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Original Article

Physicochemical and cooking properties of short grain aromatic Kalijira rice cultivars in Bangladesh

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ABSTRACT: In the present study we have selected a total of 55 small grain aromatic rice varieties including 49 accessions of Kalijira and 6 popular and local high yielding variety (HYV) seeds were collected from GRS Division, Bangladesh Rice Research Institute (BRRI). Physicochemical, cooking properties, proximate analysis and special flour characteristics were analyzed. A wide range of variation was seen in starch classification such as AAC, Amylopectin and AAC to Amylopectin ratio among 49 Kalijira accessions by 19.1-26.3%, 73.7-80.9% and 0.24-0.36 respectively. Kalijira 4815 has the lowest AAC of 19.1% and Kalijira 2500 has the highest AAC of 26.3%. Popular aromatic local HYV such as Chinigura, Chini sankor, SadaBadshabhog, Dhonia, Radha Tilok, BRRI dhan34 have intermediate AAC of 21.0, 24.4, 22.5, 20.7, 22.4 and 23.0%. PC of these varieties ranges from 8.3-10.2%. Among 49 Kalijira accessions Kalijira 4540 has the lowest amount of PC of 8.3% and Kalijira 2492 has the highest PC of 10.2%. SadaBadshabhog has the lowest PC of 6.9% and BRRI dhan34 has the highest PC of 10.2% among popular aromatic local HYV in Bangladesh. We have further analyzed few flour characteristics such as swelling capacity (SC), water absorption capacity (WAC) and oil absorption capacity (OAC) and found Kalijira rice flour specially Kalijira 4357 is suitable for rice based bakery product such as rice cake for its low AAC, GT and strong aroma. This acquainted scientific information will be helpful in establishing rice based food and bakery industries in Bangladesh.

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INTRODUCTION

In Bangladesh, short grain aromatic rice varieties usually preferred for main rice dishes in major festivals including marriage ceremony all the year around. Many well-known small grain aromatic rice varieties such as Chinigura, Kalijira, Kataribhog, Chini Sankor, Chini Atop, Bhadshabog, Dulabhog etc are used in this regard. Among them Kalijira is widely used to meet the demand of ceremonial purposes all over Bangladesh. Scientists of Bangladesh Rice Research Institute (BRRI), Gazipur, Bangladesh have collected a total of 49 different accessions of kalijira from all over Bangladesh and kept stored in the rice Genebank of Genetic Seed and Resources (GRS) Division, BRRI. Most benefits of health and nutrition are provided by aromatic rice. These are considered healthier as they possess more vitamin and fiber in their outer bran layers. Brown aromatic basmati rice contains 20% more fiber than other brown rice varieties, which prevents the formation of cancerous cells in the body[1]. According to Canadian diabetes association, glycemic index of basmati aromatic rice is lower than other rice varieties, and thus essential for those suffering from diabetes. Ayurveda supports its properties and proved it to be a great healing food. Traditional scented rice varieties have been revealed by scientists to possess higher amount of Fe and Zn and helps in the bioavailability of iron[2]. Alak et al, 2012 examined total phenolic content (TPC), 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical scavenging, hydroxyl ion scavenging, ferric reducing antioxidant power (FRAP), and total antioxidant capacity (TAC) to evaluate antioxidant properties of some Bangladeshi rice cultivars and he reported BR5 which is a small grain aromatic high yielding rice variety (HYV) possess the highest level of antioxidant properties[3]. In an invivo animal experiment Shozib et al, 2015 reported antioxidant enriched aromatic rice BR5 improves the antioxidant status in blood serum[4]. Abdul Mannan et al, 2013 reported antitumor properties of two traditional aromatic rice genotypes such as Kalijira and Chinigura on Agrobacterium tumefaciens (A. tumefaciens) strain AtSl0105, AtTa0112, and AtAc0114 as tumor forming agent and disc diffusion assay (Kirby-Bauer Method) was used to screen A. tumefaciens sensitivity test. He further reported that tumor inhibitions were observed against the strain AtSl0105 by kalijira rice bran (73.91%) and chinigura rice bran (69.56%). Both unpolished grains of kalijira and chinigura showed significant effect (kalijira 57.43%, chinigura 55.53%) to inhibit the tumor[5]. An aromatic substance named 2-acetyl 1-pyrroline (2AP) is responsible for the taste and smell of scented rice. In this present study we were aimed to explore physicochemical, cooking and functional properties of short grain aromatic rice specially Kalijira and it's 49 different accessions.

