Original Research Article

https://doi.org/10.20546/ijcmas.2018.710.167

Characterization of Physio-Chemical Properties of Starch among Traditional and Commercial Varieties of Rice (Oryza sativa L.) using Rapid Visco Analyser

B.N. Rithesh¹*, S. Ramchander², S. Rajeswari¹, D. Uma³, S. Robin¹ and P. Jeyaprakash¹

¹Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University, Coimbatore-641003, Tamil Nadu, India
²Visiting Scientist (SERB –National Post-Doctoral Fellow), IRRI-South Asia Hub, ICRISAT, Patancheru, Hyderabad, India
³Department of Biochemistry, Centre for Plant Molecular Biology & Biotechnology, Tamil Nadu Agricultural University, Coimbatore-641003, Tamil Nadu, India

*Corresponding author

A B S T R A C T

Cooking and eating quality of rice is predominantly influenced by various physio-chemical characteristics of starch. This study was aimed to characterize the physio-chemical properties of starch in commercially and traditionally cultivated rice varieties using Rapid Viscosity Analyser (RVA) in relation to identify the genotype with prominent starch composition to maximize the consumer’s acceptability. Initially a study conducted to determine the amylose content variations among the selected genotypes and measurement on RVA parameters had a significant difference among the varieties. The polished rice flour showed higher range of peak viscosity, hold viscosity, breakdown viscosity, final viscosity and setback viscosity than brown rice flour. It clearly indicated that the step of polishing had a major influence on the pasting curve. In addition, pigmented rice cultivars had variation among the pasting profile due to the effect of colour parameter. It was found that brown rice exhibited intermediate to high amylose content and ranged from 18.45 % to 25.97 % whereas the polished rice varied between 17.84 % and 23.19 % with the mean value of 22.39 % and 20.40 % respectively. The viscosity profile was also interpreted with the rice amylose content to understand the properties of starch in the selection of grains to improve cooking and eating quality for further development.

Keywords
Pasting profile, Rapid visco analyser, Pigmented rice, Cooking quality

Article Info
Accepted: 12 September 2018
Available Online: 10 October 2018

Introduction

Rice (Oryza sativa L.), one of the most dietary staple foods in the human diet and quality of rice is determined by the nutritional composition, which is considered as the major factor affecting the technological properties (Ascheri et al., 2012). The different functional properties such as amylose, amyllopectin content, gelatinization temperature and pasting profile are the important starchy properties which influence quality of rice (Juliano et al., 1965; Cruz and Khush, 2000; Vanaja and Babu, 2003). Amylose, a long straight starch
molecule that does not gelatinize during cooking is considered a major determinant of rice appearance and cooking quality (Jeevetha et al., 2014). Amylose content is positively associated with hardness and negatively associated with stickiness (Juliano and Pascaul, 1980; Windham et al., 1997). In addition, the amylose content and pasting behaviour of rice starches varies broadly between different varieties and percentage of polishing among same varieties. Pasting is defined as the phenomenon following gelatinization, involving granular swelling, extrudation of the molecular components and, eventually, the total disruption of the starch granules (Atwell et al., 1988; Meadows, 2002). The starch granules of rice play active role in less swelling of starch during gelatinization and lower peak viscosity of starch paste (Tananuwong and Malila, 2011). The Rapid Visco Analyser (RVA) has been widely used for assessing the pasting properties of flour or starch. The assessment of the viscosity during heating and cooling cycles by the RVA provide valuable information on the contact between starch and hydrocolloids (Martinez et al., 2015).

However, some characteristics of RVA are closely related to eating and cooking quality of rice and it might be used as an indirect index to evaluate the grain quality (Yan et al., 2005). Therefore, this study reveals that different accessions have different pasting properties and amylose content. The visco profile of genotypes in the form of brown and polished rice flour was determined to know its comparative status. In addition, amylose content was also studied to know the starch behaviour in the influence of pasting profile which would be helpful in selection of good quality lines. The consumer demand for better quality has increased in the developing countries and the grain quality is very important determining issue for the consumer preference and market value.

**Materials and Methods**

The present investigation was carried out during 2016-2017 at the Departments of Rice, Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University, Coimbatore (11°N latitude and 77°E longitude with an elevation of 426.72 m above the mean sea level).

Twenty-eight rice accessions including traditional and commercial varieties collected from several parts of Tamil Nadu (Table 1) were de-husked to make unpolished (brown) and polished (white) rice using laboratory rice mill (Kett rice polisher) and further each of them were made into flour using small volume (150 mg) powder mixer. Talc like powdered samples was needed for analysis. Hence, good grinding of samples and the sediment powder samples obtained were used for analysis.

