European Journal of Nutrition & Food Safety

Volume 16, Issue 9, Page 11-21, 2024; Article no.EJNFS.122014
ISSN: 2347-5641

Phytochemical and Antioxidant Profiling of Chilli (*Capsicum annuum* L.) Landraces from Hilly Regions of India

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Authors' contributions

This work was carried out in collaboration among all authors. Authors DK, Akanksha Singh and AV designed the experiment. Authors Akanksha Singh, AK, Aadisha Saini and VK analysed the data. Authors DK, SK, RK, CP and JS drafted the manuscript. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/ejnfs/2024/v16i91522

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/122014

Original Research Article

Received: 20/06/2024
Accepted: 22/08/2024
Published: 28/08/2024

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Cite as: *Kumar, Dharminder, Akanksha Singh, Ankit Kumar, Aadisha Saini, Vikas Kumar, Sandeep Kumar, Raj Kumar, Chander Parkash, Amit Vikram, and Jagmeet Singh. 2024. "Phytochemical and Antioxidant Profiling of Chilli (Capsicum Annuum L.) Landraces from Hilly Regions of India". European Journal of Nutrition & Food Safety 16 (9):11-21. https://doi.org/10.9734/ejnfs/2024/v16i91522.*

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 genotypes were 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 and genotype 'Chili SC-1' was found best in all the concerned parameters as the highest peaks of the respective sample were observed concerning all other samples. 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 chili is sometimes referred to as a vitamin C pill also [3]. 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 is the also type of carotenoids found in chili that contribute to its ultimate red color [4]. Besides, it contains beneficial bioactive substances with antibacterial, antioxidant and anti-inflammatory activities. The antioxidants present in chilli helps in scavenging free radical from the body and subsequently induces a protective effect against oxidative damage. The principal chemical element of chilli fruits is a crystalline and acrid volatile alkaloid capsaicin which is found mainly in the placenta of fruits. 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 their pungency. The level of pungency varies greatly with different genotypes [5]. 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 concerning various species of chili in hilly regions [6]. Genotypes of chilies come in a wide range of variability, which opens up a lot of opportunities for systematic breeding to increase fruit yield. However, the process is complex due to environmental fluctuations. A necessary prerequisite for creating an efficient breeding program is estimating the genetic variability available in the germplasm of a crop [7]. For the most precise and maximal effect of selection to be determined, it was recommended to take into account genetic variability in addition to heredity. There is a need to reduce the data set too. Because of this, it is imperative to know the principal component and clustering of data sets. Therefore, principal component analysis and cluster analysis are essential techniques to mask the connection between phytochemical potential [8]. Despite of immense variability observed in the crop, there is a lag of concrete information concerning its 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 Chemical and Phytochemical analysis

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 a colorimetric method [9]. Total flavonoid content (TFC) and total polyphenolic content (TPC) were estimated [10]. Total carotenoids (TC) and ascorbic acid (AA) were determined by a standard titrimetric method [11]. The total capsaicinoids (TCap) content was determined using the procedure devised by Sadasivam and Manickam [12].

Table 1. List of chilli landraces along with their sources used in the 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)

2.2 Antioxidant Activity

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 [13,14,15].

2.3 FTIR Spectra

The different genotypes of chilli were also tested for FTIR spectra using an Agilent Cary 630 FTIR spectrometer. All samples were evaluated at room temperature and the spectra were collected.

2.4 Data Analysis

The data obtained from the analysis were subjected to analysis of variance (ANOVA) with a 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

3.1 Chemical and Phytochemical Analysis

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 [16]. 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 to have significantly the highest TS as well as RS (Table 1). The different chilli genotypes were also evaluated for different phytochemical parameters and wide range of variations are attributed to genotypic differences [17]. 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). Besides, TPC is considered a major contributing factor to the antioxidant activity of chillies. 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. In an earlier study, [18] it was revealed that TPC of different chilli genotypes ranged from 53.73to 200.41mg/100g GAE DW, which is quite similar to our results.

