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Chemical properties of six indigenous rice varieties of Assam

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Abstract
The study was undertaken to assess the nutritional composition of the selected rice varieties. Six varieties of polished and unpolished rice were selected for this study namely, *Ranjit, Bahadur, TTB-404, Mulagabhuru, Luit* and *Disang.* From the proximate composition it was seen that moisture, crude protein, crude fat, total mineral content and crude fibre gets reduced after polishing whereas, during processing of the brown rice to white rice there was increase in the carbohydrate content of the polished rice. Among the minerals, the iron content were found highest in both the polished and unpolished varieties of *TTB-404 i.e.,* 3.96±0.04mg/100g and 4.28±0.09mg/100g respectively.

Keywords: rice varieties; polished, unpolished; proximate and mineral composition

1. Introduction
Rice (*Oryza sativa* L.) belongs to grass family of Gramineae which provides an inexpensive, non perishable and convenience food for urbanites and it is also grown and used by subsistence farmers in the rural areas (Tomlins *et al.*, 2007) [20]. It is the most important food crop and the staple food for more than 60% of the Indian population (Anonymous, 2012) [4] and is generally consumed by cooking the whole kernel with water. It contributes 40-80% of the total calorie intake in Asian diet. Consumer preference is based generally on the variety of rice and its origin. The nutritive quality of rice becomes secondary but since rice is eaten widely as a staple food, its implication on nutrition is of paramount importance. Diversity in climatic conditions, genetic makeup and consumer preferences have led to natural and Tran's genetic evolution of about 2000 thousand rice cultivars (Wani *et al.*, 2011) [22]. Unique geographical location and climatic condition of Assam has a significant contribution to a diverse rice genetic pool. To match with diverse land situations encountered with varying growing season, different varieties had been traditionally grown in the state since unknown past. Assam has its climatic and physiographic features favourable for rice cultivation and the crop is grown in a wide range of agro-ecological situations. It is grown from hill slopes of Karbi-Anglong to very deep-water areas of North Lakhimpur and Dhemaji during very wet humid months to drier period of the year. Studies on rice quality have been carried out by various institutions/researchers. However, information on the quality characteristics of rice varieties of Assam is limited. The present study, therefore, is an attempt to determine the chemical properties of selected rice varieties recommended for Assam.

2. Material and Methods
2.1 Procurement of raw material
For the present investigation, six varieties of rice were procured from the Regional Agricultural Research Station (RARS), Titabor, Jorhat. Each rice variety of 500gm was dehusked separately by passing through a Satake paddy dehusker to yield brown rice. After dehusking 250gm of brown rice was kept separately and the remaining was polished by Satake rice polisher for 35 seconds to get white rice. For each variety, required amount of polished and unpolished rice grains were ground with the help of an electrical grinder and sieved with BS 60 mesh size and stored in airtight container for chemical analysis.

2.2 Chemical analysis
2.2.1 Proximate composition
Determination of moisture, crude protein, crude fiber, crude lipid, and total mineral were

done based on AOAC standard method. Carbohydrate content was determined by difference method:
Carbohydrate (%) = 100% - (% moisture + fat + protein + total mineral)
Whereas, energy content was calculated based on the formula reported by Gopalan *et al*., 2000 [10].
Energy (kcal per 100g) = (crude protein × 4) + (crude lipid × 9) + (carbohydrate × 4)

2.2.2 Determination of mineral content

Estimation of iron: Iron content was determined using Wong's method. To an aliquot (6.50ml or less) of the ash solution, water is added to make the final volume of 6.50ml. Then 1ml of 30% sulphuric acid, 1ml of 7% potassium per sulphate solution, 1ml of potassium thiocyanate solution is added. The content of the test tube is mixed properly. Then the intensity is measured at 540 nm. A standard curve is prepared by taking different concentration of iron ranging from (10g to 50g). The concentration of iron present in the sample was calculated from the standard curve and expressed as mg/100g sample.

