QUALITY ANALYSIS OF PRE-RELEASE RICE CULTIVARS

By

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Dedicated

to

Daddy & Mummy

DECLARATION

I hereby declare that this thesis entitled **'Quality analysis of pre-release rice cultivars'** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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CERTIFICATE

Certified that this thesis entitled **'Quality analysis of pre-release rice cultivars'** is a record of research work done independently by **Miss. Sheena M. Kandathil** 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

INTRODUCTION

Rice *(Oryza sativa* L.) is the most important food crop of India and Asia and today more than half the population eats rice as the main food in their diets. Rice is extensively cultivated and utilised in South India and now extended to northern parts of India also and more area is being brought under rice cultivation due to improved irrigation facilities.

Rice contributes about 350 calories, 6-9 g proteins and B-complex vitamins. Rice carbohydrates are easily digestible and protein quality is relatively good compared to other cereal proteins.

Rice plants possess certain specific physical and chemical properties that are relevant to optimizing the harvesting and processing operations. These properties vary between varieties and within varieties and moreover, are affected by the environmental conditions during the growing period. New varieties with improved grain quality and better yield have been developed in recent years.

Rice kernel deterioration often begins while the crop ripens in the field. Bacteria, fungi, birds, insects and rodents may attack various parts of the plant before harvest. Post-harvest losses in storage consist of dry matter losses (such as chemical changes in protein, carbohydrate and oil) and contamination by various chemical toxins, insect fragments and rodent urine and faeces. Environmental conditions of temperature and humidity along with grain moisture content govern the biochemical changes as well as microorganisms and insect losses during storage.

A thorough knowledge of the physical and chemical properties of rice grain is then necessary in order to minimise losses and maintain the top quality of the rice product until consumption.

Quality of rice is influenced by many parameters like its physical, cooking, nutritional and organoleptic qualities. The present study is an attempt to assess various quality parameters in selected pre-release KAU rice cultivars, findings of which will be beneficial to the breeders as well as to the consumers of the state. The various quality aspects investigated are:

1. The physical characteristics
2. Cooking characteristics
3. nutritional composition
4. organoleptic qualities
5. effect of parboiling on the above mentioned quality parameters and
6. The identification of superior variety based on these qualities.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

The study entitled 'Quality analysis of pre-release rice cultivars' reviewed under

2.1 Structure and nutritive value of rice grain

2.2 Physical characteristics

2.3 Cooking characteristics

2.4 Nutritional composition

2.5 Organoleptic qualities

2.1 Structure and nutritive value of rice grain

The rice grain consists of an outer pericarp and testa, which makes up the husk or hull. Next comes the aleurone layer, part of which remains in milled or brown rice. The scutellum divides the endosperm, which is the main starchy portion of the grain from the embryo (Matsuo, 1955).

Brown rice consists of a pericarp or fruit coat (about 2 per cent), seed coat (testa) and aleurone (about 5 per cent) and endosperm (89-94 per cent). As with the other cereals, the aleurone is the outermost layer of the endosperm but is removed with the pericarp and seed coat to make the bran (Carl Hoseney, 1989). The longitudinal section of rice grain is given in Fig. 1.

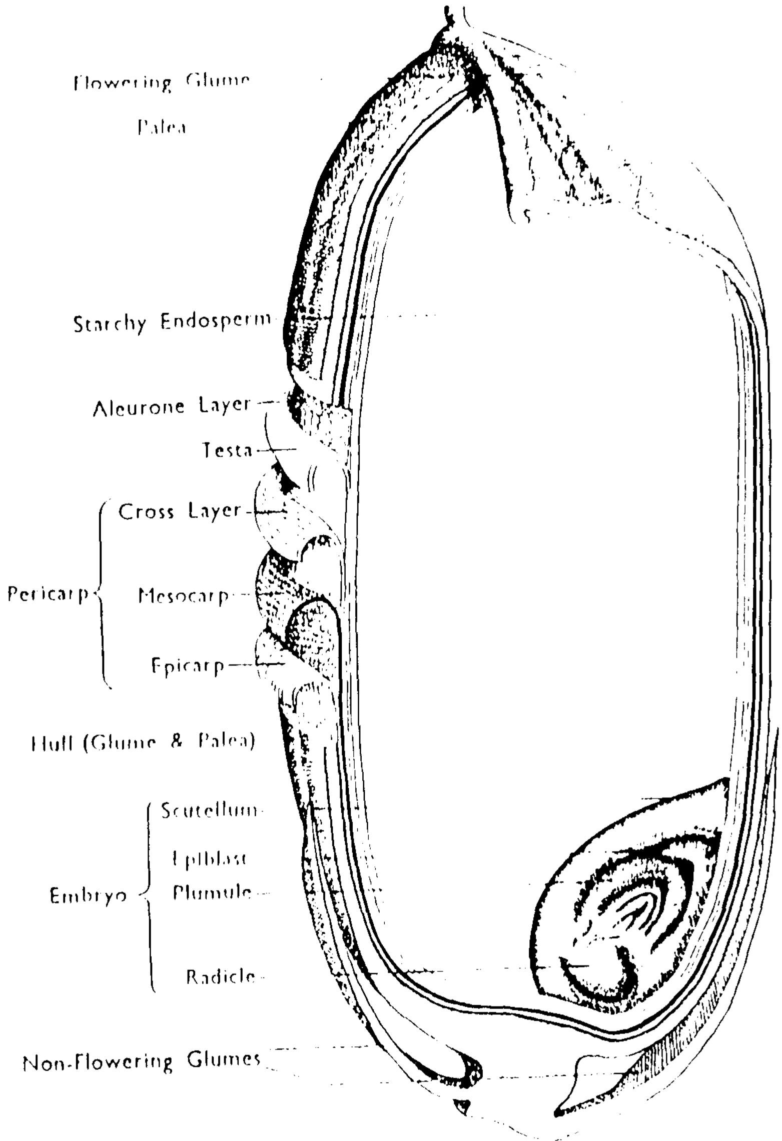


Fig.1 LONGITUDINAL SECTION OF RICE GRAIN.

Rice is a moderate source of different nutrients. A study was conducted by Sreedevi (1989), Neelofer (1992) and Nandini (1995) to analyse the nutritive value of 46 hybrid derivatives of rice evolved by KAU. The details are given in Table 1.

Table 1 Nutritive values of hybrid derivatives of rice evolved by KAU

Nutrients	Mean values
Moisture (Percentage)	13.66
Calories (kcal)	329.89
Protein (g)	8.02
Starch (Percentage)	70.19
Phosphorus (mg/100g)	147.10
Calcium (mg/100g)	9.95
Iron (mg/100g)	3.12

2.2 Physical characteristics

Physical characteristics of the grains are found to be the major determinants of quality, which are decided by factors like colour, size, shape, length-breadth ratio, thousand grain weight, head rice yield and moisture percentage.

2.2.1 Size, colour and shape

The main aspects of rice quality are the size and shape of grain, appearance, hulling and milling, cooking quality, nutritional composition and some other special qualities which include, scent and linear expansion of kernel on cooking. According to Rosamma *et al*. (1991) the two important characters about which the Kerala farmers are very specific are grain shape and kernel colour. Grain size, shape and colour are taken into consideration for the grain appearance. Bold grains with attractive shape, colour and the lustre of the grain are the major criteria for scoring (Nirmala, 1997).

The colour of parboiled rice, produced under different conditions varied from yellowish to yellowish brown (Central Food Technological Research Institute, 1960) or light brown (Raghavendra Rao and Juliano, 1970) to deep amber (Mohandoss and Pillaiyar, 1978). Various factors are reported to be responsible for this change in colour of the parboiled rice.

2.2.2 Grain dimensions

Bandyopadhyay and Roy (1992) stated that, physical dimensions of length, breadth or width and thickness as well as shape of the kernel vary according to the variety and are considered as the most important criterion of rice quality in developing new varieties for commercial production. Considerable variation in the grain dimension was also noted by Saikia and Bains (1990).

According to Quadrat-i-kuda *et al*. (1962) parboiling had the effect of reducing the length and increasing the dorso-ventral diameter in both rough and brown rice. Raghavendra Rao and Juliano (1970) had also noted the above changes in some varieties, where as in some other varieties, original dimension was retained.

Sowbhagya and Ali (1990) reported that, there was a slight but apparent change in the grain dimension of the milled rice due to parboiling and its method. Parboiled rice showed a marginal decrease in length. Bandyopadhyay and Roy (1992) indicated that parboiling and subsequent drying may cause a decrease in length and an increase in width of rough and brown rice.

2.2.3 Grain dimension ratio

The Length-Breadth ratio (L/B ratio) is used in classifying the shape. Mahadevappa and Desikachar (1968) reported that expansion in length, breadth and lateral thickness are important quality parameters.

A study on the quality characteristics of rice was carried out by Ghosh *et al*. (1968) using ten varieties of rice grown commercially in Bihar and four high yielding Taiwan varieties. According to them, varieties which had lesser length-breadth ratio gave more hull than the rice varieties with more length-breadth ratio. They claimed that the milling recovery was dependent upon the size and shape of the grain and other environmental factors. Webb *et al*. (1968) found significant relationship between kernel length, kernel width and length-breadth ratio in rice grains.

Genotypic correlations showed that, grain length was positively correlated with grain weight and length-breadth ratio. Grain width was negatively correlated with length-breadth ratio and positively correlated with the grain weight (Jun, 1985). The L/B ratio of Moncompu varieties worked by Bai *et al*. (1991) ranged from 1.95 to 2.82.

Neelofer (1992) reported that there was no significant difference in the grain dimension after parboiling, while Nandini (1995) reported a significant difference in the grain dimension ratio after parboiling.

2.2.4 Thousand grain weight

The thousand grain weight of rice varieties varied considerably with the moisture content and farmers preferred grain with higher thousand grain weight (Webb and Stermer, 1972). Sindhu *et al*. (1975) reported that, the density and thousand grain weight of coarse varieties were higher than those of the fine and medium fine varieties. Recent studies conducted by Ali *et al*. (1992) had found that split application of Nitrogen fertilizer produced significantly higher thousand grain weight.

In a study conducted by Neelofer (1992) with different pre-release rice cultivars, found that parboiled samples had higher values for thousand grain weight than raw rice. The thousand grain weight of hybrid derivatives were found to be higher when compared to traditional varieties Nandini (1995).

2.2.5 Moisture content

Moisture content of rice is a very important factor which markedly affects several facets of rice quality viz. drying time of the grain before storage or shipment, the rate of deterioration of the grain during storage, grading under ISI specifications, milling quality during drying and storage, other quality factors associated with milling, cooking and processing characteristics and the quality of rice to be used in dry breakfast cereals, for parboiling and for other processed rice and rice containing foods. Moisture content commonly accepted for safe storage period of rough rice are 12 per cent on wet basis for one year and 14 per cent for 3 to 6 months (Bandyopadhyay and Roy, 1992). Tomar (1981) reported that moisture content was of great importance and paddy must be dried to about 14 per cent moisture level to avoid losses due to breakage in milling. Studies conducted by Opakodum and

Ikeorah (1981) had shown that moisture content of 34 samples, each of locally produced and imported rice was 6.34 - 15.13 per cent and 6.68 - 12.27 per cent respectively.

Huang (1986) opined that moisture absorption by dry rice caused rice cracking that greatly influenced the milling quality. Studies conducted by Nandini (1995) had shown that, moisture content was found to be higher in traditional varieties when compared to hybrid derivatives.

2.2.6 Head rice yield

Head rice yield is the percentage yield of whole milled rice obtained on milling of paddy (Rajalekshmi, 1984). Unnikrishnan *et al*. (1982) found that soaking paddy at a temperature of 10-15°C above the gelatinization point for 1 to 2 hrs followed by draining out and hot tempering for another 1-2 hrs gave parboiled rice with acceptable degree of parboiling, good milling and low breakage. Head rice yield was significantly related to hardness and alkali spreading quality of the rice variety (Goodman and Rao, 1983). Ali and Bhattacharya (1984) reported that the head rice recovery increased with increase in moisture content, pressure and time of steaming.

Goodman (1985) had stated that long grain samples of rice gave significantly lower yields of head rice than short or medium grain samples.

In a study conducted by Banaszek and Siebenmorgen (1990) an emperical rate equation was developed to predict head rice yield for rough rice exposed to moisture absorptive conditions. They also reported that time of exposure, initial moisture content and relative humidity were reported to reduce the head rice yield due to higher moisture absorption and further a decrease in head rice yield (more than 20 per cent).

Ali *et al*. (1992) opined that split application of nitrogen fertilizer produced significantly higher head rice recovery. Bandyopadhyay and Roy (1992) found that head rice yield of a variety depends upon moisture content of the grain during harvest. The paddy harvested at higher moisture content (21-24 per cent wet basis) and dried by a mechanical drier gives better yield of milled rice when compared to paddy dried in the sun. He also stated that pre treatment methods such as soaking during parboiling helps in increasing the head rice yield. Sunita kumari and Padmavathi (1990) conducted a study on eight rice varieties and observed that the percentage of head rice recovery ranged from 63.3-69.

2.3 Cooking characteristics

Cooking quality is usually defined by (1) the time required for proper cooking (2) the increase in volume of the cooked product (3) consistency and (4) loss of solids during cooking (Bandyopadhyay and Roy 1992).

Cooking characteristics play a vital role in determining the quality of rice. Prema and Menon (1969) had indicated that some high yielding varieties were less acceptable due to poor cooking quality. Kursawa *et al*. (1969) studied the relation of properties of starch to eating and cooking qualities of milled rice and found that good correlations existed between cooking and eating qualities of rice with respect to starch content.

