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RESEARCH ARTICLE

PHYSICO-CHEMICAL CHARACTERISTICS OF BLACK RICE AND ITS ACCEPTABILITY IN TRADITIONAL RECIPES

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ABSTRACT

This study was carried out to evaluate the physico-chemical characteristics of raw rice grains of black rice and white rice using standard techniques. Characteristics studied include thousand kernel weight, hundred kernel weight, length/ breadth ratio, bulk density, porosity, volume expansion, optimal cooking time, amylose, elongation ratio and index, equilibrium moisture content on soaking and density in rice samples. Acceptability trial was carried out for black rice and white rice in traditional recipes like breakfast, lunch and snack recipes namely idli, dosa, adai, aapam, paniyaram (savory and sweet), idiyappam, roti, sweet and karam kolukattai, puttu, pongal, sweet pongal, laddu, kali, boiled rice (pressure cooked, conventionally cooked), vegetable biriyani, tamarind rice, mint rice, coconut rice, lemon rice, tomato rice, khanji, vadagam, murukku, sweet balls and kolukattai (Karam, Sweet and Milk). The results showed that black and white rice samples belonged to quasi slender varieties. The highest length / breadth ratio was found in black rice. Results revealed that more number of breakfast and lunch recipes prepared using white rice scored higher ($p < 0.01$) significant level than the black rice.

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INTRODUCTION

Rice is the staple food which is consumed as a whole grain. Rice grain quality is evaluated by four components such as cooking quality, nutritional content, grain characteristics and physico chemical property. Out of the above, cooking quality and physico-chemical property is more important with regard to acceptance. The endosperm possess certain physical and chemical characteristics basically due to amylose content (Webb, 1985; Juliano, 1998; Unnevehr *et al.*, 1992), protein content (Hsieh and Brunner, 1976), gel consistency (Cagampang *et al.*, 1972), gelatinization temperature (Juliano, 1972) and physical properties of cooked rice grain are considered as an important factors (Khatoon and Prakash, 2007).

To attract the consumers' attention, appearance of rice is important which depends on the shininess and chalkiness of the kernel. Size and shape are also important factor to consumer. Preference for grain size and shape vary from one group of consumers to another (Dipti *et al.*, 2002). The amylose content of rice is considered as the main parameter of cooking and

eating quality (Juliano, 1972). Amylose content, volume expansion, water absorption influences many of the starch properties of rice (Juliano, 1985). Cooking time is important as it determines tenderness of cooked rice as well as stickiness to great extent. Higher the imbibitions ratio of rice lower will be the energy content per unit volume or weight of cooked rice, as they will have more water and solid materials. High volume expansion of cooking is still considered to be the good quality by the working class people who do not care whether the expansion is lengthwise or crosswise. Urban people, on the other hand, prefer the varieties that expand more in length than in breadth (Dipti *et al.* 2002). Fine rice may be graded as export quality rice with normal nutritional quality. Because many functional properties of rice are believed to be closely related to physicochemical and other properties (Sompong *et al.*, 2011).

MATERIALS AND METHODS

Black rice locally known as kavuni raw rice and white rice locally known as ponni raw rice were collected from the village of Keelapoongudi, Karaikudi district, Tamilnadu, India (Lat: 10° 5' 47.256" and Long: 78° 51' 22.4172"). The collected rice samples were packed in air tight pouches to avoid any possible

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contamination before bringing to laboratory. White rice was used as control because it is used widely in Tamilnadu for daily consumption.

Evaluation of Physico-chemical Characteristics of Black Rice and White Rice

The physico-chemical characteristics of raw rice grains of black rice and white rice were studied using standard techniques. Grain length and breadth were measured by slide caliper. Classification of rice based on length indicates three major classes *wiz* long (>6 mm in length), medium (5-6 mm in length) and short (<5 mm in length). The sub-classification pertaining to size and shape includes length / breadth ratio; slender (ratio more than 3); bold (ratio 2-3); round (ratio less than 2) (Dipti *et al.*, 2002). Thousand kernel weight, bulk density, porosity, volume expansion, optimal cooking time, amylose, elongation ratio and index, equilibrium moisture content on soaking and density were measured (Bhattacharya and Sowbhagya, 1972; Swamy *et al.*, 1971; Sidhu *et al.*, 1975; Juliano, 1998; Oghbaei and prakash, 2010).