**Amylose content**

Simplified procedure of Juliano et al., (1981) with minor modification was used for the estimation of amylose content. A well powdered milled rice of 100 mg was weighted and taken into 100 ml volumetric flask. It was added with 1 ml 95% ethanol and 9 ml 1 N NaOH and left overnight. On the subsequent day distilled water was added to the samples to make up the final volume to 100 ml. Mixed solution of 5 ml from 100 ml was pipetted out into another 100 ml volumetric flask. 1 N acetic acid (1ml) followed by 2 ml iodide solution were added and the volume was made up to 100 ml. The content was stirred and allowed to stand for 20 min before absorbance was measured at 620 nm with a UV-Spectrophotometer. Amylose concentration was obtained by plotting the absorbance in the potato amylose standard curve. Amylose content of each genotype was expressed as percentage to total quantity of sample taken for analysis.
Estimation of pasting behaviours

The pasting properties of the rice entries were determined with a rapid visco analyser (Newport Scientific, Australia). Rice flour (3 g) was poured into distilled water (25 mL) in a canister and mixed thoroughly. The mixture was stirred at 960 rpm for 10 seconds and then stirred at 160 rpm. The mixture temperature was first maintained at 50°C for 1.5 min and then raised to 95°C at a rate of 12°C/min. After that, the temperature was maintained at 95 °C for 2.5 min; which was followed by a cooling down period to 50°C with a cooling rate of 12°C/min and was maintained at 50°C for 2.1 min. Each test was made in replicates. A plot of pasting viscosity in an arbitrary RVA unit (RVU) versus time was used to determine the peak viscosity, temperature at peak viscosity, breakdown viscosity, final viscosity and setback viscosity.

Statistical analysis

Analysis of Variance was performed to test the differences among the rice cultivars at 5 % significance level and Pearson correlation analysis were also performed to find out the association among the traits.

Results and Discussion

Rice quality is mainly determined by its physiochemical properties and readily available source of starch (Liu, 2005). Pasting characteristic is an essential function of starch to give thickening and sizing effects in food and non-food applications (Shafie et al., 2016). The Pasting properties determines the functional properties of starch which depend on the amylose content, lipid content, branch-chain length of the amylopectin, varieties of the starch and cropping environment (Jane, 2004). Traditional varieties have higher nutritional quality than commercial varieties in the form of whole grain (Shafie et al., 2016). The present study exhibited that the pasting parameters were significantly different (p < 0.05) among the rice cultivars. Wide range of peak viscosity, hold viscosity and final viscosity were observed among the polished rice accessions with different classes of amylose content. The trait value differences among the brown and polished rice accessions are presented in Table 2 and 3 (Fig. 1a and 1b). The variation of peak viscosity often associated with the swelling power and the rate of disruption of the starch granules (Corke et al., 1997). Peak viscosity is also an indicative of water-binding capacity and it is often correlated with final product (Thomas and Atwell, 1999; Tran et al., 2001). The peak viscosity of brown rice flour ranged from 374.00 cP (Purple puttu) to 4204.00 cP (ADT 37) with the mean value of 2221.03 cP whereas polished rice flour ranged between 814.50cP (Purple puttu) to 5529.00 cP (Bhavani) with the mean value of 3165.53cP. This study showed that polished rice flour with higher value of peak value in which the granules swell slowly and the disruption was refuted with initial flattered slow peak compared with brown rice. The variety purple puttu showed low peak viscosity in both derivatives which indicates the starch swelled rapidly and resulted in quick peak (Fig. 2a). High peak viscosity is an index of high starch content (Osungbaro, 1990) and clarifies that polished rice flour have higher mean values of peak viscosity with increased degree of polishing. The results are in accordance with Perdon et al., (2001). However, this study also explains that the pigmented rice flour had reduced peak viscosity specifies that major influence of grain colour in pasting.

Viscosity trough value or hot paste viscosity of polished rice varied accordingly with 767.50 cP (CO 51) to 4053.00 cP (ASD16) with the mean value of 2294.87cP and brown rice flour ranged from 267.50 cP (Purple puttu) to 3272.50 cP (Pusa basmathi1) with a
grand mean of 1768.71cP. Hu et al., (2004) reported that samples with high amylose content had low hot paste viscosity in rice. This study showed that lower hot paste viscosity in brown rice with higher amylose content than polished rice flour with higher hot paste viscosity. The significant difference in high trough viscosity observed in this study also indicates the tendency of rice to break down during cooking. Higher breakdown viscosity in rice is considered to be an indicator of better palatability (Danbaba et al., 2012). Break down viscosity of polished rice accessions ranged from -9cP (IR 36) to 2590.00 cP (CO 43) with a mean value of 870.66 cP whereas brown rice flour ranged between -2 cP (Swarna) to 1145.00 cP (CO43 and ADT 37) with a mean value of 452.32 cP (Fig. 2a). The rice accessions with highest breakdown viscosity are regarded as good palatable and indicated that polished rice accessions with high breakdown viscosity is more palatable than brown rice. High values of breakdown are associated with high peak viscosities, which in turns are related to degree of swelling of starch granules during heating.

Higher cool paste or final viscosity is the most commonly used parameter to determine a particular starch based sample quality and it gives an idea for the ability of the starch to have gel structure after cooking (Danbaba et al., 2012). In the present study, the cool paste viscosity of polished rice ranged from 1000.00 cP (Purple puttu) to 6583.00 cP (ASD 16) with the mean performance of 4366.05cP. In case of brown rice flour, the value ranges from 389.00cP (Purple puttu) to 6276.00cP (IR 20) with the mean value of 3563.55cP (Fig 2a). The cool paste viscosity was higher in all the rice flours when compared to peak viscosity and break down viscosity except CO 43 of polished rice flour which had low cool paste viscosity but higher break down viscosity.

