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RESEARCH ARTICLE

Endangered indigenous rice varieties as a source of B vitamins for the undernourished population

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Abstract

Background and Objectives: Rice is a staple food for half of the world's population and plays an important role to deliver several micronutrients including B vitamins to humans. The present investigation was carried out to detect some B vitamins and estimate their concentrations in 309 traditional indica rice landraces, compared with three modern rice varieties predominantly available in the Indian market.

Findings: Liquid chromatographic examination of the rice samples demonstrated that a large number of traditional rice landraces contained considerable amounts of different B vitamins. In the landraces examined, vitamin B1 (thiamine) was recorded to be present in the range of 0.01–10.55 mg/100 g, vitamin B2 (riboflavin) 0.01–2.63 mg/100 g, vitamin B3 (niacin) 0.20–4.52 mg/100 g, vitamin B5 (pantothenic acid) 0.01–18.55 mg/100 g, vitamin B6 (pyridoxine) 0.01–0.86 mg/100 g, and vitamin B7 (biotin) 0.01–5.90 mg/100 g in different rice landraces.

Conclusion: Compared with traditional rice, modern rice cultivars seem to have substantially lower B vitamin levels. It appears that these vitamin-rich traditional rice landraces if incorporated into daily diet, may serve to attain nutritional security of the poor.

Significance and Novelty: Our results show that many traditional rice landraces are nutritionally superior to any modern rice cultivar, even though traditional rice landraces are normally not in priority for agronomic research and development. This study shows how native rice landraces may be leveraged to constitute novel nutritious diet that could enhance human health.

KEYWORDS
B vitamins, HPLC, landrace, nutrition, traditional rice

1 | INTRODUCTION

Rice (*Oryza sativa* L.) is an important part of the human diet because it contains a large amount of carbohydrates, and small quantities of protein, fatty acids, dietary fibers, B vitamins, and minerals. B vitamins are critically important vitamin groups, as they help keep the nervous system (Calderón-Ospina & Nava-Mesa, 2020), skin and eyes (Shabbir et al., 2020), liver (Khan et al., 2009), brain function (Klenner, 2005), and gastrointestinal tract

(Tappenden & Deutsch, 2007) healthy and functional. These vitamins concertedly work to promote metabolism, facilitate adequate oxygen supply to cells, detoxify organs, stabilize nervous system functions, prevent vision problems (Gonçalves & Portari, 2021), and also to treat debilitating conditions (Tice, 2010).

B-vitamin deficiencies have diverse aetiologies, including inadequate intake, increased needs at different life history stages, malabsorption, drug-nutrient interactions, and other factors like hereditary diseases or health conditions (Porter et al., 2016). In many developing countries, vitamin B inadequacies are very common, particularly in those with diets that are low in animal products, fruits, and vegetables, and where cereal grains are milled before consumption. The most vulnerable groups to vitamin B deficiency are newborns, adolescents as well as pregnant and lactating women (Ashley, 2016). Infantile beriberi, a potentially fatal condition brought on by thiamine deficiency, is widely believed to be a sickness of the past in regions of the world where milled white rice consumption is the norm. Recent case reports, however, have demonstrated that thiamine deficiency is still a contributing factor in infant mortality in South and Southeast Asia. In the United States and UK, riboflavin deficiency is uncommon, but prevalent in developing countries in Asia and Africa. Niacin deficiency in the diet is usually common during periods of the food crisis, and frequent in Africa and Asia's maize-eating regions. Pyridoxine deficiency mostly occurs when the body has low levels of other B vitamins, especially vitamin B12 and folic acid, which is common in South Asia (Harding et al., 2018).

Fortification of rice with different vitamins and minerals is considered to be an important step toward addressing endemic malnutrition in rice-growing countries. While rice endosperm is virtually devoid of micronutrients, brown rice is known to contain several vitamins and minerals (Deb et al., 2015; Mondal et al., 2021; Rezaei et al., 2022; Roy et al., 2021). Knowledge of vitamin contents of specific rice landraces is important for strategizing the nutritional security of populations through the public distribution of vitamin-rich rices, as a viable and cheaper alternative to rice fortification programs. However, there is very limited information on the presence of B vitamins in rice landraces in its brown, or polished form. Liquid chromatographic method has evolved as one of the best methods for the identification and quantitative determination of B vitamins in food matrixes (Nguyen et al., 2021; Rezaei et al., 2022). Thiamine, riboflavin, nicotinic acid, biotin, pantothenic acid, and so forth have been reported by liquid chromatographic methods in a small number of *indica* rice landraces (Cho et al., 2020; Deepa et al., 2008; Priya et al., 2019; Roy et al., 2021; Sumczynski, et al., 2018). Vitamin B12 is reported to be absent in the plant system (Watanabe, 2007), although vitamin B12 derived from microbial biosynthesis is rarely found in some processed plant foods (Jedut et al., 2021). On a larger scale, there is a research gap on the profiling of B vitamins and their concentrations in diverse rice (*O. sativa* ssp. indica) landraces. In this study, we report the results of a quantitative analysis of seven crucial B vitamins in 309 *indica* rice landraces, compared to three modern rice cultivars, and discuss the compositional diversity to address nutritional security.

2 | MATERIALS AND METHODS

2.1 | Samples

Freshly harvested grains of 309 traditional rice landraces were collected in 2019 from the Centre for Interdisciplinary Study's conservation farm Basudha (http://www.cintdis.org/basudha), located in Rayagada district of Odisha (19° 42′ 32.0″N, 83° 28′ 8.4″E) where all the rice landraces are cultivated with zero external input. The farm is situated in the northern Eastern Ghat, characterized by hot subhumid eco-region with annual rainfall ranging from 1030.21 mm to 1569.50 mm. Samples of three modern varieties, namely, IR36, IR64, and BPT5204, were examined for comparison. Samples of the first two were collected from Chinsurah Rice Research Station, Hooghly, India, and BPT5204 was procured from Rajendranagar market, Hyderabad, India. All rice samples were decorticated manually in the laboratory by rubbing against a pumice stone, keeping the rice germ and bran layer intact, and ground to a fine powder using mortar and pestle, and stored at −20°C for vitamin analysis.

2.2 | Chemicals

Thiamine hydrochloride (B1), riboflavin (B2), nicotinic acid (B3), D-pantothenic acid calcium salt (B5), pyridoxine HCl (B6), and biotin (B7) and cyanocobalamin (B12) standards were purchased from Sigma-Aldrich. Methanol, chromatography-grade water and analytical-grade hydrochloric acid were obtained from Merck.

2.3 | Preparation of stock solution

Stock solutions of thiamine hydrochloride, pyridoxine HCl, cyanocobalamin, nicotinic acid, and D-pantothenic acid calcium salt were prepared by dissolving 10 mg of the respective compound in 10 mL of deionized water (1 mg/mL), and stock solutions of riboflavin, and biotin were prepared by dissolving 10 mg of the respective compound in 10 mL of 0.1 mol/L NaOH (1 mg/mL). Stock solutions were prepared afresh before each analysis.

2.4 | Extraction of B vitamins

Extraction was carried out following the methods described in Puwastien et al. (2011) with slight modification, and detailed in Roy et al. (2021).

2.5 | Chromatographic procedure

High-performance liquid chromatography (HPLC) was used for the analysis of all B vitamins from the extracted rice samples. The reverse-phase-HPLC (RP-HPLC) method, reported by Heudi et al. (2005) was adopted for standardization, with slight modification. A gradient elution method was employed to get the baseline separation of the B vitamins (Roy et al., 2021). Briefly, gradient of two mobile phases were: methanol (A) and water with 0.02% aqueous H_3PO_4 (B) were set at: 0% A + 100% B for 3 min; 10% A + 90% B for 10 min; 30% A + 70% B for 15 min and 30% A + 70% B for 35 min. The injection volume was 20 μl. The flow rate was kept at 1 mL/min and analytes were scanned at 210 nm wavelength. The peaks were identified by comparing the relative retention time with proper peak integration, co-chromatography with standard, and calibration against absorption spectra obtained from the analytical standards. Considering the large number of samples and quick completion of the analysis, we have carried out the experiments using three different liquid chromatographic machines. However, the method was identical for B complex vitamin analyses in all the instruments. The instrumental details are (i) Shimadzu Prominence Analytical HPLC System attached with Zorbax SB-C18 column (4.6 mm × 150 mm, 3.5 micron, Agilent) with Photo Diode Array Detector; (ii) Waters HPLC attached with Atlantis dC18 column (100 Å, 5 μm, 3.9 mm × 150 mm) and UV-Vis detector, and (iii) Shimadzu Prominence UFLC (Ultra-Fast Liquid Chromatography), attached with Zorbax SB-C18 column (4.6 mm × 150 mm, 3.5 μm, Agilent, USA) with dual-channel UV-Vis detector. In all these cases, the separated peaks were calculated by comparing the relative retention time with the right peak integration, standard co-chromatography, and absorption spectra calibration obtained from the authentic standard.

2.6 | Detection of B vitamins and chromatographic separation

Following the recent understanding (Sasaki et al., 2020) that all B vitamins can be spectrophotometrically detected at 210 nm. We used 210 nm wavelength to detect the presence of all seven B vitamins (Supplementary Figure S1) in our experiment. The chromatographic separation of seven B vitamins in the mixture of standard solution using the gradient elution method is shown in Supplementary Figure S2 (I). The elution order was vitamin B1 (thiamine), B3 (niacin), B6 (pyridoxin), B5 (pantothenic acid), B7 (biotin), B12 (cyanocobalamin), and B2 (riboflavin). Supplementary Figure S2 (II) shows the chromatographic separation of B vitamins from an extracted rice sample G37. All seven B vitamins were separated to the baseline and eluted as sharp peaks within 20 min. The reproducibility of the retention time was checked three times over, and only after getting an acceptable standard deviation value the method was adopted. By combining the stock solutions in the proper proportions and diluting them with mobile phase, the analytical solutions were used for assessing the linearity, range, LOD, and LOQ. Peak areas were plotted against five comparable concentrations (μg/mL) of each vitamin B molecule to develop calibration curves. Using the outcomes of these analyses, the linearity (with $R^2 > 0.998$), range, LOD, and LOQ were estimated (Table 1). The concentrations at which vitamin B compound peaks could be identified without being interfered with by baseline noise were used to determine LOD and LOQ. All vitamins were quantified by using the standard validation method and finally, the amounts of the analytes were expressed as mg/100 g. Results below the LOD were considered as not detected (ND) in case of all B vitamins.

