Effect of cooking methods on nutritional quality of rice (*Oryza sativa*) varieties

Suman* and Pinky Boora

Department of Foods and Nutrition, CCS Haryana Agricultural University, Hisar-125 004, India.

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**ABSTRACT**

The objective of the present investigation was to study the effect of four cooking methods viz. ordinary, pressure, microwave and solar cooking methods on proximate composition and *in vitro* protein and starch digestibility of six rice varieties. The study revealed that after cooking, moisture increased significantly, whereas, crude protein, fat, ash and crude fibre contents decreased significantly by 1.7 to 4.9, 20.8 to 33.8, 12.7 to 20.0 and 8.2 to 12.2 per cent, respectively under all cooking methods. The *in vitro* protein and starch digestibility upon cooking by all methods increased significantly and ranged from 81.87 to 86.60 and 90.60 to 92.14 per cent, respectively. Cooking methods differ significantly (P<0.05) in respect of moisture, fat and *in vitro* protein digestibility among rice varieties. It may be concluded that nutritional quality of rice is influenced by cooking but not much influenced by cooking methods.

**Key words:** Cooking, Microwave, Nutrient composition, Ordinary, Pressure, Rice varieties, Solar.

**INTRODUCTION**

Rice (*Oryza sativa*), the second most important cereal grain consumed worldwide plays a pivotal role in the diet of human population, especially in Asia. It provides more than one fifth of the calories consumed by humans. Rice is a nutrient rich complex carbohydrate, mainly starch; it also contains high quality protein (7%), vitamins and minerals with traces of fat. It has higher digestibility, biological value and protein efficiency ratio owing to the presence of higher concentration of lysine among all the cereals.

Rice is mainly consumed as cooked intact grains but a small amount of it is used as ingredient for processed foods and as feed. The nutritional composition of rice varieties may be influenced by cooking methods depending upon techniques and conditions including time, temperature and moisture. The most commonly used domestic cooking methods include ordinary and pressure cooking. Rice is cooked by washing and boiling in water which leads to loss of some nutrients (Ihekeronye and Ngoddy, 1985; Perez et al., 1987). As conventional energy resources are limited and depleting at a fast rate, there is need to explore the possibility of using other methods like solar cooking and microwave as an alternative method to routine cooking methods employed in common households. Microwave oven is a revolutionary appliance which is gaining popularity in modern homes during the past few decades (Arias et al., 2003). In microwave cooking, foods are cooked by frictional heat produced by the action of microwaves on water molecules causing them to vibrate at high speed. However, effect of conventional and modern cooking methods on nutritive value of important basmati and non-basmati rice varieties is lacking. Keeping this in view, the present work was undertaken to study the effect of cooking methods on proximate composition and *in vitro* protein and starch digestibility of six rice varieties.

**MATERIALS AND METHODS**

The experiment was carried out in the laboratory of department of Foods and Nutrition, College of Home Science, CCS HAU, Hisar in the year 2011. Six varieties namely Improved Pusa Basmati-I, Taraori Basmati (HBC 19) and CSR 30 of basmati and HKR 47, HKR 127 and IRBB 60 of coarse rice were procured in a single lot from Rice Research Station, Kaul (District Kaithal), CCS Haryana Agricultural University, Hisar. The paddy seeds were dehulled, polished, cleaned, free from dust, dirt and foreign materials and packed in air tight containers at room temperature prior to cooking.

**Cooking of rice:** All the six rice varieties were cleaned, washed twice and soaked for 30 minutes in distilled water prior to cooking with ordinary, pressure, microwave and solar cooking methods. Cooking time and water uptake for individual rice samples were standardized. For ordinary cooking, rice grains were cooked in a sauce pan covered with lid using seed to water ratio as 1:2.5 w/v. Whereas, seed to water ratio was 1:2 w/v, 1:2.5 w/v and 1:2 w/v for pressure, microwave and solar cooking methods, respectively.
microwave and solar cooking respectively. The cooking time was 16.3, 6.2, 14.0 and 48.9 minutes under ordinary, pressure, microwave and solar cooking methods, respectively. The pressure cooker was made up of aluminium (capacity 3 L of Hawkins Model). Microwave cooking was done in a rectangular glass tray with a lid by using high power in a microwave oven (Model INALSA-ED852S-A, 2450 MHz, 1450 watts.). Solar cooking was carried out on a bright sunny day in mid of April in a solar cooker (Model Beco, The Bharath Engg. Co.WZ-1, Phool Bagh Rampura Delhi, India). The direction of mirror was set in such a way that sun rays fell directly on it.

