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Evaluation and Comparison of Cooking and Eating Characteristics of Some Selected Rice Varieties in Jaffna Peninsula

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Abstract

The study was undertaken to evaluate and compare the cooking and eating characteristics of twelve rice varieties selected from different areas of Jaffna Peninsula which include both traditional and improved varieties. It is also intended to identify useful correlation among different grain quality characteristics. Cooking and eating characteristics like minimum cooking time, water uptake ratio, gruel solid loss, elongation ratio, cooked length-breadth ratio, gelatinization temperature and gel consistency were measured. Length and breadth of rice grains after cooking was measured by using digital image processing system. The minimum cooking time of selected rice varieties varied from 15 minutes (Basmati) to 35 minutes. Cooking time was positively correlated with water uptake and gruel solid loss but cooked length breadth ratio was correlated negatively. Water uptake was highest for 'Anilvariyan' (4.129g) and lowest value was observed for Basmati (1.977g). Highest and lowest gruel solid loss was observed in 'Anilvariyan' (3.65%) and Basmati (1.97%) respectively. Elongation ratio of tested varieties varied from 1.038 (Basmati) to 1.282 (Bg 358). Cooked length breadth ratio was highest for Basmati (2.726) and lowest for Bg 358 (1.562). Highest and lowest alkali spreading value was found in varieties such as Basmati, At 353 and H4 (55 °C to 69 °C) and Bg358 (>74 °C) respectively.

Key words: Cooking and Eating Characteristics, Rice Varieties, Jaffna Peninsula

Introduction

In the northern part of Sri Lanka's Jaffna district rice is seeded in October on well-drained to moderately drained fields which may or may not be bunded, but it may be harvested under partially flooded conditions (Datta, 1975). The target extent of paddy cultivation is 9026 ha during 2006-2007. But only 6627 ha of land was sown with paddy and 5088ha of paddy land was harvested. The total paddy production was 11824 metric tones in 2005-2006 that goes down to 4960 metric tones in 2006-2007 (Department of Agricultural Extension, 2006-2007).

Rice breeders have emphasized yield as their main breeding objective in the past. The grain quality has been given a secondary importance. The free and subsidized rice ration system which existed in Srilanka was not conducive

for creating an effective demand for better quality rice. But the recent increases in per capita income have created a growing consumer demand for physical purity as well as for better intrinsic quality of rice (Banda, 1999). Due to the increased demand for high quality rice; quality improvement has a paramount importance in the current context.

Materials and Methods

Sample collection

Rice grain samples of twelve different varieties were collected from Department of Agricultural Extension office, Thirunelvely and farmers from different parts of Jaffna peninsula like Vaddukoddai, Karaveddi, Manipay and Chavakachcheri during the period of July to August 2007.

These samples include traditional varieties such as 'Moddaikaruppan', 'Periavellai', 'Periakaruppan' and 'Anilvariyan' and improved varieties having red pericarp rice such as H4, CO10, Bg 406(500-1), At 353, At 358 and At 402 and improved varieties having white pericarp rice such as Bg 358 and Basmati. All paddy samples were sun dried separately for three consecutive days. Dried samples were cleaned by using winnowing fan and they were kept in the same storage condition (temperature 26.5 °C to 29.1 °C and RH 75% to 77%) until processed. These samples were used for the measurement of cooking and eating characteristics of rice.

Materials

Water bath, Electronic balance, Filter paper, Funnel, Beakers (50ml), Petridishes, CANON camera, Black cloth

Minimum cooking time

Head rice (two gram) sample of each replicate were taken in a test tube from each variety and were cooked with 20ml distilled water in a boiling water bath at 90 °C. The cooking time was determined by removing a few kernels at five minutes time intervals during cooking and pressing them between two glass plates until no white core was left. Minimum cooking time is the time taken by the grain in which no white core is left within the rice kernel.

