Analysis of cooking characteristics of important rice varieties marketed in Gujarat State

Bhavesh L Jani (jb9_bhavesh@yahoo.com)  
Junagadh Agricultural University  https://orcid.org/0000-0003-3509-3510

Bansee M Devani  
Junagadh Agricultural University

Sanjay H Akbari  
Anand Agricultural University

Dineshchandra C Joshi  
Agriculture University, Kota

Original article

Keywords: rice, cooking time, water uptake ratio, size

Posted Date: January 9th, 2020

DOI: https://doi.org/10.21203/rs.2.20307/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License. Read Full License
Abstract

The study was carried out to analyze cooking characteristics of important rice varieties grown and processed in Gujarat state of India. In the study cooking characteristics which are of the most important viz. optimum cooking time, elongation ratio, water uptake ratio, gruel solid loss, pasting temperature and final viscosity were determined by standard methodologies and found to be 17 min, 1.523, 2.6, 4.32%, 91.7 °C and 2558 ± 165.6 cP for parboiled rice, 12 min, 1.356, 2.7, 8.25%, 87.9 °C and 3546 ± 142.3 cP for Jeerasar rice and 14 min, 1.318, 2.8, 10%, 93.9 °C and 1523 ± 179.6 cP for GJ-17 rice, respectively. Also, the size i.e. length, width and thickness of all the three varieties were measured and plotted to observe the trend of expansion after cooking. From the above observations, it was found that parboiled rice has comparatively better cooking characteristics but has higher cooking time, which consumers may not accept for household purpose.

Introduction

Rice (Oryza sativa L.) is an important cereal grain which feeds nearly half of the world’s population. Rice is usually consumed as a whole grain after cooking, and in a regular Asian diet, can contribute for 40 to 80% of the total calorie intake (Singh et al., 20051; Hossain et al., 20092; Cai et al., 20113). Consumer preferences vary from region to region, Japanese like sticky rice (Deshpande and Bhattacharya, 19824), while Italians consume Baldo and Arborio rices that have high amylopectin and are short grain variety, which releases starch during cooking making a creamy and smooth risotto. Americans prefer a semi milled long grain rice or even brown rice, whereas Asian culinary dominates spicy and scented Basmati/Jasmine rice and the people of Indian sub-continent prefer well-milled white rice (Lyon et al., 19995). Being a major cereal grain, evaluating the nutritional and cooking qualities of rice has been given highest priority (FAO, 20046; Jiang et al., 20057). The rice produced in different parts of India varies significantly in composition and cooking quality. It has been opined that variations in composition and cooking quality of rice to mainly depend on the genetic as well as surrounding environmental factors where they are grown (Giri and Vijaya, 20008; Singh et al., 20051). Optimum water uptake ratio on cooking is an important parameter for a variety, as yield of cooked rice is directly proportional to water uptake ratio, which is an important consideration for the catering industry. Rice with high water binding capacity normally yields soft textured cooked product. As degree of milling influences cooking qualities like water uptake ratio, length expansion ratio, moreover, related to the profit of the farmers and rice milling industry, it is imperative to choose a suitable milling degree for the cultivars in order to minimize losses and improve cooking/ eating qualities. As brown rice and under milled rice is not preferred over milled rice for its poor eating quality (Piggot et al., 19919; Rao, et al., 196710; Roberts R. L., 197911; Mohapatra and Bal, 200512), the rice has to be properly milled. Based on these facts, the main objective of the present study was to analyze cooking quality of important rice varieties grown and marketed in Gujarat so that the relevant stakeholders can get ready information for processing.

Materials And Methods
Cooking qualities of the rice samples were determined using standard procedures (Batcher et al., 1956; Juliano and Bechtel, 1985; AACC, 2000; Zhou et al., 2002; Singh et al., 2003, 2005).

**Optimum Cooking Time**

In a 250 ml beaker, about 100 ml-distilled water was boiled (98 ± 1 °C) and 5 g of head rice samples dropped into it. Measurement of cooking duration was started immediately. After 10 min and every minute thereafter, 10 grains of rice were removed and pressed between two clean glass plates. Cooking time was recorded when at least 90% of the grains no longer had opaque core or un-cooked centers. The rice was then allowed to simmer for about another 2 min to ensure that the core of all grains had been gelatinized. Optimum cooking time included the additional 2 min of simmer.

**Elongation Ratio**

To determine elongation ratio, randomly selected cooked rice samples were measured for length and were divided by length of uncooked raw samples. Results were reported as elongation ratio.

