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Variability of bioactive properties and antioxidant activity in commercially grown litchi cultivars in India

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ABSTRACT

In this study, fourteen commercial litchi cultivars grown under Indian condition were analysed for variations in total anthocyanins, ascorbic acid, total phenolics, total flavonoids and total antioxidant activity. Significant differences were obtained among the cultivars with respect to different bioactive compounds and antioxidant activity. About 2.35-fold variation in ascorbic acid, 1.88-fold variation in total phenolics, 3.70-fold variation in total flavonoids and 2.02-fold variation in total anthocyanins were recorded among the different litchi cultivars. The total antioxidant activity among the litchi cultivars were also found to vary about 1.51-fold. Principal component analysis showed that the first three components represented 76.45% of total variation. Hierarchical cluster analysis classified the cultivars into six groups based on bioactive compounds and antioxidant activity. Among the cultivars evaluated, Dehra Rose, Bombay, Deshi and Large Red were found to be rich in bioactive compounds and exhibited higher antioxidant activity than other cultivars. These can be used in crop improvement programme to breed varieties rich in phytochemicals and to develop functional food-based products to increase dietary intake of health promoting bioactive compounds.

Key words: *Litchi chinensis*, phytochemicals, ascorbic acid, phenolics, variability.

INTRODUCTION

Oxidation is indispensible for the production of energy in living organisms. However, excessive production of oxidation-derived reactive oxygen species (ROS) or free radicals causes damage to cells and their functions. These ROS attack the biological macromolecules like DNA and proteins, which eventually cause ageing of cells (Apak *et al*., 1). The excessive accumulation of ROS in the human body from internal as well as environmental sources have also been associated with onset of numerous chronic diseases like cardiovascular disease, rheumatoid arthritis, cancer, alzheimer's, diabetes, etc. Consumption of dietary antioxidants can reduce excessive production of ROS and protect the organism against oxidative damage. Fruits and vegetables are the rich sources of natural antioxidants like ascorbic acid, tocopherol, anthocyanins, carotenoids, phenolics, flavonoids etc. which exhibit antioxidant or free radical scavenging activity.

Litchi (*Litchi chinensis* Sonn.) is a subtropical fruit of high commercial value due to its pleasingly flavoured juicy aril, delicate taste, high nutritive value and attractive red coloured pericarp. India is the second largest producer of litchi in the world after China. In India, Bihar state alone contributes about 40% of total litchi production in the country. The litchi fruit aril have been reported to contain several nutritional and health promoting functional compounds. The fruit aril is an excellent source of several antioxidant compounds like vitamin C, vitamin E, polyphenols and flavonoids including procyanidin A2 and leucocyanidin. The pericarp of the litchi fruit is a treasure trove of several bioactive compounds such as anthocyanins, flavan-3-ol derivatives including epicatechin and proanthocyanidins A1, A2, B2 and B4. These compounds have antioxidant, cardioprotective and anticarcinogenic activities. Considering the immense nutritional and therapeutic properties of litchi, knowledge about the functional quality and antioxidant potential of different litchi cultivars is important for the consumers. If any particular cultivar is found to be rich in bioactive compounds embodying a higher antioxidant activity, it could provide a greater health protection to the consumers. Simultaneously, assessing divergence of litchi cultivars in terms of health promoting bioactive compounds and antioxidant potential is a vital tool for litchi breeders for selection of parents in breeding programs to develop cultivars with enhanced nutraceutical properties. Likewise, it will also help the food processing industries to select cultivars having higher bioactive compounds to develop

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nutraceutical rich litchi based products. However, as per our knowledge, the information about the level of bioactive compounds and antioxidant potential in edible part of different litchi cultivars has not been reported so far. Therefore, a study was conducted to evaluate the variability of health promoting bioactive compounds and antioxidant potential in the edible part of fourteen litchi cultivars commercially grown in India.