**Preparation of cooked samples for analysis:** Moisture content was determined from freshly cooked rice samples. For nutrient analysis, all the cooked rice samples were dried in hot air oven at 55-60°C to constant weight, ground in an electric grinder (Cyclotec, M/S Tecator, Hoganas, Sweden using 0.5 mm sieve size) to fine powder and packed in air tight containers at room temperature. Respective raw samples of all the rice varieties were also analysed for comparison.

**Chemical analysis:** The proximate composition of rice samples were determined by employing the standard methods of analysis (AOAC, 2000). *In vitro* protein digestibility was carried out by using the modified method of Mertz *et al.* (1983) and *in vitro* starch digestibility was assessed by the method of Singh *et al.* (1982).

**Statistical analysis:** Statistical analysis of the obtained data was carried out using completely randomized design according to the standard method (Panse and Sukhatme, 1961) to find the level of significant differences due to cooking and among cooking methods by OPSTAT software of CCSHAU, Hisar.

**RESULTS AND DISCUSSION**

**Nutritional evaluation of cooked samples:** The data on proximate composition and *in vitro* protein and starch digestibility of rice as influenced by various cooking methods and varieties are presented in Table 1.

The moisture content was significantly (P<0.05) lower in microwave (66.62 g/100 g) and higher in ordinary (69.67 g/100 g) cooking method as compared to pressure and solar cooking methods. Khatoon and Prakash (2006) also reported that microwave cooked samples had significantly less moisture as compared to pressure cooking in Jeera rice but in other rice varieties both methods were at par. Basmati varieties contained slightly less moisture (67.15 to 67.82 g/100 g) than coarse varieties (68.43 to 70.20 g/100 g) after cooking. The results of present investigation are in agreement with those of Begum and Bhattacharyya (2000) who reported moisture content of glutinous and non-glutinous rice varieties in the range of 64.5 to 74.6 per cent. The variation of moisture content in cooked rice varieties may be due to original moisture content of their raw samples in combination with the water uptake on cooking by application of different degree of heat under various cooking methods.

**Table 1:** Proximate composition (g/100 g), *in vitro* protein and starch digestibility (%) of rice as influenced by cooking methods and varieties (on dry wt. basis).

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Moisture</th>
<th>Crude protein</th>
<th>Fat</th>
<th>Ash</th>
<th>Crude fibre</th>
<th>In vitro protein digestibility</th>
<th>In vitro starch digestibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw sample</td>
<td>11.27</td>
<td>7.68</td>
<td>0.77</td>
<td>0.55</td>
<td>0.49</td>
<td>68.45</td>
<td>46.42</td>
</tr>
<tr>
<td>Cooking method</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ordinary</td>
<td>69.67</td>
<td>7.30</td>
<td>0.51</td>
<td>0.44</td>
<td>0.44</td>
<td>81.87</td>
<td>90.60</td>
</tr>
<tr>
<td>Pressure</td>
<td>68.67</td>
<td>7.43</td>
<td>0.53</td>
<td>0.46</td>
<td>0.43</td>
<td>84.83</td>
<td>91.14</td>
</tr>
<tr>
<td>Microwave</td>
<td>66.62</td>
<td>7.40</td>
<td>0.58</td>
<td>0.47</td>
<td>0.44</td>
<td>84.00</td>
<td>91.80</td>
</tr>
<tr>
<td>Solar</td>
<td>68.27</td>
<td>7.55</td>
<td>0.61</td>
<td>0.48</td>
<td>0.45</td>
<td>86.60</td>
<td>92.14</td>
</tr>
<tr>
<td>CD (P≤0.05)</td>
<td>0.59</td>
<td>0.19</td>
<td>0.03</td>
<td>0.03</td>
<td>0.02</td>
<td>1.78</td>
<td>1.35</td>
</tr>
<tr>
<td>Raw v/s Method</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Among Methods</td>
<td>0.65</td>
<td>NS</td>
<td>0.03</td>
<td>NS</td>
<td>NS</td>
<td>1.92</td>
<td>NS</td>
</tr>
<tr>
<td>Variety</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IPB-I</td>
<td>67.15</td>
<td>8.23</td>
<td>0.62</td>
<td>0.49</td>
<td>0.47</td>
<td>89.70</td>
<td>92.52</td>
</tr>
<tr>
<td>TB (HBC19)</td>
<td>67.65</td>
<td>8.06</td>
<td>0.61</td>
<td>0.51</td>
<td>0.44</td>
<td>88.20</td>
<td>92.93</td>
</tr>
<tr>
<td>CSR 30</td>
<td>67.82</td>
<td>7.66</td>
<td>0.58</td>
<td>0.50</td>
<td>0.41</td>
<td>83.40</td>
<td>90.67</td>
</tr>
<tr>
<td>HKR 47</td>
<td>68.57</td>
<td>6.70</td>
<td>0.63</td>
<td>0.44</td>
<td>0.43</td>
<td>86.32</td>
<td>93.22</td>
</tr>
<tr>
<td>HKR 127</td>
<td>70.20</td>
<td>7.02</td>
<td>0.47</td>
<td>0.41</td>
<td>0.42</td>
<td>80.10</td>
<td>89.35</td>
</tr>
<tr>
<td>IRBB 60</td>
<td>68.43</td>
<td>6.84</td>
<td>0.44</td>
<td>0.41</td>
<td>0.47</td>
<td>78.23</td>
<td>89.85</td>
</tr>
<tr>
<td>CD (P≤0.05)</td>
<td>0.79</td>
<td>0.24</td>
<td>0.03</td>
<td>0.04</td>
<td>0.02</td>
<td>2.35</td>
<td>1.80</td>
</tr>
</tbody>
</table>