There was a significant difference in the setback viscosity of the brown and polished rice flour was observed in all the samples. Setback viscosity indicates the tendency of starch granules to retrograde on cooling. High setback is an indication of the amount of swelling power of the rice sample and is usually related to the amylose content of the sample (Jennifer and Les, 2004; Martin and Smith, 1995) and low set back values also indicates low rate of starch retro-gradation.

The setback viscosity has also been correlated with the texture of various end products. This study showed that the brown rice flour with higher amylose had wide range of setback value and varied from 15.00 cP (Purple puttu) to 2436.00 cP (IR 50) with the mean value of 1342.50cP (Fig. 2a). Polished rice flour had a setback value with low mean value of 1200.51 cP compared to brown rice flour. Brown rice flours had varied range of setback value with higher amylose content than polished rice and the rice accessions with similar amylose content may also differ in the pasting curve indicating the heating and cooling cycle among the same sample concentration.

Peak time is the measure of the cooking time and it ranged between 5.40min and 7.00 min and 3.80 min to 6.77 min among the polished and brown rice flour respectively. The influence of polishing was also observed in the peak time and significant variation was also observed between different flours. Pasting temperature indicates the initial increase in the temperature. Amylose content also influenced pasting temperature, high amylose content was associated with high pasting temperature and low amylose with lower amylose content (Pongjanta et al., 2016). The higher pasting temperature showed the resistance potential against swelling in the ingredient and in this study it varied according with respect to influenced amylose content of brown and polished rice flours.
**Table.1** List of traditional and cultivated varieties of rice used in this study

| S.no. | Genotypes       | Parentage                                      | Special Characteristics                                      |
|-------|------------------|------------------------------------------------|-------------------------------------------------------------|
| 1.    | GEB 24           | Spontaneous mutant                             | Good quality rice, fine and best table variety              |
| 2.    | TKM 9            | TKM-7/ IR-8                                    | Short bold and red grain                                    |
| 3.    | BPT 5204         | GEB 24/ Mahsuri                                 | Fine grain with good cooking quality                        |
| 4.    | CO 43            | Dasal/ IR 20                                   | Fine grain, Alkalinity and saline tolerant                  |
| 5.    | CO (R) 50        | CO 43/ ADT 38                                  | Medium Slender rice                                          |
| 6.    | CO 51            | ADT 43/ RR 272-1745                           | Fine grain, High yielding                                   |
| 7.    | ASD 16           | ADT 31/ CO39                                   | Short bold grain and more straw yield                       |
| 8.    | ADT 37           | BG 280-12/PTB 33                               | Short bold white rice                                        |
| 9.    | ADT 43           | IR 50/White ponni                              | Medium slender grain                                         |
| 10.   | ADT R 45         | IR 50/ADT 37                                   | Medium slender grain                                         |
| 11.   | IR 20            | IR 262/ TKM 6                                  | Medium slender grain                                         |
| 12.   | IR 36            | IR 1561-228/1 IR 244/O.nivara/CR 94-13         | Medium grain and white rice                                  |
| 13.   | IR 50            | IR-2153-14-1-6-2/IR 28/ IR-36                  | High yielding and short duration                            |
| 14.   | CO RH 3          | TNAU CMS 2A/CB 87 R                           | Medium slender grain and short duration hybrid               |
| 15.   | Improved White   | Selection from white ponni                     | Fine grain white rice and highly preferred for cooking      |
| 16.   | Pusa basmati 1   | Pusa -150/ Karnal Local                        | Super fine aromatic and white grain                          |
| 17.   | CR 1009 Sub 1    | Improved version CR 1009 with sub 1 gene       | Submerge tolerant, short bold grain with high milling percentage |
| 18.   | Bhavani          | Peta / BPI 76                                  | White rice colour and highly preferred for cooking          |
| 19.   | Swarna           | Vasisa / Mahsuri                               | Short bold grain                                             |
| 20.   | Improved Kavuni  | Improved from of Kavuni                        | Black rice, High antioxidant and Anti-diabetic              |
| 21.   | Kavuni           | Land race of Tamil Nadu                        | Anti-diabetic, High antioxidant, Black rice and Photosensitive |
| 22.   | Norungan         | Land race of Tamil Nadu                        | Red Rice and Long bold                                      |
| 23.   | Purple puttu     | Land race of Tamil Nadu                        | Purple grain and High antioxidant                            |
| 24.   | Thavalakannan    | Land race of Kerala                            | Red rice and Photosensitive                                  |
| 25.   | Jeeraga Samba    | Land race of Tamil Nadu                        | Fine variety, aromatic and Short slender                    |
| 26.   | Rasacam          | Land race of Tamil Nadu                        | Grain is very small and round, short slender                 |
| 27.   | Sivapuchithiraikar | Land race of Tamil Nadu              | Open panicle type, long bold                                |
| 28.   | Mappillai samba  | Land race of Tamil Nadu                        | Anti-diabetic, Red rice and Medium slender                  |
Table 2 Mean performance of pasting properties (Viscosity parameters) and amylose content for brown rice flour