Water uptake

Head rice sample (two gram) for each variety were cooked in 20ml distilled water for a minimum cooking time in a boiling water bath at 90 °C. The contents were drained and the superficial water on the cooked rice was sucked by pressing the cooked samples in filter paper sheets. The cooked samples

were then weighed accurately by an electronic balance and the water uptake ratio was calculated. This procedure was carried out in each replicates for each variety.

Water uptake = Weight of rice after cooking – Initial weight of rice

Gruel solid loss

Head rice sample (two gram) in 20ml distilled water, for each variety, were cooked for minimum cooking time in a boiling water bath at 90 °C. The gruel were transferred to 50ml beakers with several washings and made to volume with distilled water. The aliquot having leached solids was evaporated at 110 °C in an oven until completely dry. The solids were weighed and percent gruel solids were reported.

Gruel solid loss

$$\text{Percentage} = \frac{\text{Weight of beaker with gruel solid} - \text{Initial weight of beaker}}{\text{Initial weight of sample}} \times 100$$

(Singh et al., 2005).

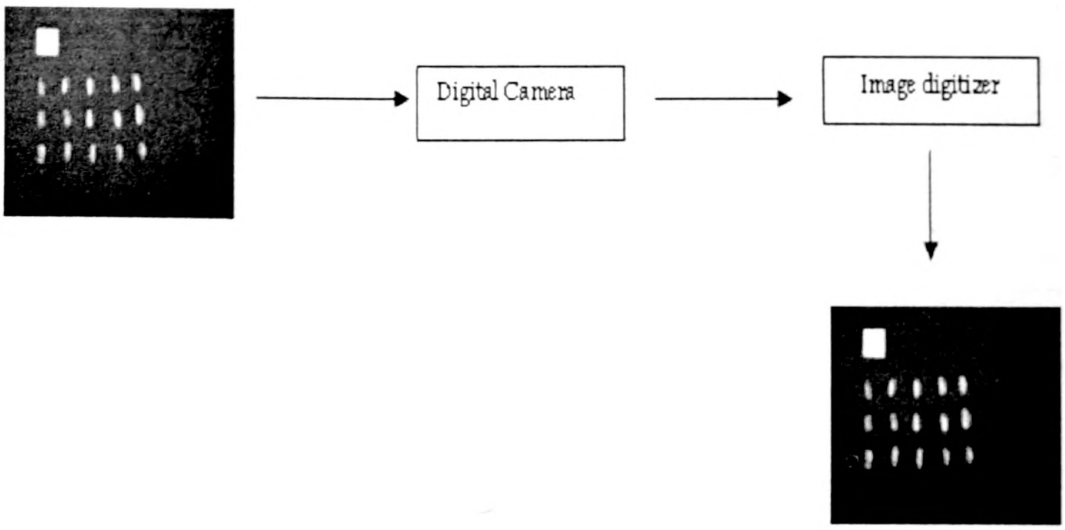
Measurement of length and breadth of rice by using digital image processing

Fifteen grains were taken as samples. The grains were used to obtain digital images using CANON A400 digital camera.

Image acquisition and pre-processing

A dark blue black background was used for acquiring the images of rice grains to improve contrast. Fifteen (15) rice grains were placed on the dark blue cloth within the frame physically separated from each grain as shown in sample images. The pictures were acquired under natural diffused day light conditionsThe objectives were to estimate the shape distribution of grains, it was necessary to find a means of calculating the (length/breadth) ratio of grains in a sample. In order to facilitate this task, a 1cm x 1cm white square piece of paper was placed on the black cloth along with the rice grains before acquiring the image. This was expected to provide a way of calculating the actual distances. Under any magnification or zoom setting of the camera, even if it may vary from sample to sample (Figure 1).

Digital images thus obtained were saved in the JPEG file format. The ultimate objective of this effort was to extract features from rice images to get quality statistics. However it was necessary to pre-process the images before each rice grain is identified and other parameters are extracted (Alahakoon and Chamikara, 2005).



