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Physicochemical properties and cooking qualities of two varieties of raw and parboiled rice cultivated in the coastal region of Dakshina Kannada, India

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Abstract

Forty-eight rice samples of Jaya (hybrid) and Kayame (local) varieties cultivated in Dakshina Kannada were collected during different seasons (Enel, Suggi and Kolake) and stages of parboiling (brown raw rice, polished raw rice, brown parboiled rice, polished parboiled rice) over a two years period. When analyzed, they showed significant variation in total carbohydrate, total proteins, total fat, reducing sugar, crude fibre, amylose content, length/breadth ratio, 1000 kernel weight, energy content and swelling number between the varieties, seasons and stages of processing. Between varieties, Jaya was found to be of better quality for the above parameters. Samples of both varieties collected during the rainy season ('Enel' crop) had a higher percentage of chemical constituents than paddy grown in dry seasons (i.e., 'Kolake' and 'Suggi' crops). Pearson's correlation analysis with regard to physico chemical properties and cooking quality between the two varieties, seasons and stages of parboiling showed significant correlations for some parameters within variety, between varieties and between seasons.

1. Introduction

Rice (*Oryza sativa* L.) is the staple food of over half the world's population. India, along with China, accounts for 55% of the total world production of 535 million tons (Anonymous, 1997). Paddy, after harvesting, is either used as milled raw rice or further processed into parboiled rice. The cooking quality of rice is determined on the basis of the variety and its physicochemical properties, but mainly the amylose content. Dakshina Kannada is an important paddy-growing region in coastal Karnataka with an area of about 9.84 lakhs ha., with both local and high-yielding varieties under cultivation. Annually, three crops of paddy are grown in different seasons namely 'Enel' (June–October), 'Suggi' (September–January) and 'Kolake' (February–March).

The present study aims to investigate the physicochemical properties and cooking qualities of brown and polished, raw and parboiled rice of both local (Kayame) and high-yielding (Jaya) varieties cultivated in Dakshina Kannada.

2. Materials and methods

One local and a high-yielding variety of paddies were selected for the present study. Forty-eight samples, comprising six samples each, of Jaya brown raw rice (JBRR), Jaya brown parboiled rice (JBPR), Jaya polished raw rice (JPRR), Jaya polished parboiled rice (JPPR), Kayame brown raw rice (KBRR), Kayame brown parboiled rice (KBPR), Kayame polished raw rice (KPRR) and Kayame polished parboiled rice (KPPR) were collected from different seasons, both from farmers and rice mills engaged in parboiling in Mangalore taluk, Dakshina Kannada over a period of two years (1999–2001). All the collected samples were stored at −4 °C in a freezer until further use.

Standard procedures were employed for the estimation of total carbohydrate (Whistler & Be Miller, 1962),

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total protein (Basha, Cherry, & Young, 1976), reducing sugar and amylose (Sadasivam & Manikam, 1992), while crude fibre, fat and ash contents were estimated by AOAC (1970) methods. The energy content of the samples was determined by the procedure of Osborne and Voogt (1978). Thousand-kernel weight, cooking qualities (length/breadth (L/B) ratio before and after cooking) and swelling number (SN) were determined by the standard procedure described by Raghavaiah and Kaul (1970). Ten replicates were tested in each of the experiments. The results were subjected to Pearson's correlation analysis to find out the statistical relationship among the different parameters within the variety, between the varieties and between the seasons.

