre-release rice cultures were unsuitable for iddli. However better scores were obtained for cultures 8754 and 8756 when puttu and idiappam were prepared.

Fermented foods of South India such as iddli are acidic products of cereals and legumes. Iddli was prepared using parboiled rice samples. While preparing iddli, during the steaming of the batter, the proteins coagulated and the starch get gelatinized. This will help to solidify the liquid batter, and this will give good shape and size to the iddli made. Solids in the batter are responsible for the

impression made and the air space is indicated as hollow patches in the impression. The impressions of iddlies if uniform, may indicate soft texture.

Data on the mean scores obtained for colour for the cooked rice (raw) vary widely in pre-release rice cultures. High score was obtained only for cultures 8754 and 8756 followed by 8755. However, the parboiled rice samples were given less scores mainly because of the reddish brown colour developed due to the processing. Lesser acceptibility of parboiled rice may be probably due to the fact that the absorbed water during parboiling dissolves the colouring pigments in the hull and the heat applied during parboiling process diverse the pigments inward to the endosperm which impart a dark colour to the grain (Gariboldi 1974). According to Pillaiyar and Mohandoss (1979) rice colour depended on the temperature of soaking and parboiling.

Steamed preparation like iddli, idiappam, puttu made of raw as well as parboiled rice samples were found suitable. Considering the colour of iddli all the pre-release rice samples were having low mean score for iddli. The low mean score was due to the colour of iddli from pinkish to reddish brown. Cultures 8754 and 8756 had pinkish white colour and hence obtained high score. In a study conducted by Roberts (1978) it was reported that fifty per cent of the consumers preferred under milled rice samples, on overall basis only, though by colour alone, they were less preferred.

Remaining quality attributes like flavour, texture and taste, for iddli obtained only low scores. The highest mean score for flavour was obtained for culture 8754 and all the other cultures had obtained a moderate mean score for raw cooked rice. However for cultures 871 and 8756 highest score was obtained for flavour in parboiled rice. A low mean score was seen in cultures 8754 and 8755. All the cultures were highly acceptable for the attribute flavour especially for the preparation viz. Puttu and idiappam.

Mean scores obtained for quality attribute "texture" was found to be in the range of 4.0 to 4.7 for the pre-release rice cultures in cooked rice(raw). The cultures 8754 and 8755 had obtained the highest mean score. But culture 8756 was slightly sticky and had lowest mean score. Compared to raw rice cultures, parboiled samples obtained lower scores. However variation in the mean score obtained among rice cultures of both forms were found to be significant. Stickiness of culture 8756 may be due to high gelatinization temperature. All the other pre-release cultures were preferrable for their texture. The result of the study by Despande and Bhattacharya (1982) reported that stickiness was universaly proportional to the consistency of the preparation. According to Juliano and Villareal (1981) the harder texture of cooked rice products is mainly due to the higher molecular weight of their amylopectin. Low scores for parboiled cooked rice for texture, may also be due to rubbery texture due to rice bran.

According to Steinkrans et al (1967) increase in batter volume would effect the texture of iddli. This is in accordance with this study. Culture 8772 and Red Triveni for which the batter volume was more, had obtained high score for texture of iddli.

Iddli made from pre-release cultures were not accepted for their texture being sticky or hard. Among the different rice samples soft and porus iddlies were resulted only in the preparation made with cultures 871, Red Triveni and 8772. In iddli when doneness of the different rice cultures were taken into consideration it was seen that all the cultures were having higher mean scores. Lowest mean scores was obtained only for culture 8755 and 871.

Among the various quality attributes, taste is the primary and important one. When the taste of the different rice cultures were taken into consideration if was seen that all the pre-release cultures had preferable mean score except cultures 8755 and 8770. Among the cultures, highest mean score was given for culture 871 for cooked rice. Doneness was found to be same for cooked rice (parboiled) among the pre-release rice culture and Red Triveni. A general analysis of the scores obtained for various quality attributes revealed that appearance was the quality for which raw rice cultures were scored higher. This was followed by taste and flavour. Similarly parboiled rice cultures were preferred most for their "taste" followed by

flavour. Iddli and puttu are well comparable with Red Triveni. For idiappam culture 8755 and Red Triveni were highly acceptable for taste and lowest score was for culture 8755. and Culture 8756 had obtained the lowest value for cooked rice. In idiappam, data on the mean score obtained for doneness for different pre-release cultures from Pattambi in general had high scores.

