QUALITY PARAMETERS OF POPULAR RICE VARIETIES

BY

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THESIS

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DECLARATION

I hereby declare that this thesis entitled 'Quality parameters of popular rice varieties" is a bonafide record of research work done by me during the course of research and that the thesis had not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society

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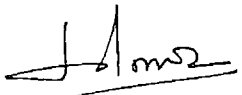
CERTIFICATE

Certified that this thesis entitled 'Quality parameters of popular rice varieties' is a record of research work done independently by Kum SREEDEVI A 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

In the early 60's breeding programme in rice on a basis similar to those successfully undertaken in wheat lead to the development of a large number of high yielding varieties. This assured the green revolution in rice closely following that of wheat In the evolvement of many of these high yielding varieties, yield alone had been the primary consideration.

Around 1965-67 the variety Tainan-3 was the first high yielding variety tried on an extensive scale in Kerala and it disappeared from the agricultural scene of Kerala within an year. This was mainly because the variety Tainan-3, though it was very high yielding, presented problems in threshing and rice cooked from it had pasty qualities totally unacceptable to the highly choosy and discriminating palate of the Keralites. The failure at the introduction of Tainan-3 made agricultural scientists realise that as far as rice is concerned acceptability and its quality is also as important as its yield

Rice is one of the cereal staples which can be just boiled and cooked without involving cumbersome preparations. It cook soft and is therefore suitable

for toothless young as well as toothless aged and convalescents Cooked rice has an attractive colour and can easily be blended with other foods.

A range of breakfast and snack preparations can be made with rice based preparations.

The quality parameters, the physical characteristics, the nutritional qualities the cooking characteristics and the organoleptic qualities of rice parboiled as well as raw rice and their quality for being used in traditional preparations needs to be assessed. It is very much possible that a variety which is good for one purpose need not be so for another purpose Recognising this on a priority basis, it was realised that these characteristics of rice when cokked as whole grain needs to be investigated initially for a number of varieties which are traditionally used, in comparison with varieties evolved by Kerala Agricultural University This programme was therefore undertaken with the working objectives as indicated

1. To assess the nutritional composition of popular rice varieties

2 To assess their physical characteristics

3 To assess their organoleptic and cooking characteristics

4 To study the effect of different types of processing on the quality parameters mentioned under objectives 1 to 3

5 To study the effect of different methods of cooking on the quality parameters mentioned under objectives 1 to 3.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

About 90 per cent of the world's rice crop is grown and consumed in Asia, (Juliano, 1985) In India rice is the staple food of various states including Kerala Rice contributes about 70 per cent of the dietary energy and is the major protein source of Indian population, Rice is important because it has the highest digestibility, biological value and protein efficiency ratio among all the cereals (Anonymous 1964)

Bhat and Rani (1982) reported that the protein content of high yielding rice varieties on dry matter basis ranged from 6 68 to 7.43 g/100g Chandrasekhar and Mulk (1970) conducted studies on the nutritive value of three high yielding rice varieties Jaya, Padma and Hamsa. Among the three analysed Hamsa was reported to have the highest protein content Studies on the quality characteristics of some high yielding varieties of rice from Andhra Pradesh by Geervani and George (1971) had reported that varieties such as Pankaj, Hamsa and HR 35 had high protein content and dense distribution of protein in the endosperm They also found that Jaya had a low percentage of albumin fractions Datta and Barua (1978) evaluated the nutritional quality of some

rice varieties grown in Assam and found that among the varieties analysed the high yielding varieties contained lower amount of protein

The quality characteristics of six high yielding rice varieties of Punjab were evaluated by Sekhon et al (1980) and reported that the lysine content ranged from 3 25 to 3 5 per cent in the varieties analysed The chemical score ranged from 60-67, for which the highest was observed for variety Jaya According to Wahid et al (1975) the essential amino acid content except lysine were higher for variety IR 6 than for Basmati-370 Chandrasekhar and Mulk (1970) reported that among the varieties studied, high yielding variety Jaya had the best isoleucine leucine ratio Datta and Barua (1978) indicated that the distribution of essential amino acids in some of the high yielding rice varieties of Assam were better than that in most of the protein rich varieties Ellis et al (1986) reported that the endosperm storage protein decreases in amount with increasing distance from the aleurone layer Tara and Bains (1971) reported that the milled rice when cooked experienced a negligible loss of lysine and threonine A slight decrease of lysine in parboiled rice was attributed to the longer cooking time

Biological value studies conducted in high yielding rice varieties in comparison with traditional varieties of Andhra Pradesh by Geervani and George (1971) demonstrated the poor nutritive quality of Jaya According to Wahid et al (1975) there was significant different in the protein content between unpolished and polished rice, of different varieties Among the varieties analysed variety Basmati-370 was reported to contain an amount of 7 03 and 6 57 protein for unpolished and polished rice respectively Damyir (1985) found that the protein content of rice increased as a result of parboiling Roberts (1978) reported that the protein content of rice varieties decreased with different degrees of milling Roxas et al (1978) reported that rice with only the husk removed had more crude fibre than well milled rice and showed a lower digestibility and retention of nitrogen

Bhat andRani (1982) reported that the calcium content of raw rice varied from 8 00 to 16 00 per cent Chandrasekhar and Mulk (1970) indicated that among the varieties analysed Hamsa had the highest phosphorus content They had also reported that the calcium phosphorus ratio was highest for the variety Padma According to Chandrasekhar and Mulk (1970) variety Jaya had the highest iron among the varieties studied Roberts (1978)

reported that the iron content in the different rice varieties decreased with different degrees of milling Analysing the nutritional quality of some high yielding rice varieties, Bhat and Rani (1982) reported that Jhona-349 had the highest amount of iron among the varieties analysed.

Pederson and Eggum (1983) reported that the mineral content in different rice varieties decreased considerably during milling and the extent of decrease differed between minerals. According to Damir (1985) the mineral salts of rice were found to have increased as a result of parboiling Doesthale et al (1970) found out that the degree of milling and the initial content of mineral in grain determined the magnitude of loss on milling. Parboiling seemed to alter the distribution of minerals except Zn, Mg and Cu

Resurreccion et al (1970) reported that starch and amylose content of starch increased progressively from the surface to the centre of the grain Datta and Barua (1978) reported that the starch content was low in the two sticky glutinous varieties analysed. According to Bhat and Rani (1982) among the varieties analysed raw PR-106 had the highest amount of starch and Jhona-349 had the lowest amount The nutrient content and

distribution in a low protein and high protein rice were studied by Resurreccion et al (1970) and reported that the non-starch constituents decreased from the surface to the centre of the grain in both rices Enzymatic inter-conversion of amylose and amylopectin fractions of starch due to parboiling was postulated by De et al (1966).

Chandrasekhar and Mulk (1970) reported that among the varieties analysed Jaya had the highest riboflavin content Tung et al (1985) found out that thiamine and niacin content of different rice varieties decreased considerably among varieties with increase in milling.

As reported by Nurunnabi et al (1975) the thiamine, riboflavin and niacin contents of husked rice varied significantly As a result of parboiling and milling to 8% bran removal the average retention of thiamine was 72% and riboflavin 75% while niacin content increased 22.7%

Grewal et al (1988) reported that milled parboiled rice contained more thiamine and riboflavin than milled raw rice at six and eight per cent degree of milling. He also reported a reduction in thiamine content in brown rice after parboiling

Vandrasek and Warthesen (1987) reported a rapid initial thiamine leaching by thiamine uptake as water was

absorbed during cooking white rice He also reported that the extended cooking time required for tenderness in brown rice resulted in a greater percentage of thiamine loss Roberts (1978) studied the composition of rice milled to different degrees and concluded that there was a considerable decrease in the thiamine riboflavin and niacin content of rice varieties with increase in degree of milling

Datta and Barua (1978) reported that the crude fibre content was high in all the glutinous varieties of rice analysed.

The scented and sticky rice varieties were reported to contain higher amounts of lipids (Datta and Barua, 1978)

Das et al (1983) reported that there was a close relationship between grain weight and grain dimensions which are the important physical characteristic influencing the quality Sowbhagya et al (1984) had stated that certain indices deciding dimensional classification of rice such as normalised grain weight, grain weight per unit breadth length and grain breadth and grain weight are important physical characteristics deciding the quality of rice Environmental factors like time of harvesting and moisture content are reported to be

major factors influencing the milling recovery of rice (Tomar 1981) He had reported further that it would be influenced by Kernel size and shape also. Lee (1986) reported that the recovery rate of milled rice obtainable from paddy varied from about 60-70 per cent according to the type of mill, milling efficiency and the variety of rice. The author also found that moisture content was of great importance and paddy must be dried to about 14 per cent to avoid great losses due to breakage in milling Huang (1986) reported that moisture absorption by dry rice caused rice cracking that greatly influenced the milling quality

Pillaiyar and Mohandoss (1979) reported that the milling breakage was influenced by the parboiling conditions adopted Unnikrishnan et al (1982) found that soaking paddy at a temperature of 10-15 C above the gelatinization point for 1½ - 2 hours followed by draining out and hot tempering for another 1-2 hour gave parboiled rice with acceptable degree of parboiling milling and breakage.

Goodman and Rao (1985) reported that long grain samples of rice gave significantly lower yields of head rice than short or medium grain samples The author also

indicated that there was a positive correlation between the kernel hardness and the head rice yield Ali and Bhattacharya (1984) found that the head rice recovery increased with increase in moisture content pressure and time of steaming Webb et al (1986) reported that correlations between hardness and rice grain quality parameters showed some associations but were generally either low or insignificant.

Juliano (1970) found out that the kernel hardness of rice was significantly correlated with protein content According to Proctor and Goodman (1985) the polycronic acids were found to affect the hardness of rice kernels.

Nakamura et al (1983) reported that the gelatinization onset temperature was significantly affected by starch fraction level in the rice suspension Bhattacharya and Sowbhagya (1980) reported that when immersed in dilute potassium hydroxide solution, milled rice kernels of different varieties undergo different types of degradation These types correlated well with other quality indices of rice (Ali and Bhattacharya (1980)). Parboiled rice viscograms show a higher gelatinization temperature when compared to raw rice and when studied at identical slurry concentrations.

Juliano 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 desirable quality attributes include clear whole grain raw milled rice and suitable cooked rice texture, depending on the texture preference in each area (Juliano 1985).

Unnikrishnan et al (1982) described an improved method for parboiling of paddy by simple soaking in hot water, which gave a reasonably good parboiled rice with an acceptable colour Kuppuswamy and Ramalingam (1978) had developed a new method of parboiling involving the hydration of the paddy by passing saturated hot air instead of soaking in liquid water The advantage of this method was minimum loss of nutrients through the boiling water. Raj et al (1981) improved the conventional parboiling of rice through prevention of husk opening by application of 0.5 to 1.0 per cent of common salt This ensured husk sealed grains in parboiling The improved method of parboiling standardised by Raj et al (1981) gave a better appearance to milled rice.

Aguerre et al (1986) reported that the degree of breakage during milling increased as temperature of drying increased (from 40 - 70 C) and relative humidity decreased during the process of parboiling Hoh and Kawamura (1983) reported that the thickness, bulk density and whiteness of brown rice decreased with increasing integrated gelatinization time temperature Cracking hardness was also found to be increasing with increasing gelatinization time temperature

Raj et al (1981) also found out that the improved method of parboiling which produced husk sealed grains facilitated quick drying He further indicated that the closed grains remained free from fungal growth when drying was slow

Ali and Bhattacharya (1984) had reported that the degree of transluscence index, retrogradation index, cooking resistance index and colour, increased with increase in moisture content pressure and time of steaming during the process of parboiling Unnikrishnan and Bhattacharya (1987) studied the influence of varietal differences on properties of parboiled rice and reported that hydration amylose solubility, gel mobility, pasting behaviour, slurry viscosity and texture

of cooked rice samples were the characteristic generally influenced due to parboiling The author had also indicated that the initial gradation of properties among the different varieties were reported to remain largely unchanged after parboiling and although rice became harden and less sticky after parboiling However his observations further revealed that a sticky variety remained relatively sticky and a non sticky variety relatively non sticky.

Kurien et al (1984) reported a slight decrease in length and increase in breadth in milled parboiled grains as compared to raw rice Doesthale et al (1979) reported that parboiling perse had no effect on composition of rice The author indicated that parboiling seemed to alter the distribution of minerals except Zn, Mg and Cu He also reported that milling losses for other minerals were lower in parboiled than in raw rice.

Villareal and Juliano (1987) studied about the varietal difference in quality characteristics of puffed rice samples and reported that among the nine rice samples parboiled for 10 min at 100°C samples with waxy and low amylose content rices were reported to five higher puffed volume than higher amylose content

non waxy rice samples The authors had further reported that puffed rice hardness was lower for the more expanded products, parboiled at 127 C than at 100 C Protein content was also reported to be negatively correlated to the expansion ratio of puffed rices (Villareal and Juliano 1987) The effect of processing conditions on puffed rice was studied by Murugesan and Bhattacharya (1986) and the results of the study indicated that immature kernels did not puff well while cracked grains showed slightly increased puffed volume The authors had also reported that parboiling reduced puffed volume

Bhattachatarjee and Nath (1985) reported that better puffing was followed by increased ageing of rice samples Murugesan and Bhattacharya (1986) found out that sun-drying of paddy before moisture adjustment substantially increased the puffed volume Addition of salt was also reported to increase the puffed volume by the authors Chinnaswamy and Bhattacharya (1983) reported that optimum puffing was obtained by heating milled parboiled rice at a moisture content of 10 5 to 11 per cent with 15 X in its weight of fine sane at 250 C for 10-11 sec

Ananthachar et al (1982) made improvement in the traditional process of making rice flakes According to

the authors, soaking paddy in water for 18 hours at 70C, roasting in hot sand at 260 C for 30 to 35 sec tempering for 4 min and flaking in edge runner for 40-45 sec were found to be optimal for flaking They also reported that such modifications resulted in 2 per cent increase in yield as compared to traditional method Ananthachar et al (1982).

Chinnaswamy and Bhattacharya (1983) reported that expansion of milled parboiled rice correlated strongly with amylose content being maximum at 27 per cent total amylose They had further reported that protein content had a small negative correlation while mineral content of milled grain had no effect Overall shape of the rice grain was reported to remain largely unchanged after expansion Chinnaswamy and Bhattacharya (1983) reported that raw and mildy parboiled rice gave minimal expansion which increased with increasing severity of parboiling upto a steam pressure of 1.5kg/cm^2 They further reported that rice parboiled by heating with sand (250 °C, 2 5 min) expanded best and addition of salt increased this expansion

Kaul (1970) had reported that rice starch is compared of a linear molecular component amylose and a branched chain component amylopectin He had further stated that the proportion between these two types determine the texture of cooked rice According to the author high amylose containing rice cook dry and fluffy while high amylopectin containing rice result in a moist and sticky mass Sekhon and Anand (1983) reported that cooking time was increased by the processing treatments and pressure steamed rice, require more time to cook Juliano and Perea (1983) indicated that the cooking rate was mainly influenced by the reactivity of the grain constituents with water Pillaiyar and Mohandoss (1981) 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.

Pressure steaming treatments adopted in rice processing was reported to improve the appearance and decrease the stickness but imparted slight discolouration and increased hardness in the cooked rice samples (Sekhon and Anand, 1983) According to Pillaiyar and Mohandoss (1981) kernel elongation on cooking and extent

of amylose solubility were other two factors which influenced the cooking qualities of rice The temperature of parboiling influenced the linear elongation of the kernel after cooking Geervani and George (1971) reported that size of the grain and cooking temperature influenced the hydration characteristics of the rice grains. Nirmala and Philomina (1971) indicated that the rice varieties with large and long grains tend to give acceptable products on cooking and tend to form good gels They had also reported that varieties with small size kernels tend to give sticky products on cooking which are not generally acceptable Smith et al (1985) devised a new method for producing quick cooking rice by soaking raw, white, long grain rice in aquous sodium citrate and calcium chloride solution at 50 C for 15 min and freeze drying to 20% moisture followed by connective air drying to a final moisture of 1 2 per cent.

Juliano et al (1965) reported that there was a definite relationship between the physicochemical characters and cooking quality of rice varieties.

Sekhon et al (1980) reported that among the varieties studied Basmati 370 had the lowest uptake of water at 77 °C

and had the best cooking qualities This variety was reported to have the greatest grain length, linear expansion and swelling ratio by the authors Basmati 370 was also reported to have a high amylose content and PR-106 was the next best variety with respect to these characteristics (Sekhon et al 1980)

A study conducted by Geervani and George (1971) had revealed that traditional vafieties were found to be much inferior in cooking quality when compared to high yielding varieties of rice evolved at Andhara Pradesh.

Bhat and Rani (1982) evaluated the cooking quality and nutritive value of high yielding rice varieties and reported that among the varieties studied, cooked PR-106 got the highest mean scores for colour,taste, flavour texture, doneness and overall acceptability According to the author PR-106 had also the largest volume after cooking water absorption during cooking, elongation and swelling ratios.

Clarke (1982) reported that the losses of solids of upto one fifth or more of the material occured during cooking and preparation of a mixture of grain sizes. According to him the losses sustained by the small brokens

were much higher Perez et al (1987) reported that washing and cooking of waxy and non waxy milled rice and rice flour resulted in extraction of lipids and carbohydrates, principally starch and non-starch polysaccharides Lipids extracted were mainly non-starch lipids, principally free fatty acids According to Yanase and Ohtsubo (1985) when 10-30 per cent broken rice grains were blended into head rice, the values of cooking parameters such as water uptake ratio expended volume and total solid content in residual liquid increased, compared with those for whole rice It was also found that values for hardness decreased and those for viscosity and adhesiveness of cooked rice increased significantly. Danvir (1985) reported that the parboiled grains were shorter but wider, with lower water absorption and swelling capacity during cooking than those of raw milled rice.

Metcalf and Lund (1985) reported that the water uptake was reduced by limited water low temperature or the presence of solutes He had further reported that it was enhanced when GMS was present in 0 55 g/g drs and by steaming prior to soaking with sucrose present in 0.55 g water/g drs Juliano and Perez (1983) reported that water rice ratio for acceptable soft texture increased with increasing amylose.

Deshpande and Bhattacharya (1982) had reported that stickness was not appreciably affected by the water to rice ratio used during cooking but was marked by reduced by storage especially in the cold Consistency was reported to increase with storage and decrease with increasing water ratio (R) The results of this study indicated that stickness was inversely proportional to consistency.

Jennings et al (1979) developed a simple laboratory test to evaluate aroma of different rice varieties at International Rice Research Institute. The arima was rated as strong intermediate, slight or absent in comparison with a strongly scented variety Pillaiyar (1984) found out a rapid test to indicate the texture of parboiled rice without cooking. The results of the study indicated that the gel strength was significantly more for parboiled rice varieties than for raw rice varieties. And the author had also reported that the gel length of the parboiled rice varieties were reported to increase significantly with the temperature of (severity) of parboiling and the latter significantly expressing the negative correlation with the texture of cooked grains.

