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Screening of short-day onion cultivars of India for vitamin-C content

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ABSTRACT

Onion has been used to cure various health problems and has many functional and therapeutic values. Its bulbs are a rich source of sulphur containing organic compounds, minerals, vitamins, etc. However, onion bulbs as a source of vitamin C are specifically undervalued. Vitamin C or ascorbic acid is an indispensable constituent of all living cells and tissues for various metabolic functions and acts as a potent antioxidant to mitigate oxidative stress. For quantification of ascorbic acid, forty-five short-day Indian commercial varieties representing white to red bulb colour were used for the present study. A highly significant variation in the concentration of ascorbic acid among genotypes was observed. The ascorbic acid concentration in raw bulbs ranged from 4.94 to 45.05 mg/100 g on a fresh weight (FW) basis, whereas it varied from 59.51 to 173.56 mg/100 g on a dry weight (DW) basis. Variations in ascorbic acid content were observed with respect to bulb colour. White onion exhibited lower concentration compared to red-coloured varieties. As per the recommendation of ICMR, one hundred grams of raw onion bulb of variety containing the highest ascorbic acid could supply 85-90% of the recommended daily allowance (RDA) of vitamin C to adults per day. This information would also greatly help future breeding programs to develop new cultivars possessing higher amounts of ascorbic acid to ensure nutritional security in India.

Keywords: *Allium cepa*, Short day, Ascorbic acid, Bulb colour.

INTRODUCTION

Vitamin C, as water-soluble vitamin, has attained utmost attention and focus from nutritionists, plant scientists, and other researchers, primarily due to its strong antioxidant properties (Campos *et al.,* 4). During the recent pandemic of COVID-19 (SARS-CoV2), this vitamin gained unanticipated popularity amongst common people as an immunity booster and source of other useful phytonutrients (Carr and Rowe, 5; Kumari *et al.,* 12; Singh *et al.,* 21). For various physiological and biochemical activities in the body, various vitamins are needed but most of these vitamins like A, B, C, E, K, etc are not produced by the body. Hence, such vitamins could be acquired from the diet. Vitamin C, also known as ascorbic acid, is one of the important vitamins which is water-soluble, unstable, and oxidized easily in the body. It plays important role in the body for normal physiological activities *viz*., tyrosine, tryptophan, and folic acid metabolism; strong antioxidant; regulation of nervous system; reducing blood cholesterol; tissue growth and healing of wounds; neurotransmitters formation; and enhancing the absorption of iron in the gut region. On the other hand, its deficiency leads to scurvy, bleeding gums, anaemia, muscle degeneration, neurotic disturbances, poor wound healing, etc (Iqbal *et al.,* 10). As such, no toxicity has been documented due to excess intake of Vitamin C.

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Considering the United Nation's second Sustainable Development Goal (SDG-2), it is necessary to reorient our food production from a traditional way to enhance quality with more essential nutrients in a sustainable method. To address malnutrition, food quality and diversity are critical factors. For ages, plants have been used for various essential nutrients and as traditional medicines for several diseases and health benefits. Subsequently, there are various biologically active non-nutrient phytochemicals present in vegetables and fruits that are being consumed for decades for proper functioning, maintenance, growth, and development of the human body (Schreiner and Huyskens-keil, 18). Vegetables are the cheapest and most affordable source of essential nutrients such as minerals, vitamins, and other beneficial phytochemicals.

Among vegetables, onion (*Allium cepa* L.), is the most important crop grown from cool temperate to tropical climatic conditions and used in almost every kitchen of India for culinary and fresh purposes (Singh and Khar, 20). Onions have been grown since antiquity for culinary and medicinal purposes owing to their properties. *Alliums* have been utilized for the treatment of various infections and diseases (Rose *et al.,* 15) and onion demand is soaring day by day (Dhumal *et al.,* 7). Subsequently, the onion processing industry has also evinced keen interest to process it

into several processed products like powder, pickles, and juice concentrate for seasoning and flavouring food and also for cosmetic industrial uses (Böttcher *et al.*, 3). Variation in the bulb colour may affect their nutritional properties, taste, flavour, and pungency under specific growing conditions.

