Effects of the Various Parboiling Methods on the Proximate Composition, Amylose and Resistant Starch of Two Rice Varieties from Sri Lanka

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Abstract: Chemical properties of rice grain are a potential concern for human health. The effects of different parboiling treatments on the chemical properties of rice were investigated. Two Sri Lankan rice varieties, short white pericarp (Bg 360) and medium red pericarp (Bg 406) were used. Chemical properties were compared for non-parboiled (NP) and parboiled rice in four various methods; traditional parboiling (TP), pressure parboiling (PP), central food technological research institute parboiling (CFTRIP) and dehusked rice parboiling (DRP). The significant differences due to parboiling method and rice variety were determined by factor factorial experiment. Parboiling improves protein, fat and ash content, while reduces carbohydrate and crude fibre content. The increment of protein content parboiled by DRP method were 8.5% and 7.6% in Bg 406 and Bg 360 varieties respectively.

Key words: Nutrient, Parboiling, Rice

1. Introduction

Rice (Oryza sativa L.) is the major food crop in the world [1, 2] and it consume in various forms. Which are raw rice, parboiled rice and parboiled rice product [3]. In Sri Lanka, Rice intakes both as raw and parboiled [4]. Around half of the daily energy requirement fulfilled by rice consumption of the Sri Lankans [5] and their average consumption of rice is 109.72 kg/yr in 2013.

The preference for the parboiled rice appears to be increasing in the world[6]. Rice processing industry is one of most wide spread and largest agro based industries in Sri Lanka is producing valuable products. Parboiling is the popular agro based industry in Sri Lanka and about 70% of the total production of paddy rice grains is parboiled [4, 7]. Parboiling of paddy is practiced in both village level and in commercial level [4]. Soaking, steaming and drying conditions are different for rice varieties used for parboiling. There is good or emerging evidence that parboiling changes nutrition composition in rice by the process of parboiling[8]. Various parboiling methods have been followed for preparation of parboiled rice[3]. Analyzing different techniques used for parboiling in terms of their chemical properties are essential to increase the efficiency of the system in rice processing industry. Analyzing nutrition content in rice which are parboiled in various ways is essential to determine the method of parboiled rice consisting of required percentage of important nutritional profile of poor people by enrichment of nutrition composition of the rice. However there are no studies were conducted in comparison of these properties changes by the parboiling method in a same rice variety. Hence, an attempt has been developed to investigate the effect of parboiling method on chemical properties. For the appreciation finding in above concept, two Sri Lankan rice varieties has been selected.

2. Materials and methodology

2.1. Materials

2.1.1. Paddy samples

Two Sri Lankan rice varieties (Bg 406 and Bg 360) were selected and obtained from the Plant Genetic Resource Centre (PGRC), Gannoruwa, Peradeniya through Paranthan, Rice Research Development Institute. Purity percentage of two varieties was 99 % and the samples had been harvested four months before parboiling. Cleaned paddy was air dried up to 12.6±0.1% moisture content and then stored prior to parboiling.

2.1.2. Rice flour preparation
Rough rice samples were dehusked in a satake testing rice husker (THU-35A, Satake Engineering Co. Ltd. Tokyo, Japan) for removal of husk. The brown rice was polished till 8.0 ± 0.25% of bran removal in satake laboratory rice whitening machine (MC-250, Satake Engineering Co. Ltd. Tokyo, Japan).

Head rice were powdered in an ultra centrifugal rice mill and the flour was passed through a 60-mesh sieve. The powdered samples were kept at 4°C in screw-capped tubes [9].

2.2. Laboratory parboiling

Four popular parboiling methods were selected in this study. Parboiling was done in three important steps. Such as soaking (steeping), steaming and drying. Paddy is to water ratio was kept as 1:1.3 in all treatments [10]. Every parboiling methods were done in triplicates for accuracy.

2.2.1. Traditional parboiling

Paddy varieties Bg 360 and Bg 406 were soaked in water at ambient temperature for 24 hours and 48 hours respectively. Paddy grains were then open steamed till their hulls split off (35.5 ± 0.5% (w.b.) of moisture content). It was then cooled and sun dried [10, 11].

2.2.2. Pressure parboiling

Both of paddy varieties Bg 360 and Bg 406 were soaked in water at ambient temperature for 6 h. Then the Paddy was exposed to steam under pressure at 15 p.s.i g (121°C) for 15 minutes. At the end of steaming, paddy was reached 30.7 ± 0.5% & 26.52 ± 0.4% (w.b.) of moisture content respectively in rice varieties Bg 360 & Bg 406. Then parboiled paddy was tempered for 30 minutes and sun dried after steaming [12].

2.2.3. CFTRI parboiling

Paddy varieties Bg 360 and Bg 406 were hot water soaked in thermo stable water bath at the temperature of 65°C for 3h and 4.5h respectively. Paddy grains were then open steamed and sun dried.

