Evaluation of physico-chemical and milling properties of selected paddy varieties in Sri Lanka

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1. Introduction

Rice (*Oryza sativa* L.) is the world's overwhelming cereal, providing 60-70% of the caloric value for human beings. To enhance the standard of rice varieties, it is essential to confirm the good post-harvest processing by providing information based on the physico-chemical and milling properties of paddy grains. For individuals involved in rice production, the physical parameters of grains are of critical concern. These dimensions are crucial for the commercialization, categorization, development of new rice varieties, and drying and processing processes. As well, the milling quality will determine the quality of rice. It involves the removal of husk and bran to get an endosperm for human consumption. A significant proportion of head rice, high milling recovery, low broken rice, lack of contaminants, and good appearance is the major quality determinants of rice. The milled rice has a longer shelf life and offers consumers the physical characteristics they want. Rice is a good source of energy and the protein quality of rice is relatively high especially in lysine amino acids. When rice is taken as whole grains rather than refined grains, it will provide a variety of minerals and vitamins, as well as bioactive components and dietary fibres. Rice quality determines the market value of the commodity, and it also influences the development and adoption of new varieties. Therefore, the research study was carried out to assess the physicochemical and milling properties of selected paddy varieties in Sri Lanka.

2. Materials and Methods

The research study was conducted at the Rice Research and Development Institute, Bathalagoda in the *Yala* season. The maximum temperature of 34 °C, minimum temperature of 19 °C and mean relative humidity ranged between 65-75% were noticed during the study period. The paddy grain varieties such as Bg 300, Bg 352, At 311, Suwendel, and Suduheenati were selected for the experiments. The initial moisture content of selected paddy samples were 12.5%, 13.1%, 12.9%, 13.2% and 12.6% respectively. The paddy rice was de-husked using rice husker (Satake, DH035B) and the obtained brown rice was polished with rice polisher (Satake THO 50) into milled rice. They were manually separated into head rice and broken rice grain. The weights obtained were recorded after each operation and they were used to determine the milling characteristics such as percentage of brown rice, polished rice, milling degree, head rice and broken rice according to the IRRI (2009).

The physical characteristics of milled rice such as length, width, and length/width ratio (L/W) were determined using Vernier calliper. RRDI (2018) was used to determine the size and shape of grains. The grain size was classified based on length; long (6-7mm), intermediate (5-5.99mm) and short (<5mm). The shape of grain was classified considering L/W; slender (>3.0), medium (2.4-3.0); bold (2-2.39) and round (< 2.0). A moisture metre (G-WON GMK303, South Korea) was used to assess the moisture content of rice samples. The protein and fat content were determined by AOAC (2005). Juliano's simplified technique for estimating amylose content was used. The index of the alkali digestibility test was used to determine the gelatinization temperature. ANOVA was used to statistically evaluate the results of the experiment. Duncan Multiple Range Test (DMRT) was used to examine the differences in means using SAS package version 9.1. Further, the correlation was carried out to see the relationship between the amylose content and gelatinization temperature with the milling properties of rice.

3. Results and Discussion

Table 1 shows the milling and physical properties of different selected rice varieties. The highest brown rice percentage was recorded as 79.94% in Bg 352 and a minimum of 75.61% for Suwendal. In general, husk comprises 20-22 percent of rough rice, with a range of 18-26 percent reported (Cruz & Khush, 2000). The highest total milled rice percentage was observed 74.73% in Bg 352 and a minimum of 69.06% for Suduheenati and the highest percentage of head rice was recorded 83.34% in Suwendel and a minimum of 50.94% for At 311. The highest broken rice percentage was recorded at 12% in At 311 and a minimum of 1% in Suwendel. The highest degree of polishing was recorded in Suduheenati and the lowest degree was recorded in Bg 352. Suwendel had the shortest length of 4.47 mm, while At 311 had the longest length of 6.98 mm (Table 1). Three varieties were categorized under intermediate class except At 311 and Suwendel. The highest width was 2.92 mm for Bg 352 and a minimum of 1.92 mm for At 311 while the highest length and width ratio was 3.64 in At 311 was categorized slender in shape. Otegbayo et al. (2001) reported length-width ratio ranged from 2.12 mm to 2.62 mm.

Table 1. The milling and physical properties of different selected paddy grain varieties.

Variety	Brown Rice (%)	Total Milled Rice (%)	Head Grain (%)	Broken Grain (%)	Degree of Polishing (%)	Length (mm)	Width (mm)
Bg 300	79.62±0.07^{c}	72.56±0.2^{b}	65.04±0.15^{c}	3.4±0.09^{c}	8.87±0.12^{c}	5.7±0.04^{c}	2.84±0.1^{c}
Bg 352	79.94±0.06^{a}	74.73±0.09^{a}	77.06±0.25^{b}	2.1±0.07^{d}	6.52±0.09^{e}	5.93±0.07^{b}	2.92±0.14^{a}
At 311	79.69±0.04^{b}	72.20±0.15^{c}	50.94±0.19^{e}	12±0.12^{a}	9.40±0.21^{b}	6.98±0.06^{a}	1.92±0.09^{e}
Suwendel	75.61±0.08^{e}	70.54±0.21^{d}	83.34±0.17^{a}	1.0±0.07^{e}	6.71±0.09^{d}	4.47±0.04^{e}	2.86±0.14^{b}
Suduheenati	76.45±0.04^{d}	69.06±0.34^{e}	57.34±0.29^{d}	4.2±0.11^{b}	9.67±0.06^{a}	5.66±0.07^{d}	2.72±0.11^{d}

The values are the means ± standard error. Means with the same letter are not significantly different at the 5% level.