Vitamin C, being an essential and inexpensive nutrient, has been proposed for SARS-CoV-2 coronavirus patients (Carr and Rowe, 5). Documentation of assessment of Vitamin C in Indian onion is not much available in the literature. Onion bulbs possess a good amount of Vitamin C (Mitra *et al.*, 13). Elhassaneen and Sanad (8) evaluated two local varieties for vitamin C content and recorded 14.63±4.70 and 13.84±2.90 mg per 100 g of the edible portion of red and white onion bulb varieties, respectively. Samancioglu *et al.,* (16) observed Vit C of about 14.66±1.45 mg per 100 g of fresh weight basis in *Allium ampeloprasum* L. Information on vitamin C content of onion is scanty. The aim of this research study was to assess the amount of vitamin C in Indian short-day onion varieties possessing white to red bulb colour for ensuring nutritional security and boosting immunity.

MATERIALS AND METHODS

The field experiment was conducted at Research Farm, Division of Vegetable Science, Indian Agricultural Research Institute, New Delhi (latitude 35° 54′ 55″ N, long. 128° 46′ 96″E, alt. 24 m) during the 2020-21 growing season. The research trial was laid out in randomized complete block design (RCBD) with three replications. Onion varieties (n=45), with the bulb colour ranging from white to dark red, were collected from the DUS project IARI, New Delhi (Table 1). Seedlings of all varieties were transplanted and recommended agronomic practices were followed for the successful bulb crop.

Fully matured bulbs were harvested at an optimum harvesting stage of each variety. Three random bulbs were selected from three replications and fresh samples were taken by cutting 1.5-2 mm central whole circular ring for the determination of Vitamin C content. 1.0g sample was crushed in 3% metaphosphoric acid and stored in the refrigerator overnight at 4°C. The next day, samples were centrifuged at 8000 rpm for 10 mins. After that, the supernatant was collected and made up to the volume of 10 ml by adding 3% metaphosphoric acid. From this 10 ml volume, 500 µl of each sample was taken and added 700 µl of 3% metaphosphoric acid and 2.8 ml of double-distilled water. Subsequently added 400 µl Folin Ciocalteu Reagent (FCR) and mixed properly. After 30 mins, UV- visible spectrophotometer (Shimadzu UV-1900i UV-Vis Spectrophotometer, Japan) was used to take OD value at 760 nm wavelength. For blank, 3% metaphosphoric acid was used (Jagota and Dhani, 11). A standard curve was prepared using ascorbic acid from 0.1 to 1%.

One-way analysis of variance (ANOVA) was performed to test for differences amongst varieties with respect to their Vitamin C content. The mean difference of Vitamin C content, among varieties, was declared significant on the basis of the least significant difference (LSD) test at 5% level of significance. UPGMA and Euclidean distance were used to make dendrogram using SAS Software version 9.3 (SAS Institute, Cary, NC, USA).

RESULTS AND DISCUSSION

Significant variation in the level of Vitamin C among genotypes was observed (Table 1) both on the basis of fresh and dry weight. The concentration of Vitamin C in bulbs ranged from 4.94 to 45.05 mg/100 g on a fresh weight basis (Fig. 2). Further, it was observed that bulb colour influenced the availability of Vitamin C in the fresh bulbs. The vitamin C levels were relatively low in the white coloured bulbs compared to light-red coloured bulbs. In the same way, Elhassaneen and Sanad (8) documented that red coloured bulbs contained more vitamin C content than white onion.

On the basis of fresh weight, among forty-five varieties, red coloured variety ‘NHRDF-Red L-28’ contained a significantly higher amount of vitamin C (45.05 mg/100 g of FW), followed by ‘RO-59’ (31.01) and Bhima Dark Red (20.48). On the other hand, the lowest amount of vitamin C was quantified in the white variety ‘Akola Safed’ (4.94 mg/100 g of FW) followed by yellow coloured ‘Early Grano’ (6.67) and white coloured ‘Bhima Shubra’ (7.22). It was determined that the difference between the variety possessing the highest and lowest amount was more than 9 times. The popular red coloured bulb commercial variety ‘Pusa Red’ had approximately three times less vitamin C (16.09 mg/100 g FW) than ‘NHRDF-Red’ (L-28). Vitamin C content in both the red coloured varieties ‘KRR’ and ‘Sukhsagar’ was significantly *at par i.e.*, 18.19 and 19.09 mg per 100 g FW, respectively. Sami *et al*. (17) estimated 45.07 mg/100 g−1 FW Vitamin C content in the red coloured onion variety in Saudi Arabia.