Study the Acceptability of Black Rice in Traditional Recipes

The sensory attributes such as colour, appearance, flavor, texture and taste assess the uniqueness of the food. The discipline of sensory examination requires the use of panel members, in which test outcome are recorded based on their responses to the products under test. Traditional recipes were prepared using black and white rice; the recipes were completely replaced by the black rice with white rice which is commonly in use, to know the acceptability of black rice. Seven point hedonic rating scale was used to evaluate the sensory characteristics of the developed recipes. The sensory evaluation was carried out in the laboratory as per the standard procedure administered by 50 semi-trained panel members (Bianchi *et al.*, 2009). Water was provided to panel members before and after tasting the recipe.

The breakfast items such as idli, dosa, adai, aapam, paniyaram (karam and sweet), idiyappam, roti, sweet and karam kolukattai, puttu, pongal, sweet pongal, laddu and kali were tried out using organoleptic qualities. Lunch items included boiled rice (pressure cooked, conventionally cooked), vegetable biriyani, tamarind rice, mint rice, coconut rice, lemon rice, tomato rice and khanji, some of the snack items such as vadagam, murukku, sweet balls and kolukattai (savoury, sweet and milk). The mean scores of the organoleptic evaluation were calculated on the basis of the total scores obtained.

Statistical Analysis and Interpretation of Data

Descriptive statistics (mean and standard deviation) was used to represent the morphological, physical, chemical and cooking properties of black and white rice. Descriptive statistics (mean and standard deviation) was used to represent the acceptability scores of black rice and white rice in breakfast, lunch and snack recipes. Two way ANOVA was used to compare the significant difference between the groups and the attributes in the groups using Agres stat (version 3.1).

RESULTS AND DISCUSSION

Physico - Chemical Characteristics of Black Rice and White Rice

Morphological Properties of Rice Varieties

Rice grain quality is reported to be influenced by various physico-chemical characteristics that determine the cooking behaviour as well as the cooked rice texture (Bocevska *et al.*, 2009; Moongngarm, 2010). The morphological properties of rice varieties are given in Table I.

Table I Morphological Properties of Rice Varieties

Rice Varieties	100 Kernel Weight(g)	1000 Kernel Weight (g)	Broken Kernel weight(g)	Length (mm)	Breadth (mm)	Length/ Width ratio
Black Rice (Raw)	1.67±0.05	18.28±0.04	0.53±0.02	0.63±0.03	0.21±0.02	2.95±0.02
White Rice (Raw)	1.38±0.12	10.66±0.09	0.61±0.02	0.58±0.02	0.20±0.00	2.67±0.03

The 1000 kernel weight was found to be 18.28±0.04g and 10.66±0.09g for black and white rice. The 100 kernel weight of black and white rice was found to be at 1.67±0.05g and 1.38±0.12g respectively. Zhang *et al.* (2005) reported the similar value in 100 kernel weight of black rice. Length and breadth of rice varied from 0.63 to 0.58 mm and 0.20 to 0.21mm, respectively. Singh *et al.* (1982), Yadav *et al.* (2007), Deepa *et al.* (2007) reported the related morphological values of rice varieties. Length and width ratio for black rice and white rice samples were 2.95±0.02 and 2.67±0.03 which denoted the shape and size of the grains. According to the classification of rice given by Bhattacharya and Sowbhagya (1972) based on grain dimensions (shape and L/B ratio), both samples belonged to quasi slender varieties (ratio bigger than 3 – slender, 2.4 to 3.0 – quasi slender and 2.0 to 2.39 – bold grain). The maximum length / breadth ratio was found in black rice.

Physical Properties of Rice Varieties

Table II shows the physical properties of rice varieties

Table II Physical Properties of Rice Varieties

Rice Varieties	Bulk density (g/ml)	Density (g/ml)	Porosity (%)
Black Rice (Raw)	0.77±0.00	1.32±0.04	27.57±0.47
White Rice (Raw)	0.83±0.00	1.24±0.09	30.07±0.48

Bulk density of any material indicates the weight volume ratio and is an important parameter from storage point of view (Oghbaei and Prakash, 2010). Bulk density of samples in the present study was found to be 0.77±0.00 and 0.83±0.00 g/ml for black and white rice respectively. Singh *et al.* (1982) and Yadav *et al.* (2007) reported that the bulk densities of various rice cultivars varied between 0.83 to 0.92 g/ml which are higher for coarse grains. Bhattacharya and Sowbhagya (1972) observed that bulk density is related to the kernel shape i.e. L/B ratio, the more round the kernel, the greater is the bulk density. Density and porosity of black rice and white rice were 1.32±0.04 g/ml, 27.57±0.47 per cent and 1.24±0.09g/ml, 30.07±0.48 per cent respectively. Bhattacharya and Sowbhagya (1972) reported a mean density of 1.452 g/ml, for

different rice varieties. The porosity, which indicates the index for different samples in comparison with reported values of 35 per cent to 46 per cent. It is stated that since density is practically constant in rice, the bulk density curve would be the exact reverse of the porosity curve and is dependent on the grain shape. The more round the grain, the greater is the bulk density and lower the porosity and vice versa. This fact is clearly seen in black rice which shows the density and lowest porosity and the reverse case was seen in Basmati rice.