MATERIALS AND METHODS

A total of 55 small grain aromatic rice varieties including 49 different accessions of kalijira such as 247, 607, 856, 897, 971, 1129, 1130, 1303, 1589, 1937, 2492, 2493, 2494, 2495, 2496, 2497, 2498, 2499, 2500, 2501, 3200, 3429, 4357, 4358, 4359, 4540, 4755, 4814, 4815, 4820, 4832, 4862, 4872, 7066, 7073, 7290, 7505, 7551,7879,7945, N/C746, N/C790, N/C791, N/C992, N/C793, N/C799, N/C817, N/C816 and N/C839 and 6 popular local and HYV such as Chinigura, Chini Sankor, SadaBadshabhog, Dhonia, Radha Tilok and BRRI dhan34 were collected from Genetic Resource and Seed (GRS) Division and Grain Quality and Nutrition (GQN) Division of Bangladesh Rice Research Institute (BRRI), Gazipur, Bangladesh during Aman season 2017-2018. Rice grain was processed milling at un-parboiled condition for physicochemical and cooking properties analysis. Milling outturn (MOT%) were determined by dehulling 200g rough rice in Satake Rice mill, followed by 45 second polishing in a satake rice grain Testing Mill TM-05. All physical parameters were measured following IRRI evaluation standard (SES)[6]. Slide Calipers was used for the measurement of grain length and breadth. Milled rice was first classified into three classes based on length, long (>6.0 mm in length), medium (5-6 mm in length) and short (<5.0 mm in length). They were again classified into three classes according to the length/breadth (L/B) ratio; slender (ratio more than 3.0); Bold (ratio 2.0-3.0) bold, Round (ratio <2.0) to determine size and shape. AAC was determined by the procedure of Juliano[7] and alkali spreading value was determined according to the procedure of Little et al[8]. Protein contents were calculated from nitrogen and were determined by Micro Kjeldahl method. Volumes of cooked and milled rice were measured by water displacement method. Five grams of milled rice was placed in a graduated cylinder containing 50 mL of water and the change in volume was noted. For cooked rice volume 5 g of milled rice was cooked and the cooked rice was placed in the same cylinder and the change in volume was measured. Cooking time was measured when 90% of cooked rice totally gelatinized. One gram of freshly harvested milled rice was placed into a centrifuge tube (50 mL, round bottom) and 20 mL of distilled water was added. The tubes are then covered with aluminum foil. The samples were placed in a boiling water bath for 10 min. The cooked samples were allowed to cool and the presence of aroma was determined for every sample. The samples are scored as strongly aromatic, moderately aromatic, slightly aromatic, and non aromatic. A strongly scented variety is used as a check for comparison. The gelatinization temperature (GT) rice varieties may be classified as low (55 to 69 °C), intermediate (70 to 74 °C), and high (>74 °C). An estimate of the gelatinization temperature is indexed by the alkali digestion test (Little et al 1958). It is

measured by the alkali spreading value. The degree of spreading value of individual milled rice kernels in a weak alkali solution (1.7% KOH) is very closely correlated with GT. Rice with a low GT. disintegrates completely, whereas rice with an intermediate GT shows only partial disintegration. Rice with a high GT remains largely unaffected in the alkali solution. A duplicate set of six whole-milled kernels without cracks is selected and placed in a plastic box (5×5×2.5cm). Ten (10) mL of 1.7% (0.3035 M) potassium hydroxide (KOH) solution is added. The samples are arranged to provide enough space between kernels to allow for spreading. The boxes are covered and incubated for 23 h in a 30 °C oven. Samples can be placed outside in the absence of an oven if the ambient temperature is almost the same as what is required. Starchy endosperm is rated visually based on a 7-point numerical spreading scale. The swelling capacity was determined by the method described by Okaka and Potter[9]. 100 ml graduated cylinder was filled with the sample to 10 ml mark. The distilled water was added to give a total volume of 50 ml. The top of the graduated cylinder was tightly covered and mixed by inverting the cylinder. The suspension was inverted again after 2 min and left to stand for a further 8 min and the volume occupied by the sample was taken after the 8th min. The water absorption capacity of the flours was determine by the method of Sosulski et al. (1976). One gram of sample mixed with 10 mL distilled water and allow to stand at ambient temperature (30 ± 2°C) for 30 min, the centrifuged for 30 min at 3000 rpm or 2000 × g. Oil absorption was examined as percent oil bound per gram flour. The oil absorption capacity was determine by the method of Sosulski et al.[10]. The volume of 100 g of the flour was measured in a measuring cylinder (250 ml) after tapping the cylinder on a wooden plank until no visible decrease in volume was noticed, and based on the weight and volume, the apparent (bulk) density was calculated by Jones et al.[11]. One gram of sample mixed with 10 ml soybean oil (Sp. Gravity 0.9092) and allow to stand at ambient temperature (30 ± 2 °C) for 30 min, then centrifuged for 30 min at 300 rpm or 2000 × g. Water absorption was examined as percent water bound per gram flour. Statistical analysis were done using SPSS, version 20.0.