On the basis of dry weight, significant differences were observed but lower as compared to fresh weight basis (Table 1 and Fig. 4) and it ranged from 59.51 to 173.56 mg/100 g DW. Among the forty-five onion varieties, IARI variety red bulb coloured ‘Pusa Madhavi’ (173.56 mg/100 g DW) exhibited significantly highest amount of Vitamin on the basis of dry weight followed by ‘Bhima Super’ (160.85

Table 1. Assessment of vitamin C on fresh and dry weight basis (mg per 100 g) in the open pollinated and commercially adopted sort day onion varieties from India.

S. No.	Variety	Releasing State	Bulb Colour	Mean value of Vit C mg/100 g of FW*	Mean value of Vit C mg/100 g of DW
1	Akola Safed	Maharashtra	White	4.94^{a}	59.51^{a}
2	Early Grano	New Delhi	Yellow	6.67^{b}	80.52^{abcde}
3	Bhima Shubra	Maharashtra	White	7.22^{bc}	87.78^{abcde}
4	JWO-1	Gujarat	White	7.79^{cd}	113.29^{abcdefgh}
5	Bhima Shweta	Maharashtra	White	7.85^{cde}	123.04^{abcdefgh}
6	Pusa Riddhi	New Delhi	Red	8.64^{def}	109.82^{abcdefgh}
7	PWR	New Delhi	White	8.77^{defg}	85.18^{abcde}
8	NHRDF Fursungi	Maharashtra	Red	8.89^{efg}	133.95^{cdefgh}
9	PKV White	Maharashtra	White	8.95^{fgh}	93.51^{abcdef}
10	Bhima Shakti	Maharashtra	Red	9.01^{fghi}	61.40^{ab}
11	PWF	New Delhi	White	9.14^{fghij}	73.12^{abc}
12	VL Pyaz	Uttarakhand	Red	9.75^{ghijk}	123.46^{abcdefgh}
13	RO-252	Rajasthan	Red	10.00^{hijkl}	77.72^{abcde}
14	Udaipur Local	Rajasthan	Red	10.05^{ijklm}	72.03^{abc}
15	GJWO-3	Gujarat	White	10.12^{jklm}	158.34^{fgh}
16	GJWO-11	Gujarat	White	10.45^{klmn}	90.83^{abcde}
17	JNDWO-085	Gujarat	White	10.69^{klmno}	131.09^{cdefgh}
18	Arka Pitamber	Karnataka	Yellow	10.91^{lmnop}	91.85^{abcde}
19	Bhima Kiran	Maharashtra	Red	11.11^{mnopq}	131.16^{cdefgh}
20	Phursungi Local	Maharashtra	Pink	11.23^{nopq}	81.74^{abcde}
21	Pusa Shobha	New Delhi	Brown	11.36^{nopqr}	101.89^{abcdefg}
22	XP Red	New Delhi	Red	11.48^{nopqr}	83.13^{abcde}
23	AFW	Maharashtra	White	11.56^{opqrs}	120.72^{abcdefgh}
24	Pusa Sona	New Delhi	Yellow	11.57^{opqrs}	127.69^{cdefgh}
25	Talaza Red	Gujarat	Red	11.81^{pqrst}	82.74^{abcde}
26	JRO-11	Gujarat	Red	11.85^{pqrst}	70.97^{abc}
27	Bhima Raj	Maharashtra	Red	11.98^{pqrst}	125.07^{bcdefgh}
28	HOS-4	Haryana	Red	12.099^{pqrstu}	122.61^{abcdefgh}
29	Bhima Light Red	Maharashtra	Red	12.33^{rstuv}	109.73^{abcdefgh}
30	Pusa Madhavi	New Delhi	Red	12.59^{stuvw}	173.56^{h}
31	Arka Bheem	Karnataka	Red	12.59I^{stuvw}	89.54^{abcde}
32	NHRDF Red-4	Maharashtra	Red	12.84^{tuvw}	128.62^{cdefgh}
33	L-819	Haryana	Red	13.17^{uvw}	120.74^{abcdefgh}
34	Punjab Naroya	Punjab	Red	13.33^{vw}	134.59^{cdefgh}
35	Bhima Super	Maharashtra	Red	13.58^{wx}	160.85^{gh}
36	Hisar-2	Haryana	Red	14.57^{xy}	77.26^{abcd}
37	B-780	Maharashtra	Red	15.57^{yz}	132.98^{cdefgh}
38	Bhima Safed	Maharashtra	White	15.89$^{z{}}$	122.91^{abcdefgh}
39	Pusa Red	New Delhi	Red	16.09$^{z{}}$	92.63^{abcde}

Contd...