Table 2. Chemical and phytochemical evaluation of chilli landraces

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^{li}	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^{jkl}	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}

Where, TFC: Total flavonoid content; TPC: Total polyphenolic content

**Data is represented as mean ± standard deviation, where n = 24; Different alphabets (a, b, c……) in superscripts represents significant difference between different genotypes.*

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^{jk}	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}

Where, DPPH: 2,2-diphenyl-1-picryl-hydrazyl-hydrate, FRAP: Ferric reducing antioxidant power, ABTS: Azino-bis 3-ethylbenzothiazoline-6-sulfonic acid, RPA: Reducing power assay, MCA: Metal chelating activity

**Data is represented as mean ± standard deviation, where n = 24; Different alphabets (a, b, c……) in superscripts represents significant difference between different genotypes.*

Table 4. Principal component analysis for different quality traits of chilli landraces

Traits	Principal Component		
	PC1	**PC2**	**PC3**
Total sugars	-0.29	-0.23	-0.37
Reducing sugars	-0.29	-0.41	-0.21
Total flavonoid content	-0.17	0.51	-0.33
Total polyphenolic content	-0.38	-0.13	0.04
Total carotenoids	-0.14	-0.45	-0.39
Ascorbic acid	-0.26	0.16	-0.06
Total capsaicinoids content	-0.19	-0.03	0.13
DPPH(2,2-diphenyl-1-picryl-hydrazyl-hydrate)	-0.35	0.08	0.26
FRAP (Ferric reducing antioxidant power)	-0.36	0.14	0.25
ABTS (Azino-bis 3-ethylbenzothiazoline-6-sulfonic acid)	-0.35	0.21	0.24
RPA (Reducing power assay)	-0.39	-0.03	0.08
MCA (Metal chelating activity)	0.07	-0.45	0.59
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**