3. Results and discussion

The physicochemical properties and cooking quality of raw and parboiled rice varieties are shown in Fig. 1. Significant variation in the L/B ratio, 1000 kernel weight, energy content, total carbohydrate, total protein, fat, crude fibre, reducing sugars, amylose content and SN, before and after cooking, in both raw and parboiled rice, as well as between the varieties and during different seasons, were observed. The L/B ratio between the varieties was highest (3.1) in JBRR harvested during the Enel season, which decreased to 3.0 after polishing. The L/B ratio of samples collected during the other two seasons and stages of processing showed no significant variation. A decrease in the L/B ratio after polishing was observed in both varieties. The L/B ratio of the Enel crops, JBPR and JPPR, were considerably decreased before cooking and after cooking, with values of 2.5, 2.4 and 2.3, respectively, as compared to that of raw rice. The expansion ratios, along both the length and breadth of parboiled rice, were lower than the raw cooked rice, due to more expansion of breadth in parboiled rice, compared to raw rice. The relatively greater expansion of parboiled rice along its breadth after cooking gives it a characteristic short and plump appearance (Kurien, Radhakrishna Murthy, Desikachar, & Subrahmanyan, 1964; Mahadevappa & Desikachar, 1968; Raghavendra Rao & Juliano, 1970). Rice that showed an increased L/B ratio was found to have good cooking quality (Raghavaiah & Kaul, 1970). When compared to the hybrid variety, Jaya, the local variety Kayame showed the lowest L/B ratio before and after cooking in all four stages, namely brown raw rice (2.1 and 2.5), brown parboiled rice (1.7 and 1.5), polished raw rice (2 and 2.4) and polished parboiled rice (1.6 and 1.5). Variations in L/B ratio were also found between the varieties, and also between the different stages of the same variety in different seasons. However, Pearson's correlation between L/B ratios, with other parameters did not show any significant changes within variety or between varieties on seasons. Between varieties, the Jaya variety has fine quality rice and the grains are white, slender and better in cooking quality, than the local variety (Kayame), which has short, plump and red grains which stick on cooking.

The Enel crop of JBRR shows higher 1000-kernel weight (19.3 g) than the JPRR, (18.6 g), further decreasing to 18.6 g in JBPR and 17.5 g in JPPR. The lowest value of 15.8 g was observed in KPRR. Pillaiyar (1988) reported that grains ripening during cool seasons were heavier than those ripening in summer.

A gradual decrease of total carbohydrate content in the grain collected during dry seasons, for all samples, was observed. The carbohydrate content of polished raw rice, in both varieties, is high. The Enel crops JPRR and KPRR had carbohydrate contents of 78.5% and 77.6% and with parboiling they marginally decreased to 77.4% and 76.6%, respectively. Carbohydrate is a source of energy for the synthesis of lipids and proteins (Basha et al., 1976), and it decreases in the dry seasons. The correlations (Table 1) of carbohydrate contents between the seasons within the variety Jaya (JBRR) showed a negative significant correlation ($r = -0.719$, $p < 0.01$). Within variety, Kayame (KBRR) showed a positive significant correlation ($r = 0.663$, $p < 0.05$).

The JBRR Enel crop has 9.46% protein, which increased to 10.4% during parboiling. Protein content is the most important criterion of quality, since cereals are the main source of proteins for Indians. Devadoss, Prema, and Kannan (1968) and Demopoulos and Muller (1972) observed a slight increase in protein content of the milled rice after parboiling. There is variation in protein content, ranging from 8.43% to 9.46% in JBRR, 9.24% to 10.4% in JBPR, 6.71% to 7.33% in JPRR, 7.75% to 8.71% in JPPR, 5.88% to 7.18% in KBRR, 6.94% to 7.68% in KBPR, 5.18% to 6.71% in KPRR and 5.58% to 7.21% in KPPR. Between two seasons (Enel and Kolake) the protein content of JBRR showed a negative significant correlation ($r = -0.776$, $p < 0.01$). Protein content varies much with environmental and cultural practices. High solar radiation during grain development generally reduces protein content (Resurreccion, Hara, Juliano, & Yosida, 1997).

The Enel JBPR crop showed higher percentages of fat, crude fibre, ash and reducing sugar, namely 2.06%, 0.96%, 1.48% and 0.888%, respectively, which for KPRR were 0.93%, 0.44%, 0.69% and 0.390%, respectively. Ash content, which in turn indicates the mineral composition of the grain, showed variations between different seasons and parboiling processes also. The severity of steaming increased the ash content of the milled rice samples as compared to that of the raw milled rice. The mineral nutrient elements migrate deep into the grain during parboiling, resulting in a greater retention of nutrients in milled parboiled grain (Deosthale, Shankar Rao, & Belavady, 1970). The ash contents, of