MATERIALS AND METHODS

Fourteen commercial litchi cultivars of India namely Purbi, China, Deshi, Kasba, Dehradun, Dehra Rose, Rose Scented, Shahi, Bombay, Bedana, Muzaffarpur, Large Red, Ajhouli and Green grown in the experimental orchard of Horticulture Garden, Department of Horticulture, Bihar Agricultural University, Sabour, Bhagalpur were taken for the study. Fruits were harvested at ripe stage exhibiting 90 – 100% red peel colour. Immediately after harvesting fruits were brought to the laboratory and healthy fruits of uniform size, shape, colour and free from disease, pest or physical injury were selected for the study. Total thirty fruits were taken for each cultivar with three replications, having ten fruits per replication.

The total anthocyanins content in the fruit peel was determined by pH-differential method (Wrolstad *et al*., 15). Litchi pericarp was finely sliced and the pigments were extracted by crushing with ethanol (80%). The extract was centrifuged and the supernatants were diluted with potassium chloride buffer and sodium acetate buffer. Then the absorbance was recorded at 520 nm and 700 nm in a spectrophotometer (HALO DB-20S UV-VIS Double beam spectrophotometer, Australia) and the results were expressed as cyanidin-3-glucoside equivalent in mg 100 g^{-1} of fresh pericarp weight.

Ascorbic acid content in the fruit aril was quantified by 2,6-dichlorophenol indophenol dye method. Five gram of fruit sample was crushed and diluted to 100 ml with 3% metaphosphoric acid solution. The mixture was then centrifuged and the supernatants were titrated with dye till a pink end point (persisting for 15 s). The titre value was recorded and the results were expressed as mg 100 g^{-1} FW (fresh weight).

The total phenolics content in the edible portion of litchi fruit was estimated spectrophotometrically by using folin-ciocalteu reagent (Singleton *et al*., 12). To do this, 100 µl of sample extract (in ethanol) was added to 2.9 ml of distilled water, 0.5 ml of folin-ciocalteu reagent and 2.0 ml of Na_2CO_3 solution. Then the absorbance was recorded at 760 nm and the results were expressed as gallic acid equivalent (µg GAE g^{-1} FW).

Total flavonoids content in the fruit aril was analysed using method of Zhishen *et al*. (16). An aliquot of 1.0 ml litchi extract in methanol was added to 4.0 ml of distilled water, 0.3 ml of 5% sodium nitrite and 0.3 ml of 10% aluminium chloride. The mixture was then allowed to stand for 6 min., 2.0 ml of 1 N NaOH was added to it and volume was adjusted to 10.0 ml with distilled water. The absorbance was recorded at 510 nm in a spectrophotometer and results were expressed as catechin equivalent (mg CE 100 g^{-1} FW).

The antioxidant activity of litchi fruit was estimated following three in vitro methods. The reducing power of fruit aril extract was determined following CUPRAC and FRAP methods while, free radical scavenging activity was estimated following DPPH method.

Cupric reducing antioxidant capacity (CUPRAC)- Cupric reducing antioxidant capacity of litchi was estimated by method of Apak *et al*. (1). For this, 100 µl of sample extract (in 80% ethanol) was added to 1.0 ml each of copper(II) chloride solution, neocuproine solution, ammonium acetate buffer solution and distilled water. Then absorbance was recorded at 450 nm against a reagent blank and results were expressed as trolox equivalent (µmol TE g^{-1} FW).

Ferric reducing antioxidant power (FRAP)- Ferric reducing antioxidant power was determined by method of Benzie and Strain (4). The FRAP reagent was prepared by mixing acetate buffer, 2,4,6-tripyridyl-s-triazine in HCl and ferric chloride in the ratio 10 : 1 : 1 (v/v/v). Then, 100 µl of sample extract was added to 3.0 ml of FRAP reagent in a test tube and incubated at 37°C for 30 min in a water bath. Following that, absorbance was measured at 593 nm in a spectrophotometer and results were expressed as trolox equivalent (µmol TE g^{-1} FW).

