

Original Research Article

Phytochemical and antioxidant profiling of chilli landraces from hilly regions of India

Abstract: The present study was carried out to assess the phytochemical and antioxidant potential of 24 chilli landraces grown in hilly regions of India viz. Himachal Pradesh & Assam and evaluated for different phytochemical parameters and antioxidant assays. Highest total sugar (3.43 %), reducing sugar (2.22 %), polyphenolic content (153.85 mg /100g GAE), total carotenoids (101.66 mg/100g, ascorbic acid (12.85 mg/100g) and reducing power assay (70.76 mM/g TE) were found in the genotype 'Chilli SC-1', while 'Chilli CHI-15' was found superior for total flavonoid content (547.01 mg/100g QE). The genotype, 'Chilli SC-1' followed 'Chilli L-2' were found best owing to their Trolox equivalent antioxidant activity. The above results were also confirmed with spectral studies using FT-IR spectroscopy. Further, principal component analysis indicated that the genotype 'Chilli SC-1', 'Chilli LC-2', 'Chilli AC-9' and 'Chilli AC-10' are the major contributors to divergence within different quality traits under study.

Keywords: *Capsicum annuum* L., divergence, FT-IR, PCA, variability

1. INTRODUCTION

Chilli (*Capsicum annuum* L.) is a major vegetable as well as spice crop potentially cultivated in tropical and sub-tropical regions of the world [1]. It is considered as one of the most significant commercially farmed vegetable and spice crops in India owing to its various uses viz. vegetable, spice, condiment, sauce and pickle. Chilli not only adds eye-catching colours and mouth-watering flavours to food, but it also boosts nutritional value [2]. It contains vitamins A (carotenoids), B complex, vitamin C, vitamin E and significant macro as well as micro-minerals. Due to its high content of ascorbic acid, the chilli is also referred as a vitamin C pill. It also possesses a high concentration of carotenoids that contribute to fruit color which is a dietary precursor for vitamin A. On the other hand, capsanthin, capsorubin and capsanthin 5,6-epoxide are different types of carotenoids found in chilli that contribute to its ultimate red color. Besides, it contains beneficial bioactive substances with antibacterial, antioxidant and anti-inflammatory activities. The antioxidants present in chilli help in scavenging free radical from the body and subsequently induce a protective effect against oxidative damage. The principal chemical element of chilli fruits is a crystalline and acid

volatile alkaloid capsaicin which is found mainly in the placenta of fruits and this particular component persuades the commercial worth concerning chillies. Among all capsaicinoids, capsaicin and dihydrocapsaicin make up more than 80% of the total capsaicinoids which majorly contributes towards its pungency. The level of pungency varies greatly with different genotypes [3]. It is also a good source of oleoresin, which has a variety of applications in the processing of food and beverages as well as in the pharmaceutical industry.

There is an enormous diversity of chilli in hilly regions of the country. Despite of immense variability observed in the crop, there is a lag of concrete information concerning their biochemical composition and antioxidant potential. Therefore, in order to provide more nutritious and phytochemicals rich chillies for industrial as well as household uses, the present study was carried out to assess the phytochemical and antioxidant potential of 24 chilli genotypes collected from hilly regions of India.

2. MATERIALS AND METHODS

2.1 Plant sampling

The 24 landraces of chilli collected from different locations of Himachal Pradesh and Assam were grown at the Dr. YS Parmar UHF RHR & TS, Jachh, Nurpur, District Kangra, HP during Summer, 2022 (Table 1). Fruits of each genotype were harvested at maturity (red ripe stage) and dried with the help of a freeze drier, powdered and stored at -18 °C till further analysis. The total sugars (TS) and reducing sugars (RS) were determined using colorimetric method [4]. Total flavonoid content (TFC) and total polyphenolic content (TPC) was estimated [5]. Total carotenoids (TC) and ascorbic acid (AA) were determined by a standard titrimetric method [6]. The total capsaicinoids (TCap) content was also determined [7] and several antioxidant assays DPPH (2,2-diphenyl-1-picryl-hydrazyl-hydrate), ferric reducing antioxidant power (FRAP) and reducing power assay (RPA) were determined by following the free radical method [8]. While azino-bis 3-ethylbenzothiazoline-6-sulfonic acid (ABTS) and metal chelating activity (MCA) were also estimated [9,10]. The different genotypes of chilli were also tested for FTIR spectra using an Agilent Cary 630 FTIR spectrometer. All of the samples were evaluated at room temperature and the spectra were collected.