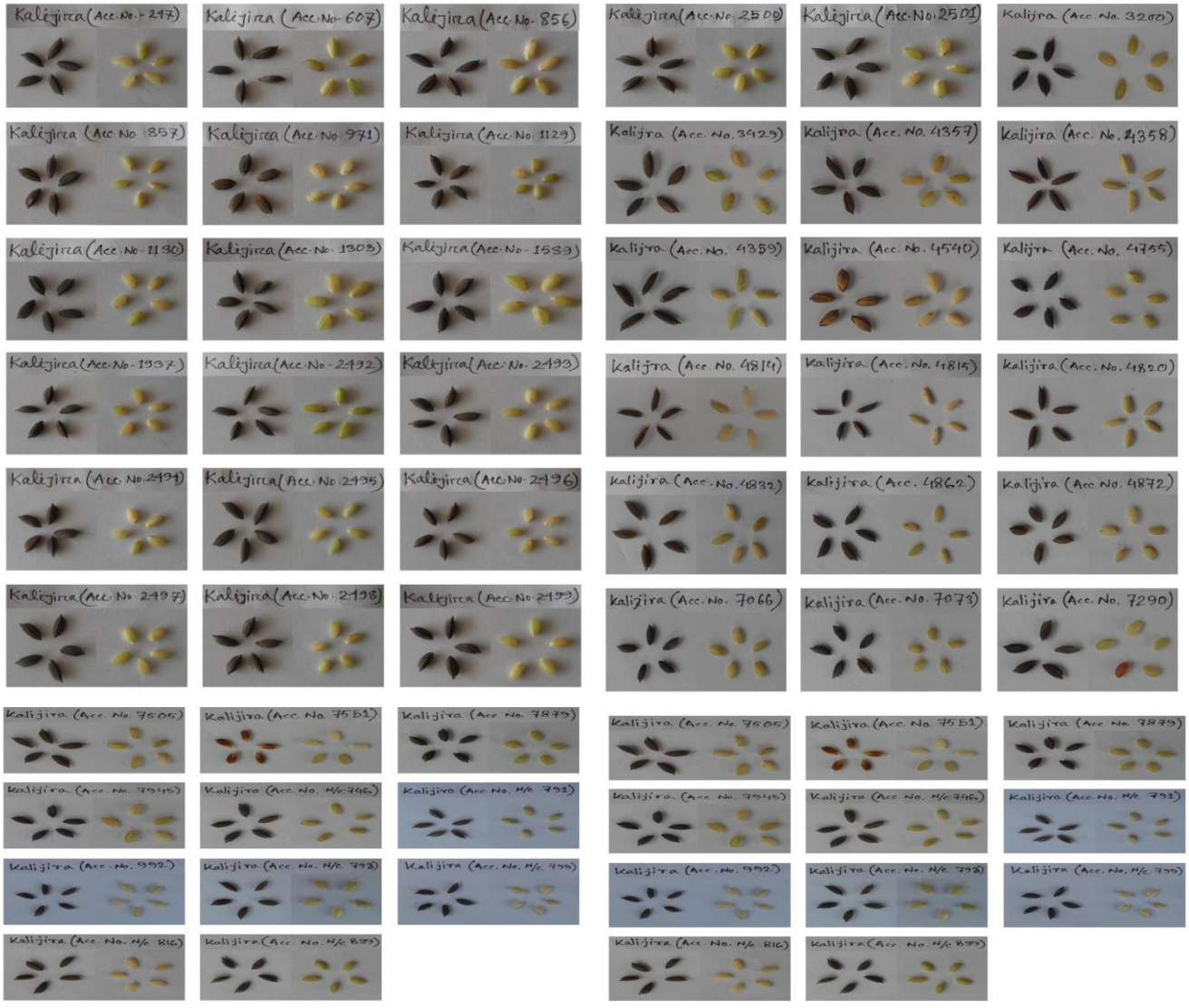

Figure 1: Pictorial view of 49 Kalijira accessions of BRRI GeneBank of Bangladesh.

RESULTS AND DISCUSSION

Milling yield or milling outturn (MOT) is one of the most significant criteria of rice quality, especially from a marketing point of view. A variety should possess a high turnout of whole kernel (head) rice and total milled rice (Webb 1985). MOT ranges from 62.3 to 70.8% and HRY ranges from 30.6 to 65.9%. We have observed variation in physicochemical properties of 49 Kalijira accessions in this experiment. So we considered all individual entity as unique Kalizira accession and analyzed accordingly. Kalijira 897 showed the highest MOT% and HRY % of 70.8% and 65.9% respectively which is similar as other popular small grain aromatic varieties such as Chini Sankor (70.8%, 69%), Dhonia (70.7%, 67.1%) and Radha Tilok (70.8%, 68.0%). The appearance of milled rice is important to consumers. A total of 12.24% of Kalijira accessions had shown very good appearance (6 out of 49) and 87.76% shown good appearance. Among popular varieties, both Chinigura and BRRI dhan34 posses very good appearance. Chalkiness of kernel was visually scored for the present of white belly, Wb, (dorsal side of the grain), white center, Wc and degree of translucency (Tr) or opaque (Op). In visual estimation of chalkiness in 49 Kalijira accessions, we found mixture of translucent and opaque type grain 22.44% (Tr/Op), only opaque type 4% (Op) and mostly translucent type 73.56% (Tr). Chinigura, SadaBadshabhog, Radha Tilok, BRRI dhan34 have translucent type grain but Chini Sankor and Dhonia have mixture of translucent and white bally or white center type chalkiness (Table 1). Preferences for grain size and shape vary from customers to consumers. The physical dimensions of rice kernels are of vital interest to those engaged in the many facets of the rice industry. Rice varieties may be objectively classified into grain-type categories based upon two physical parameters: length and shape. In our analysis, average kernel length of 49 Kalijira accessions was 4.2±0.05 (Mean±SE) mm and length to breath (L/B) ratio was 2.05±0.04 (Mean±SE) which resemble grain size and shape as small size and bold shape (SB). In addition 6.12% kalizira accessions are medium type and bold shape grain. It was also noticed that all small grain popular aromatic rice varieties are small size and bold shape (SB) such as Chinigura, Chini Sankor, SadaBadshabhog, Radh Tilok, BRRI dhan34 except Dhonia which is SR as small size (3.9 mm) and round shape (1.5) (Table 1).

Table 1. Physicochemical parameters of 55 aromatic rice varieties including 49 different Kalijira accessions and 6 popular local and HYV in Bangladesh at aman season.

SN	Kalijira BRRI Acc.	MOT %	HRY %	Appear.	Chalk.	L (mm)	L/B	S & S	Aroma	1000 gwt (g)
1	Kalijira 247	66.7	56.4	Good	Tr	4.3	2.2	SB	++	11.2
2	Kalijira 607	67.7	61.0	Good	Op/Tr	4.0	2.0	SR	++	9.9
3	Kalijira 856	67.0	59.0	Good	Tr	4.2	2.1	SB	++	10.0
4	Kalijira 897	70.8	65.9	Good	Tr	4.3	2.1	SB	++	15.0
5	Kalijira 971	67.6	50.7	Good	Op/Tr	3.6	1.6	SR	++	9.6
6	Kalijira 1129	68.0	46.8	Good	Tr	4.0	1.8	SR	++	12.2
7	Kalijira 1130	67.3	52.7	Good	Tr	4.2	1.9	SR	++	7.6
8	Kalijira 1303	66.9	52.6	Good	Tr	4.0	1.9	SR	++	15.6
9	Kalijira 1589	68.9	50.8	Good	Tr	4.0	1.8	SR	++	12.0
10	Kalijira 1937	69.2	50.2	Good	Tr	4.0	1.9	SR	++	11.0
11	Kalijira 2492	66.6	54.6	Good	Tr	4.3	2.1	SB	++	8.7
12	Kalijira 2493	68.1	55.9	Good	Tr	4.2	1.9	SR	++	13.5
13	Kalijira 2494	68.4	49.3	Good	Op/Tr	4.1	2.0	SR	++	10.8
14	Kalijira 2495	69.5	63.3	Good	Tr	4.2	2.1	SB	+	9.4
15	Kalijira 2496	68.5	58.2	V. Good	Tr	4.3	2.0	SB	++	11.7
16	Kalijira 2497	70.7	60.6	Good	Tr	4.0	1.8	SR	++	12.2
17	Kalijira 2498	69.6	45.6	Good	Tr	4.1	1.9	SR	++	9.1
18	Kalijira 2499	68.8	58.8	V. Good	Tr	4.0	1.9	SR	+	9.7
19	Kalijira 2500	64.5	51.0	Good	Tr	4.7	2.3	SB	++	8.1
20	Kalijira 2501	68.1	47.2	V. Good	Tr	4.0	1.9	SR	++	11.4