Figurel: Image acquisition setup

Image analysis software system

Images were analyzed by using Coral draw 11 version .The program developed for rice image analysis starts to evaluate the physical qualities of rice once an image file is selected and import into the Coral draw package. Then the selected image was expanded and dimension tool was activated. Expanded length and width of 1cm x 1cm square piece paper was measured and then the sample also. After that, expanded length of square piece of paper and sample were converted to actual length and breadth by using Microsoft Excel 2003.

Elongation Ratio

Elongation ratio means the length of cooked grains kernels divided by length of uncooked raw kernels. Length of cooked and uncooked rice kernels were obtained by digital image processing system said by Alahakoon and Chamikara (2005).

$$E(\text{Elongation ratio}) = \frac{L\ (\text{Length of cooked rice kernel})}{L\ (\text{Length of raw rice kernel})}$$

Cooked length-Breadth ratio

Cooked length-breadth ratio means length of cooked rice kernels divided by the breadth of cooked rice kernels. Cooked length-Breadth ratio of rice was

determined by digital image processing system said by Alahakoon and Chamikara (2005).

$$\text{Cooked length breadth ratio} = \frac{\text{L (Length of cooked rice kernel)}}{\text{B (Breadth of cooked rice kernel)}}$$

(Singh et al., 2005).

Gel consistency test

All rice samples were ground separately to a fine powder by domestic grinder at 29.1 °C and sieved through a 125 µm sieve in the laboratory. These samples were stored in the same room for at least two days so that the moisture content is similar. One hundred milligram of powder was weighed in duplicate in to the culture tubes (13 x 100mm). Then ninety five percentage ethyl alcohol of 0.2ml containing 0.025 % Thymol blue (alcohol prevents clumping of the powder during alkali gelatinization, while Thymol blue imparts colour to the alkali paste to make the gel front easier to read) was added into the above culture tubes and later 2.0ml of 2M KOH was added. The contents were mixed using a Vortex Genie mixer with the speed set at six. The test tubes were covered with screw cap (To prevent steam loss and to reflux the samples). The samples were cooked in a vigorously boiling water bath at 100 °C for eight minutes. The test tubes were removed from the water bath and left to stand at room temperature (29.1 °C) for five minutes. The tubes were cooled in an ice-water bath at 0 °C for 20 minutes and laid horizontally on a laboratory table lined with millimeter scale graphing paper. The total length of the gel was measured in millimeter from the bottom of tube to gel front.

Gelatinization Temperature

A duplicate set of ten whole-milled rice kernels without cracks from each variety was selected and placed in a petridish (95 mm diameter). Then thirty five milliliter of 1.7 % (0.3035 M) potassium hydroxide (KOH) solution was added into the above Petridishes. The samples were arranged to provide enough space between kernels to allow for spreading. The Petridishes were covered and allowed for overnight at room temperature (29.1 °C). Starchy endosperm was rated visually based on a seven-point numerical spreading scale. The degree of spreading was increased with increasing score.

Score 1-No effect on grain at all.
Score 7- Grain completely dissolved (Cruz, 2002).

Statistical analysis

Data related to cooking and eating characteristics of rice obtained from replicates of each variety were fitted into a completely randomized design

(CRD) and analyzed with ANOVA for significance, under $\mu = 0.05$ using SAS for Windows version 8.0.All correlation coefficients were obtained by fitting data of relevant variables into Pearson correlation test using SAS Windows version 8.0.

Results and Discussion

Minimum cooking time

Cooking time of the rice depends on coarseness of the grain and its gelatinization temperature. Data from this study showed that the cooking time of rice varieties varied from 15 minutes to 35 minutes. All traditional varieties and Bg 406 and At 358 had the highest cooking time (35 minutes) followed by At 402 (30 minutes) (Table 1).