| Genotypes        | Peak viscosity (cP) | Hot paste viscosity (cP) | Break down viscosity (cP) | Cool paste viscosity (cP) | Setback viscosity (cP) | Peak time (mins) | Pasting temperature (C) | Amylose content (%) |
|------------------|---------------------|--------------------------|---------------------------|----------------------------|------------------------|-------------------|--------------------------|----------------------|
| GEB 24           | 1611.50             | 1419.00                  | 192.50                    | 3807.00                    | 2195.50                | 6.17              | 90.55                    | 22.09                |
| TKM 9            | 1395.00             | 1263.50                  | 131.50                    | 2313.00                    | 918.50                 | 6.57              | 90.55                    | 19.69                |
| BPT 5204         | 1204.50             | 1166.50                  | 38.00                     | 2841.00                    | 1637.00                | 6.50              | 93.30                    | 19.76                |
| CO 43            | 3216.00             | 2071.00                  | 1145.00                   | 4276.00                    | 1060.50                | 5.60              | 79.73                    | 18.45                |
| CO (R) 50        | 3684.50             | 2584.50                  | 1100.00                   | 4925.00                    | 1240.50                | 5.70              | 79.70                    | 21.50                |
| CO 51            | 745.00              | 447.50                   | 297.50                    | 1542.00                    | 797.00                 | 5.50              | 88.95                    | 21.84                |
| ASD 16           | 3736.00             | 2944.00                  | 792.00                    | 5158.00                    | 1422.50                | 5.93              | 83.30                    | 22.14                |
| ADT 37           | 4204.00             | 3059.00                  | 1145.00                   | 5533.00                    | 1329.00                | 5.80              | 82.15                    | 21.62                |
| ADT 43           | 1483.50             | 1473.00                  | 10.50                     | 3101.00                    | 1618.00                | 6.77              | 90.15                    | 23.49                |
| ADT (R) 45       | 1614.00             | 1451.00                  | 163.00                    | 3503.00                    | 1888.50                | 6.30              | 88.88                    | 20.36                |
| IR 20            | 4157.00             | 3176.50                  | 980.50                    | 6276.00                    | 2119.00                | 6.10              | 82.15                    | 23.45                |
| IR 36            | 2168.50             | 2050.00                  | 118.50                    | 3894.00                    | 1725.00                | 6.64              | 88.53                    | 20.15                |
| IR 50            | 2740.00             | 2398.50                  | 341.50                    | 5176.00                    | 2436.00                | 5.97              | 85.68                    | 23.28                |
| CO R(H) 3        | 1557.50             | 1065.50                  | 492.00                    | 2860.00                    | 1302.50                | 5.93              | 88.13                    | 20.80                |
| Improved white   | 1427.00             | 1283.50                  | 143.50                    | 2701.00                    | 1274.00                | 6.40              | 89.73                    | 23.88                |
| Ponni            |                     |                          |                           |                            |                        |                   |                          |                      |
| Pusabasmathi 1   | 3706.00             | 3272.50                  | 433.00                    | 5192.00                    | 1486.00                | 6.35              | 86.45                    | 22.62                |
| CR 1009 sub 1    | 3208.00             | 2320.00                  | 888.00                    | 5190.50                    | 1982.50                | 6.00              | 80.13                    | 23.32                |
| Bhavani          | 2556.50             | 1753.00                  | 803.50                    | 3735.00                    | 1179.00                | 5.50              | 82.95                    | 21.06                |
| Swarna           | 464.50              | 466.50                   | -2.00                     | 831.00                     | 366.50                 | 6.40              | 92.90                    | 22.28                |
| Improved kavuni  | 1326.00             | 1309.00                  | 17.00                     | 2693.50                    | 1367.50                | 6.60              | 89.80                    | 23.71                |
| Kavuni           | 984.50              | 970.50                   | 14.00                     | 1945.00                    | 961.00                 | 6.24              | 84.90                    | 25.66                |
| Norungan         | 2232.00             | 1713.50                  | 518.50                    | 3397.50                    | 1165.50                | 5.87              | 84.10                    | 24.75                |
| Purple puttu     | 374.00              | 267.50                   | 106.50                    | 389.00                     | 15.00                  | 3.80              | 73.80                    | 23.10                |
| Thavalakannan    | 2482.00             | 2105.50                  | 376.50                    | 3710.50                    | 1228.50                | 6.40              | 84.83                    | 23.88                |
| Jeeraga samba    | 2062.00             | 1718.50                  | 343.50                    | 3718.00                    | 1656.00                | 6.07              | 86.55                    | 19.97                |
| Rasacadam        | 1787.00             | 1268.00                  | 519.00                    | 2953.00                    | 1166.00                | 5.83              | 77.73                    | 25.97                |
| Sivapuchitiraikar| 2453.00             | 1831.00                  | 622.00                    | 3702.00                    | 1249.00                | 5.87              | 77.75                    | 23.67                |
| Mapillai samba   | 3610.00             | 2675.50                  | 934.50                    | 4414.00                    | 804.00                 | 5.43              | 80.45                    | 24.53                |
| Mean             | 2221.03             | 1768.71                  | 452.32                    | 3563.55                    | 1342.50                | 6.00              | 85.13                    | 22.39                |
| CV (%)           | 14.30               | 10.16                    | 50.00                     | 14.60                      | 44.55                  | 5.13              | 2.44                     | 5.91                 |
| CD @ 5%          | 651.43              | 368.43                   | 463.65                    | 1066.59                    | 1226.14                | 0.63              | 4.27                     | 2.71                 |