2.2 Data analysis

The data obtained from the analysis were subjected to analysis of variance (ANOVA) with completely randomized design (CRD) using SPSS 16.0 (IBM, SPSS Inc., USA). Data were also analyzed using a post hoc test (Duncan's Multiple Range Test. Principal component analysis (PCA) was carried out using the software Indostat 8.1.

3. RESULTS AND DISCUSSION

The TS and RS ranged from 0.29 % (Chilli AC-6) to 3.43 % (Chilli SC-1) and 0.13 % (DKC-8) to 2.22 % (Chilli SC-1), respectively. The genotype, Chilli SC-1 was found have significantly highest TS as well as RS (Table 1). A wide range for TFC was noticed ranging from 176.92 mg/100 g QE (Arka Harita) to 547.01 mg/100 g QE (Chilli CHI-15). TPC of 24 genotypes ranged from 18.16 mg/100g GAE (Chilli AC-6) to 153.85 mg/100g GAE (Chilli SC-1) on a dry weight basis. Significantly highest TPC was found in genotype Chilli SC-1.

The TC content was ranged between 18.41 mg/100g (Chilli CHI-5) to 101.66 mg/100g (Chilli SC-1) while ascorbic acid content was found highest in the genotype Chilli SC-1 (12.85 mg/g), while lowest was observed in Arka Harita (2.86 mg/g) on a dry weight basis. Besides this, the genotypes Chilli CHI-13 and Chilli CHI-15 were also found higher in AA concentration. The highest capsaicinoids content was found in DKC-8 (0.49 %) and lowest was noticed in Chilli AC-7 (0.18 %).

The highest DPPH activity was found in the genotype Chilli L-2 (11.69), whereas, the lowest was observed in Chilli AC-6 (2.69 mM/g TE). Similar trends were observed in case of FRAP and ABTS activity as the highest (61.84 and 44.97 mmol/g TE, respectively) and lowest (11.85 and 12.14 mmol/g TE, respectively) values for the aforesaid assays were found in genotype Chilli L-2 and Chilli AC-6, respectively. In case of RPA, the highest reducing power was observed in Chilli SC-1 (70.76 mmol/g TE) and the lowest was noticed in Chilli AC-6 (16.83 mmol/g TE). Concerning MCA, small variation was observed among the genotypes which ranged between 0.47 mmol /g EDTA (Chilli CHI-15) to 0.77 mmol /g EDTA (Arka Harita).

In the present study, the first three principal components with eigen value greater than one explained 77.09 % of the total variation (Table 4). The major contributor towards variation in PC1 is MCA, while the variations in PC2 are mainly due to TFC, ABTS, AA, and FRAP. The variations in PC3 are mainly due to MCA followed by DPPH, FRAP, and ABTS. The PCA biplot (Figure 1) depicts the original variable as a vector. The longer the arrow, the higher the variability. When two vectors form an acute angle, then the respective variables are positively correlated. Therefore, the variables i.e., TPC, TFC, DPPH, RPA, FRAP, AA, and ABTS are highly correlated with each other. Among all, the variables ABTS and AA were found to be highly correlated with each other. The vector of traits, viz. TPC, TFC, RPA, FRAP, and ABTS have a longer vector length indicating a positive contribution to both components. The chilli genotypes have been distributed based on their relative performance concerning PC1 and PC2. Further, loading of different genotypes based on first two principal components indicated that the genotype Chilli SC-1, Chilli LC-2, Chilli AC-9 and Chilli AC-

10 are major contributors to divergence between different quality traits under study, whereas contribution of DKC-8 and Chilli LC-4 was found least in divergence.

In FTIR spectra, the bands around 3500-3300 cm^{-1} indicate the presence of N-H stretching and O-H bending attributed towards functional amines which are the functional groups of capsaicin and dihydrocapsaicin. It also represents the presence of phenols in the sample. It is indicated in figure 2 that Chilli SC-1 possesses the highest amount of capsaicin among all. The spectrum ranges from 2900-2800 cm^{-1} showing very weak peaks of C-H stretching indicating the presence of alkanes. The bands ranging between 1750-1300 cm^{-1} is indicating C-H bending which represents aromatic compounds in chilli. The absorption band especially, between 1650-1600 cm^{-1} represents C=C stretching which is indicative of the presence of alkenes in the product. The bands at 1230.9-1149.8 cm^{-1} represents C-N stretching which indicates the presence of primary amines in the samples. These two peaks represent the presence of sulphoxide and anhydride groups, respectively. The bands lying in between the 780-650 cm^{-1} range have shown the C-Cl and C-Br stretching indicating Aliphatic Chloro and Bromo groups.