Table 1: Cooking characteristics of the selected rice varieties in Jaffna

Varieties	Minimum cooking time (min)	Water uptake	Elongation ratio	Gruel solid loss	Cooked length Breadth ratio
'Moddaikaruppan'	35	3.409(±0.157)	1.150	2.840(±0.260)	1.894(±0.050)
'Periavellai'	35	3.195(±0.090)	1.132	2.597(±0.132)	1.855(±0.052)
'Periakaruppan'	35	2.997(±0.187)	1.125	2.400(±0.202)	1.864(±0.008)
'Anilvariyan'	35	4.129(±0.245)	1.210	3.626(±0.260)	1.962(±0.099)
H4	25	4.063(±0.074)	1.052	2.193(±0.058)	2.574(±0.080)
Bg 406	35	2.908(±0.123)	1.154	1.599(±0.058)	1.932(±0.045)
CO10	25	2.692(±0.264)	1.047	1.824(±0.225)	1.791(±0.091)
Bg 358	20	3.013(±0.075)	1.282	1.994(±0.050)	1.562(±0.060)
Basmati	15	1.978(±0.297)	1.042	1.212(±0.247)	2.726(±0.188)
At 353	25	2.836(±0.045)	1.100	1.948(±0.029)	2.568(±0.049)
At 358	35	2.916(±0.135)	1.212	1.445(±0.202)	1.984(±0.038)
At 402	30	2.479(±0.061)	1.130	1.558(±0.029)	2.080(±0.084)

Basmati variety showed the lowest of cooking time of 15 minutes. Bg 358 also has white pericarp like Basmati, but its cooking properties differed from Basmati. It had the cooking time of 20 minutes. Long medium grains of H4 and At 353 showed the cooking time of 20 minutes except Indian variety CO10 which had the cooking time of 25 minutes.

Water uptake

Water uptake was highest for 'Anilvariyan' (4.129g) followed by 'Moddaikaruppan' (4.063g), and 'Periavellai' (3.409g), whereas Basmati rice had the lowest water uptake (1.977g). Water uptake of 'Anilvariyan' and 'Moddaikaruppan' were not significantly differed ($p>0.05$) with each other and statistically significant ($p<0.05$) with all other varieties. At the same time water uptake of 'Periakaruppan' was not significant ($p>0.05$) with 'Periavellai' and also with H4, Bg 358, At 358 and Bg 406, but significant ($p<0.05$) with other varieties. 'Periavellai' variety showed a statistically significant difference ($p<0.05$) with most of the varieties except 'Periakaruppan' in water uptake. Water uptake of H4, Bg 358, At 358 and Bg 406 were not significantly differed ($p>0.05$) with each other, but they significantly ($p>0.05$) differed with all other varieties except At 353. But At 358 and Bg 406 do not show a significant difference ($p>0.05$) with At 353 and CO10. At the same time CO10 was not significant ($p>0.05$) with At 402, but significantly differed ($p<0.05$) with other varieties. The rice with higher bulk density which has a compact structure, showed a slower water uptake, resulting in longer cooking time when compared to rice with lower bulk density (Figure 2).

