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Nutrient composition and antioxidant components of newer carrot germplasms

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Abstract
Nine newly identified carrot germplasms and one local carrot variety were evaluated in terms of nutrient composition and antioxidant components. For the proximate composition the difference in the mean values were significant at $p < 0.01$ level among the carrot germplasm. The total dietary fibre and sugar content of germplasms varied from 3.69 – 5.96 g/100 g and 8.38 – 11.18 g/100 g respectively. The minerals like calcium, phosphorous and iron content ranged from 75.16 – 101.75 mg/100g, 50.80 – 64.60mg/100 g. and 2.32 – 3.17mg/100 g respectively. The antioxidant components of carrots *viz*. total carotene, beta carotene, phenols and antioxidant activity varied from 4.35 – 13.74 mg/100g, 0.91 – 4.16 mg/100g, 1.97 – 3.98 mg/ 100g and 24.15 – 32.21% respectively. Germplasms UHSBC64, UHSB101 and UHSBC44-1 were good sources antioxidant components. Carrot germpalsms UHSBC53, UHSBC64 and UHSBC23-1 were on par with local carrot variety with regard to proximate composition, total dietary fibre, sugars, minerals and antioxidant components.

Keywords: Carrot germplasms, nutrient composition, total carotene, beta carotene, antioxidant activity

Introduction
Carrot is the diverse coloured crop grown for the edible purpose belonging to *Umbelliferae* family grown throughout the world. It is the only colored root crop with different types of pigments in the form of carotenoids and flavonoids that impart antioxidant properties in addition to colour. The carrot roots are the unique roots rich in carotenoids and have a characteristic flavor due to the presence of terpenoids and polyacetylenes. The amount of sugars in carrots has an obvious influence upon the perception of the sweet taste and can also hide bitter taste. In carrots glucose, fructose and sucrose are major sugars and their availability is relatively high. The variance in the pigments results in the formation of red, orange, yellow, purple, black and white roots.

Carrot is rich in pro-healthy antioxidants. Carotenoid content varies considerably among carrot genotypes. Orange and red rooted carrots accumulate large amounts of carotenoids mainly α and β-carotene, yellow carrots contain low amounts of carotenoids and white-rooted ones contain negligible amounts of carotenoids. Carrots are also a good source of carbohydrates and minerals like calcium, iron, phosphorous and magnesium. High biological value of carrots is mainly due to presence of carotenoid compounds and dietary fibre.

The consumption of carrots has many health benefits. Carotenoids help for inhibition of mutagenic activity contributing to decrease the risk of cancers. Beta carotene helps to protect vision, especially night vision and provides protection against macular degeneration and development of cataract, the leading cause of blindness in aged people. Phenols exert anticarcinogenic activities, reduce inflammatory insult, and modulate immune response. Dietary fibre lowers cholesterol levels, helps to control blood sugar levels and normalize bowel movements.

High yielding newer carrot varieties are grown in the horticulture department and are not tested for their nutrient composition and antioxidant components. Hence the present study was undertaken with an objective to analyse the nutrient composition and antioxidant components of newer carrot germplasms.

Material and methods
Nine newly identified carrot germplasms *viz*. UHSBC51, UHSBC52, UHSBC53, UHSBC59, UHSBC64, UHSBC101, UHSBC23-1, UHSBC34-1 and UHSBC44-1 were collected from Regional Horticulture Research and Extension centre Dharwad, University of Horticulture sciences Bagalkot, Karnatka. One variety was taken for comparison from Dharwad local market as a control (LC).

Nutrient composition

Proximate composition of carrot germplasms (moisture, crude fat, crude protein, crude fiber and ash) was determined using standard AOAC method (Anon., 2005) [1]. The carbohydrate were calculated by difference method. The soluble, insoluble and total dietary fibre fractions were analyzed by enzymatic method (Asp *et al*, 1983) [2]. The total, reducing and non-reducing sugars were determined by Nelson-Somogyi's method. The minerals viz., calcium was determined by titrimetric method, phosphorous was measured by colorimetrically at 650 nm (Ranganna 1986) [13] and iron content was estimated by using Atomic Absorption Spectrophotometer.

Antioxidant components

The total carotene and beta carotene were estimated by using column chromatography and absorbance of the extract was measured at 452 nm. Polyphenol was estimated using Folin – Ciocalteau reagent (Sadashivam and Manicham, 2008) [15]. Antioxidant activity was assessed using DPPH spectrophotometric method (Dorman *et al.,* 2004) [6]. The results were statistically analyzed by one way ANOVA using SPSS software.