Cagampang et al (1973) reported that unlike in low amylose rices which are inherently associated with soft texture in high amylose rices, the texture varies as demonstrated by the parameters of gel consistency

Bhattacharya et al (1978) reported that the stickness and consistency of cooked rice and viscogram characteristics could not be explained on the basis of the total amylose content alone but they correlated well with the insoluble amylose content They had also indicated that as the insoluble amylose increased the consistency and the set back increased and the stickness and break down decreased Juliano and Villareal (1987) reported that high gelatinization temperature waxy rice starch amylopectin has higher sedimentation coefficient than low GT waxy rice amylopectin The harder texture of cooked rice products from high GT waxy rices compared to the texture of products from low GT waxy rices may be due to the higher molecular weight of their amylopectin. Pillıyar and Mohandoss (1981) developed a pressing device to measure the texture of cooked rice The results of the experiments indicated that the pressed area of the cooked rice and length breadth ratio of uncooked samples correlated positively

The pressed area was correlated negatively with the temperature of parboiling. Juliano et al (1987) reported that among three high amylose starches, differing in gel consistency the hard gel starch Corresponding to hardness cooked rice had higher amylograph consistency and set back higher gel viscocity in 0.2 N potassium hydroxide and higher alkali viscograph peak than starch with soft or medium gel consistency Hard gel consistency starch had less extractable starch and amylose in boiling water than soft or medium gel consistency starches The three starches had similar amylose the difference in gel consistency were due to the amylopectin fraction

Roberts (1979) reported that a data of an acceptability trial indicated about half preferred the lightly milled samples and half the conventional well milled white rice The under milled rice showed higher milling yields and levels of protein, fibre, fat vitamins and minerals than the white rice. Cereda et al (1983) reported that rice soaked at 40 °C was rejected by a because taste panel of its impleasant flavour

Kim and chang (1981) reported that the average moisture content after cooking by open boiling was 65 17 per cent and that of steaming was 64 52 per cent.

Sharp et al (1985) reported that increased roasting time in parboiled milled rice resulted in decreased whiteness and yellowness and increased redness but the intensity of the colour change was diminished by hydration.

Perez and Juliano (1988) reported that acceptable cakes were obtained with non waxy, low gelatinization temperature rice flour, increasing the amount of water in the batter based on amylose content improved cake weight

MATERIALS AND METHODS

MATERIALS AND METHODS

The present study on 'Quality parameters of popular rice varieties" is based on different physio-chemical properties of processed and cooked rice of different local varieties as well as high yielding varieties evolved by Kerala Agricultural University.

Materials

The varieties selected for the study were nine popular high yielding rice varieties evolved by KAU and four local varieties. The varieties used for the study are as follows

High yielding varieties evolved by Kerala Agricultural University

1. Annapurna
2. Bharathi
3. Jaya
4. Jyothi
5. Mahsuri
6. Pavizham
7. Reshmi
8. Swarnaprabha
9. Triveni

Local varieties

1. Kazhama
2 Kuthiran
3 Malaidumban
4. Navara

The high yielding varieties of rice listed above were procured from the Regional Agricultural Research Station Pattambi, the Cropping System Research Station, Karamana, and the Instructional Farm Vellayani The local varieties were procured from local farmers from different locations of Kerala.

Methods

Different processing methods were employed and rice grains obtained by each of the method subjected to various estimations namely nutritional composition, physical characteristics, cook ng characteristics and organoleptic characteristics.

Processing methods

Three major processing methods were employed, viz milling rice as such and collecting raw rice, processing for parboiled rice by two methods namely cold water soaking method as suggested by Bhattacharya and Subha Rao (1966) and RT soaking method as suggested by Bhattacharya and Indudharaswamy (1967) Besides this puffed samples were

also prepared by the method of Rajalekshmi (1984) for some estimations

2 kg each of the thirteen varieties of rice were processed by each of the three methods of processing listed above. The samples obtained after milling each of them were air dried to constant moisture and stored in 2 kg polythene containers.

3.1 Nutritional composition

The major nutrients analysed in the processed samples prior to and after cooking are listed below with the methods employed against each.

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

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

3.1.3 Calcium and iron — The calcium and iron content were estimated by wet digestion of the samples using diacid mixture and determining under A A.S - PE 3030 (Jackson, 1973).

3 1 4 Phosphorus — Phosphorus was estimated by wet digestion with diacid mixture and measuring the yellow colour of vanadomolybdate reagent at 410 nm in Spectronic-2000 (Jackson, 1973)

3 1.5 Starch — Starch was estimated by the Ferricyanide method of Aminoff et al (1970)

3 1.6 Ash — Ash content was estimated by the method of Raghuramulu et al (1983)

3 1.7 Crude fibre — Crude fibre content was estimated by the method of Raghuramulu et al (1983)

3 2 Physical characteristics

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

3 2.1 Thousand grain weight of different rice samples were determined by monitoring the weight of one thousand paddy seeds randomly selected

3.2 2 Grain dimensions Grain dimensions of rice varieties were estimated as per the method of Pillaiyar and Mohandoss (1981)

3 2.3 Moisture Moisture content was estimated by the method of Indudharaswamy, CFTRI (unpublished)

3 2.4 Gelatinization temperature Gelatinization temperature of rice samples were estimated with the Brabender Amylograph (Anker and Geddes, 1944).

3 2.5 Head rice yield The head rice yield was calculated by subtracting the weight of bran, polish and brokens from the total weight of milled rice and the percentage was worked out

3.3 Cooking characteristics

All the varieties processed by the three methods mentioned above were subjected to studies on different cooking characteristics The various methods employed are

3 3 1 Optimum cooking time Optimum cooking time was estimated by the method of Bhattacharya and Sowbhagya (1971)

3.3.2 Elongation ratio Elongation ratio of milled rice samples were estimated by the method of Pillaiyar and Mohandoss (1981 b)

3.3 3 Elongation index Elongation index of milled rice samples were estimated as per the method suggested by Sood and Siddiq (1980)

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

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

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

3 3.7 The total amylose content was estimated by the method of Mac Cready and Hassid (1943)

3.4 Organoleptic characteristics

The organoleptic characteristics of the different varieties of rice processed by the three different methods were estimated For the conduct of the acceptability trials the panel members were selected from a group of 30 healthy women in the age group of 19-23 using the triangle method of Jellinek (1964) A small highly sensitive panel would usually give more reliable results than large less sensitive groups Thus from the thirty women, eight very sensitive women were selected by the triangle test.

The acceptability trials were conducted using eight panel members The major quality attributes scored by the panel members on a five point hedonic scale were appearance, colour, flavour, taste, doneness and adhesiveness The testing was conducted as per the standard procedure prescribed by Swaminathan (1974)

The data was subjected to statistical analysis as per the method suggested by Panse and Sukhatme (1967)

RESULTS

RESULTS

The quality parameters of rice varieties were determined by assessing their nutritional composition, physical characteristics cooking characteristics, organoleptic qualities and acceptability The effect of different methods of cooking on the nutritional composition was also studied Among the thirteen varieties of rice selected for the study nine were high yielding varieties evolved by KAU and the remaining four were local varieties.

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

The nutritional composition of rice varieties are presented in Table 1

Table 1 The nutritional composition of different rice varieties

No.	Varieties	Calories (Kcal/ 100g)	Protein (g/100g)	Calcium (mg/ 100g)	Iron (mg/ 100g)	Phosphorus (mg/ 100g)	Fibre (mg/ 100g)	Ash (mg/ 100g)	Starch (percentage)
High yielding varieties									
1	Annapurna	313 00	8.50	10.20	3 60	162.80	0.31	0.69	62 80
2	Bharathi	341.00	7.80	10.40	3 20	160 30	0 41	0.72	75.30
3	Jaya	332 00	8.60	10.40	4.10	165.50	0 27	0.70	61.10
4	Jyothi	344 70	8.10	9.60	3.50	161.80	0.24	0 73	67 20
5	Mahsuri	310.30	8.70	9 80	3.20	153.50	0.38	0.72	60.70
6	Pavizham	326 70	8 10	9.90	3.20	143 80	0.32	0.71	69.70
7	Reshmi	348 30	7 90	9 80	3.30	157 09	0 30	0.71	69 70
8	Swarnaprabha	325 30	8.05	9.80	3.40	147.50	0.27	0.70	66.20
9	Triveni	330 70	8 03	9.50	4.20	161 90	0.27	0.72	69.90
Local varieties									
10	Kazhama	290 70	7.70	9.80	3.00	141.20	0.27	0.73	62.90
11.	Kuthiran	289.00	6.70	8.70	2.80	154.60	0.36	0.68	64.30
12	Malaidumban	299.70	6.30	8.20	2.90	142.60	0.25	0.67	73.40
13.	Navara	308.30	6.40	9.10	2.90	156 50	0 25	0 70	69.05

As revealed in Table 1, among the nine varieties of rice evolved by KAU Bharathi was found to have the highest calorific value The calorific value of rice varieties ranged from 289-351 Kcal/100g For protein content Mahsuri was ranked first and it ranged from 6 30 g to 8 70 g/100g The rice varieties Bharathi and Jaya were found to contain higher amounts of calcium Jaya was found to be higher in phosphorus also, while Triveni was found to be rich in iron Higher range for fibre and starch were recorded in variety Bharathi while Jyothi was found to be high in ash content compared to the rice varieties evolved by KAU, the local varieties were found to contain lesser amounts of most of the nutrients studied

Table 2 presents the physical characteristics of different rice varieties.

The major physical characteristics assessed were thousand grain weight, grain dimensions, head rice yield, moisture content and gelatinization temperature.

Table 2 The physical characteristics of different rice varieties

No.	Varieties	Thousand grain weight (g)	Grain dimensions (ratio)			Head rice yield percentage	Moisture (g/100g)	Gelatinization temperature (C)
			Paddy	Brown rice	Milled rice			
High yielding varieties								
1	Annapurna	24.50	2.60	2.30	2.20	39 03	14.00	89.80
2	Bharathi	26.90	3 20	3.03	2.90	40 50	13 70	94 00
3	Jaya	29 60	3.20	2 60	2 50	38 70	14.20	85 50
4	Jyothi	28.30	3.40	2.80	2.50	37 07	13.90	85 00
5	Vahsuri	14.60	3.00	2.70	2.70	41.00	13.80	88.00
6	Pavizham	25.40	2.00	2.30	2.20	39.03	13.70	86.50
7	Reshmi	31.90	3.08	3 00	2 80	39 50	14.10	85 50
8	Swarnaprabha	25.20	3 20	3 00	3 01	38 70	14 00	87.70
9	Triveni	22 30	2 80	2.70	2 70	38.03	13 90	85.50
Local varieties								
10	Kazhama	28 10	2.60	2 30	2 40	34 03	14.03	89.50
11	Kuthiran	33.70	2 90	2.40	2 40	37 50	14.30	92.90
12	Malaidumban	28.20	2 70	2.60	2.50	37.00	14.20	86.50
13	Navara	23.50	3 10	2.70	2 60	35 03	13 90	82.00

As revealed in Table 2, the mean value for thousand grain weight of the thirteen varieties of rice ranged from 14.60g to 33.7g This value was highest for the local variety Kuthiran, the moisture content was also found to be highest in Kuthiran highest value for grain dimensions was recorded in Swarnaprabha Head rice yield is calculated subtracting the weight of bran, polish and brokens from the total weight of rice The head rice recovery for all the thirteen varieties ranged from 34.03 to 41 per cent Compared to local varieties, the high yielding varieties had a higher percentage of head rice yield The highest percentage of head rice yield was recorded for Mahsuri The gelatinization temperature of the thirteen varieties ranged from 82 to 94 C The highest value in this context was recorded for Bharathi.

Table 3 details the cooking characteristics of different rice varieties.

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

Table 3 The cooking qualities of different rice varieties

Varieties	Optimum cooking time (minutes)	Elongation (ratio)	Elongation index (ratio)	Volume of expansion (percentage)	Water uptake (g/g)	Total amylose (percentage)	Gruel loss (Percentage)
High yielding varieties							
1 Annapurna	30	1 70	1.00	324.80	2 40	24.05	4.70
2 Bharathi	25	1 60	0 80	272.80	2 40	21.06	3.90
3 Jaya	20	60	1 00	325.00	2 40	25 70	3 90
4 Jyothi	20	60	1 03	350.20	2.80	31 70	4.30
5 Mansuri	20	1 60	1 09	272.00	2 60	24.80	4 20
6 Pavizham	25	1 0	0 9	315.20	2 50	25.60	3.90
7 Reshmi	30	1	0 90	424.50	2 60	25 30	4 40
Swarnaprabha	25	1 0	8	290.00	2 60	25.40	3.80
9 Triveni	25	60	0 87	278.30	2 0	27 80	5.03
Local varieties							
10 Kaznama	25	1 60	1 00	377.05	2 60	24.90	3 09
11 Kuthiran	25	1 60	0 70	249.50	2 30	22.40	4.80
12 Malaidumban	30	1 70	0 70	335.30	2 50	26 30	5.90
13. Navara	25	1 50	0 70	339.50	2 60	25.70	5 08

As revealed in Table 3 the optimum cooking time of nine rice varieties evolved by KAU was found to range from 20 to 30 minutes The lowest value was recorded for Jaya, Jyothi and Mahsuri Higher values for elongation ratio and elongation index were recorded in different varieties of rice evolved by KAU, which is a positive and desirable trend in rice crops when compared to local varieties Among the high yielding varieties elongation ratio was found to be highest in Reshmi where as highest value for elongation index was recorded for Jaya. The percentage volume of expansion was highest for Reshmi Jyothi was found to have the highest water uptake and gruel loss was found to be highest in Malaidumban, which is a local variety.

Among the local varieties the optimum cooking time ranged from 25-30 minutes No considerable difference was found in elongation ratio, elongation index Volume of expansion and water uptake between the rice varieties evolved by KAU and local rice varieties But the gruel loss was higher for all the local varieties except Kazhama. The total amylose content in the thirteen different varieties ranged from 21.06 to 31 7 per cent the highest amylose content was recorded for the variety Jyothi.

Table 4 Effect of processing on the calorific value of different rice varieties (Kcal/100g)

No.	Variety (Va)	Raw (Pr 1)	Parboiled: RT soaking (Pr 2)	Parboiled: Cold water soaking (Pr 3)	Mean
High yielding varieties					
1	Annapurna	313.00	321.70	325.30	320.00
2	Bharathi	351 00	351.30	351.70	351.30
3.	Jaya	332.00	343.00	344./0	339.90
4.	Jyothi	344./0	351.00	354.00	349.90
5	Mahsuri	319.30	323.00	323./0	322.00
6.	Pavizham	326./0	337.30	334.30	322.80
7.	Reshmi	348 30	350 /0	344./0	347.90
8.	Swarnaprabha	325.30	339.00	336./0	333.70
9.	Triveni	330./0	343.30	343.30	339.10
Local varieties					
10.	Kazhama	299./0	305./0	302.00	302.40
11.	Kuthiran	289.00	310.00	311.00	303.30
12.	Malaidumban	299./0	318.30	317./0	311./0
13.	Navara	308 30	311.00	317 /0	312.30
	Mean	322.10	331.20	331.20	..

CD-Values

CD - Va 1 554
CD - Pr 0 746
CD - Va Pr 2 692

The effect of processing on the calorific value of thirteen different rice varieties are presented in Table 4. The data represents the mean values of uncooked rice samples (triplicate) The different processing methods adopted were processing the paddy as raw (Pr.1) and two methods of parboiling namely RT soaking (Pr.2) and cold water soaking (Pr.3)

A significant difference was observed in the calorific value of the different rice varieties after processing. The highest calorific value for processed rice was recorded for Bharathi, while the lowest value was observed for the local variety Kazhama.

Different methods of processing tried had a significant effect on the calorific value of the rice varieties Both the parboiling methods retained more calories when compared to rice processed as raw, in all the rice varieties.

A significant interaction between the processing methods and the varieties was also observed.

Table 5 Effect of processing on the protein content of different rice varieties (g/100g)

No.	Variety (Va)	Raw	Parboiled		Puffed	Mean
			RT soaking (Pr.2)	Cold water soaking (Pr.3)	(Pr.4)	
High yielding varieties						
1	Annapurna	8.50	8.50	8 40	9.40	8 70
2	Bharathi	7 80	7.60	7.50	9.21	8 05
3	Jaya	8 60	8.50	8.10	9 50	8 70
4.	Jyothi	8 10	8 30	8.05	9 30	8.40
5	Mahsuri	8 70	8 20	7.90	9 80	8 60
6	Paviznam	8 10	8.10	7.90	9 20	8.30
7	Reshmi	7 90	7.30	6 40	9.20	7 70
8	Swarnaprabha	8 05	7 50	7 40	9 20	8 03
9	Triveni	8 03	7.80	7 60	9 40	8 20
Local varieties						
10.	Kazhama	7.70	7 40	7.30	8.70	7 80
11	Kuthiran	6 70	6 20	6.10	8 03	6.80
12.	Malaidumbai	6.30	5 80	5 20	8.20	6.40
13.	Navara	6.40	6.20	6.10	8.30	6 80
Mean		7.80	7.50	7.30	9.04	.

CD values

CD - Va = 0 0434
CD - Pr = 0.0240
CD - Va Pr= 0 0867

Table 5 presents date on the protein content of thirteen different varieties of rice as influenced by four processing methods namely processing the paddy as raw (Pr 1) parboiling by two methods (Pr 2 & Pr 3) and puffing (Pr.4). The values obtained are mean values of uncooked rice samples (triplicate).

A significant difference in the protein content was observed among the different rice varieties. The protein was retained more in varieties like Annapurna and Jaya while there was a considerable loss in protein content in the local variety Malaidumban.

A significant difference was observed for the different processing methods. The puffed rice in general was found to contain the highest amount of protein, the most significant increase being seen for the local varieties Navara and Malaidumban There was a significant loss in the protein content after processing by the two methods of parboiling when compared to raw rice samples

The interaction between the processing methods and the varieties was also found to be significant

Table 6 Effect of processing on the calcium content of different rice varieties (mg/100g)

No	Variety (Va)	Raw (Pr.1)	Parboiled		Puffed (Pr 4)	Mean
			RT soaking (Pr.2)	Cold water soaking (Pr.3)		
High yielding varieties						
1	Annapurna	10.20	9.20	8 80	23 40	12.90
2	Bharathi	10 40	8 90	8.50	22 09	12 50
3	Jaya	10.90	8 70	7 90	21 00	11.90
4	Jyothi	9 60	9 07	8 90	23.20	12 70
5	Mahsuri	9.80	9 50	9 50	23 80	13 10
6	Pavizham	9 90	9 10	9 03	22 70	12 70
7	Reshmi	9.80	9 07	8 90	21 80	12 40
8	Svarnaprabha	9 80	9 10	9.04	21 90	12 50
9	Triveni	9.50	8 90	8 70	22.20	12.30
Local varieties						
10	Kazhama	9.80	9 20	9.10	21 70	12.50
11	Kuthiran	8 70	7.70	7 00	20 00	11 20
12	Malaidumban	8.20	8 00	7.80	20 76	11 02
13	Navara	9 10	8 60	8 40	20 60	11 70
Mean		9.60	8.60	8 60	21.90	

CD - Va 0 067
CD -- Pr 0 037
CD - Va Pr 0 130

The data on the calcium content of different rice varieties as influenced by different processing methods such as processing the paddy as raw (Pr 1), parboiling by two methods (Pr.2 and Pr 3) and puffing (Pr.4) are presented in Table 6 The values are mean values of uncooked rice samples (triplicate).