2.7 | Statistical analysis

Data are presented as the mean of three replications. Pearson's correlation and principal component analysis (PCA) were performed using R statistical software (v4.2.2; R Core Team 2022). Considering replications ($df = 2$), the confidence limit was set at $p < .05$. Using the same data sets, bidirectional heatmap clustering was performed.

3 | RESULTS AND DISCUSSIONS

3.1 | Analysis of B vitamins in rice samples

The concentrations of different B vitamins in 309 rice landraces and three modern rice cultivars examined

TABLE 1 LOD and LOQ of B vitamins in chromatographic detection and variation of B vitamins across rice lines achieving recommended daily intake.

Name of B vitamins	LOQ (ppm)	LOD (ppm)	Variations B vitamins in rice landraces (mg/100 g)	Average recommended Daily Intake[a] for an adult (19-60 years)	A few recommended rice lines with high amount of B vitamins
Thiamine	0.04	0.05	0.01–10.55	1.2 (mg)	C09, DD16, G43, TT16, B24
Riboflavin	0.07	0.01	0.01–2.63	1.3 (mg)	B38, M04, M33, K71
Nicotinic acid	0.02	0.008	0.20–4.52	16 (mg)	SS04, M51, S54, G12
Pantothenic acid	0.03	0.005	0.01–18.55	5 (mg)	A10, DD18, S61, T01
Pyridoxine	0.02	0.01	0.01–0.86	1.3 (mg)	C12, B21, S54, G12
Biotin	0.03	0.008	0.01–5.90	30 (μg)	SS02, SH06, SH04, M33
Cyanocobalamin	0.01	0.006	N.D.	2.4 (μg)	---

Abbreviations: LOD, Limit of detection; LOQ, limit of quantitation; N.D., not detected.

[a]Taken from Kennedy (2016).

here are given in Supplementary Tables S1 and S2, respectively. Vitamin B1 (thiamine) was present in the range of 0.01–10.55 mg/100 g, vitamin B2 (riboflavin) 0.01–2.63 mg/100 g, vitamin B3 (nicotinic acid) 0.20–4.52 mg/100 g, vitamin B5 (D-pantothenic acid calcium salt) 0.01–18.55 mg/100 g, vitamin B6 (pyridoxine hydrochloride) 0.01–0.86 mg/100 g, and vitamin B7 (biotin) 0.01–5.90 mg/100 g in different rice landraces. In comparison with several traditional rice landraces, the modern rice cultivars IR36, IR64, and BPT5204 contained much lower quantities of B vitamins in their grains (Supplementary Table S2). In contrast, among the 309 landraces studied here, there were several landraces containing remarkably high levels of different B vitamins in their grains (Figure 1), implying that their consumption could meet the recommended daily intake (RDI) of these vitamins (Table 1). There was no strong correlation among the levels of different B vitamins in the rice landraces examined here (Supplementary Figure S3).

The association between the rice landraces was investigated using important B vitamins to determine suitable rice landraces for future studies. The outcomes of the heat-map analysis of the rice landraces are shown in Supplementary Figure S4. The efficacy of applied methodologies in identifying rice landraces based on phenotypic data is highlighted in the heatmap, which clearly classifies 309 landraces into five main clusters and 12 sub-clusters. Our PCA failed to detect any distinctive group among our rice samples Supplementary Figure S5. However, separation was visible in the first two main components, which collectively account for 54.7% of variation. The principal component 1 (Dim-1, 36.2%) score and loading indicated that the rice lines had greater concentrations of B1, B2, B3, B5, and B6 with high and positive relations among each other. On the other hand, the level of B7 was higher in the PC2 loading (Dim2, 18.5%) plot and score than those in PC1. These findings, however, do not indicate that the concentrations of any B vitamin had any influence on the presence of other B vitamins in the rice grains. It is likely that edaphoclimatic diversity of origin of the landraces and different agronomic factors (Choi et al., 2012)—in addition to the varietal genotype—may independently influence the B vitamin contents in these rice landraces.

3.1.1 | Vitamin B1 (thiamine)

Almost 96% of the rice landraces examined here contained much greater than 0.1 mg/100 g of thiamine in their grains (Figure 1). The higher contents of thiamine were found especially in DD16, C09, G43, and TT16 samples, in a range between 9.03 and 10.55 mg/100 g. As Supplementary Table S1 shows, traditional rice landraces are a rich source of thiamine. The major forms of this vitamin in cells are free thiamine, thiamine monophosphate, and thiamine pyrophosphate, which are one of the cofactors for the enzymes of basic metabolic pathways like glycolysis, pentose phosphate pathway, and tricarboxylic acid pathway, amino acid and acetyl Co-A biosynthesis pathways (Rapala-Kozik, 2011). Deficiency of thiamine leads to beriberi, which affects cardiovascular and nervous systems (Lonsdale, 2006). Our finding suggests that RDI may be attained by consuming whole grain (unpolished) rice in a daily diet (Table 1).

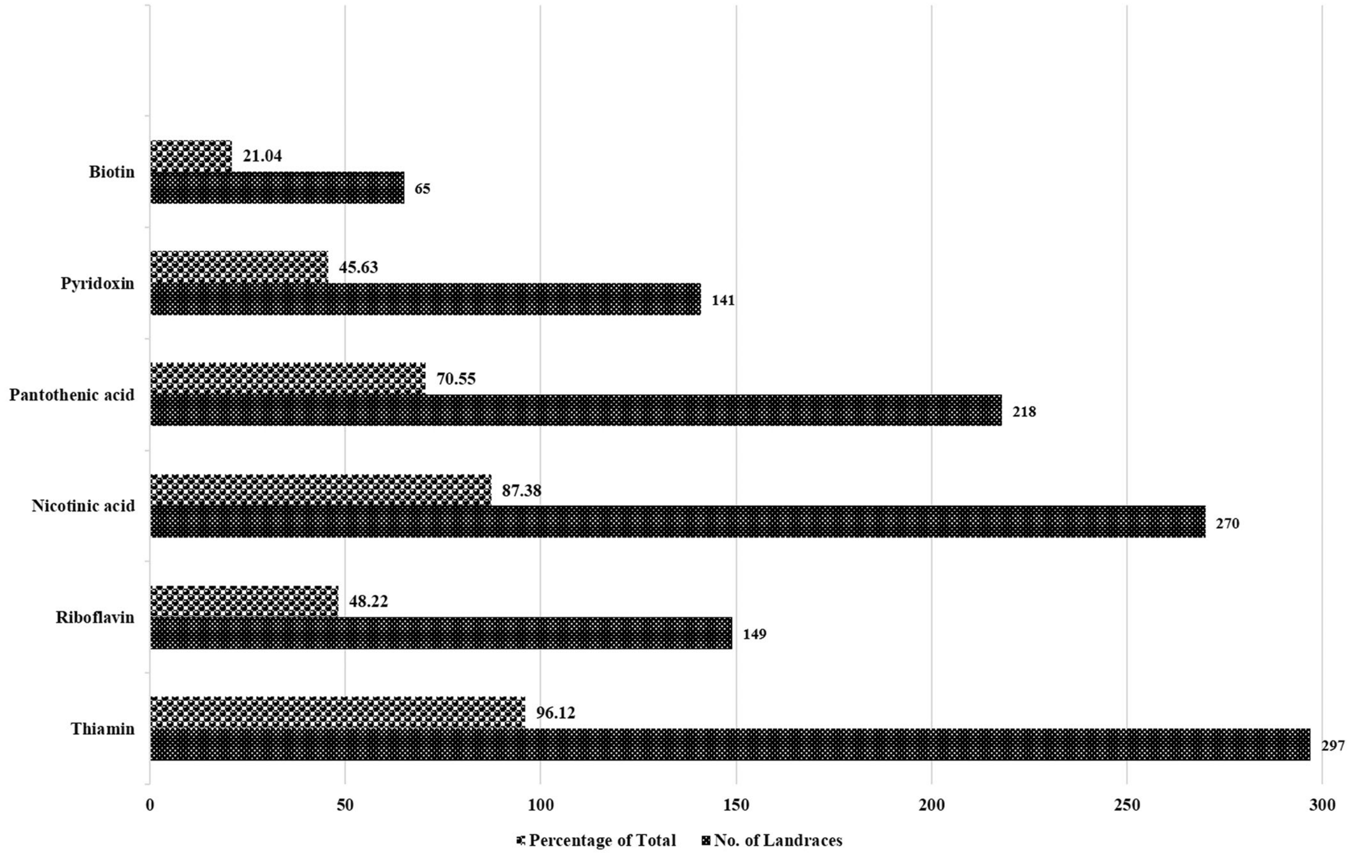

FIGURE 1 The number of landraces (dotted bars) and their proportions (bubble bars), Containing > 100 μg of different B complex vitamins in 100 g of sample. Figures beside the bubble bars indicate the % of $N = 309$ landraces examined.

3.1.2 | Vitamin B2 (riboflavin)

Considerably high riboflavin levels were found in M04 (2.63 mg/100 g) and B38 (1.05 mg/100 g) rice landraces. Riboflavin is a precursor of various redox-active coenzymes associated with different proteins, which act as cofactors in different metabolic enzymes (Giancaspero et al., 2013). Deficiency of vitamin B2 in the diet leads to anemia, neurological, and developmental disorders (Powers, 2003). Our study indicates that RDI may be achieved by consuming some traditional rice landraces, which were a good source of vitamin B2 and could be recommended to patients suffering from ariboflavinosis (Table 1).