Cooking and Chemical Properties of Rice Varieties

Table III gives the cooking and chemical properties of rice varieties.

Table III Cooking and Chemical Properties of Rice Varieties

Rice Varieties	Gel Consistency (mm)		Optimal Cooking time (mins)	Elongation Ratio	Elongation Index	Amylose Content (%)	Gruel Solid Loss (%)
	30 min	60 min					
Black Rice(Raw)	27.0±0.0	27.0±0.0	68	2.16±0.01	1.13±0.05	6.76±0.83	3.65±0.2
White Rice(Raw)	32±0.0	32±0.0	28	2.03±0.0	1.27±0.06	19.49±0.56	5.83±0.01

Amylose content as well as gelatinization temperature and gel consistency can highly influence cooking and eating qualities of rice, which can vary based on the varieties (Juliano, 1998; Bhattacharjee and kulkarni, 2000). The gelatinization ability of starches is influenced by many properties such as the amylase: amylopectin ratio, the degree of hydration and the size of starch granule. Gel consistency differs depending upon the source of starch and variety of grain. The results of gel consistency for 30 and 60 minutes in both samples were similar. Black rice exhibited a value of 27.0 and white rice, 32. Sarkar *et al.* (1994) reported the gel consistency range from 22 to 78 mm for scented and non- scented rice varieties.

The optimal cooking time for black rice and white rice were found to be at 68 mins and 28 mins. Dipti *et al.* (2002) and Danbaba *et al.* (2011) reported that varied rice varieties took time from 10 – 35 minutes to cook more than 20 minutes. The elongation ratio and elongation index of black rice and white rice were 2.16±0.01, 1.13±0.05 and 2.03±0.0, 1.27±0.06 respectively. Similar result was observed by Dipti *et al.* (2002) in that, elongation ratio of the fine rice varieties ranged from 1.2 to 1.5. It is an important parameter for cooked rice. If rice elongates more lengthwise it gives a finer appearance and if expands girthwise, it gives a coarse look. Hossain *et al.* (2009) reported kernel length/width ratio of cooked rice ranging from 2.04 to 3.95 and 2.39 to 5.07 respectively. Amylose is a key parameter that determines the cooking quality and taste quality of rice. High amylose rice will produce hard texture cooked rice, otherwise the low amylose rice produces sticky and soft cooked rice (Yusoff *et al.*, 2002). The amylose content of black and white rice were found to be 6.76±0.83 per cent and 19.49±0.56 per cent respectively. Sompong *et al.* (2011) reported two types of black rice with very low amylose content of 6 to 9 per cent. Rice is grouped based on its amylose content into waxy (0 – 2%), very low (3-9%), intermediate (20-25%) and high (25%). Amylose content of rice determines the hardness and stickiness of cooked rice. Amylose content higher than 25 per cent gives non sticky soft or hard cooked rice. Rice having 20-25 per cent amylose gives soft and relatively sticky cooked rice (Dipti *et al.*, 2002). Similar results were observed

by Dipti *et al.*, (2002), Singh *et al.*, (1982), yadav *et al.*, (2007) and Danbaba *et al.*, (2011).

With regard to gruel solid loss, black rice and white rice showed 3.65 and 5.83 per cent of gruel loss. Low solid contents in the cooking gruel can be attributed to the fact that the surface area in contact with water is smaller, resulting in a lower l/b ratio. These observations are comparable to the report of Hirannaiah *et al.*, (2001) and yadav *et al.*, (2007) who have also observed minimum gruel solid loss in rice varieties. Rice varieties with higher amylose content are more prone to leaching out into the cooking water as starch grains expand during cooking (Juliano, 1998).

cooked l/b ratio of rice and stickiness of cooked rice (Juliano and Perez, 1983). Table IV gives the moisture equilibrium pattern of uncooked rice on soaking.

Moisture Equilibrium Pattern of Uncooked Rice on Soaking

Table IV gives the moisture equilibrium pattern of uncooked rice on soaking.