Estimation of calcium: Calcium was determined by using flame photometer according to the method A.O.A.C (2000) [5]. A stock solution of Ca having concentration 200 ppm was prepared by dissolving 500mg $CaCO_3$ in 1000ml distilled water. A few drops of (1:1) HCl were added to dissolve the $CaCO_3$. From the stock solution another three solutions having concentration 75 ppm, 100 ppm and 150 ppm were prepared by appropriate dilution. The solutions were now placed under the flame photometer and reading was taken. The concentration of calcium present in the sample was calculated from the standard curve and expressed as mg/100g sample.

2.2.4 Statistical analysis

All the analysis were performed in triplicates and presented as mean ± standard deviation. Statistical significance of the data obtained was analyzed by One-way analysis of variance (ANOVA) by using Microsoft excel (2007). The significance difference was tested by F-test at 5% probability level.

3. Results and Discussion

3.1 Proximate composition

The proximate composition of the rice grains obtained from the present study are depicted and discussed in terms of moisture, crude protein, crude fat, total mineral, crude fibre, carbohydrate and energy.

3.1.1 Moisture content of rice

Moisture content, invariably affects the quality and palatability of rice grains (Oko and Onekywere, 2010) [12]. The rice varieties evaluated for their moisture content both in polished and unpolished samples and are presented in Table 1. The moisture content of unpolished samples ranges from 12.25±0.00g/100g in *Mulagabharu* to 15.50±0.70g/100g in *Luit* which were statistically different (p>0.05) from each other. Mbatchou and Dawda, 2013 [11] in a study reported that the moisture content of milled rice samples ranged from of 8.50g/100g to 22.00g/100 which were wider a range as compared to the present study. Among the polished rice samples, the moisture content ranged from 9.75±0.00g/100g in *Mulagabhuru* to 12.00±1.41g/100g in *Luit*. The findings of the present study are in concordance with the earlier research work by Sonowal, 2013 [18] who reported that the moisture content varied from 9.75±0.00g/100g to 11.25±0.01g/100g. The moisture content reduced in the polished samples as compared to the unpolished samples. Percent reduction in moisture content of the polished samples was recorded in all the varieties which ranged from 20.41% in *Mulagabharu* to 29.93% in *Ranjit*. The difference in the moisture level between the polished and unpolished samples may be due to the presence of bran in the unpolished rice which contains high protein, fibre and fat content which helps the moisture to remain intact.

Table 1: Moisture content of rice varieties

S. No.	Variety	Unpolished (g/100g)	Polished (g/100g)	% reduction
1.	*Ranjit*	15.50 ± 0.00 ^{a}	10.86 ± 0.00 ^{a}	29.93
2.	*Bahadur*	13.25 ± 0.70 ^{c}	10.50 ± 0.70 ^{b}	20.75
3.	*TTB 404*	14.50 ± 0.70 ^{b}	10.50 ± 0.07 ^{b}	27.59
4.	*Mulagabharu*	12.25 ± 0.00 ^{c}	9.75 ± 0.00 ^{c}	20.41
5.	*Luit*	15.50 ± 0.70 ^{a}	12.00 ± 1.41 ^{a}	22.58
6.	*Disang*	14.75 ± 1.06 ^{b}	10.75 ± 1.06 ^{b}	27.12

Values are mean ± SD. Variation in superscripts within the columns for given parameters indicate significant differences (ANOVA) (p > 0.05).