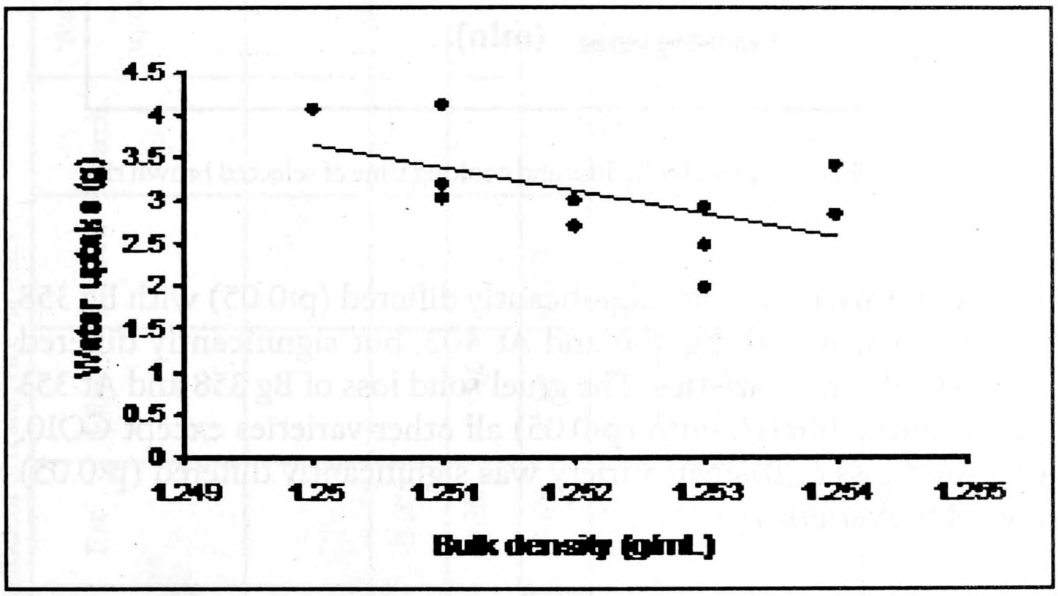


Figure 2: Relationship between water uptake and bulk density of selected brown rice varieties

Gruel solid loss

The gruel solid loss was negatively correlated with bulk density ($r = -0.159$) and 1000 kernel weight ($r = -0.181$). The varieties showing the longer cooking time showed higher gruel solid loss and vice-versa (Figure 3). Varieties with higher length breadth ratio offer larger surfaces to contact with water. Among

the rice varieties, 'Anilvariyan' showed the highest gruel solid loss (3.626%), followed by 'Moddaikaruppan' (2.840%) and 'Periavellai', whereas, Basmati showed the lowest of 1.212%. The gruel solid loss of 'Anilvariyan' was significantly differed ($p>0.05$) with all other varieties. Gruel solid loss of 'Moddaikaruppan' do not show a statistically significant difference ($p>0.05$) with 'Periavellai' and showed a significant with other varieties. But 'Periavellai' was not significant ($p>0.05$) with At 358 and 'Periakarupan'. H4 were not significantly differed ($p>0.05$) with At 358 and 'Periakaruppan' and also with Bg 358 and At 353, but significant ($p<0.05$) with other varieties.

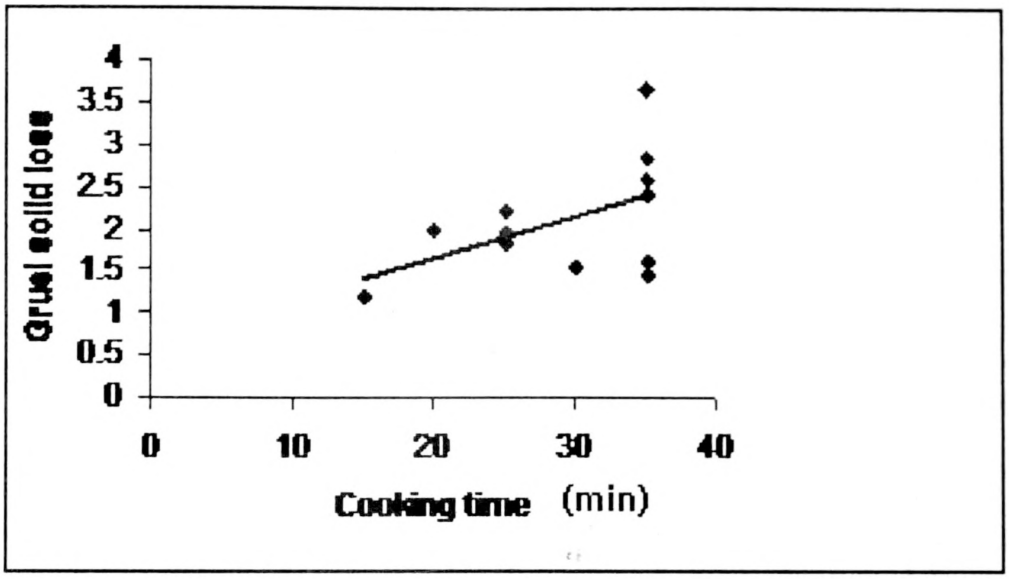


Figure 3: Relationship between gruel solid loss and cooking time of selected brown rice varieties