21	Kalijira 3200	66.9	51.0	Good	Op	3.7	1.7	SR	++	8.1
22	Kalijira 3429	67.8	60.7	Good	Op/Tr	3.9	1.9	SR	++	10.4
23	Kalijira 4357	69.9	53.5	Good	Op/Tr	4.4	2.1	SB	++	9.0
24	Kalijira 4358	67.1	51.3	Good	Tr	5.2	2.8	MB	+	12.2
25	Kalijira 4359	62.3	30.6	Good	Op/Tr	5.2	2.7	MB	+	13.2
26	Kalijira 4540	67.9	51.1	Good	Op	4.5	2.0	SB	+	15.4
27	Kalijira 4755	70.7	48.0	V. Good	Tr	4.0	1.9	SR	+	12.3
28	Kalijira 4814	67.2	51.1	V. Good	Tr	5.1	2.8	MB	++	10.0
29	Kalijira 4815	63.6	43.3	Good	Tr	5.0	3.0	SB	++	10.6
30	Kalijira 4820	66.1	47.7	Good	Op/Tr	4.8	2.4	SB	+	13.4
31	Kalijira 4832	67.4	55.3	Good	Tr	4.0	2.1	SB	+	8.7
32	Kalijira 4862	68.3	47.5	Good	Tr	4.2	2.2	SB	++	9.5
33	Kalijira 4872	66.6	51.6	Good	Tr	3.9	1.9	SR	+	10.9
34	Kalijira 7066	65.5	55.7	Good	Tr	3.9	1.9	SR	+	11.2
35	Kalijira 7073	68.9	54.7	Good	Op/Tr	4.0	2.0	SR	++	9.8
36	Kalijira 7290	67.8	47.9	Good	Tr	3.9	1.7	SR	++	9.0
37	Kalijira 7505	68.6	49.9	Good	Op/Tr	4.1	2.1	SB	+	10.0
38	Kalijira 7551	67.9	51.6	Good	Tr/Wc$_5$	4.4	1.8	SR	+	14.6
39	Kalijira 7879	69.1	45.7	Good	Tr	4.0	1.7	SR	++	13.1
40	Kalijira 7945	66.3	61.0	Good	Tr	4.1	1.7	SR	++	12.1
41	Kalijira N/C 746	66.8	45.7	Good	Op/Tr	4.0	2.0	SB	+	11.8
42	Kalijira N/C 790	67.8	51.4	Good	Tr	4.2	2.1	SB	+	8.0
43	Kalijira N/C 791	67.0	43.5	Good	Tr	4.1	2.1	SB	+	11.8
44	Kalijira N/C 992	68.9	54.8	Good	Tr	4.2	2.0	SB	+	8.6
45	Kalijira N/C 793	69.9	44.0	Good	Tr	4.2	2.1	SB	+	11.0
46	Kalijira N/C 799	69.1	47.2	Good	Tr	4.1	2.0	SB	++	12.6
47	Kalijira N/C 817	67.9	51.4	Good	Tr	4.0	2.2	SB	++	9.5
48	Kalijira N/C 816	69.1	47.7	Good	Tr	4.1	2.1	SB	+	4.8
49	Kalijira N/C 839	68.2	43.3	V. Good	Tr	4.1	2.0	SR	++	8.4
Mean ± SE (n=49)		**67.8±.2**	**51.61±0.9**	**N/A**	**N/A**	**4.2±0.05**	**2.05±0.04**	**N/A**	**N/A**	**10.78±0.3**
Range		**62.3-70.8**	**30.6-65.9**	**N/A**	**N/A**	**3.6-5.2**	**1.6-3.0**	**N/A**	**N/A**	**4.8-15.6**
50	Chinigura	71.8	66.6	V. Good	Tr	4.1	2.2	SB	+	12.5
51	Chini Sankor	70.8	69.0	Good	Tr/Wc$_5$	4.3	2.0	SB	+ +	11.6
52	SadaBadshabhog	71.8	65.5	Good	Tr	4.3	2.3	SB	+	12.3
53	Dhonia	70.7	67.1	Good	Tr/Wb$_5$	3.9	1.5	SR	+	11.6
54	Radha Tilok	70.8	68.0	Good	Tr	4.1	2.1	SB	+	12.1

55	BRRI dhan34	73.0	69.1	V. Good	Tr	3.7	2.3	SB	++	13.5

Mean ± SE= Mean ± Standard Error, MOT% = Milling outturn %, HRY% = Head rice yield%, Appear.=Appearance, Chalk.=Chalkiness, Tr = Translucent, Op= Opaque, Wb= White Bally, Wc = White Center, MB = Medium Bold, SB=Short Bold, SR=Short Round, V. Good= Very Good.