A significant difference in the calc um content was observed among the different rice varieties after processing. The highest calcium content for processed rice was observed for the variety Mahsuri, while the lowest value was recorded for the local variety, Malaidumban

The processing methods significantly influenced the calcium content of the rice varieties The calcium content was retained more in puffed rice samples and the loss in calcium was higher for the rice samples processed by cold water soaking method of parboiling. A further analysis of the effect of processing methods on the varieties indicated that the variety Mahsuri showed maximum variation in calcium content as a result of puffing.

A significant interaction was found between the varieties and processing methods also

Table 7 Effect of processing on the iron content of different rice varieties (mg/100g)

No.	Variety	Raw (Pr.1)	Parboiled		Puffed (Pr.4)	Mean
			RT soaking (Pr 2)	Cold water soaking (Pr.3)		
High yielding varieties						
1	Annapurna	3.40	4 05	4.03	6 40	4.50
2	Bharathi	3.30	4.20	4 20	7.02	4 70
3	Jaya	4.10	4 30	4 20	7 20	5.00
4.	Jyothi	3 50	4 30	4 20	6 30	4 60
5	Mahsuri	3.20	4 40	4 30	6 20	4.50
6	Pavizham	3 20	4 20	4 10	7.40	4.70
7	Reshmi	3 30	4 08	4 03	6 80	4.60
8	Swarnaprabha	3 40	4 30	4 30	6.80	4.70
9	Triveni	4.20	4 50	4.50	5.90	4.80
Local varieties						
10	Kazhama	3 00	4 00	3.90	5.50	4 09
11	Kuthiran	2.80	3.90	3.80	5.70	4 06
12	Malaidumban	2.90	3.80	3 80	5.70	4.04
13	Navara	2.90	3 90	3 80	5.60	4 07
Mean		3.30	4 10	4.09	6.40	

CD - Va 0.029
CD - Pr 0.012
CD - Va Pr 0.042

Table 7 presents data on the iron content of different varieties of rice as influenced by the different processing methods, namely processing the paddy as raw (Pr.1), two methods of parboiling (Pr 2 and Pr.3) and puffing (Pr.4).

A significant difference was observed in the iron content among the different varieties of processed rice. Highest content of iron was observed in the variety Jaya, while the lowest iron content was found in the local variety Malaidumban

The processing methods were also found to significantly influence the iron content Iron was retained more in parboiled rice and puffed rice as compared to raw rice samples, the variation being more significant in puffed rice samples

The interaction between the varieties and processing methods, was also found to be significant.

Table 8 Effect of processing on the phosphorus content of different rice varieties (mg/100g)

No.	Variety	Raw (Pr.1)	Parboiled		Puffing (Pr.4)	Mean
			RT soaking (Pr.2)	Cold water soaking (Pr.3)		
High yielding varieties						
1.	Annapurna	162.80	140.50	146.40	136.70	148.09
2	Bharathi	100 30	142.20	142.09	150.00	148 80
3	Jaya	165.50	146 50	146.40	151.03	152.40
4	Jyothi	161 80	134.20	134 08	150.03	145.04
5	Mahsuri	153.50	141.09	140.00	142 80	144 50
6	Pavizham	143 80	131 20	131.04	146.10	138 03
7	Reshmi	15 09	139 90	139.00	147.50	146.03
8.	Swarnaprabha	147.50	132 00	132.40	140 50	139 80
9	Triveni	161.90	132 60	132 10	147.40	143.50
Local varieties						
10	Kazhama	141 20	125 40	124.90	146.50	134.50
11	Kuthiran	154.60	131 20	131.10	146 20	140.80
12	Malaidumban	142.00	140.20	140.04	140.80	140 90
13	Navara	150.50	136.60	136 30	147.40	144.20
Mean		154.50	136 90	130.70	140.10	.

CD values

CD - Va 0 245
CD - Pr 0 136
CD - Va Pr 0 490

The phosphorus content of thirteen different rice varieties as influenced by the different processing methods namely processing the paddy as raw (Pr.1), two methods of parboiling (Pr 2 & Pr 3) and puffing (Pr.4) are presented in table 8. The values presented are mean values of uncooked rice samples (triplicate)

A significant difference in the phosphorus content was observed among the different varieties of processed rice The highest phosphorus content was observed for the variety Jaya while the lowest was recorded for the local variety Kazhama.

There was significant difference in the phosphorus content of rice samples treated by different processing methods Except for processing the paddy as raw, all other processing methods experienced a significant loss in phosphorus. The phosphorus content decreased significantly as a result of parboiling by two methods when compared to puffing except in the case of variety Annapurna.

A significant interaction between the processing methods and varieties was also found.

Table 9 Effect of processing on the fibre content of different rice varieties (mg/100g)

No	Variety (Va)	Raw (Pr 1)	Parboiled RT soaking (Pr.2)	Parboiled Cold water soaking (Pr.3)	Mean
High yielding varieties					
1.	Annapurna	0.31	0.34	0.34	0.33
2.	Bharathi	0 41	0 37	0.38	0.39
3.	Jaya	0.27	0 28	0.28	0.28
4.	Jyothi	0 24	0.22	0.22	0.23
5.	Mahsuri	0.38	0.33	0.33	0.35
6.	Pavizham	0.32	0.30	0.28	0.30
7.	Reshmi	0.30	0 26	0 26	0.27
8.	Swarnaprabha	0.27	0.31	0 31	0.30
9	Triveni	0.27	0 28	0 28	0 28
Local varieties					
10.	Kazhama	0 27	0 31	0.32	0.30
11.	Kuthiran	0.36	0.37	0.35	0.36
12	Malaidumban	0 25	0.24	0.21	0.24
13.	Navara	0.25	0.26	0.26	0.25
	Mean	0.30	0.30	0.29	..

CD-Values

CD - Va	0.010
CD - Pr	0.005
CD - Va Pr	0 017

Table 9 presents data on the fibre content of different rice varieties as influenced by three different processing methods namely processing the paddy as raw (Pr.1) and parboiling by two methods (Pr 2 & Pr.3) The values are mean values of uncooked triplicate samples

A significant difference was observed among the different rice varieties in fibre content after processing. The highest value for fibre was observed for the variety Bharathi whereas the lowest value was recorded for the variety Jyothi.

The different processing methods significantly influenced the fibre content The cold water soaking method of parboiling (Pr.3) significantly decreased the fibre content when compared to the RT soaking method and also processing the paddy as raw (Pr 2)

The interaction between the rice varieties and the three processing methods was also significant.

Table 10 Effect of processing on the ash content of different rice varieties (mg/100g)

No	Variety	Raw (Pr.1)	Parboiled		Mean
			RT soaking (Pr.2)	Cold water soaking (Pr.3)	
High yielding varieties					
1.	Annapurna	0.69	0.76	0.75	0.73
2.	Bharathi	0.72	0.80	0.82	0.78
3.	Jaya	0.70	0.72	0.74	0.72
4.	Jyothi	0.73	0.81	0.82	0.79
5	Mahsuri	0.72	0.79	0.81	0.77
6.	Pavizham	0.71	0.77	0.82	0.77
7	Reshmi	0.71	0 79	0.78	0.76
8	Swarnaprabha	0.70	0 80	0.81	0.77
9	Triveni	0.72	0.82	0.84	0.79
Local varieties					
10	Kizhama	0.73	0.78	0 78	0.76
11.	Kuthiran	0.68	0.76	0.77	0.74
12.	Malaidumban	0 67	0.77	0.82	0.76
13.	Navara	0.70	0.78	0.78	0.75
Mean		0.71	0.78	0.80	

CD-Values

CD - Va	0.014
CD - Pr	0 007
CD - Va Pr	0.024

Table 10 presents data on the effect of processing on the ash content of thirteen varieties of rice The processing methods adopted were processing the paddy as raw (Pr.1) and two methods of parboiling (Pr 2 & Pr 3) The values obtained are expressed as mean values of uncooked rice samples (triplicate)

A significant difference in the ash content was observed for the different varieties after processing The highest ash content was observed for the varieties Triveni and Jyothi while the lowest value for ash content was observed in Jaya

A significant difference in the ash content among the different processing methods were also observed A significant variation in the ash content was observed in the parboiled samples as compared to raw samples, the most significant variation being seen in the cold water soaking method of parboiling (Pr.3).

A significant interaction was observed between the varieties and the processing methods also

Table 11 Effect of processing on the starch content of different rice varieties (percentage)

No.	Variety (Va)	Raw	Parboiled		Mean
			RT soaking	Cold water soaking	
		(Pr.1)	(Pr.2)	(Pr 3)	
High yielding varieties					
1	Annapurna	62 80	57.04	57.06	58 90
2.	Bharathi	75 30	72 40	71.80	73.20
3	Jaya	61.10	60.40	59 80	60.50
4	Jyothi	67.20	67 10	62.40	65 60
5.	Mahsuri	60 70	60 60	60 30	60 50
6	Pavizham	69 70	66 90	66 70	67 80
7	Reshmi	69 70	64.20	62 90	65.60
8.	Swarnaprabha	66 20	64 90	62 70	64 60
9	Triveni	69.90	67 00	66 70	67 90
Local varieties					
10	Kazhama	62.90	57 07	56 80	58.90
11.	Kuthiran	64 30	62 90	62 80	63.30
12.	Malaidumban	73.40	6 80	67 60	68.90
13	Navara	78.05	62 80	62.50	67.80
Mean		67.80	63 70	63 09	.

CD-Values

CD - Va	0.088
CD - Pr	0.042
CD - Va Pr	0.153

Table 11 presents data on the starch content of thirteen different varieties of rice as influenced by three processing methods The processing methods tried were processing the paddy as raw (Pr.1) and two methods of parboiling (Pr.2 & Pr 3) The data presents the mean values of uncooked rice samples (triplicate)

A significant difference was observed in the starch content of the different varieties after processing The highest value for starch content was observed in the variety Bharathi while the lowest starch content was seen in the local variety Kazhama as well as the high yielding variety Annapurna.

The starch content of the varieties were found to be influenced significantly by the three processing methods. A significant loss in starch content was observed in the parboiling methods when compared to the rice samples processed as raw.

The interaction between variety and processing methods was also found to be significant.

The abstract of ANOVA related to the effect of processing on the nutritional composition of different rice varieties are presented in Appendix III and IV.

4.2 The physical characteristics of rice varieties studies were assessed by estimating the thousand grain weight moisture content grain dimension , head rice yield and gelatinization temperature

Table 12 Effect of processing on the thousand grain weight of different rice varieties (g)

No	Variety (Va)	Raw (Pr 1)	Parboiled		Mean
			RT soaking (Pr 2)	Cold water soaking (Pr 3)	
High yielding varieties					
1	Annapurna	24 50	24.60	24 90	24.70
2.	Bharathi	26 90	27 02	27 07	27.01
3	Jaya	29.60	29 70	30.30	29 90
4	Jyothi	28 30	28 50	28 70	28 50
5	Mahsuri	14 60	14 70	15 40	14.90
6.	Pavizham	25 40	25 90	25 00	25.40
7	Reshmi	31.90	32 20	31 90	32.00
8	Swarnaprabha	25 20	26 00	25 10	25 40
9	Triveni	22 30	25 30	23 20	22.90
Local varieties					
10	Kazhama	28 10	28 70	28 90	28 60
11	Kuthiran	33 70	34 10	35 07	34 30
12.	Malaidumban	28 20	29 60	29.70	29.20
13.	Navara	23 50	24.10	23 80	23 80
	Mean	26 30	26 80	26 80	.

CD-Values

CD - Va	0 092
CD - Pr	0 044
CD - Va Pr	0.159

The effect of processing on the thousand grain weight of thirteen different rice varieties are presented in Table 12 The processing methods adopted were processing the paddy as raw (Pr.1) and two methods of parboiling (Pr.2 & Pr.3) The data presents mean values of unmilled and uncooked rice samples.

The thousand grain weight was found to vary significantly among the different varieties after processing. The value for thousand grain weight was recorded for the local variety Kuthiran while the lowest value was observed for the high yielding variety Mahsuri.

A significant difference was observed among the different processing methods The parboiled samples when compared to raw paddy was found to be experiencing a significant variation in the thousand grain weight

The interaction between the rice varieties and the different processing methods was also found to be significant

Table 13 Effect of processing on the moisture content of different rice varieties (g/100g)

No	Variety (Va)	Raw	Parboiled		Mean
			RT soaking	Cold water soaking	
		(Pr 1)	(Pr 2)	(Pr.3)	
High yielding varieties					
1	Annapurna	14.00	13 70	13.60	13.70
2	Bharathi	13.70	13.60	13 70	13.90
3	Jaya	14.20	13.80	13 80	13 90
4	Jyothi	13 90	13 70	13 70	13.80
5	Mahsuri	13 80	13 40	13 40	13.60
6	Pavizham	13 70	13 o0	13.60	13.70
7	Reshmi	14 10	14 02	14 00	14.04
8	Swarnaprabha	14 00	13 50	13 50	13.70
9	Triveni	13 90	13 50	13.50	13.60
Local varieties					
10.	Kazhama	14 03	13.70	13 o0	13.80
11	Kuthiran	14 30	14.02	14 03	14.10
12	Malaidumban	14 20	13.80	13 80	13 90
13	Navara	13.90	13 50	13 50	13 60
Mean		14 00	13.70	13 70	..

CD-Values

CD - Va 0.019
CD - Pr 0.009
CD - Va.Pr 0.033

Table 13 presents data on the effect of processing on the moisture content of different varieties of rice. The processing methods adopted were processing the paddy as raw (Pr.1) and two methods of parboiling (Pr.2 & Pr.3) In the table the mean values of uncooked rice samples (triplicate) are given.

There was a significant difference among the different rice varieties in the moisture content after processing The moisture content was highest in the local variety Kuthiran where as a lowest value for moisture content was observed in Mahsuri, Triveni and Navara.

The different processing methods were also found to be affecting significantly the moisture content of different rice varieties A significant loss in moisture content was observed in the parboiled samples when compared to the raw samples.

The interaction between the varieties and processing methods was also found to be significant

Table 14 Effect of processing on the grain dimensions of different rice varieties unmilled (ratio)

No	Variety (Va)	Raw	Parboiled		Mean
			RT soaking	Cold water soaking	
		(Pr 1)	(Pr 2)	(Pr 3)	
High yielding varieties					
1	Annapurna	2.o0	2 50	? 50	? 50
2.	Bharathi	3 30	3 30	3 04	3.?0
3.	Jaya	3 2J	2 80	2 90	3.00
4.	Jyothi	3 40	3 03	3.40	3.30
5.	Mahsuri	3 00	2 7J	2 90	2.90
6	Pavizham	2 60	2 50	2.40	2.50
7	Reshmi	3 08	2.o0	2 o0	?.80
8	Swarnaprabha	3 20	3 06	3 01	3.10
9	Triveni	? 80	2 70	2.70	2.70
Local varieties					
10	Kazhama	2 60	2 60	2.o0	2.60
11	Kuthiran	2 90	2.o0	2 70	2.70
12.	Malaidumban	2 70	2 40	2.40	2 50
13	Navara	3 10	3 05	3 03	3 06
Mean		3 00	2 80	2 80	

CD-Values

CD - Va 0 021
CD - Pr 0 010
CD - Va Pr 0 037

Table 14 presents data on the grain dimensions of thirteen varieties of rice as influenced by three methods of processing namely processing the paddy as raw (Pr 1) and parboiling by two methods (Pr.2 & Pr 3) The mean values of unmilled and uncooked rice samples (triplicate) are presented.

A significant difference was observed in the grain dimensions of paddy of different varieties after processing The grain dimension ratio was highest for the variety Jyothi while the lowest ratio was observed for the varieties Annapurna and Pavizham and also the traditional variety Malaidumban.

The processing methods were also found to be significantly affecting the grain dimensions of paddy A significant decrease was observed in the ratio after parboiling when compared to raw paddy.

The interaction between the varieties and the processing methods was also found to be significant

15 Effect of processing on the grain dimensions of different rice varieties Brown rice (ratio)

No	Variety (Va)	Raw (Pr 1)	Parboiled RT soaking (Pr)	Parboiled Cold water soaking (Pr 3)	Mean
High yielding varieties					
1.	Annapurna	2 20	2.10	2.10	2.20
2.	Bharathi	2 90	2 80	2 80	2.90
3.	Jaya	2 50	2 50	2.50	2.50
4.	Jyothi	2 50	2 50	2 50	2 50
5	Mahsuri	2 70	2 40	2 60	2 60
6	Pavizham	2 20	2 20	2 10	2.10
7	Reshmi	2.80	2 70	2 80	2 80
8	Swarnaprabha	3 01	2 60	2 80	2.80
9	Triveni	2 70	2 70	2 50	2.60
Local varieties					
10.	Kazhama	2 40	2 20	2.20	2.30
11.	Kuthiran	2.40	2.40	2 40	2 40
12	Malaidumban	2 50	2 50	2 50	2 50
13	Navara	2 60	2 60	2 60	2.60
Mean		2 60	2 50	2 50	

CD-Values

CD - Va 0 008
CD - Pr 0 004
CD - Va Pr 0 014

The effect of processing on the grain dimensions of different rice varieties are presented in Table 15 The processing methods tried were processing the paddy as raw (Pr.1) and parboiling by two methods (Pr 3 & Pr 3) The data presents grain dimension ratio of unpolished and uncooked rice samples (triplicate)

A significant difference was observed among the different varieties The highest grain dimension ratio was observed for the variety Bharathi while the lowest ratio was recorded for Pavizham

A significant decrease was found in the grain dimensions of brown rice, parboiled by two methods when compared to raw

The interaction between the processing methods and the varieties was also found to be significant

Table 16 Effect of processing on the grain dimensions of different rice varieties-milled rice (ratio)

No	Variety (Va)	Raw	Parboiled		Mean
			RT soaking	Cold water soaking	
		(Pr 1)	(Pr 2)	(Pr 3)	
High yielding varieties					
1	Annapurna	2 20	? 10	?.10	2.20
2.	Bharathi	2.90	2 80	2 80	2.90
3	Jaya	2 50	2 50	? 50	2 50
4	Jyothi	2 50	? 50	2 40	2 50
5	Mahsuri	2 70	2 40	? 60	2.60
6	Pavizham	2 20	2 20	2 10	2.10
7	Reshmi	2 80	2 70	? 80	2 80
8	Swarnaprabha	3 01	2 60	2.80	2 80
9	Triveni	2 70	2 70	2 50	2.60
Local varieties					
10	Kazhama	2 40	? 20	2 20	? 30
11	Kuthiran	2 40	? 40	2 40	? 40
12	Malaidumban	2 50	2 50	2 50	2 60
13	Navara	2 60	2 60	2 60	2 60
Mean		2.60	2.50	?.50	

CD-values

CD - Va 0 153
CD - Pr 0 073
CD - Va Pr 0 265

Table 16 presents data on the effect of processing on the grain dimensions of different rice varieties The processing methods adopted were processing paddy as raw (Pr.1) and two methods of parboiling (Pr 2 and Pr 3) The mean values of milled and uncooked rice samples (triplicate) are presented in the above table

Among the different varieties a significant difference was observed for grain dimension ratio after processing. The highest value for grain dimension among the different varieties of milled rice was seen in the variety Bharathi while the lowest value was recorded for Pavizham.

A significant difference was observed among the different processing methods A significant decrease in the grain dimension ratio was observed for the parboiled rice samples when compared to raw samples.