*Data are based on the average of two replicates and the values are significantly different at p<0.05*
### Table 3 Mean performance of pasting properties (Viscosity parameters) and amylose content for polished rice flour

| Genotypes               | Peak viscosity (cP) | Hot paste viscosity (cP) | Break down viscosity (cP) | Cool paste viscosity (cP) | Setback viscosity (cP) | Peak time (mins) | Pasting temperature (C) | Amylose content (%) |
|-------------------------|---------------------|--------------------------|---------------------------|---------------------------|------------------------|------------------|------------------------|---------------------|
| GEB 24                  | 1842.00             | 1686.00                  | 156.00                    | 3146.00                   | 1304.00                | 6.50             | 87.75                  | 20.29               |
| TKM 9                   | 1543.00             | 1379.00                  | 164.00                    | 2321.50                   | 778.50                 | 6.33             | 88.90                  | 19.67               |
| BPT 5204                | 992.00              | 894.50                   | 97.50                     | 2065.00                   | 1073.00                | 6.24             | 86.55                  | 17.84               |
| CO 43                   | 5145.00             | 2555.00                  | 2590.00                   | 4974.00                   | -171.00                | 5.40             | 78.55                  | 18.43               |
| CO (R) 50               | 5086.00             | 2974.00                  | 2112.00                   | 5615.50                   | 529.50                 | 5.54             | 78.58                  | 20.51               |
| CO 51                   | 1399.00             | 767.50                   | 631.50                    | 1706.00                   | 307.00                 | 5.70             | 80.48                  | 20.45               |
| ASD 16                  | 5471.00             | 4053.00                  | 1418.00                   | 6583.00                   | 1112.00                | 6.10             | 82.15                  | 19.54               |
| ADT 37                  | 4705.00             | 3357.00                  | 1348.00                   | 6446.00                   | 1741.00                | 5.87             | 82.45                  | 18.19               |
| ADT 43                  | 2975.00             | 2816.00                  | 159.00                    | 6101.00                   | 3126.00                | 6.44             | 88.90                  | 20.01               |
| ADT (R) 45              | 3813.50             | 3180.50                  | 633.00                    | 6158.00                   | 2344.50                | 5.94             | 83.80                  | 19.88               |
| IR 20                   | 4495.00             | 2514.50                  | 1980.50                   | 5206.00                   | 711.00                 | 5.60             | 80.90                  | 23.19               |
| IR 36                   | 2357.00             | 2366.00                  | -9.00                     | 4405.00                   | 2048.00                | 7.00             | 89.80                  | 18.62               |
| IR 50                   | 4170.50             | 3256.50                  | 914.00                    | 6116.00                   | 1945.50                | 5.94             | 84.45                  | 21.32               |
| CO R(H) 3               | 2699.00             | 1762.00                  | 937.00                    | 3523.50                   | 824.50                 | 6.04             | 79.75                  | 20.10               |
| Improved white ponni    | 1889.00             | 1626.00                  | 263.00                    | 3221.00                   | 1332.00                | 6.27             | 87.15                  | 19.45               |
| Pusabasmathi 1          | 3721.00             | 3164.00                  | 557.00                    | 6370.00                   | 2649.00                | 6.04             | 88.03                  | 18.66               |
| CR 1009 sub 1           | 4505.00             | 2987.00                  | 1518.00                   | 6185.00                   | 1680.00                | 5.87             | 78.90                  | 20.58               |
| Bhavani                 | 5529.00             | 3293.50                  | 2235.50                   | 6006.50                   | 477.50                 | 5.64             | 81.68                  | 20.93               |
| Swarna                  | 1146.50             | 961.50                   | 185.00                    | 1761.00                   | 614.50                 | 6.03             | 88.20                  | 21.97               |
| Improved kavuni         | 2930.00             | 2407.00                  | 523.00                    | 4464.00                   | 1534.00                | 6.30             | 82.55                  | 21.71               |
| Kavuni                  | 1972.50             | 1762.50                  | 210.00                    | 3250.50                   | 1278.00                | 6.00             | 84.20                  | 22.23               |
| Norungan                | 3006.50             | 2039.00                  | 967.50                    | 3876.00                   | 869.50                 | 5.64             | 80.90                  | 20.97               |
| Purpleputtu             | 814.50              | 781.00                   | 33.50                     | 1000.00                   | 185.50                 | 5.60             | 72.95                  | 21.53               |
| Thavalakannan           | 2644.50             | 2295.00                  | 349.50                    | 4282.50                   | 1638.00                | 6.47             | 85.73                  | 21.40               |
| Jeeraga Samba           | 3255.50             | 2453.00                  | 802.50                    | 4931.50                   | 1676.00                | 5.97             | 86.10                  | 19.75               |
| Rasacadam              | 2366.00             | 1753.00                  | 613.00                    | 3388.50                   | 1022.50                | 5.97             | 77.00                  | 21.49               |
| Sivapuchitiraikar       | 2612.50             | 1959.50                  | 653.00                    | 3754.50                   | 1142.00                | 5.94             | 77.78                  | 21.01               |
| Mapillai samba          | 4306.00             | 3123.00                  | 1183.00                   | 5153.50                   | 847.50                 | 5.43             | 80.48                  | 21.53               |
| Mean                    | 3165.53             | 2294.87                  | 870.66                    | 4366.05                   | 1200.51                | 5.93             | 82.66                  | 20.40               |
| CV (%)                  | 9.84                | 10.13                    | 26.52                     | 6.99                      | 20.30                  | 6.72             | 2.10                   | 5.91                |
| CD @ 5%                 | 638.69              | 476.68                   | 473.44                    | 626.16                    | 499.62                 | 0.81             | 3.57                   | 2.47                |