Table IV
Moisture equilibrium pattern of uncooked rice on soaking
(water uptake in percent)

Time Intervals	Rice Varieties	
	Black Rice (Raw)	White Rice (Raw)
0 min	12.46±0.05	16.46±0.05
15 min	22.39±0.1	25.39±0.1
30 min	24.93±0.11	28.46±0.05
60 min	27.89±0.1	28.86±0.15
3 hr	29.46±0.05	29.16±0.15
6 hr	30.39±0.1	29.39±0.1
9 hr	31.96±0.05	29.46±0.05
12 hr	32.89±0.1	9.93±0.11
15 hr	34.39±0.1	30.56±0.05
18 hr	36.46±0.05	30.53±0.11
21 hr	37.39±0.1	30.46±0.23
24 hr	39.03±0.05	30.49±0.17

Equilibrium moisture content relates to the hydration ability of rice. As can be seen in Table IV, the moisture contents were 12.4 and 16.4 per cent for black rice and white rice initially and sudden increase of 24.9 and 28.4 percent was observed in next 30 mins for both samples. After one hour, both samples reached to equilibrium position of 27.8 and 28.8 per cent moisture for both samples respectively. Finally when time persists, in a 24 hour, it reached to 39 per cent and 30 per cent of moisture equilibrium content in black and white rice. The result coincides with the results of Oghbaei and Prakash, (2010). Related results of physico-chemical and cooking properties were observed by Deepa *et al.*, (2007).

Acceptability of Black Rice in Traditional Recipes

Food based approaches have higher potential for achieving glycaemic control and long lasting benefits for diabetes and

other metabolic disorders. In karaikudi village, Tamil Nadu where the black rice is grown, the farmers and natives use this rice to prepare sweet pongal recipe only.

Since it is a rich source of antioxidants, it was thought of interest to prepare traditional recipes using black rice. The recipes were selected on the basis of popularity and consumption pattern of south Indian people. The acceptability was tested by using seven point hedonic scale. Sensory characteristics namely appearance, flavor, colour, texture and taste of prepared commonly consumed breakfast, lunch and snack recipes were evaluated and presented in Tables V, VI and VII.

Results showed that idli, dosa, pongal, khanji, idiyappam and kali prepared using white rice showed one per cent significant difference ($p < 0.01$) between the recipes. Idiyappam prepared using white rice, appearance, flavor and colour scored the best attributes among the recipes.

adai, aapam and puttu prepared by using black rice were equally acceptable as white rice recipes by the panelists.

Other breakfast recipes prepared by black rice were not acceptable when compared to white rice, but the attributes in between the rice varieties are equally acceptable as it was scored the non significant level.

Results revealed that all the lunch recipes (boiled rice (pressure cooked, conventionally cooked), tamarind rice, tomato rice, mint rice, lemon rice, coconut rice, vegetable biriyani) prepared using white rice scored higher ($p < 0.01$).

But the scores of attributes like appearance, flavor, colour, texture, taste and overall acceptability when compared between the rice varieties showed no significant significance. It may be concluded that black rice recipes are well accepted.

Table V Acceptability Scores of Black Rice and White Rice in Breakfast Recipes

S.No	Recipes	Sample	Appearance	Flavour	Colour	Texture	Taste	Overall Acceptability	p value
1.a	Idli	Black Rice	6.14±0.92	5.66±1.04	5.73±1.08	5.91±0.69	5.58±0.72	5.87±0.54	0.15657**
1.b		White Rice	6.28±0.86	6.18±0.92	6.44±0.59	6.02±0.31	6.28±0.23	6.62±0.68	
2.a	Dosa	Black Rice	5.79±0.89	5.78±1.00	5.85±1.08	5.99±0.75	5.91±0.72	5.91±0.69	0.16414**
2.b		White Rice	6.44±0.43	6.34±0.82	6.46±0.56	6.08±0.38	6.42±0.63	6.06±0.96	
3.a	Adai	Black Rice	6.55±0.57	6.36±0.78	6.40±0.64	6.55±0.53	6.50±0.61	6.65±0.51	NS
3.b		White Rice	6.52±0.23	6.46±0.65	6.16±0.38	6.58±1.25	6.46±0.98	6.68±0.83	
4.a	Aapam	Black Rice	6.06±0.79	6.02±0.80	6.09±0.84	6.03±0.72	6.31±0.85	6.20±0.68	NS
4.b		White Rice	6.56±0.31	6.30±0.46	6.32±0.25	6.12±1.27	6.34±0.89	6.22±0.64	
5.a	Pongal	Black Rice	5.75±0.58	5.55±1.10	5.56±0.98	5.76±0.93	5.93±0.97	5.90±0.80	0.17492**
5.b		White Rice	6.40±0.34	6.20±0.29	6.26±0.42	6.40±0.98	6.14±0.71	6.02±0.29	
6.a	Khanji	Black Rice	5.84±0.89	5.84±0.97	5.64±0.92	5.82±0.90	5.82±1.00	5.96±0.82	0.16489**
6.b		White Rice	6.16±0.09	6.02±0.44	6.27±0.97	6.22±0.58	6.18±0.62	6.52±0.18	
7.a	Puttu	Black Rice	6.41±0.60	6.38±0.77	6.31±0.85	6.45±0.70	6.37±0.86	6.46±0.61	NS
7.b		White Rice	6.30±0.52	6.46±0.46	6.20±0.83	6.56±0.32	6.46±0.79	6.34±0.64	
8.a	Idiyappam	Black Rice	5.75±0.95	5.62±0.99	5.62±1.02	5.18±1.37	5.05±1.35	5.41±0.86	0.18905**
8.b		White Rice	6.34±0.25	6.68±0.99	6.58±1.02	6.1±0.05	6.16±0.68	6.36±0.91	
9.a	Roti	Black Rice	6.20±0.90	6.02±0.65	6.15±0.88	5.83±1.08	6.09±1.88	6.14±0.80	0.13012*
9.b		White Rice	6.36±0.63	6.68±0.87	6.16±0.07	6.02±0.02	6.3±0.04	6.34±0.92	
10.a	Kali	Black Rice	5.67±1.06	5.76±1.04	5.65±0.95	6.00±1.10	5.77±1.11	5.65±0.95	0.18680**
10.b		White Rice	5.96±0.83	6.32±0.51	6.26±0.15	6.1±0.37	6.66±0.84	6.54±0.62	