The interaction between varieties and processing methods was also found to be significant

Table 17 Effect of processing on the head rice yield of different rice varieties (percentage)

No	Variety (Va)	Raw	Parboiled		Mean
			RT soaking	Cold water soaking	
		(Pr 1)	(Pr 2)	(Pr 3)	
High yielding varieties					
1	Annapurna	39 03	78 70	61.20	59.70
2.	Bharathi	40.50	66 03	65 00	57 20
3	Jaya	38 70	80 50	77 50	65 60
4	Jyothi	37 07	78.20	77 50	64.30
5	Mahsuri	41.00	65.50	65 00	57.20
6	Pavizham	39 03	78 20	77 50	64 90
7	Reshmi	39 50	70 50	70 00	60.00
8	Swarnaprabha	38 70	67 50	66 20	57.50
9	Triveni	38.03	57 20	56 50	50 60
Local varieties					
10	Kazhama	34 03	55 50	55.00	48.20
11	Kuthiran	37 50	78 00	67 50	61.00
12.	Malaidumban	37 00	80.00	70.00	62 30
13.	Navara	35 03	80 00	78 00	64.30
Mean		38 09	72 003	68.20	

CD at 5%

CD - Var

CD - Pr

CD - Va Pr

The data on the head rice yield as influenced by different processing methods are presented in Table 17 The processing methods tried were processing the paddy as raw (Pr 1) and two methods of parboiling (Pr.2 & Pr.3) The data presents mean values of uncooked rice samples (triplicate)

A significant difference in the percentage head rice yield was observed among the varieties The highest percentage of head rice yield was observed for the variety Jaya, while the lowest percentage was seen in the local variety Kuzhama.

Among the processing methods a most significant difference was observed The percentage head rice yield was much higher in parboiled samples when compared to raw rice samples.

A significant difference was observed in the interaction between different varieties and the different processing methods also

Table 18 Effect of processing on the gelatinization temperature of different rice varieties (°C)

No	Variety (Va)	Raw (Pr 1)	Parboiled		Mean
			RT soaking (Pr 2)	Cold water soaking (Pr 3)	
High yielding varieties					
1	Annapurna	89 80	92 00	92.90	91.60
2	Bharathi	94.00	95 00	95 00	94.70
3	Jaya	85 30	93 00	92 00	90 10
4	Jyothi	85.00	93 00	87.70	85 50
5	Mahsuri	88 00	94.00	94.00	92 00
6	Pavizham	86 50	93.20	92 00	90.00
7	Reshmi	85 50	88 80	89 50	87 90
8	Swarnaprabha	87 70	91 70	92 08	90 50
9	Triveni	85 50	92 90	91.70	90 03
Local varieties					
10	Kazhama	89 50	92 70	91 00	91.06
11	Kuthiran	92 90	93 00	94 70	94.20
12	Malaidumban	86 80	88 00	88 00	87 60
13	Navara	82 00	89.50	92 08	87 90
Mean		87 60	92.20	91 70	.

CD at 5%

CD - Va 0 852
CD - Pr 0 409
CD - Va Pr 1 476

The effect of processing on the gelatinization temperature of different rice varieties are presented in Table 18 The processing methods tried were processing the paddy as raw (Pr 1) and parboiling by two methods (Pr.2 & Pr 3) The values presented are mean values of uncooked rice samples (triplicate)

A significant difference was observed in the gelatinization temperature among the different varieties. The highest gelatinization temperature after processing was recorded for the variety Bharathi, while the lowest was recorded for the variety Jyothi.

There was a significant difference between the processing methods also A significantly higher gelatinization temperature was seen in parboiled rice samples when compared to raw saples

A significant interaction was also seen between the varieties and the processing methods

The abstract of ANOVA related to the effect of processing on the physical characteristics of different rice varieties are presented in Appendix V.

4.3 The major cooking characteristics assessed in the rice varieties were optimum cooking times elongation ratio, elongation index, gruel loss during cooking, volume expansion, apparent water uptake and total amylose content.

Table 19 Effect of processing on the optimum cooking time of different varieties of rice (minutes)

No	Varieties (Va)	Raw (Pr 1)	Parboiled		Mean
			RT soaking (Pr.2)	Cold water soaking (Pr.3)	
High yielding varieties					
1	Annapurna	30	35.00	35.00	33.30
2	Bharathi	25	30 00	30.00	28 30
3	Jaya	20	30 00	30.00	26 70
4.	Jyothi	20	30.00	30.00	26.70
5	Mahsuri	20	30 00	40 00	30.00
6	Pavizham	25	30.00	30.00	28 30
7	Reshmi	30	40 00	40 00	35 00
8	Swarnaprabha	25	40.00	40.00	35.00
9	Triveni	25	30 00	30.00	28.30
Local varieties					
10	Kazhama	25	35.00	35.00	31 70
11.	Kuthiran	25	30.00	30.00	28.30
12	Malaidumban	30	40.00	40.00	36.70
13	Navara	25	40 00	40 00	35.00
Mean		25	33 80	34 60	..

Table 19 presents data on the optimum cooking time of different rice varieties as influenced by different methods of processing The processing methods tried were processing the paddy as raw (Pr 1) RT soaking method of parboiling (Pr.2) and cold water soaking method of parboiling (Pr 3)

From the table it was evident that different varieties needed different time to be cooked to an optimum level Compared to parboiled rice samples, the raw rice samples needed lesser time to cook to an optimum level.

As the variance was found to be zero statistical analysis was not possible

Table 20 Effect of processing on the elongation ratio of different rice varieties (ratio)

No	Variety (Va)	Raw (Pr.1)	Parboiled: RT soaking (Pr 2)	Parboiled: Cold water soaking (Pr 3)	Mean
High yielding varieties					
1	Annapurna	1.70	1.40	1.60	1 60
2	Bharathi	1 50	1 30	1.40	1 40
3	Jaya	1 60	1 50	1.50	1.50
4	Jyothi	1 60	1 40	1.50	1.50
5	Mahsuri	1 60	1 50	1.50	1.50
6	Pavizham	1 50	1 40	1.40	1 40
7	Reshmi	1 80	1 80	1 70	1 80
8	Swarnaprabha	1 40	1 40	1 40	1 40
9	Triveni	1 60	1 50	1 50	1 50
Local varieties					
10	Kazhama	1 50	1 40	1.40	1.40
11	Kuthiran	1 50	1 40	1 40	1 40
12	Malaidumban	1 70	1 50	1 60	1 60
13	Navara	1 50	1 40	1 40	1 40
Mean		1.60	1 50	1.50	..

CD-at 5%

CD - Va	0.015
CD - Pr	0.007
CD - Va Pr	0 027

Table 20 presents data on the elongation ratio of different rice varieties as influenced by different processing methods namely processing the paddy as raw (Pr.1) and parboiling by two methods (Pr.2 & Pr.3) The data represents the mean values of cooked rice samples (triplicate)

A significant difference was observed in the elongation ratio of different rice varieties after processing. The highest elongation ratio after cooking was observed for the variety Re hmi while the lowest ratio was seen in the variety Bharathi

Different processing methods had a significant effect on the elongation ratio of different varieties. The elongation ratio was observed to decrease as a result of parboiling

The interaction between different varieties and the processing methods was also found to be significant.

Table 21 Effect of processing on the elongation index of different rice varieties (ratio)

No	Variety (Va)	Raw (Pr 1)	Parboiled: RT soaking (Pr 2)	Parboiled: Cold water soaking (Pr.3)	Mean
High yielding varieties					
1	Annapurna	1.00	1.05	1.10	1.04
2	Bharathi	0.80	0.90	0.80	0.90
3	Jaya	1.20	1 21	1 20	1.20
4	Jyothi	1 03	1 05	1 04	1.04
5	Mahsuri	1 09	1 10	1 04	1 08
6	Pavizham	0 90	0.90	1.00	0.90
7	Reshmi	0 90	0.90	1 09	1.00
8	Swarnaprabha	0 80	1 00	1 00	0.90
9	Triveni	0 80	0 95	1 07	0.90
Local varieties					
10.	Kazhama	1 00	1 09	1 08	1.05
11	Kuthiran	0 70	1 02	0 90	0.90
12	Malaidumban	0 70	0.90	1.10	0 90
13	Navara	0.70	0 90	0.80	0.80
Mean		0 90	1 10	1 02	

CD at 5%

CD - Va	0 022
CD - Pr	0.011
CD - Va Pr	0.039

The elongation index of thirteen different rice varieties as influenced by different processing methods are presented in Table 21 The processing techniques adopted were processing the paddy as raw (Pr 1) and two methods of parboiling (Pr.2 & Pr 3)

Among the different varieties, a significant difference was observed in the elongation index after processing The elongation index was highest for the variety Mahsuri and lowest for the local variety Navara.

The different processing methods were also found to be significantly affecting the elongation index of different rice varieties A significant increase in the elongation index was found in the rice samples processed by the two parboiling methods when compared to the raw rice samples.

A significant interaction was found between the processing methods and the varieties also.

Table 22 The effect of processing on the gruel loss of different rice varieties (percentage)

No	Variety (Va)	Raw (Pr 1)	Parboiled: RT soaking (Pr 2)	Parboiled: Cold water soaking (Pr 3)	Mean
High yielding varieties					
1	Annapurna	4 70	4 20	4 20	4.40
2	Bharathi	3.90	3 00	3 10	3.30
3.	Jaya	3.90	2 80	2 80	3 20
4.	Jyothi	4 30	3 90	3 90	4 05
5	Mahsuri	4.20	3 70	3 80	3 90
6	Pavizham	3 90	2 70	2 80	3 20
7	Reshmi	4.40	2 70	2 70	3.30
8	Swarnaprabha	3 80	2 90	2 80	3 20
9	Triveni	5 03	4 00	4.20	4.40
Local varieties					
10	Kazhama	3 09	2 70	2 80	2.90
11	Kuthiran	4 80	3 20	3 30	3 80
12.	Malaidumban	5.90	4.00	4 40	4.70
13	Navara	5.08	4 00	4 30	4.40
Mean		4.40	3 40	3.50	.

CD at 5%

CD - Va 0 018
CD - Pr 0.008
CD - Va Pr 0.031

The effect of processing on the gruel loss after cooking of different rice varieties are presented in Table 22 The values presented are the mean values of triplicate samples of rice samples processed as raw as well as parboiled by two methods (Pr.1 Pr 2 & Pr 3)

The gruel loss was found to vary significantly among the different rice varieties after processing The minimum loss in the gruel after cooking was observed for the local variety Kazhama and the maximum loss was recorded in another local variety 'Malaidumban

A significant difference was observed in the gruel loss among the different processing methods also There was significant decrease in the gruel loss in the parboiled rice samples when compared to raw rice samples.

The interaction between the varieties and the processing methods was also found to be significant

Table 23 Effect of processing on the volume of expansion of different rice varieties (percentage)

No	Variety (Va)	Raw (Pr 1)	Parboiled		Mean
			RT soaking (Pr 2)	Cold water soaking (Pr 3)	
High yielding varieties					
1.	Annapurna	324 80	200.50	149 20	224.80
2	Bharathi	272 80	165 50	165 20	201 20
3	Jaya	325 00	180 00	209 80	238 30
4	Jyothi	350 20	250.20	219 50	273 30
5.	Mahsuri	272 00	200 20	200 20	224 10
6	Pavizham	315 20	189 80	180 50	228.50
7	Reshmi	424 50	163 60	165 50	251.20
8	Swarnaprabha	290 00	179 20	241 60	236 90
9	Triveni	278 30	253 50	246 70	259 50
Local varieties					
10	Kazhama	377 05	180 50	174.80	244.10
11	Kuthiran	249 50	200 20	208.50	219 40
12	Malaidumban	335 30	200.50	288 10	274 60
13	Navara	339 50	220 50	228 70	262 90
	Mean	319 55	198 80	206.02	

CD - at 5%

CD - Va 2 059
CD - Pr 3 989
CD - Va Pr 3,566

Table 23 presents data on the percentage of volume of expansion of thirteen different rice varieties as influenced by three different processing methods namely processing the paddy as raw (Pr 1) and parboiling (Pr 2 & Pr.3) The values are mean values of triplicate samples

A significant difference was observed among the different rice varieties in the volume of expansion after cooking as a result of processing The highest percentage of volume of expansion was observed in Jyothi and the lowest percentage in Bharathi.

The different processing methods also had a significant effect on the volume of expansion. The percentage expansion was found to be significantly decreased for parboiled rice when compared to raw rice samples.

The interaction between the processing methods and the varieties were also found to be significant.

Table 24 Effect of processing on the water uptake of different rice varieties (g/g)

No	Variety (Va)	Raw	Parboiled		Mean
			RT soaking	Cold water soaking	
		(Pr.1)	(Pr 2)	(Pr.3)	
High yielding varieties					
1	Annapurna	2.40	1.90	1.90	2.07
2.	Bharathi	2.40	1 70	1.70	1.90
3.	Jaya	2 40	2 06	2 08	2.20
4.	Jyothi	2 80	2.20	2.20	2.40
5.	Mahsuri	2.30	1.90	1.90	2.07
6	Pavizham	2 50	2 04	2 05	2.20
7	Reshmi	2 50	2.20	2.20	2.30
8	Swarnaprabha	2 50	2 10	2.10	2.20
9.	Triveni	2 50	2.10	2 10	2.30
Local varieties					
10.	Kazhama	2.50	2 10	2.10	2.20
11	Kuthiran	2.30	1 90	1.90	2 10
12.	Malaidumban	2.50	2.20	2.10	2.30
13	Navara	2 00	2 10	2.10	2.30
Mean		2.50	2.04	2.05	..

CD at 5%

CD - Va	0.017
CD - Pr	0.008
CD - Va Pr	0.030

The apparent water uptake of thirteen different rice varieties after cooking as influenced by different methods of processing such as processing the paddy as raw and parboiling by two methods (Pr 1 Pr 2 & Pr 3) are presented in Table 24.

A significant difference was observed in the water uptake after processing in the rice varieties The highest water uptake was recorded in Jyothi while the lowest was observed in Bharathi

The water uptake by the rice varieties were found to be varying significantly as a result of processing Thus the water uptake decreased significantly after parboiling when compared to raw rice.

The interaction between the varieties and processing methods was also found to be significant.

Table 25 Effect of processing on the total amylose content of different rice varieties (percentage)

No	Variety (Va)	Raw (Pr 1)	Parboiled: RT soaking (Pr 2)	Parboiled: Cold water soaking (Pr.3)	Mean
High yielding varieties					
1	Annapurna	24 05	24.50	21.90	23 40
2	Bharathi	21 06	18.40	19.70	19.70
3	Jaya	25 70	24 40	24 00	24.90
4	Jyothi	31.70	26 40	26 40	28.10
5	Mahsuri	24 80	22 20	22 10	23.04
6	Pavizham	25 06	24 60	23 10	24 40
7	Reshmi	25.30	24 70	25.00	25.00
8	Swarnaprabha	25.40	24 20	24 30	24 00
9.	Triveni	27 80	23 50	23 70	25.00
Local varieties					
10.	Pazhama	24 90	23 70	23 60	24.05
11	Kuthiran	22 40	21 07	21 20	21 00
12	Malaidumban	26 30	24.40	25 01	25.20
13.	Navara	25.70	24.60	24 70	25.03
Mean		25.40	23 00	23 50	.

CD at 5%

CD - Va	0.016
CD - Pr	0.008
CD - Va Pr	0.028

The effect of processing on the total amylose content of thirteen rice varieties as influenced by different processing methods are presented in Table 25 The data presents mean values of rice samples processed as raw (Pr 1) and parboiled by two methods (Pr 2 & Pr.3) in triplicate.

The values for total amylose varied significantly among the different rice varieties, after processing The highest value for amylose was recorded for the variety Jyothi and the lowest value in Bharathi

There was a significant difference in the total amylose content obtained for rice varieties after processing The amylose content decreased significantly in the parboiled samples when compared to the raw samples.

A significant interaction was found between the varieties and the processing methods in the amylose content.

The abstract of ANOVA related to the effect of processing on the cooking qualities of different rice varieties are presented in Appendix VI

4.4 Appearance, colour, flavour, taste, donenes, and adhesiveness are the major quality parameters which may decide the popularity and acceptability of a crop In the present study these qualities of different varieties of rice processed by various methods were determined Score card method was used to ascertain the quality parameters of boiled rice samples

Table 26 Effect of processing on the quality parameters of different rice varieties (Appearance)

No	Variety (Va)	Raw	Parboiled		Mean
			RT soaking	Cold water soaking	
		(Pr.1)	(Pr.2)	(Pr.3)	
High yielding varieties					
1.	Annapurna	3.70	3.40	3.70	3 60
2.	Bharathi	2.40	3.20	3.50	3.04
3	Jaya	3.20	2.90	3.40	3.20
4.	Jyothi	3.20	2.70	4.20	3.40
5.	Mahsuri	3.70	3.50	3.70	3.70
6	Pavizham	3.60	3.90	3.50	3.70
7.	Reshmi	3.40	2 00	3.50	2.90
8.	Swarnaprabha	2.90	2.70	3.40	3.00
9.	Triveni	2.20	2 00	2.40	2 20
Local varieties					
10	Kazhama	2 90	3.70	3.70	3.40
11.	Kuthiran	3.50	3.20	3.40	3.40
12.	Malaidumban	3.20	3.90	3.90	3.70
13	Navara	2.50	4.40	2.20	3.04
Mean		3.10	3.20	3.40	..

CD at 5%

CD - Va	0.515
CD - Pr	0.247
CD - Va Pr	0 892

Table 26 presents the mean scores obtained for the "appearance' of different rice varieties processed by three methods (Pr.1 Pr 2 & Pr 3).

A significant difference was observed in the mean scores obtained among different varieties of rice. Among the high yielding varieties Mahsuri and Pavizham had obtained highest score for appearance while Triveni had obtained lowest. In general the appearance of local varieties were found to be more acceptable when compared to the evolved varieties.

There was significant difference in the mean scores attained for appearance for each variety when processed by different methods Annapurna and Mahsuri had obtained higher score for appearance when processed as 'raw' (Pr.1) while Pavizham parboiled by RT soaking (Pr 2) and Malaidumban parboiled by two methods (Pr.2 & Pr 3) had obtained higher score Between the processing methods, rice varieties processed by cold water soaking method (Pr.3) had obtained higher score for appearance except in the case of local varieties Kazhama, Malaidumban and Navara.

The interaction between the varieties and processing methods was also found to be significant

Table 27 Effect of processing on the quality parameters of different rice varieties (colour)

No.	Variety (Va)	Raw	Parboiled		Mean
			RT soaking	Cold water soaking	
		(Pr 1)	(Pr 2)	(Pr.3)	
High yielding varieties					
1.	Annapurna	3.20	3.00	3.10	3.10
2.	Bharathi	2 50	2.90	3 00	2.80
3	Jaya	3.40	2 60	2 60	3.40
4	Jyothi	3 60	3.00	3.60	3.90
5	Mahsuri	4 60	3.60	3.60	3.40
6	Pavizham	3.60	3.10	3.40	3.40
7.	Reshmi	3. 0	3 10	3.00	3.20
8	Swarnaprabha	2 50	2 50	3 10	2.70
9	Triveni	3.00	2 00	2.50	2.50
Local varieties					
10	Kazhama	3 60	3 50	3.00	3.40
11	Kuthiran	3 50	3.40	3 10	3 30
12.	Malaidumban	3 50	3.00	3.70	3.40
13.	Navara	3.50	3.40	2 70	3.20
Mean		3 40	3.01	3 10	.