3.1.3 | Vitamin B3 (nicotinic acid)

The higher contents of niacin were found in SS04 (4.52 mg/100 g), M51 (4.05 mg/100 g), S54 (3.86 mg/100 g), and so forth rice landraces. However, 87.38% of the rice landraces examined here contained more than 0.1 mg/100 g in their grains (Figure 1, Supplementary Table S1). Niacin is a precursor of pyridine alkaloids (Noctor, 2006) and helps to metabolize macronutrients, resulting in the healthy functioning of the nervous system. Severe deficiency of niacin in the diet causes pellagra, poor concentration, anxiety, depression, and so forth (Penberthy & Kirkland, 2020). Consuming the rice varieties examined here may not meet the need of RDI of vitamin B3 in diet (Table 1), but a moderate amount of niacin present in rice landraces could be helpful for people who are suffering from vitamin B3 deficiency.

3.1.4 | Vitamin B5 (D-pantothenic acid calcium salt)

The higher contents of pantothenic acid were found in 70.55% of rice landraces. Pantothenic acid (B5) is commonly available among other B vitamins and could be found in both animal and plant-based food items. It is the precursor of coenzyme A which is essential for fatty acid metabolism. It is also responsible for the secondary metabolite synthesis pathway (Coxon et al., 2005). Pantothenic acid deficiency in humans is extremely rare and has received less attention. The RDI for vitamin B5 could be easily achieved by consuming traditional rice landraces, which are an excellent source of pantothenic acid as our data suggest (Table 1).

3.1.5 | Vitamin B6 (pyridoxin hydrochloride)

The higher contents of pyridoxine (B6) were found in 45.63% of the total rice landraces (Figure 1). Vitamin B6 is a potent antioxidant that helps to metabolize sugars and fatty acids and acts as a cofactor in different enzymatic reactions (Drewke & Leistner, 2001). Deficiency of vitamin B6 leads to depression, lower immunity, kidney diseases, rheumatoid arthritis, and so forth (Sharifzadeh et al., 2018). Vitamin B6 may lower the risk of cancer (Mocellin et al., 2017), help with brain function by lowering levels of homocysteine (Rutjes et al., 2018), and prevent cardiovascular diseases. Our results suggest that a good number of traditional rice landraces contain this vitamin in moderate amounts.

3.1.6 | Vitamin B7 (biotin)

An adequate amount of biotin was found in 21% of the rice landraces examined here (Figure 1), which are capable to meet the RDI (Table 1). Plants, most bacteria, and some fungi can synthesize biotin, whereas animals and some other fungi must obtain biotin from their diet because they are unable to synthesize it. Biotin operates as a cofactor for enzymes that are required in many biological functions (Knowles, 1989). Deficiency of vitamin B7 leads to brittle and thin fingernails, conjunctivitis, red rash on the face, and neurological symptoms such as depression, lethargy, hallucination, and so forth (Penberthy & Kirkland, 2020).

There are some recent reports of a few traditional rice landraces containing B vitamins. Specifically, Njavara from Kerala and Jyothi from Karnataka are reported to contain thiamine (0.35–0.52 mg/100 g), riboflavin (0.053–0.071 mg/100 g), niacin (7.15–7.32 mg/1100 g), and folic acid (0.05 mg/100 g) (Deepa et al., 2008). Similarly, 32 folk rice varieties from Meghalaya are reported to contain thiamine (0.17–0.38 mg/100 g), riboflavin (0.03–0.09 mg/100 g), nicotinic acid (1.43–3.87 mg/100 g), pantothenic acid (0.36–3.10 mg/100 g), and pyridoxine (0.03–0.17 mg/100 g) (Longvah et al., 2020). Roy et al. (2021) also reported different B vitamins, namely, thiamine (0.11–1.38 mg/100 g), riboflavin (0.01–0.56 mg/100 g), niacin (0.17–0.80 mg/100 g), pantothenic acid (0.81–2.9 mg/100 g), pyridoxine (0.1–0.2 mg/100 g), and biotin (0.01–0.24 mg/100 g) in a few selected rice landraces, also included in our present study of 309 rice landraces. In this study, we detected an outstandingly high concentration of thiamine in some landraces, to the extent of more than 9 mg/100 g. In addition to thiamine, the concentrations of pantothenic acid, pyridoxine, niacin, biotin in these folk rice grains are much greater than in the three modern high-yielding rice cultivars (Supplementary Tables S1 and S2). In fact, most of the B vitamins are not yet reported in any modern high-yielding rice cultivars (Deepa et al., 2008; Roy et al., 2021). In this study, the richness of B vitamins in the grains of some traditional rice landraces implies a robust solution to the problem of vitamin B deficiency, especially in rice-eating cultures. We suggest that the recommended daily dietary requirement of many B vitamins may adequately be fulfilled by a large number of traditional rice landraces (Table 1), most of which are not yet adequately examined.

This research indicates how indigenous rice landraces might be utilized into a nutritious rice-based product that is high in vitamins or used as a component in novel functional foods that could improve human health (Itagi et al., 2023). While folk rice landraces are typically not high on the priority list for agronomic research and development, our findings indicate that a large number of rice landraces are nutritionally superior to any modern rice cultivar.

4 | CONCLUSION

The present work is the first quantitative study of several B vitamins in fresh decorticated grains of a large number (309) of *indica* rice landraces, compared to 3 modern rice cultivars. Most of the landraces examined here have almost disappeared from rice farms as a result of preferences for modern HYVs. The extinction of these landraces from rice farms indicates a substantial loss of a wealth of indigenous rice genetic diversity, with their great potential to ensure nutritional security for the poor. One apparent policy recommendation is to conserve and promote the cultivation and consumption of traditional rice landraces. Widespread cultivation and consumption would be a viable means to assuring nutritional security for the poor and marginal sections of the country's population.

AUTHOR CONTRIBUTIONS

Debal Deb and Priyabrata Roy conceived the presented idea. Debal Deb designed the analyses and selected the rice cultivars, Tanima Saha and Thalappil Pradeep verified the analytical methods. Debal Deb, Brindaban Roy, Tanima Saha, and Thalappil Pradeep enlisted

Priyabrata Roy and Arunan Suganya to investigate all the analyses, statistical computations, provided the access and instrumental facilities for all analyses and supervised the entire work. Priyabrata Roy and Tanima Saha prepared the first draft of manuscript. All authors contributed to the final manuscript.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

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SUPPORTING INFORMATION

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Endangered indigenous rice varieties as a source of B vitamins for the undernourished population.

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Supplementary table 1: Concentrations of seven B complex vitamins in 309 traditional rice landraces.

Sl. No.	Sample	Landrace Name	B_1 (mg/100g)	B_2 (mg/100g)	B_3 (mg/100g)	B_5 (mg/100g)	B_6 (mg/100g)	B_7 (mg/100g)	B_{12} (mg/100g)
1	AA03	Aash	1.17	0.31	1.09	2.88	0.15	0.06	N.D.
2	AA24	Abor Xali	0.11	0.16	1.82	1.87	0.15	0.06	N.D.
3	A13	Ahana	0.38	0.05	0.21	0.06	0.03	0.02	N.D.
4	AA08	Ajipa	1.54	0.28	1.37	2.32	0.10	0.05	N.D.
5	A01	Akshay Rani	1.42	N.D.	0.43	0.06	0.04	0.01	N.D.
6	AA16	Alta Pati	0.38	0.06	0.25	0.05	0.03	0.04	N.D.
7	A02	Amar-Sal	0.43	N.D.	1.13	0.06	0.01	0.01	N.D.
8	A08	Amit	0.58	0.12	0.86	1.08	0.05	0.01	N.D.
9	AA26	Ampakhi Bora	2.71	0.26	0.50	4.11	0.13	0.07	N.D.
10	AA23	Anandi	0.12	0.15	1.90	1.80	0.11	0.09	N.D.
11	AA21	Anandur Sanna	3.49	0.31	0.43	2.91	0.14	0.10	N.D.
12	A11	Artharayi	0.48	N.D.	N.D.	0.06	0.01	0.05	N.D.
13	A10	Arunurvadllu	3.67	N.D.	1.35	18.55	0.54	0.04	N.D.
14	AA31	Aryan	4.45	N.D.	1.13	1.36	0.07	N.D.	N.D.
15	AA01	Asanleya	1.09	0.32	1.26	0.48	0.10	0.05	N.D.
16	AA10	Ashphal	0.63	0.14	0.68	1.51	0.04	0.04	N.D.

Sl. No.	Sample	Landrace Name	B_1 (mg/100g)	B_2 (mg/100g)	B_3 (mg/100g)	B_5 (mg/100g)	B_6 (mg/100g)	B_7 (mg/100g)	B_{12} (mg/100g)
17	AA05	Ashwin Jharia (P)	0.39	N.D.	0.25	0.16	0.02	0.02	N.D.
18	A04	Athi Karaya	0.50	0.01	0.46	0.07	0.02	0.01	N.D.
19	AA19	Aurar	1.64	0.47	3.00	1.49	0.29	0.04	N.D.
20	AA07	Ausha Bonkata	0.42	0.06	0.24	0.06	0.01	0.02	N.D.
21	B100	Bada Dhan	0.41	N.D.	0.90	0.06	0.02	0.02	N.D.
22	B22	Badabona	4.95	0.01	0.85	1.67	0.14	N.D.	N.D.
23	B06	Bagh Jhapta	1.14	0.05	1.90	1.54	0.24	0.04	N.D.
24	B09	Baid Dhusuri	1.19	0.12	1.29	1.30	0.19	0.03	N.D.
25	B10	Baid Dulah	1.40	0.63	2.89	7.43	0.42	0.21	N.D.
26	B05	Baid Kalamkathi	0.53	0.08	0.62	0.47	0.06	0.01	N.D.
27	B14	Baidras	0.23	0.06	0.82	0.47	0.07	N.D.	N.D.
28	B21	Bakul Phool	0.01	0.02	N.D.	3.60	0.86	1.38	N.D.
29	B55	Balaram-Sal	1.14	0.15	1.51	1.32	0.16	0.03	N.D.
30	B02	Bank Chur	1.36	0.32	1.46	2.59	0.08	0.04	N.D.
31	B40	Bankui	0.64	0.29	0.94	3.13	0.10	0.08	N.D.
32	B65	Bankuli	3.56	0.34	0.48	3.54	0.13	0.12	N.D.
33	B49	Banmae Jo	1.46	0.17	1.96	1.19	0.14	0.01	N.D.
34	B38	Bansh Mugur	0.95	1.05	0.80	1.86	0.05	0.05	N.D.
35	B07	Bansh Pati	0.55	N.D.	0.25	0.13	0.03	0.03	N.D.
36	B24	Bansh Tara	8.32	0.09	0.94	3.13	0.13	0.11	N.D.
37	B60	Banya-Sal	0.28	N.D.	0.38	0.04	0.04	0.03	N.D.