NS- Not significant; ** - 1% significant level; * - 5% significant level

Table VI Acceptability Scores of Black Rice and White Rice in Lunch Recipes

S.No	Recipes	Sample	Appearance	Flavour	Colour	Texture	Taste	Overall Acceptability	p value
1.a	Boiled Rice	Black Rice	5.10±1.12	4.80±1.34	5.06±1.23	4.73±1.26	4.44±1.46	4.81±1.30	0.22352**
1.b		White Rice	5.60±0.26	5.86±0.53	6.34±0.28	6.14±0.87	6.06±0.89	6.42±0.25	
2.a	(Conventionally Cooked)	Black Rice	5.10±1.32	4.63±1.29	5.00±1.30	4.86±1.38	4.48±1.56	4.81±1.38	0.22599**
2.b		White Rice	6.32±0.73	6.38±0.11	6.30±0.16	6.28±0.63	6.16±0.80	6.68±0.24	
3.a	Tamarind Rice	Black Rice	5.59±0.84	5.79±0.88	5.75±0.87	5.55±0.83	5.78±1.00	5.69±0.87	0.16719**
3.b		White Rice	6.2±0.60	5.98±0.08	6.12±0.50	6.16±0.46	6.26±0.68	6.62±0.31	
4.a	Tomato Rice	Black Rice	5.76±0.60	5.58±0.80	5.60±0.66	5.44±0.73	5.60±0.93	5.69±0.63	0.14621**
4.b		White Rice	6.32±0.86	6.44±0.09	6.40±0.07	6.30±0.91	6.26±0.14	6.32±0.17	
5.a	Mint Rice	Black Rice	5.13±0.85	5.32±0.77	5.19±0.80	5.20±0.90	5.10±0.99	5.07±0.88	0.45694**
5.b		White Rice	6.04±0.21	6.26±0.53	6.34±0.53	6.22±0.61	6.48±0.12	6.30±0.39	
6.a	Lemon Rice	Black Rice	5.70±0.82	5.79±0.88	5.58±0.93	5.76±0.88	5.82±0.95	5.92±0.82	0.16612**
6.b		White Rice	6.22±0.52	6.26±0.29	6.20±0.04	6.22±0.16	6.40±0.73	6.24±0.94	
7.a	Coconut Rice	Black Rice	5.91±0.69	5.95±0.86	5.87±0.75	5.88±0.76	5.98±0.78	6.02±0.68	0.14975**
7.b		White Rice	6.12±0.26	6.12±0.53	6.60±0.87	6.36±0.97	6.30±0.71	6.28±0.13	
8.a	Vegetable Biriyani	Black Rice	6.02±0.77	6.26±0.76	5.89±0.83	6.00±0.79	6.24±0.81	6.18±0.71	0.13482**
8.b		White Rice	6.12±0.60	6.3±0.08	6.52±0.50	6.2±0.46	6.22±0.29	6.28±0.16	

** - 1% significant level

Roti prepared from white rice scored 5 per cent significant level between the rice varieties but the attributes scores were not significant between the groups. Adai, aapam and puttu prepared from rice varieties did not show significant difference;

Table VII depicted that sweet balls prepared by black rice gained significantly higher scores ($p < 0.05$) than the sweet balls (laddu) prepared using white rice. The attributes like appearance, flavour, colour and overall acceptability earned the significant level in sweet balls (laddu) prepared by black rice than the white rice.