*Data are based on the average of two replicates and the values are significantly different at p<0.05*
Table 4 Genotypic correlation among the pasting profile traits and amylose content for brown rice flour

|       | Peak   | Hot    | Break  | Cool   | Set     | Time   | Temp   | Amy    |
|-------|--------|--------|--------|--------|---------|--------|--------|--------|
| Peak  | 1      | 0.977**| 0.872**| 0.978**| 0.648** | -0.006 | -0.442*| -0.029 |
| Hot   | 1      | 0.748**| 0.971**| 0.687**| 0.139   | 0.313  | 0.010  |        |
| Break | 1      |        | 0.819**| 0.442* | -0.303  | -0.660**| -0.116 |
| Cool  | 1      |        |        | 0.792**| 0.152   | -0.297 | -0.034 |
| Set   | 1      |        |        |        | 0.543** | 0.211  | -0.037 |
| Time  | 1      |        |        |        |         | 0.750**| -0.022 |
| Temp  |        |        |        |        |         |        | -0.298 |
| Amy   |        |        |        |        |         |        | 1      |

**, * Correlation is significant at 1% and 5%.

Table 5 Genotypic correlation among the pasting profile traits and amylose content for polished rice flour

|       | Peak   | Hot    | Break  | Cool   | Set     | Time   | Temp   | Amy    |
|-------|--------|--------|--------|--------|---------|--------|--------|--------|
| Peak  | 1      | 0.922**| 0.871**| 0.895**| 0.102   | -0.943**| -0.220 | -0.123 |
| Hot   | 1      | 0.613**| 0.981**| 0.442* | -0.483* | 0.008  | -0.167 |
| Break | 1      |        | 0.582**| -0.351 | -0.971**| -0.458*| -0.039 |
| Cool  | 1      |        |        | 0.536**| -0.307  | 0.071  | -0.178 |
| Set   | 1      |        |        |        | 0.947** | 0.573**| -0.164 |
| Time  | 1      |        |        |        |         | 0.971**| 0.073  |
| Temp  |        |        |        |        |         |        | -0.282 |
| Amy   |        |        |        |        |         |        | 1      |

PV : Peak viscosity HPV : Hot paste viscosity BV : Break down viscosity
SV : Setback viscosity CPV : Cool paste viscosity Time : Time at viscosity peak
Temp : Pasting temperature Amy : Amylose content

**, * Correlation is significant at 1% and 5%.
**Fig. 1a** Comparative pasting profile of brown rice in traditional and cultivated varieties of rice

![Brown Rice Pasting Profile](image1)

**Fig. 1b** Comparative pasting profile of polished rice in traditional and cultivated varieties of rice

![Polished Rice Pasting Profile](image2)
Fig. 2a Comparison of starch pasting properties between brown and polished rice of traditional and cultivated varieties of rice
Higher range of pasting temperature with higher amylose content was observed in the all brown rice flour with the mean value of 85.13°C compared with polished rice flour of 82.66°C (Fig 2a).

Amylose content is widely recognized as the most important determinant of the cooking and eating quality of rice. Amylose content of the rice also influences the Glycemic index value where rice that was high in amylose usually has lower GI value (Miller et al., 1992). Therefore, the variation in Glycemic index in rice is mainly due to the proportion of starch, particularly the ratio of amylose and amylpectin. The different accessions show different functional properties specially related to their different amylose content and therefore to their degree of retrogradation. The amylose content of the polished rice flour ranged from 17.84 % to 23.19% with the mean value of 20.40%. High value of amylose content was observed in IR 20 followed by kavuni and low value of amylose content recorded in BPT 5204. In case of brown rice flour, the amylose content was varied accordingly with high value of 25.97 % (Rasacadam) followed by 25.66 % (Kavuni) and low amylose content was observed for CO 43 (18.45 %). Variation in amylose content has a major influence in the pasting profile. Brown rice flour with high to intermediate amylose content becomes dry, fluffy and harder upon cooking. Higher setback values and pasting temperature was also observed in brown rice flour when compare to polished rice flour. Whereas polished rice flour with low to intermediate amylose content had higher peak viscosity, breakdown viscosity, lower value of setback and absorbs water in equal ratio tends to have better cooking and eating quality. Current study showed that the difference in pasting profile among the brown and polished rice flour with varied level of amylose content which had reflected in pasting curve.