An assessment of the overall acceptability of the pre-release cultures, revealed that 8754 and 8756 were highly acceptable for the various preparations.

SUMMARY

A study on "Quality parameters of certain pre-release ~~rice~~ cultures of rice developed at Regional Agricultural Research Station (RARS) Pattambi", was conducted to assess the effect of different methods of processing on their nutritional compostion, physical characteristics, cooking characteristics and organoleptic qualities. The suitability of these cultures for various preparations was also assessed. For comparison Red Triveni was used as a check.

The nutritional compsotion of rice cultures were ascertained by estimating calories, starch, protein, ash, calcium, phosphorus and iron. The calorific value of different pre-release rice cultures were found to be superior with reference to the calorific value of Red Triveni. Parboiling rice was found to have a positive influence in increasing the calorific value in rice cultures. A high variation in starch was observed in pre-release rice cultures. Parboiling process was found to decrease the starch content. The assessment of protein content of different rice cultures revealed that most of the pre-release cultures had high protein value when compared to Red Triveni. Parboiling was found to decrease the protein content. No marked significant difference in ash content was observed in pre-release rice cultures. The raw samples were found to retain more ash when compared to parboiled samples. An analysis of other components like calcium iron

and phosphorus had indicated that pre-release rice cultures were nutritionally superior. Parboiling in general, was found to decrease calcium and phosphorus, while an increase in the iron content was observed. The highest value for iron was observed in Red Triveni.

The physical characteristics studied were thousand grain weight, grain dimension ratio, head rice yield, moisture content and gelatinization temperature. Thousand grain weight was high for Red Triveni. Parboiling was found to influence thousand grain weight significantly. Parboiled samples generally had a higher thousand grain weight than the raw rice samples except in the case of culture 8756. There was no variation in the grain dimension between the raw and parboiled rice. The dimension of milled raw rice were generally more than that of parboiled milled rice. Culture 871 had obtained highest grain dimension followed by Red Triveni in raw samples. Compared to Red Triveni, higher head rice yield was found in pre-release rice cultures. The percentage of head rice yield was found to be increased with parboiling. The moisture content was comparatively found to be more or less same in pre-release rice culture. A marked decrease in moisture content was observed when parboiled. No significant difference in gelatinization temperature was observed between the pre-release rice cultures and Red Triveni. The gelatinization temperature was found to be higher in parboiled rice samples.

Different cooking characteristics studied were optimum cooking time, elongation ratio, elongation index, volume of expansion, water uptake, total amylose content and gruel loss. The optimum cooking time did not vary much among the different rice cultures. In the case of raw rice cultures less time was required for cooking when compared to parboiled rice samples. Red Triveni required moderate time for cooking. When compared to Red Triveni, the elongation ratio was found to be lower in the pre-release rice cultures. Parboiling was found to decrease elongation ratio of cooked rice.

No significant difference in elongation index was observed between the rice cultures. When compared to Red Triveni, the elongation index was found to be lower in some of the pre-release rice cultures. A slight increase in the elongation index was observed as a result of parboiling.

After cooking the volume of expansion was found to be influenced by the water uptake. Increase in water uptake directly influenced the volume of expansion of the rice cultures. Parboiling was found to decrease the volume of expansion of rice after cooking. No difference in water uptake was observed among the pre-release cultures. When compared to Red Triveni, the rice cultures had lower value for water uptake except culture 871. Parboiling increased the water absorption capacity of rice on cooking.

No significant difference in total amylose content was found between the cultures. Parboiling was found to decrease the total amylose content in all the varieties. The assessment of gruel loss after cooking reveled that pre-release cultures have lower gruel loss when compared to the Red Triveni. The loss of solid in the gruel was found to be decreased as a result of parboiling.

A significant different was observed in flour volume of different rice cultures. Parboiled rice cultures had less flour yield when compared to raw rice.

Appearance, colour, flavour, taste, doneness and texture were the major parameters tested to decide the popularity and acceptability of the rice samples. Puttu, raw cooked rice, parboiled and cooked rice, idiappam and iddli were various preparations attempted to ascertain the suitability.

Among the pre-release cultures, culture 8754 was found to be most suitable for cooked rice because of its appearance, colour, flavour, texture, taste and doneness. Texture was not satisfactory for culture 8756 while appearance and colour were poor for culture 8770 and 8772. Taste of culture 8755 and 8770 when cooked was not acceptable. Parboiling had a negative effect on "cooked rice" samples except in cultures 8754 and 8756.