The quality characteristics of ten varieties of rice popularly cultivated and consumed in Andhra Pradesh were studied by George (1971). Varieties in which there is a low dispersion of amylose into the cooking water, were found to be superior in cooking quality. Varieties with good cooking quality disintegrated into clear masses when treated with alkali whereas varieties with poor cooking quality disintegrated into opaque masses.

Rao (1970) had reported that the cooking quality and glutinous nature of rice largely depend upon its amylose and amylopectin ratio of starch. Juliano (1985a) had stated that the quality of rice can be further improved in terms of cooking properties, nutrient content, colour and flavour by adopting improved practices for processing of paddy. The author had also reported that there was a definite relationship between the physico chemical characters and cooking qualities of rice varieties.

2.3.1 Optimum cooking time

Juliano (1967) had revealed that cooking time and gelatinization temperature of milled rice correlated positively. According to Govindaswamy and Ghosh (1970) the cooking time was positively correlated with the protein content. Raghavendra Rao and Juliano (1970) had opined that parboiled low amylose samples cooked 1.5 minutes faster than raw kernels.

Sabularse *et al*. (1981) revealed that cooking time was not significantly affected by storage. According to Chatterjee and Maiti (1981) had revealed that rice with high protein content (more than 10 per cent) or a high gelatinization temperature (74°C or high) require more water and a longer cooking time to produce cooked rice with the same degree of doneness as for rice with lower values.

Priestly (1976) had stated that parboiled rice generally takes longer time to cook than raw rice. The author also stated that irradiated rice samples showed differences in cooking time.

Vandrasekh and Warthesen (1987) had reported that the thermal degradation was slower in brown rice than in white rice but the extended cooking period for attaining tenderness in brown rice was observed to be higher due to the greater percentage of thiamine loss.

A significant increase in cooking time was noticed in rice varieties as a result of parboiling (Nandini, 1995).

2.3.2 Water uptake

Batcher *et al*. (1957) reported that grain type appeared to be an influencing factor in water absorption of rice, in that most of the long grain varieties absorbed more water than either the medium or short grain varieties, although there was some overlapping of water uptake ratio among the three types studied. Varieties of rice that had high water uptake ratio tended to yield large volume of cooked rice.

Desikachar and Raghavendra (1965) observed a direct relationship between degree of milling and water absorption. They reported that unpolished rice absorbed water very slowly and had poor cooking qualities.

Pillaiyar and Mohandoss (1981c) had reported that the cooking characteristics of parboiled rice were influenced by the hydration behaviour of rice at temperature above and below the gelatinization point. Juliano and Perez (1984) had found that water - rice ratio for acceptable soft texture increased with increasing amylose content. Damir (1985) stated that the parboiled grains were shorter but wider with lower absorption and swelling capacity during cooking than those of raw milled rice. High water uptake in boiling water was an indicator of good cooking quality of rice (Govindaswamy (1985). Karim *et al.* (1993) noticed that the water absorption ratio is maximum at the intermediate milling pressure of 2.0 and 2.5. Nandini (1995) observed that water uptake ratio of hybrid derivatives were found to be higher when compared to traditional varieties.

2.3.3 Volume expansion

Higher volume expansion after cooking is a desirable trait preferred by consumers.

Mahadevappa and Desikachar (1968) carried a study to see the expansion and swelling of raw and parboiled rice during cooking. Parboiled rice showed lower values for these criteria than raw rice varieties. According to Juliano (1979) volume expansion, water absorption and resistance to disintegration of milled rice during cooking were directly related to amylose - amylo pectin ratio of starch.

Increase in water uptake directly influences the volume expansion of rice varieties (Sreedevi 1989). A study conducted by Gupta (1990) among 15 rice varieties of West Bengal revealed that volume expansion ranged between 3.81 to 5.45. Volume expansion was found to be decreased significantly in the case of parboiled rice samples, when compared to raw rice samples (Nandini 1995).

2.3.4 Gruel loss

Higher the gruel loss, greater will be the nutrient loss. Hence decreased gruel loss is advantageous from the nutritional point of view. The loss of solids in the gruel of raw, soft parboiled and hard parboiled rice was reported as 4.5, 3.5 and 2 per cent respectively by Bhattacharya and Subba Rao (1966). According to Neelofer (1992) gruel loss was found to vary among the different rice samples after processing.

Nandini (1995) reported that the gruel loss was higher in traditional varieties than in hybrid derivatives. The author also indicated a minimum loss of gruel in cooking when parboiled. The same results was also observed by Rajalakshmi (1984) and Sreedevi (1989).

2.3.5 Gelatinization temperature

According to Govindaswamy (1985) the gelatinization temperature of starch is the range of temperature within which it starts to swell irreversibly in hot water with a simultaneous loss of crystallinity.

Hallick and Kelly (1959) carried a study on gelatinization and pasting characteristics of rice varieties as related to cooking behaviour. The sample tested consisted seventeen varieties of rice. It was found that amylograms of short and medium grain varieties generally exhibited lower gelatinization temperature and shorter gelatinization times than did those of the long grain varieties.

Juliano *et al*. (1969) carried out a study to compare the properties of waxy and non waxy rice differing in starch gelatinization temperature. Waxy samples of low and high gelatinization temperature gave similar eating quality scores for cooked rice, although the samples differed in the alkali digestibility and cooking time of milled rice.

Bandyopadhyay and Roy (1992) studied the influence of gelatinization temperature on cooking behaviour of rice varieties. Greater the degree of gelatinization, higher is the hydration ability of the resultant rice of temperatures below 70°C. The author also found that above the gelatinization point, the rate of hydration decreases on parboiling. The extent of decrease was again proportional to the severity of parboiling.

2.3.6 Viscosity

Viscosity is a measure of the resistance of a fluid to shear forces and hence to flow.

A noticeble variation in the viscosity was observed among different varieties of rice. (Nandini, 1995). The author also reported that there was an increase in viscosity of rice varieties after parboiling.

2.3.7 Elongation ratio and Elongation index

Elongation ratio is the ratio between the length of cooked and that of raw grain.

The cooking qualities of some local varieties and of some promising short lines of rice in Iran were studied by Niafuzad (1978). He reported that there was no strong relationship between elongation ratio and any of the physico-chemical properties tested. However, there was some indication that rice with medium gel consistency tended to have a greater elongation ratio than those possessing a soft or hard gel consistency.

Chinnaswamy and Bhattacharya (1983) reported that raw and mildy parboiled rice gave minimal expansion which increased with increasing severity of parboiling.

A inter laboratory collaborative test on the measurement of grain elongation of milled rice during cooking was undertaken by Juliano and Perez (1984) on five selected milled rice samples with the use of a simple common method in 19 laboratories in 16 countries. Elongation ratio and elongation index showed similar ranking of the samples, but statistical analysis showed interaction betweeen samples. Elongation ratio measurement provided more consistent results than the elongation index and was simpler, requiring the measurement of grain length only.

Pillaiyar (1988) had stated that increase in milling to 8 per cent nominally increased the elongation ratio. In a study conducted by Gupta (1990) in West Bengal among 15 rice varieties revealed that the elongation ratio ranged between 1.74 to 1.22. Ali *et al.* (1993) reported that rice stored as milled grain improved in cooking quality as it aged and recorded greater elongation.

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 acceptability of the varieties. Damir (1985) had stated that the parboiled grains were shorter but wider with lower absorption and swelling capacity during cooking than those of raw milled rice.

2.4 Nutritional composition of rice grain

The nutritional composition of rice grain is a major parameter influencing the quality of rice grains. The major nutrients in rice are energy, protein, starch, crude fibre, calcium, phosphorus and iron.

2.4.1 Energy

Rice is the chief source of carbohydrate. According to Grist (1986), being a staple food, rice is reported to provide 80 per cent of the calorie requirement of the diet.

Juliano (1990) reported that rice provides 68 per cent of the total energy and 69 per cent of the total dietary protein in South Asia. To Indians, it is the most important food crop supplying, on an average one third of the calories required (Saikia and Bains, 1990).

In a study conducted by Sreedevi (1989) using 13 varieties of rice, revealed that high yielding rice varieties evolved by Kerala Agricultural University were found to be richer sources of calories when compared with local/traditional varieties. She further observed that calorific value was increased after parboiling, which is attributed due to the imbibition of rice bran oil into the endosperm at the time of parboiling, which enables a higher calorific value to be shown by the rice grains obtained after parboiling.

2.4.2 Protein

Rice is reported to be a moderate source of protein. However, rice is considered to be a major source of dietary protein in Indian diets. Protein content in brown rice varies from 4.3 to 18.2 per cent (IRRI, 1978) and in milled rice from 5.0 to 14.0 per cent (Juliano, 1966). Sikka *et al*. (1993) found that with increasing doses of nitrogen fertilizer there was an increase in the protein content.

According to Srinivasa Rao *et al*. (1969) Indian rice varieties contained protein in the range of 11-13 per cent.

Mahadevappa and Shankara Gowde (1973) had observed 6-11 per cent protein in sixty rice varieties studied. Bhat and Rani (1982) reported that the protein content of High Yielding Rice on dry matter basis ranged from 6.68-7.43 gm/100 gm.

The protein content varies much with the environment and cultural practices. High solar radiation during grain development generally reduces protein content, whereas the increase in mean temperature increases the protein content in the Japonica variety and not in the indica variety (Resurrection *et al*. 1977).

Ellis *et al*. (1986) reported that the endosperm storage protein, decreased in amount with increasing distance from the aleurone layer. Ullah and Khondaker (1988) found a positive correlation between grain protein content and yield.

According to Nandini (1995) the protein content dropped slighly after parboiling, because of leaching out of non protein nitrogen and also decrease in total aminoacids.

2.4.3 Starch

Aberg (1994) had found that starch is the major constituent in cereal grain and is the nutritional reservoir in plants. The author also reported that protein is negatively correlated to starch content. According to Singh (1993) starch is a mixture of amylose and amylopectin. Neelofer (1992) and

Nandini (1995) reported that starch content of rice varieties were decreased as a result of parboiling.

2.4.4 Amylose

Amylose content is the major determinant of cooking and eating characteristics (Juliano *et al*. 1965). Varieties with high amylose, cook dry and flaky are suitable for making canned and quick-cooking rice.

Bhattacharya *et al*. (1978) carried out a study to see the importance of insoluble amylose as a determinant of rice quality. It was found that textural properties of the sample could not be explained on the basis of total amylose content alone, but they correlated well with the insoluble amylose contents.

As the insoluble amylose increased, the consistency and the set back increased whereas the stickiness and breakdown decreased.

According to Unnevehr *et al*. (1985) consumers generally prefer rice with intermediate amylose. Stickiness of cooked rice was more closely related to amylose content. Bai *et al*. (1991) had found that the amylose content of Moncompu varieties vary from 16 per cent to 29 per cent.

Schoh (1967) reported that the ratio of amylose to amylopectin in starch is characteristic of the plant species and is under genetic control.

2.4.5 Fibre

Rice is reported to be a moderate source of fibre. Pillaiyar (1979) observed that brown rice constituted 0.7 per cent crude fibre and 0.1 per cent dietary fibre whereas milled rice had 0.1 per cent crude fibre and 0.6 per cent dietary fibre.

Eggum (1979) had stated that low content of tannin and crude fibre in rice had positively influenced the digestibility of rice protein and energy.

2.4.6 Minerals

Rice is reported to be a moderate source of minerals. Sood *et al*. (1980) reported that rice bran contained maximum calcium, potassium, magnesium and phosphorus, while milled rice contained the lowest level in all the rice varieties. Bhat and Rani (1982) observed that calcium content of raw rice varied from 8.00 - 16.00 per cent.

According to Sreedevi (1989) parboiled rice samples have lesser calcium content, when compared to raw samples, while Nandini (1995) reported that parboiling process positively influenced the calcium content of rice varieties.

The milling losses varied in magnitude for different elements and were directly proportional to the degree of milling. Barber (1972) observed a very high percentage loss in iron content of the grain in commercially milled rice.

Neelofer (1992) and Nandini (1995) reported that iron content was found to be retained more in parboiled rice samples when compared to raw rice samples.

Hussain *et al*. (1987) opined that red grain varieties had higher phosphorus content than white varieties but according to Miyoshi *et al*. (1987) phosphorus balance was neative in brown rice.

Pillaiyar (1988) and Nandini (1995) found that phosphorus content of parboiled rice was higher compared with that of raw milled rice but Sreedevi (1989) had reported a decrease in phosphorus content during parboiling.

2.5 Organoleptic qualities of rice grain

Organoleptic quality characteristics included in the study were the colour, appearance, flavour, texture and taste. The quality characteristics of ten varieties of rice popularly cultivated and consumed in Andhra Pradesh were stuided by George (1971). Varieties absorbing high percentage of water found to have a high palatability score.

Evaluation and comparison of sensory quality of cooked rice were done by Kim *et al*. (1986). Cooked rice samples of one waxy and three non waxy varieties were evaluated for odour, taste, appearance and texture by subjective means. Cooked waxy rice was more watery, glossy, sticky, smooth and gummy than non-waxy cooked rice samples. Amount of water added to rice for cooking significantly affected texture and appearance of cooked rice, whereas, flavour was unaffected.

Bandyopadhyay and Roy (1992) reported that the attributes viz., appearance, tenderness and flavour of cooked rice are the final criteria for cooking quality and determines the palatability of cooked rice.