The results of correlation analysis between the pasting parameters of brown and polished rice cultivars are presented in the table 4 and 5 respectively. In brown rice flour, the peak viscosity had significant and positive association with hot paste viscosity (0.977), break down viscosity (0.872), cool paste viscosity (0.978), setback viscosity (0.648) and negative correlation with pasting temperature (-0.442). Hot paste viscosity showed significant and positive correlation with breakdown viscosity (0.748), cool paste viscosity (0.971) and setback viscosity (0.687). Break down viscosity showed significant and positive association with cool paste viscosity (0.819). Significant and positive association was also observed between cool paste viscosity and setback viscosity (0.792).In case of polished rice flour, Peak viscosity had significant and positive association with hot paste viscosity (0.922), Break down viscosity (0.871) and cool paste viscosity (0.895). Both hot paste and cool paste viscosity showed significant and positive correlation with setback viscosity (0.422 and 0.536).The correlation among various pasting parameters revealed that no significant association was observed among the amylose content and pasting traits. The study also confirms with the report of Danbaba et al., (2012) that significant positive correlation between peak and breakdown viscosity indicates the starch pasting curve observed during heating and cooling cycle, gelatinization of starch reaches its peak, disruption of granules is observed as decrease in viscosity and results in gel structure after cooking at the end. Therefore, the RVA profile also often altered by changing its time and temperature whereas decreases by heating and increases when the paste is cooled.

Traditionally pigmented rice flour namely TKM 9, Kavuni, Improved kavuni, Norungan, Purple puttu, Thavalakannan and Mapillai
samba had different pasting profile than commercial white rice accessions which was clearly shown by RVA curves. Kesarwani et al., (2016) found that the RVA profile is closely associated with the taste (palatability) and quality of rice, whereas high peak, breakdown and smaller setback value had enhanced the grain quality such as soft and glutinous in texture. The study revealed that polished rice had higher peak and breakdown viscosity with reduced setback value which indicated that polished rice has soft texture and good taste quality with increased consumer preference. RVA profiles among the brown and polished rice flour gives a good source for creating variation for desirable traits associated to cooking quality on the basis of consumer preference (Allahgholipour et al., 2006). However, entire pasting parameter showed significant changes with marked difference in amylose content.

The present study revealed that all the rice accessions showed diverse pasting profile. Rice polishing had increased the range of pasting parameter with wide range of peak viscosity, hold viscosity, breakdown viscosity and final viscosity. The rice accessions with similar amylose content differed in all the pasting profile indicating the heating and cooling cycle among the same sample concentration. The combined study of amylose content with RVA profile will provide a better understanding in evaluating the rice cooking and eating quality and RVA based pasting parameters provides a quick selection of quality rice genotypes with mere precision. Correlation among pasting traits showed that the pasting parameters such as peak viscosity, setback viscosity and pasting temperature was found to be the most substantial variables in determining the amylose content of rice flour. Better understanding on nutritional quality among the brown and polished rice flour has increased in the developing countries with the increased consumer preference. Also, previous study shows brown rice affords numerous health benefits including prevention and management of cardiovascular diseases. Therefore, pasting profile associated with amylose content will provided a basic baseline in selection of cooking and eating quality grain for further development.

**Acknowledgement**

This study was supported by Department of Biotechnology, Government of India and Indian Council of Agricultural Research under Rice Biofortification Scheme.

**References**

Allahgholipour, M., Ali, A.J., Alinia, F., Nagamine, T. and Kojima, Y., 2006, Relationship between rice grain amylose and pasting properties for breeding better quality rice varieties. Plant Breeding.125:357-362

Ascheri, D.P.R., Boêno, J.A., Bassinello, P.Z. and Ascheri, J.L.R., 2012, Correlation between grain nutritional content and pasting properties of pre-gelatinized red rice flour. Rev. Ceres, Viçosa, 59:1.16-24

Atwell, W.A., Hood, L.F., Lineback, D.R., Varriano- Marston, E. and Zobel, H.F., 1988, The Terminology and Methodology Associated with Basic Starch Phenomena. Cereal Foods World.33:306–311.

Brand-Miller, J.C., Holt, S.H.A., Pawlak, D.B. and McMillan, J., 1992. Glycemic index and obesity. American J. Clin. Nutr., 76(1): 281-285.

Corke, H., Wu, H., Yue, S. and Sun, H., 1997, Developing Specialty Starches from New Crops: A Case Study Using Grain Amaranth. In Cereals: Novel Uses and Processes, 95–100. New York: Plenum Press.
Cruz, N.D. and Khush, G.S., 2000, Rice grain quality evaluation procedures. In Singh, R.K., Singh U.S., and Khush, G.S. (eds). Aromatic Rices. Oxford and IBH Publishing Co Pvt. Ltd, New Delhi, pp. 15 – 28.

Danbaba, N., Anounye, J., Gana, A., Abo, M., Ukwungwu, M. and Maji, A., 2012, Physical and pasting properties of ‘ofada’ rice (Oryza sativa L.) varieties. Nigerian Food Journal. 30:18-25.