Sl. No.	Sample	Landrace Name	B_1 (mg/100g)	B_2 (mg/100g)	B_3 (mg/100g)	B_5 (mg/100g)	B_6 (mg/100g)	B_7 (mg/100g)	B_{12} (mg/100g)
38	B71	Basan Kayal	5.53	0.02	0.57	1.05	0.08	0.02	N.D.
39	B04	Basumati	1.23	N.D.	2.88	0.04	0.38	N.D.	N.D.
40	B81	Baya Gunda	1.12	0.25	1.88	1.07	0.14	0.02	N.D.
41	B30	Belgam Sanna	1.06	0.32	1.23	3.96	0.15	0.04	N.D.
42	B26	Benajhuri	0.39	0.02	0.72	0.05	0.03	0.03	N.D.
43	V25	Bhaboli Joha	0.42	0.06	N.D.	0.02	0.04	N.D.	N.D.
44	V04	Bhalki	1.26	N.D.	0.39	0.05	0.08	N.D.	N.D.
45	V10	Bhasa Kalmi	0.40	N.D.	N.D.	0.16	0.11	N.D.	N.D.
46	V13	Bheral	0.67	0.24	0.32	0.15	0.08	N.D.	N.D.
47	V27	Bhog Dhan	0.39	N.D.	N.D.	0.04	0.17	N.D.	N.D.
48	V19	Bhoglaya	0.84	0.31	2.86	1.51	0.29	0.03	N.D.
49	V07	Bhuri	1.34	0.08	1.12	0.99	0.05	0.03	N.D.
50	V23	Bhusihara	1.99	N.D.	1.14	0.03	0.07	N.D.	N.D.
51	V20	Bhutta Churi	0.84	0.31	2.86	1.51	0.29	0.03	N.D.
52	B101	Bita Kaberi	1.04	0.27	1.34	4.42	0.18	0.06	N.D.
53	B75	Biti Dhadi Budda	2.75	0.19	2.49	0.42	0.30	0.04	N.D.
54	B57	Boddimani	1.14	0.15	1.51	1.32	0.16	0.03	N.D.
55	B90	Bogi Xali	1.91	0.18	1.08	1.16	0.11	0.01	N.D.
56	B20	Bokra	0.89	N.D.	2.84	0.03	0.44	N.D.	N.D.
57	B68	Boloi Genti	1.86	N.D.	0.70	0.05	0.03	0.02	N.D.
58	B87	Bor Jahingia	2.12	0.14	0.54	1.49	0.05	0.10	N.D.

Sl. No.	Sample	Landrace Name	B_1 (mg/100g)	B_2 (mg/100g)	B_3 (mg/100g)	B_5 (mg/100g)	B_6 (mg/100g)	B_7 (mg/100g)	B_{12} (mg/100g)
59	B33	Bora	1.76	0.02	0.23	1.13	0.03	0.26	N.D.
60	B69	Bou Bhog	0.94	0.26	1.16	2.03	0.05	0.04	N.D.
61	B72A	Burma Black-A	2.75	0.19	2.49	0.42	0.30	0.04	N.D.
62	C34	Chakhaw Poireiton	0.40	N.D.	0.20	0.21	0.02	0.09	N.D.
63	C02	Chakramala	1.26	N.D.	0.43	0.05	0.01	0.05	N.D.
64	C14	Champa	0.70	N.D.	0.26	3.28	0.09	0.02	N.D.
65	C12	Chandrakanta	3.94	0.01	1.30	1.07	0.86	0.13	N.D.
66	C13	Cheena Kamini	0.97	0.18	1.32	1.16	0.12	0.05	N.D.
67	C06	Chenga	2.10	0.10	1.46	1.93	0.30	0.43	N.D.
68	C19	Chenga Rangi	2.04	0.16	1.07	1.10	0.10	0.01	N.D.
69	C31	Chengeeran	0.26	N.D.	N.D.	0.05	0.02	0.10	N.D.
70	C07	Cheng-Sal	1.26	N.D.	0.45	0.07	N.D.	0.04	N.D.
71	C26	Chennellu	0.65	0.13	0.72	2.55	0.09	0.04	N.D.
72	CH03	Chhota	2.17	0.15	0.79	1.16	0.10	0.01	N.D.
73	CH01	Chhoto Nuniya	0.77	0.27	1.22	3.32	0.16	0.03	N.D.
74	C24	Chiittiga	1.83	0.12	0.85	1.55	0.05	0.03	N.D.
75	C20	Chila Meteh	2.38	0.01	1.90	2.44	0.26	0.33	N.D.
76	C18	Chila Patnai	2.83	0.02	0.63	1.40	0.19	0.03	N.D.
77	C21	Chinna Poni	1.17	0.33	1.81	1.92	0.19	0.14	N.D.
78	C28	Choura Goda	1.29	0.01	3.05	4.02	0.42	N.D.	N.D.
79	C09	Churnokathi	9.43	0.22	1.39	3.75	0.13	0.38	N.D.

Sl. No.	Sample	Landrace Name	B_1 (mg/100g)	B_2 (mg/100g)	B_3 (mg/100g)	B_5 (mg/100g)	B_6 (mg/100g)	B_7 (mg/100g)	B_{12} (mg/100g)
80	D05	Dambar Salé	1.19	0.39	1.52	3.69	0.13	0.05	N.D.
81	DD02	Darka-Sal	4.82	N.D.	2.18	1.96	0.08	0.02	N.D.
82	DD06	Dar-Sal	1.07	0.19	1.57	1.75	0.17	0.01	N.D.
83	DD18	Dashra Mathiya	0.82	N.D.	0.32	16.89	0.14	0.01	N.D.
84	DD04	Dayal Madina	1.55	0.30	1.62	3.77	0.10	0.03	N.D.
85	DD05	Dehradun	1.22	0.02	1.56	2.94	0.33	0.07	N.D.
86	DD13	Dehradun-Bas	5.51	0.06	1.46	4.12	0.27	0.54	N.D.
87	DD10	Deulabhog	3.00	0.35	0.53	4.47	0.12	0.09	N.D.
88	D08	Dewri Baw	1.23	N.D.	0.40	0.03	0.02	0.05	N.D.
89	DH02	Dhanashree	0.77	N.D.	N.D.	0.04	0.02	0.11	N.D.
90	DX01	Dhankadi Deepa	3.21	0.46	0.62	3.70	0.15	0.08	N.D.
91	DH05	Dhowa-Sal	1.34	0.34	1.42	3.69	0.15	0.05	N.D.
92	DH04	Dhula Dhusuri	2.37	0.17	1.16	1.83	0.14	0.02	N.D.
93	DH01	Dhusuri	0.70	0.08	1.71	0.96	0.08	0.02	N.D.
94	DD30	Dodda Vallya	0.41	N.D.	1.34	0.04	0.03	0.02	N.D.
95	D10	Dokra Mesa	0.41	N.D.	0.50	0.05	0.02	0.02	N.D.
96	D06	Dopeh	0.81	0.24	0.96	3.17	0.10	0.03	N.D.
97	DD19	Dorangi	1.90	0.02	3.21	3.04	0.39	0.13	N.D.
98	DD16	Dudhe Bolta	10.55	0.05	1.56	4.24	0.26	0.50	N.D.
99	DD21	Dukhi Darbar	3.41	N.D.	0.55	3.30	0.11	N.D.	N.D.
100	DD26	Durga Sundari	1.43	0.13	0.32	0.84	0.04	0.03	N.D.

Sl. No.	Sample	Landrace Name	B_1 (mg/100g)	B_2 (mg/100g)	B_3 (mg/100g)	B_5 (mg/100g)	B_6 (mg/100g)	B_7 (mg/100g)	B_{12} (mg/100g)
101	E04	Elchir	0.97	0.34	1.44	1.40	0.15	0.04	N.D.
102	G37	Gaada Dhan	0.97	0.20	1.98	1.32	0.14	0.02	N.D.
103	G19	Gandheswari	1.08	0.05	1.04	0.34	0.05	0.01	N.D.
104	G15	Garia	0.55	N.D.	N.D.	0.05	0.03	0.03	N.D.
105	G02	Garib-Sal	0.41	0.02	0.95	N.D.	N.D.	1.37	N.D.
106	G20	Garo Joha	0.86	0.14	1.05	0.46	0.06	0.01	N.D.
107	G06	Gentu	1.00	N.D.	0.30	0.07	0.03	0.29	N.D.
108	W03	Ghaiya	0.62	0.13	1.45	0.77	0.08	0.03	N.D.
109	W01	Ghasraiz	0.73	0.30	1.40	1.07	0.12	0.04	N.D.
110	W02	Ghasraji	0.73	0.30	1.40	1.07	0.12	0.04	N.D.
111	W05	Ghoi Bir	1.41	N.D.	0.36	1.33	0.06	N.D.	N.D.
112	W07	Ghunsi	1.02	0.38	2.79	0.56	0.20	0.03	N.D.
113	G32	Gidda Batha	1.00	0.24	1.05	1.90	0.08	0.04	N.D.
114	G43	Gidda Gowri	9.21	0.03	1.60	3.25	0.27	0.12	N.D.
115	G39	Gidhan Dhan	0.59	N.D.	2.84	0.02	0.40	N.D.	N.D.
116	G17	Gita	0.81	0.27	0.97	2.13	0.07	0.03	N.D.
117	G11	Gochari Patnai	0.92	0.22	1.14	1.75	0.06	0.23	N.D.
118	G12	Gopalbhog	1.65	0.87	3.70	9.45	0.56	0.25	N.D.
119	G35	Government Churi	0.62	0.07	0.66	0.25	0.06	0.01	N.D.
120	G44	Gulvady Sanna	1.19	0.15	1.43	0.97	0.14	0.06	N.D.
121	H07	Hagmuni	0.53	0.01	2.12	4.69	0.32	N.D.	N.D.