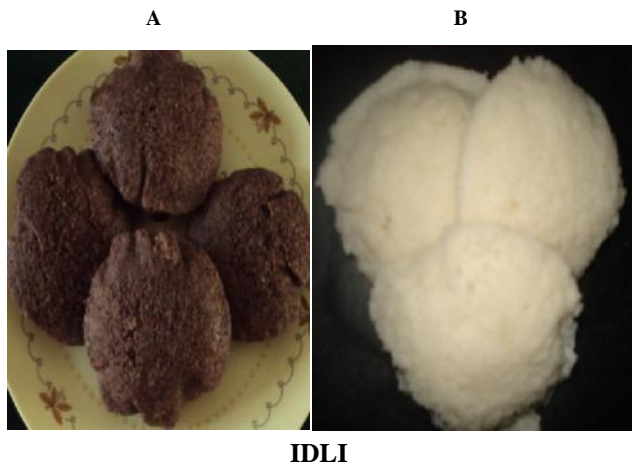
Table VII Acceptability Scores of Black Rice and White Rice In Snack Items

S.No	Recipes	Sample	Appearance	Flavour	Colour	Texture	Taste	Overall Acceptability	P value
1.a	Paniyaram	Black Rice	6.12±0.90	6.01±0.71	5.86±0.86	5.71±1.13	5.87±0.94	5.91±0.66	NS
1.b	(savoury)	White Rice	6.14±0.86	6.22±0.09	6.02±1.25	6.10±0.44	6.48±0.52	6.36±0.04	
2.a	Paniyaram	Black Rice	6.66±0.61	6.55±0.60	6.38±0.81	6.43±0.73	6.65±0.55	6.61±0.52	NS
2.b	(Sweet)	White Rice	6.4±0.73	6.36±0.91	6.38±0.14	6.38±0.37	6.58±0.53	6.48±0.61	
3.a	Sweet Balls	Black Rice	5.44±1.05	5.97±0.80	5.62±1.14	4.37±1.29	5.65±1.19	6.00±0.97	0.13712*
3.b	(Laddu)	White Rice	6.02±0.25	6.16±0.55	6.08±0.16	5.58±0.38	5.7±0.92	5.68±0.22	
4.a	Murukku	Black Rice	6.01±0.98	5.83±0.99	5.83±1.00	6.06±1.04	6.13±0.98	6.14±0.91	NS
4.b		White Rice	6.26±0.80	6.02±0.34	6.18±0.26	6.04±0.17	6.28±0.49	6.24±0.21	
5.a	Sweet	Black Rice	5.73±1.03	5.74±1.19	5.90±0.91	6.01±0.97	6.10±1.13	6.12±0.92	NS
5.b	Pongal	White Rice	6.28±0.69	6.22±0.53	6.2±0.37	6.12±0.45	6.14±0.06	6.22±0.15	
6.a	Vadagam	Black Rice	6.52±0.50	6.48±0.50	6.35±0.72	6.78±0.40	6.70±0.45	6.70±0.45	NS
6.b		White Rice	6.44±0.41	6.4±0.76	6.32±0.96	6.56±0.78	6.58±0.30	6.58±0.54	
7.a	Kolakattai	Black Rice	5.78±1.05	5.47±1.06	5.36±1.16	5.18±1.30	5.31±1.23	5.66±1.03	NS
7.b	(savoury)	White Rice	5.86±0.48	5.98±0.71	5.76±0.16	6.02±0.31	5.96±0.18	6.06±0.03	
8.a	Kolakattai	Black Rice	5.76±0.92	5.79±1.18	5.58±0.53	5.55±1.13	6.07±0.71	6.06±1.00	NS
8.b	(Sweet)	White Rice	6.14±0.86	6.08±0.10	6.16±0.77	6.16±0.51	6.10±0.46	6.16±0.34	
9.a	Kolakattai	Black Rice	6.05±1.01	6.17±0.76	5.94±0.91	5.68±1.16	5.96±0.84	6.20±0.72	NS
9.b	(Milk)	White Rice	6.14±0.24	6.12±0.36	6.04±0.47	6.02±0.81	6.26±0.13	6.18±1.26	