Table 1 contd...

S. No.	Variety	Releasing State	Bulb Colour	Mean value of Vit C mg/100 g of FW*	Mean value of Vit C mg/100 g of DW
40	PRO-6	Punjab	Red	16.91$^{\{}$	158.56^{fgh}
41	KRR	Uttar Pradesh	Red	18.19$^{|}$	124.04^{abcdefgh}
42	Sukhsagar	West Bengal	Red	19.09$^{|}$	120.46^{abcdefgh}
43	BDR	Maharashtra	Red	20.48$^{}$	142.70^{efgh}
44	RO-59	Rajasthan	Red	31.01$^{~}$	142.34^{defgh}
45	NHRDF-Red L-28	Haryana	Red	45.05$^{□}$	139.36^{defgh}

*Means were separated by Least Significance Difference (LSD) at 5% probability. Means followed by the same letters within a column do not differ significantly.

mg/100 g DW), 'PRO-6' (158.56 mg/100 g DW) and 'GJWO-03' (173.56 mg/100 g DW). However, the lowest values were recorded in 'Akola Safed' (59.51 mg/100 g DW) followed by 'Bhima Shakti' (61.40 mg/100 g DW) and 'JRO-11' (70.97 mg/100 g DW).

Among yellow coloured bulb varieties, 'Early Grano' recorded a significantly lower amount (6.67 mg/100 g FW) than 'Arka Pitamber' and 'Pusa Sona' (10.91 and 11.57, respectively). However, both were not significantly different from each other. Similarly, Mota *et al.,* (14) determined 1889±69 mg/100 g on dry weight basis Vitamin C from a Portuguese local variety 'Mondego'. It is well documented that various factors such as genotype, climatic or seasonal conditions, and physiological stage of the bulb influence the quantity of several phytochemicals significantly possessed by onion bulbs (Sellappan and Akoh, 19). Quantification of vitamin C content in Indian commercial cultivars and even in other countries have not been given much attention. In general, a lesser amount of Vitamin C is determined in white onions compared to red coloured bulb onions. It is well documented that various factors such as genotype, seasonal conditions and physiological stage of the bulb influence the quantity of several phytochemicals significantly possessed by onion bulbs (Bilyk *et al*., 2; Crozier *et al*., 6; Sellappan and Akoh, 19). In citrus, Barros *et al*. (1) documented a widespread range in vitamin C content.

The clustering of commercially grown 45 open-pollinated Indian onion varieties based on their Vitamin C concentration in the edible portion is displayed in the UPGMA dendrogram (Fig. 1). In cluster analysis, 45 commercial onion varieties were clustered into two clusters. Cluster I comprised of two genotypes namely NHRDF-Red (L-28) and RO-59 which possessed an exceptionally higher level of vitamin C and had red coloured bulbs. On the other hand, Cluster II is comprised of 43 varieties having red, white and yellow bulb colours. Cluster II was further subclustered into subcluster IIA and IIB which contained 15 and 28 varieties, respectively (Table 2). Furthermore, subcluster IIA formed two groups and IIB was subdivided into two groups. Bhima Dark Red, Sukhsagar, and KRR having red coloured bulbs formed one group while, varieties developed from Gujarat formed one group namely JNDWO-85, GJWO-11, and GJWO-3 on the basis of similarity index.

The concentration of Vitamin C possessed by 45 onion varieties was significantly influenced by genotype and bulb colour (Table 2, Fig. 3). The vitamin C ranged from 4.94-45.05 mg per 100 g fresh weight of bulb onions cultivated under trans-

Table 2. Clustering of onion varieties on the based on the vitamin C content on fresh weight basis.

Cluster	Sub-cluster	Number	Varieties included
I	-	2	NHRDF-Red (L-28) and RO-59
II	IIA	15	Bhima Dark Red, Sukhsagar, KRR, PRO-6, Pusa Red, Bhima Safed, B-780, Hisar-2, Bhima Super, Punjab Naroya, L-819, NHRDF Red, Arka Bheem, Pusa Madhavi and Bhima Light Red
	IIB	28	HOS-4, Bhima Raj, JRO-11, Talaja Red, Pusa Sona, AFW, XP Red, Pusa Shobha, Phursungi Local, Bhima Kiran, Arka Pitamber, JNDWO-85, GJWO-11, Udaipur Local, RO-252, VL Pyaz, PWF, Bhima Shakti, PKV White, NHRDF Fursungi, PWR, Pusa Riddhi, Bhima Shweta, JWO-1, Bhima Shubra, EG and Akola Safed