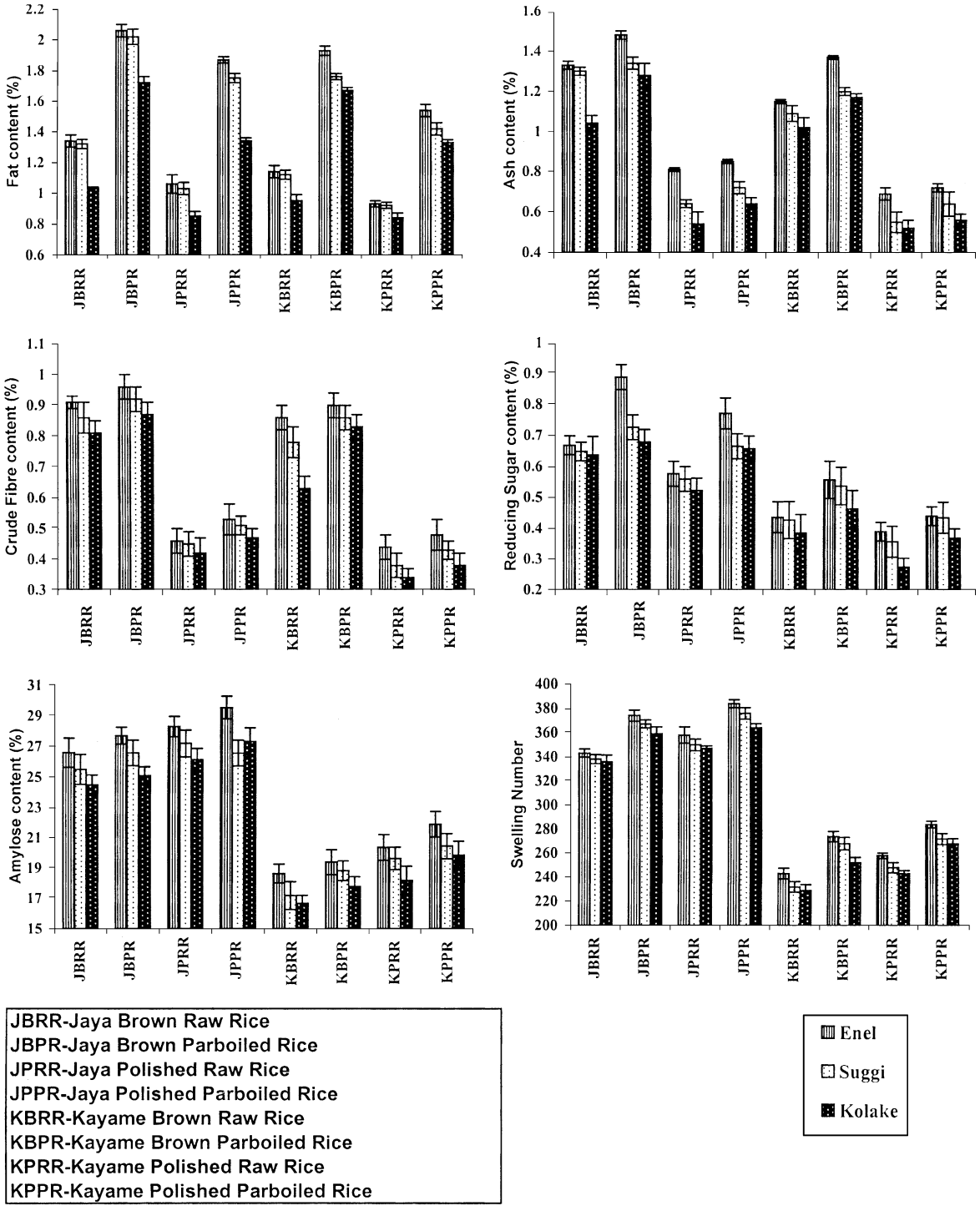

Fig. 1. Physicochemical and cooking qualities of two varieties of raw and parboiled rice cultivated in three different seasons in the coastal region of Dakshina Kannada, India.

KBPR and JBPR (Enel and Kolake crop) showed negative significant correlations ($r = -0.764$, $p < 0.01$ and $r = -0.687$, $p < 0.05$) between the seasons.