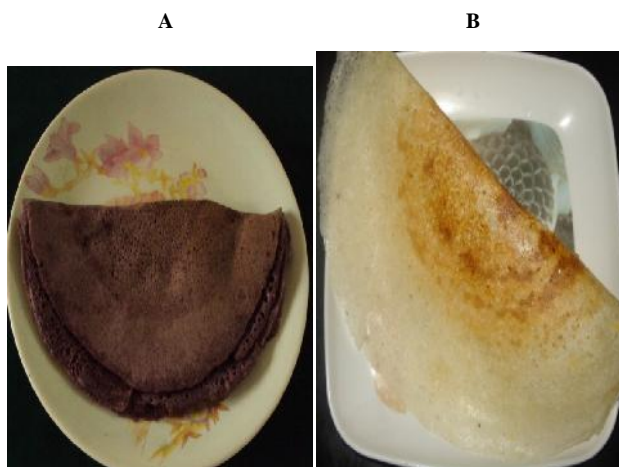
NS- Not significant; * - 5% significant level

Other snack recipes like paniyaram (savoury and sweet), murukku, sweet pongal, vadagam and kolukattai (milk, sweet and savoury) prepared by black rice and white rice showed the no significant different scores between the rice varieties and also in attributes in between the groups.

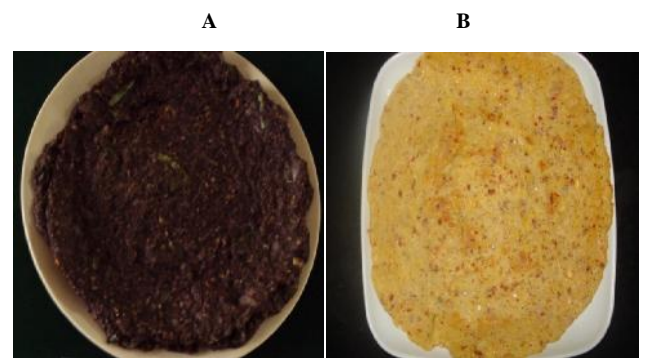
Plate 1 Breakfast recipes of black rice and white rice



IDLI

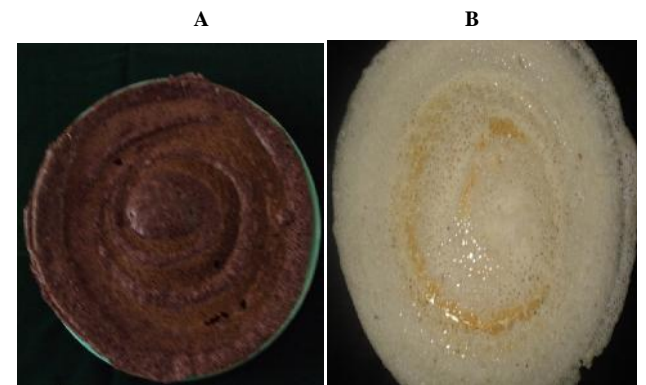


DOSA

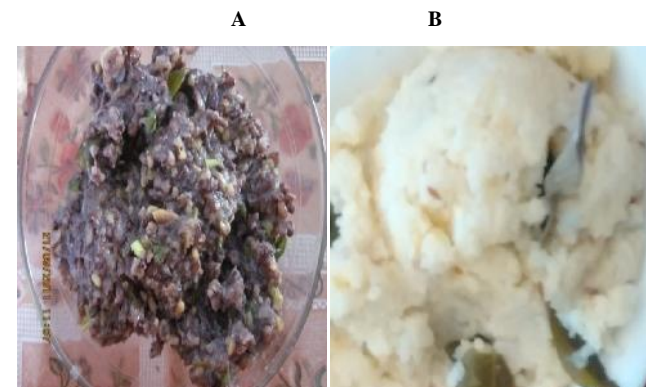


ADAI

Plate 2 Breakfast Recipes of Black Rice and White Rice



AAPAM



PONGAL

A

B



PUTTU

Thus it shown that the snack items prepared both from black rice and white rice were equally acceptable. This shows that the black rice blends very well with snack items. The standard recipes prepared using white rice obtained higher scores for many recipes than black rice recipes.

Plate 3 Breakfast Recipes of Black Rice and White Rice

A

B



Idiyappam

Lunch recipes of Black rice and White rice Boiled Rice (Pressure Cooked)

A

B



A: Black rice recipe

B: White rice recipe

Plate 4 lunch recipes of black rice and white rice boiled rice Conventionally cooked

A

B



Tamarind Rice

However the difference in overall acceptability scores of white rice and black rice recipes was less. In general, the recipes prepared by black rice were moderately accepted. Black rice incorporated sweet snack recipes were found to be highly acceptable.