3.1.2 Crude protein, crude fat and crude fibre content of rice varieties

The nutritional quality of rice depends on the protein content and rice is the poor source of protein among cereals. Therefore the quality of protein depends on the composition of amino acids. The rice protein is superior because of its unique composition of essential amino acids (Eggum, B.O. 1979) [9]. From table 2 it can be evident that the crude protein content in the unpolished and polished rice varieties were found to be lowest in *Disang* i.e. 10.75±0.24g/100g and 9.91±1.35g/100g respectively and highest in *Luit* i.e. 18.19±0.26g/100g and 16.85±0.04g/100g respectively. Crude protein content recorded in this study were generally higher than what has been previously observed for polished rice varieties which ranged from 5.30 – 5.90% (Diako *et al*., 2011) [8]. The present findings were higher as compared with the findings of Thomas, Nadiah, and Bhat, 2013 [19] who found the protein content of brown rice to be 6.48 g/100g. As a result of polishing the protein content get reduced in all the varieties which ranged from 6.63% in *Mulagabhuru* to 9.48% in *Bahadur*. Loss in protein content due to polishing may be due to the removal of bran of the brown rice where nutrient gets lost as nutrients are mostly concentrated in the bran layer. The crude fat content depicted in table 2 showed that the unpolished rice samples ranged from 1.95±0.49g/100g in *Bahadur* to 3.95±0.35g/100g in *Luit* whereas, the crude fat content of polished rice samples ranged from 0.45±0.07g/100g in *Bahadur* to 1.40±0.07g/100g in *Ranjit*. The values obtained were higher than those reported in the literature (Shayo *et al*., 2006) [17]. The difference could be accounted for by the differences in the degree of milling since most of the fat in rice is concentrated in the aulerone layer of the kernel (Wang *et al*., 2006) [21]. The unpolished milled rice might have remained with some small particles of bran hence causing higher fat values. Reduction in crude fat content of was recorded in all the polished varieties which range from 44.00% in *Ranjit* to 76.90% in *Bahadur* Reduction may be due to the reason that highest per cent of fat content is localized in the outer thin layer which gets removed on processing.

Milling of rice generally decreases the fibre contents of rice. The highest amount of crude fibre content in the unpolished and polished samples were observed in *Ranjit i.e.*, 2.96±0.23g/100g and 2.60±0.14g/100g respectively whereas among the unpolished and polished varieties *TTB 404* showed the lowest crude fibre content i.e., 0.88±0.03g/100g and 0.74±0.06g/100g respectively (Table 2). Although this range is a bit lower than. The range (1.50 to 2.00%) obtained by Oko and Ugwu, 2011 [14] were almost similar to the present study. Percent reduction was observed in all the varieties of polished rice. The highest per cent reduction was observed in *Bahadur* (17.70%) followed by *Mulagabharu* (17.29%), while the lowest reduction was seen in *Ranjit* (12.16%). The difference in the crude fibre content of polished and unpolished samples may be because of the high amount of fibre that occurs in bran or the outer layer of rice which is present only in the brown rice.

Table 2: Crude protein, crude fat and crude fibre content of rice varieties

S. No.	Variety	Unpolished (g/100g)	Polished (g/100g)	% reduction
Crude protein content				
1.	*Ranjit*	13.32 ± 0.28 ^{c}	12.24 ± 0.01 ^{c}	8.10
2.	*Bahadur*	14.44 ± 0.62 ^{b}	13.07 ± 0.09 ^{b}	9.48
3.	*TTB 404*	14.16 ± 0.22 ^{b}	12.93 ± 0.17 ^{c}	8.69
4.	*Mulagabharu*	14.93 ± 0.07 ^{b}	13.98 ± 0.02 ^{b}	6.36
5.	*Luit*	18.19 ± 0.26 ^{a}	16.85 ± 0.04 ^{a}	7.36
6.	*Disang*	10.75 ± 0.24 ^{c}	9.91 ± 1.35 ^{c}	7.81
Crude fat content				
1.	*Ranjit*	2.50 ± 0.14 ^{b}	1.40 ± 0.14 ^{a}	44.00
2.	*Bahadur*	1.95 ± 0.49 ^{c}	0.45 ± 0.07 ^{c}	76.90
3.	*TTB 404*	2.20 ± 0.00 ^{b}	1.10 ± 0.42 ^{b}	50.00
4.	*Mulagabharu*	2.50 ± 0.42 ^{b}	1.05 ± 0.49 ^{b}	58.00
5.	*Luit*	3.95 ± 0.35 ^{a}	0.75 ± 0.35 ^{c}	74.57
6.	*Disang*	2.45 ± 0.35 ^{b}	1.05 ± 0.21 ^{b}	57.14
Crude fibre content				
1.	*Ranjit*	2.96 ± 0.23 ^{a}	2.60 ± 0.14 ^{a}	12.16
2.	*Bahadur*	0.96 ± 0.04 ^{c}	0.79 ± 0.06 ^{d}	17.70
3.	*TTB 404*	0.88 ± 0.03 ^{c}	0.74 ± 0.06 ^{d}	15.90
4.	*Mulagabharu*	1.85 ± 0.18 ^{a}	1.53 ± 0.31 ^{b}	17.29
5.	*Luit*	1.96 ± 0.48 ^{a}	1.65 ± 0.35 ^{b}	15.81
6.	*Disang*	1.11 ± 0.29 ^{c}	0.95 ± 0.35 ^{d}	14.41