Whiteness and lustre are said to be the important factors affecting the appearance of cooked rice. In a study conducted by Priestly (1976) it was reported that for appearance, parboiled rice was fluffy, less cohesive and highly acceptable with a better shape after cooking.

According to Sreedevi (1989) parboiled samples were observed to be less acceptable on the basis of the quality attribute 'colour ' when compared to raw rice samples and also the long grain varieties tended to be more white and less creamy than short and medium grain types.

Sowbhagya *et al*. (1987) studied the relationship between cooked rice texture and the physico-chemical characteristics of ric and it was observed that the instrumental textural parameters were negatively correlated with the sensory attributes of cooked rice (tenderness, moisture and stickiness). The textural parameters were very highly correlated with total and water insoluble amylose contents of milled rice and to a lesser extent with gel consistency.

According to Sreedevi (1989) the texture of parboiled rice are not much acceptable as raw rice.

Among various quality attributes taste is the primary and important one, followed by flavour. Study conducted by Sreedevi (1989) and Neelofer (1992) reported that parboiled rice samples were preferred most for their taste and flavour.

According to absorption theory recently proposed, even large molecules that cannot be recepted by taste buds are capable of having taste (Kurihara, 1983). Thus carbohydrates and nitrogen compound with fairly large molecules may have something to do with the taste of cooked rice.

Bandyopadhyay and Roy (1992) stated that the flavour of the parboiled product is the result of hydrolysis and decomposition of certain constitutents such as carbohydrates and proteins, under the influence of steam at high temperature during parboiling. They also reported that the secondary products responsible for the characteristic flavour are the protein consisting of the sulphur containing amino acids which produce sulphurous compound (mercaptans) having a characteristic flavour and aroma.

MATERIALS AND METHODS

MATERIALS AND METHODS

The present investigation entitled 'Quality analysis of pre-release rice cultivars' encompasses an assessment of various parameters like physical characteristics, cooking characteristics, nutritional composition and organoleptic qualities of ten pre-release rice cultivars evolved by Rice Research Stations of Kerala Agricultural University located at Moncompu and Pattambi.

3.1 Materials selected

Ten varieties of pre-release paddy samples from two different sources i.e. eight from Rice Research Station, Moncompu and two from Rice Research Station, Pattambi were collected for the study.

The eight pre-release varieties from Moncompu were

1. M-57-9-1-1
2. IET-6661
3. MO-1-20-19-4
4. M-57-18-1-1
5. M-38-4-1
6. M-38-4-2
7. M-42-6-3
8. M-45-20-1

The two pre-release varieties from Pattambi were

1. Cul-87117
2. Cul-87136

1 - 1 1/2 kg of the above rice cultivars were collected and processed by two methods (raw milled and parboiled milled).

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.

3.2 Quality parameters selected

Different quality parameters studied on the materials were:

1. Physical characteristics
2. Cooking characteristics
3. Nutritional composition and
4. Organoleptic qualities

3.2.1 Physical characteristics

Physical characteristics of the rice grains were found to be a major determinant of quality and acceptability of rice.

Different indicators ascertained under physical characteristics are

1. Colour

Colour of the ten pre-release rice cultivars were ascertained by direct observation.

2. Shape

Shape of the rice varieties were determined by classifying them, according to length-width ratio. The rice samples were classified into 3 classes i.e. slender, long grain rice; bold, medium grain rice and round, short grain rice according to the method given by FAO (1970).

1. Slender, long grain rice - L/B ratio > 3.0
2. Bold, medium grain rice - L/B ratio 2.0-3.0
3. Round, short grain rice - L/B ratio < 2.0

3. Size

For determining size, the rice samples were classified into three classes i.e. extra bold, bold and medium bold according to the method given by FAO (1970).

1. Extra bold - Thousand grain weight > 25 gm
2. Bold - Thousand grain weight 20 - 25 gm
3. Medium bold - Thousand grain weight < 25 gm

4. Length-Breadth ratio

Length-Breadth (L/B) ratio of rice varieties were estimated as per the method of Pillaiyar and Mohandoss (1981b).

5. Moisture

Moisture content was estimated by the method of A.O.A.C. (1960).

6. Thousand grain weight

Thousand grain weight of different rice samples were determined by weighing one thousand rice grains randomly selected Sidhu *et al*., 1975). An electronic balance was used for recording the thousand grain weight.

7. Head rice yield

Head rice yield of different rice samples were determined by the method of Rajalakshmi (1984).

3.2.2 Cooking characteristics

Cooking and processing qualities are the major determinants of consumer preference and acceptance that ultimately decides eating quality. Different indicators ascertained under cooking characteristics are furnished below.

1. Optimum cooking time

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

2. Volume expansion

The volume expansion was estimated by the method of Pillaiyar and Mohandoss (1981a).

3. Water uptake

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

4. Gruel loss

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

5. Elongation ratio

Elongation ratio was measured by the method of Pillaiyar and Mohandoss (1981).

6. Elongation Index

Elongation index of milled rice (both raw and parboiled) samples were estimated as per the method suggested by Sood and Siddiq (1980).

7. Gelatinization temperature

Gelatinization temperature of rice varieties were estimated by the method of Mac Masters (1964).

8. Viscosity

Viscosity of different rice varieties were estimated by the method of ISI (1960).

9. Amylose - Amylo pectin ratio

Amylose - Amylo pectin ratio of different rice samples were estimated by the method of Mc Cready and Hassid (1943).

3.2.3 Nutritional composition

The major nutrients analysed in the raw and parboiled samples are listed below with the methods employed.

1. Engery

Energy or calorific value was estimated using a Bomb calorimeter as per the method outlined by Swaminathan (1984).

2. Protein

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

3. Starch

Starch was estimated by the ferricyanide method suggested by Aminoff *et al*. (1970).

4. Fibre

Crude fibre content was estimated by the method of Raghuramalu *et al*. (1983).

5. Calcium

Calcium was estimated after wet digestion of the sample with tripple acid (Jackson, 1973). The tripple acid digest was then fed in to an AAS to obtain the calcium content.

6. Iron

The iron was estimated by feeding the tripple and digest of the sample prepared into an AAS (Jakson, 1973).

7. Phosphorus

Phosphorus was estimated after wet digestion of the sample by the vandomolybdate yellow colour method as outlined by Jackson (1973).

8. Amylose

Total amylose content was estimated by the method of McCready and Hassid (1943).

3.2.4 Organoleptic qualities

The organoleptic qualities of different varieties of rice both raw and parboiled were estimated. For the acceptability trials ten panel members were selected by using triangle test (Jellink, 1964) and the test was conducted as per the standard procedure prescribed by Swaminathan (1974) (Appendix-1). The major quality attributes colour, appearance, flavour, texture and taste were scored by the panel members on a five point hedonic scale (Appendix-2).

3.2.5 Statistical analysis

Statistical analysis was carried out as follows.

1. Analysis of variance for the comparison of cultivars with respect to various quality attributes (Snedecor and Cochran, 1967).

2. Discriminant function analysis to determine the superior variety (Fisher, 1936).

RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

The study entitled 'Quality analysis of pre-release rice cultivars' was conducted to ascertain the following quality parameters of the raw and parboiled rice varieties.

1. Physical characteristics
2. Cooking characteristics
3. Nutritional composition and
4. Organoleptic qualities

4.1 Physical characteristics

Size, colour, shape, length, width, length-breadth ratio, moisture content, thousand grain weight and head rice yield were deter-mined to assess the physical characteristics of rice cultivars.

Table 2 shows the colour and shape of rice varieties. Among the ten varieties analysed, all the varieties were found to have red colour except the varieties Cul-87136 and IET-6661 were white in colour.

Based on length-width ratio, FAO (1970) classified the rice grains in to three categories such as

1. Slender, long grain rice - L/B ratio > 3
2. Bold, medium grain rice - L/B ratio 2-3
3. Round, short grain rice - L/B ratio < 2

Table 2 Colour and shape of rice varieties

Sl.No.	Varieties	Colour	Shape
1	Cul-87117	Red	Bold, medium
2	Cul-87136	White	Round, short
3	IET-6661	White	Round, short
4	MO-1-20-19-4	Red	Round, short
5	M-38-4-1	Red	Round, short
6	M-38-4-2	Red	Round, short
7	M-42-6-3	Red	Bold, medium
8	M-45-20-1	Red	Round, short
9	M-57-9-1-1	Red	Round, short
10	M-57-18-1-1	Red	Round, short

According to this classification, it was observed in the present study that rice varieties - Cul-87117 and M-42-6-3 were found to be bold whereas all the other varieties were found to be round.

Physical dimensions of grain such as length, breadth or width and thickness as well as the shape of the kernel vary from variety to variety. These are considered to be important criteria of rice quality especially for developing new varieties for commercial production (Bandyopadhyay and Roy, 1992).

Table 3 presents the length, width and L/B ratio of the rice varieties. Length of the grain is measured in its greatest dimension, width along the ventral side and thickness across the dorsal side. In the present study, the length and width varied significantly between the varieties. The length was found to be highest for the variety Cul-87117 (5.73mm) and lowest for the varieties M-38-4-2 and MO-1-20-19-4 (4.65 mm). When statistically analysed the variety M-42-6-3 was on par with the variety Cul-87117.

There was a slight but apparent change in the length of milled rice due to parboiling. Parboiling significantly reduced the length of the rice varieties. The grain appear to undergo a vertical shrinkage due to escape of moisture during parboiling. This result confirms with the earlier observations on parboiled rice by Das *et al*. (1983) and Bandyopadhyay and Roy (1992).

In the present study, the width was found to be highest (3.05 mm) in cultivars Cul-87117 and M-57-18-1-1, when compared to other varieties. The width was found to be ranging from 2.65 - 3.00 mm in raw rice and 1.8-3.1 mm in parboiled rice. There was a significant difference between the varieties for width, whereas, no significant difference was observed between the width of raw and parboiled rice varieties. Similar results were also reported by Sowbhagya and Ali (1990).

Table 3 Length, width and L/B ratio of rice varieties

Sl. No.	Varieties	Length (mm)			Width (mm)			L/B ratio		
		Raw	Par boi-led	Mean	Raw	Par boi-led	Mean	Raw	Par boi-led	Mean
1	Cul-87117	6.50	4.95	5.73	3.00	3.10	3.05	2.15	1.56	1.85
2	Cul-87136	5.10	5.00	5.05	3.00	3.00	3.00	1.65	1.63	1.64
3	IET-6661	5.60	4.50	5.05	2.90	1.80	2.35	1.82	1.95	1.88
4	MO-1-20-19-4	4.80	4.50	4.65	2.80	2.90	2.85	1.62	1.57	1.60
5	M-38-4-1	4.90	4.70	4.80	2.70	2.60	2.65	1.84	1.70	1.77
6	M-38-4-2	4.75	4.55	4.65	2.70	2.80	2.75	1.83	1.65	1.74
7	M-42-6-3	5.70	5.50	5.60	2.70	2.90	2.80	2.00	1.90	1.95
8	M-45-20-1	4.85	4.50	4.67	2.65	2.75	2.70	1.89	1.74	1.81
9	M-57-9-1-1	4.95	4.50	4.73	2.70	2.80	2.75	1.85	1.57	1.71
10	M-57-18-1-1	4.85	4.50	4.68	3.00	3.10	3.05	1.61	1.47	1.54
Mean		5.20	4.72		2.82	2.78		1.83	1.68	
CD values										
Varieties			0.237			0.159			0.130	
Processing			0.106			0.071			0.058	
Variety x Processing			0.335			0.224			0.183	

The data when analysed statistically revealed a significant interaction between the varieties and processing with respect to length and width of rice varieties.

The L/B ratio varied significantly between the different cultures. Values for grain dimension ratio was recorded highest for the culture M-42-6-3 (1.95) and lowest value for the variety M-57-18-11 (1.54). In raw rice the L/B ratio was ranged between 1.61-2.15 and in parboiled rice, it was between 1.47-1.95. Similar result was observed by Saikia (1990) in his study on Assam rice varieties.

A significant difference in the grain dimension ratio was noticed after parboiling. As revealed from the table, the grain dimension ratio was found to be decreased in all the parboiled rice samples when compared to raw samples. Parboiling process increased the dorsiventral diameter of the grains and this might be one of the reasons for the reduction in the L/B ratio during parboiling. Raghavendra Rao and Juliano (1970) have reported similar findings. The interaction between the variety and processing was also found to be significant (Appendix-3a).

The thousand grain weight, head rice yield and moisture content of rice varieties were presented in Table 4.

A significant difference in the thousand grain weight was observed among the pre-release rice cultures. Values for thousand grain weight was recorded highest for the culture M-45-20-1 (20.55 gms) and lowest for the culture Cul-87136 (18.43 gms).