Hu, P., Zhao, H., Duan, Z. and Linlin, Z., 2004, Starch digestibility and the estimated glycemic score of different types of rice differing in amylose content. J. Cereal Sci., 40: 231–237.

Jane, J., 2004, Starch: Structure and Properties. Chemical and Functional Properties of Food Saccharides. Pp. 82–96.

Jeevetha, S., Nisak, M.Y.B., Ngan, H.B., Ismail, A. and Azlan, A., 2014, Relationship between Amylose Content and Glycemic Index of Commonly Consumed White Rice. Journal of Agriculture and Veterinary Science. 7: 12-18.

Jennifer Minh-Chau Dang and Les Copeland, 2004. Genotype and environmental influences on pasting properties of rice flour. Cereal Chem., 81 (4): 486 – 489.

Juliano, B.O. and Pascaul C.G., 1980, Quality characteristics of milled rice grown in different countries. IRRI Res, Paper Ser.48, Int. Rice Res, Inst. Los Bancos, Laguna, Philippines.

Juliano, B.O., Onate, L.U. and Del, M.A.M., 1965, Relation of starch composition, protein content and gelatinization temperature to cooking and eating quality of milled rice. Food Technol., 19: 1006 – 1011.

Juliano, B.O., Perez, C.M. and Blakeney, A.B., 1981, International Cooperative testing on the amylose content of milled rice. Starch. 33(5), pp. 157-162.

Kesarwani, A., Chiang, P.Y. and Chen, S.S., 2016, Rapid visco analyzer measurements of japonica rice cultivars to study interrelationship between pasting properties and farming system. International Journal of Agronomy. 2016: 6.

Liu, Q., 2005, Understanding Starches and Their Role in Foods. In Cui, S.W. (Ed). Food Carbohydrates: Chemistry, Physical Properties, and Applications p. 1-340.

Martin, C. and Smith, A.M., 1995, Starch biosynthesis. Plant Cell 7: 971 – 985.

Martínez, M. M., Pico, J. and Gómez, M., 2015, Effect of different polyols on wheat and maize starches paste and gel properties. Food Hydrocolloids. 44: 81-85.

Meadows, F., 2002, Pasting Process in Rice Flour Using Rapid Visco Analyser Curves and First Derivatives. Cereal Chemistry. 79(4): 559–562.

Osungbaro, T.O., 1990, Effect of difference in variety and dry milling of maize on textural characteristics of Ogi. J. Food Agric. 54:1-11

Perdon, A. A., Siebenmorgen, T. J., Mauromoustakos, A., Griffin, V. K. and Johnson E. R., 2001, Degree of Milling Effects on Rice Pasting Properties. Cereal Chemistry. 78(2):205–209

Pongjanta, J., Chomsri, N. and Meechoui, S., 2016, Correlation of pasting behaviors with total phenolic compounds and starch digestibility of indigenous pigmented rice grown in upper Northern Thailand. Foods in Health and Disease. 6(3): 133-143

Shafie, B., Cheng, S.C., Lee, H.H. and Yiu, P.H., 2016, Characterization and classification of whole-grain rice based on rapid visco analyzer (RVA) pasting profile. International Food Research Journal. 23(5): 2138-2143.
Tananuwong, K., and Malila, Y., 2011, Changes in physicochemical properties of organic hulled rice during storage under different conditions. Food Chemistry. 125(1):179–185.

Thomas, D.J. and Atwell, W.A., 1999, Starches. Eagan Press Handbook Series. Am. Assoc. Cereal Chem., St. Paul, MN.

Tran, U.T., Okadome, H., Murata, M., Homma, S. and Ohtsubo, K., 2001, Comparison of Vietnamese and Japanese rice cultivars in terms of physicochemical properties. Food Sci. Technol. Res., 7: 323 – 330.

Vanaja, T. and Babu, L., 2003, Association between physicochemical characters and cooking qualities in high yielding rice varieties of diverse origin. Genetic Resources IRRN 28: 28 – 29.

Windham, W.R., Lyon, B.G., Champagne, E.T., Barton, F.E., Webb, B.D., Mcclung, A.M., Moldenhauer, K.A, Linscombe, S. and Mckenzie, K.S., 1997, Prediction of cooked rice texture quality using near- infrared reflectance analysis of whole-grain milled samples. Cereal chemistry. 74(5):626-632.

Yan, C. J., Li, X., Zhang, R., Sui, J. M., Liang, G. H., Shen, X. P., Gu, S. L. and Gu, M. H., 2005, Performance and inheritance of rice starch RVA profile characteristics. Rice Sci., 12:39—47.

How to cite this article:

Rithesh, B.N., S. Ramchander, S. Rajeswari, D. Uma, S. Robin and Jeyaprakash, P. 2018. Characterization of Physio-Chemical Properties of Starch among Traditional and Commercial Varieties of Rice (Oryza sativa L.) using Rapid Visco Analyser. Int.J.Curr.Microbiol.App.Sci. 7(10): 1490-1503. doi: https://doi.org/10.20546/ijcemas.2018.710.167