**Water Uptake Ratio**

One gram of rice samples were cooked in 10 ml of distilled water for an optimum cooking time in a boiling water bath. The cooked sample was then drained and dried by pressing the samples between filter papers. Cooked rice samples were weighed and the water uptake ratio was calculated (determined as increase in weight of rice samples after cooking).

**Gruel Solid Loss**

To measure the gruel solid loss, approximately 2 g of rice grains were cooked in 20 ml of distilled water for minimum cooking time. The gruel obtained was transferred to beakers (50 ml) after few washing (3-5 times), and the volume was made up with distilled water. Further, the aliquot was evaporated in a vacuum oven (at 110°C) until it was completely dried. The solid obtained were weighed and the percentage of gruel solid loss was calculated.

**Viscosity and Pasting Temperature**

Milled rice sample for viscosity and pasting temperature analysis was ground with a grinder and sieved with 100-mesh screen. Three grams of the ground-milled rice was weighed (weight adjusted to 12% moisture basis) determined by AACC 44-31A and with 25 mL distilled water was blended. After blending, the rice-water slurry was transferred to the Rapid Visco-Analyzer.

**Results And Discussion**

**Cooking Properties**
As indicated in Table 4, the lowest value of optimum cooking time was found in Jeerasar rice (12 min.) followed by GJ-17 (14 min.) and Parboiled rice (17 min.) varieties, respectively. The parboiled rice variety had shown uniform increase in size i.e. length, breadth and height after cooking for all the observed kernels. While, in case of Jeerasar variety, non-uniform increase in size was observed by analyzing randomly 10 kernels. Linear trend was observed in the size of GJ-17 rice variety after cooking. The observations obtained during the experiment are mentioned in Table 1, Table 2 and Table 3 for Parboiled, Jeerasar and GJ-17 rice varieties, respectively.

The values of water uptake ratio, elongation ratio and gruel solid are shown in Table 4. For the same quantity and condition of cooking, water uptake ratio was higher in GJ-17 rice varieties than Jeerasar and Parboiled rice varieties. Though, the elongation ratio was found more in Parboiled rice as compared to the Jeerasar and GJ-17 rice varieties, which are having the elongation ratio at par with each other. Solid in gruel obtained after cooking for an optimum time, was found highest in GJ-17 rice, moderately lesser in Jeerasar rice and the lowest in Parboiled rice.

Table 1
Size of Raw and Cooked rice kernels of Parboiled variety

| Sr. No. | L, mm | B, mm | T, mm |
|---------|-------|-------|-------|
|         | Raw   | Cooked| Raw   | Cooked| Raw   | Cooked |
| 1       | 4.499 | 6.955 | 1.541 | 2.188 | 1.451 | 1.802  |
| 2       | 4.787 | 7.136 | 1.613 | 2.126 | 1.561 | 1.923  |
| 3       | 4.566 | 6.781 | 1.607 | 2.113 | 1.497 | 1.886  |
| 4       | 4.787 | 6.836 | 1.816 | 2.834 | 1.613 | 1.983  |
| 5       | 4.416 | 7.306 | 1.563 | 2.732 | 1.432 | 1.881  |
| 6       | 4.326 | 7.236 | 1.568 | 2.981 | 1.362 | 1.873  |
| 7       | 4.636 | 7.003 | 1.431 | 2.12  | 1.236 | 1.786  |
| 8       | 4.726 | 6.773 | 1.623 | 2.106 | 1.593 | 1.818  |
| 9       | 4.936 | 6.893 | 1.443 | 2.013 | 1.263 | 1.806  |
| 10      | 4.213 | 6.983 | 1.632 | 2.453 | 1.526 | 1.799  |
| Average | 4.589 | 6.990 | 1.583 | 2.366 | 1.453 | 1.855  |
Table 2
Size of Raw and Cooked rice kernels of Jeerasar variety

| Sr. No. | L, mm | B, mm | T, mm | Raw | Cooked | Raw | Cooked | Raw | Cooked |
|---------|-------|-------|-------|-----|--------|-----|--------|-----|--------|
|         |       |       |       | Raw |        | Cooked |        | Raw |        |
| 1       | 7.621 | 11.505| 1.693 | 2.807| 1.642  | 2.453 |
| 2       | 7.973 | 10.713| 1.696 | 2.775| 1.663  | 2.122 |
| 3       | 7.826 | 10.573| 1.633 | 2.284| 1.449  | 2.029 |
| 4       | 7.613 | 9.201 | 1.525 | 2.312| 1.423  | 2.465 |
| 5       | 7.426 | 9.432 | 1.631 | 2.236| 1.481  | 2.121 |
| 6       | 7.718 | 10.476| 1.623 | 2.883| 1.605  | 2.026 |
| 7       | 7.413 | 10.621| 1.612 | 2.913| 1.598  | 2.721 |
| 8       | 7.92  | 9.236 | 1.541 | 2.423| 1.522  | 2.453 |
| 9       | 7.521 | 11.532| 1.713 | 2.836| 1.631  | 2.433 |
| 10      | 7.621 | 10.721| 1.88  | 2.883| 1.663  | 2.121 |
| Average | 7.665 | 10.401| 1.654 | 2.635| 1.567  | 2.294 |
Table 3
Size of Raw and Cooked rice kernels of GJ-17 variety