Free radical scavenging activity using DPPH (2,2-diphenyl-1-picrylhydrazyl)- DPPH assay was used to estimate the scavenging activity of antioxidants in litchi towards the stable radical DPPH (Brand-Williams *et al*., 5). A 100 µl sample extract was added to 3.9 ml DPPH solution in methanol and shaken vigorously. The change in absorbance of the sample was measured at 515 nm in a spectrophotometer for 30 min, till the absorbance reached a steady state. Free radical scavenging activity (RSA) was calculated by the following formula: % RSA = $(A_0 – A_1)/ A_0 \times 100$ where, A_0 was the initial absorbance obtained by measuring the same volume of solvent and A_1 was the final absorbance of the sample extract.

The experiment was conducted in a completely randomized design with three replicates. Data were presented as mean ± standard error. The results were statistically analysed using ANOVA and the mean values were compared by Duncan's multiple range test at a significance level of P £ 0.05. All analyses

were performed using the SAS statistical system 9.2 (SAS Institute, Cary, NC, USA).

RESULTS AND DISCUSSION

The bright red colour of litchi fruit is attributed to presence of anthocyanin pigments in the pericarp. In the present study, total anthocyanins content in the litchi fruit pericarp was found to vary significantly ($p < 0.05$) among the cultivars, ranging from 10.22 to 20.74 mg 100 g^{-1} depicting about two-fold variations (Table 1). The maximum total anthocyanins content was recorded in cv. Purbi while, it was minimum in cv. Bedana. The total anthocyanins content in the litchi cultivars grown under Indian condition in decreasing order was: Purbi ≥ China ≥ Kasba ≥ Deshi ≥ Shahi ≥ Dehra Rose ≥ Large Red ≈ Dehradun ≥ Ajhouli ≈ Rose Scented ≥ Green ≈ Muzaffarpur > Bombay ≈ Bedana. In total, seven types of anthocyanin pigments have been reported to present in the litchi pericarp, namely cyanidin-3-rutinoside, cyanidin-3-glucoside, cyanidin-3-galactoside, malvidin-3-glucoside, malvidin-3-acetylglucoside, pelargonidin-3-glycoside and quercetin-3-rutinoside. Among these, cyanidin-3-glucoside and cyanidin-3-rutinoside are the predominant anthocyanin pigments present in litchi pericarp. Similar variations in anthocyanins content ranging from 1.77 to 20.94 mg 100 g^{-1} have also been reported among nine litchi cultivars grown in China (Li *et al*., 11). Likewise, it was reported that in blueberry, anthocyanin content vary by 4-fold among different cultivars. Significant variation in anthocyanin content among different cultivars was also reported by several workers such as in strawberry, plum and sweet cherry (Vangdal and Slimestad, 14; Conoor *et al*., 6).

Ascorbic acid is a water soluble antioxidant, plays an important role in scavenging free radicals. Asocrbic acid and its oxidized form, dehydroascorbic acid both contribute to vitamin C content. High consumption of ascorbic acid has been reported to be associated with reducing risk of cancer. The variation in ascorbic acid content was ranged between 19.18 and 45.11 mg 100 g^{-1} FW, depicting about 2.35-fold variation among the different cultivars (Table 1). The order of decreasing ascorbic acid content in litchi cultivars were: Dehra Rose > Deshi > Green ≥ Ajhouli ~ Kasba ≥ Rose Scented ≥ Dehradun ≥ Purbi ≈ Shahi ≥ Large Red ≥ Bombay ≈ Bedana ≥ China ≥ Muzaffarpur. Our findings suggested that consumption of 100 g of varieties like Dehra Rose, Deshi, Ajhouli and Green can provide 100% recommended dietary intake (RDI) of ascorbic acid (Table 1). Ascorbic acid content among five different genotypes of black currant was found in the range of 148 to 310 mg 100 g^{-1} FW (Vagiri *et al*., 13). Among twelve cultivars of Indian jujube, ascorbic acid content varied from 19.54 to 99.49 mg 100 g^{-1} (Koley *et al*., 8). Similarly, significant variation was noted in ascorbic acid content (5.40 – 22.50 mg

Table 1. Total anthocyanin, total phenolics, total flavonoids and ascorbic acid content among litchi cultivars.