Sl. No.	Sample	Landrace Name	B_1 (mg/100g)	B_2 (mg/100g)	B_3 (mg/100g)	B_5 (mg/100g)	B_6 (mg/100g)	B_7 (mg/100g)	B_{12} (mg/100g)
122	H14	Haldi Guri	0.11	0.51	2.16	4.50	0.29	0.06	N.D.
123	H10	Hanseswari	1.71	N.D.	0.22	0.01	0.04	0.03	N.D.
124	H27	Harfoni = Salpuna	1.03	0.17	0.93	0.23	0.09	0.01	N.D.
125	H04	Hari Shankar	1.25	0.06	1.55	3.74	0.35	0.26	N.D.
126	H21	Hati Dhan	0.81	0.08	0.84	0.61	0.04	0.01	N.D.
127	H18	Heerai Joha	0.45	N.D.	0.21	0.14	0.02	0.03	N.D.
128	H33	Hende Baba	0.40	N.D.	0.37	0.14	0.03	0.02	N.D.
129	H38	Hettalu Mnie	0.50	0.22	1.30	0.17	0.02	0.04	N.D.
130	H05	Hinche Saroo	2.61	0.02	1.55	0.81	0.29	0.08	N.D.
131	H22	Hudar	1.31	0.39	1.69	3.16	0.16	0.05	N.D.
132	J12	Jabra = Bor Dhan	0.02	0.32	1.97	2.60	0.21	0.05	N.D.
133	J18	Jagannath Bhog	1.15	N.D.	0.25	0.07	0.02	0.03	N.D.
134	J26	Jahingia	2.30	0.33	1.20	5.95	0.11	0.11	N.D.
135	J30	Jarhan Baihar	0.38	N.D.	N.D.	0.05	0.03	0.06	N.D.
136	J15	Jata Leta-Sal	1.31	0.46	2.42	2.82	0.08	0.04	N.D.
137	Z10	Jhanti	1.34	0.19	0.80	0.56	0.04	0.01	N.D.
138	Z04	Jhuli (N)	1.30	N.D.	0.69	0.04	0.03	N.D.	N.D.
139	Z02	Jhuloor	1.62	0.11	0.44	0.74	0.05	0.02	N.D.
140	Z16	Jhulpo	3.65	0.17	0.55	1.63	0.12	0.06	N.D.
141	Z17	Jhumpuri	0.97	0.30	1.16	1.40	0.15	0.01	N.D.
142	Y02	Jugal	1.42	N.D.	N.D.	0.03	0.01	0.99	N.D.

Sl. No.	Sample	Landrace Name	B_1 (mg/100g)	B_2 (mg/100g)	B_3 (mg/100g)	B_5 (mg/100g)	B_6 (mg/100g)	B_7 (mg/100g)	B_{12} (mg/100g)
143	J37	Juna Kolam	0.38	N.D.	0.27	0.05	0.01	0.02	N.D.
144	K136	Kaberi	0.71	N.D.	N.D.	0.06	0.16	0.02	N.D.
145	K50	Kabiraj-Sal	1.18	0.31	1.83	1.56	0.21	0.08	N.D.
146	K79	Kadaliya	0.07	0.72	2.22	2.46	0.19	0.03	N.D.
147	K87	Kaggi Salla	0.43	N.D.	0.39	0.07	0.03	0.02	N.D.
148	K43	Kajal Kathi	0.75	0.19	0.79	0.47	0.09	0.02	N.D.
149	K103	Kala Malli	0.03	0.09	1.21	1.07	0.10	0.02	N.D.
150	K126	Kala Namak	1.23	0.16	1.19	0.69	0.13	0.02	N.D.
151	K105	Kalam Dani	2.21	0.20	0.57	0.54	0.13	0.01	N.D.
152	K28	Kalam Kathi	0.25	0.07	0.62	0.79	0.04	0.01	N.D.
153	K144	Kaleswar	1.24	0.03	0.78	0.80	0.05	0.03	N.D.
154	K68	Kali Jira	0.88	0.10	1.15	0.68	0.09	0.02	N.D.
155	K13	Kali Komad	0.03	0.48	2.07	1.75	0.13	0.08	N.D.
156	K39	Kalishankar	1.06	0.21	0.78	0.54	0.10	0.02	N.D.
157	K71	Kalo Dhepa	1.28	0.89	3.20	4.80	0.35	2.10	N.D.
158	K49	Kalo Meteh	0.35	0.12	1.17	0.34	0.07	0.01	N.D.
159	K34	Kalo Nuniya	1.26	0.09	1.30	1.06	0.11	0.02	N.D.
160	K140	Kalo Tulsi	4.16	0.16	0.82	1.46	0.07	0.03	N.D.
161	K21	Kankhiri	0.57	N.D.	N.D.	0.53	0.01	0.06	N.D.
162	K45	Kankhria	0.89	0.15	1.44	0.85	0.08	0.05	N.D.
163	K92	Kariga Javeli	1.26	N.D.	N.D.	0.03	0.03	0.15	N.D.

Sl. No.	Sample	Landrace Name	B_1 (mg/100g)	B_2 (mg/100g)	B_3 (mg/100g)	B_5 (mg/100g)	B_6 (mg/100g)	B_7 (mg/100g)	B_{12} (mg/100g)
164	K77	Karni	0.63	0.22	0.80	2.11	0.10	0.10	N.D.
165	K33	Kartik-Sal	0.65	0.12	0.73	0.36	0.04	0.01	N.D.
166	K112	Kashi Phool (J)	1.42	N.D.	0.96	0.06	0.03	0.02	N.D.
167	K73	Kata Raini	1.44	0.17	0.59	0.49	0.03	0.01	N.D.
168	K100	Kba Lyngkot	1.02	0.16	1.94	0.93	0.11	0.04	N.D.
169	K94	Kempu Purigo Nellu	0.56	N.D.	0.22	0.07	0.02	0.12	N.D.
170	K31	Keshab-Sal	0.80	N.D.	0.21	0.09	0.02	0.06	N.D.
171	K151	Ketsarü	0.03	0.42	2.43	2.34	0.13	0.05	N.D.
172	Q09	Kharisha Bhog	1.79	0.25	1.54	1.06	0.12	0.01	N.D.
173	Q06	Khatia Tika	2.07	N.D.	0.62	0.09	N.D.	0.05	N.D.
174	K115	Kokua Baw	0.37	0.61	N.D.	0.07	0.04	0.20	N.D.
175	K101	Kola Amona Baw	1.38	0.25	2.03	2.39	0.18	0.01	N.D.
176	K96	Koliya Lengri	1.18	N.D.	0.38	0.11	0.02	0.15	N.D.
177	K119	Kona Musori	1.31	N.D.	0.33	0.08	0.07	0.05	N.D.
178	K98	Koshi Kamon	1.65	0.20	0.57	0.28	0.06	0.02	N.D.
179	K147	Kotpe	0.58	N.D.	0.61	0.05	0.03	0.04	N.D.
180	K65	Kulthi Kayame	0.40	N.D.	0.50	0.08	0.02	0.02	N.D.
181	K24	Kumrogorh	0.65	0.32	0.82	2.70	0.11	0.09	N.D.
182	K131	Kundapullan	0.93	0.32	1.29	3.27	0.09	0.04	N.D.
183	K10	Kurai	1.02	0.16	1.94	0.93	0.11	0.04	N.D.
184	L43	Ladari	5.88	N.D.	1.92	3.78	0.17	N.D.	N.D.

Sl. No.	Sample	Landrace Name	B_1 (mg/100g)	B_2 (mg/100g)	B_3 (mg/100g)	B_5 (mg/100g)	B_6 (mg/100g)	B_7 (mg/100g)	B_{12} (mg/100g)
185	L18	Lakshmi Chura	1.03	0.17	1.45	1.28	0.15	0.04	N.D.
186	L39	Lakshmi Kajal	0.51	N.D.	0.46	0.12	0.01	0.03	N.D.
187	L31	Lal Bahal	6.47	N.D.	2.40	0.02	N.D.	N.D.	N.D.
188	L50	Lal Dhan Patla	N.D.	N.D.	1.66	0.14	0.01	0.02	N.D.
189	L27	Lal Gobindabhog	1.17	0.31	1.92	1.91	0.21	0.14	N.D.
190	L02	Lal Jhulur	1.52	N.D.	N.D.	0.17	0.01	0.07	N.D.
191	L34	Lal Kamal	0.39	N.D.	N.D.	0.05	0.01	0.06	N.D.
192	L24	Lal Kamini	0.90	0.08	1.61	4.83	0.10	N.D.	N.D.
193	L47	Lalu Dhan	0.57	N.D.	N.D.	0.05	0.01	0.01	N.D.
194	L45	Langka	0.82	N.D.	0.29	0.29	0.02	0.04	N.D.
195	L59	Lankeswari	1.42	N.D.	0.37	0.08	0.01	0.01	N.D.
196	L53	Laser	0.64	N.D.	N.D.	0.07	0.01	0.08	N.D.
197	L16	Lata-Sal	1.17	0.35	1.79	1.69	0.10	0.03	N.D.
198	L12	Lebu-Sal	0.64	0.17	1.62	1.00	0.08	0.04	N.D.
199	L09	Lohajangi	0.49	0.13	1.50	0.83	0.07	0.01	N.D.
200	L01	Lugdhi-Sal	0.89	N.D.	0.28	0.02	0.01	1.38	N.D.
201	M30	Maadu	0.40	N.D.	N.D.	0.04	0.02	0.02	N.D.
202	M09	Madhumita	3.68	0.34	0.45	2.88	0.14	0.11	N.D.
203	M38	Madhuri	0.42	0.10	0.94	0.33	0.02	0.01	N.D.
204	M17	Madraraj	0.43	0.07	0.87	0.50	0.02	0.02	N.D.
205	M02	Mahadi	0.57	0.23	2.11	0.51	0.11	0.02	N.D.