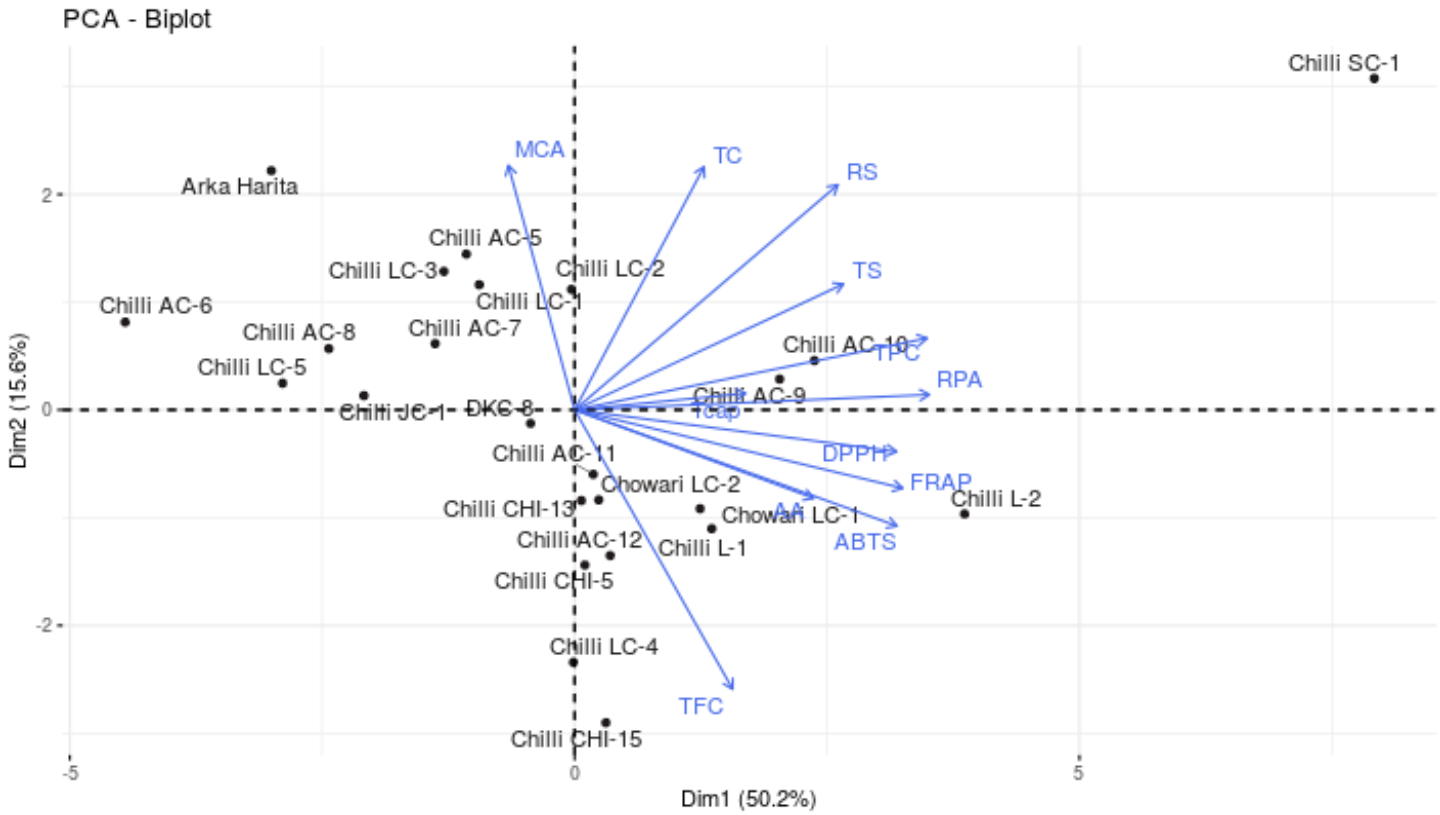

Fig. 1. Loading of different traits and landraces based on the first two principal components