Cultivars	Total anthocyanin content (mg 100 g^{-1})	Total phenolics content (µg GAE g^{-1} FW)	Total flavonoids content (µg CE g^{-1} FW)	Ascorbic acid content (mg 100 g^{-1} FW)	Fulfillment of RDA of vitamin C (%)*
Purbi	20.74 ± 2.18 a	558.56 ± 12.19 de	25.47 ± 1.53 ef	31.00 ± 1.35 def	51.67
China	20.43 ± 1.32 ab	569.48 ± 20.78 de	18.52 ± 2.77 gh	23.47 ± 1.92 gh	39.12
Deshi	18.28 ± 1.07 bcd	546.60 ± 12.60 def	52.80 ± 2.26 a	39.56 ± 1.11 b	65.93
Kasba	19.62 ± 0.86 abc	699.13 ± 27.18 c	23.20 ± 2.54 fg	34.73 ± 0.86 bcd	57.89
Dehradun	16.04 ± 1.73 def	622.70 ± 35.55 d	17.32 ± 0.59 gh	31.18 ± 2.03 cdef	51.97
Dehra Rose	17.42 ± 1.42 cdef	563.05 ± 9.27 de	39.60 ± 1.80 bc	45.11 ± 1.58 a	75.19
Rose Scented	15.55 ± 1.33 ef	536.60 ± 27.89 ef	14.23 ± 1.57 h	34.02 ± 0.09 bcde	56.71
Shahi	17.57 ± 0.81 cde	525.69 ± 12.491 ef	46.17 ± 2.36 b	30.80 ± 1.37 def	51.34
Bombay	12.05 ± 0.57 g	792.27 ± 38.86 b	43.17 ± 2.34 bc	26.81 ± 2.11 fg	44.70
Bedana	10.22 ± 0.34 g	618.96 ± 15.23 d	32.86 ± 2.15 d	26.13 ± 2.56 fg	43.55
Muzaffarpur	15.05 ± 0.90 f	482.22 ± 23.59 f	29.93 ± 1.68 def	19.18 ± 0.84 h	31.98
Large Red	16.07 ± 0.52 def	910.6 ± 38.35 a	36.63 ± 3.43 cd	28.41 ± 2.39 efg	47.35
Ajhouli	15.79 ± 1.10 ef	613.33 ± 15.72 d	25.70 ± 2.86 ef	36.40 ± 2.37 bcd	60.67
Green	15.12 ± 1.59 f	553.54 ± 17.18 def	31.41 ± 2.17 de	37.07 ± 2.53 bc	61.79

Values represent the mean ± SE of three replicates per cultivar. Mean followed by the same letters are not significantly different ($p < 0.05$).
*Recommended Dietary Allowance (RDA) of ascorbic acid = 60 mg/ day

100 g^{-1} FW) among six different cultivars of peach (Hajilou *et al*., 7).