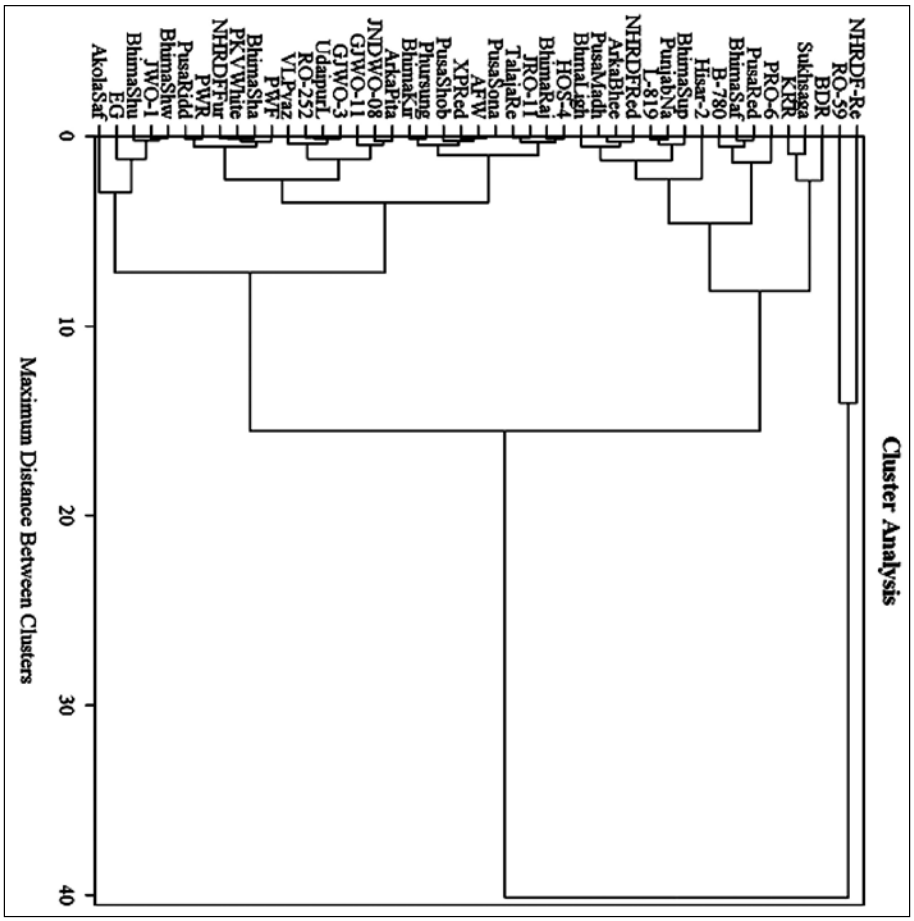

Fig. 1. Dendrogram obtained from Euclidean distance and Unweighted Pair Group Method using Averages (UPGMA) based on Vitamin C content on fresh weight basis possessed by 45 commercial open pollinated onion varieties.