The nutritional characteristics of different selected rice varieties are shown in Figure 1. According to our study, the fat, protein, and amylose contents of the rice varieties differed significantly ($p<0.05$), while the moisture content of the rice varieties did not differ significantly ($p>0.05$). The highest moisture content was observed in Bg 352 (12.3%) and the minimum was observed in Suwendel (11.4%). Bg 352 had the highest fat content (4.6%) and the minimum was observed in At 311 (2.08%). Yodmanee et al. (2011) reported slightly lower values of the fat content of eight varieties of dehusked pigmented rice grain. While Cui et al. (2010) reported 3.27% fat content in brown rice. The protein content varied from 7.29% to 9.64%. The results were in accordance with Sompong et al. (2011) who reported 7.16-10.36% protein content in red rice varieties of different countries.

As shown in Figure 1, the highest amylose content was recorded 26.29% in Bg 300 and Bg 352, also the minimum was recorded 18.96% in At 311. According to the IRRI (2004) classification At 311 categorized as low amylose content, Suwendel and Suduheenati varieties were categorized into intermediate amylose content, also Bg 300 and Bg 352 were categorized into high amylose content. The results were in accordance with Gealy and Bryant (2009) who reported the amylose content in red rice ranged from 21.8 to 25.0% and in red rice crosses ranged from 15.1 to 25.5%. There was a statistically significant relationship between the amylose content and milling properties such as head grain (r=0.733, $p<0.01$), broken grain (r= -0.817, $p<0.01$) and width of grain (r=0.863, $p<0.01$) and there was no statistically significant relationship between the amylose content and milling properties such as brown grain (r=0.154, $p>0.01$), total milled rice ((r=0.488, $p>0.01$) and length of grain (r= -0.512, $p>0.01$).

One of the most significant variables of cooking quality is the temperature at which the rice grain gelatinizes (Cuevas & Fitzgerald, 2012). Bg 300 and Suwendel varieties fall into the intermediate gelatinization temperature (GT) (70-74 °C) category as indicated by scale 4. At 311 and Suduheenati varieties were categorized into high gelatinization temperature (>75 °C) as indicated by scales 2 and 3. Low GT values were found in Bg 352 between 55 and 69 °C, as indicated by a scale of 6 (IRRI, 2004). There was a statistically significant relationship between the gelatinization temperature and milling properties such as total milled rice (r= -0.779, $p<0.01$) and head grain (r= -0.647, $p<0.01$) and there was no statistically significant relationship between the gelatinization temperature and milling properties such as brown rice (r= -0.388, $p>0.01$), broken grain (r=0.517, $p>0.01$), length of grain (r= 0.122, $p>0.01$) and width of grain (r= -0.546, $p>0.01$).

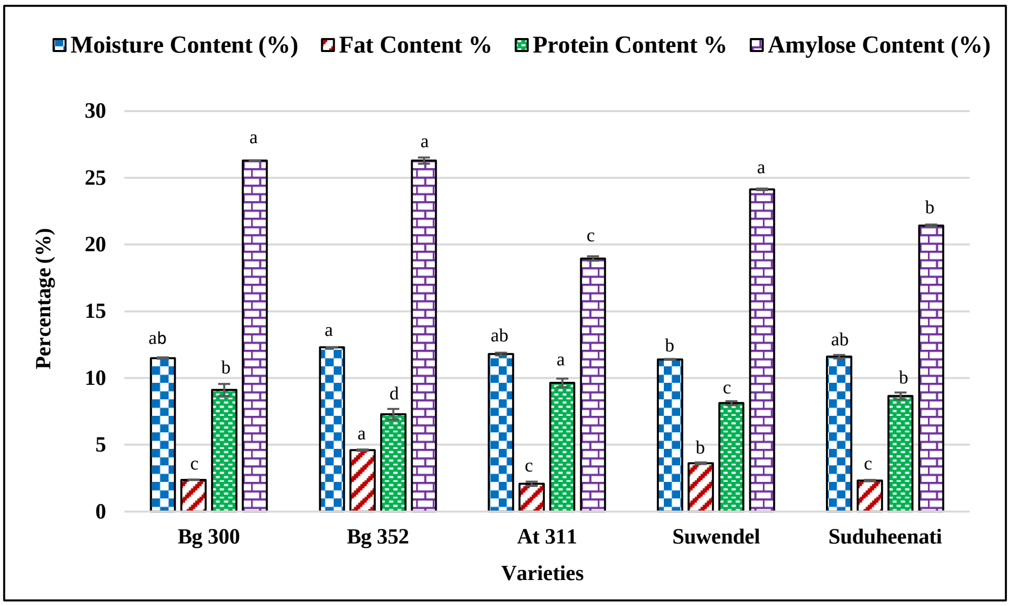

Figure 1. Nutritional composition of different selected rice varieties (% dry weight).
The values are the means of 4 replications. The vertical bars indicate the standard errors. The bars with the same letter(s) are not significantly different at the 5% level.

4. Conclusions

According to the study, the highest percentage of brown rice and total milled rice were observed for Bg 352 and the highest percentage of head rice was recorded in Suwendel. Three varieties were categorized under intermediate class except At 311 and Suwendel. There were significant variations ($p<0.05$) in the fat, protein, and amylose contents of five rice varieties other than the moisture content, and also there was a significant relationship ($p<0.01$) between the amylose content and milling properties such as head grain, broken grain and width of grain. Bg 300 and Suwendel varieties fall into the intermediate gelatinization temperature category and there is a distinct preference for those categories in rice-growing countries. There was a significant relationship ($p<0.01$) between the gelatinization temperature and milling properties such as total milled rice and head grain. Therefore, information from this study could be used to produce nutritious rice products and as well as in rice breeding programmes.

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