Phenolic compounds and flavonoids in plant are one of the important contributors of functional quality owing to their role in counteracting reactive oxygen species and minimizing molecular damage (Barman *et al*., 2). Recently, these compounds have aroused considerable interest of researchers because of their potential beneficial effects on human health. They are the most important group of secondary compounds in terms of abundance and potential health benefit due to their ability to scavenge free radicals, superoxide and hydroxyl radical. Among fourteen cultivars of litchi, total flavonoids content and total phenolics content in the edible portion varied significantly ($p < 0.05$) ranging from 14.23 µg CE g^{-1} FW to 52.80 µg CE g^{-1} FW and 482.22 µg GAE g^{-1} FW (cv. Muzaffarpur) to 910.60 µg GAE g^{-1} FW (cv. Large Red) depicting 3.71-fold and 1.88-fold variation respectively (Table 1). The content of total flavonoids among the evaluated litchi cultivars in decreasing order was: Deshi ≥ Shahi ≥ Bombay ≈ Dehra Rose ≥ Large Red ≥ Bedana ≥ Green ≥ Muzaffarpur ≥ Ajhouli ≈ Purbi ≥ Kasba ≥ China ≈ Dehradun ≥ Rose Scented. The concentration of total phenolics in decreasing order among the cultivars was: Large Red ≥ Bombay ≥ Kasba ≥ Dehradun ≈ Bedana ≈ Ajhouli ≥ China ≈ Dehra Rose ≈ Purbi ≥ Green ≈ Deshi ≥ Rose Scented ≈ Shahi ≥ Muzaffarpur. These variations might be attributed to difference in genotypic background of litchi cultivars. This genetic diversity was mostly resulting from natural cross pollination. This finding is in agreement with the study which reported that content of total phenolics in Indian jujube varied from 172 – 328.6 mg GAE 100 g^{-1} FW (Koley *et al*., 8). Significant variation in total phenolics content in the litchi pericarp of nine different commercial cultivars were observed in the range of 9.39 – 30.16 mg GAE g^{-1} FW (Li *et al*., 11). Likewise, the total phenolics content among nine cultivars of sweet cherry and plum was found in the range of 23 – 168 mg 100 g^{-1} FW and 27 – 54 mg 100 g^{-1} FW, respectively (Vangdal and Slimestad, 14). Similarly, it was reported that total flavonoids content in the peel of nine cultivars of litchi varied from 7.12 – 23.46 mg CE g^{-1} FW (Li *et al*., 11). A significant variation in flavonoids content (8.36 – 21.97 mg CE 100 g^{-1}) was also observed among cultivars of Indian jujube (Koley *et al*., 8).

In the present study, antioxidant activity of litchi fruit was measured by three *in vitro* assays, namely free radical scavenging assay by DPPH and reducing power by FRAP and CUPRAC assays. In recent years, determination of antioxidant activity has become increasingly important in the field of nutrition research to evaluate the functional quality and health benefits of fruits and vegetables, without analysing individual antioxidant compound. Isolation and quantification of individual antioxidant compound from fruit matrix is difficult due to its chemical diversity. Different antioxidant compounds work synergistically and/or antagonistically in the complex food matrix through multiple phase reaction mechanism. Due to this reason, a single method for precise and quantitative analysis of total antioxidant activity does not exist (Koley *et al*., 9). In this study, antioxidant activity among the litchi cultivars ranged from 4.28 to 6.47 µmol TE g^{-1} FW and 2.41 to 4.23 µmol TE g^{-1} FW in CUPRAC and FRAP assays, respectively (Table 2). Thus, about 1.51-fold variation in CUPRAC assay and 1.75-fold variation in FRAP assay was found among the different litchi cultivars. The antioxidant activity for CUPRAC assay in decreasing order was recorded as Dehra Rose ≥ Bombay ≥ Large Red ≥ Rose Scented ≈ Green ≈ Deshi ≥ Dehradun ≥ Bedana ≈ Shahi ≈ Ajhouli ≈ China ≈ Kasba ≈ Purbi ≥ Muzaffarpur. However, in FRAP assay, the antioxidant activityin decreasing order was: Bombay ≈ Dehra Rose ≥ Deshi ≥ Shahi ≈ Green ≥ Large Red ≥ Kasba ≥ Bedana ≥ Ajhauli ≥ Muzaffarpur ≥ Dehradun ≈ China ≈ Purbi ≥ Rose Scented. Free radical scavenging activity of different litchi cultivars was measured using DPPH assay. The free radical scavenging activity among the cultivars ranged from 43.77 to 75.61% (Table 3). Overall, 1.72-fold variation was noted among the cultivars under study. The free radical scavenging activity of antioxidants for DPPH assay in decreasing order was: Deshi ≥ Bombay ≈ Shahi ≈ Dehra Rose ≥ Large Red ≈ Green ≈ Bedana ≥ Kasba ≥ Ajhauli ≈ Muzaffarpur ≥ Rose Scented ≈ Purbi ≥ Dehradun ≈ China.