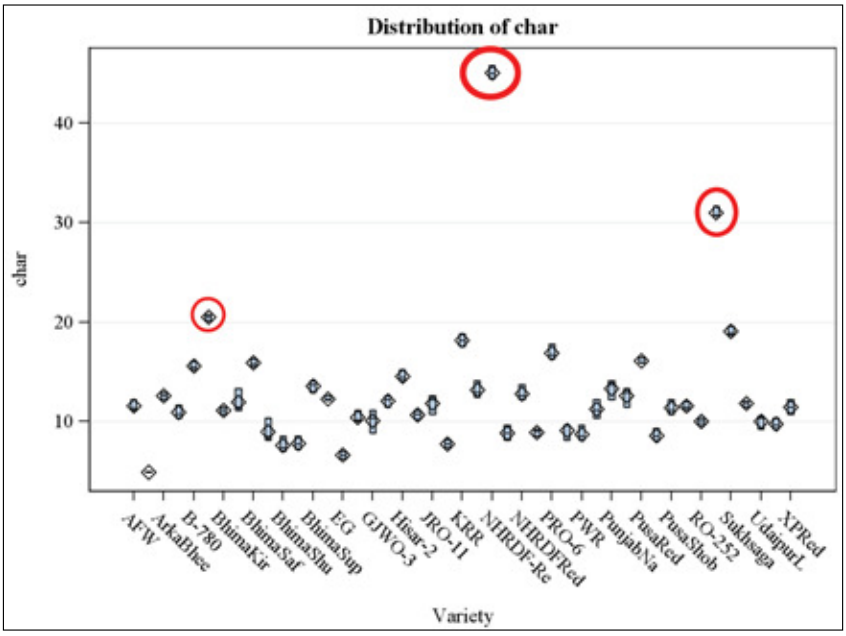

Fig. 2. Scatter diagram of 45 onion varieties possessing variable Vitamin C content on fresh weight basis.

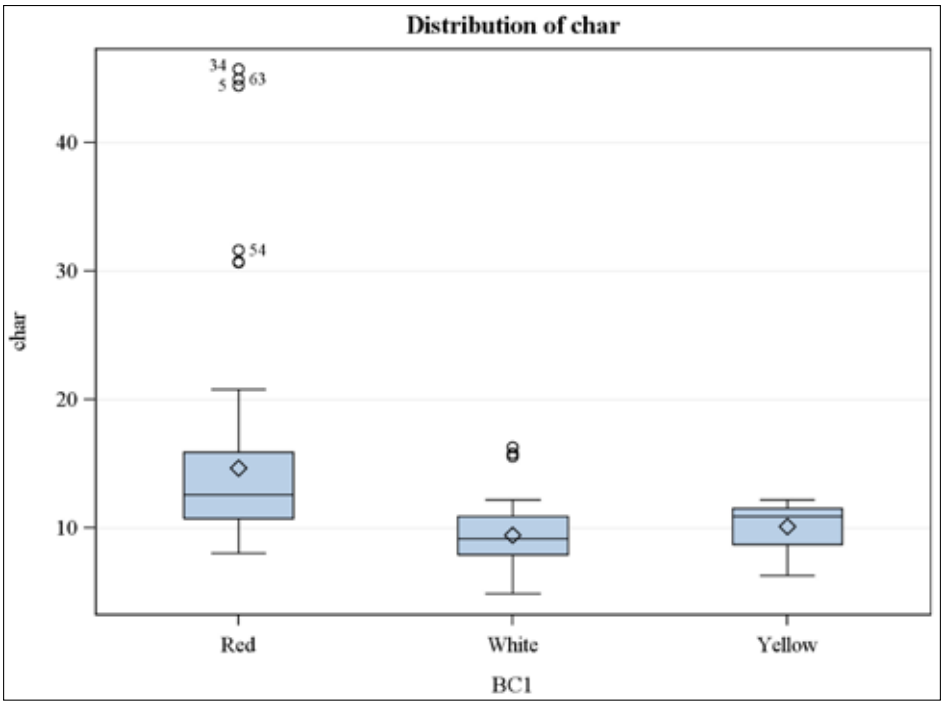

Fig. 3. Boxplot distribution of Vitamin C concentration on the basis of bulb colour and on fresh weight basis