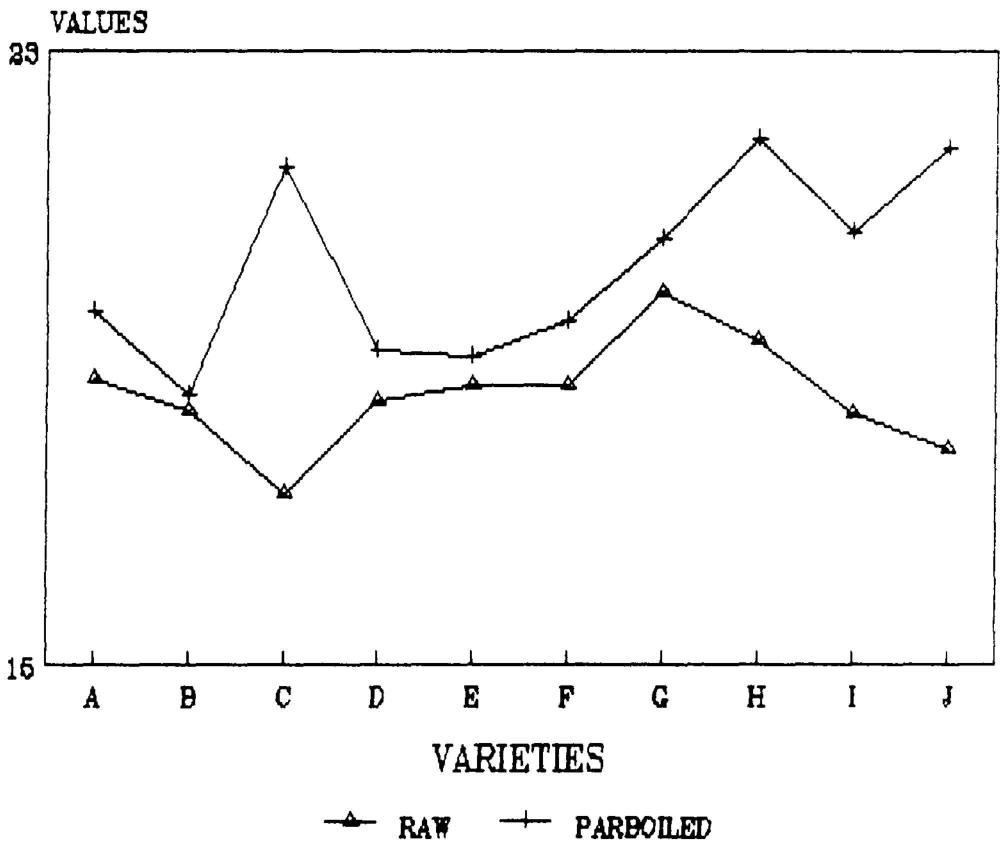
Table 4 Thousand grain weight, head rice yield and moisture content of rice varieties

Sl. No.	Varieties	Thousand grain weight (gm)			Moisture (Percentage)			Head rice yield (Percentage)		
		Raw	Parboilled	Mean	Raw	Parboiled	Mean	Raw	Parboiled	Mean
1	Cul-87117	18.73	19.60	19.17	14.06	13.17	13.62	57.06	66.06	61.56
2	Cul-87136	18.33	18.53	18.43	14.52	14.06	14.29	45.33	57.10	51.21
3	IET-6661	17.23	21.47	19.35	14.63	12.43	13.53	67.44	69.73	68.58
4	MO-1-20-19-4	18.43	19.10	18.77	15.56	13.30	14.43	64.93	73.47	69.20
5	M-38-4-1	18.66	19.00	18.83	15.40	14.26	14.83	49.80	66.16	57.98
6	M-38-4-2	18.63	19.46	19.05	14.43	11.50	12.96	54.22	78.57	66.39
7	M-42-6-3	19.83	20.53	20.18	15.10	13.50	14.30	37.97	74.03	56.00
8	M-45-20-1	19.23	21.86	20.55	15.16	12.36	13.76	54.86	62.06	58.47
9	M-57-9-1-1	18.27	20.63	19.45	16.13	15.30	15.71	58.68	65.47	62.07
10	M-57-18-1-1	17.83	21.73	19.78	14.26	13.33	13.80	72.34	78.56	75.45
	Mean	18.52	20.19		14.93	13.32		56.26	69.12	

CD values

	Thousand grain weight	Moisture	Head rice yield
Varities	0.296	0.260	0.240
Processing	0.132	0.116	0.107
Variety x Processing	0.418	0.369	0.340

FIG. 2. EFFECT OF PARBOILING ON THOUSAND GRAIN WEIGHT OF RICE VARIETIES



A	:	Cul 87117	F	:	M-38-4-2
B	:	Cul 87136	G	:	M-42-6-3
C	:	IET 6661	H	:	M-45-20-1
D	:	Mo-1-20-19-4	I	:	M-57-9-1-1
E	:	M-38-4-1	J	:	M-57-18-1-1

Results obtained indicated that, varietal variations had a profound influence on this variable. According to Webb and Stermer (1972) the thousand grain weight of rice varieties varied considerably with the moisture content in the grain. Varietal variation in thousand grain weight may occur due to variation in the shape and structure of the grains and climatic conditions at the time of harvest. In earlier studies, it has been reported that the grain harvested during the virippu season (July-August) had higher volume and weight than the grains harvested during the Mundakan season (December-January) (Dev, 1991).

The thousand grain weight was found to vary significantly after parboiling. Parboiled samples had significantly higher thousand grain weight compared to raw samples (Fig. 2). The increase in thousand grain weight after parboiling might be due to the excess moisture content absorbed during the process.

The data when analysed statistically revealed that, there is significant interaction between the varieties and the processing with respect to thousand grain weight.

Based on thousand grain weight FAO (1970) has classified rice grains into three categories.

Extra bold	-	Thousand grain weight > 25 gms.
Bold	-	Thousand grain weight 20-25 gms.
Medium bold	-	Thousand grain weight < 20 gms.

According to the above classification, it was observed in the present study that all the raw rice varieties were medium bold whereas the parboiled forms of IET-6661, M-42-6-3, M-45-20-1, M-57-9-1-1 and M-57-18-1-1 were found to be bold.

In the present study the moisture content was found to be ranging from 14.06 - 16.13 per cent in raw rice and 11.5 - 15.3 per cent in parboiled rice varieties. Highest moisture content was observed in the variety M-57-9-1-1 in both raw (16.13 per cent) and parboiled rice (15.30 per cent). Lowest moisture content was observed in M-38-4-2 (12.96 per cent). Moisture content of rice grains are expected to be 18.7 g/100 g for raw rice and 13.3 g/100g for parboiled rice (ICMR, 1987).

A significant decrease in moisture content was observed in parboiled rice samples, when compared to raw samples. Similar findings were also reported by Luh and Mickus (1979) and Nandini (1995).

According to Pillaiyar (1988) the extent of retrogradation depended on the temperature of storage as well as the moisture content of parboiled paddy. The interaction between varieties and processing method was also found to be significant with respect to moisture content.

Head rice yield is the yield of milled rice obtained on milling of paddy. Head rice yield of a variety depends upon the moisture content of the grain during harvest. The paddy harvested at higher moisture content (21-24 per cent wet basis) and dried by a mechanical drier gives better yield of milled rice when compared to paddy dried in the sun (Bandyopadhyay and Roy, 1992).

In the present study there was a significant difference between the rice varieties with respect to head rice yield. The highest percentage of head rice yield was observed for the variety M-57-18-1-1 (75.45 per cent) and the lowest value for the variety Cul-87136 (51.21 per cent). The head rice yield was found to be ranging from 37.97 - 72.34 percentage in raw rice and 57.1 - 78.57 percentage in parboiled rice samples. Head rice yield of the parboiled rice samples were significantly higher when compared to that of the raw rice samples. This may be due to the changes in the process of the hardening of the endosperm of the grain. Similar observations were reported by Neelofer (1992) and Nandini (1995). A pre treatment method of soaking during parboiling is reported to increase the head rice yield (Bandyopadhyay and Roy, 1992) (Appendix-3b).

Salient findings

Among various indicators under physical characteristics a higher value for thousand grain weight, grain dimension ratio and head rice yield and a lower value for moisture content depict a better quality score for the grain.

A comparison among the ten pre-release rice cultures, with respect to different physical characteristics revealed that, varieties IET-6661, M-42-6-3 and M-45-20-1 satisfy the above requirements. These three varieties are also found to have favourable values for the four important indicators mentioned earlier.

4.2 Cooking characteristics

The cooking characteristics of the rice varieties were evaluated by determining the optimum cooking time, volume expansion, water uptake, gruel loss, gelatinization temperature, viscosity, amylose content, amylose-amylopectin ratio, elongation ratio and elongation index.

Cooking time is one of the major determinants of the quality of rice grains and consumers prefer rice grains with lesser cooking time (Table 5).

In the present study, the optimum cooking time was found to be significantly different among the varieties. In these, variety M-57-9-1-1 took significantly higher cooking time (55.83 min.) and variety M-38-4-1 took lesser time (28.83 min.). As revealed in the table, the optimum cooking time of ten raw rice varieties were found to be in the range of 26 min. - 43.33 min.

Table 5 Optimum cooking time and gruel loss of rice varieties

Sl. No.	Varieties	Optimum cooking time (minutes)			Gruel loss (Percentage)		
		Raw	Parboiled	Mean	Raw	Parboiled	Mean
1	Cul-87117	33.33	38.66	36.00	2.05	1.92	1.98
2	Cul-87136	30.66	35.00	32.83	4.62	1.70	3.16
3	IET-6661	36.66	42.66	39.66	3.84	3.71	3.77
4	MO-1-20-19-4	26.00	36.66	31.33	3.24	2.21	2.73
5	M-38-4-1	26.00	31.66	28.83	2.50	1.13	1.81
6	M-38-4-2	31.66	51.66	41.66	4.60	2.13	3.36
7	M-42-6-3	36.66	51.00	43.83	3.25	1.30	2.27
8	M-45-20-1	28.33	53.33	40.83	4.02	1.01	2.52
9	M-57-9-1-1	43.33	68.33	55.83	2.78	1.16	1.97
10	M-57-18-1-1	36.66	60.00	48.33	1.58	1.24	1.41
	Mean	32.93	46.90		3.25	1.75	

CD values

	Optimum cooking time	Gruel loss
Varities	3.076	0.052
Processing	1.375	0.023
Variety x Processing	4.350	0.073

The optimum cooking time was significantly affected by parboiling. Parboiling increased the cooking time of rice varieties. The significant increase in the optimum cooking time after parboiling may be due to the variation in the rate of hydration and consequent gelatinization. Priestly (1976), Sreedevi (1989) and Nandini and Prema (1996) have also reported similar observations. The mean value of cooking time of the parboiled rice varieties were 46.9 minutes. The interaction between the varieties and processing was also significant with respect to cooking time.

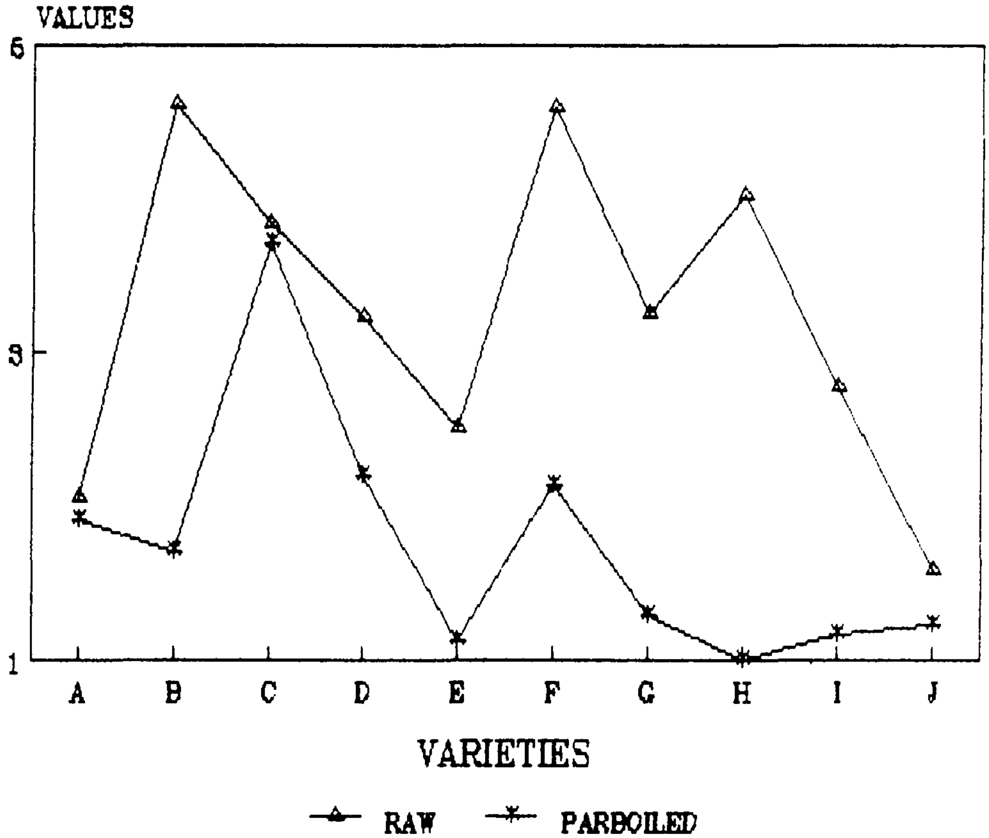
The loss of carbohydrates, principally starch and non-starch polysaccharides and lipids through the gruel is termed as gruel loss. Gruel loss is an important cooking characteristic of rice (Table 5).

As evident from the Fig. 3, more gruel loss was experienced from raw rice when compared to parboiled rice since starch is already gelatinized in parboiled rice. This study is in line with the findings of Rajalakshmi (1984), Sreedevi (1989) and Nandini and Prema (1997).

There was a significant difference among the varieties with respect to gruel loss. Among the ten pre-release rice cultures, the percentage of gruel loss was found to be highest in IET-6661 (3.77 per cent). Higher the gruel loss, greater will be the nutrient loss. So the variety' which has lower gruel loss is nutritionally superior. In the present study, least gruel loss was observed for the variety M-57-18-1-1 (1.41 per cent). The present study also revealed a significant interaction effects between varieties and processing.