Correlation coefficient between ascorbic acid, total phenolics, total flavonoids and antioxidant activity (CUPRAC, DPPH and FRAP assay) were also evaluated to study the interrelationship between them (Table 3). A positive correlation (R^2 = 0.762 in DPPH and 0.795 in FRAP) was recorded between total flavonoids content and antioxidant activity (DPPH and FRAP assay). Likewise, ascorbic acid was found positively correlated with FRAP assay (R^2 = 0.407) and CUPRAC assay (R^2 = 0.396); and total phenolics content with CUPRAC assay (R^2 = 0.253). Similarly, higher antioxidant activity owing to presence of higher amount of flavonoids, ascorbic acid and phenolic compounds has also been reported earlier in litchi, mango, plum and carrot (Kumari *et al*., 10; Barman *et al*., 2; Barman and Asrey, 3; Koley *et al*., 9).

Principal component analysis (PCA) is the process of minimizing variables by developing

Table 2. Total antioxidant capacity among litchi cultivars.

Cultivars	Total antioxidant capacity (CUPRAC assay) (µmol TE g^{-1} FW)	Total antioxidant capacity (FRAP assay) (µmol TE g^{-1} FW)	Radical scavenging activity (DPPH assay) (%)
Purbi	4.42 ± 0.15 cd	2.44 ± 0.20 fg	51.19 ± 3.11 cd
China	4.53 ± 0.62 cd	2.51 ± 0.120 fg	43.77 ± 2.07 d
Deshi	5.42 ± 0.30 abcd	3.90 ± 0.06 ab	75.61 ± 7.78 a
Kasba	4.47 ± 0.10 cd	3.18 ± 0.13 cde	60.29 ± 3.25 abcd
Dehradun	5.03 ± 0.23 bcd	2.56 ± 0.06 fg	44.23 ± 3.00 d
Dehra Rose	6.47 ± 0.51 a	4.15 ± 0.21 a	72.77 ± 1.84 ab
Rose Scented	5.53 ± 0.50 abcd	2.41 ± 0.24 g	51.61 ± 7.77 cd
Shahi	4.79 ± 0.13 cd	3.41 ± 0.23 bc	73.19 ± 6.89 ab
Bombay	6.16 ± 0.03 ab	4.23 ± 0.27 a	74.38 ± 7.45 ab
Bedana	4.85 ± 0.36 cd	3.00 ± 0.14 cdef	63.90 ± 5.13 abc
Muzaffarpur	4.28 ± 0.27 d	2.64 ± 0.06 efg	55.60 ± 1.56 bcd
Large Red	5.67 ± 0.45 abc	3.21 ± 0.21 cd	68.77 ± 9.34 abc
Ajhouli	4.77 ± 0.62 cd	2.80 ± 0.03 defg	56.10 ± 4.97 bcd
Green	5.44 ± 2.17 abcd	3.38 ± 0.09 bc	68.47 ± 3.09 abc

Values represent the mean ± SE of three replicates per cultivar. Mean followed by the same letters are not significantly different ($p < 0.05$).

Table 3. Correlation coefficient among different parameters of litchi.