A huge difference in quality traits was observed in 24 genotypes of chillies attributed to their diverse genetics and location specificity. Total sugar and reducing sugar content have not been widely explored by researchers in earlier studies, however, it is an important parameter concerning the shelf-life of processed products from chillies. Especially, RS plays an important role in Maillard and caramelization reactions [11]. The different chilli genotypes were also evaluated for different phytochemical parameters and wide range of variations are attributed to genotypic differences [12]. Besides, TPC is considered a major contributing factor to the antioxidant activity of chillies. In an earlier study, [13] it was revealed that TPC of different chilli genotypes ranged from 53.73 to 200.41 mg/100g GAE DW, which is quite similar to our results.

The major colouring component of chillies is the carotenoids. A wide variation was observed among the genotypes concerning total carotenoids. In a previous study, three Mexican genotypes of chillies showed varied concentrations of carotenoids i.e., guajillo-3406 $\mu\text{g/g}$, pasilla-2933 $\mu\text{g/g}$, and ancho-1437 $\mu\text{g/g}$ [14]. The above instances revealed that chillies are a good source of TC with a wider range of variability. Earlier [15] it was found that wide range of AA content (139.46 mg/100g to 209.60 mg/100g) in five genotypes of chilli on a fresh weight basis. These facts confirm that chillies are a vital source of ascorbic acid. Chillies are majorly consumed for their capsaicin content. In the present study, the different genotypes were found to have a moderate level of capsaicinoids (~0.50%). However, previous studies

indicate that chillies of Indian origin possess a high amount of capsaicinoids [16]. The variation in capsaicinoids content may be attributed to genotypic differences.

Various antioxidant assays i.e., DPPH, FRAP, ABTS, RPA, and MCA were performed to assess the antioxidant properties of chillies (Table 3). DPPH and ABTS test assists us in studying the ability of chillies to donate hydrogen as well as stabilizing the radicals [17]. FRAP measures the reducing potential of an antioxidant reacting with the ferric tripyridyl triazine (TPTZ) complex producing a coloured complex [18]. The RPA denotes the reducing power of particular components present in the extract which possess the ability to reduce the reactive oxygen species whereas MCA calculates the capacity of the extract to chelate metal ions which may induce the free radical-producing reaction [19]. The variation lies in the antioxidant properties of different chilli genotypes are highly attributed to ascorbic acid content, TFC, TPC, and other phytochemicals [17]. The FTIR was applied to chilli genotypes to detect the functional as well as other fingerprint groups (Figure 2). The FTIR spectra of chilli samples were recorded in the range of 4000 to 400 cm^{-1} and the peaks were elaborated [20].

4. CONCLUSION

The genotype Chilli SC-1 followed by Chilli L-2 and Chilli CHI-15 were observed as the most promising one concerning their phytochemical composition and antioxidant activities. The present study could be of immense value for breeders and biotechnologists for developing genotypes with exceptionally good quality attributes. This investigation will also assist in consumer awareness concerning their possible uses in food, nutraceutical, and pharmaceuticals.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Authors declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of the manuscript.

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Table 1. List of chilli landraces along with their sources used in present study

Sr. No.	Genotypes	Source
1.	Chilli SC-1	Pakyong(Sikkim)