Similarly CO10 variety was not significantly differed ($p>0.05$) with Bg 358 and At 353 and also with Bg 406 and At 402, but significantly differed ($p>0.05$) with all other varieties. The gruel solid loss of Bg 358 and At 353 were significantly differed with ($p<0.05$) all other varieties except CO10. The gruel solid loss of Basmati variety was significantly differed ($p<0.05$) with most of the varieties.

Elongation ratio

Elongation ratio of tested varieties varied from 1.038 to 1.282. The highest ratio was observed in Bg 358 (1.282), whereas Basmati showed the lowest ratio of 1.042, both length breadth ratio and amylose content are important in determining the elongation of cooked grains.

Cooked length breadth ratio

Cooked length breadth ratio was highest for Basmati (2.726) followed by H4 (2.574) and At 353 (2.568). Bg 358 showed the lowest ratio after cooking

(1.562). Within traditional varieties 'Anilvariyan' had high cooked length breadth ratio (1.962) than other varieties. Cooked length breadth ratio showed a negative correlation with water uptake (r =-0.190) and gruel solid loss (r = -0.084) (Table 2 and Figure 4).

Table 2: Pearson correlation coefficient of tested rice varieties

Properties	Ash	Fat	Fiber	Protein	Starch	Water uptake	Gruel solid loss	Cooked L/B ratio	1000 kernel Weight	Bulk density
Fat	-0.107									
Fiber	-0.184	-0.096								
Protein	-0.201	-0.213	-0.096							
Starch	0.070	-0.173	-0.181	-0.129						
Water uptake	-0.089	0.074	-0.174	-0.203	-0.088					
Gruel solid loss	-0.121	-0.101	0.080	-0.194	-0.173	-0.079				
Cooked L/B	0.103	-0.153	-0.105	0.108	-0.173	-0.190	-0.084			
ratio	-0.157	0.122	-0.141	-0.148	0.077	-0.154	-0.180	-0.096		
1000 kernel weight	-0.189	-0.164	0.077	-0.126	-0.114	0.069	-0.159	-0.191	-0.093	
Bulk density	-0.208	-0.223	-0.190	0.216	0.106	-0.187	-0.230	-0.0003	0.070	-0.173
L/B ratio										