Sl. No.	Sample	Landrace Name	B_1 (mg/100g)	B_2 (mg/100g)	B_3 (mg/100g)	B_5 (mg/100g)	B_6 (mg/100g)	B_7 (mg/100g)	B_{12} (mg/100g)
206	M04	Mala	0.33	2.63	1.26	2.25	0.18	0.07	N.D.
207	M36	Malabati	0.44	0.05	0.52	0.34	0.02	0.01	N.D.
208	M03	Malgudia Kalam	0.35	0.10	0.96	0.25	0.04	0.01	N.D.
209	M15	Mallika	0.13	0.33	1.29	2.00	0.15	0.05	N.D.
210	M82	Mami Dhan	0.76	N.D.	1.36	0.03	0.02	0.02	N.D.
211	M95	Mangu Gadi	0.38	N.D.	N.D.	0.15	0.02	0.02	N.D.
212	M74	Manipura Batta	1.10	0.31	2.38	1.07	0.19	N.D.	N.D.
213	M06	Marich Mukul	0.40	N.D.	N.D.	0.15	0.04	0.04	N.D.
214	M75	Maskati	1.06	0.36	2.31	2.70	0.16	0.01	N.D.
215	M33	Mathallaga	1.11	0.90	1.92	5.53	0.21	2.95	N.D.
216	M84	Mavilon	1.37	N.D.	0.36	0.23	0.01	0.03	N.D.
217	M63	Maw Thlen	0.83	N.D.	0.31	0.31	0.06	0.02	N.D.
218	M77	Meese Batta	2.01	0.19	0.35	1.11	0.03	0.03	N.D.
219	M49	Mehdi	1.85	0.25	0.93	1.91	0.11	0.07	N.D.
220	M52	Melhitte	2.00	0.26	1.21	0.87	0.18	0.01	N.D.
221	M21	Mohanbhog	0.19	0.23	1.49	2.11	0.16	0.38	N.D.
222	M44	Mohanmala	0.45	0.10	1.05	0.86	0.09	0.01	N.D.
223	M13	Mohanras	0.19	0.25	1.23	1.58	0.11	0.02	N.D.
224	M51	Moynaguri	1.02	0.28	4.05	1.50	0.19	0.02	N.D.
225	M59	Muttu Gulla	0.09.	N.D.	0.06	0.31	0.09	0.03	N.D.
226	N21	Nagaland Kalo	1.64	0.30	2.73	1.65	0.19	0.02	N.D.

Sl. No.	Sample	Landrace Name	B_1 (mg/100g)	B_2 (mg/100g)	B_3 (mg/100g)	B_5 (mg/100g)	B_6 (mg/100g)	B_7 (mg/100g)	B_{12} (mg/100g)
227	N07	Nagra	1.45	0.21	3.69	1.23	0.18	0.06	N.D.
228	N14	Najirma	0.38	N.D.	0.45	0.27	0.02	0.02	N.D.
229	N42	Nalwa	0.46	N.D.	N.D.	0.16	0.01	0.20	N.D.
230	N18	Narahasoi	1.08	0.39	3.15	0.71	0.27	0.04	N.D.
231	N36	Nekera	1.07	0.23	1.88	0.98	0.24	0.01	N.D.
232	N32	Nellur Pisthal	0.23	N.D.	0.89	0.12	0.02	0.02	N.D.
233	N12	Nona	0.54	N.D.	1.23	0.17	0.01	0.22	N.D.
234	N29	Nona Khirish	1.50	0.33	1.59	1.27	0.15	0.03	N.D.
235	N19	Nona-Sal	2.02	0.38	1.64	1.31	0.15	0.02	N.D.
236	O01	Olee	0.39	N.D.	N.D.	0.28	0.02	N.D.	N.D.
237	O02	Orah	1.26	N.D.	N.D.	0.16	0.02	0.03	N.D.
238	P32	Paloi Thopa	2.20	N.D.	0.60	0.09	0.01	0.09	N.D.
239	P21	Panati	5.73	0.05	0.70	0.34	0.17	0.03	N.D.
240	P12	Panirui	0.57	N.D.	0.36	0.09	0.01	0.08	N.D.
241	P24	Paramita	1.81	0.17	0.70	1.61	0.05	0.01	N.D.
242	P29	Pateni	0.73	0.15	0.87	0.51	0.10	N.D.	N.D.
243	F02	Phul Mugri	1.40	N.D.	0.26	0.06	0.03	0.27	N.D.
244	P35	Pittasalé	0.43	0.05	N.D.	0.06	N.D.	0.05	N.D.
245	P40	Pusa Badh	0.99	0.25	1.26	0.73	0.14	0.03	N.D.
246	P05	Putikali	0.57	0.12	0.63	0.15	0.01	0.03	N.D.
247	R14	Raban-Sal	1.40	N.D.	0.67	0.01	0.01	0.03	N.D.

Sl. No.	Sample	Landrace Name	B_1 (mg/100g)	B_2 (mg/100g)	B_3 (mg/100g)	B_5 (mg/100g)	B_6 (mg/100g)	B_7 (mg/100g)	B_{12} (mg/100g)
248	R53	Radha Jugal	0.39	N.D.	N.D.	0.07	0.02	0.03	N.D.
249	R07	Radhuni Pagal	1.31	N.D.	0.26	0.06	0.12	N.D.	N.D.
250	R41	Raj Bako	0.49	N.D.	N.D.	0.06	0.02	0.05	N.D.
251	R02	Raj Jhinga	0.38	N.D.	N.D.	0.08	0.01	0.07	N.D.
252	R34	Raj Kamal	0.41	N.D.	0.87	0.02	0.01	0.27	N.D.
253	R31	Ramigali	0.39	N.D.	0.21	0.03	0.02	0.17	N.D.
254	R60	Ranga Dhan	0.40	N.D.	N.D.	0.04	0.04	0.75	N.D.
255	R25	Rani Akand	0.38	N.D.	N.D.	0.03	0.06	0.22	N.D.
256	R56	Rani Siyali	0.43	N.D.	N.D.	0.06	0.02	0.65	N.D.
257	R22	Rani-51	1.08	N.D.	0.56	0.04	0.09	0.52	N.D.
258	R48	Rassi	1.34	0.21	2.06	4.90	0.43	0.14	N.D.
259	R19	Ratnachuri	1.85	N.D.	0.28	0.02	0.01	0.23	N.D.
260	R29	Reda Dhan	0.12	0.56	1.95	2.94	0.20	0.10	N.D.
261	R28	Riso Nano Veronese	1.87	0.58	2.61	5.80	0.33	0.19	N.D.
262	S05	Sada Chenga	1.32	N.D.	0.70	0.05	0.06	0.02	N.D.
263	S21	Sada Dhan	0.87	0.24	0.81	0.50	0.05	N.D.	N.D.
264	S23	Sada Dhepa	1.42	0.28	1.56	1.53	0.10	0.03	N.D.
265	S43	Sada Jabra	0.52	N.D.	N.D.	0.04	0.03	0.86	N.D.
266	S01	Sada Kaya	1.92	0.23	1.02	1.24	0.10	0.02	N.D.
267	S39	Sada Meteh	5.34	0.14	0.32	2.63	0.14	0.32	N.D.
268	S36	Sada Mota	0.38	N.D.	N.D.	0.05	0.03	1.08	N.D.

Sl. No.	Sample	Landrace Name	B_1 (mg/100g)	B_2 (mg/100g)	B_3 (mg/100g)	B_5 (mg/100g)	B_6 (mg/100g)	B_7 (mg/100g)	B_{12} (mg/100g)
269	S61	Salaer	5.18	0.01	1.08	17.17	0.21	N.D.	N.D.
270	S53	Sanna Bhatta	0.37	0.06	0.65	0.42	0.03	0.01	N.D.
271	S54	Sanna Vallya	0.02	N.D.	3.86	2.76	0.60	N.D.	N.D.
272	S76	Sarasbhog	0.38	N.D.	0.34	0.04	0.03	0.14	N.D.
273	S33	Saroo Gurguri	0.42	N.D.	0.60	0.02	0.05	0.51	N.D.
274	S16	Sateen	0.39	N.D.	1.35	0.01	0.01	0.66	N.D.
275	SH08	Sesh Phal	0.51	0.16	1.24	0.56	0.05	0.01	N.D.
276	SH19	Shamla	2.65	0.21	0.90	0.90	0.10	0.04	N.D.
277	SH14	Shankari Komal	2.68	0.07	0.35	1.39	0.05	N.D.	N.D.
278	SS02	Shati Jeleh	0.43	N.D.	0.26	0.05	0.05	5.90	N.D.
279	SS04	Shatia Bhadoi	1.01	N.D.	4.52	0.07	0.05	0.27	N.D.
280	SH01	Shishaphal	1.83	N.D.	N.D.	0.04	0.03	0.07	N.D.
281	SH02	Shiuli	0.69	0.15	0.82	0.71	0.04	N.D.	N.D.
282	SH15	Shivappu Kuzhiadichan	0.61	0.57	0.75	4.05	0.11	0.14	N.D.
283	SH04	Shiyal Raj	0.38	N.D.	N.D.	0.04	0.03	4.09	N.D.
284	SH06	Shua Kalma	0.05	N.D.	N.D.	0.05	0.05	4.20	N.D.
285	S82	Sona Pan	0.46	0.02	0.24	0.05	0.02	0.26	N.D.
286	S15	Sonajhuli	0.77	0.26	1.80	1.31	0.16	0.02	N.D.
287	S47	Soorakuruvai	0.40	N.D.	N.D.	0.03	0.06	0.07	N.D.
288	SH10	Srabanti-Sal	1.96	0.20	1.03	0.81	0.15	0.01	N.D.