Parboiled rice cultures were used for preparing iddli. The mean scores obtained for iddli prepared from different

cultures revealed the acceptability. Highest mean score was obtained for culture No.8754. Puttu prepared with 8754 and 8756 was acceptable except for lack of texture culture 8770 had low mean score for all the quality attributes except puttu prepared with culture 871 and Red Triveni was least acceptable because of its colour even though the preparation had high mean score for taste, flavour and texture. Pre-release rice cultures were found suitable for preparing idiappam with reference to the quality attributes like flavour, texture, taste and doneness except for appearance and colour. Lowest score was obtained for culture 8772 and 8770.

Like Red Triveni, pre-release cultures in general were acceptable for preparations like idiappam, puttu and raw cooked rice. The rate of fermentation, batter yield and acidity were high for Red Triveni when compared to all the rice cultures studied.

Based on the above four assessments, culture 8754 and 8756 are found to be the most acceptable among the pre-release rice cultures studied.

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* Original not seen.

APPENDICES

APPENDIX - 1

Effect of processing on the nutritionalcomposition of different rice cultures

Abstract of ANOVA

	Source	Variety (Va)	Processing Methods (Pr)	Va x Pr	Error
	DF	6	1	6	28
	Protein	6.887**	.217	.292	.266
Mean	Calcium	13.922**	25.661**	2.761	1.218
Square	Iron	2.399**	2.333**	7.359	106.721
	Phos-phorous	141.489**	2125.5**	106.71**	10.623
	Calorie	2672.833**	4.335**	99.667**	7.554
	Ash	4.530	.0602**	3.932	3.858
	Starch	220.656**	57.172**	6.32	2.748

** F. value significant at 1% level

* F. Value significant at 5% lelvel

APPENDIX-2

Effect of processing on the physical characteristics of different pre-release rice cultures

Abstract of ANOVA

	Source	Variety (Va)	Processing Methods (Pr)	VA x Pr	Error
	DF	6	1	6	28
Mean square	Thousand grain weight	19.589**	7.719**	1.189	.786
	Grain dimension	.392**	5.082	1.323	.027
	Gelatini-zation temperature	9.688**	175.469**	13.167**	1.535
	Moisture	.374**	1.323**	1.034	2.836
	Head rice yield	2.150**	8549.438**	89.634**	3.460

** F value significant at 1% level

* F value significant at 5% level

APPENDIX - 3

Effect of processing on the cooking characteristics of different rice cultures

Abstract of ANOVA

	Source	Variety (Va)	Processing Methods (Pr)	VA x Pr	Error
	DF	6	1	6	28
Mean square	Elongation ratio	1.052**	1.167	8.887**	3.571
	Elongation Index	6.326**	1.678	6.301	5.890
	Gruel loss	2.989**	7.662**	.395**	7.436
	Apparent water uptake	2.350**	1.40**	5.261	2.694
	Volume of Expansion	9004.875**	93895.5**	632.9167**	8.098
	Total amylose	70.112**	58.226**	4.109**	1.776**

** F value significant at 1% level

* F value significant at 5% level

APPENDIX 4
Correlation Matrix

	P	TGW	GD	HRY	GT	OCT	ER	EI	GL	VE	WU	TA
P	1.0000											
TGW	0.1334	1.0000										
GD	-0.3126*	0.2406	1.0000									
HRY	0.0626	0.3198*	-0.1998	1.0000								
GT	-0.0033	0.5105**	-0.2021	0.7081**	1.0000							
OPT	-0.1194	0.5119**	-0.0721	0.6517**	0.8999**	1.0000						
ER	-0.2819	-0.4769**	-0.2132	-0.3000	0.2509	-0.2481	1.0000					
EI	-0.0682	-0.0278	-0.1320	-0.1379	0.1512	0.0964	0.1962	1.0000				
GL	-0.4417**	0.1755	0.0172	-0.4327**	-0.3405**	-0.3782*	0.653	-0.1219	1.0000			
VE	-0.2543	-0.2628	0.5351**	-0.4622**	-0.6332**	-0.4882**	-0.1305	-0.2416	0.3437*	1.000		
WU	-0.1284	-0.3184*	0.5796*	-0.5236**	-0.7625**	-0.5800**	-0.0277	-0.1936	0.2286	0.8459**	1.0000	
TA	-0.5540**	0.2137	0.0301	-0.3380	-0.2166	-0.2113	0.1352	-0.1022	0.8813**	0.1940	0.1014	1.0000