2.	Chilli JC-1	Jachh(HP)
3.	Chilli LC-1	Bilaspur(HP)
4.	Chilli LC-2	Ghumarwin(HP)
5.	Chilli LC-3	Gangath(HP)
6.	Chilli LC-4	Kathgarh(HP)
7.	Chilli LC-5	Indora(HP)
8.	Chilli AC-5	Dhemaji(Assam)
9.	Chilli AC-6	Dhemaji(Assam)
10.	Chilli AC-7	Karbi Analong(Assam)
11.	Chilli AC-8	Diphu(Assam))
12.	Chilli AC-9	Kahikuchi(Assam)
13.	Chilli AC-10	Dispur(Assam)
14.	Chilli AC-11	Barpeta(Assam)
15.	Chilli AC-12	Jorhat(Assam)
16.	UHF CHI-5	YSP UHF, Nauni(HP)
17.	UHF CHI-13	YSP UHF, Nauni(HP)
18.	UHF CHI-15	YSP UHF, Nauni(HP)
19.	Chowari LC-1 (small)	Chowari, Chamba(HP)
20.	Chowari LC-2 (long)	Chowari, Chamba(HP)
21.	DKC-8	YSP UHF, Nauni(HP)
22.	ArkaHarita	YSP UHF, Nauni(HP)
23.	Chilli L-1	Jachh, Nurpur(HP)
24.	Chilli L-2	Jachh, Nurpur(HP)

Table 2. Physicochemical and phytochemical evaluation of chillilandraces

Genotype	Total sugars (%)	Reducing sugars (%)	TFC (mg /100 g QE)	TPC (mg/100g GAE)	Total carotenoids (mg/100g)	Ascorbic acid (mg/g)	Total Capsaicinoids (%)
Chilli SC-1	3.43±0.06 ^a	2.22±0.05 ^a	342.09±10.73 ^g	153.85±1.98 ^a	101.66±3.07 ^a	12.85±0.51 ^a	0.48±0.02 ^{ab}
Chilli JC-1	0.69±0.0 ^{hi}	0.47±0.02 ^g	314.42±12.47 ^h	43.75±1.14 ^j	35.15±1.30 ^m	3.57±0.05 ^{fgh}	0.36±0.01 ^{gh}
Chilli LC-1	0.97±0.01 ^f	0.60±0.01 ^d	257.48±10.44 ^j	59.62±1.18 ^g	55.17±1.74 ^g	2.86±0.11 ^h	0.40±0.01 ^e
Chilli LC-2	2.27±0.08 ^b	0.64±0.01 ^c	368.38±3.32 ^f	51.05±0.92 ⁱ	57.86±1.56 ^f	5.71±0.21 ^{gh}	0.31±0.01 ^j
Chilli LC-3	0.62±0.01 ^j	0.46±0.01 ^g	336.86±10.02 ^g	43.15±0.51 ^j	76.85±0.07 ^b	4.28±0.12 ^{gh}	0.30±0.03 ^{jk}
Chilli LC-4	0.83±0.03 ^g	0.16±0.01 ^k	454.91±11.07 ^c	53.05±0.77 ^{hi}	28.67±0.98 ^{nop}	7.85±0.01 ^{fgh}	0.43±0.01 ^c
Chilli LC-5	0.40±0.01 ⁿ	0.29±0.02 ^j	227.88±8.42 ^k	33.96±1.29 ^k	58.80±0.42 ^f	3.28±0.07 ^h	0.35±0.03 ^{hi}
Chilli AC-5	0.68±0.03 ⁱ	0.40±0.02 ^h	204.49±6.08 ^l	52.73±0.43 ⁱ	66.23±0.72 ^e	2.86±0.07 ^h	0.29±0.01 ^k