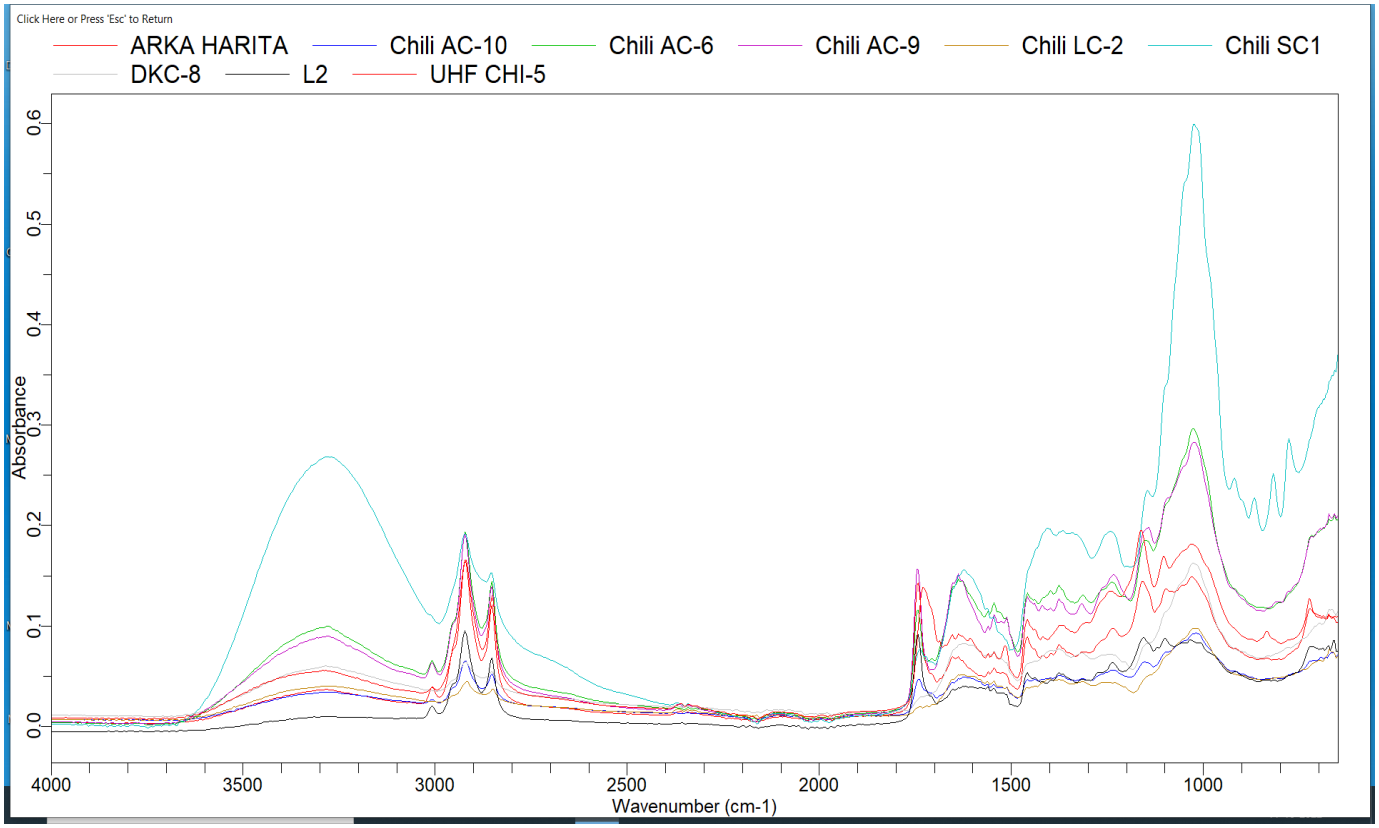

Fig. 2. FTIR characterization of chilli landraces

The major colouring component of chillies is the carotenoids. A wide variation was observed among the genotypes concerning total carotenoids. It was ranged between 18.41 mg/100g (Chilli CHI-5) to 101.66 mg/100g (Chilli SC-1). In a previous study, three Mexican genotypes of chillies showed varied concentrations of carotenoids i.e., guajillo-3406 µg/g, pasilla-2933 µg/g, and ancho-1437 µg/g [19]. The above instances revealed that chillies are a good source of TC with a wider range of variability. The ascorbic acid content was found to be 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. Earlier [20] 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. The highest capsaicinoids content was found in DKC-8 (0.49%) and lowest was noticed in Chilli AC-7 (0.18%). 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 [21]. The variation in capsaicinoids content may be attributed to genotypic differences.

3.2 Antioxidant Activity

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 [22]. FRAP measures the reducing potential of an antioxidant reacting with the ferric tripyridyl triazine (TPTZ) complex producing a coloured complex [23]. The highest DPPH activity was found in the genotype Chilli L-2 (11.69), whereas, the lowest was observed in ChilliAC-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. 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 [24]. 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). The variation lies in the antioxidant properties of different chilli genotypes are highly attributed to ascorbic acid content, TFC, TPC, and other phytochemicals [22].

3.3 Principal Component Analysis

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 (Fig. 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 the 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 the divergence between different quality traits under study, whereas the contribution of DKC-8 and Chilli LC-4 was found least in divergence.

3.4 FTIR Spectra

The FTIR was applied to chilli genotypes to detect the functional as well as other fingerprint groups (Fig. 2). The FTIR spectra of chilli samples were recorded in the range of 4000 to 400 cm^{-1} and the peaks were elaborated [25]. 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 Fig. 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} indicate 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. Genotype Chili SC-1 was found best in all the concerned parameters as the highest peaks of the respective sample were observed concerning all other samples.

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 andantioxidant 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.

ACKNOWLEDGEMENTS

The author would like to thank the Department of Vegetable Science, Dr. YS Parmar UHF, Nauni (Solan) HP 173230, India.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/122014