Sl. No.	Sample	Landrace Name	B_1 (mg/100g)	B_2 (mg/100g)	B_3 (mg/100g)	B_5 (mg/100g)	B_6 (mg/100g)	B_7 (mg/100g)	B_{12} (mg/100g)
289	S11	Subasita	1.13	0.12	0.40	0.67	0.01	0.01	N.D.
290	S09	Sundar Mukhi	0.08	N.D.	0.91	0.07	0.01	0.17	N.D.
291	S58	Supari	0.38	0.15	N.D.	0.03	0.09	0.14	N.D.
292	T01	Tangra Patnai	0.77	N.D.	0.30	13.57	0.12	0.02	N.D.
293	T08	Teloshing	0.39	N.D.	0.30	0.04	0.05	N.D.	N.D.
294	TX01	Thakur-Sal	0.39	N.D.	0.45	0.03	0.07	0.20	N.D.
295	TT15	Thavala Kannan	1.50	0.28	1.42	1.57	0.24	0.04	N.D.
296	TH04	Thevürü Lha	0.99	0.17	0.99	0.42	0.07	0.01	N.D.
297	TH05	Thonnuran	1.47	0.27	1.65	1.43	0.21	0.04	N.D.
298	TH07	Thonnuran Thondi	1.38	0.30	1.39	0.81	0.12	0.03	N.D.
299	TH03	Thupa Bora	2.68	N.D.	0.70	3.41	0.19	0.07	N.D.
300	TH01	Thupi-Sal	2.01	N.D.	0.23	0.03	0.06	N.D.	N.D.
301	T11	Tike Churi	0.11	0.20	2.19	0.64	0.09	0.03	N.D.
302	T03	Tikia Patnai	0.81	N.D.	1.41	0.05	0.07	N.D.	N.D.
303	TT19	Tsorünyü	1.11	0.18	0.63	0.30	0.10	0.02	N.D.
304	TT16	Tulasi Xali	9.03	0.10	0.59	3.72	0.26	0.08	N.D.
305	TT09	Tulo Pajoy	1.92	N.D.	0.27	0.02	0.14	N.D.	N.D.
306	TT07	Tulsibhog	0.49	N.D.	1.95	0.03	0.05	N.D.	N.D.
307	V21	Vella Thondi	6.65	0.01	0.65	5.78	0.10	0.10	N.D.
308	B36	Vishnu Bhog	6.85	N.D.	2.29	0.01	N.D.	N.D.	N.D.
309	Y04	Yella Salli	0.80	0.24	1.67	1.21	0.15	0.02	N.D.

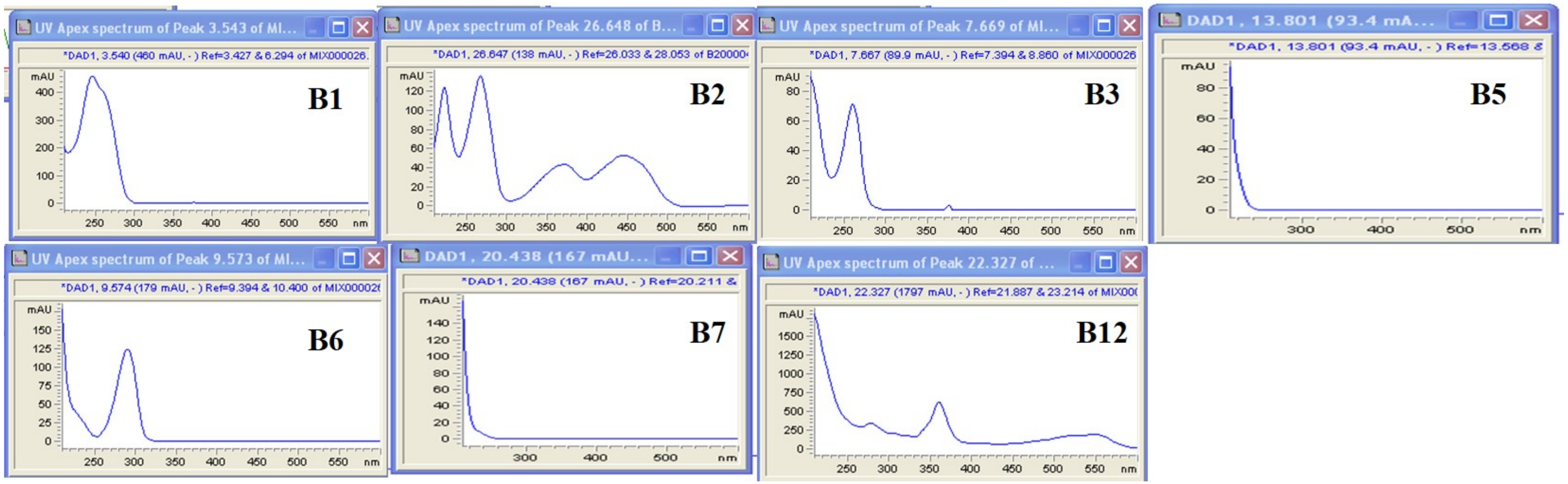
* Values are the mean of three determinations. N.D. Not detected.

Supplementary table 2: Concentrations of Seven B vitamins in 3 modern rice cultivars.

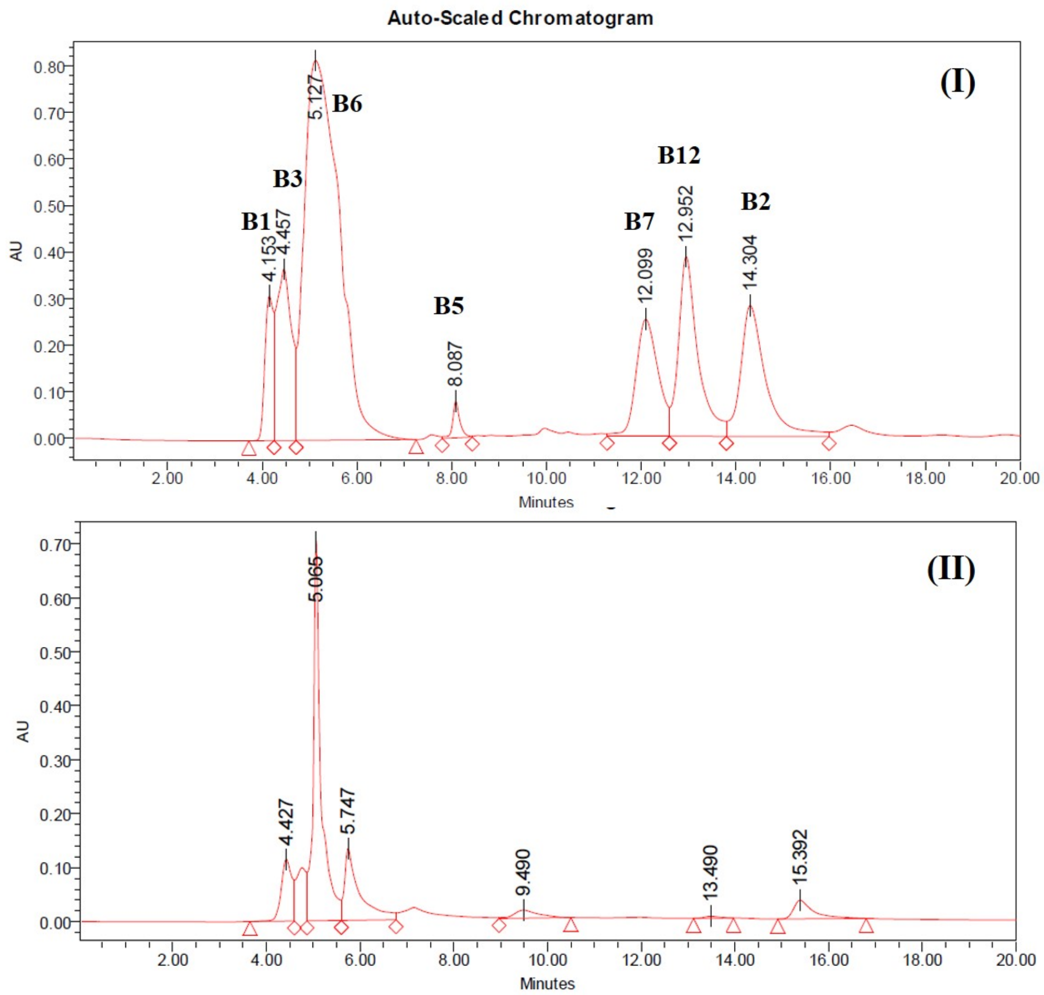
Sl. No.	Sample	Rice cultivers	B1 (mg/100g)	B2 (mg/100g)	B3 (mg/100g)	B5 (mg/100g)	B6 (mg/100g)	B7 (mg/100g)	B12 (mg/100g)
310	BPT5204	BPT5204	0.37	0.02	0.50	N.D.	N.D.	0.01	N.D.
311	IR36	IR 36	3.50	0.25	2.10	1.50	N.D.	0.30	N.D.
312	IR64	IR 64	0.41	0.08	2.90	N.D.	0.09	N.D.	N.D.

* Values are the mean of three determinations. N.D. Not detected.