Chilli AC-6	0.29±0.01 ^{op}	0.16±0.01 ^k	187.07±3.20 ^m	18.16±0.43 ^m	30.36±0.25 ⁿ	4.28±0.08 ^{fgh}	0.34±0.01 ⁱ
Chilli AC-7	0.51±0.01 ^{lm}	0.42±0.01 ^h	187.61±2.87 ^m	51.53±1.90 ⁱ	37.07±0.9 ^{klm}	9.28±0.23 ^{def}	0.18±0.01 ^m
Chilli AC-8	0.56±0.03 ^k	0.29±0.01 ^j	263.25±9.02 ^j	43.16±1.13 ^j	35.84±0.42 ^m	4.28±0.01 ^{gh}	0.25±0.01 ^l
Chilli AC-9	1.25±0.05 ^e	0.54±0.02 ^e	287.18±0.52 ⁱ	62.42±0.34 ^{ef}	42.33±0.92 ⁱ	3.57±0.02 ^{gh}	0.43±0.02 ^c
Chilli AC-10	0.87±0.03 ^g	0.83±0.03 ^b	398.18±6.46 ^{de}	85.97±0.93 ^c	75.71±3.21 ^{bc}	8.57±0.21 ^{efg}	0.38±0.02 ^f
Chilli AC-11	0.53±0.02 ^{kl}	0.40±0.01 ^h	387.71±13.21 ^e	63.99±1.55 ^{de}	40.46±0.93 ^{ij}	3.57±0.01 ^{gh}	0.35±0.01 ^{hi}
Chilli AC-12	0.47±0.02 ^m	0.17±0.01 ^k	412.39±18.21 ^d	58.4±2.16 ^g	36.89±1.43 ^{lm}	5.71±0.21 ^{fgh}	0.37±0.01 ^{fg}
Chilli CHI-5	1.23±0.03 ^e	0.62±0.03 ^{cd}	514.32±9.27 ^b	63.45±1.03 ^{de}	18.41±0.17 ^r	4.28±0.18 ^{efg}	0.25±0.01 ^l
Chilli CHI-13	0.55±0.05 ^{kl}	0.51±0.02 ^f	293.80±1.32 ⁱ	52.86±0.57 ^{hi}	21.9±0.75 ^q	12.45±0.17 ^{ab}	0.48±0.01 ^{ab}
Chilli CHI-15	0.62±0.01 ^j	0.12±0.01 ^l	547.01±6.90 ^a	43.56±0.55 ^j	50.87±2.25 ^h	10.32±0.37 ^{abc}	0.24±0.01 ^l
Chowari LC-1	1.87±0.04 ^c	0.30±0.02 ^{ij}	462.61±12.51 ^c	55.03±2.38 ^g	73.41±1.79 ^{cd}	9.28±0.14 ^{cde}	0.42±0.02 ^{cd}
Chowari LC-2	1.33±0.02 ^d	0.29±0.01 ^j	407.59±2.20 ^d	60.21±1.47 ^{fg}	38.66±0.77 ^{ijkl}	5.56±0.06 ^{gh}	0.41±0.01 ^{de}
DKC-8	0.61±0.01 ^j	0.13±0.01 ^l	313.14±6.77 ^h	60.32±1.36 ^{fg}	39.39±1.24 ^{jk}	6.43±0.08 ^{gh}	0.49±0.01 ^a
ArkaHarita	0.40±0.01 ⁿ	0.32±0.01 ⁱ	176.92±5.10 ^m	29.52±1.09 ^l	72.86±1.18 ^d	2.86±0.08 ^{fgh}	0.40±0.02 ^e
Chilli L-1	0.76±0.02 ^h	0.32±0.01 ⁱ	411.75±5.57 ^d	64.79±2.80 ^{dd}	54.90±2.33 ^g	5.02±0.07 ^{def}	0.37±0.01 ^{fg}
Chilli L-2	0.85±0.02 ^g	0.40±0.01 ^h	318.06±10.32 ^h	104.96±1.04 ^b	27.33±0.52 ^{op}	12.28±0.48 ^{bcd}	0.47±0.02 ^b