Volume expansion or kernel expansion is determined from the ratio between the cooked volume of rice to that of

FIG. 3. EFFECT OF PARBOILING ON GRUEL LOSS OF RICE VARIETIES



A : Cul 87117

B : Cul 87136

C : IET 6661

D : Mo-1-20-19-4

E : M-38-4-1

F : M-38-4-2

G : M-42-6-3

H : M-45-20-1

I : M-57-9-1-1

J : M-57-18-1-1

uncooked rice. A comparison of the ten rice varieties revealed significant change in volume expansion among the different rice varieties (Table 6). The variety M-38-4-1 (6.40) have a significantly higher volume expansion ratio when compared to other varieties. The lowest value for volume expansion was observed for the variety M-57-18-1-1 (4.68). Gupta (1990) found that the volume expansion of fifteen rice varieties of West Bengal ranged between 3.81-5.45. Higher volume expansion after cooking is a desirable trait preferred by consumers.

A significant increase in volume expansion was observed, when rice varieties were parboiled. This may be due to loosened husk and other factors related to changes brought about during the parboiling operations. The mean value of volume expansion of parboiled rice varieties were 5.64, While that of raw rice varieties were 5.04.

Water uptake is a measure of the hydration characteristics of rice, which may be influenced by factors such as gelatinization temperature and porosity of the kernel. (Bandyopadhyay and Roy, 1992). Higher water uptake is an indicator of better cooking quality of rice. Juliano (1979) had observed that some of the properties of the rice were closely related to other qualities of rice such as volume expansion, water absorption and resistance to disintegration of milled rice during cooking.

Table 6 Volume expansion and water uptake of rice varieties

Sl. No.	Varieties	Volume expansion (ratio)			Water uptake (ratio)		
		Raw	Parboiled	Mean	Raw	Parboiled	Mean
1	Cul-87117	5.26	5.59	5.42	3.53	3.78	3.65
2	Cul-87136	5.37	6.00	5.68	4.03	4.60	4.31
3	IET-6661	4.74	4.82	4.78	3.46	3.64	3.55
4	MO-1-20-19-4	4.23	6.41	5.32	3.43	4.13	3.78
5	M-38-4-1	6.30	6.50	6.40	3.41	3.53	3.47
6	M-38-4-2	4.51	5.70	5.11	3.56	3.86	3.71
7	M-42-6-3	4.80	5.23	5.02	3.45	4.16	3.81
8	M-45-20-1	5.78	6.03	5.91	3.53	3.76	3.65
9	M-57-9-1-1	5.00	5.26	5.13	3.66	4.26	3.96
10	M-57-18-1-1	4.45	4.90	4.68	3.36	3.76	3.56
	Mean	5.04	5.64		3.54	3.95	
CD values							
Varities			0.022			0.102	
Processing			0.010			0.046	
Variety x Processing			0.031			0.145	

It was evident from Table 6 that the water uptake ratios of rice varieties were significantly different. Among the rice varieties, Cul-87136 possessed higher water uptake ratio (4.31) and the variety M-38-4-1 (3.47) had the lowest.

Compared to raw rice varieties, parboiled rice of the same varieties have a significantly higher value for water uptake ratio. The mean value of water uptake ratio of raw rice varieties were 3.54, while that of parboiled rice varieties were 3.95. Parboiling changes the absorptive capacity of rice and radically alters the hydration characteristics. Thus parboiled rice samples were found to absorb a higher amount of water during cooking. Similar results were also reported by Neelofer (1992).

Pillaiyar and Mohandoss (1981c) had reported that the cooking characteristics of parboiled rice were influenced by hydration behaviour of rice at temperatures above and below the gelatinization point. The interaction between the varieties and processing methods was also found to be significant.

The gelatinization temperature of starch is the range of temperature, within which the starch starts to swell irreversibly in hot water with simultaneous loss of crystallinity (Govindaswamy, 1985).

A significant difference was observed in the gelatinization temperature among the different rice varieties (Table 7). As revealed from the table the highest value for gelatinization temperature was observed for the variety IET-6661 (86.58°C) and the lowest for M-38-4-1 (76.16°C) which was found to be on par with the variety MO-1-20-19-4 (76.66°C) when statistically analysed.

The gelatinization temperature of raw rice varieties were found to be ranging from 73.33-85.33°C and that of parboiled rice varieties were 78-88.16°C. There was a significant difference between raw and parboiled rice varieties. A significantly higher gelatinization temperature was seen in parboiled rice samples when compared to raw rice samples. Earlier studies indicated that gelatinization temperature is related to the texture of cooked rice (IRRI, 1977) and processing of rice varieties were found to influence positively the gelatinization temperature. Similar findings were also reported by Ali and Bhattacharya (1980) and Nandini (1995). The interaction between different rice varieties and processing method was also found to be significant.

Viscosity is a measure of the resistance of a fluid to shear forces and hence to flow (Anon, 1991). A significant variation in the viscosity was observed among different varieties of rice as given in Table 7. The viscosity ranged between 1.98-3.05 Nsm^{-2} in raw rice samples and 2.11-3.10 Nsm^{-2} in parboiled rice samples. The highest viscosity was noticed in the variety M-38-4-2 (3.08 Nsm^{-2}) and the lowest in M-57-9-1-1 (2.04 Nsm^{-2}).

The viscosity was found to increase significantly in the parboiled rice samples. This might be due to a decrease in fluidity consequent to the dissolution of cooked starch in cooking water. Similar results were also reported by Nandini (1995).

Table 7 Gelatinization temperature and viscosity of rice varieties

Sl. No.	Varieties	Gelatinization temperature (°C)			Viscosity (NSm^{-2})		
		Raw	Parboiled	Mean	Raw	Parboiled	Mean
1	Cul-87117	78.16	79.66	78.91	2.70	2.79	2.74
2	Cul-87136	76.33	79.00	77.66	2.11	2.15	2.13
3	IET-6661	85.33	87.83	86.58	2.84	2.90	2.87
4	MO-1-20-19-4	75.33	78.00	76.66	2.50	2.67	2.58
5	M-38-4-1	73.33	79.00	76.16	2.74	2.85	2.79
6	M-38-4-2	82.66	88.16	85.41	3.05	3.10	3.08
7	M-42-6-3	79.33	82.00	80.66	2.90	2.94	2.92
8	M-45-20-1	80.33	82.00	81.16	2.82	2.88	2.85
9	M-57-9-1-1	80.33	84.00	82.16	1.98	2.11	2.04
10	M-57-18-1-1	76.00	79.33	77.66	2.64	2.70	2.67
	Mean	78.71	81.90		2.63	2.71	

CD values

	Gelatinization temperature	Viscosity
Varities	0.807	0.009
Processing	0.361	0.004
Variety x Processing	0.141	0.010

Amylose is the linear component of rice starch and is highly correlated to the texture of cooked rice as well as to eating quality. Cooked rice with high amylose is dry and fluffy, while rice with low amylose is sticky and moist. Consumers in general prefer rice which on cooking elongate appreciably without breaking and are not sticky.

In the present study the amylose content varied significantly among varieties (Table 8). The highest amylose content (32.07 per cent) was noticed in the variety M-38-4-2 while the lowest (18.11 per cent) in M-57-18-1-1.

Table 8 Amylose and Amylose - Amylopectin ratio of rice varieties

Sl. No.	Varieties	Amylose (per cent)			Amylose-Amylopectin ratio		
		Raw	Parboiled	Mean	Raw	Parboiled	Mean
1	Cul-87117	21.73	20.33	21.03	0.40	0.41	0.40
2	Cul-87136	28.56	28.00	28.28	0.51	0.59	0.55
3	IET-6661	19.34	18.23	18.78	0.33	0.36	0.34
4	MO-1-20-19-4	28.03	25.05	26.54	0.68	0.61	0.64
5	M-38-4-1	29.14	24.46	26.80	0.57	0.52	0.54
6	M-38-4-2	32.49	31.65	32.07	0.66	0.71	0.68
7	M-42-6-3	22.43	21.29	21.86	0.36	0.37	0.37
8	M-45-20-1	23.16	22.70	22.93	0.39	0.42	0.40
9	M-57-9-1-1	28.06	23.76	25.91	0.53	0.54	0.53
10	M-57-18-1-1	18.75	17.46	18.11	0.29	0.30	0.29
	Mean	25.17	23.29		0.47	0.48	

CD values		
Varities	0.064	0.004
Processing	0.028	0.001
Variety x Processing	0.090	0.006

Based on total amylose content Juliano (1970) has classified the rice into four categories. viz.

Waxy rice	-	Amylose content 1-2 per cent
Low amylose rice	-	Amylose content 8-20 per cent
Intermediate amylose rice	-	Amylose content 21-25 per cent
High amylose rice	-	Amylose content more than 25 per cent

Consumers prefer a rice grain with intermediate amylose content. Among the ten varieties studied, three varieties viz. Cul-87117 (21.03 per cent) M-42-6-3 (21.86 per cent) and M-45-20-1 (22.93 per cent) belonged to the group of intermediate amylose rice. Two varieties viz. IET-6661 (21.03), M-57-18-1-1 (18.71) belonged to the low amylose rice and the rest five varieties were grouped under high amylose rice. None of the varieties were found to be waxy. High amylose content results in dry and fluffy rice after cooking, while glutinous or waxy rice becomes very sticky on cooking.

A significant decrease in amylose content was observed after parboiling. This might be due to the loss of gluten into the gruel. Negative effect of parboiling on amylose content was also reported by Sreedevi (1989) and Nandini (1995). The mean value of amylose content among the raw rice varieties were 25.17 per cent and that of parboiled rice varieties were 23.29 per cent. The data when analysed statistically revealed a significant interaction effects between variety and processing with respect to amylose content. (Appendix-4a).

Amylopectin is the major starch constituent and is the only starch fraction of waxy (glutinous) rice. (Schoch, 1967). The author also reported that the ratio of amylose to amylopectin in starch is characteristic of the plant species and hence genetically controlled.

The amylose - amylopectin ratio varied significantly among different rice varieties (Table 8). The highest ratio was found for the variety M-38-4-2 (0.68) and the lowest value for the variety M-57-18-1-1 (0.29).

In raw rice, the amylose-amylo pectin ratio ranged between 0.29-0.68 while in parboiled rice, it was between 0.30-0.71. There was a slight but significant increase in the amylose-amylo pectin ratio after parboiling. The variation in the ratio among the varieties and parboiling methods might be due to variation in the total starch and total amylose content. Similar findings were also reported by Ali and Bhattacharya (1976) and Nandini (1995).

Elongation ratio is the ratio between the length of cooked grain and that of the raw grain. Higher values in elongation ratio of cooked rice is a positive and desirable character.

A significant varietal variation was observed in the elongation ratio of different rice varieties (Table 9). In a study conducted by Gupta (1990) revealed that the elongation ratio ranged between 1.22-1.74. In the present study, the highest elongation ratio was possessed by the variety M-57-9-1-1 (1.98) and lowest by the variety M-42-6-3 (1.49).

Table 9 Elongation ratio and Elongation Index of rice varieties

Sl. No.	Varieties	Elongation ratio			Elongation index		
		Raw	Parboiled	Mean	Raw	Parboiled	Mean
1	Cul-87117	1.34	1.83	1.58	0.90	1.25	1.08
2	Cul-87136	1.82	1.91	1.86	1.60	1.56	1.58
3	IET-6661	1.70	2.01	1.85	1.34	1.42	1.38
4	MO-1-20-19-4	1.86	1.83	1.84	1.14	1.10	1.12
5	M-38-4-1	1.60	1.82	1.71	1.10	1.38	1.24
6	M-38-4-2	1.66	1.69	1.68	1.20	1.35	1.28
7	M-42-6-3	1.32	1.66	1.49	1.00	1.12	1.06
8	M-45-20-1	1.41	1.92	1.66	1.00	1.21	1.10
9	M-57-9-1-1	2.02	1.94	1.98	1.04	1.10	1.07
10	M-57-18-1-1	1.44	1.89	1.67	1.20	1.42	1.31
	Mean	1.62	1.85	1.16	1.15	1.29	

CD values

Varities	0.102	0.07
Processing	0.045	0.03
Variety x Processing	0.144	0.01

Parboiling significantly increased the elongation ratio. The elongation ratio of parboiled rice varieties ranged from 1.66-2.01 and that of raw rice varieties ranged from 1.32-2.02. The interaction between different rice varieties and processing methods were also found to be significant.

Chinnaswamy and Bhattacharya (1983) reported that, raw and mildy parboiled rice gave minimum expansion, which increases with increasing severity of parboiling. An increase in length during cooking is a desired character in determining the quality of rice. Similar observations were also reported from IRRI (1986) in the case of Basmati 370 variety, a well known rice variety.

Elongation index is the ratio between the length and width of cooked grain and that of uncooked grain. It is related to grain dimension. The elongation index will give a measure of the percentage increase in grain dimension after cooking.

As revealed in Table 9, the elongation index of the rice varieties varied significantly. The highest value for elongation index was seen in the variety Cul-87136 (1.58) and the lowest value in M-42-6-3 (1.06) (Appendix-4b).

There was a significant increase in the elongation index as a result of parboiling. This might be due to short and plump appearance of the grains. Similar trends in the results were also observed by Mahadevappa and Desikachar (1968) and Nandini (1995).