2.2.4. Dehusked rice parboiling

Dehusked rice of paddy varieties Bg 360 and Bg 406 were soaked in water at the temperature of 80°C for 25 minutes and 45 minutes respectively and cooled at room temperature for 2 h followed by it was then open steamed till 35.2 ± 0.2% (w.b.) of moisture content for 20 min. It was then dried under shade [13].

2.3. Proximate analysis

Moisture contents were measured by using oven dry method at 105 °C until a constant weight was attained [14]. The total nitrogen present in the samples were determined by using microKjeldahl method and protein contents of the samples were calculated by multiplying the percentage of nitrogen by the conversion factor (Nx5.95) based on the methods outlined in AOAC (2000) [15]. Total fat contents were examined by manual extraction method [16]. Crude fibre and ash contents by Incineration method were investigated [15]. Carbohydrate contents of the samples were obtained by subtracting the percentage of moisture, ash, crude protein, fat and crude fibre from 100. The equation is shown below [17].

Percentage of carbohydrate = 100 - (% moisture + % ash + % crude protein + % fat + % crude fibre)

2.4. Estimation of energy value

Energy values were determined by bomb calorimeter. Sample of 0.5 g was weighed into a crucible, and placed inside a stainless steel container (Decomposition vessel) filled with 1200 MPa of oxygen. Then decomposition vessels were placed in a bomb calorimeter and the lid was closed. After that sample weight entered in the display using the keyboard. Then the sample was ignited through a cotton thread connected to an ignition wire inside the decomposition vessel and burned. All organic matter was burned under these conditions, and oxidized. At the end point calorific value was displayed in the bomb calorimeter display.

2.5. Quantitative determination of amylose

Purified potato amylose was used as a standard for determination of the amylose percentage of sample [18].

2.6. Estimation of resistant starch content

Resistant starch values were analyzed by Enzymatic Digestion method [19].

2.7. Statistical method

Data obtained from each variety under different parboiling conditions were fitted into a factorial (5x2) completely randomized design (CRD) with three replicates and subjected to analysis of variance (ANOVA). Mean separation was done using the Duncan’s Multiple Range Test to determine the statistical differences among properties at a significance level of 0.05. Statistical analysis was carried out using SAS software package.

3. Results and Discussions

3.1. Proximate composition of milled rice

Proximate composition of ten milled rice samples of two Sri Lankan varieties is presented in Table 1.
The moisture content varied between 12.91% and 14.05% among the samples of both varieties. There is an increase in ash value of the parboiled samples compared to NP rice. Ash values were significantly different amongst the varieties whereas white variety tends to have higher ash contents and was highest for the TP kernels with 1.53% in rice variety Bg 360, respectively. The result shows a gradual increase in the ash content of rice by the process of parboiling with increasing temperature of soaking.

There were marked significant differences in the protein content values between the parboiling methods in a variety. The obtained values were within the range (5-14%) for polished rice found by Damardjati, Soekarto (1985). Bg 360 variety showed the higher protein value than Bg 406 variety. Since the protein content of NP rice type in both variety is the lowest value amongst all type of parboiled and NP samples rice of variety especially in DRP and CFTRIP samples, which had 2.64% and 2.43%, which were 28% and 22% increment in fat content than NP samples respectively, while the highest% obtained for CFTRIP and DRP samples, 2.04% and 1.96% respectively, which were 24.5% and 21.5% increment in fat content than NP samples rice of variety Bg 360. This is because of leaching and rupturing of the oil globules that occur due to increase in temperature that occurs during the parboiling process [22]. It is known from previous studies (found by Chakravarty and Ghose mentioned by Pillaiyar 1988) that oil content in bran increases with increasing temperature of soaking.
parboiled and NP rice have been reported by Sareepuang, Siriamornpun et al (2008) and AKHTER, ALI et al (2014). Protein influences the nutritional eating quality of rice [9, 23]. In this study the protein content was appreciably high (>5.96%) for all parboiled and NP rice. Especially the CFTRIP sample showed the highest protein values 6.51% and 7.57%, which was 8.51% and 6.8% increment in Protein content than NP for Bg 406 and Bg 360 varieties respectively, and thus are interesting for food products [9].

Figure 3. Variations of protein content with method of parboiling in two rice cultivars.

Findings in the crude fibre showed significant differences between treatments at the 5% probability level. In all parboiled samples, crude fiber was found to decrease and a maximum decrease was observed in CFTRIP samples 0.11% and 0.15% respectively in rice varieties, Bg 406 and Bg 360 [20, 22, 24]. However PP samples resulted in higher values (0.35%) than NP (0.30%) rice in both varieties. The response of crude fibre to PP agrees with the results obtained by Otegbayo, Osamuel et al (2004).