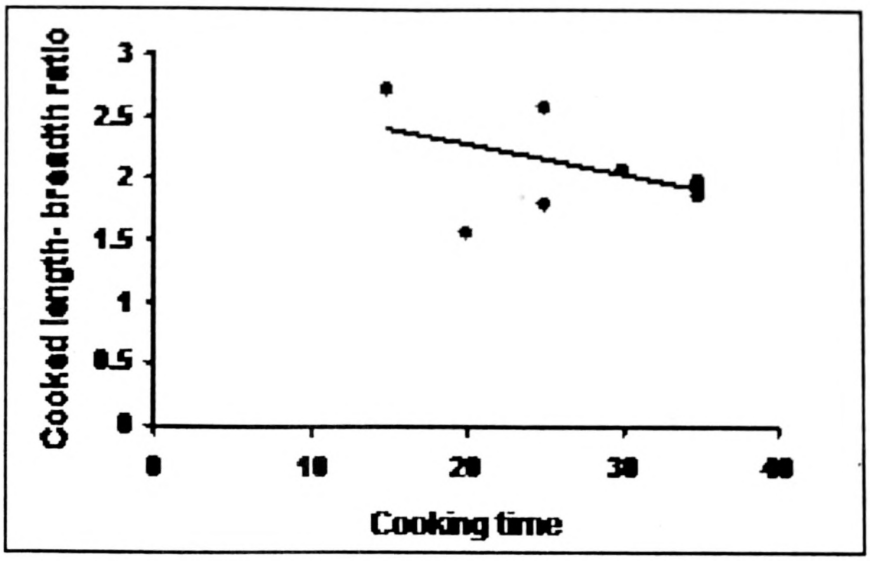


Figure 4: Relationship between cooked length breadth ratio and cooking time of selected brown rice varieties

Cooked length breadth ratio of Basmati variety was significantly differed ($p<0.05$) with all other varieties. At the same time cooked length breadth ratio of varieties of H4 and At 353 were not significantly differed ($p>0.05$) with each other but significant ($p<0.05$) with all other varieties. At 358 was not statistically significant ($p<0.05$) with At 402 in cooked length breadth ratio and also with 'Anilvariyan', Bg 406, 'Moddaikaruppan', 'Periavellai' and 'Periakarupan'. But At 402 was statistically not significant ($p>0.05$) with At 358, 'Anilvariyan' and Bg 406, but significant ($p<0.05$) with all other varieties. CO10 was not significantly differed ($p>0.05$) with 'Periavellai', 'Periakarupan', 'Moddaikaruppan' and Bg 406, but significant ($p<0.05$) with others. Bg 358 is a white pericarp varieties, which cooked length breadth ratio significantly differed ($p<0.05$) with all varieties.

Gelatinization temperature

Alkali spreading value of six Bangladesh varieties varied between 3.0 to 3.9 (Dipti et al., 2002). They also conducted an experiment in ten *Beruin* rice varieties which showed that the alkali spreading value varied between 4.3 to 7.0 (Dipti et al., 2003).

From our results higher alkali spreading value (six) was found in varieties such as Basmati, At 353 and H4 (Figure 5) This result shows extra long and long grains varieties have higher spreading than other medium and short grain varieties. Therefore these grains were come under the low class category having gelatinization temperature between 55 to 69 °C.

Bg 358 had the lowest alkali spreading value (two) when compared to other eleven selected varieties. It was a short bold type grain and having gelatinization temperature greater than 74 °C. This was classified under high class category.