CD at 5%

CD - Va 0.522
CD - Pr 0 251

The mean scores obtained for the 'colour' of different varieties of processed and boiled rice are presented in Table 27.

A significant difference was observed in the mean scores among different varieties of rice Among the high yielding rice varieties Mahsuri had obtained highest score for colour while Triveni had obtained lowest In general, the local varieties of rice had secured higher score for this quality when compared to rice varieties evolved by KAU, Jyothi, Mahsuri and Pavizham were exceptions

The colour preference was found to be significantly affected by the processing methods adopted Mahsuri had obtained higher score for colour when processed as raw (Pr 1) while Malaidumban had obtained higher score for colour when processed as parboiled (Pr 3) Between the processing methods rice varieties processed by cold water soaking method (Pr 3) had obtained higher scores for 'colour' except in the case of Reshmi, Kazhama, Kuthiran and Navara In the case of Jaya and Mahsuri the mean scores remained the same.

Table 28 Effect of processing on the quality parameters of different rice varieties (Flavour)

No	Variety (Va)	Rice (Pr 1)	Parboiled: RT soaking (Pr.2)	Parboiled: Cold water soaking (Pr 3)	Mean
High yielding varieties					
1.	Annapurna	3.20	3.20	3.20	3 20
2.	Bharathi	2.60	3 20	3 20	3.04
3.	Jaya	2.90	2.70	3.40	3.00
4	Jyothi	2 70	2.70	3.20	2.90
5	Mahsuri	3 20	3.00	3 50	3.20
6.	Pavizham	3 10	3.20	3.20	3.20
7	Reshmi	2.70	3.50	2.90	3 04
8.	Swarnaprabha	3 00	3 00	3 50	3.20
9.	Triveni	2 20	3 10	3 20	2.90
Local varieties					
10.	Kazhama	2 60	3 50	3.20	3.10
11.	Kuthiran	2.70	3 20	3.40	3.10
12	Malaidumban	2 90	3.20	3.30	3.20
13	Navara	2.70	3.00	3.20	3.00
Mean		2.80	3.10	3 30	..

CD at 5%

CD - Pr 0.241

Mean scores obtained for 'flavour' of different varieties of rice processed by the three methods (Pr.1, Pr 2 and Pr.3) are presented in Table 28

There was no significant difference among the varieties in the mean scores obtained for flavour. Among the high yielding varieties Annapurna, Mahsuri, Pavizham and Swarnaprabha had obtained higher score for flavour while Jyothi and Triveni had obtained lower score In general all the rice varieties had obtained a mean score above three except for Jyothi and Triveni.

The flavour of the different rice varieties were found to be significantly influenced by processing methods Flavour preference was in general higher for rice varieties processed by parboiling (Pr 3) Between the processing methods rice varieties processed by cold water soaking (Pr 3) had obtained hicher score for flavour except in the case of Reshmi and Kazhama and for the varieties Annapurna Bharathi and Pavizham, the mean scores remained the same

Table 29 Effect of processing on the quality parameters of different rice varieties (Taste)

No	Variety (Va)	Raw	Parboiled		Mean
			RT soaking	Cold water soaking	
		(Pr 1)	(Pr.2)	(Pr 3)	
High yielding varieties					
1.	Annapurna	3.20	3 20	3.10	3.20
2	Bharathi	2 70	3 10	3 50	3.10
3	Jaya	2 50	2 70	2.90	2 70
4	Jyothi	2 40	3.20	3.40	3 30
5	Mahsuri	3 20	3.00	3 00	3.08
6	Pavizham	3.20	2 90	3 20	3.10
7	Reshmi	2 90	3.20	3 60	3.20
8	Swarnaprabha	3.10	2.90	3.20	3.08
9	Triveni	2.20	2.90	3.40	2.80
Local varieties					
10	Kazhama	2 70	3 60	3.50	3.30
11.	Kuthiran	3.40	3 10	3.00	3.20
12.	Malaidumban	3 20	3 20	3 10	3.20
13	Navara	3.20	3 20	3.10	3.20
Mean		3.00	3 09	3.20	.

Table 29 presents the mean scores obtained for taste of different varieties of rice as influenced by processing (Pr.1, Pr 2 and Pr.3)

Significant varietal difference was not observed The local varieties obtained higher scores for taste when compared to rice varieties evolved by KAU Among the evolved varieties Jyothi and Jaya obtained highest and lowest scores respectively The taste of different rice varieties was found not to be influenced by the processing methods also

Table 30 Effect of processing on the quality parameters of different rice varieties (Doneness)

No.	Variety (Va)	Raw (Pr.1)	Parboiled		Mean
			RT soaking (Pr 2)	Cold water soaking (Pr.3)	
High yielding varieties					
1	Annapurna	3.40	2.90	3.20	3.20
2.	Bharathi	3.00	3 10	3.40	3.20
3.	Jaya	2.90	3.20	3.60	3.20
4.	Jyothi	3.50	3 40	3.70	3.50
5.	Mahsuri	3.20	3 40	3.50	3.40
6.	Pavizham	3 00	3.00	3.10	3.04
7	Reshmi	3.10	2.50	3 00	2.90
8	Swarnaprabha	3 60	3.20	3.20	3.40
9.	Triveni	2.90	3 00	3.50	3.10
Local varieties					
10.	Kazhama	3.40	2.60	3 10	3 04
11	Kuthiran	3.20	3.40	3 50	3.40
12.	Malaidumban	3.90	3 20	3.50	3.50
13.	Navara	3 60	3 70	3.40	3.60
Mean		3.30	3.10	3.40	..

Mean scores obtained for doneness of different varieties of rice as influenced by different methods of processing are presented in Table 30

There was no significant difference among the varieties in the mean scores obtained for doneness. Local varieties were found to obtain higher scores. Among the rice varieties evolved by KAU Reshmi obtained lowest score and Jyothi obtained highest score. Mean score obtained for Jyothi was comparable with the mean scores of local varieties.

Processing was found to have no significant influence on the quality of the rice varieties.

Table 31 Effect of processing on the quality parameters of different rice varieties (Adhesiveness)

No	Variety (Va)	Raw	Parboiled		Mean
			RT soaking	Cold water soaking	
		(Pr 1)	(Pr.2)	(Pr.3)	
High yielding varieties					
1.	Annapurna	4.00	3.40	3.20	3.50
2.	Bharathi	3.70	3.60	3 10	3.50
3.	Jaya	3.20	3.40	2 50	3.04
4	Jyothi	3.10	3 10	3 00	3.08
5.	Mahsuri	3 70	3 40	3.50	3.50
6	Pavizham	2.90	3 10	3 60	3.20
7	Reshmi	3 70	3 20	3 40	3.60
8	Swarnaprabha	3.20	3 20	3.10	3.20
9	Triveni	4.00	3.50	3.60	3.70
Local varieties					
10.	Kazhama	2 20	3 60	3.50	3.10
11	Kuthiran	4.00	3.20	3.10	3.40
12.	Malaidumban	3 20	3 60	3.90	3.40
13	Navara	3.90	4.20	4.10	4.08
Mean		3.50	3.00	3.30	.

CD at 5%

CD - Va 0.437
CD - Va Pr 0.757

Mean scores obtained for adhesiveness of different rice varieties are presented in Table 31.

A significant different was observed in the mean scored obtained for adhesiveness among the thirteen different varieties The traditional variety Navara was highly preferred compared to other variety Among the different varieties Jaya obtained the lowest score.

The interaction between the varieties and processing methods was found to be significant in the case of adhesiveness.

The abstract of ANOVA related to the effect of processing on the organoleptic characteristics of different rice varieties are presented in Appendix VII

4.5 Rice as a staple food constitutes the major component of Indian diet and hence becomes the major supplier of protein and other nutrients However different methods of cooking applied on this food prior to consumption, changes the nutritional composition Hence an assessment of the effect of different methods of cooking on the nutritional composition of processed rice varieties were done.

Different methods of cooking tried were baking, roasting, frying, boiling and steaming The nutrients analysed were protein, calcium, iron and phosphorus.

Table 32 Effe of differe me hods f cooking on pro e n en (mg/ 00g f d ffere var e s of proce sed ri e

No Var ety	Baking (C_1)				Ba ng (C_2)				Fry g (C_3)				Bo ing (C_4)				S ami g (C_5)				Mean f ar e ies over (B_3) proce ing me hods & king me hods	Mean of var e es under processing m ho s over cooking me hods		
	Raw (B_1)	HT oak (B_2	CW soak (B_3)	Mean o C ov $B_1B_2B_3$	Raw (B_1)	HT soak (B_2)	CW soak (B_3)	Mean f C_2 e $B_1B_2B_3$	Raw (B_1)	HT soak (B_2)	CW e ak B_3	Mean f C_3 over $B_1B_2B_3$	Ra (B_1)	HT soak (B_2	CW oak (B_3)	Mean f C4 ve $B_1B_2B_3$	Raw (B_1)	HT e ak (B_2)	CW e sk (B_3)	Mean o C_5 over $B_1B_2B_3$		Raw (B_1	HT k (B_2)	CW soak (B_3)
Hig y d g																								
Ann purna	8 38	8 50	8 30	8 40	8 60	8 50	8 50	8 50	8 50	8 30	8 20	8 30	8 0	60	40	7 0	8 0	8 20	8 0	8 20	8 0	8 40	8 20	8 0
2 Bh thi	60	60	50	60	8 05	7 80	70	80	7 80	7 60	7 50	60	60	40	7 30	7 0	7 90	50	7 40	60	60	80	7 60	40
3 aya	8 30	8 50	8 05	8 30	8 0	8 50	8 0	8 50	8 60	8 40	8 0	8 40	8 30	8 0	8 03	8 0	8 40	8 20	8 0	8 20	8 30	8 50	8 0	8 0
4 Jyo h	8 03	8 0	8 04	8 07	8 20	8 0	8	8 0	8 0	8 03	8 02	8 05	0	0	30	60	8 03	80	80	90	7 90	8 0	7 90	7 80
5 Ahsur	8 50	8 40	7 80	8 20	8 0	8 40	8 04	8 40	8 0	8 0	80	8 20	8 20	80	50	80	8 40	8 05	60	8 04	8 0	8 50	8 02	70
6 Pa sham	8 08	8 30	8 0	8 0	8 30	8 30	8 02	8 20	7 80	8 0	90	90	60	60	30	7 50	7 80	60	60	70	7 90	90	8 00	7 80
Ra hmi	8 30	60	6 40	40	8 0	7 50	6 50	40	7 60	7 30	6 30	09	40	20	6 0	6 90	60	7 20	6 20	04	20	80	7 40	6 30
8 Swarn pra ha	8 03	50	40	60	8 0	50	40	7 70	8 0	40	7 30	60	7 60	7 20	20	7 30	7 0	30	03	0	50	90	7 40	30
9 Tr veni	8 06	80	7 70	90	8 0	7 80	7 0	90	8 02	60	20	7 60	60	50	30	50	7 90	60	20	60	7 0	90	0	40
Lo ri e																								
0 Ka h ma	60	7 50	40	50	80	0	40	0	0	40	20	40	6 0	6 0	6 0	6 30	50	20	0	30	7 20	50	7 20	05
Ku i an	6 50	6 30	6 20	6 30	6 80	6 40	6 20	6 50	6 60	6 20	6 0	6 30	6 20	6 05	6 02	6 09	6 40	6 0	6 00	6 20	6 30	6 50	6 20	6 0
2 Ma aidumban	6 0	5 90	5 40	5 80	6 40	5 90	5 40	5 90	6 20	5 80	5 0	5 70	6 0	5 0	5 05	5 40	6 20	5 80	5 20	5 70	5 0	6 0	5 70	5 20
3 Ma ara	6 20	6 30	6 20	6 30	6 60	6 40	6 20	6 40	6 30	6 0	6 0	6 20	6 20	6 04	6 04	6 0	6 30	6 0	6 0	6 20	6 20	6 30	6 20	6 0
Mea s	7 70	60	30		90	60	40		7 0	0	0		30	04	6 80		60	30	03			60	7 40	0
CD a 5%	0 08				0 053				0 09				0 024				0 0 9				0 026	0 0 3		

CD B x C 0 028

CD A x B x C 0 78

Table 32 presents data on the effect of different methods of cooking on the protein content of different varieties of rice processed as raw (B_1) and parboiled B_2 and B_3)

In general a significant difference in the protein content was observed among the different varieties. Mean values obtained for each variety after the application of different cooking methods indicated that variety Jaya had the highest protein content The traditional variety Malaidumban scored the lowest value for protein, irrespective of the cooking methods adopted

Different cooking methods had significant influence on the protein content The protein content was least altered by baking and roasting while it was significantly decreased by boiling Frying and steaming were found to retain more protein than boiling but retained lesser protein than baking and roasting.

From the table it was also evident that the variety Annapurna retained the highest amount of protein when cooked by baking and roasting While the variety Jaya was found to retain more protein when cooked by frying, boiling and steaming. The most significant loss in the protein content as a result of boiling was experienced in the traditional variety Kazhama

A significant difference in the protein content was observed among the different processed rice samples, after the application of each methods of cooking The loss in the protein content was greater in the parboiled rice samples when compared to raw rice samples, after cooking The most significant loss was found in Reshmi processed by cold water soaking method of parboiling.

A further analysis of the data brought out the fact that the variety Jaya processed as raw when roasted and the variety Mahsuri processed as raw when fried, retained the highest amount of protein in the grain.

Table 33 Effect of different methods of cooking on the calcium content (mg/100g) of different varieties of processed rice

No	Variety	Baking (C)				Roasting (C_2)				Frying (C_3)				Boiling (C_4)				Steaming (C_5)				Mean of varieties over (B_3)	Mean of varieties under processing methods & cooking methods over cooking methods		
		Raw (B_1)	RT soak (B_2)	CW soak (B_3)	Mean of C over $B_1B_2B_3$	Raw (B_1)	RT soak (B_2)	CW soak (B_3)	Mean of C_2 over $B\ B_2B_3$	Raw (B)	RT soak (B_2)	CW soak (B_3)	Mean of C_3 over $B_1B_2B_3$	Raw (B)	RT soak (B_2)	CW soak (B_3)	Mean of C_4 over $B_1B_2B_3$	Raw (B_1)	RT soak (B_2)	CW soak (B_3)	Mean of C_5 o er $B_1B_2B_3$		Raw (B_1)	RT soak (B_2)	CW soak (B_3)
High y elding varieties																									
1	Annapurna	10 20	9 20	8 80	9 40	0 20	9 50	9 00	9 60	0 20	9 20	8 90	9 40	8 20	7 60	7 40	7 70	8 20	8 20	8 10	8 20	9 10	9 80	9 00	8 60
2	Bharathi	0 40	9 00	8 60	9 30	0 30	9 10	8 70	9 40	0 40	9 00	8 60	9 30	7 60	7 40	7 30	7 40	7 90	7 50	7 40	7 60	9 09	0 00	8 70	8 40
3	Jaya	10 40	8 80	8 90	9 04	0 50	8 80	7 90	9 07	0 40	8 80	7 90	9 04	8 30	8 0	8 03	8 10	8 40	8 20	8 0	8 20	8 70	10 10	8 40	7 70
4	Jyothi	9 60	9 09	8 90	9 20	9 90	9 20	8 90	9 30	9 60	9 10	8 90	9 20	7 70	7 70	7 30	7 60	8 03	7 80	7 80	7 90	8 90	9 30	8 70	8 50
5	Mahsuri	9 80	9 50	9 50	9 60	10 09	9 70	9 50	9 70	9 80	9 60	9 50	9 60	8 20	7 80	7 50	7 80	8 40	8 05	7 60	8 04	9 30	9 50	9 30	9 20
6	Pavisham	10 20	9 20	9 07	9 50	10 02	9 20	9 05	9 40	9 90	9 0	9 04	9 40	7 60	7 60	7 30	7 50	7 80	7 60	7 60	7 70	9 09	9 60	8 90	8 70
7	Reshmi	9 80	9 08	8 90	9 30	0 09	9 20	8 90	9 40	9 80	9 08	8 90	9 30	7 40	7 20	6 10	6 90	7 60	7 20	6 20	7 04	9 00	9 50	8 80	8 60
8	Swarnaprabha	9 80	9 10	9 05	9 30	10 01	9 20	9 10	9 40	9 90	9 0	9 04	9 40	7 60	7 20	7 20	7 30	7 70	7 30	7 03	7 30	9 03	9 50	8 80	8 70
9	Triveni	9 50	8 90	8 70	9 06	9 50	9 05	8 80	9 0	9 50	8 90	8 70	9 05	7 60	7 50	7 30	7 50	7 90	7 60	7 20	7 60	9 00	9 40	8 80	8 70
Local v rieties																									
0	Kashama	9 80	9 30	9 20	9 40	9 90	9 40	9 20	9 50	9 80	9 20	9 20	9 40	6 70	6 10	6 10	6 30	7 50	7 20	7 07	7 30	9 20	9 60	9 06	8 90
1	Kuthiran	8 80	7 80	7 60	8 06	8 80	7 70	7 70	8 09	8 70	7 70	6 70	8 05	6 20	6 05	6 02	6 10	6 40	6 07	6 00	6 20	7 90	8 50	7 60	7 50
2	Malaidumban	8 20	8 07	7 90	8 04	8 30	8 03	7 90	8 09	8 20	8 00	7 90	8 04	6 0	5 07	5 05	5 40	6 20	5 80	5 20	5 70	7 90	8 0	7 90	7 70
13	Navara	9 0	8 60	8 40	8 70	9 30	8 70	8 40	8 80	9 0	8 70	8 40	8 70	6 20	6 04	6 04	6 10	6 30	6 10	6 10	6 20	8 60	9 03	8 60	8 30
	Means	9 70	8 90	8 60		9 80	9 00	8 70		9 70	9 90	8 70		7 30	7 04	6 80		7 60	7 30	7 03			9 40	8 60	8 40
CD at 5%			0 077				0 098				0 079				0 035				0 083			0 034		0 0 6	
CD for B x C			0 036																						
CD for A x B x C			0 228																						

Table 33 presents data on the effect of different methods of cooking on the calcium content of different types of processed rice samples.

Mean values obtained for each variety of processed rice after the application of different cooking methods indicated a significant difference It was found that, the variety Mahsuri retained the highest amount of Calcium while the local varieties Kuthiran and Malaidumban were found to retain the lowest amount of calcium irrespective of all the cooking methods tried.

A significant difference in the calcium content among the different cooking methods was observed A least alteration in the calcium content was observed in the roasted samples while the most significant loss in calcium content was observed in boiled and steamed samples. Baking and frying was found to be on par in retaining the calcium content.

From the table it was evident that the variety Mahsuri retained the highest amount of calcium when cooked by baking roasting and frying While the variety Jaya was found to retain the highest amount of calcium when boiled and steamed variety, Annapurna was also found to retain highest amount of calcium when steamed The local

variety Kazhama was found to have experienced the most significant loss in calcium after boiling.

The calcium content wa found to vary significantly among the different proces ing methods after each methods of cooking Thus the calcium content was found to be decreased as a result of parboiling when compared to raw rice. The most s gnificant loss was found in the variety Jaya.