Values are mean ± SD. Variation in superscripts within the columns for given parameters indicate significant differences (ANOVA) ($p > 0.05$).

3.1.3 Total mineral content of rice

The total mineral content of different polished and unpolished rice varieties were shown in table 3. In this study, the range of total mineral content of the unpolished rice varieties were found to be in the range of 1.00±0.28 g/100g in *Disang* to 1.60±0.00g/100g in *Mulagabhuru*. Similar findings were reported by Deepa. Singh and Naidu, 2008 [7] who found the total mineral content of unpolished rice samples ranged from 1.27g/100g to 1.42g/100g. In case of polished samples, it was found that *Mulagabharu* had the highest total mineral content (1.00±0.00g/100g) whereas *Disang* had the lowest content of 0.60±0.00g/100g. The results of the present study showed that among the polished samples the percent reduction was found to be in the range of 35.71% to 46.66%. The variations in the total mineral content may be due to the degree of milling and polishing and it may also be due to varietal differences within the samples.

Table 3: Total mineral content of rice varieties (per 100g)

S. No.	Variety	Unpolished (g)	Polished (g)	% reduction
1.	*Ranjit*	1.40 ± 0.00 ^{b}	0.90 ± 0.14 ^{a}	35.71
2.	*Bahadur*	1.50 ± 0.14 ^{b}	0.80 ± 0.00 ^{b}	46.66
3.	*TTB 404*	1.40 ± 0.00 ^{b}	0.80 ± 0.00 ^{b}	42.86
4.	*Mulagabharu*	1.60 ± 0.00 ^{b}	1.00 ± 0.00 ^{a}	37.50
5.	*Luit*	1.50 ± 0.14 ^{b}	0.90 ± 0.00 ^{a}	40.00
6.	*Disang*	1.00 ± 0.28 ^{c}	0.60 ± 0.00 ^{c}	40.00

Values are mean ± SD. Variation in superscripts within the columns for given parameters indicate significant differences (ANOVA) ($p > 0.05$).

3.1.4 Carbohydrate content of rice varieties

Rice is the main source of carbohydrates for more than 1/3rd of the people in world. The rice varieties were evaluated in their carbohydrate content and results were shown in table 4. In the unpolished samples, the carbohydrate content was found to be in the range of 61.67±0.11g/100g in *Luit* to 70.00±0.07g/100g in *Disang* while in the polished samples it ranged from 71.79±1.73g/100g in *Luit* to 79.18±0.28g/100g in *Lachit*. During processing of the brown rice to white rice there was increase in the carbohydrate content of the polished rice. Percent increase was seen to be in the range of 6.18 % in *Bahadur* to 10.12 % in *Luit*. It was found that carbohydrate content decreased in unpolished rice varieties and this may be due to presence of bran layer as bran contains mostly non-starch constituents (approx. 30-40% starch) (Al-Bayati and Al-Ryees, 1981) [3]. The results were quiet similar with the findings of Abdulaziz and Bahrany, 2002 [2] who found the carbohydrate content between 75.69 to 77.38g/100g while in an earlier study by Premila Devi Thongbam, 2012 [16] found the carbohydrate to be in the range of 70.00 – 89.25%. The difference in the carbohydrate content between the polished and unpolished samples may be due to the starch content of polished rice varieties which contains approx. 70-80% of starch which is nothing but carbohydrate while the outer thin brown layer in the brown rice are rich in non-starch constituents i.e., approx. 20-30% of starch.