Aromatic rice is more lucrative than the usual aman season rice varieties. In Bangladesh, North Bengal's farmers specially Dinajpur, cultivate aromatic rice such as Chinigura, Kalijira, Kataribhog not only for the idea of delectable cuisine but also for making immediate cash. Aromatic rice can produce averagely 2.7 tons per hectare to sell for around approximately 1444 USD but popular aman rice varieties might produce average 3.6 tons per hectare, which sells for approximately 1018 USD. The most popular aromatic variety is BRRI dhan34 among all cultivated local and HYVs. With high sales prices and suitable geography, aromatic rice farming across the north is flourishing. In Bangladesh, we can hardly think of having a festival or celebratory meal without such types of rice. Farmers are often advice to use organic fertilizer which preserves that tell-tale scent and taste. Since the prospect of producing export-quality aromatic rice in this northern Bangladesh region is very bright and farmers are interested in crop diversification. Aromatic rice farming can be highly profitable With the right technological approach. In 2017 aman season a total of 13,779 hectares of northern region devoted to various aromatic rice cultivars, which is an increase of 762 hectares from the previous year aman season.

Cooking and eating characteristics are largely determined by the properties of the starch that makes up 90% of milled rice. Gelatinization temperature (GT), apparent amylose content (AAC), and alkaline spreading value (ASV) are few important starch properties that influence cooking and eating characteristics such as cooking time (CT), elongation ratio (ER) and imbibitions ratio (IR). A wide range of variation was seen in AAC, Amylopectin and AAC to Amylopectin ratio among 49 Kalijira accessions by 19.1-26.3%, 73.7-80.9% and 0.24-0.36 respectively (Table 2). Kalijira 4815 has the lowest AAC of 19.1% and Kalijira 2500 has the highest AAC of 26.3%. Popular aromatic local and HYV such as Chinigura, Chini sankor, SadaBadshabhog, Dhonia, Radha Tilok, BRRI dhan34 have intermediate AAC of 21.0, 24.4, 22.5, 20.7, 22.4 and 23.0%. Protein content of these varieties ranges from 8.3-10.2%. Among 49 Kalijira accessions Kalijira 4540 has the lowest amount of PC of 8.3% and Kalijira 2492 has the highest PC of 10.2% (Table 2). SadaBadshabhog has the lowest PC of 6.9% and BRRI dhan34 has the highest PC of 10.2% among popular aromatic local and HYV in Bangladesh. Since rice has the highest total digestibility (TD) of 99.6% and net protein utilization (NPU) of 73.8% among all cereals such as wheat, corn, barley, millet and sorghum, so we can get maximum of 10.2*4=48.2 kcal from 100g serving of BRRI dhan34 uncooked rice grain.

Table 2. Chemical and cooking parameters of 55 aromatic rice varieties including 49 different Kalijira accessions and 6 popular local and HYV in Bangladesh at aman season.

SN	Kalijira BRRI Acc.	AAC %	Amy %	AAC/Amy	N_2 (%)	PC (%)	ASV	CT	ER	IR
1	Kalijira 247	22.1	77.9	0.3	1.5	9.1	5.9	16.3	1.4	4.3
2	Kalijira 607	21.9	78.1	0.3	1.5	8.7	5.8	15.1	1.4	4.2
3	Kalijira 856	22.3	77.7	0.3	1.5	9.0	5.3	15.5	1.4	4.1
4	Kalijira 897	22.2	77.8	0.3	1.6	9.2	5.3	16.1	1.4	3.8
5	Kalijira 971	20.5	79.5	0.3	1.7	9.8	5.6	17.2	1.5	3.8
6	Kalijira 1129	24.1	75.9	0.3	1.5	8.7	5.8	17.0	1.5	4.6
7	Kalijira 1130	24.5	75.5	0.3	1.6	9.3	5.8	16.4	1.4	3.2
8	Kalijira 1303	24.6	75.4	0.3	1.6	9.4	5.8	15.1	1.4	4.0
9	Kalijira 1589	24.7	75.3	0.3	1.5	8.7	5.9	15.5	1.5	4.1
10	Kalijira 1937	22.5	77.5	0.3	1.5	8.7	5.8	14.5	1.4	4.5
11	Kalijira 2492	23.2	76.8	0.3	1.7	10.2	6.0	15.1	1.3	3.8
12	Kalijira 2493	23.3	76.7	0.3	1.6	9.5	6.0	16.1	1.4	3.5
13	Kalijira 2494	24.2	75.8	0.3	1.6	9.2	5.9	15.1	1.4	4.6
14	Kalijira 2495	24.5	75.5	0.3	1.7	9.9	5.7	14.0	1.4	4.0
15	Kalijira 2496	23.0	77.0	0.3	1.6	9.4	5.8	14.5	1.4	4.1