Figure 4. Variations of Crude fibre content with method of parboiling in two rice cultivars.

The percentage of carbohydrate content showed significant differences amongst all type of parboiled and NP rice samples, where NP sample tend to have the highest carbohydrate content for the rice varieties Bg 406 and Bg 360, 77.07% and 76.9% respectively. Similar observations have been observed in previous study [21]. This is because of leaching of carbohydrate substances during soaking. However previous study revealed that carbohydrate content of the parboiled rice samples were higher than that of the NP sample [22]. Significant differences were observed between methods of parboiling in both rice varieties.

Figure 5. Variations of Carbohydrate content with method of parboiling in two rice cultivars.

For calorie value, a significant differences was recorded between NP and parboiled rice (P<0.05). The DRP sample (356.8) has significantly highest calories value than the rest samples of Bg 406 variety, while CFTRIP sample resulted highest calories value (350.85) in rice variety Bg 360. Some methods of parboiled samples have higher calories than NP rice, while some have lower values of calories [22].
The contents of resistant starch and amylose in the freshly cooked rice samples is given in Table 2. The changes in percentage of amylose and resistant starch content during this various processes. It has indeed been reported that the components of leached starch consist of amylose and amyllopectin, at a different proportion (Ong and Blanshard, 1995b). The amount of leached amylopectin is generally higher than that of leached amylose; the short-chain amyllopectin is considered the main proportion of the leached starch [25] and insoluble amylose-lipid complex is formed by the process of parboiling [6, 8]. As a result, percentage of amylose is higher in parboiled rice. Similar observations have been reported in previous studies[12]. Pillaiyar (1988) estimated that the soluble amylose content is altered, depending upon the severity of parboiling. Recent studies suggested that, high amylose rice exhibits lower starch digestion rate [26, 27].

The amylose content of rice is an important factor, used to determine of rice grain quality in terms of cooking and pasting properties [9, 23]. Amylose values showed significant differences amongst parboiling methods at the 5% probability level (Table 4.10). Based on the Srinivasa, Raman et al (2013) classification, all the type rice of Bg 406 rice variety had high amylose content, the amylose content varied between 25.12% and 29.03% in rice variety Bg 406. While all parboiled and NP samples of Bg 360 variety rice had intermediate amylose content except DRP rice, which had high content of amylose (25.04±0.03%).

DRP rice type, it has the highest amylose content value amongst same variety, 29.03±0.15% and 25.04±0.03% respectively in rice varieties Bg 406 and Bg360. There was increase in the amylose content of the parboiled rice samples [12]. They have reported, the value of amylose content of brown rice in parboiled and NP is 26.57% and 22.39% respectively.

RS values ranged between 0.12% and 1.6% on a dry matter basis, which is in agreement with literature data [6]. The resistant starch level was higher in DRP rice of both variety (Table 4.10).

### Table 2. Resistant starch, amylose content of freshly cooked rice

<table>
<thead>
<tr>
<th>Rice variety</th>
<th>Parboiling method</th>
<th>RS (%DM) a</th>
<th>Amylose (%DM) a</th>
<th>Amylose classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bg 406</td>
<td>NP</td>
<td>0.19±0.03²</td>
<td>25.12±0.04⁴</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>TP</td>
<td>0.51±0.04⁹</td>
<td>26.13±0.12³</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>PP</td>
<td>0.9±0.09⁴</td>
<td>27.33±0.36⁴</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>CFTRIP</td>
<td>1.01±0.4³</td>
<td>26.54±0.42⁴</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>DRP</td>
<td>1.6±0.13⁴</td>
<td>29.03±0.15⁴</td>
<td>High</td>
</tr>
<tr>
<td>Bg 360</td>
<td>NP</td>
<td>0.12±0.05⁵</td>
<td>22.48±0.33⁴</td>
<td>Intermediate</td>
</tr>
<tr>
<td></td>
<td>TP</td>
<td>0.31±0.19⁵</td>
<td>23.02±0.02⁵</td>
<td>Intermediate</td>
</tr>
</tbody>
</table>

Mean values of same variety within a column superscripted by the same letter are not significantly different at p< 0.05.

### 4. Conclusion

Different parboiling methods practiced to parboil two different paddy varieties, Bg 406 and Bg 360 have strong impact on chemical properties.

From the results obtained in this study, it can be concluded that parboiling in rice processing changes Chemical properties. It improves protein, fat and ash content, while reduces carbohydrate and crude fibre content. The increment of protein content parboiled by DRP method were 8.5% and 7.6% in Bg 406 and Bg 360 varieties respectively. The increase in protein content of the parboiled rice can also serve as an effective means of improving the protein intake in people’s diet therapy enhancing their nutritional status.

### 5. References


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