A

B



A: Black rice recipe

B: White rice recipe

Plate 5 Lunch Recipes of Black Rice and White Rice

Tomato rice

A

B



Mint Rice

A

B



A: Black rice recipe

B: White rice recipe

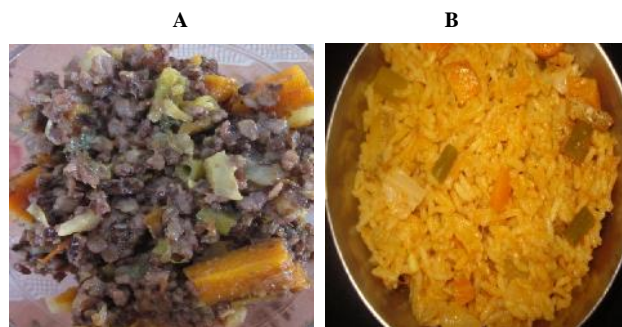
Plate 6 Lunch recipes of black rice and white rice Coconut Rice

A

B

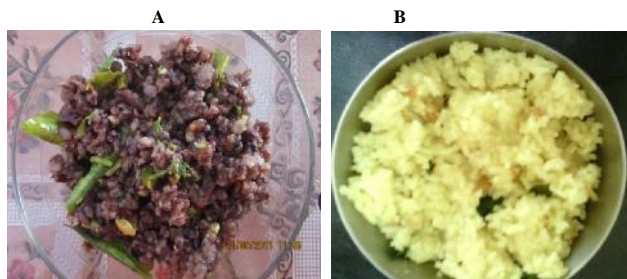


Vegetable Biriyan



A: Black rice recipe B: White rice recipe

Plate 7 lunch recipes of black rice and white rice
Lemon rice



Paniyaram (Karam)



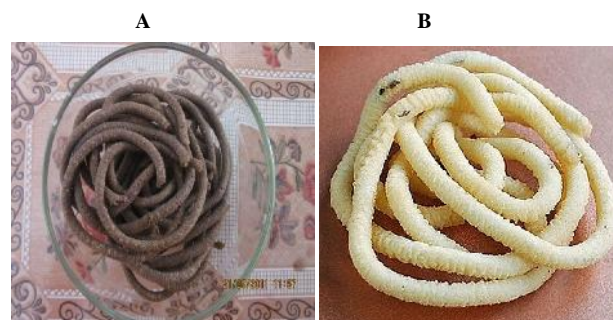
Paniyaram (Sweet)



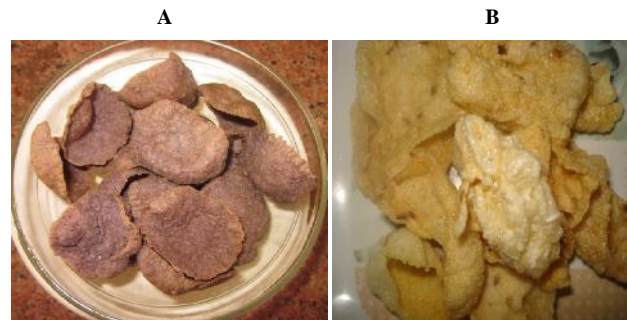
A: Black rice recipe

B: White rice recipe

Plate 8 Snack items in black rice and white rice
Murukku



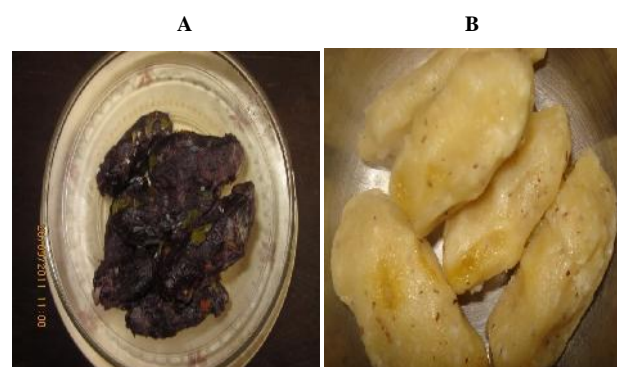
Vadagam



Kolukattai (Karam)



Plate 9 Snack items in black rice and white rice
Kolukattai (sweet)



A: Black rice recipe

B: White rice recipe

SUMMARY AND CONCLUSION

In summary, both black and white rice samples belonged to quasi slender varieties. The highest length / breadth ratio was found in black rice. The results of gel consistency for 30 and 60 minutes in both samples were similar. The optimal cooking time for black rice took higher time than the white rice. The findings of the study showed that more number of breakfast and lunch recipes prepared using white rice scored higher ($p < 0.01$) significant level. The snack items prepared both from black rice and white rice were equally acceptable.

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