16	Kalijira 2497	25.5	74.5	0.3	1.5	9.1	6.0	15.4	1.4	3.6
17	Kalijira 2498	25.5	74.5	0.3	1.5	8.7	6.0	16.0	1.5	4.3
18	Kalijira 2499	24.1	75.9	0.3	1.5	8.7	7.0	14.5	1.4	4.3
19	Kalijira 2500	26.3	73.7	0.4	1.5	9.1	7.0	15.2	1.2	4.1
20	Kalijira 2501	22.8	77.2	0.3	1.5	8.9	7.0	15.5	1.4	4.7
21	Kalijira 3200	22.6	77.4	0.3	1.5	9.1	4.5	13.4	1.5	4.0
22	Kalijira 3429	23.8	76.2	0.3	1.6	9.4	6.0	13.5	1.4	3.8
23	Kalijira 4357	19.5	80.5	0.2	1.5	8.6	6.0	14.5	1.2	3.7
24	Kalijira 4358	22.3	77.7	0.3	1.4	8.5	5.5	13.0	1.5	4.5
25	Kalijira 4359	19.5	80.5	0.2	1.4	8.5	4.8	14.3	1.2	3.5
26	Kalijira 4540	22.3	77.7	0.3	1.4	8.3	6.3	14.1	1.6	3.3
27	Kalijira 4755	23.7	76.3	0.3	1.5	8.7	7.0	15.2	1.4	4.0
28	Kalijira 4814	22.3	77.7	0.3	1.5	8.6	6.0	13.3	1.3	4.2
29	Kalijira 4815	19.1	80.9	0.2	1.4	8.4	5.0	12.5	1.1	4.0
30	Kalijira 4820	20.0	80.0	0.3	1.6	9.4	5.8	14.3	1.3	4.3
31	Kalijira 4832	19.7	80.3	0.3	1.6	9.3	5.9	13.4	1.5	4.0
32	Kalijira 4862	19.9	80.1	0.3	1.6	9.2	6.5	15.0	1.3	4.7
33	Kalijira 4872	20.2	79.8	0.3	1.7	10.0	6.2	15.2	1.5	4.7
34	Kalijira 7066	20.1	79.9	0.3	1.5	9.0	6.8	16.0	1.4	3.6
35	Kalijira 7073	20.6	79.4	0.3	1.6	9.2	7.0	16.1	1.4	4.0
36	Kalijira 7290	22.4	77.6	0.3	1.6	9.3	7.0	17.5	1.5	4.7
37	Kalijira 7505	19.9	80.1	0.3	1.5	8.7	6.8	14.0	1.5	3.6
38	Kalijira 7551	22.3	77.7	0.3	1.5	8.6	5.5	15.2	1.5	3.7
39	Kalijira 7879	23.6	76.4	0.3	1.4	8.4	7.0	17.2	1.4	3.7
40	Kalijira 7945	23.6	76.4	0.3	1.6	9.2	6.8	16.4	1.4	4.7
41	Kalijira N/C746	19.6	80.4	0.2	1.5	9.0	6.8	15.2	1.3	4.6
42	Kalijira N/C790	22.3	77.7	0.3	1.5	8.6	6.3	14.1	1.4	4.6
43	Kalijira N/C791	21.2	78.8	0.3	1.4	8.4	6.5	14.2	1.5	3.7
44	Kalijira N/C992	21.4	78.6	0.3	1.5	8.9	6.3	13.2	1.4	4.0
45	Kalijira N/C793	20.7	79.3	0.3	1.5	8.8	6.3	13.5	1.3	4.0
46	Kalijira N/C799	22.8	77.2	0.3	1.4	8.5	5.9	13.0	1.5	4.0
47	Kalijira N/C817	22.3	77.7	0.3	1.4	8.5	4.5	13.2	1.5	4.0
48	Kalijira N/C816	20.1	79.9	0.3	1.5	8.7	5.9	12.5	1.4	4.2
49	Kalijira N/C839	22.2	77.8	0.3	1.5	8.7	5.8	12.3	1.4	4.2
Mean ± SE		**22.3±0.3**	**77.7±0.3**	**0.3±0.01**	**1.4±0.1**	**8.9±0.1**	**6.0±0.1**	**14.8±0.2**	**1.4±0.02**	**4.1±0.1**
Range		**19.1-26.3**	**73.7-80.9**	**0.24-0.36**	**1.3-1.6**	**8.3-10.2**	**4.5-7.0**	**12.3-17.5**	**1.1-1.6**	**3.2-4.7**
50	Chinigura	21.0	79.0	0.3	1.4	8.2	6.1	15.0	1.4	3.7
51	Chini sankor	24.4	75.6	0.3	1.2	7.2	5.8	13.0	1.5	4.3
52	SadaBadshabhog	22.5	77.5	0.3	1.2	6.9	5.1	13.5	1.5	3.7

53	Dhonia	20.7	79.3	0.3	1.4	8.2	5.3	16.5	1.8	3.2
54	Radha Tilok	22.4	77.6	0.3	1.4	8.5	5.2	15.1	1.7	4.1
55	BRRI dhan34	23.0	77.0	0.3	1.7	10.2	5.3	13.0	1.4	4.0

AAC=Apparent Amylose Content, Amy=Amylopectin, AAC/Amy= Amylose to Amylopectin Ratio, PC=Protein Content, ASV=Alkaline Spreading Value, CT=Cooking Time, ER= Elongation Ratio, IR=Imbibition Ratio.

Kalijira 4540 has the highest ER of 1.6. In cooked rice condition, Kalijira 4540 grain was found the highest length of 7.2 mm in average and in uncooked condition it was found 4.5 mm which means ER ratio becomes 1.6. Radha Tilok has the highest ER ratio of 1.7 among all small grain aromatic rice varieties in Bangladesh. A wide range of variation in IR was found as 3.2-4.7 among 49 Kalijira accessions (Table 2). In the present study, various type of functional properties of flours such as moisture, protein, fat, ash, fiber, carbohydrate, gelatinization temperature (GT), bulk density (BD), swelling capacity (SC), water absorbsion capacity (WAC %) and oil absorption capacity (OAC%) were analyzed for seven selective Kalizira accessions such as Kalijira 4357, Kalijira 1303, Kalijira 2492, Kalijira 3200, Kalijira 4820, Kalijira 7551 and Kalijira 2500. Selection criteria were variation in both chalkiness such as Opaque or Translucent or combination of both etc. and AAC from low to high AAC. Kalijira 4357 and Kalijira 4820 have the highest value of moisture content of 13% were observed (Table 3). The value of swelling capacity was found highest for Kalijira 1303 and Kalijira 4820 flour (25.0 ml). The swelling capacity of flours depends on size of particles and types of variety. Water absorption capacity or characteristics represent the ability of a product to associate with water under conditions where water is limited[12]. The highest WAC of rice flour could be attributed to the presence of higher amount of carbohydrates (starch) and fibre in rice flour. Water absorption capacity is a critical function of protein in various food products such as dough and baked products[13]. The WAC was observed highest in Kalijira 4357 flour (174%) followed by Kalijira 2500 flour (171%), Kalijira 1303 (170%) Kalijira 2492 (165%), Kalijira 4820 (165%) and 155% for both Kalijira 3200 and Kalijira 7551 (Table 3).

Table 3: Proximate analysis and functional properties of seven (7) selected Kalijira rice flours.