When the interaction among the varieties, processing methods and cooking methods were taken into consideration, the variety Jaya proc ssed as raw when roasted gave the best combination which retained the highest amount of calcium

Table 34 Effect of different methods of cooking on the iron content (mg/ 00g) of different varieties of processed rice

No	Variety	Baking (C_1)				Roasting (C_2)				Frying (C_3)				Boiling (C_4)				Steaming (C_5)				Mean of varieties over (B_3)	Mean of varieties under processing methods over cooking methods		
		Raw (B_1)	RT soak (B_2)	CW soak (B_3)	Mean of C_1 over $B_1B_2B_3$	Raw (B_1)	RT soak (B_2)	CW soak (B_3)	Mean of C_2 over BB_2B_3	Raw (B_1)	RT soak (B_2)	CW soak (B_3)	Mean of C_3 over $B_1B_2B_3$	Raw (B_1)	RT soak (B_2)	CW soak (B_3)	Mean of C_4 over $B_1B_2B_3$	Raw (B_1)	RT soak (B_2)	CW soak (B_3)	Mean of C_5 over $B_1B_2B_3$	Mean of processing methods & cooking methods	Raw (B_1)	RT soak (B_2)	CW soak (B_3)
High yielding varieties																									
1	Annapurna	3 40	4 05	4 03	3 80	5 50	5 70	5 70	5 60	6 60	6 90	6 70	6 70	1 80	2 40	2 30	2 20	3 30	4 05	4 03	3 80	4 40	4 10	4 60	4 50
2	Bharathi	3 20	4 20	4 20	3 90	6 07	6 90	6 80	6 60	6 70	6 90	6 80	6 80	1 40	2 30	2 20	2 0	3 30	4 20	4 20	3 90	4 60	4 0	4 90	4 80
3	Jaya	4 0	4 30	4 20	4 20	5 80	5 90	5 90	5 90	6 80	6 90	6 60	6 80	2 09	2 50	2 40	2 30	4 10	4 30	4 20	4 20	4 70	4 60	4 80	4 60
4	Jyothi	3 50	4 30	4 20	4 00	5 40	5 70	5 70	5 60	6 60	6 80	6 80	6 70	1 06	2 05	2 02	1 70	3 50	4 30	4 20	4 00	4 40	4 0	4 60	4 60
5	Mahsuri	3 20	4 40	4 30	4 00	6 0	6 60	6 50	6 40	6 50	6 80	6 60	6 60	2 00	2 40	2 40	2 30	3 20	4 40	4 30	4 00	4 60	4 20	4 90	4 80
6	Pav zham	3 20	4 0	4 0	3 80	6 05	6 40	6 30	6 20	6 40	6 90	6 70	6 70	10	2 08	2 06	80	3 20	4 20	4 0	3 80	4 50	4 09	4 70	4 70
7	Reshmi	3 30	4 07	4 03	3 80	5 80	6 00	5 90	5 90	6 60	6 70	6 50	6 60	40	2 50	2 40	2 08	3 30	4 06	4 03	3 80	4 40	4 09	4 60	4 50
8	Swarnaprabha	3.40	4 30	4 20	4 00	6 50	6 90	6 60	6 70	6 80	7 00	6 90	6 90	80	2 09	2 08	2 00	3 40	4 30	4 20	4 00	4 70	4 40	4 90	4 80
9	Triveni	4 20	4 50	4 50	4 40	6 70	6 90	6 80	6 80	7 0	7 30	7 20	7 20	2 70	2 90	2 80	2 80	4 20	4 50	4 50	4 40	5 0	5 00	5 20	5 0
Local varieties																									
0	Kashama	3 00	4 00	3 90	3 60	5 90	6 20	6 0	6 08	6 20	6 50	6 30	6 40	0 90	2 60	2 40	2 00	2 90	4 00	3 90	3 60	4 30	3 80	4 60	4 50
1	Kuthiran	2 80	3 90	3 80	3 50	6 00	6 30	6 30	6 20	5 60	6 20	6 07	5 90	0 80	2 40	2 30	80	2 80	3 90	3 80	3 50	4 20	3 60	4 50	4 50
2	Malaidumban	2.90	3 80	3 80	3 50	5 80	5 90	5 80	5 80	6 05	6 30	6 0	10	0 50	2 03	70	40	2 90	3 80	3 80	3 50	4 08	3 60	4 40	4 20
3	Vayara	2 90	3 90	3 80	3 50	5 90	6 03	5 90	5 90	5 70	5 07	5 90	5 80	0 80	2 30	2 10	70	2 90	3 90	3 80	3 50	4 0	3 60	4 40	4 30
	Mean	3 30	4 0	4 08		6 00	6 30	6 20		6 40	6 70	6 50		40	2 30	2 20		3 30	4 10	4 08			4 08	4 70	4 60
CD at 5%			0 077				0 038				0 547				0 040				0 025			0 0 6		0 007	

CD for B x C 0 0 8

CD for A x B x C 0

Table 34 presents data on the effect of different cooking methods on the iron content of different varieties of rice processed by different methods (B_1, B_2 and B_3)

In general a significant difference was observed in the iron content of the different varieties after cooking. The mean value obtained for each variety of processed rice after cooking indicated that the highest amount of iron was retained in the variety Triveni while the lowest iron content was observed in the local variety Malaidumban

A significant variation in the iron content was observed among the different cooking methods The iron content was least altered after baking and steaming. But a significant increase in iron content was observed as a result of roasting and frying and a significant loss was found as a result of boiling The values observed showed that baking and steaming were on par in retaining the iron content.

From the table it was evident that the variety Triveni was found to secure the highest iron content when cooked under all the five methods The most significant increase in iron content as a result of frying

was found in the varieties Annapurna, Bharathi, Pavizham and Swarnaprabha, while the most significant loss in iron content as a result of boiling was observed for the variety Jyothi

A significant difference in the iron content was observed among the different processing methods after each method of cooking. The iron content was found to be significantly increased as a result of parboiling. The most significant increase was found in the RT soaking sample of local variety Malaidumban

Further the table revealed that the variety Triveni, processed by the RT soaking method of parboiling (B_2) retained the highest amount of iron when fried in an iron pan.

Table 35 Eff differe me od f ooki g e phosphorus en (mg/ 00g) f d ff re e s proces ed r e

No Var e y	Baking C)				R as ing (C_2)				Fry ng (C_3)				Bo ng (C_4)				S eami g (C_5)				Me a ove (B_3) proc ss ng me hods & o k ng me hods	Mea und m o proces s ng me hod		
	Raw (B_1)	RT soak (B_2)	CW s ak (B_3)	Mean C $B_1B_2B_3$	Raw (B_1)	RT soak (B_2)	CW s ak (B_3)	Mean C_2 $B_1B_2B_3$	Raw (B_1)	RT oak (B_2)	CW s ak (B_3)	Mean C_3 ver $B_1B_2B_3$	Raw B_1)	RT s ak (B_2)	CW oak (B_3)	M a C4 ove $B_1B_2B_3$	Raw (B_1)	RT s ak (B_2)	CW ak B_3)	Mean C_5 r $B_1B_2B_3$		Raw (B_1)	RT k (B_2)	W k (B_3)
H gh y d g ri es																								
Ann purn	6 00	46 90	45 90	52 30	62 90	46 50	46 40	5 90	63 0	46 50	4 40	52 0	2 60	05 60	05 50	0 90	6 80	46 0	46 0	5 90	4 20	5 0	8 40	8 0
2 Bhara hi	60 20	42 30	42 09	48 20	60 30	42 20	42 07	48 20	60 30	42 20	42 08	48 20	09 09	03 70	03 70	05 50	60 30	42 20	4 09	48 20	9 0	50 04	34 50	34 40
3 Jay	65 40	46 40	46 30	52 70	65 50	46 40	46 30	52 0	65 50	46 50	46 30	52 80	4 40	05 30	05 30	08 30	65 50	46 50	46 40	58 80	43 90	55 30	38 20	38 00
4 Jyo hi	62 00	34 20	34 0	43 40	6 80	34 20	34 0	43 40	6 80	34 20	34 05	43 30	0 80	04 70	04 70	06 0	6 80	34 0	34 07	43 40	36 05	5 60	28 30	28 20
5 Mahsuri	53 50	4 00	40 40	44 90	53 50	4 08	40 60	45 04	53 50	4 08	40 60	45 05	02 40	96 50	96 50	98 40	5 50	4 08	40 60	45 05	3 0	4 0	32 0	3 70
6 Pa shas	43 80	3 0	3 08	35 30	43 80	3 0	3 04	35 30	43 90	3 0	3 03	35 30	96 90	89 80	89 70	92 0	43 80	3 20	3 05	35 30	26 70	34 0	22 90	22 80
Ra hai	57 09	39 90	39 50	45 50	57 0	39 90	39 60	45 50	5 0	39 90	39 60	45 50	03 70	97 0	9 50	99 60	5 0	3 90	39 6	45 50	6 30	40	3 40	3 0
8 Swarnaprabha	47 60	32 60	32 40	37 50	47 50	32 60	3 40	3 50	47 50	32 60	32 40	3 50	96 40	94 50	94 50	95 0	4 50	32 60	3 40	3 50	9 04	3 30	2 00	24 80
9 Triveni	6 90	32 50	32 0	42 20	6 80	32 60	32 20	42 20	6 90	32 60	32 30	42 20	0 80	04 80	04 70	06 80	6 90	32 60	32 0	42 20	35 0	5 70	04	6 70
Lo ri es																								
0 Kashasa	4 0	25 40	25 0	30 50	4 0	25 40	24 40	30 50	4 0	25.40	24 90	30 50	9 0	90 0	90 04	90 40	4 20	25 40	24 90	30 50	22 50	3 0	8 30	8 00
K hiran	54 70	3 0	3 0	39 00	54 70	3 0	30 90	38 90	54 0	3 0	3 08	39 00	04 70	0 80	0 70	02 80	54 60	3 20	3 06	38 90	3 0	44 0	25 30	5 20
2 Ma a dum an	42 60	40 06	40 03	40 90	4 0	40 20	40 06	4 00	42 70	4 20	40 05	4 00	93 0	90 0	93 30	92 60	42 60	40 20	40 05	40 90	3 30	32 80	30 20	30 70
3 Na ra	56 50	36 60	36 30	43 0	56 50	36 60	35 90	43 00	56 50	6 60	3 30	43 0	00 50	9 50	9 40	98 50	56 50	36 60	36 30	43 0	34 0	45 30	28 80	8 50
Me	54 60	36 90	3 60		5 60	136 90	36 60		54 60	3 90	36 0		03 60	98 0	98 80		54 50	36 90	36 0			44 40	0 80	9 0
CD a 5%	0 68				0 546				0 250				0 343				0 324				0 60	0 07		

CD B x C 0 72
CD A x B x C 0 2

Table 35 presents data on the effect of different methods of cooking on the phosphorus content of different varieties of rice as influenced by different methods of processing (B_1, B_2 and B_3).

Mean values obtained for each variety of processed rice after different cooking methods indicated a significant difference in the phosphorus content From the table it was found that the variety Jaya retained the highest amount of phosphorus while the local variety Kazhama retained the lowest amount of phosphorus after cooking.

A significant difference was observed in the phosphorus content among the different cooking methods A least alteration was observed in all the cooking methods except boiling, which showed a significant loss in phosphorus content It was found that baking, roasting, frying and steaming were on par in retaining the phosphorus content.

From the table it was observed that the variety Jaya was found to retain the highest amount of phosphorus when cooked by all the five methods The local variety Malaidumban was found to have experienced the greatest low in phosphorus after boiling.

The phosphorus content was found to vary significantly among the different processing methods after each method of cooking The phosphorus content was found to be decreased as a result of parboiling when compared to raw rice The most significant loss was observed for the variety Triveni.

When the interaction among the variety, processing methods and cooking methods were taken into consideration the combination of variety Jaya processed as raw and cooked by either roasting, frying or steaming was found to be best in retaining the phosphorus content.

The abstract of ANOVA related to the effect of different methods of cooking on the nutritional composition of different rice varieties are presented in Appendix VIII

FIG.1 EFFECT OF DIFFERENT METHODS OF COOKING ON THE NUTRITIONAL COMPOSITION OF DIFFERENT VARIETIES OF RAW MILLED RICE (MEAN VALUE)

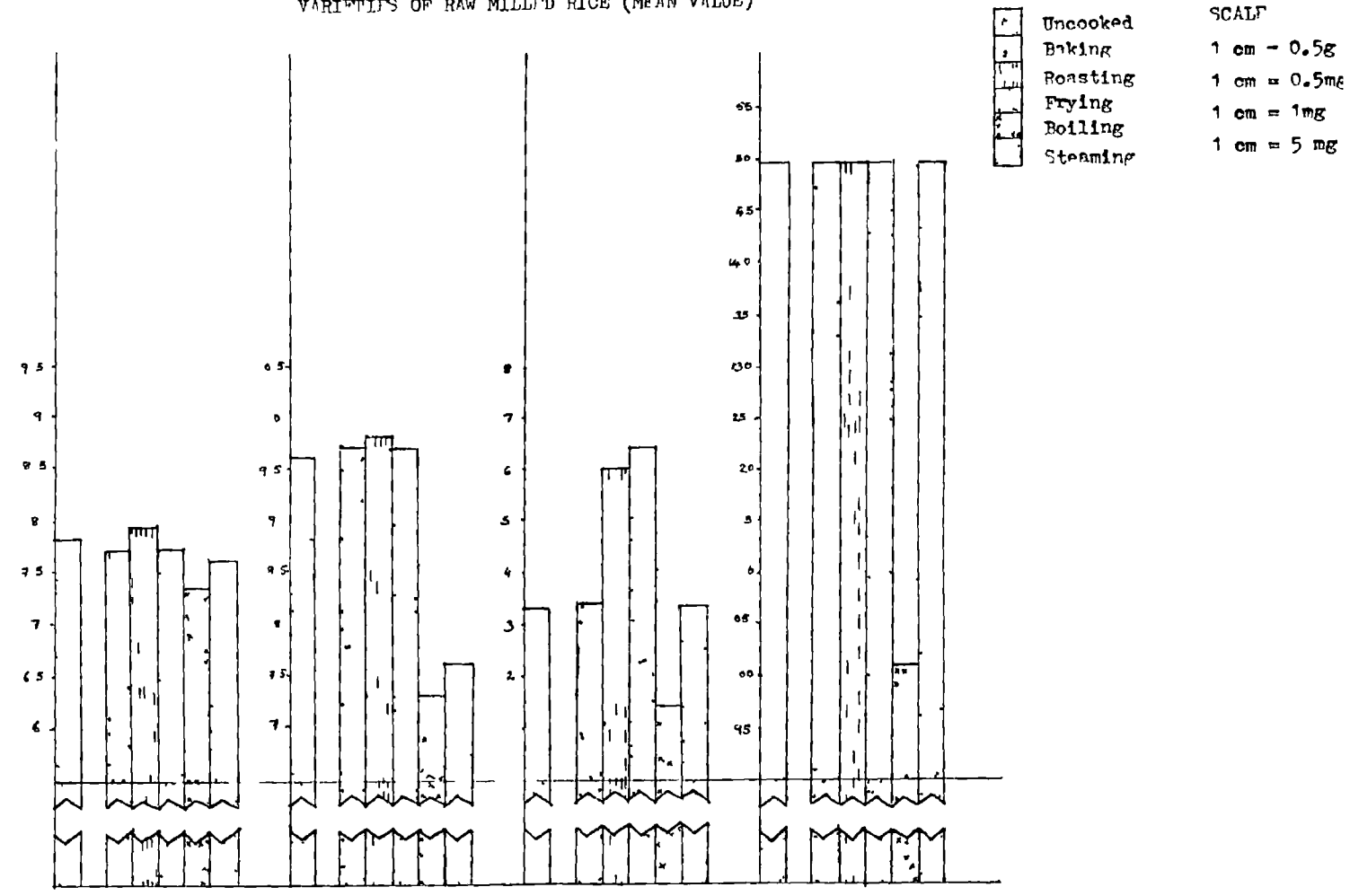
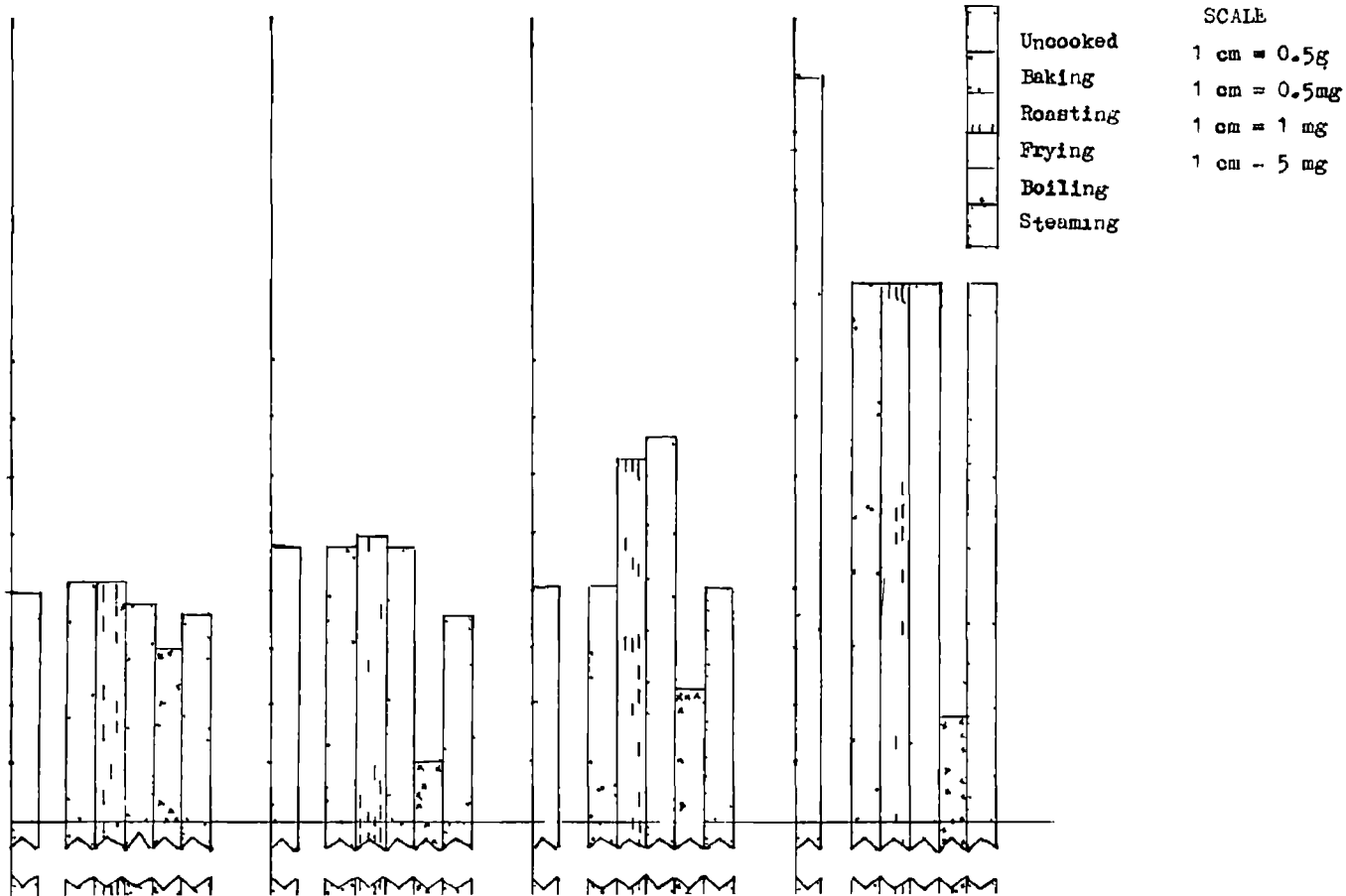
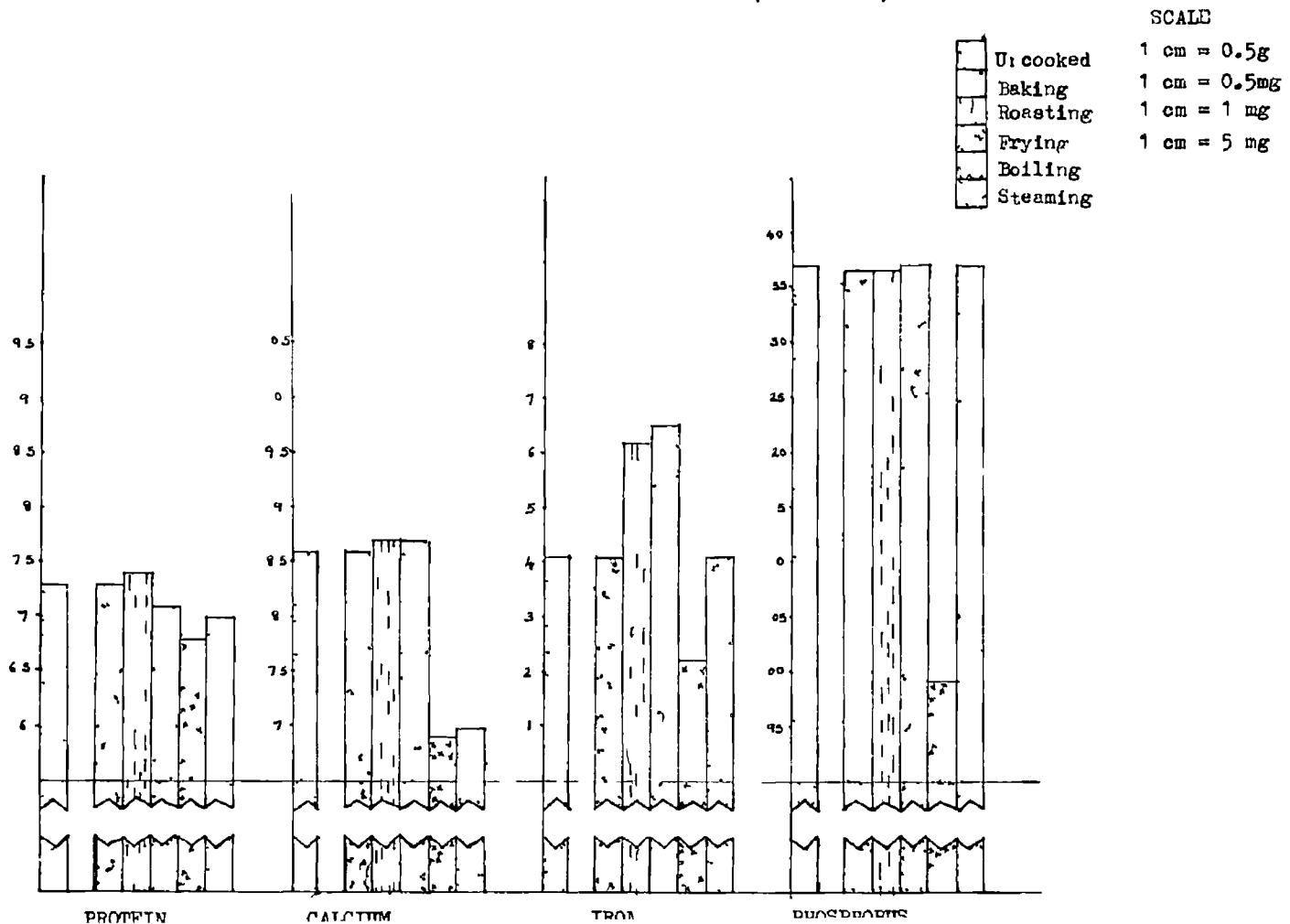