	AsA	TPC	TFC	CUPRAC	DPPH	FRAP
AsA	1.000	-0.083	0.189	0.396	0.289	0.407
TPC		1.000	0.103	0.253	0.206	0.248
TFC			1.000	0.383	0.762	0.795
CUPRAC				1.000	0.463	0.554
DPPH					1.000	0.793
FRAP						1.000

Note: AsA – Ascorbic acid, TPC – Total phenolics content, TFC – Total flavonoids content, CUPRAC – Cupric reducing antioxidant capacity, DPPH –2,2-diphenyl-1-picrylhydrazyl, FRAP – Ferric reducing antioxidant power.

smaller number of artificial variable. The observed value of PCA in this study showed that four of seven principal components have eigen value greater than 0.7 and these all four contributed 88.38% of total variation (Table 4). Principal component 1, 2 and 3 explained approximately 76.45% of total variation (PC1 = 45.65%, PC2 = 17.48% and PC3 = 13.32%) (Table 4). Variables like ascorbic acid, total phenolics, total flavonoids, antioxidant activity (CUPRAC, FRAP and DPPH) were positively related to PC1, whereas total anthocyanins content was negatively related with PC1. Therefore, PC1 divided the fourteen cultivars into two groups with low and high antioxidant content (Fig. 1A). In Fig. 1B, the variable are said to be related to one another if

Table 4. Principal component analysis of litchi cultivars.

Variables	PC1	PC2	PC3	PC4	PC5	PC6	PC7
Ascorbic acid	0.2587	0.6198	-0.1849	0.4255	-0.5319	0.0665	-0.2153
Total phenolics	0.1686	-0.4804	-0.7719	-0.1864	-0.2943	0.0687	-0.1373
Total flavonoids	0.4669	-0.0231	0.3133	-0.3633	0.0857	0.4870	-0.5540
CUPRAC	0.3935	0.0297	-0.3125	0.4625	0.7265	0.4870	-0.5540
DPPH	0.4937	-0.0382	0.1635	-0.2134	-0.1003	-0.8159	-0.0827
FRAP	0.5226	0.027	0.0527	0.1167	-0.107	0.2897	0.7838
Total anthocyanins	-0.1222	0.6177	-0.3803	-0.6158	0.2716	-0.0567	0.0522
Eigen value	3.1953	1.2239	0.9324	0.8353	0.4426	0.2269	0.1438
% of variance	45.65	17.48	13.32	11.93	6.32	3.24	2.05
Cumulative proportion	0.4565	0.6313	0.7645	0.8838	0.9470	0.9795	1.0000