The amylose contents, recorded for the varieties KBRR and KPRR, were 18.6% and 20.4%, respectively. The maximum values obtained for JBPR and JPPR were 27.7% and 29.5%, respectively. In general, the hybrid variety, JPPR Enel crop, showed highest amylose content and better cooking quality. Hallick and Kenearter (1956) reported a high amylose content for good quality rice. On the other hand, Resurreccion et al. (1997) reported that a higher temperature could result in a lower amylose content. The same variety, grown under different environmental conditions, will fall into different

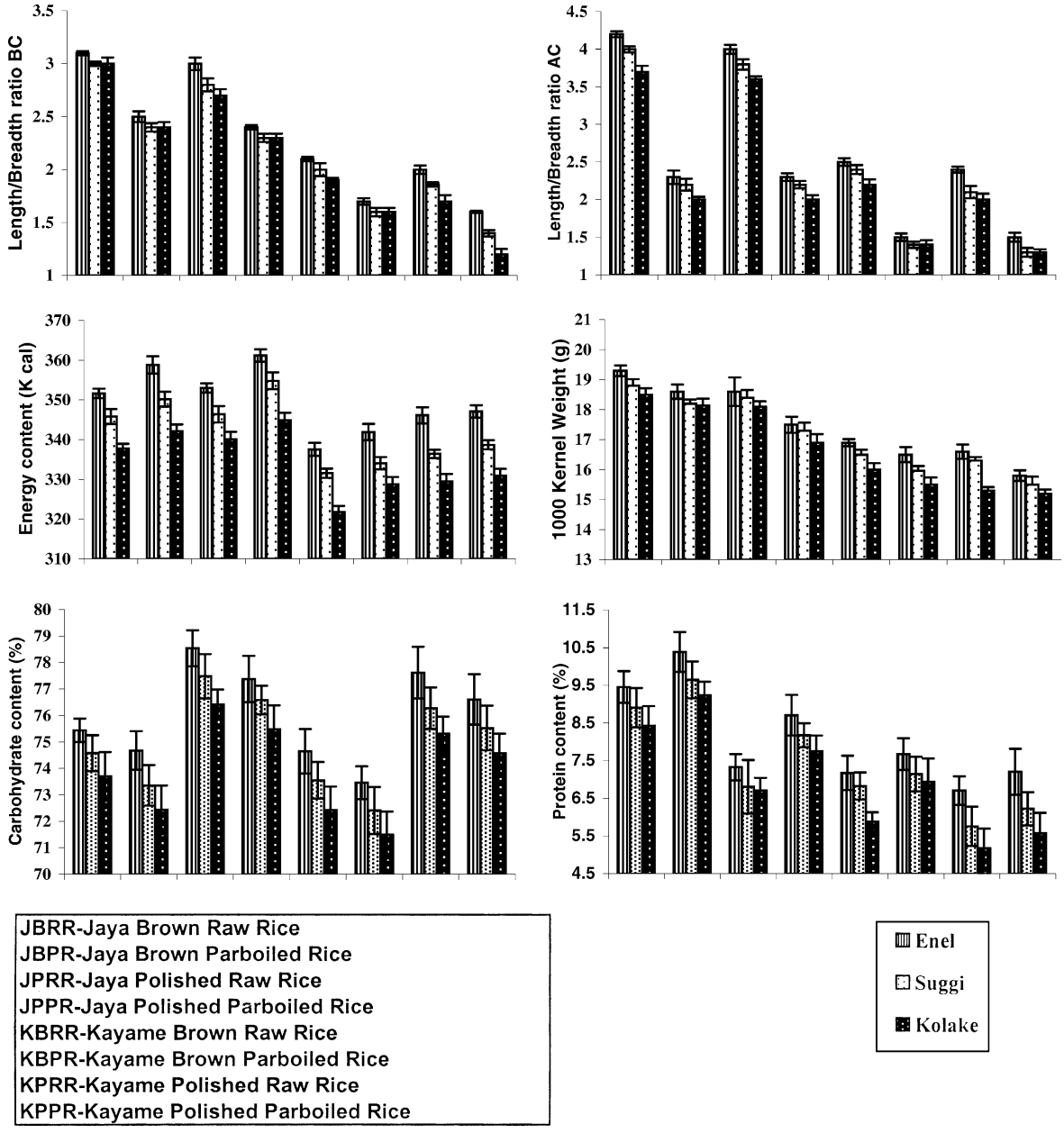

Fig. 1. *(continued)*

amylose groups and temperature influences the amylose content of rice endosperm during the ripening period (Paule, 1977). Amylose contents of JBRR and JBPR in Enel seasons showed a significant correlation ($r = 0.683$, $p < 0.05$) with regard to swelling number.