IPB-I - Improved Pusa Basmati-I and TB - Taraori Basmati

Moisture – (on fresh wt. basis)
Solar cooking did not show any significant change in mean protein content (7.55 g/100 g) as compared to raw rice protein content (7.68 g/100 g), whereas, in ordinary (7.30 g/100 g), pressure (7.43 g/100 g) and microwave (7.40 g/100 g) cooked rice, the protein content decreased significantly. The per cent decrease in protein content over the raw control was 1.7 in solar, 3.2 in pressure, 3.6 in microwave and 4.9 in ordinary cooking method (Fig. 1). However, all the cooking methods did not differ significantly to each other in respect of changing the protein content of rice varieties. The results of present study are almost on the similar lines as reported by Khatoon and Prakash (2006) and Sagum and Arcot (2000), who reported no significant differences in protein content of rice among various cooking methods. The decrease in protein content in cooked rice of various varieties was 3.1 to 3.6 percent (Fig. 2). Both basmati varieties Taraori Basmati and Improved Pusa Basmati-I retained higher protein content (8.06 to 8.23 g/100 g) even after cooking as compared to other varieties. Similarly, the loss in crude protein content in cooked rice as compared to raw rice was reported as 4.2 percent by Shekib et al. (1985) and 2 to 7 percent by Juliano (1993). Ebuehi and Oyewole (2007) reported that the protein contents of ofada and aroso rice varieties were affected by cooking and soaking in water. Cooking of rice denatures the protein and soaking results in solubility of some proteins which leads to reduction in proteins.

The fat content decreased significantly (Fig. 1) in cooked rice samples due to cooking methods and it ranged from 20.8 in solar to 33.8 percent in ordinary cooking method. Both microwave and solar cooked rice had significantly (P<0.05) higher fat content than pressure and ordinary cooked samples. The decrease in fat content as a result of cooking may be due to chemical and physical changes that occur in fat during heating (Roth and Rock, 1972). The differential loss in fat content among different methods might be due to variation in loss of volatile components resulting due to fat hydrolysis by the combined effect of available water and temperature differences during cooking (Begum and Bhattacharyya, 2000). On mean basis, the fat content decreased by 22.5 to 25.6 percent in basmati varieties and 30.0 to 30.9 percent in coarse rice varieties after cooking by various methods (Fig. 2). Khatoon and Prakash (2006) had reported a decrease in fat as 20 to 60 percent under both pressure and microwave methods in different rice varieties. However, the differences between two cooking methods were not significant. This decrease in fat content could be attributed to the washing process which leads to washing of the lipids which are concentrated on the outer layer of the grain.

All cooking methods brought about a significant decrease (12.7 to 20.0%) in ash content of cooked rice samples as compared to raw rice (Fig. 1). However, no significant difference in ash content was recorded among the cooking methods. The ash content in basmati varieties after cooking was significantly (P<0.05) higher in spite of higher percent decrease of 16.4 to 20.6 as compared to coarse varieties with decrease of 12.8 to 17.0 percent under various cooking methods (Fig. 2). In earlier studies percent decrease in ash content of rice varieties with cooking was reported as 10.9 by Shekib et al. (1985) and 11.0 to 38.0 by Matsuzaki et al. (1992), whereas, Khatoon and Prakash (2006) reported decrease of 20.0 to 33.0 percent with pressure and microwave cooking methods but differences between these methods were not significant.

The crude fibre content decreased significantly by 8.2 to 12.2 percent under various cooking methods compared to raw samples (Fig. 1). However, among various cooking methods non significant differences were observed in fibre content. Cooking resulted in significant (P<0.05) decrease in crude fibre content (4.4 to 13.7%) of rice varieties (Fig. 2). Improved Pusa Basmati-I and IRBB 60 retained significantly (P<0.05) higher fibre content (0.47 g/100 g) after cooking as compared to other varieties (0.41 to 0.44 g/100 g). Shekib et al. (1985) reported significant loss (27.6%) in crude fibre of rice due to cooking. Ebuehi and Oyewole (2007) had also observed significant variation in crude fibre content of rice varieties after cooking.
content of rice varieties after cooking with decrease in fibre content from 28.6 to 33.3 per cent.