Table 3. Evaluation of chilli landraces for antioxidant properties

Genotype	DPPH (mM/g TE)	FRAP (mM/g TE)	ABTS (mM/g TE)	RPA (mM/g TE)	MCA (mM/g EDTA)
Chilli SC-1	10.88±0.40 ^b	58.56±1.65 ^{ab}	42.58±1.63 ^b	70.76±0.67 ^a	0.71±0.01 ^{bc}
Chilli JC-1	4.79±0.20 ^l	22.89±0.85 ^j	18.00±0.63 ^k	27.86±1.18 ^m	0.63±0.01 ^{gh}
Chilli LC-1	7.18±0.27 ⁱ	26.39±0.38 ^{ij}	23.62±1.57 ^j	25.25±1.02 ⁿ	0.67±0.02 ^{ef}
Chilli LC-2	7.09±0.20 ⁱ	29.21±0.26 ^{hij}	23.70±0.21 ^j	31.13±0.42 ^k	0.71±0.02 ^{bc}
Chilli LC-3	7.56±0.16 ^h	27.15±0.61 ^{hij}	18.57±0.15 ^k	29.58±0.13 ^l	0.74±0.02 ^{ab}
Chilli LC-4	6.42±0.27 ^j	33.27±0.87 ^{ghi}	29.33±1.26 ^{fg}	34.83±0.97 ^{gh}	0.49±0.02 ^k
Chilli LC-5	4.02±0.10 ^m	21.56±0.68 ^{ik}	17.81±0.50 ^k	19.25±0.17 ^{op}	0.53±0.02 ^j
Chilli AC-5	7.35±0.15 ^{hi}	26.21±0.83 ^{ij}	29.48±1.08 ^{efg}	33.74±1.22 ^{hi}	0.72±0.02 ^{bc}
Chilli AC-6	2.69±0.02 ⁿ	11.85±0.47 ^k	12.14±0.16 ^m	16.83±0.67 ^q	0.71±0.01 ^{bc}
Chilli AC-7	8.41±0.24 ^f	25.16±0.25 ^{ij}	24.60±1.33 ^j	27.22±0.91 ^m	0.73±0.01 ^{bc}
Chilli AC-8	6.42±0.24 ^j	22.85±0.27 ^j	18.63±0.44 ^k	24.87±0.31 ⁿ	0.73±0.01 ^{bc}
Chilli AC-9	10.38±0.18 ^c	55.32±0.75 ^{def}	42.14±2.79 ^b	46.18±1.21 ^c	0.74±0.03 ^{ab}
Chilli AC-10	9.13±0.19 ^{de}	44.51±0.28 ^{cd}	36.12±1.17 ^d	44.86±1.50 ^d	0.68±0.03 ^{de}
Chilli AC-11	8.60±0.17 ^f	51.46±1.21 ^{bc}	26.75±1.30 ⁱ	32.56±0.36 ^{ij}	0.67±0.01 ^e
Chilli AC-12	8.02±0.13 ^g	45.16±1.67 ^{cd}	35.60±1.12 ^d	35.96±0.13 ^{fg}	0.66±0.01 ^{gh}
Chilli CHI-5	7.99±0.30 ^g	36.41±0.39 ^{efg}	29.53±1.22 ^{efg}	31.56±0.85 ^{jk}	0.63±0.01 ^{gh}
Chilli CHI-13	7.98±0.14 ^g	30.12±1.01 ^{hij}	28.41±2.95 ^{gh}	27.18±1.18 ^m	0.64±0.02 ^{fg}
Chilli CHI-15	8.05±0.20 ^g	37.24±1.44 ^{def}	30.01±1.33 ^{ef}	36.58±0.20 ^f	0.47±0.01 ^j
Chowari LC-1	9.09±0.20 ^e	34.04±0.28 ^{efg}	30.71±1.06 ^e	27.69±0.45 ^m	0.53±0.02 ^j
Chowari LC-2	7.37±0.25 ^{hi}	33.57±0.70 ^{ghi}	29.94±1.03 ^{ef}	34.56±0.50 ^h	0.61±0.03 ^{hi}
DKC-8	7.17±0.12 ⁱ	28.57±0.95 ^{hij}	27.12±0.29 ^{hi}	34.98±0.91 ^{gh}	0.70±0.02 ^{cd}
ArkaHarita	5.82±0.12 ^k	20.26±0.82 ^{jk}	14.07±0.47 ^l	17.08±0.57 ^q	0.77±0.03 ^a
Chilli L-1	9.46±0.20 ^d	43.06±1.59 ^{cde}	40.28±2.32 ^c	41.27±0.67 ^e	0.60±0.02 ⁱ
Chilli L-2	11.62±0.29 ^a	61.84±0.84 ^a	44.79±1.09 ^a	52.17±0.66 ^b	0.76±0.02 ^a

Table 4. Principal component analysis for different quality traits of chillilandraces

Traits	Principal Component		
	PC1	PC2	PC3
TS	-0.29	-0.23	-0.37
RS	-0.29	-0.41	-0.21
TFC	-0.17	0.51	-0.33
TPC	-0.38	-0.13	0.04
DPPH	-0.35	0.08	0.26
FRAP	-0.36	0.14	0.25
ABTS	-0.35	0.21	0.24
RPA	-0.39	-0.03	0.08
MCA	0.07	-0.45	0.59
TC	-0.14	-0.45	-0.39
AA	-0.26	0.16	-0.06
TCap	-0.19	-0.03	0.13
Eigen value	6.02	1.88	1.36
Percentage of variance	50.15	15.63	11.30
Cumulative percentage of variance	50.15	65.79	77.09