Kalijira BRRI Acc.	**Selection criteria**	**Mois %**	**PC %**	**Fat %**	**Ash %**	**Fib. %**	**Carb %**	**GT °C**	**BD (g/cc)**	**SC mL**	**WAC %**	**OAC%**
Kalijira 4357	Op/ Tr & Low AAC (19.5%)	13.0	8.6	0.5	0.5	0.4	77.0	58.0	0.9	15.0	174.0	120.0
Kalijira 2500	Tr & Intermediate AAC (24.6%)	12.8	9.4	0.5	0.6	0.5	76.2	57.5	0.9	25.0	170.0	130.0
Kalijira 2492	Tr & Intermediate AAC (23.2%)	12.7	10.2	0.4	0.5	0.5	75.7	61.0	1.0	20.0	165.0	110.0
Kalijira 3200	Op & Intermediate AAC (22.6%)	12.9	9.1	0.5	0.4	0.4	76.7	71.0	0.9	21.0	155.0	123.0
Kalijira 4820	Op / Tr & Intermediate AAC (20%)	13.0	9.4	0.4	0.6	0.5	76.1	58.5	0.9	25.0	165.0	130.0
Kalijira 7551	Tr/ WC_5 & Intermediate AAC (22.3%)	12.7	8.6	0.5	0.5	0.3	77.4	59.3	0.9	15.0	155.0	120.0
Kalijira 2500	Tr & High AAC (26.3%)	12.7	9.1	0.6	0.4	0.4	76.8	74.0	0.9	20.0	171.0	130.0
Mean ± SE		**12.8 ±0.1**	**9.2 ±0.2**	**0.49 ±0.03**	**0.50 ±0.03**	**0.43 ±0.03**	**76.56±0.2**	**62.7 ±2.5**	**0.90 ±0.01**	**20.1 ±1.5**	**173.6 ±3.1**	**123.3 ±2.8**

Fib=Fiber, Mois=Moisture, Tr=Translucent, Op= Opaque, WC_5= White center, PC=Protein Content, Fib=Fiber, Carb=Carbohydrate, GT= Gelatinization Temperature, BD=Bulk Density, SC=Swelling Capacity, WAC=Water Absorption Capacity, OAC=Oil Absorption Capacity.

The highest value of OAC was observed for Kalijira 1303, Kalijira 7551 and Kalijira 2500 flour (130%) followed by Kalijira 3200 flour (123% %), Kalijira 4357 (120%) and Kalijira 7551 (120%) (Table 3). The water and oil binding capacity of food protein depend upon the intrinsic factors such as amino acid composition, protein conformation and surface polarity or hydrophobicity. The ability of the proteins of these flours to bind with oil makes it useful in food system where optimum oil absorption is desired. This makes flour to have potential functional uses in foods production. The OAC also makes the flour suitable in facilitating enhancement in flavor and mouth feel when used in food preparation. Due to these properties, the protein probably could be used as functional ingredient in foods. The temperature at which gelatinization of starch take place is known as the gelatinization temperature[14]. The highest GT was observed for Kalijira 2500 flour (74°C) and lowest for Kalijira 2500 flour (57.5°C). The highest bulk density was observed for Kalijira 2492 flour (1.0 g/cc) (Table 3). The present study revealed that bulk density depends on the particle size and initial moisture content of flours. The high bulk density of flour suggests their suitability for use in food preparations. On contrast, low bulk density would be an advantage in the formulation of complementary foods[15].

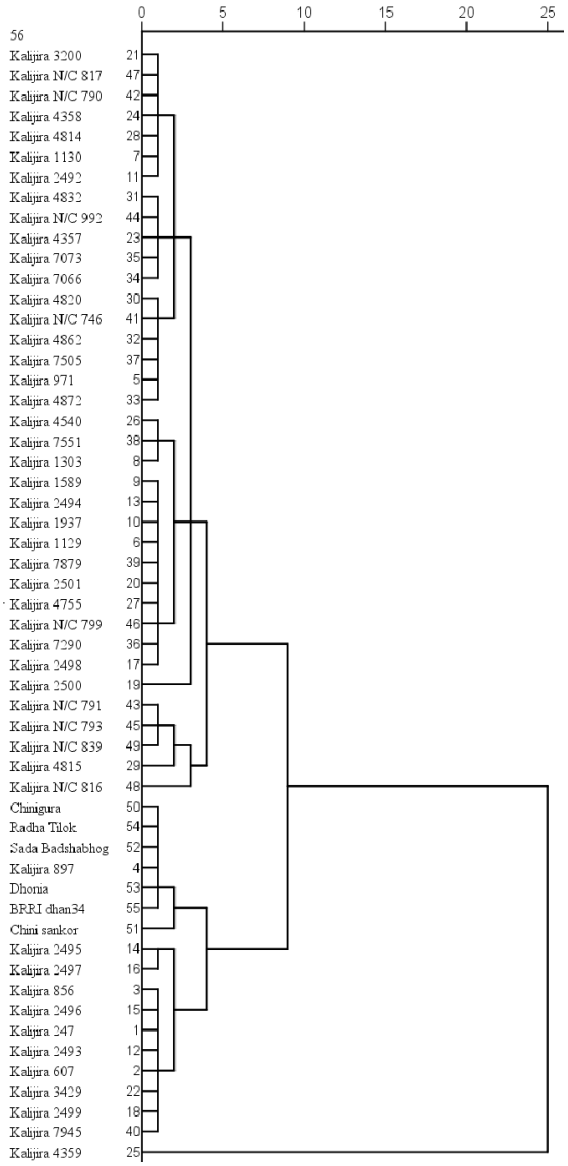

Figure 1: Dendrogram using average linkage between groups.