FIG 2 EFFECT OF DIFFERENT METHODS OF COOKING ON THE NUTRITIONAL COMPOSITION OF DIFFERENT VARIETIES OF PARBOILED MILLED RICE - RT SOAKING (MEAN VALUE)



F G 3 EFFECT OF DIFFERENT METHODS OF COOKING ON THE NUTRITIONAL COMPOSITION OF DIFFERENT VARIETIES OF PARBOILED MILLED RICE - C.W.SOAKING (MEAN VALUE)



An attempt was made to bring out the extent of interaction between the physical properties, cooking qualities and the nutritional composition of the different varieties under test through statistical correlation of different parameters The acceptability as derived from organoleptic tests was also included as one of the varieties in the correlation study The correlations which are technically relevant and statistically significant are presented in Table

Table 36

CORRELATION MATRIX

X_2	X_9	X_{12}	X_{13}	X_{15}	X_{16}	X_{17}	X_{18}	X_{19}	X_{20}	X_{21}	X_{42}	X_{43}
1 0000												
-0 3943**	-1.0000											
-0 0898	-0 0650	1.0000										
-0 2170	0 1126	-0.2006	1.0000									
-0 1523	0 1805	-0 0117	0 6486**	1.0000								
-0 4770**	0 0580	-0.0138	0.6572**	0.3735**	1.0000							
0 0890	0.1247	0 1623	-0.3988**	-0.1485	-0.0747	1 0000						
0.3252**	-0.0398	-0.3200**	0 4030**	0 2524*	0.1543	0 0471	1 0000					
-0 1220	-0.2270*	0 0432	-0 5153**	-0 4288**	-0 3045**	0.3707**	-0 4593**	1 0000				
0 0846	0 0101	0 1923*	-0 7408**	-0 4414**	-0 5486**	0 4475**	-0.3355**	0 6198**	1 0000			
0 0111	-0 2238*	0 1747	-0.8345**	-0 7509**	-0 4654**	0 2774**	-0 5163**	0.7277**	0 7419**	1.0000		
-0 0546	-0 1007	0 3755**	-0 2042*	-0 3593**	-0 1130	0 4841**	-0 2359*	0 6907**	0 4270**	0 4679**	1.0000	
-0 1577	-0 0772	-0 0706	0 0169	0.0798	0 0498	0.0122	-0 0285	0.1413	-0 0097	0.0338	-0.0154	1.0000

Significant at 1% level

Significant at 5% level

r value

$r_{100,\ 05} = 1946$

$r_{100,01} = .2540$

X_2 - Protein N

X_9 - Thousand grain weight

X_{12} - Grain dimensions of milled rice

X_{13} - Head rice yield

X_{15} - Gelatinization temperature

X_{16} - Optimum cooking time

X_{17} - Elongation ratio

X_{18} - Elongation index

X_{19} - Gruel loss

X_{20} - Volume of expansion

X_{21} - Water uptake

X_{42} - Total amylose

X_{43} - Acceptability

DISCUSSION

DISCUSSION

The present study on the "Quality parameters of popular rice varieties" was carried out to assess the nutritional composition, physical characteristics, cooking characteristics, as well as the organoleptic qualities of thirteen different rice varieties which included nine high yielding varieties evolved by KAU and four local varieties The effect of different methods of processing on the nutritional composition, physical characteristics, cooking characteristics, organoleptic qualities and the effect of different methods of cooking on the nutritional composition was also assessed

5.1 Nutritional composition

While assessing the nutritional composition of the rice varieties, major nutrients determined were calories, protein, calcium, iron, phosphorus, starch, fibre and ash

5.1.1 Calories

The calorific value of high yielding rice varieties evolved by KAU were found to be higher when compared to the local varieties studied In all the rice varieties the samples processed by parboiling in two

methods (Pr.2 and Pr 3) were found to obtain higher calorific value This might be 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 while such a phenomenon is not possible for raw milled rice The calorific value of the rice varieties were also found to be influenced by the starch content of the varieties since Bharathi which had the highest calorific value was found to contain the highest starch content also.

5 1.2 Protein

The high yielding rice varieties evolved by KAU were found to contain more protein as compared to the local varieties studied 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 43 g/100g but in the present study the protein content of the rice varieties evolved by KAU were in the range of 7 7 to 8 7 g/100g As shown by earlier works the variability in protein content of rice was mainly due to the environment in which it has been grown In the present study parboiling resulted in a decreas in the protein content

of rice varieties This is in line with the study of Schroeder (1965) who also reported a decrease in the protein value of rice due to decrease in total free amino acids content as a result of parboiling. Among the two parboiling methods tried the rice varieties parboiled by the cold water soaking method of parboiling (Pr.3) were found to secure the lowest protein value Higher amounts of protein was retained in the puffed rice samples.

5 1 3 Calcium

The local varieties were found to contain a lesser amount of calcium compared to the high yielding varieties evolved by KAU. This can be attributed to the high absorption rate of minerals into the grain in high yielding varieties Processing in general was found to affect the calcium content of all the varieties. Among the different processing methods tried rice samples processed by puffing were found to retain more calcium than the raw milled rice or rice samples parboiled by two methods This is probably because of loss of moisture during puffing The loss in calcium content consequent to parboiling may be due to the calcium being dissolved out by the parboiling water.

5.1.4 Iron

The iron content of high yielding varieties were higher when compared to the local varieties. The assessment of the iron content of rice varieties after processing indicated that there was an increase in the iron content after parboiling when compared to raw rice Earlier studies had reported an increase in iron content due to parboiling (Damir, 1985) Among different processing methods tried the puffed rice was found to contain a higher amount of iron

5.1.5 Phosphorus

A comparatively higher amount of phosphorus was seen in the high yielding varieties of rice evolved by KAU, than the local varieties studied. Among the different processing methods tried the phosphorus content was found to be experiencing a loss in all the processing methods except raw milled rice.

5.1.6 Starch

A wide variation was observed in the starch content of the different varieties of rice The lowest value for starch was recorded for the local variety Kazhama

and the high yielding variety Annapurna All other varieties were found to contain higher amounts of starch. A loss in the starch content was observed as a result of parboiling The same result was observed by Kuzimina and Torzhinskaya (1973).

5.1.7 Fibre

The fibre content was found to be more in the high yielding varieties evolved by KAU when compared to the local varieties Processing was found to have no effect on the fibre content of the rice varieties.

5.1.8 Ash

The ash content was found to be more or less same in all the varieties, except for a slight decrease in the local varieties Among the different processing methods tried, the rice samples processed by parboiling were found to retain more ash

An analysis of various nutrients present in rice samples, especially the protective nutrients like protein, calcium, iron and phosphorus had indicated that rice varieties evolved by KAU are nutritionally superior to the local varieties.

5.2 Physical characteristics

Major physical characteristics of the rice grains assessed were thousand grain weight, moisture content, grain dimensions, head rice yield and gelatinization temperature.

5.2.1 Thousand grain weight

Thousand grain weight is a factor which influences the popularity of rice varieties Most farmers prefer grains with a higher thousand grain weight In the present study the thousand grain weight of rice varieties evolved by KAU wa found to be lower when compared to local varieties Navara was an exception in this context Webb and Sterner (1972) reported that thousand grain weight of rice varieties varied considerably with the moisture content In the present study also, thousand grain weight was found to be higher in grains with higher moisture content The thousand grain weight of parboiled rice varieties were observed to be more when compared to raw rice

5.2.2 Moisture

Moisture content of rice grain are expected to be 13.7 g/100g for raw rice and 13.3 g/100g for parboiled rice (ICMR,1987) In the present study it was found to be ranging from 13.7 to 14.3 g/100g in raw rice and

13.4 to 14.03 g/100g in parboiled rice A slight decrease in moisture content after parboiling was reported in the studies of Luh and Mickus (1979)

5.2.3 Grain dimensions

Rice grains come in many sizes and shapes. The grain length and breadth differ greatly from variety to variety In the present study the effect of processing on the grain dimensions, ie. the length/breadth ratio of different rice varieties are estimated by assessing the length/breadth ratio of paddy, brown rice and milled rice.

5.2.3.1 Grain dimensions of paddy

The grain dimension ratio of the different paddy samples showed that there was not much difference in the ratio, between the evolved varieties and local varieties The grain dimension ratio was found to be decreased in parboiled rice samples when compared to raw samples The highest grain dimension ratio was observed for Jyothi.

5 2.3.2 Grain dimensions of brown rice

In the brown rice samples also much difference in the grain dimension ratio was not observed between the different varieties evolved by KAU and local

varieties. But the ratio was found to be decreased as a result of parboiling in all the varieties The highest value for length/breadth ratio was observed for Bharathi

5 2.3 3 Grain dimensions of milled rice

The values obtained for grain dimension of milled rice samples indicated a similar trend in both evolved varieties and local varieties And the parboiled samples showed a lesser grain dimension ratio when compared to raw rice samples.

5.2.4 Head rice yield

Head rice yield is the yield of whole milled rice, also called head milled rice, obtained on milling of paddy expressed as per cent In the present study the percentage head rice yield was found to be higher in high yielding rice varieties evolved by KAU when compared to the local varieties especially in the raw form Parboiling was found to increase the head rice yield. This result tally with the findings of Rajalekshmi (1984) The thousand grain weight of parboiled rice varieties were observed to be more when compared to raw rice.

5 2.5 Gelatinization temperature

The range of temperature at which the gelatinization of starch occurs is called the geletinization temperature.

The gelatinization temperature was found to be negatively influenced by the total amylose content. A considerable variation in the gelatinization temperature was observed among the varieties Compared to local varieties, evolved varieties were found to have higher gelatinization temperature especially in raw form. Processing of rice varieties were found to influence positively the gelatinization temperature since the parboiled rice visco gram show a higher gelatinization temperature when compared to raw rice Similar results were reported earlier by Ali and Bhattacharya (1980). This characteristic of evolved rice varieties have influenced the acceptability of the rice samples negatively

The physical characteristics such as thousand grain weight, head rice yield and gelatinization temperature are major factors determining the popularity of a variety compared to evolved varieties of KAU, local rice varieties were observed to score higher on these characters

5.3 Cooking characteristics

A major criterion generally considered while evolving new varieties are high yield. Earlier studies

had indicated that such high yielding exotic varieties had failed to gain acceptability among the farmers due to poor cooking quality (Prema and Menon 1969) Major cooking characteristics to be considered in this content are optimum cooking time, elongation ratio elongation index, gruel loss, volume of expansion, water uptake and amylose content

5.3.1 Optimum cooking time

In the present study the optimum cooking time did not vary much among different varieties, eolved as well as local varieties However a higher optimum cooking time was recorded for parboiled rice samples. This result is in accordance with the result of Priestley (1976)

5.3.2 Elongation ratio

Elongation ratio is the ratio between the length of cooked grain and length of raw grain Earlier studies had shown that the length wise expansion of cooked rice without increase in girth was a desirable trait and the world famous Basmati rice elongated 100 per cent upon cooking Among the varieties studied, the local varieties showed a medium increase in length, except for

Malaidumban which showed a higher elongation ratio. Among the high yielding rice varieties, the elongation ratio was found to be higher A slight decrease in the elongation ratio of all the varieties except Swarnaprabha was observed after parboiling Pillaiyar and Mohandoss (1981) had also reported that the temperature of parboiling influenced the linear elongation of the rice kernel after cooking

5.3.3 Elongation index

Elongation index is the ratio between the length width of cooked grain and length Width of uncooked grain 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 The elongation index in local varieties were found to be lesser except in the case of Kazhama when compared to high yielding varieties A slight increase in the elongation index was observed as a result of parboiling This can be explained by the finding of Kurien et al (1964) who had indicated that parboiled rice grains after cooking appeared bigger and bolder than cooked raw rice.

5.3.4 Gruel loss

Decreased gruel loss during cooking is advantageous

nutritionally. The solids lost through the cooking water include the water soluble vitamins, minerals, carbohydrates and to some extent proteins. The gruel loss was found to be more in local varieties when compared to the high yielding varieties evolved by KAU. The local variety Kazhama was an exception This variety obtained the lowest loss in gruel after cooking compared to all other varieties In the present study all the varieties showed a minimum loss in cooking when parboiled Earlier studies of Rajalekshmi (1984) had indicated similar trends.

5.3.5 Apparent water uptake

Apparent water uptake is the weight of moisture absorbed by the grain during cooking In the present study the parboiled rice samples were found to absorb a lesser amount of water during cooking The values obtained for water uptake among the varieties were almost the same for high yielding as well as local varieties of rice.

5.3.6 Volume of expansion

Higher volume of expansion after cooking is a desirable trait among the consumers as far as staple

food crops are concerned The volume of expansion was found to be influenced by the apparent water uptake during cooking increase in water uptake directly influences the volume of expansion of rice varieties In the present study the parboiled rice samples seemed to have a lesser percentage in volume of expansion when compared to raw rice samples Among the varieties studied higher values for volume of expansion were obtained for local varieties like Malaidumban, Navara and a high yielding variety, Jyothi

5.3 / Total amylose

Amylose is the linear molecular component of rice starch which determines the texture of cooked rice Amylose is the polysaccharide with which the starch granule is filled while the granule shell itself is composed of amylopectin The high amylose rice cook dry and fluffy In the present study the total amylose content was found to be more or less similar for all the varieties. The high yielding varieties Bharathi and Jyothi were exceptions The former variety gave the lowest value and the latter the highest value The parboiled rice samples gave lower values for totalamylose when compared to raw rice samples.

5.4 Organoleptic qualities

The organoleptic qualities and acceptability of the different rice varieties were assessed by determining their appearance, colour, flavour taste, doneness and adhesiveness using the score card method by a selected taste panel

5.4.1 Appearance

When the appearance of the different rice varieties processed by three different methods, was taken into consideration it was seen that all the local varieties obtained higher scores Among the local varieties Malaidumban was highly acceptable and among high yielding varieties Mahsuri and Pavizham evolved by KAU were the most preferred ones compared to raw rice samples, in general parboiled rice scored higher value for appearance Earlier studies had indicated that parboiled rice retained better shape after cooking was fluffy and less cohesive (Priestley, 1976).

5.4.2 Colour

The quality attribute colour was found to be varying widely among the varieties The local varieties, in general, were found to obtain a higher score for colour In the present study preference was shown for raw rice

samples Parboiled rice samples showed a decrease in the mean scores obtained for colour in local as well as evolved varieties 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 the pigments inward to the endosperm which imparts a darker colour to the grain (Garibaldi, 1974) But in an earlier study conducted by Roberts (1970) it was reported that fifty per cent of the consumers preferred on overall basis under milled rice samples though by colour alone they were less preferred.

5.4.3 Flavour

Considering the flavour of the different rice varieties it was observed that, in general, the preference was more for local varieties It was also observed that the parboiled rice samples had obtained a higher mean score for flavour, when compared to the raw rice samples in local as well as evolved varieties.