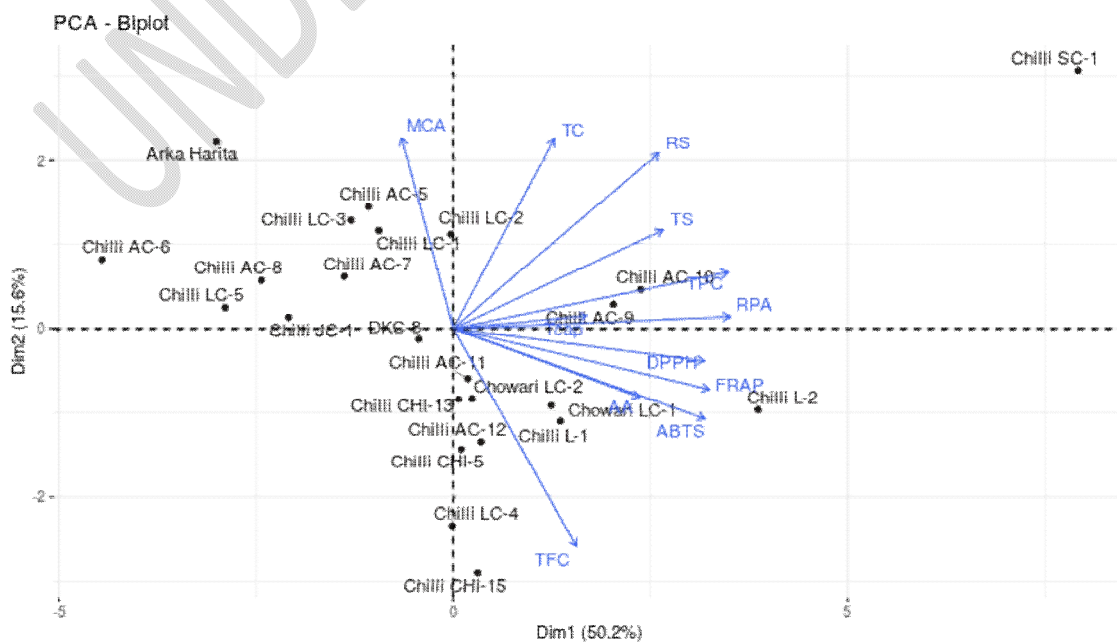


Fig. 1. Loading of different traits and landraces based on first two principal components

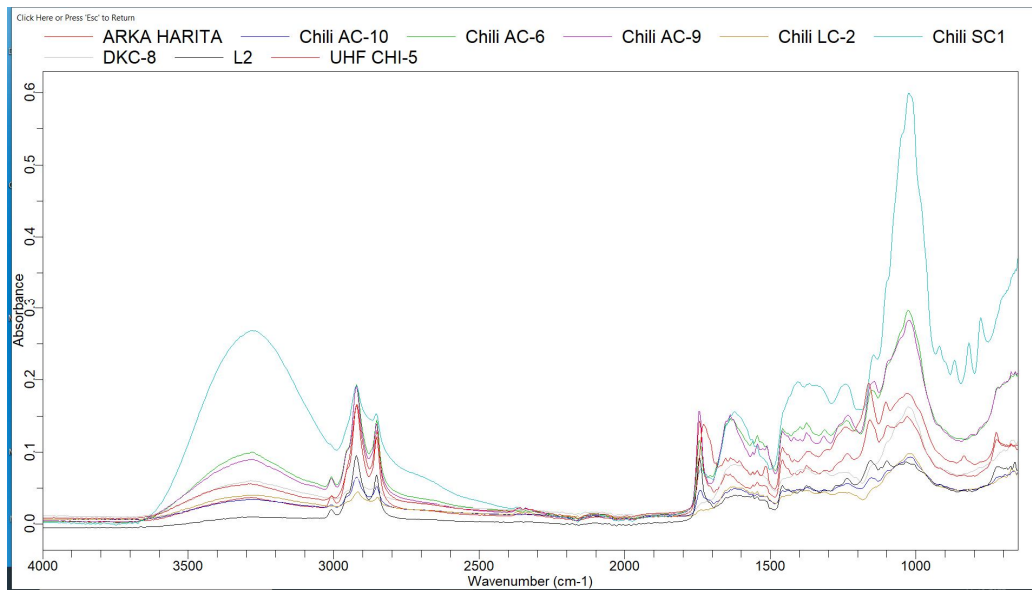


Fig. 2. FTIR characterization of chili landraces