Figure 2: Rice cake

We have applied hierarchical cluster analysis by SPSS 20 on few selective parameters such as AAC, PC and ASV data of 55 small grain aromatic rice varieties including 49 different Kalijira accessions and 6 popular local and HYV in Bangladesh at aman season in Bangladesh and classified into five distinct clusters

such as CL1: Cluster 1, CL1.2: Sub-cluster 1.2, CL1.2.1: Sub-cluster 1.2.1, CL1.2.2: Sub-cluster 1.2.2, SC1: Sub-sub cluster 1. Chinigura, Radha Tilok, Sada Badshabhog, Kalijira 897, Dhonia, BRRI dhan34, Chini Sankor are in same cluster of CL1.2.2 (Fig. 1). Existing clusters resemble variation among 49 Kalijira accessions along with popular small grain aromatic local as well as HYV rice varieties in Bangladesh for aman season. Rice flour (Selective aromatic Kalijira 4357), sugar, milk, egg, lubricating agent such as sagu powder, butter, plum oil, refined yeast powder and rice bran oil (RBO).We did not use any essence as baked product produced natural aroma from aromatic baked rice flour of Kalijira 4357. Since rice does not possess any gluten protein so the greatest challenge in using rice flour in baking industries is uneven texture or cracked. In order to overcome the constrain we took several steps such as soaking milled rice for 1 hour water at room temperature before grinding into flour. We found low AAC (19.5%) and GT (58 ^{8}C) content of Kalijira 4357 rice flour mostly suitable for rice based bakery products and analyzed few flour parameters such as OAC (120%), WAC (174%), SC (15 mL) etc in this regard. We considered local traditional sagu (free of gluten) powder as thickening, stabilizing, suspending, and binding agent. In proximate analysis of rice cake, we found carbohydrate 52%, fat 28%, protein 10%, Moisture 8%, Dietary fiber 1% and ash 1% and produce 500 kcal in 100g of serving. In addition, we further analyzed few BSTI (Bangladesh Standards and Testing Institution) recommended parameters such as zinc (2.15 mg), iron (0.51mg), calcium (3.04 mg), phosphate (115mg) and did not find any trace amount of arsenic, lead, cadmium, nikel and aflatoxins in our rice based bakery food products such as rice cake. Since In Bangladesh, there is a limited use of rice based food products such as puffed, popped and flattened rice and no bakery product is available so, it is assumed that rice based energy dense and gluten free cake might be popular as bakery product in Bangladeshi population specially children.

CONCLUSION

In quest of physicochemical variation among 49 Kalijira accessions, we found variation in few important parameters such as Chalkiness, AAC, PC, ASV, IR ratio and grain size & shape. In addition, we applied hierarchical cluster analysis on few selective parameters such as AAC, PC and ASV data of 55 small grain aromatic rice varieties including 49 different Kalijira accessions and 6 popular local and HYV in Bangladesh at aman season in Bangladesh Existing clusters also resemble variation among 49 Kalijira accessions along with popular small grain aromatic local as well as HYV rice varieties in Bangladesh for aman season. We have further analyzed few flour characteristics such as SC, WAC and OAC and found Kalijira rice flour specially Kalijira 4357 suitable for rice based bakery pro duct such as rice cake for its low AAC, GT and strong aroma.

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REFERENCES

1. Bhat, F.M. and Riar, C.S., Health Benefits of Traditional Rice Varieties of Temperate Regions. *Med Aromat Plants* 2015, 4:3:198.
2. Chaudry, R.C. and Tran, D.V., Specialty rice's of the world-a prologue. In: Specialty rice's of the world: *Breeding, Production and Marketing*. FAO, Rome, Italy, and Oxford and IBH Publishing Co.pvt. Ltd, New Delhi, India, 2001:3-14.
3. Alak, K.D., Partha S.G., Subrata B., Sukh M., Muhammad A.S., Yearul K., Antioxidant properties of ten high yielding rice varieties of Bangladesh. *Asian Pacific Journal of Tropical Biomedicine*, 2012, 2:1: 99-103.
4. Shozib, H.B., Saima J., Shourab B., Farzana H., Mahmud H., Mohammad O. F., Rahman, S.M. and Muhammad A. S., Dietary administration of rice in improving the antioxidant status in Long Evans rat, *Biojournal of Science and Technology (BJST)* 2015, 2:1-7.
5. Mohammad A.M., Tushar C.S., Ahmad H.K., Mostafizur M.R., Firoz M.A., Antitumor properties of two traditional aromatic rice genotypes (Kalijira and Chinigura). *Avicenna Journal of Phytomedicine* 2013
6. IRRI standard evaluation system (SES) for rice, *International Rice Research Institute (IRRI)*, P.O. Box 933, 1099 Manila, Philippines. 2013, edition 5th.
7. Juliano, B.O., Simplified Assay for Milled-Rice Amylose. Cereal Science Today, 1971,16: 334-338.
8. Little, R.R., Hilder, G.B., Dawson, E.H., Differential effect of dilute alkali on 25 varieties of milled white rice. *Cereal Chem.* 1958, 35:111-126.
9. Okaka J.C., Potter, N.N., Functional and storage properties of cow pea-wheat flour blends in bread making. *J. Food Sci.* 1977, 42:828-833.
10. Sosulski, F.W., Garatt, M.O., Slinkard, A.E., Functional properties of ten legume flours. *Int. J. Food Sci. Technol.* 1976, 9:66-69.
11. Jones D., Chinnaswamy R., Tan Y., Hanna, Physiochemical properties of ready-to-eat breakfast cereals. *Cereal Foods World* , 2000, 45:164-168.
12. Singh U., Functional properties of grain legume flours. *J Food SciTechnol*. 2001, 38:191–199.

13. Adeyeye, E.I., Aye P.A., Chemical composition and the effect of salts on the food properties of wheat flour. *Pak. J. Nut.* 2005, 4: 187-196.
14. Sahay, K.M. and Singh, K.K., Unit operations of Agricultural Processing. Vikas Publishing House Pvt. Ltd. New Delhi. P. 237.
15. Akpata, M.I., Akubor, P.I., Chemical composition and selected functional properties of sweet orange (Citrus sinensis) seed flour. *Plant Foods Hum. Nutr.* 1999, 54: 353-362.