| Sr. No. | L, mm | B, mm | T, mm |
|---------|-------|-------|-------|
|         | Raw   | Cooked| Raw   | Cooked| Raw   | Cooked |
| 1       | 5.98  | 7.386 | 1.812 | 2.764 | 1.571 | 1.954  |
| 2       | 5.783 | 7.4   | 1.721 | 2.71  | 1.563 | 1.76   |
| 3       | 5.883 | 7.52  | 1.691 | 2.62  | 1.612 | 1.93   |
| 4       | 5.426 | 7.66  | 1.761 | 2.77  | 1.626 | 1.952  |
| 5       | 5.668 | 7.51  | 1.783 | 2.81  | 1.599 | 1.941  |
| 6       | 5.038 | 7.29  | 1.891 | 2.84  | 1.481 | 1.982  |
| 7       | 5.53  | 7.34  | 1.943 | 2.87  | 1.58  | 1.921  |
| 8       | 5.678 | 7.321 | 1.821 | 2.712 | 1.599 | 1.932  |
| 9       | 5.68  | 7.491 | 1.814 | 2.926 | 1.58  | 1.942  |
| 10      | 5.78  | 7.5   | 1.776 | 2.804 | 1.619 | 1.979  |
| Average | 5.644 | 7.441 | 1.801 | 2.782 | 1.583 | 1.929  |
Table 4
Cooking characteristics of different varieties of rice

| Sr No | Properties          | Varieties          | Parboiled Rice | Jeerasar Rice | GJ-17 Rice |
|-------|---------------------|-------------------|----------------|--------------|------------|
|       |                     |                   | Before Cooking | After Cooking | Before Cooking | After Cooking |
| 1.    | Avg. Length, mm     | 4.5892            | 6.9902         | 7.6652       | 10.401     | 5.6446       | 7.4418       |
| 2.    | Avg. Breadth, mm    | 1.5837            | 2.3666         | 1.6547       | 2.6352     | 1.8013       | 2.7826       |
| 3.    | Avg. Thickness, mm  | 1.4534            | 1.8557         | 1.5677       | 2.2944     | 1.583        | 1.9293       |
| 4.    | Optimum Cooking     | 17                | 12             | 14           |            |              |              |
|       | Time, min           |                   |                |              |            |              |              |
| 5.    | Water Uptake Ratio  | 2.6               | 2.7            | 2.8          |            |              |              |
| 6.    | Elongation Ratio    | 1.523             | 1.356          | 1.318        |            |              |              |
| 7.    | Gruel solid loss, % | 4.32              | 8.25           | 10           |            |              |              |
| 8.    | Pasting Temperature, °C | 91.7           | 87.9           | 93.9         |            |              |              |
| 9.    | Viscosity, cP       | 2558 ± 165.6      | 3546 ± 142.3   | 1523 ± 179.6 |            |              |              |

As per Table 4, viscosity and pasting temperature, important characteristics during commercial utilization, are found the highest and lowest, respectively in Jeerasar variety. Pasting Temperature is the highest in case of GJ-17 rice variety while for the same variety, viscosity is the lowest. Figure 1 clearly depicts the changes in three dimensions of rice kernels before and after cooking.

**Conclusion**

Analyzing cooking characteristics, it can be concluded that Jeerasar variety though having less cooking time, gave higher solid loss in gruel and lower elongation ratio. While that of GJ-17 expanded in length approximately equally to that of Jeerasar rice. All over, parboiled rice has comparatively better cooking characteristics but has higher cooking time, which consumers may not accept for household purpose. As well as, on the basis of size, Jeerasar gave longer appearance than the others. This primary data of important commercial rice varieties will be helpful to processors to choose and market and to growers, for their choice of cultivation of variety.

**References**
1. Singh, N., Kaur, L., Singh, S. N. and Sekhon, K. S. (2005). Physicochemical, cooking and textural properties of milled rice from different Indian rice cultivars. *Food Chemistry*. 89: 253–259.