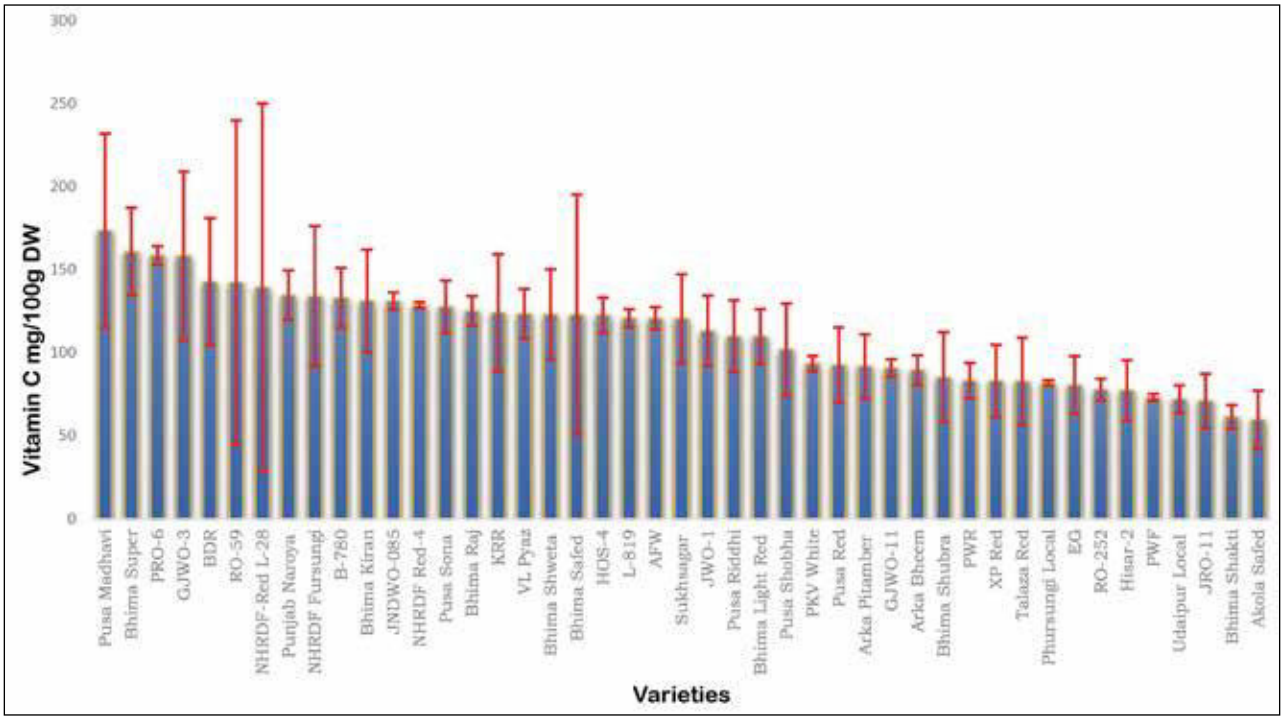

Fig. 4. Vitamin C concentration in the forty-five open pollinated Indian short-day onion varieties on the basis of dry weight (expressed in mg/100 g dry weight).

Gangetic plains of Delhi. The average of Vitamin C in red, yellow, and white bulbs was calculated as 14.67, 10.13, and 9.48 mg per 100 g FW exhibited a significant difference among the three groups. This data displayed that the bulb colour of onion affects vitamin C amount (Table 3). In the case of red bulbs,

Table 3. ANOVA on the basis of colour of bulb.

	Red	White	Yellow
Mean	14.67	9.48	10.13
Standard Deviation	7.30	2.65	2.16
Minimum	8.07	4.90	6.30
Maximum	45.74	16.30	12.22

the wideness of range was broad from 8.07 to 45.74 mg. The lowest amount among all studied cultivars was found in 'Akola Safed' which is developed for the tropical climate of Maharashtra.

The human body cannot synthesize ascorbic acid and are dependent only on the daily diet particularly vegetables and fruits. To ensure nutritional security, a nutrient-enriched healthy and balanced diet comprising of vegetables and fruits is mandatory. For India, 40 mg per day of vitamin C for both normal men and women are recommended. However, 60 and 80 mg are recommended for pregnant and lactating ladies, respectively (ICMR, 9). On the basis of the average amount of vitamin C in Indian 45 onion varieties, consumption of 100 g bulb provides about 30% RDA of Vitamin C as recommended by ICMR. However, 100 g of NHRDF-Red L-28, 150 g of RO-59, and 200 g of Bhima Dark Red and Sukhsagar would fulfil the daily required Vitamin C amount.

Based on the data obtained by the current study, the commercial Indian onion varieties such as NHRDF-Red (L-28), RO-59, Bhima Dark Red, Sukhsagar (red coloured); Bhima Safed (white), and Pusa Sona (yellow) might be exploited as a parent for further breeding program and intensive study for biofortification of onion with Vitamin C. In the future, cultivars with higher amounts of vitamin C could also be advantageous for the food and processing industry. Other than vitamin C-enriched vegetables, onion could be another option to fulfil the daily requirement of Vitamin C since this bulbous crop is being used almost in every Indian kitchen. Now, it becomes essential to develop new cultivars enriched with Vitamin C along with other beneficial phytochemicals in India. The data obtained from the present study will enable more efficient and rapid exploitation of their potential in further onion quality breeding programs to ensure nutritional security.

AUTHORS' CONTRIBUTION

Conceptualization (AK, HS); Designing of the experiments (AK, HS); Execution of field/lab experiments and data collection (HS, PV); Analysis of data and interpretation (AK, HS); Preparation of the manuscript (HS, AK).

DECLARATION

The authors declare that they have no conflict of interest.

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