JPPR showed a high SN of 384; in JPRR it was 358. It was found that increase in the amylose content resulted in an increased SN. According to Rao, Vasudeva Murthy, and Subramanya (1952) SN of a variety is an index of its quality. Parboiled rice gives higher SN than raw rice for the same degree of softness of the cooked rice, although the former rice takes more time to cook (Ali & Ojha, 1977; Mahadevappa & Desikachar, 1968). Removal of the pericarp (bran) layer adhering to the endosperm coincidentally increased amylose content, which contributes to better cooking quality (Sidhu, Gill, & Bains, 1975). Amylose content is considered to be the most important quality parameter examined during variety development (Williams & Bates, 1958). It directly affects kernel firmness and inversely affects stickiness and glossiness of the cooked grain. Enel season JBPR showed a positive significant correlation ($r = 0.845$, $p < 0.001$) between amylose and SN. Analysis of raw and parboiled, brown and polished rice, of both the varieties, showed that brown parboiled rice had higher percentages of protein, fat, crude fibre and reducing sugar than polished rice. The varieties grown in the rainy season had higher contents of chemical constituents than the varieties

Table 1
Pearson's correlation coefficient (r) between different parameters in two varieties of rice cultivated in Dakshina Kannada in different seasons and stages of parboiling

	Season	Samples	Carbohydrate	Protein	Fat	Ash	Crude fibre	Reducing sugar	Amylose	Swelling number
Within the variety	Enel vs. Kolake	JBRR	−0.719**	−0.776**	−0.557	−0.442	0.224	0.415	−0.492	0.384
		KBRR	0.663*	0.149	0.448	0.358	−0.364	−0.395	0.546	−0.095
		JBPR	−0.425	−0.385	0.316	−0.687*	0.275	0.332	−0.132	0.264
		KBPR	−0.354	0.487	0.422	−0.764**	−0.500	−0.348	0.508	−0.487
Between the stages	Enel	JBRR vs. JBPR	0.518	−0.263	−0.338	0.498	0.388	0.267	−0.683*	−0.565
Between parameters amylose vs.	Enel	JBPR	0.264	0.089	−0.047	0.312	−0.421	−0.278	0.362	0.845***

*,**,*** – significant at $p < 0.05$, 0.01 and 0.001, respectively.
JBRR: Jaya brown raw rice; JBPR: Jaya brown parboiled rice; KBRR: Kayame brown raw rice; KBPR: Kayame brown parboiled rice.

grown in dry seasons. Brown rice is the major source of energy in the diet as it also provides valuable quantities of minerals. Quality of the rice varied with the seasons and method of irrigation. Marked differences in the chemical constituents were observed during dry seasons in the two varieties. Nutrient quality was decreased in the dry seasons. This may be due to a high level of solar radiation and greater photosynthetic activity. Variety is the principal factor contributing to grain quality. Good post-harvesting handling can maintain or even improve it. Parboiled rice retains more protein, fat, ash, crude fibre, reducing sugar and amylose and is thus more nutritious than raw milled rice. The hybrid variety, Jaya, is good quality rice compared to the local variety Kayame and, in the same variety, the percentage of nutrients decreases during different seasons and there was no marked difference in the chemical constituents of the two varieties between the years. Advantages of parboiling over raw milled rice are a better recovery of whole grains during milling, making a translucent hard grain, resistant to breakage, inactivation of enzymes, biological sanitation, easier removal of the hull during milling, better grain swelling during cooking, less starch in the cooking water, change in taste and texture of rice.

Since rice is the most important food crop of India and the bulk population of the country subsists on it, the present investigation between the varieties and seasons is of great importance.

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