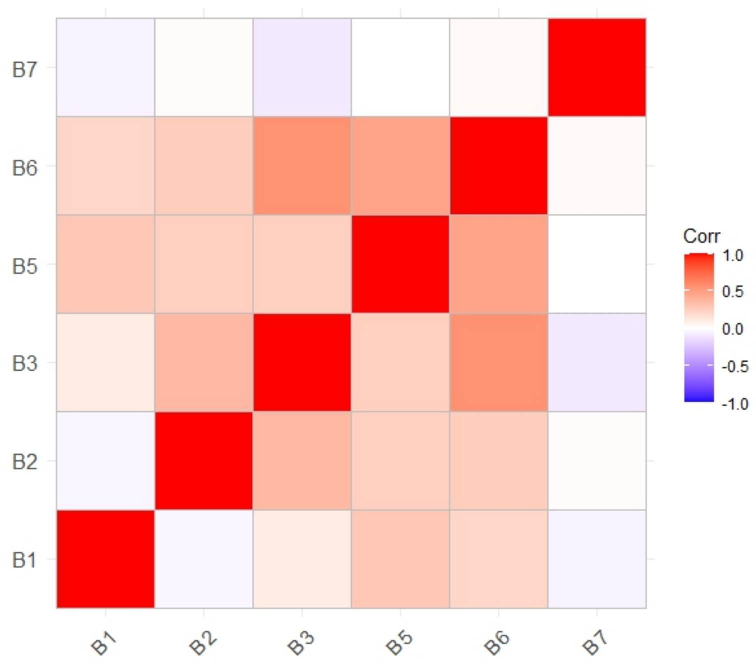
Supplementary figure 1: The UV spectrum of seven B vitamins was used to identify the individual vitamins from sample chromatograms.



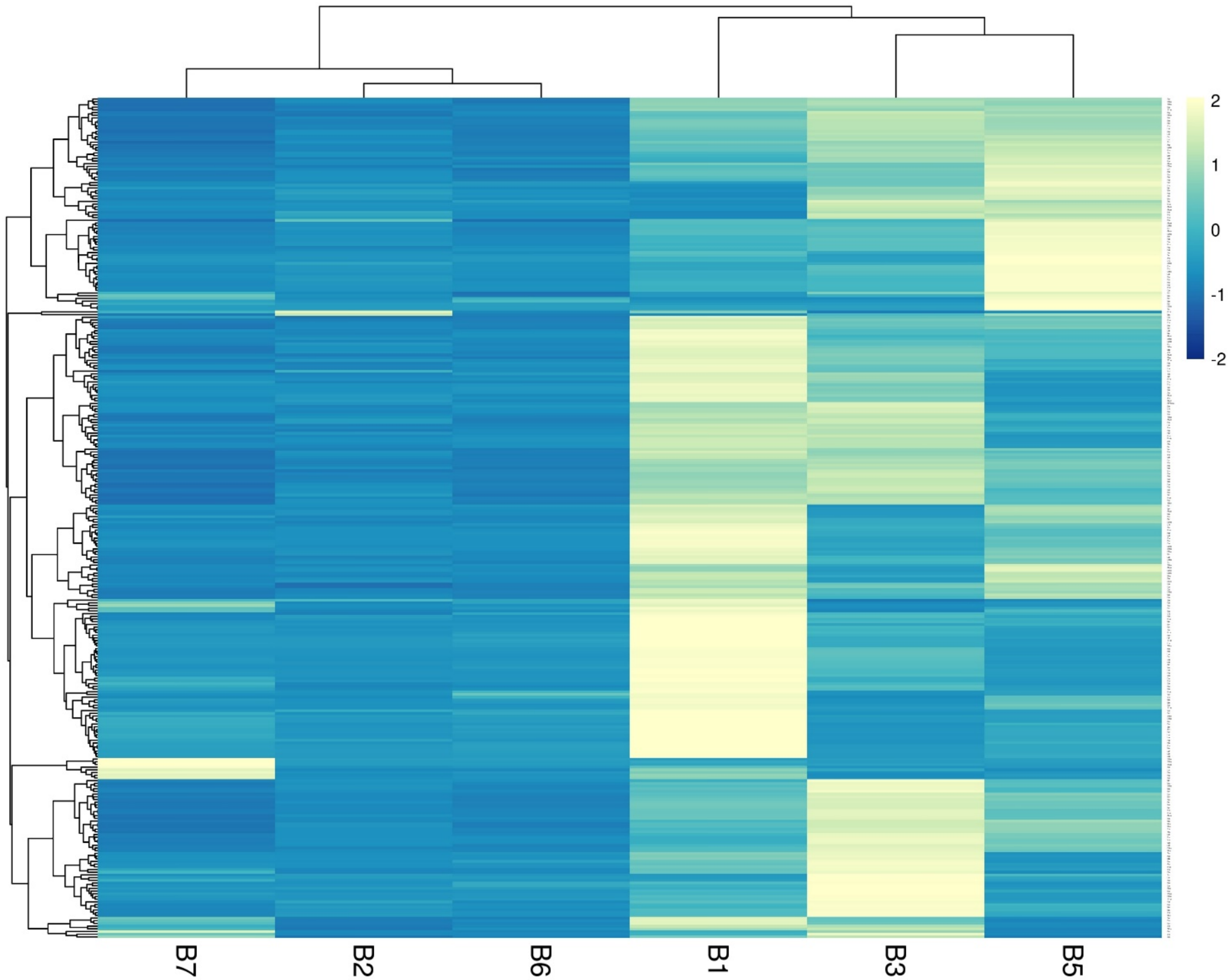
Supplementary figure 2: (I): The baseline separation of seven B vitamins by RP-HPLC and (II): the chromatographic separation of extracted B vitamins from G37 rice sample. RP-HPLC, reverse-phase-high-performance liquid chromatography.



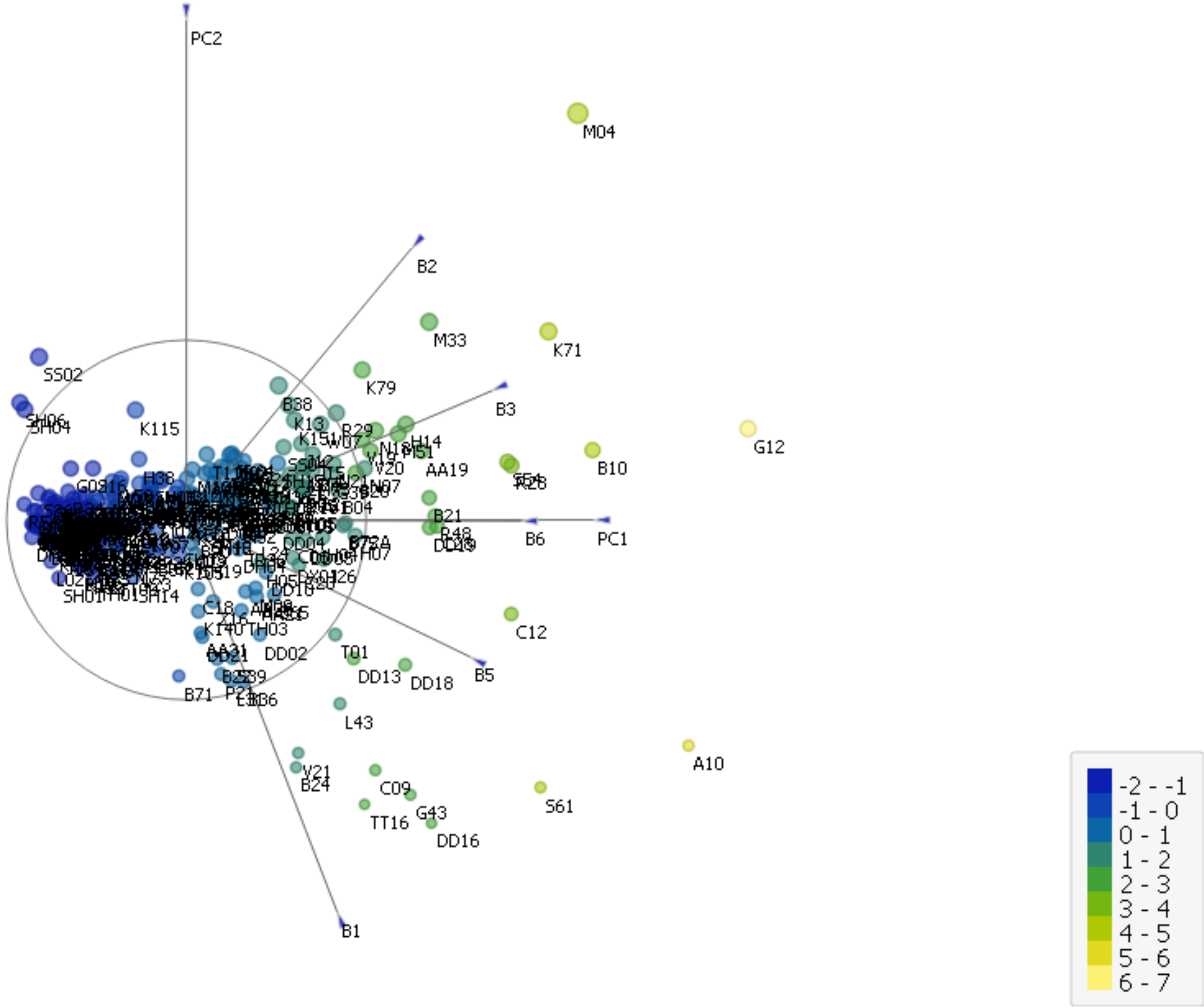
Supplementary figure 3: Correlation heatmap plot of B vitamins among 309 traditional rice landraces.



Supplementary figure 4: The bidirectional heat-map analysis of the rice landraces based on phenotypic data of B vitamins.



Supplementary figure 5: PCA biplot of rice landraces based on different B vitamins


PC2
PC1
B1
B2
B3
B5
B6
M04
M33
K71
K79
G12
B10
AA19
SS02
K115
C12
T01
DD13
DD18
L43
A10
S61
V21
B24
C09
G43
TT16
DD16
B71
DD02
-2 - -1
-1 - 0
0 - 1
1 - 2
2 - 3
3 - 4
4 - 5
5 - 6
6 - 7