2. Hossain, M. S., Singh, A. K. and Fasih-uz-Zaman. (2009). Cooking and eating characteristics of some newly identified inter sub-specific (indica/japonica) rice hybrids. *Science Asia*. 35: 320-325.

3. Cai, Y., Liu, C., Wang, W. and Cai, K. (2011). Differences in physicochemical properties of kernels of two rice cultivars during grain formation. *Journal of Science of Food and Agriculture*. 91: 1977–1983.

4. Deshpande, S. S. and Bhattacharya, K. R. (1982). The texture of cooked rice. *Journal of Texture Studies*, 13, 31–42.

5. Lyon, B. G., Champagne, E. T., Vinyard, B. T., Windham, W. R., Barton, F. E. and Webb, B. D., (1999). Effects of degree of milling, drying condition, and moisture content on sensory texture of cooked rice. *Cereal Chemistry*, 76(1), 56–62.

6. Food and Agriculture Organization (FAO). (2004). Rice is Life. Italy: FAO.

7. Jiang, G-H., Hong, X-Y, Xu, C-G, Li, X-H. and He, Y-Q. (2005). Identification of quantitative trait loci for grain appearance and milling quality using a doubled-haploid rice population. *Journal of Integrative Plant Biology* 47: 1391−1403.

8. Giri, C. C. and Vijaya, G. (2000). Production of transgenic rice with agronomically useful genes: an assessment. *Biotechnology Advances* 18: 653-683.

9. Piggot, J. R., Morrison, W. R. and Clyne, J. (1991). Changes in lipids and sensory attributes on storage of milled rice milled to different degrees. *Journal of Food Science and Technology*, 26, 615–627.

10. Rao, R. S. N., Narayana, M. N., & Desikachar, H. S. R. (1967). Studies on some comparative milling properties of raw and parboiled rice. *Journal of Food Science and Technology*, 4, 150–155.

11. Roberts, R. L. (1979). Composition and taste evaluation of rice milled to different degrees. *Journal of Food Science*, 44(1), 127−129.

12. Mohapatra, D. and Bal, S. (2005). Cooking quality and instrumental textural attributes of cooked rice for different milling fractions. *Journal of Food Engineering*, 73, 253–259.

13. Batcher, O. M., Helmintoller, K. F. and Dawson E. H. (1956). Development and application of method for evaluating cooking and eating quality of rice. *Rice Journal*. 59:4-8, 32.

14. Juliano, B. O. and Bechtel, D. B. (1985). The rice grain and its gross composition. In B. O. Juliano (Ed.), Rice: chemistry and technology (2nd, pp. 17–50). St. Paul, Minnesota, USA: American Association of Cereal Chemists.

15. American Association of Cereal Chemists (2000), Approved Methods of Analysis, American Association of Cereal Chemists (AACC), Saint Paul, Minn, USA, 10th

16. Zhou, Z., Robards, K., Helliwell, S. and Blanchard, C. (2002). Ageing of Stored Rice: Changes in Chemical and Physical Attributes. *Journal of Cereal Science* 35:65–78.

17. Singh, N., Sodhi, N. S., Kaur, M. and Saxena, S. K. (2003). Physico-chemical, morphological, thermal, cooking and textural properties of chalky and translucent rice kernels. *Food Chemistry*. 82: 433–439.
### Tables

**Table 1** Size of Raw and Cooked rice kernels of Parboiled variety

|Sr. No. | L, mm | B, mm | T, mm |
|--------|-------|-------|-------|
|        | Raw   | Cooked| Raw   | Cooked| Raw   | Cooked|
|1       | 4.499 | 6.955 | 1.541 | 2.188 | 1.451 | 1.802 |
|2       | 4.787 | 7.136 | 1.613 | 2.126 | 1.561 | 1.923 |
|3       | 4.566 | 6.781 | 1.607 | 2.113 | 1.497 | 1.886 |
|4       | 4.787 | 6.836 | 1.816 | 2.834 | 1.613 | 1.983 |
|5       | 4.416 | 7.306 | 1.563 | 2.732 | 1.432 | 1.881 |
|6       | 4.326 | 7.236 | 1.568 | 2.981 | 1.362 | 1.873 |
|7       | 4.636 | 7.003 | 1.431 | 2.12  | 1.236 | 1.786 |
|8       | 4.726 | 6.773 | 1.623 | 2.106 | 1.593 | 1.818 |
|9       | 4.936 | 6.893 | 1.443 | 2.013 | 1.263 | 1.806 |
|10      | 4.213 | 6.983 | 1.632 | 2.453 | 1.526 | 1.799 |
|Average | **4.589** | **6.990** | **1.583** | **2.366** | **1.453** | **1.855** |