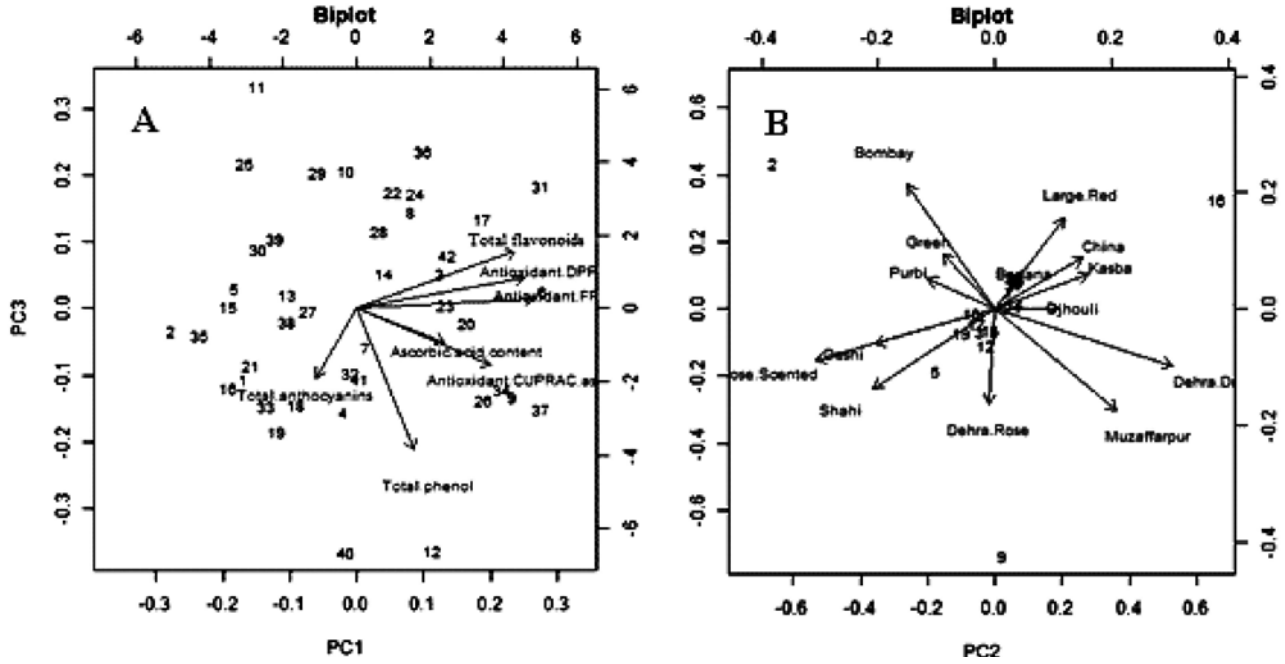

Fig. 1 **A.** Variability of bioactive compounds among litchi cultivars under PC axis 1 and 3 of a PCA (CUPRAC – Cupric reducing antioxidant capacity, DPPH – 2,2-diphenyl-1-picrylhydrazyl, FRAP – Ferric reducing antioxidant power). **B.** Relationship among litchi cultivars for the principal component 2 and 3 of a PCA based on bioactive compound contents.

they are close to one other in the same geometric plane of biplot and higher distance from variables are negatively correlated.

Hierarchical Cluster analysis (HCA) of the data was performed and the litchi cultivars were grouped on the basis of similarities in content of health promoting bioactive compounds. HCA was carried out by the method of average distance. In this study, the scale from 0 – 120 based on ward analysis was taken to determine the relationship among different litchi cultivars (Fig. 2). The whole cluster was divided into six sub-clusters. The first cluster was divided into two major sub-clusters. Cluster-1 has seven cultivars namely Green, Ojhouli, Large Red, Muzaffarpur, Bedana, Bombay and Shahi which was similar in total flavonoids content and radical scavenging activity. Cluster-2 contains three cultivars namely Rose scented, Dehra Rose and Dehra Doon which was similar in total phenolics content, total anthocyanins content, total antioxidant capacity (CUPRAC and FRAP assay) and radical scavenging activity (DPPH assay). Sixth cluster contains only one cultivar Purbi which is almost homogenous to all other thirteen cultivars with respect to bioactive compounds.

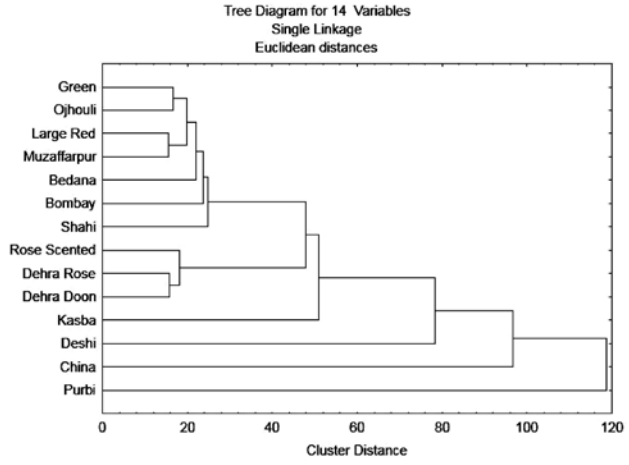

Fig. 2. Hierarchical cluster analysis of litchi cultivars based on health promoting bioactive compounds.

In conclusion, a considerable variation in terms of bioactive compounds and antioxidant activity was found among the litchi cultivars. Cultivars like Dehra Rose, Bombay, Deshi and Large Red were identified as rich in phytochemicals and antioxidant activity. Findings of this study offer an opportunity to improve the functional quality of litchi cultivars by selecting cultivars with high antioxidant potential and use them in crop improvement programme to breed varieties with high nutraceuticals. These cultivars also have potential to increase the intake of bioactive compounds through diet and develop functional food-based products.

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