Abbreviations

TGW - Thousand grain weight
HRY - Head rice yield
GD - Grain dimension
GT - Gelatinization temperature
OCT - Optimum cooking time
P - Protein
GL - Gruel loss
ER - Elongation ratio
EI - Elongation Index
WU - Water uptake
VE - Volume of expansion
TA - Total amylose

APPENDIX 5
Chi-Square Value

Attributes	Puttu	Idiappam	Iddli	Raw Rice	Parboiled Rice
Appearance	39.51389**	38.09227**	55.17246**	57.68189**	45.59326**
Colour	43.01786**	40.34129**	50.13196**	57.70737**	51.89949**
Flavour	45.20867**	30.5311**	45.30458**	31.46048**	48.34839**
Texture	33.50844**	19.96248**	46.54135**	24.002**	37.16895**
Taste	29.14732**	48.09906**	14.15775**	46.37815**	50.57045**
Doneness	11.84193*	16.41518**	16.77646**	4.27644*	7.111115*

Table X_2 = 12.592

** Significant at 1% level

* Significant at 5% level

APPENDIX 6

SPECIMEN EVALUATION CARD FOR TRIANGLE TEST

Name : Date :

Prdouct : Time :

Two of the three samples are identical

Determine the odd sample

Pair No.	Code No. of Samples	Code No. of Odd Sample
1.		
2.		
3.		
4		

(Signature)

APPENDIX 7

SPECIMEN EVALUATION CARD FOR COMPOSITE SCORING TEST

Name : Date :

Prdouct : Time :

Assign scores for each sample for various characteristics

Quality Attributes	Maximum Score	Code No. of Samples 1	2	3	4	5	6	7
Appearance	5							
Colour	5							
Flavour	5							
Texture	5							
Taste	5							
Doneness	5							
Total Score	30							

Comments

(Signature)

QUALITY PARAMETERS OF CERTAIN PRE-RELEASE CULTURES OF RICE DEVELOPED AT REGIONAL AGRICULTURAL RESEARCH STATION, PATTAMBI

BY
NEELOFAR ILLIASKUTTY

ABSTRACT

submitted in partial fulfilment of the requirement for the Degree

MASTER OF SCIENCE IN HOMESCIENCE
FOODSCIENCE AND NUTRITION

FACULTY OF AGRICULTURE
KERALA AGRICULTURAL UNIVERSITY

DEPARTMENT OF HOMESCIENCE
COLLEGE OF AGRICULTURE
VELLAYANI, TRIVANDRUM

1992

ABSTRACT

"The quality parameters of certain pre-release ~~rice~~ of rice cultures developed at Regional Agricultural Research Station (RARS) Pattambi" were determined by assessing their nutritional compositon, physical characteristics, cooking characteristic, as well as organoleptic qualities with Red Triveni as check. The effect of processing methods was also taken into consideration.

The nutritional composition of pre-release rice cultures, with reference to calories, starch, protein, ash, calcium, phosphorus and iron were found to be high when compared to Red Triveni. The calorific value, and iron of the parboiled rice sampels were also found to be higher.

Among the physical characteristics all the pre-release rice cultures were observed to have low values for thousand grain weight and grain dimension, unlike for head rice yield and gelatinization temperature. A decrease on all the physical characteristics except thousand grain weight and head rice yield was observed in samples parboiled.

Compared to Red Triveni pre-release rice cultures had obtained lower values for cooking characteristics such as optimum cooking time, elongation index, gruel loss and water uptake and higher value for elongation ratio, volume of expansion and amylose content. As a result of parboiling, optimum cooking time, and elongation ratio were found to

increase and there was a decrease in elongation index, gruel loss, volume of expansion, water uptake, amylose content due to parboiling.

The flour volume of all the pre-release rice cultures was comparatably high when compared to Red Triveni. Parboiled rice cultures had low flour yield when compared to raw cultures. The increase in batter yield after fermentation was more for Red Triveni when compared to the pre-release rice cultures. Acidity value for all the pre-release cultures were low when compared to Red Triveni.

All the pre-release cultures were more acceptable as cooked rice (raw). Parboiling had a negative influence on cooked rice mainly because of less acceptable appearance and colour.

Puttu was more acceptable for all the quality attributes in all the rice cultures including Red Triveni. Red Triveni was less acceptable because of its reddish colour. For idiappam, the quality attributes colour and appearance had obtained less score for Red Triveni, cultures 8770 and 871. Iddli made from parboiled rice obtained lower score for the attributes colour, appearance and texture for all the cultures. Red Triveni had batter texture than all the cultures.