**Table 2** Size of Raw and Cooked rice kernels of Jeerasar variety
| Sr. No. | L, mm  | B, mm  | T, mm  |
|---------|--------|--------|--------|
|         | Raw    | Cooked | Raw    | Cooked | Raw    | Cooked |
| 1       | 7.621  | 11.505 | 1.693  | 2.807  | 1.642  | 2.453  |
| 2       | 7.973  | 10.713 | 1.696  | 2.775  | 1.663  | 2.122  |
| 3       | 7.826  | 10.573 | 1.633  | 2.284  | 1.449  | 2.029  |
| 4       | 7.613  | 9.201  | 1.525  | 2.312  | 1.423  | 2.465  |
| 5       | 7.426  | 9.432  | 1.631  | 2.236  | 1.481  | 2.121  |
| 6       | 7.718  | 10.476 | 1.623  | 2.883  | 1.605  | 2.026  |
| 7       | 7.413  | 10.621 | 1.612  | 2.913  | 1.598  | 2.721  |
| 8       | 7.92   | 9.236  | 1.541  | 2.423  | 1.522  | 2.453  |
| 9       | 7.521  | 11.532 | 1.713  | 2.836  | 1.631  | 2.433  |
| 10      | 7.621  | 10.721 | 1.88   | 2.883  | 1.663  | 2.121  |
| Average | 7.665  | 10.401 | 1.654  | 2.635  | 1.567  | 2.294  |

Table 3 Size of Raw and Cooked rice kernels of GJ-17 variety

| Sr. No. | L, mm  | B, mm  | T, mm  |
|---------|--------|--------|--------|
|         | Raw    | Cooked | Raw    | Cooked | Raw    | Cooked |
| 1       | 5.98   | 7.386  | 1.812  | 2.764  | 1.571  | 1.954  |
| 2       | 5.783  | 7.4    | 1.721  | 2.71   | 1.563  | 1.76   |
| 3       | 5.883  | 7.52   | 1.691  | 2.62   | 1.612  | 1.93   |
| 4       | 5.426  | 7.66   | 1.761  | 2.77   | 1.626  | 1.952  |
| 5       | 5.668  | 7.51   | 1.783  | 2.81   | 1.599  | 1.941  |
| 6       | 5.038  | 7.29   | 1.891  | 2.84   | 1.481  | 1.982  |
| 7       | 5.53   | 7.34   | 1.943  | 2.87   | 1.58   | 1.921  |
| 8       | 5.678  | 7.321  | 1.821  | 2.712  | 1.599  | 1.932  |
| 9       | 5.68   | 7.491  | 1.814  | 2.926  | 1.58   | 1.942  |
| 10      | 5.78   | 7.5    | 1.776  | 2.804  | 1.619  | 1.979  |
| Average | 5.644  | 7.441  | 1.801  | 2.782  | 1.583  | 1.929  |
Table 4 Cooking characteristics of different varieties of rice

| Sr No | Properties               | Parboiled Rice | Jeerasar Rice | GJ-17 Rice |
|-------|--------------------------|----------------|---------------|------------|
|       | Before Cooking           | After Cooking  | Before Cooking| After Cooking| Before Cooking| After Cooking|
| 1.    | Avg. Length, mm          | 4.5892         | 6.9902        | 7.6652     | 10.401       | 5.6446       | 7.4418       |
|       | Avg. Breadth, mm         | 1.5837         | 2.3666        | 1.6547     | 2.6352       | 1.8013       | 2.7826       |
|       | Avg. Thickness, mm       | 1.4534         | 1.8557        | 1.5677     | 2.2944       | 1.583        | 1.9293       |
| 2.    | Optimum Cooking Time, min| 17             |               | 12         |             | 14           |             |
| 3.    | Water Uptake Ratio       | 2.6            | 2.7           | 2.8        |             |             |             |
| 4.    | Elongation Ratio         | 1.523          | 1.356         | 1.318      |             |             |             |
| 5.    | Gruel solid loss, %      | 4.32           | 8.25          | 10         |             |             |             |
| 6.    | Pasting Temperature, °C  | 91.7           | 87.9          | 93.9       |             |             |             |
| 7.    | Viscosity, cP            | 2558 ± 165.6   | 3546 ± 142.3  | 1523 ± 179.6 |             |             |             |

Figures
Figure 2

Increase in Three dimensions of rice kernels before and after cooking