**In vitro protein digestibility:** The *in vitro* protein digestibility of rice was significantly (P<0.05) increased by cooking methods (81.87 to 86.60%) over raw samples (68.45%). On mean basis, the per cent increase was 19.6, 23.9, 22.7 and 26.5 (Fig. 3) under ordinary, pressure, microwave and solar cooking methods as compared to raw samples. Among various cooking methods, the *in vitro* protein digestibility did not differ significantly in pressure and solar cooking methods. Also, microwave was at par to pressure and ordinary cooking methods. Improved Pusa Basmati-I had significantly (P<0.05) highest *in vitro* protein digestibility (89.70%) after cooking except Taroari Basmati (88.20%) which was also significantly superior to other varieties except HKR 47. The increase in *in vitro* protein digestibility in cooked rice of various varieties was 10.2 to 28.5 percent over raw samples (Fig. 4). In earlier studies, Khatoon and Prakash (2006) had recorded *in vitro* protein digestibility percentage in the range of 82.1 to 91.0 in pressure and 80.0 to 90.8 in microwave cooked samples. They also observed higher digestibility in aromatic rice varieties in comparison with non-aromatic rice and in pressure cooked samples in comparison with microwave method, though not significantly. Sagum and Arcot (2000) also recorded improved protein digestibility of rice varieties on boiling (76.5 to 80.5%) and pressure cooking (90.9 to 92.2%). Deka (1998) reported 16.6 to 25.4 per cent increase in protein digestibility of rice varieties upon cooking. The increase in protein digestibility may be attributed to the inactivation of protease inhibitors and the opening up of the protein structure through denaturation on heating. The low *in vitro* protein digestibility observed in microwave and ordinary cooked samples may be due to prolonged severe heat treatment compared to pressure and solar cooking methods.

**In vitro starch digestibility:** *In vitro* starch digestibility of cooked rice ranged from 90.60 to 92.14 percent under various cooking methods which was 95.2 to 98.5 percent (Fig. 3) higher than raw rice (46.42%). However, *in vitro* starch digestibility did not differ significantly among the cooking methods. HKR 47, Taroari Basmati and Improved Pusa Basmati-I were almost similar (92.52 to 93.22%) and had significantly (P<0.05) higher *in vitro* starch digestibility after cooking than other varieties (89.35 to 90.67%). Cooking resulted in significant (P<0.05) increase in *in vitro* starch digestibility (86.3 to 102.2%) of rice varieties as compared to raw samples (Fig. 4). The results of present study are in agreement with those reported earlier by Khatoon and Prakash (2006). They reported *in vitro* starch digestibility percentage in the range of 92.9 to 93.8 under pressure cooking and 93.1 to 93.9 in microwave cooking method and the differences in both the methods were not significant but increased the starch digestibility two folds compared to uncooked samples. However, Sagum and Arcot (2000) had reported lower values of starch digestibility in Doongara, Inga and Japonica rice varieties in raw, boiled and pressure cooked rice samples with increase in digestibility after cooking in the range of 2.1 to 2.5 times of the uncooked samples. Devi and Geervani (2000) had reported more than three folds increase in starch digestibility with boiling of rice varieties of Andhra Pradesh. Starch digestibility is influenced by physico-chemical properties such as gelatinization temperature, cooking time, amyllograph consistency and volume expansion upon cooking as well as the extent of amylose retrogradation and the formation of resistant starch (Dreher et al., 1986; Devi and Geervani, 2000). During cooking, starch granules are gelatinized and partly solubilized, becoming available to digestive enzymes thus enhancing the starch digestibility. Socorro et al. (1989) had reported that heating greatly increases the susceptibility to α-amylolysis of each starch assayed.

**CONCLUSION**

The moisture and fat contents in cooked rice samples differed significantly (P<0.05) among cooking methods, whereas, ash, crude fibre and crude protein contents did not
differ significantly. The decrease in fat content in cooked samples was significantly less in microwave and solar cooking as compared to ordinary and pressure cooking methods. The solar and pressure cooked rice had significantly (P<0.05) higher in vitro protein digestibility than ordinary cooked samples, whereas, starch digestibility of cooked rice did not differ significantly among various cooking methods. It may be concluded from the present study that nutrient composition of rice was significantly effected by washing and cooking but remained almost similar among cooking methods.

REFERENCES