A good quality rice grain is expected to give lower values for optimum cooking time, gruel loss, gelatinization temperature and viscosity and higher values for water uptake, volume expansion, elongation ratio and elongation index.

A comparison among the ten pre-release rice cultures with respect to different cooking characteristics revealed that Cul-87136 and M-45-20-1 satisfied the above requirements for volume expansion and water uptake ratio while with respect to elongation ratio and elongation index, Cul-87136 and IET-6661 have favourable values. In brief, Cul-87136 is found to have favourable values for all the cooking charateristics mentioned earlier.

4.3 Nutritional composition

The calorific value, protein, starch, fibre, phosphorus, calcium and iron content of the rice cultures were determined to assess their nutritional composition (Appendix-5).

Calorific value

Rice contributes about 70 per cent of the dietary energy of the people of Kerala. Rice is important, because it has the highest digestibility, biological value and protein efficiency ratio among all the cereals (Juliano, 1985b).

The calorific value of ten pre-release rice cultivars were found to vary significantly (Table 10). The variety M-38-4-1 was found to have highest calorific value (350.06 Kcal). Among the ten pre-release rice varieties the variety M-57-18-1-1 had the lowest value (339.43 Kcal). All the rice samples were found to have higher calorific values after parboiling (Fig. 4). During parboiling, the brown outer layer (scutellum and germ) adheres to the grain and most of the nutrients in it are driven into the interior of the grain. An increase in calorific value due to parboiling was also reported by Rajalakshmi (1984), Sreedevi (1989) and Nandini *et al*. (1996). The mean calorific value of different raw rice varieties were 341.35 Kcal and that of parboiled rice varieties were 346.91 Kcal. The data statistically revealed that a significant interaction effects between varieties and processing with respect to calorific value.

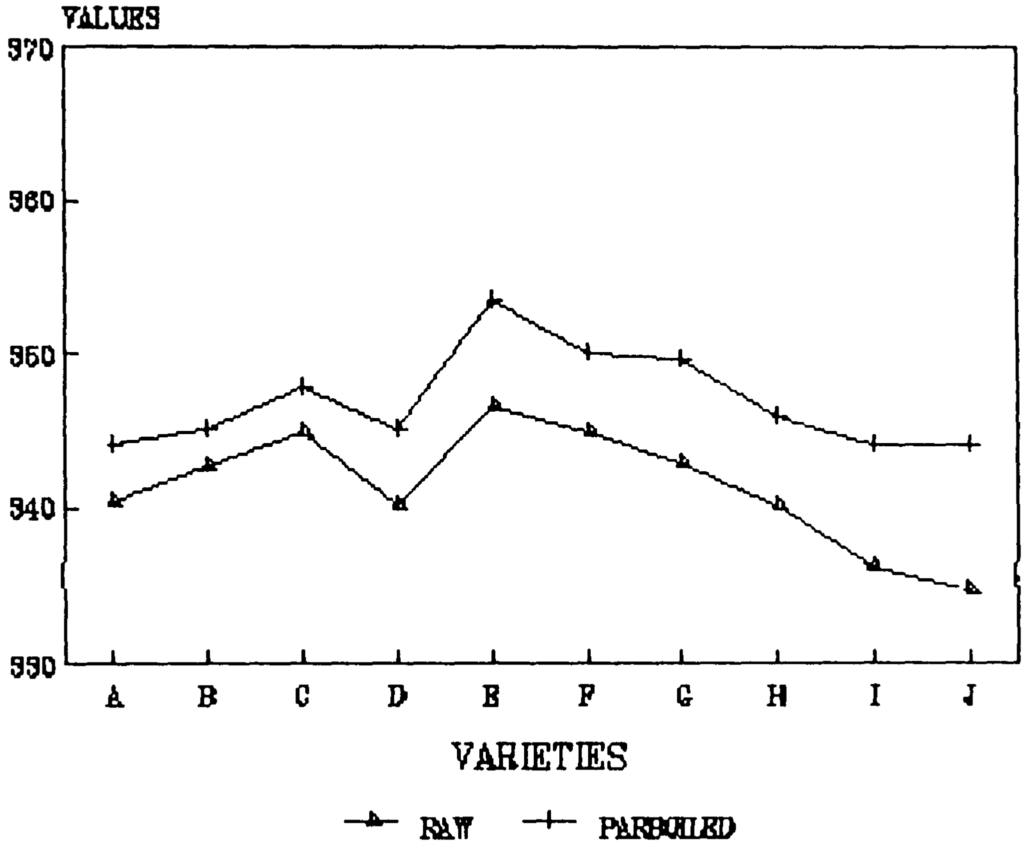
Rice is considered to be a major source of dietary protein in Indian diets. As reported by Bhat and Rani (1982) the protein content of high yielding rice varieties evolved by Haryana Agricultural University ranged from 6.88 to 7.43g/100g.

Table 10 Energy and Protein content of rice varieties

Sl. No.	Varieties	Energy (kcal)			Protein (g/100g)		
		Raw	Parboiled	Mean	Raw	Parboiled	Mean
1	Cul-87117	340.26	344.10	342.18	9.15	8.91	9.03
2	Cul-87136	342.63	345.00	343.81	8.95	8.75	8.85
3	IET-6661	344.83	347.83	346.33	9.31	9.07	9.19
4	MO-1-20-19-4	340.10	345.16	342.63	9.24	8.99	9.12
5	M-38-4-1	346.60	353.53	350.06	9.49	9.32	9.41
6	M-38-4-2	344.98	350.06	347.52	10.31	9.99	10.15
7	M-42-6-3	342.83	349.56	346.20	9.82	9.66	9.74
8	M-45-20-1	340.16	345.83	343.00	9.58	9.49	9.53
9	M-57-9-1-1	336.33	344.06	340.19	9.02	8.83	8.92
10	M-57-18-1-1	334.83	344.03	339.43	8.91	8.75	8.83
	Mean	341.35	346.91		9.38	9.17	
CD values							
Variety			0.319			0.007	
Processing			0.142			0.003	
Variety x Processing			0.451			0.009	

But in the present study, the protein content of rice varieties evolved by KAU was in the range of 8.83 to 10.15 g/100g (Table 10). The protein content of rice varied much with cultural practices. High solar radiation during grain development generally reduced protein content (Resurrection *et al*., 1977). Split application of nitrogen was reported to increase the protein content (Swaminathan, 1971 and Sikka *et al*., 1993).

FIG. 4. EFFECT OF PARBOILING ON ENERGY CONTENT OF RICE VARIETIES



A	:	Cul 87117	F	:	M-38-4-2
B	:	Cul 87136	G	:	M-42-6-3
C	:	IET 6661	H	:	M-45-20-1
D	:	Mo-1-20-19-4	I	:	M-57-9-1-1
E	:	M-38-4-1	J	:	M-57-18-1-1

As represented in the table, the highest protein content was observed in the variety M-38-4-2 (10.15 g/100g) and the lowest in M-57-18-1-1 (8.83 g/100g).

In the study, it was noticed that parboiling resulted in a decrease in the protein content of rice varieties. The decrease in protein content of parboiled rice might be due to the decrease in the total free amino acid content or leaching out of non-protein nitrogen and albumin during the process of parboiling. Similar indications were observed by schroeder (1965); Subramanian and Dakshinamoorthy (1977) and Nandini (1995).

Starch content of the rice varieties are presented in Table 11. The highest value for starch content was recorded in the variety M-42-6-3 (81.01 per cent) and the lowest in Cul-87117 (72.26 per cent). In raw rice varieties, starch content ranged between 75.16 - 84.26 per cent and in parboiled rice it was between 65.83 - 77.76 per cent.

Parboiling reduced the percentage starch content of rice varieties. All the parboiled rice varieties had lesser value for starch content, when compared to raw rice samples. During parboiling, starch granules are gelatinized and squeezed together making the endosperm hard and compact. Similar results were also reported by Kuzimina and Torzhinskaya (1973); Sreedevi (1989) and Nandini (1995).

Ali and Bhattacharya (1980) had stated that the total starch content was unaltered in parboiling, but the soluble amylose content was increased depending upon the severity of parboiling. The interaction between the varieties and processing was also found to be significant with respect to starch content.

Crude fibre is a mixture of substances, which make up the frame work of plants and is composed of cellulose, hemicellulose and lignin of the cell walls. Rice is reported to be a moderate source of fibre (Table 11).

In the present study, the fibre content ranged from 0.245-0.420 per cent and it was observed that there was a significant difference between the varieties.

Among the raw rice varieties the fibre content was highest in the variety M-38-4-2 (0.42 per cent). In the case of parboiled rice varieties, the same variety also showed the highest percentage of fibre content. Statistical analysis observed that parboiling significantly influenced the fibre content.

Table 11 Starch and fibre content of rice varieties

Sl. No.	Varieties	Starch (Percentage)			Fibre (Percentage)		
		Raw	Parboiled	Mean	Raw	Parboiled	Mean
1	Cul-87117	75.16	69.36	72.26	0.25	0.26	0.25
2	Cul-87136	84.03	75.00	79.51	0.24	0.25	0.25
3	IET-6661	77.76	68.46	73.11	0.27	0.28	0.28
4	MO-1-20-19-4	68.53	65.83	67.18	0.27	0.29	0.28
5	M-38-4-1	80.03	71.53	75.78	0.30	0.31	0.31
6	M-38-4-2	81.46	75.73	78.60	0.42	0.42	0.42
7	M-42-6-3	84.26	77.76	81.01	0.30	0.31	0.31
8	M-45-20-1	81.53	76.73	79.13	0.32	0.34	0.33
9	M-57-9-1-1	80.10	67.76	73.93	0.29	0.29	0.29
10	M-57-18-1-1	81.50	75.63	79.06	0.29	0.30	0.29
	Mean	79.44	72.48		0.29	0.31	
CD values							
Variety			0.097			0.010	
Processing			0.043			0.004	
Variety x Processing			0.138			0.014	

The phosphorus content of pre-release rice cultures varied from 127.47-142.50 mg/100g (Table 12). The assessment of phosphorus content of the rice cultures after parboiling indicated a significant increase in phosphorus content after parboiling when compared to raw rice. This is because of the diffusion of minerals from the outer layers into the endosperm and spreading and redistribution among the various parts during soaking and steaming of the grain.

In the case of parboiled samples a highest value of 151.66 mg/100g was observed in the variety M-38-4-2 and the lowest value of 136.50 mg/100g in variety M-57-18-1-1. Studies conducted by Pillaiyar (1988), Bandyopadhyay and Roy (1992) and Nandini (1995) had also indicated the influence of parboiling on phosphorus content on similar lines. When the data was statistically analysed, the interaction between variety and processing methods were found to be significant with respect to phosphorus content.

Iron content was found to be significantly different between the varieties. The highest iron content was observed in the variety M-38-4-2 (3.425 mg/100g) and the lowest in variety IET-6661 (2.77 mg/100g) (Table 12). A significant increase in iron content was noticed after parboiling.

A significant difference in the calcium content was observed among the different rice varieties. The highest calcium content (12.66 mg/100g) was noticed in the culture M-38-4-2 (Table 12). The lowest calcium content was observed in the variety Cul-87117 (8.66 mg/100g).

Table 12 Phosphorus, iron and calcium content of rice varieties

Sl. No.	Varieties	Phosphorus (mg/100g)			Iron (mg/100g)			Calcium (mg/100g)		
		Raw	Parboilled	Mean	Raw	Parboiled	Mean	Raw	Parboiled	Mean
1	Cul-87117	123.37	141.55	132.46	2.63	2.78	2.71	8.16	9.16	8.66
2	Cul-87136	125.16	143.37	134.26	2.71	3.03	2.87	9.23	10.26	9.75
3	IET-6661	119.99	140.32	130.16	2.67	2.88	2.78	9.60	10.33	9.96
4	MO-1-20-19-4	120.83	146.58	133.70	3.26	3.34	3.30	10.60	10.93	10.76
5	M-38-4-1	116.58	138.37	127.47	3.21	3.36	3.29	11.26	10.53	10.90
6	M-38-4-2	133.36	151.66	142.51	3.40	3.44	3.43	12.43	12.90	12.66
7	M-42-6-3	124.83	145.06	134.94	3.07	3.21	3.14	10.10	10.26	10.18
8	M-45-20-1	121.65	143.40	132.52	3.01	3.12	3.07	10.26	10.60	10.43
9	M-57-9-1-1	119.71	136.50	128.10	3.16	3.25	3.21	8.26	9.20	8.73
10	M-57-18-1-1	121.50	140.49	130.99	2.66	2.92	2.79	8.53	9.56	9.05
	Mean	122.70	142.73		2.98	3.14		9.84	10.37	
CD values										
Variety			0.368			0.023			0.169	
Processing			0.165			0.010			0.075	
Variety x Processing			0.521			0.033			0.240	

Parboiling significantly increased the calcium content of the rice varieties. The mean value of calcium content for raw rice varieties were 9.84 mg and that of parboiled rice varieties were 10.37 mg. Lower calcium content in raw rice when compared to parboiled rice may be due to removal of the outer layers which constitute approximately five per cent of the whole kernel by weight.

According to Ocker *et al.* (1976) the severity of steaming in parboiling greatly influenced the mineral distribution in parboiled rice. Steaming increased the calcium content of the treated milled rice samples compared with that of the raw milled rice. Similar results was also observed by Nandini (1995).

During parboiling, mineral elements migrated deeper into the grain, resulting in a greater retention of these nutrients in the parboiled grain. This confirms with the results of Doesthale (1979) and Damir (1985).