Table 4: Carbohydrate content of rice samples (per 100g)

S. No.	Variety	Unpolished (g)	Polished (g)	% increase
1.	*Ranjit*	65.17 ± 0.27 ^{b}	72.46 ± 0.29 ^{c}	7.29
2.	*Bahadur*	69.00 ± 0.13 ^{a}	75.18 ± 0.68 ^{a}	6.18
3.	*TTB 404*	66.93 ± 0.06 ^{b}	75.47 ± 0.95 ^{a}	8.54
4.	*Mulagabharu*	65.23 ± 0.44 ^{b}	72.46 ± 1.22 ^{c}	7.23
5.	*Luit*	61.67 ± 0.11 ^{c}	71.79 ± 1.73 ^{c}	10.12
6.	*Disang*	70.00 ± 0.07 ^{a}	77.29 ± 2.63 ^{a}	7.29

Values are mean ± SD. Variation in superscripts between mean values for given parameters indicate significant differences (ANOVA) ($p > 0.05$).

3.1.5 Energy content of rice varieties

The energy content of different polished and unpolished rice samples was shown in table 5. In the present investigation, energy content of the unpolished rice samples was found to be in the range of 345.55±3.84 kcal/100g to 498.41±3.79 kcal/100g. The range of energy content of polished rice sample was found to be in the range of 333.98±1.86 kcal/100g in *Chilarai* to 360.19±2.42 kcal/100g in *Bokul Joha.* In a study by Oko, Ubi and Dambala, 2012 [13], it was found that the energy content ranged from 262.94 to 398.82 kcal/100g which was found to be slightly similar with the present

results. It was also found that there was a reduction in the energy content which was found to be highest in *TTB 404* (15.82%) and the lowest percent reduction was seen in *Ranjit* (10.64%) and these differences within the samples may be due to varietal differences.

Table 5: Energy content of rice varieties (per 100g)

S. No.	Variety	Unpolished (Kcal)	Polished (Kcal)	% reduction
1.	*Ranjit*	354.35 ± 2.61^{c}	343.71 ± 3.32 ^{c}	10.64
2.	*Bahadur*	364.94 ± 3.03 ^{b}	351.94 ± 4.03 ^{b}	13.00
3.	*TTB 404*	358.19 ± 3.77 ^{c}	342.37 ± 3.77 ^{c}	15.82
4.	*Mulagabharu*	365.02 ± 4.50 ^{b}	353.16 ± 2.40 ^{b}	11.86
5.	*Luit*	498.41 ± 3.79 ^{a}	351.27 ± 2.18 ^{b}	11.14
6.	*Disang*	494.82 ± 3.60 ^{a}	357.74 ± 3.26 ^{a}	11.08

Values are mean ± SD. Variation in superscripts between mean values for given parameters indicate significant differences (ANOVA) ($p > 0.05$).

3.2 Mineral composition: The mineral content that were analyzed is discussed under the following headings:

3.2.1 Iron and calcium content of rice varieties

The results demonstrated that the mineral content in brown rice is always greater than in the white rice. The iron and calcium content of rice varieties in both polished and unpolished state are shown in Table 6. Among the unpolished samples, the highest iron content was observed in the cultivar *Bahadur* (4.68mg/100g) and the lowest was seen in *Disang* (1.54mg/100g) whereas the iron content of polished samples was found to be in the range of 1.33±0.21mg/100g in *Disang* to 3.96±0.04mg/100g in *TTB 404* and were statistically similar within them. Results reported by showed that white rice contains 3.30µg/g and brown rice contains 7.30µg/g which is lower than the results obtained in the present study (Bagirathy A/P Govarethinam, 2014) [6]. The highest per cent reduction was observed in *Ranjit* (16.71%) followed by *Bahadur* (16.66%) and the lowest reduction was seen in *TTB 404* (13.15%) followed by *Disang* (13.63%). The variations in the iron content within the varieties may be due to the environmental conditions and removal of bran layer. Since greater amount of rice bran are removed during polishing to get white rice, as a result most of the minerals are lost i.e., approx. 40% (Pederson, 1983) [15].