5.4.4 Taste

Data on the mean scores obtained for taste shows that the local varieties in general scored higher values for taste The taste of the rice samples were found to be improved as a result of parboiling

5 4.5 Doneness

For doneness a higher mean score was obtained for local varieties except Kazhama The mean scores obtained for doneness were less for parboiled rice in all the varieties.

5.4.6 Adhesiveness

When the adhesiveness of the different rice varieties were considered the local varieties except Kazhama was found to obtain a higher mean score. The parboiling was found to decrease this quality

5.5 Effect of different methods of cooking on the nutritional composition.

The effect of different methods of cooking on the nutritional composition of different varieties of rice processed by different methods (B_1, B_2 & B_3) were assessed The cooking methods tried were baking, roasting, frying, boiling and steaming The nutrients analysed were protein, calcium, iron and phosphorus

5 5 1 Protein

The protein content was found to vary significantly among the varieties and the cooking methods. In general the local varieties were found to retain a lesser amount of protein when compared to the high yielding varieties

evolved by KAU after cooking The cooking method boiling which involved the discarding of cooked water resulted in a significant loss of protein, compared to boiling Other methods of cooking retained a higher amount of protein but when compared to uncooked samples the cooking methods were found to decrease the protein content. This result is in accordance with Rajalekshmi (1984) The cooked rice samples were also found to be having a decreased protein content for parboiled rice The roasted samples of the rice varieties were found to retain the highest amount of protein.

5.5.2 Calcium

When the calcium content was taken into consideration it was observed that in general, the high yielding varieties evolved by KAU were found to retain a higher amount of calcium when compared to the local varieties studied In general the calcium content experienced a loss during cooking The most significant loss was observed in boiling which involved the discarding of cooked water. The calcium content was found to be least altered by roasting Earlier studies by Rajalekshmi (1984) indicated that if the cooked water was discarded, the loss was more significant.

5.5.3 Iron

From the data it was observed that the local varieties retained lesser amount of iron after cooking, than the evolved varieties. A marked loss in the iron content was observed when the samples were boiled and the cooked water was discarded A more significant increase in the iron content was observed when the samples were roasted or fried This might be due to the fact that the iron content from the cast iron pans used, might have got incorporated into the samples (Rajalekshmi, 1984) The iron content was found to be increased as a r esult of parboiling in all the cooking methods.

5.5.4 Phosphorus

The local varieties were found to retain a lesser amount of phosphorus, when compared to the high yielding varieties evolved by KAU The phosphorus content was found to be experiencing a loss after cooking only when the sample was boiled and the cooked water was discarded. All other methods of cooking were found to retain a comparatively higher amount of phosphorus

5.6 Correlation studies

A general review of the results of correlation studies revealed that the nutritional composition of rice

varieties are not determined by the physical features of the grains, the nutritional composition do not influence the cooking quality either Same was the case with the relationship between the acceptability and the nutrient content Therefore a rice variety with attractive physical features as well as best cooking qualities need not be recommendable in terms of nutritional value The only one nutritional parameter found to have a certain extent of influence on the physical or cooking qualities was the protein content, however, the correlations of protein with other parameters do not suggest any significant inference, except that a high protein content may result in short cooking times lower head rice yield as evidenced by the significant negative correlation obtained.

The physical characteristics of rice grains were found to have profound influence on the cooking quality of rice This was evident from the sigrificant correlations obtained between head rice yield as well as gelatinization temperature and the various cooking qualities A variety which is prone to breakage during processing may result in a higher elongation index, high gruel loss, high volume of expansion and high water uptake during cooking Moreover the total amylose content also will be higher in cases where the head rice

yield is low. The optimum cooking time is increased when the head rice yield as well as gelatinization temperature are higher and when protein content is lower.

An assessment of the gelatinization temperature will reveal many of the cooking qualities of a rice variety especially the optimum cooking time, elongation index, gruel loss, volume of expansion, water uptake and total amylose content Optimum cooking time and elongation index were found to increase wherever gelatinization temperature is high The correlation between gelatinization temperature and the other cooking qualities are however negative.

Another significant observation is that most of the cooking qualities under study are interrelated and the data on any one parameter may give an indication of the other qualities However a scientific explanation on the possible reasons of the observed interactions can be given only through a histological/ embryological/physiological approach, which do not come under the perview of the present investigation.

Another interesting finding from the correlation studies is that, the ultimate acceptability of a rice variety after it is cooked (revealed through organoleptic tests) is not influenced by neither the physical features nor the cooking qualities. Hence it can be concluded that the choice of rice varieties depends mainly on personal preference of the consumer for physical attractiveness as well as easiness in cooking The palatability of rice is accepted more or less uniformly irrespective of the features which may affect the selection of rice for cooking.

SUMMARY

SUMMARY

The study on 'Quality parameters of popular rice varieties" was an assessment of the effect of different methods of processing on the nutritional composition, physical characteristics, cooking characteristics and organoleptic qualities The effect of different methods of cooking on the nutritional composition of the processed rice varieties was also assessed The results of this study are summarised below

1 The assessment of calorific value of different rice varieties revealed that the high yielding varieties of rice evolved by KAU retained higher amount of calories when compared to local varieties Processing by parboiling was found to increase the calorific value in all the varieties.

2. The protein content was found to be higher in the high yielding varieties of rice evolved by KAU when compared to the local varieties. Processing by parboiling was found to decrease the protein content while an increase in protein content was observed as a result of puffing in all the varieties.

3 The high yielding varieties of rice evolved by KAU obtained higher values for minerals namely calcium, iron and phosphorus when compared to the local varieties Processing by parboiling was found to decrease the content of calcium and phosphorus, while an increase in the iron content was observed as a result of parboiling The calcium and iron content of all the varieties were found to be retained more in puffed rice samples, while phosphorus was found to be decreased

4. The starch content was found to be more or less similar in all the varieties Parboiling was found to decrease the starch content

5. The non-nutrient fibre content was found to be higher in the high yielding varieties evolved by KAU when compared to the local varieties studied Parboiling per se had no effect on the fibre content

6 The ash content was found to be slightly higher in the high yielding rice varieties evolved by KAU than the local varieties The samples were found to retain more ash when parboiled.

7. The thousand grain weight was found to be higher in local varieties of rice when compared to the high yielding varieties evolved by KAU Parboiling was found to increase the thousand grain weight

8 A comparatively higher moisture content was observed in the local varieties and the moisture content was found to be decreased as a result of parboiling.

9 No significant difference in the grain dimensions was observed between the local varieties and high yielding varieties of rice evolved by KAU But the grain dimension ratio was found to be decreased as a result of parboiling

10 The head rice yield was found to be higher in the evolved varieties of KAU in the raw form but a higher percentage head rice yield was obtained for local varieties when parboiled. A marked increase in the head rice yield was observed when parboiled.

11 When compared to the local varieties studied the high yielding varieties of rice evolved by KAU were found to have a higher gelatinization -

temperature especially in the raw form The gelatinization temperature was found to be higher in parboiled rice samples.

12. The optimum cooking time did not vary much among the different varieties of rice studied, both high yielding as well as local varieties However a higher optimum cooking time was observed for the parboiled rice samples of all the varieties.

13 When compared to the local varieties the elongation ratio was found to be higher in the high yielding varieties of rice evolved by KAU In general a slight decrease was found in the elongation ratio of cooked rice after parboiling

14. The elongation index was found to be higher in the high yielding rice varieties evolved by KAU, when compared to the local varieties A slight increase in the elongation index was observed as a result of parboiling.

15 The gruel loss after cooking was found to be higher in the local varieties, when compared to the high yielding varieties of rice evolved by KAU The loss of solids in the gruel was found to be decreased as a result of parboiling

16. The values obtained for apparent water uptake did not show any marked difference between the local and high yielding varieties evolved by KAU Parboiling was found to decrease the apparent water uptake by all the varieties

17 The volume of expansion after cooking was found to be influenced by the water uptake Increase in water uptake directly influenced the volume of expansion of the rice varieties The volume of expansion was found to be decreased as a result of parboiling

18 The total amylose content was found to be more or less similar for both local as well as high yielding varieties of rice evolved by KAU Parboiling was found to decrease the total amylose content in all the varieties

19 From a study on organoleptic qualities, the mean scores obtained for appearance showed that all the local varieties obtained higher scores Compared to raw rice samples, in general, the parboiled samples scored a higher value.

20. A higher mean score for colour was obtained for the local varieties. The colour preference was found to be more for raw rice samples when compared to parboiled rice samples

21 Considering the flavour of the different rice varieties, it was found that the preference was more for local varieties The parboiled rice samples had obtained a higher mean score for flavour

22 The data on the mean scores obtained for taste showed that the local varieties in general scored higher values The taste of the rice samples were found to be improved as a result of parboiling

23 For doneness a higher mean score was obtained for local varieties A decrease in mean scores for doneness was observed for all the varieties as a result of parboiling.

24 The local varieties were found to obtain a higher mean score for adhesiveness Parboiling was found to decrease this quality

25 The protein content was found to be least altered by the method of roasting The cooking method boiling which involved discarding of cooked water resulted in a significant loss of protein Other methods of cooking such as baking frying and steaming retained a higher amount of protein but when compared to uncooked samples, the cooking methods were found to decrease the protein content The cooked rice samples were found to be having a decreased protein content for parboiled rice

26 The calcium content experienced a loss during cooking A more significant loss was observed in boiling which involved the discarding of cooked water It was found to be least altered by roasting The parboiled rice samples when cooked experienced a loss in calcium content

27. The iron content of the different rice varieties were found to be significantly increased as a result of roasting and frying in an iron pan and also found to be experiencing a significant loss as a result of boiling and discarding the cooked water The iron content of cooked rice was found to be increased as a result of parboiling.

28 The phosphorus content of the different rice varieties were found to be experiencing a loss when boiled and the cooked water was discarded. All other methods of cooking were found to retain a comparatively higher amount of phosphorus Parboiling was found to decrease the phosphorus content after cooking

29 The results of the correlation studies revealed that the nutritional composition of rice varieties were not determined by the physical characteristics of the grains The nutritional composition did not influence the cooking quality either The only one nutritional parameter which have a certain extent of influence on the physical or cooking qualities was the protein content.

30 The physical characteristics of rice grains were found to have profound influence on the cooking quality of rice This was evident from the significant correlations obtained between head rice yield and gelatinization temperature and the various cooking qualities

31 Most of the cooking qualities studied were interrelated and the data on any one parameter may give an indication of the other qualities.

32 The ultimate acceptability of a rice variety after it is cooked was not influenced by neither the physical features nor the cooking qualities.

The results of the study enables one to conclude that the evolved varieties compared to local varieties have better nutritional composition Cooking qualities and physical characteristics were also on the advantageous side for the high yielding varieties evolved by KAU. There are two options before the plant breeders while they recommend varieties for popularisation, that is, either the varieties should have attractive physical characteristics and easy cooking qualities, or the consumer should be made aware that these qualities are not going to affect the ultimate taste of the prepared product It may also be noted that during the organoleptic test presented elsewhere, it was revealed that local varieties with low nutrient contents were more acceptable than the improved varieties with better nutritive values Therefore public awareness programmes on the nutritional advantageous of new variety should be initiated while it is released for cultivation This may prevent the extinction of otherwise promising varieties just because of the physical nature of the grain or its cooking quality.

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APPENDICES

APPENDIX - I

EVALUATION CARD FOR TRIANGLE TEST

Name of the product Sugar solution

Note Two of the three samples are identical
Identify the odd sample

Serial No	Code No of sample	Code No of identical samples	Code No of odd samples

APPENDIX -II

Score card for the organoleptic evaluation of different varieties of cooked rice

Quality attributes	Sub divisions of attributes	Score to each sub-division	Score for samples Code No											
			I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
Appearance	Excellent	5													
	Good	4													
	Satisfactory	3													
	Fair	2													
	Poor	1													
Colour	Pure white	5													
	Pinkish white	4													
	Brownish white	3													
	Chalky white	2													
	Yellowish white	1													
Flavour	Excellent	5													
	Good	4													
	Satisfactory	3													
	Fair	2													
	Poor	1													
Taste	Excellent	5													
	Good	4													
	Satisfactory	3													
	Fair	2													
	Poor	1													

CONTD

Quality attributes	Sub divisions at attributes	Score to each sub-division	Score for samples Code No									
			I	II	III	IV	V	VI	VII	VII	IX	X	XI	XII
Doneness	Well cooked	5												
	Fairly cooked	4												
	Just cooked	3												
	Slightly under cooked	2												
	Slightly over cooked	1												
Adhesiveness	Grainy	5												
	Not sticky	4												
	Moderately sticky	3												
	Very sticky	2												
	Waxy	1												

APPENDIX III

Effect of processing on the nutritional composition of different rice varieties

Abstract of ANOVA

Source	D F	Mean squares			
		Protein	Calcium	Iron	Phosphorus
Variety (Va)	12	7 154**	4.892**	1 212**	276 896**
Processing methods (Pr)	3	24 451**	1626 971**	66.745**	2836 583**
Va x Pr	36	0 238**	0 624**	0.301**	75 424**
Error	104	0.003	0 007	0 0007	0.091

** Significant at 1% level

* Significant at 5% level

APPENDIX IV

Effect of processing on the nutritional composition of different rice varieties

Abstract of ANOVA

Source	D F	Mean squares			
		Calories	Fibre	Ash	Starch
Variety (Va)	12	2709**	0 020**	0.004**	167 867**
Processing methods (Pr)	2	1071**	0 0006**	0 091**	251 906**
Va X Pr	24	49 917**	0 001**	0 0008**	17 108**
Error	78	2 731	0 0001	0 0002	0 009

** Significant at 1% level

* Significant at 5% level

APPENDIX V

Effect of processing on the physical characteristics of different rice varieties

Abstract of ANOVA

Source	D.F	Mean squares						
		Thousand grain weight	Grain dimensions of paddy	Grain dimensions of brown rice	Grain dimensions of milled rice	Moisture	Head rice yield	Gelatinization temperature
Variety (Va)	12	208 069**	0 632**	0 569**	0 404**	0 255**	259 161**	45 547**
Processing methods (Pr)	2	3 281**	0 459**	0 203**	0.129**	1 148**	13469 270**	253 281**
Va x Pr	24	0 405**	0 032**	0 031**	0.018**	0 017**	88 367**	8 900**
Error	78	0 009	0 0005	0 0002	0.00008	0.0004	0.026	0 821

** Significant at 1% level

* Significant at 5% level

APPE DIX VI

• Effect of processing on the cooking characteristics of different rice varieties

Abstract of ANOVA

Source	D.F	Mean squares					
		Elonga-tion ra io	Elonga-tion index	Gruel loss	Apparent water uptake	Volume of expansion	Total amylose
Variety (Va)	12	0 109**	0 092**	3 443**	0 160**	4415.2618**	36 161**
Processing methods (Pr)	2	0 149**	0 181**	12 210**	2 414**	178943 69**	7 910**
Va x Pr	24	0 005**	0 015**	0 248**	0 012**	4804.0425**	2 676*
Error	78	0 0003	0 0006	0 0003	0 0005	5.0166	0.0003

** Significant at 1% level

* Significant at 5% level

APPENDIX VII

Effect of processing on the organoleptic characteristics of different rice varieties

Abstract of ANOVA

Source	D.F	Mean squares					
		Colour	Appearance	Flavour	Taste	Doneness	Adhesiveness
Variety (Va)	12	3 836*	2 667*	5 743**	1 542^{ns}	1.542^{ns}	0.676^{ns}
Processing methods (Pr)	2	3 499**	4 149**	0.369^{ns}	0 754^{ns}	1 163^{ns}	2.072**
Va x Pr	24	0 791^{ns}	2 239**	0 459^{ns}	0 559^{ns}	0 448^{ns}	1.062*
Error	78	0 850	0 828	0 789	0 75	0 905	0 596

** Significant at 1% level

* Sign ficant at 5% level

ns Not significant

APPENDIX VIII

Effect of different methods of cooking on the nutritional composition of different rice varieties

Source	D.F	Mean squares			
		Protein	Calcium	Iron	Phosphorus
Variety (A)	12	30 961**	9 101**	3 625**	1688 667**
Processing method(B)	2	12 374**	47 844**	22 322**	15021**
Cooking method (C)	4	5 194**	39 636**	410.945**	41982 25**
A x B	24	0 642**	1 225**	0 257**	162 625**
B x C	8	0 079**	0 320**	1 378**	433 25**
A x C	48	0 152**	0 465**	0 389**	30 667**
A x B x C	96	0 027**	0 036**	0.057**	8 812**
Error	388	0.004	0 007	0.002	0 149

** Significant at 1% level

* Significant at 5% level

QUALITY PARAMETERS OF POPULAR RICE VARIETIES

BY

SREEDEVI A

ABSTRACT OF A THESIS

submitted in partial fulfilment of the requirement

for the Degree

MASTER OF SCIENCE IN FOOD SCIENCE AND NUTRITION

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Department of Home Science

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Vellayani Trivandrum

1989

ABSTRACT

A study was conducted on the "Quality parameters of popular rice varieties" The study was based on the assessment of the nutritional composition, physical characteristics, cooking characteristics and organoleptic qualities as influenced by different processing methods. The effect of different cooking methods on the nutritional composition was also assessed

The results of the analysis showed that all the nutrients studied were found to be higher in the high yielding rice varieties evolved by KAU when compared to the local varieties studied Among the nutrients analysed, the calorific value, iron content and ash content were found to be increased as a result of parboiling, while all other nutrients experienced a loss. Protein, calcium and iron were experiencing an increase as a result of puffing

The physical characteristics studied showed that the local varieties were having a higher value for thousand grain weight and moisture content, while the grain dimensions, head rice yield and gelatinization temperature were found to be higher in the high yielding

varieties evolved by KAU As a result of parboiling all the physical characteristics except moisture content and grain dimension ratio were found to be increased.

The cooking characteristics studied revealed that there was not much difference in the optimum cooking time, water uptake, volume of expansion and total amylose between the local as well as evolved varieties But the elongation ratio and elongation index was found to be higher in the high yielding varieties of rice evolved by KAU. A decrease in all the cooking characteristics except optimum cooking time and elongation index was observed as a result of parboiling

The organoleptic qualities of the different rice varieties showed a marked preference for the local varieties in all the six quality attributes studied. Among the six quality attributes, appearance flavour and taste were found to obtain a higher mean score as a result of parboiling.

The results of the effect of different methods of cooking on the nutritional composition showed that all the nutrients studied were experiencing a loss when boiled and retained more when roasted The protein, calcium and phosphorus content were found to be decreased

as result of parboiling after cooking, while the iron content was increased Roasting and frying in a cast iron pan was found to increase the iron content In general the high yielding varieties of rice evolved by KAU were found to contain higher amounts of all the nutrients studied when compared to the local varieties after cooking

The results of correlation analysis revealed that the nutritional composition of rice varieties were not determined by the physical characteristics of the grains The nutritional composition did not influence the cooking quality either The physical characteristics of rice grains were found to have profound influence on the cooking quality of rice Most of the cooking qualities studied were inter related The ultimate acceptability of a rice variety after it was cooked, was not influenced by neither the physical features nor the cooking qualities

The results of the study enables one to conclude that the high yielding rice varieties evolved by KAU when compared to local varieties have better nutritional composition, though to taste panels on the basis of organoleptic qualities local varieties were more preferred Cooking qualities and physical characteristics were also on the advantageous side for the evolved varieties.