4.4 Organoleptic characteristics

The eating quality of rice is usually judged by the sensory evaluation, which seems unscientific and variable according to personal preference (Lii and Chang, 1986).

Quality attributes selected in this study were colour, appearance, flavour, texture and taste. The attributes such as appearance, tenderness and flavour of cooked rice are the final criteria of cooking quality and determine the palatability or eating characteristics of cooked rice.

A significant difference was observed in the mean scores obtained for different varieties of rice for the quality attribute namely appearance (Table 13). Among the ten pre-release rice cultivars, variety M-38-4-2 had obtained highest score for appearance (4.45), while M-57-18-1-1 had obtained the lowest (2.5).

There was significant difference in the mean scores obtained for appearance for each variety, when processed by raw and parboiled methods. Raw rice varieties have higher scores when compared to parboiled rice varieties and this may be due to the shape of the raw rice varieties. Most of the raw rice varieties were bold medium grain rice, while all the parboiled varieties were round short grain rice, which were not acceptable as bold type. The interaction between the varieties and methods were not found to be significant with respect to 'appearance'.

A significant difference was observed in the mean scores obtained for the quality attribute 'colour' (Table 13). Among the ten pre-release rice cultures, variety M-38-4-2 had obtained highest score (4.40) for colour, while the variety M-57-18-1-1 had obtained the lowest (2.35).

Table 13 Appearance and colour of the rice varieties

Sl. No.	Varieties	Appearance Raw	Appearance Parboiled	Appearance Mean	Colour Raw	Colour Parboiled	Colour Mean
1	Cul-87117	2.70	2.60	2.65	3.10	2.70	2.90
2	Cul-87136	2.50	2.60	2.55	2.90	2.40	2.65
3	IET-6661	2.80	3.00	2.90	3.50	3.30	3.40
4	MO-1-20-19-4	2.60	2.10	2.35	3.00	2.80	2.90
5	M-38-4-1	3.30	3.00	3.15	3.20	3.40	3.30
6	M-38-4-2	4.70	4.20	4.45	4.50	4.30	4.40
7	M-42-6-3	4.20	4.00	4.10	4.00	3.80	3.90
8	M-45-20-1	3.80	3.70	3.75	3.40	3.10	3.25
9	M-57-9-1-1	2.80	2.50	2.65	2.60	2.40	2.50
10	M-57-18-1-1	2.60	2.40	2.50	2.40	2.30	2.35
	Mean	3.20	3.00		3.26	3.05	

Mean scores

CD values

	Appearance	Colour
Variety	0.340	0.431
Processing	0.152	0.193
Variety x Processing	0.481	0.610

The colour preference was found to be significantly affected by the parboiling method. In the present study, preference was shown for the colour of raw rice samples when compared to parboiled samples. Lesser acceptability of parboiled rice may be due to the fact that the absorbed water during parboiling dissolves the colouring pigments in the hull and the heat applied during parboiling process drives away the pigments inwards to the endosperm, which imparts a darker colour to the grain. Similar findings were also reported by Gariboldi (1974). The mean score obtained for colour of raw rice varieties were 3.26, and that of parboiled rice varieties were 3.05.

Table 14 Flavour and texture of rice varieties

Sl. No.	Varieties	Mean scores: Flavour Raw	Flavour Parboiled	Flavour Mean	Texture Raw	Texture Parboiled	Texture Mean
1	Cul-87117	2.40	2.80	2.60	2.80	2.60	2.70
2	Cul-87136	2.20	2.50	2.35	2.40	1.90	2.15
3	IET-6661	2.50	2.90	2.70	3.40	3.20	3.30
4	MO-1-20-19-4	2.50	2.80	2.65	3.00	2.80	2.90
5	M-38-4-1	2.60	2.70	2.65	3.00	3.00	3.00
6	M-38-4-2	4.10	4.50	4.30	4.00	3.80	3.90
7	M-42-6-3	3.70	4.20	3.95	3.60	3.50	3.55
8	M-45-20-1	3.50	3.60	3.55	3.40	3.30	3.35
9	M-57-9-1-1	2.20	2.70	2.45	2.50	2.30	2.40
10	M-57-18-1-1	1.80	2.00	1.90	2.40	2.20	2.30
	Mean	2.75	3.07		3.05	2.86	

CD values

	Flavour	Texture
Varities	0.460	0.390
Processing	0.200	0.173
Variety x Processing	0.640	0.550

There was a significant difference among the different rice varieties for the quality attribute 'flavour' (Table 14). As in the cases of appearance and colour, the highest score for flavour was also obtained for the variety M-38-4-2 (4.3) and the lowest score for the variety M-57-18-1-1 (1.9).

The flavour of the different rice varieties were found to be significantly influenced by parboiling method. The mean score obtained for 'flavour' of raw rice varieties were 2.75 and that of parboiled rice varieties were 3.07. Flavour preference was in general, higher for rice varieties processed by parboiling.

Parboiled rice has a characteristic flavour compared to raw rice. This may be the reason for the increased acceptability of parboiled rice. According to Bandyopadhyay and Roy (1992) the flavour of the parboiled product is the result of hydrolysis and decomposition of certain constitutents such as carbohydrates, proteins, under the influence of steam at high temperature during parboiling. They also reported that the secondary products responsible for the characteristic flavour are proteins consisting of the sulphur containing amino acids, which produce sulphurous compound (mercaptans) having a characteristic flavour and aroma.

The mean scores obtained for texture of the cooked rice, vary significantly in pre-release rice cultures as represented in Table 15. Highest score was obtained for the variety M-38-4-2 (3.90) whereas the varieties Cul-87136 and M-57-18-1-1 were slightly sticky and had lowest mean score. There was a significant variation between the texture of raw and parboiled rice varieties. Parboiled rice samples had obtained lower scores when compared to raw rice samples.

According to Juliano (1970) amylose content mainly determines the texture of cooked rice. In the present study, amylose content of raw rice varieties were higher when compared to parboiled rice varieties. This may be the reason for the lowest score observed in the texture of parboiled rice.

Among the various quality attributes, taste is the primary and most important one. Significant differences were noticed among the rice varieties for the quality attribute 'taste' (Table 16). Among the ten varieties, highest mean score was obtained for the variety M-38-4-2 (4.0) and lowest score for the variety M-57-18-1-1 (2.05) which was statistically on par with the variety M-57-9-1-1 (2.30) with respect to taste.

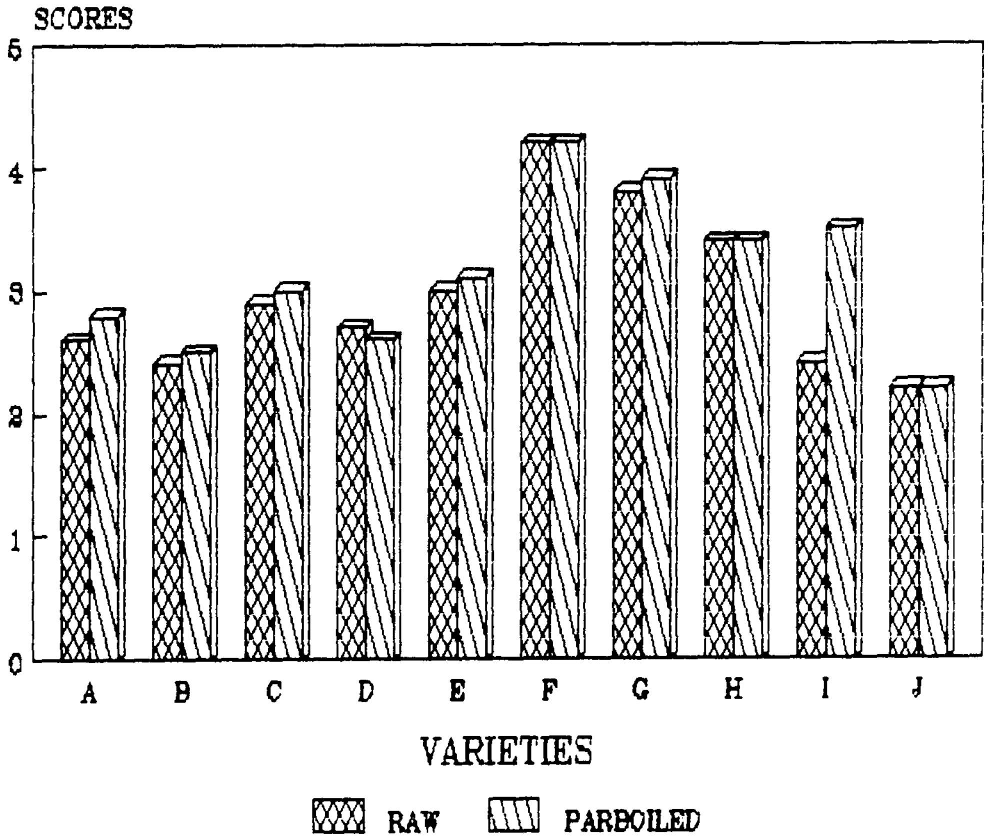
Parboiled rice has a characteristic taste and aroma, which is mostly accepted by Keralites compared with other states of India. The taste of rice samples were found to be improved as a result of parboiling. When compared to raw rice, a significantly higher value was obtained for parboiled rice. Similar results were also reported by Sreedevi (1989).

The overall acceptability of different rice varieties were significantly different. The variety M-38-4-2, was found to be the most acceptable rice with a maximum score of 4.20, followed by the variety M-42-6-3 (3.86) (Table 15 and Fig. 5).

Table 15 Taste and overall acceptability of rice varieties

Sl. No.	Varietties	Mean scores					
		Taste			Overall acceptability		
		Raw	Parboiled	Mean	Raw	Parboiled	Mean
1	Cul-87117	2.20	3.10	2.65	2.60	2.80	2.70
2	Cul-87136	2.10	2.90	2.50	2.40	2.50	2.45
3	IET-6661	2.40	2.60	2.50	2.90	3.00	2.95
4	MO-1-20-19-4	2.60	2.70	2.65	2.70	2.60	2.65
5	M-38-4-1	3.10	3.60	3.35	3.00	3.10	3.05
6	M-38-4-2	3.70	4.30	4.00	4.20	4.20	4.20
7	M-42-6-3	3.40	4.20	3.80	3.80	3.90	3.85
8	M-45-20-1	3.00	3.30	3.15	3.40	3.40	3.40
9	M-57-9-1-1	2.00	2.60	2.30	2.40	2.50	2.45
10	M-57-18-1-1	1.90	2.20	2.05	2.20	2.20	2.20
	Mean	2.64	3.15		2.98	3.02	
CD values							
Variety			0.410			1.000	
Processing			0.180			0.470	
Variety x Processing			0.580			1.490	

FIG. 5. OVERALL ACCEPTABILITY OF COOKED RICE (RAW AND PARBOILED)



A : Cul 87117

B : Cul 87136

C : IET 6661

D : Mo-1-20-19-4

E : M-38-4-1

F : M-38-4-2

G : M-42-6-3

H : M-45-20-1

I : M-57-9-1-1

J : M-57-18-1-1

There was no significant difference between the raw and parboiled rice varieties with respect to overall acceptability. It means that raw as well as parboiled rice were equally acceptable after cooking.

Salient findings

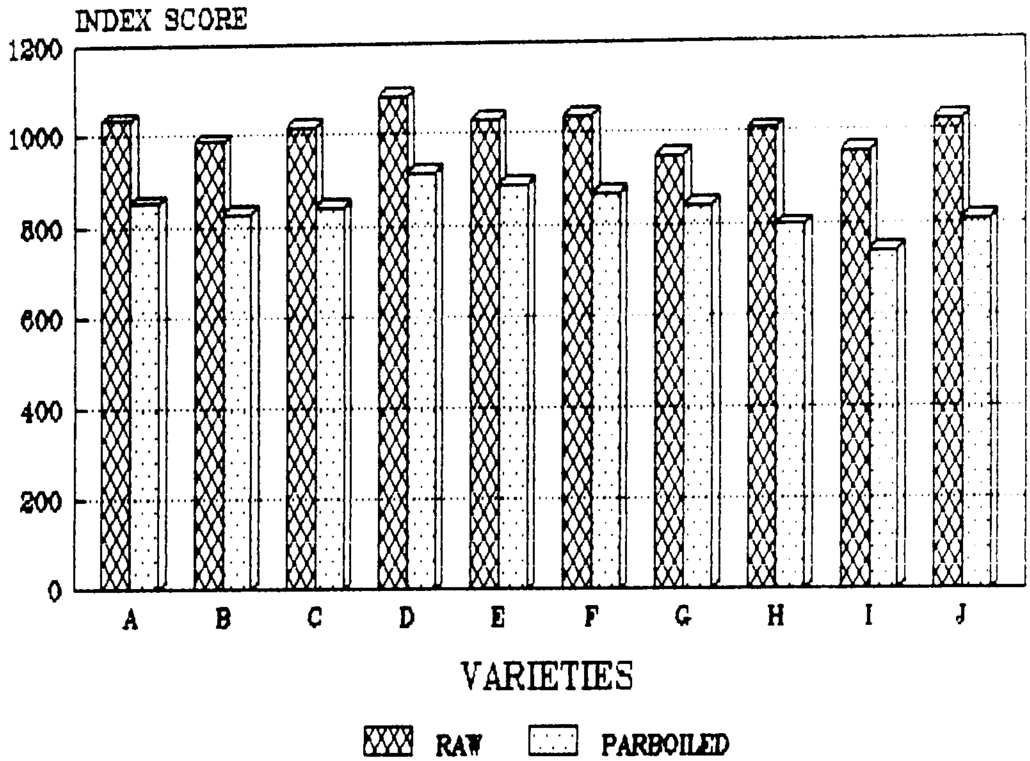
A general analysis of the scores obtained for various quality attributes revealed that appearance, colour and texture were the qualities for which raw rice varieties were scored higher when compared to parboiled rice whereas parboiled rice varieties were preferred most for their taste and flavour.