The calcium content of the both the unpolished and polished rice varieties were found to be lowest in *Ranjit i.e.,* 11.00±2.8mg/100g and 9.00±2.8mg/100g respectively, and highest in *Mulagabhuru i.e.,* 18.00±2.80mg/100 and 15.00±1.04mg/100g respectively. Abbas *et al.*, 2011 [1] in a study on the effect of processing on nutritional value of rice found that the calcium content of brown rice to be 0.10mg/100g which was quite lower than the present results. During processing of the unpolished rice to obtain polished rice reduction in calcium content was observed. The percent reduction was found to be in the range of 14.28% in *TTB 404* to 18.75% in *Bahadur*. The variations in the calcium content may be due to the degree of milling and polishing, varietal differences within the samples and may also be due to the fact that as calcium is mostly concentrated in the outer bran layer during milling of the unpolished rice to get polished rice approx. 40% of calcium is lost.

Table 6: Iron and calcium content of rice varieties (per 100g)

S. No.	Variety	Unpolished (mg)	Polished (mg)	% reduction
Iron content				
1.	*Ranjit*	3.47 ± 0.66 ^{b}	2.89 ± 0.08 ^{b}	16.71
2.	*Bahadur*	4.68 ± 0.09 ^{a}	3.90 ± 0.04 ^{a}	16.66
3.	*TTB 404*	4.56 ± 0.37 ^{a}	3.96 ± 0.04 ^{a}	13.15
4.	*Mulagabharu*	1.60 ± 0.51 ^{c}	1.35 ± 0.21 ^{c}	15.62
5.	*Luit*	2.30 ± 0.33 ^{c}	1.96 ± 0.27 ^{c}	14.78
6.	*Disang*	1.54 ± 0.31 ^{c}	1.33 ± 0.60 ^{c}	13.63
Calcium content				
1.	*Ranjit*	11.00 ± 2.82 ^{c}	9.00 ± 2.82 ^{c}	18.18
2.	*Bahadur*	16.00 ± 2.82 ^{b}	13.00 ± 4.24 ^{b}	18.75
3.	*TTB 404*	14.00 ± 0.00 ^{c}	12.00 ± 0.00 ^{c}	14.28
4.	*Mulagabharu*	18.00 ± 2.82 ^{a}	15.00 ± 1.41 ^{a}	16.66
5.	*Luit*	17.00 ± 1.41 ^{a}	14.00 ± 1.41 ^{b}	17.65
6.	*Disang*	17.00 ± 1.41 ^{a}	14.00 ± 2.82 ^{b}	17.64

Values are mean ± SD. Variation in superscripts within the columns for given parameters indicate significant differences (ANOVA) ($p > 0.05$).

The detailed investigation has led to the conclusion that the findings are important data base for the recommended rice varieties of Assam Agricultural University based on which the superior varieties with more nutrient content can be recommended to the population. As Assam is rice eating population and major portion of carbohydrate is contributed from rice so it may help to combat Protein Energy Malnutrition (PEM). Investigations on the polished and unpolished rice varieties indicated differences in the proximate and mineral composition. From the investigation it can thus be concluded that the unpolished rice varieties were highly nutritious in comparison to the polished rice so, consumption of brown rice should be encouraged for table purpose. Thus, varieties with more iron and calcium both in polished and unpolished form may be encouraged to include in the daily diet to address the problem of nutrient deficiencies.

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