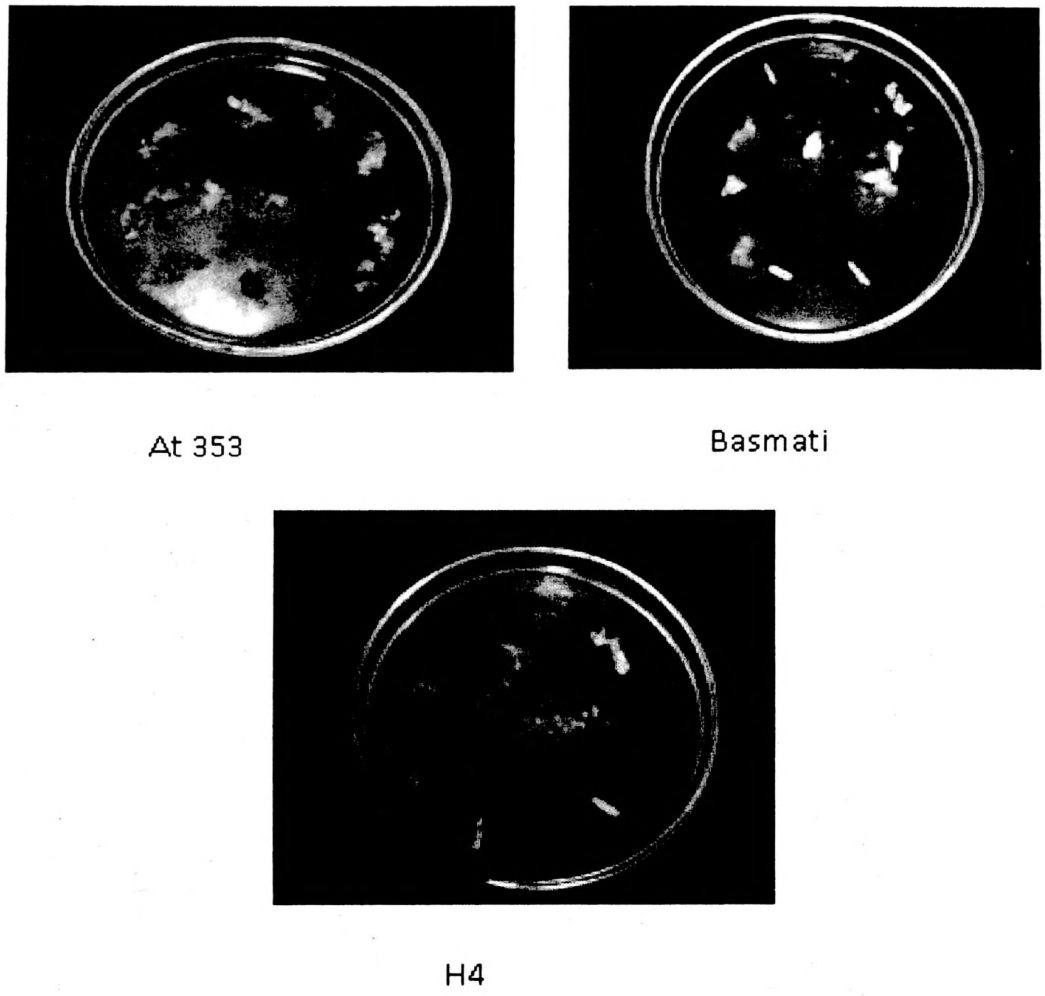


Figure 5: Rice varieties that have the alkali spreading value of six

Other varieties including traditional varieties such as 'Moddaikaruppan', 'Periavellai', 'Periakaruppan', 'Anilvariyan' and improved varieties such as CO10, Bg 406, At 358, At 402 were classified as intermediate class, because it has alkali spreading value of three. Therefore these varieties have gelatinization temperature between 70 to 74 °C.

Gel consistency

Varietal differences in gel consistency exist among varieties of similar amylose content (>25%). The gel consistency test is based on the consistency of the rice paste and differentiates among varieties with high amylose content (Rani et al., 2006). Gel formation was not observed in our experiment even the same procedure as said in material and methods were followed. Therefore we unable to classify the above selected varieties based on the gel consistency test.

Conclusion

The present study fulfilled the requirements of complete information on the cooking and eating characteristics some selected rice varieties cultivated in the Jaffna peninsula. The results indicated that the above said properties vary significantly among different varieties.

The modern technique of the image processing system was quite capable of providing quantitative estimation of the physical dimension of each variety. Basmati showed the lowest cooking time of 15 minutes. All traditional varieties and Bg 406 and At 358 had the highest cooking time of 35 minutes. Cooking time was positively correlated with water uptake and gruel solid loss but cooked length breadth ratio was correlated negatively. Among the tested varieties in this study Basmati had lowest water uptake, gruel solid loss and elongation ratio but it had highest cooked length breadth ratio. The rice with higher bulk density, i.e., compact structure, showed a slower water uptake, resulting in longer cooking time. The gruel solid loss was negatively correlated with bulk density and 1000 kernel weight. The varieties which had the highest elongation ratio showed the lowest cooked length breadth ratio. Cooked length breadth ratio showed a negative correlation with water uptake ($r = -0.190$) and gruel solid loss ($r = -0.084$). Extra long and long grains varieties have higher alkali spreading value than other medium and short grain varieties so they having gelatinization temperature of between 55 to 69 °C.

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