Among the ten pre-release rice cultures, the varieties M-38-4-2 and M-42-6-3 scored the highest value for all the five quality attributes, considered here. So these two varieties are considered as top scores with respect to eating qualities.

4.5 Selection of superior variety

The superior variety was selected based on physical, cooking, nutritional and organoleptic qualities of rice varieties (Table 16, Fig. 6).

FIG. 6. SELECTION OF SUPERIOR VARIETY BASED ON PHYSICAL COOKING NUTRITIONAL & ORGANOLEPTIC QUALITIES.



A : Cul 87117

B : Cul 87136

C : IET 6661

D : Mo-1-20-19-4

E : M-38-4-1

F : M-38-4-2

G : M-42-6-3

H : M-45-20-1

I : M-57-9-1-1

J : M-57-18-1-1

Table 16 Selection of superior variety based on physical, cooking, nutritional and organoleptic qualities

Sl. No.	Varieties	Index score	
		Raw rice	Parboiled rice
1	MO-1-20-19-4	1085.06 (1)	915.69 (1)
2	M-38-4-2	1039.31 (2)	865.99 (3)
3	Cul-87117	1035.06 (3)	848.68 (4)
4	M-38-4-1	1030.29 (4)	888.04 (2)
5	M-57-18-1-1	1026.00 (5)	805.22 (8)
6	IET-6661	1018.22 (6)	837.26 (6)
7	M-45-20-1	1007.28 (7)	795.10 (9)
8	Cul-87136	986.88 (8)	826.28 (7)
9	M-57-9-1-1	957.05 (9)	736.73 (10)
10	M-42-6-3	947.78 (10)	840.44 (5)

(Numbers in paranthesis indicate rank order)

Variety MO-1-20-19-4 was found to be the superior variety of rice both in raw (1085.06) and in parboiled (915.69) form. The varieties M-38-4-2, Cul-87117 and M-38-4-1 assumed the next 3 ranks in both forms, with variation among themselves. Parboiling has favourably influenced the scores for M-38-4-1 while in the case of other two, the situation was different. Parboiling had similar negative effect on varieties like M-57-18-1-1, M-45-20-1 and M-57-9-1-1. The variety M-57-9-1-1 occupied the lowest rank in both the cases. In the case of variety M-42-6-3, there was a great shift in the ranks with respect to parboiled samples. This may be due to the significant variations in the quality parameters of this variety after parboiling. Parboiling had no significant effect on the variety IET-6661 in ranking.

SUMMARY

SUMMARY

The study on 'Quality analysis of pre-release rice cultivars' was conducted to assess the major quality parameters such as physical characteristics, cooking characteristics, nutritional composition and organoleptic characteristics and also the effect of parboiling on the above characteristics. Ten pre-release rice cultivars procured from Rice Research Station of Kerala Agricultural University located at Moncompu and Pattambi were selected for the study and the results are summarised below.

The physical characteristics studied were colour, size, shape, length, width, L/B ratio, thousand grain weight, head rice yield and moisture content.

1. All the rice varieties were found to have red colour except for the varieties viz: Cul-87136 and IET-6661, which were white in colour.

2. The shape of Cul-87117 and M-42-6-3 were bold and medium. All the other varieties were round grain rice.

3. The length and width of rice varieties were found to be higher in Cul-87117. Parboiling had a significant negative effect on length, and have no effect on width of different rice varieties.

4. L/B ratio was found to be decreased in all the parboiled rice samples when compared to raw rice. Grain dimension ratio was highest for the variety M-42-6-3 and lowest for M-57-18-1-1.

5. Thousand grain weight was recorded highest for the culture M-45-20-1. Parboiled samples had a significantly higher thousand grain weight compared to raw samples.

6. Lowest moisture content was observed in variety M-38-4-2. Parboiling had a negative effect on moisture content.

7. The highest percentage of head rice yield was observed for the variety M-57-18-1-1. Head rice yield of parboiled rice samples were significantly higher when compared to that of raw rice samples.

The important cooking characteristics studied were optimum cooking time, gruel loss, volume expansion, water uptake, gelatinization temperature, viscosity, amylose, amylose - amylopectin ratio, elongation ratio and elongation index.

8. Parboiling increased the optimum cooking time of rice varieties. The variety M-38-4-1 took less time, while the variety M-57-9-1-1 took maximum time to cook.

9. More gruel loss was experienced from raw rice when compared to parboiled rice. The variety which have less gruel loss is nutritionally superior and in the present study less gruel loss was observed for the variety M-57-18-1-1.

10. The variety M-38-4-1 had a significantly higher volume expansion ratio when compared to other varieties. Volume expansion was higher in parboiled rice compared to raw rice.

11. Higher water uptake is an indicator of better cooking quality and in the present study, Cul-87136 possessed higher water uptake ratio. Parboiling had a positive effect on water uptake.

12. The highest gelatinization temperature was found in IET-6661. A significantly higher gelatinization temperature was observed in parboiled rice samples.

13. There was a significant increase in viscosity after parboiling. The highest viscosity was noticed in the variety M-38-4-2.

14. Consumers prefer a rice grain with intermediate amylose content and in the present study varities CUL-87117, M-45-20-1 and M-42-6-3 have intermediate amylose content. Parboiling had a significant negative effect on amylose content.

15. The highest amylose-amylopectin ratio was found in M-38-4-2. Amylose-amylopectin ratio was found to increase after parboiling.

16. Parboiling significantly increased the elongation ratio. The variety M-57-9-1-1 had the highest elongation ratio.

17. In the present study, culture Cul-87136 possessed the highest elongation index. There was a significant increase in the elongation index as a result of parboiling.

The nutritional composition of rice varieties were assessed by estimating calorific value, protein, crude fibre, starch, phosphorus, calcium and iron.

18. Calorific value was significantly increased by parboiling, and the variety M-38-4-1 had the highest calorific value.

19. Protein content was highest in M-38-4-2. There was a negative effect on protein content as a result of parboiling.

20. Parboiling had a negative effect on starch content. The highest starch content was observed for the variety M-42-6-3.

21. There was a slight difference between the raw and parboiled rice varieties with respect to fibre content. Parboiling significantly increased the fibre content.

22. The variety, M-38-4-2 had the highest iron, calcium and phosphorus content. Parboiling had a positive effect on the concentration of the above minerals.

A study was conducted on organoleptic qualities of cooked raw and parboiled rice, with the quality attributes of appearance, colour, flavour, texture and taste.

23. Variety M-38-4-2 had obtained highest score for all the five quality attributes mentioned above.

24. For 'appearance' raw rice varieties had higher scores when compared to parboiled rice.

25. The mean score obtained for 'colour' of raw rice varieties were higher when compared to parboiled rice.

26. The 'flavour' of different rice varieties were found to increase significantly by parboiling.

27. The 'texture' of raw rice varieties were good when compared to parboiled rice.

28. The 'taste' of rice samples were found to be improved as a result of parboiling.

29. There was no significant difference between the raw and parboiled samples with respect to overall acceptability. Variety M-38-4-2 was found to be the most acceptable rice in both the raw and parboiled forms.

30. Based on physical, cooking, nutritional and organoleptic qualities, discriminant function analysis was carried out, and it was found that variety MO-1-20-19-4 was the superior variety in raw and parboiled forms, followed by varieties like M-38-4-2, Cul-87117 and M-38-4-1. Variety M-57-9-1-1 was found to be comparatively the inferior variety in both the cases.

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* Originals not seen

APPENDICES

APPENDIX - 1

Specimen evaluation card for triangle test

Name : Date:

Product: 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 - 2

Specimen evaluation card for composite scoring test

Name :   Date:

Product: Time:

Assign scores for each sample for various characteristics

Quality attributes	Maximum score	1	2	3	4	5	6	7	8	9	10
Appearance	5										
Colour	5										
Flavour	5										
Texture	5										
Taste	5										
Total	25										
Comments											
Number of panel members selected	10										
Number of replications	2										

(Code No. of samples: 1–10)

(Signature)

APPENDIX - 3a

Physical characteristics of rice varieties

Abstract of ANOVA

Character	Variety (va)	Mean square processing method (Pr)	VaxPr	Error
DF	9	1	9	180
Length	3.214**	11.520**	1.097**	0.146
Width	0.905**	0.079	0.724**	0.065
L/B ratio	0.345**	1.167**	0.174**	0.043

** Denotes the significance of corresponding F at 1% level

APPENDIX - 3b

Physical characteristics of rice varieties

Abstract of ANOVA

Character	Variety (va)	Mean square processing method (Pr)	VaxPr	Error
DF	9	1	9	40
Thousand grain weight	2.602**	42.003**	3.365**	0.064
Head rice yield	314.612**	2479.93**	156.98**	0.050
Moisture	3.576**	38.593**	1.180**	0.042

** Denotes the significance of corresponding F at 1% level

APPENDIX - 4a

Cooking characteristics of rice varieties

Abstract of ANOVA

Character	Variety (va)	Mean square processing method (Pr)	VaxPr	Error
DF	9	1	9	40
Optimum cooking time	403.676**	2926.016**	113.053**	6.95
Volume expansion	1.681**	5.040**	0.607**	0.0003
Water uptake	0.359**	2.468**	0.074**	0.007
Gruel loss	3.413**	33.537**	1.796**	0.002
Gelatinization temperature	77.390**	152.000**	3.034**	0.478
Viscosity	0.673**	0.096**	0.002**	0.00006
Amylose	118.259**	52.828**	3.569**	0.003
Amylose-Amylo pectin ratio	0.105**	0.001**	0.003**	0.00001

** Denotes the significance of corresponding F at 1% level

APPENDIX - 4b

Cooking characteristics of rice varieties

Abstract of ANOVA

Character	Variety (va)	Mean square processing method (Pr)	VaxPr	Error
DF	9	1	9	180
Elongation ratio	0.437**	2.726**	0.238**	0.02
Elongation index	0.572**	0.971**	8.560**	0.01

** Denotes the significance of corresponding F at 1% level

APPENDIX - 5

Nutritional composition of rice varieties

Abstract of ANOVA

Character	Variety (va)	Mean square processing method (Pr)	VaxPr	Error
DF	9	1	9	40
Energy	67.440**	464.500**	6.770**	0.075
Protein	1.105**	0.627**	0.006**	0.00003
Starch	111.875**	725.968**	11.875**	0.007
Fibre	0.014**	0.001**	0.00005	0.00007
Phosphorus	108.430**	6018.750**	10.069**	0.100
Iron	0.390*	3.358**	0.011**	0.0004*
Calcium	8.636**	4.215**	0.456**	0.021

** Denotes the significance of corresponding F at 1% level

APPENDIX - 6

Organoleptic qualities of rice varieties

Abstract of ANOVA

Character	Variety (va)	Mean square processing method (Pr)	VaxPr	Error
DF	9	1	9	180
Appearance	10.927**	1.805*	0.260	0.301
Colour	8.127**	2.204*	0.171	0.485
Flavour	11.650**	5.110**	0.108	0.541
Texture	6.616**	1.804*	0.082	0.391
Taste	8.471**	13.005*	0.382	0.444
Overall acceptability	210.058 **	2.880	0.720	2.900

** Denotes the significance of corresponding F at 1% level
 * Denotes the significance of corresponding F at 5% level

ABSTRACT

QUALITY ANALYSIS OF PRE-RELEASE RICE CULTIVARS

By

SHEENA M. KANDATHIL

ABSTRACT OF THE THESIS
SUBMITTED IN PARTIAL FULFILMENT
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ABSTRACT

The 'Quality analysis of pre-release rice cultivars' were determined by assessing their physical characteristics, cooking characteristics, nutritional composition and organoleptic qualities. The effect of parboiling on the above quality aspects were also studied.

Among the physical characteristics, thousand grain weight was found to be higher for the variety M-45-20-1. Lower moisture content was observed in variety M-38-4-2. Higher percentage of head rice yield was observed in the variety M-57-18-1-1. Parboiling significantly increased the thousand grain weight and head rice yield of rice varieties, while moisture content and L/B ratio was found to be decreased after parboiling.

The cooking characteristics of rice varieties with reference to optimum cooking time and gruel loss was higher in M-38-4-1 and M-57-18-1-1 respectively. The variety M-38-4-1 had a significantly higher volume expansion ratio, when compared to the other varieties. Varieties Cul-87117, M-45-20-1 and M-42-6-3 have intermediate amylose content. Parboiling had a positive influence on the cooking characteristics of rice varieties.

Compared to other varieties, M-38-4-2 had obtained higher values for nutritional characteristics such as protein, phosphorus, calcium and iron content. Variety M-38-4-1 had the highest calorific value. Parboiling significantly increased the cooking characteristics except protein and starch content.

From the organoleptic evaluation of cooked rice, it was found that M-38-4-2 was more acceptable with respect to five quality attributes such as colour, appearance, flavour, texture and taste.

Based on physical, cooking, nutritional and organoleptic qualities, discriminant function analysis was carried out and it was found that variety MO-1-20-19-4 was the superior variety in both raw and parboiled forms.