Results and discussion

The proximate composition of carrot germplasms viz., moisture, crude protein, crude fat, crude fiber, ash and carbohydrate on dry weight basis are presented in Table 1. The difference in the mean values were significant at $p < 0.01$ level among the carrot germplasms. The moisture, protein, fat, crude fibre, ash and carbohydrate content of carrots ranged from 6.08 – 7.92 %, 4.72 – 6.82 g/100g, 1.40 – 2.04 g/100g, 8.51- 10.48 g/100g, 5.28 – 7.47 % and 66.98 - 73.99 % respectively. Highest moisture content was observed in the germplasm UHSBC101 (7.92 %), protein in UHSBC101 (6.82 g/100 g), fat in local carrot variety (2.04 g/100 g), crude fibre in UHSBC23-1 (10.48 g/100 g), ash in UHSBC51 (7.47%) and carbohydrate in UHSBC59 (73.99%). Germplasm UHSBC59 had got a least values for proximate composition i.e. moisture (6.08%), crude protein (4.72 g/100 g), crude fat (1.40 g/100 g), crude fiber (8.51 g/100 g) and ash (5.28%). Similar studies have been reported by various authors. The mean values obtained in the present study are in agreement with the studies conducted by Shankaralingam (2004) [16] and Singh *et al.* (2013) [19] for moisture, protein and ash content. However, Nagarajaiah and Prakash (2015) [12] and Atta *et al.* (2017) [3] reported higher values for fat and crude fibre content than that of our study. But Gull *et al.* (2013) [11] and Galvez *et al.* (2016) [9] noted lower values for protein and fat content. The wide variation in values of the present study in comparison to other studies of carrots may be attributed to varietal difference, type of soil, irrigation practices, climatic condition and temperature during growing season.

Dietary fibre content of carrot germplasms is presented in the Table 2. The soluble, insoluble and total dietary fibre content of carrots differed significantly ($p < 0.01$) among the carrot germplasm. The insoluble dietary fibre in germplasms varied from 3.30 – 5.13 g/100 g and highest level was found in the germplasm UHSBC53 (5.13 g/100 g). The soluble dietary fibre ranged from 0.70 – 0.83 g/100 g and highest level was observed in the variety LC (0.83 g/100 g). The total dietary fibre of the carrots ranged from 4.10 – 5.96 g/100 g and germplasm UHSBC53 (5.96 g/100 g) recorded highest values. Germplasm UHSBC59 recorded least values for soluble (0.63 g/100 g), insoluble (3.30 g/100 g) and total dietary fibre (3.96 g/100 g). The values of our study are higher than that reported by Silva *et al.* (2007) [18] for soluble, insoluble and total dietary fibre (0.86 – 1.14 g/100 g, 4.41 – 5.39g and 5.22 – 5.44 g/100 g respectively). Dhingra *et al.* (2012) reported different values for soluble, insoluble and total dietary fibre (0.77 – 1.47 g/100 g, 1.50 – 3.27g and 2.91 – 3.30 g/100 g respectively). The difference in the values of the present study in comparison to other studies may be due to several factors such as stage of maturity, genetic variability, environmental and seasonal factors.

The sugar content of the carrot germplasms is presented in the Table 3. The difference in the mean values of reducing, non-reducing and total sugars were significant at $p < 0.01$ level among the carrot germplasms. The reducing, non-reducing and total sugars of the carrots varied from 3.16 – 4.17 g/100 g, 4.74 – 6.66 g/100 g and 8.38 – 11.18 g/100 g respectively. The highest level of reducing sugar (4.17 g/100 g), non-reducing (6.66 g/100 g) and total sugar content (11.18g/100 g) was found in local carrot variety. The values of the present study are on par with the findings reported by Sink *et al.* (2017) for reducing, non-reducing and total sugars (3.12 – 4.21g, 3.71 – 5.82g and 7.56 – 9.61 g/100 g respectively). However Gocan *et al.* (2012) [10] have reported slightly different values for reducing, non-reducing and total sugars (range from 0.66 – 5.9g, 2.80 – 7.26g and 8.4 – 10.93 g/100 g respectively). The difference in the values of sugar content of the present study in comparison to other studies of carrots may be due to difference in the genotype, soil type and temperature during growing season.

Mineral content of carrot germplasms is shown in the Table 4. The difference in the mean values for calcium, phosphorous and iron were significant at $p < 0.01$ level among the germplasms. The calcium content of the carrot germplasm ranged from 75.16 – 101.75 mg/100 g. Highest level was observed in the germplasm UHSBC51 (101.75 mg/100 g) and least in UHSBC44-1 (75.16 mg/100 g). The phosphorous content of the carrot germplasms varied from 50.80 – 64.60 mg/100 g. highest level was observed in the germplasm UHSBC23-1 (64.60 mg/100 g) and least in local carrot variety (50.80 mg/100 g). The iron content of the carrots ranged from 2.32 – 3.17 mg/100 g. Highest level was observed in local carrot variety (3.17 mg/100 g) and least in the germplasms UHSBC59 (2.32 mg/100 g). The study conducted by Singh *et al.* (2012) reported higher values for calcium, phosphorous and iron which ranged from 33 – 80mg/100mg, 35 – 54.6 m g/100g and 0.3 – 2.2 mg/100g respectively. However Atta *et al.* (2017) [3] reported higher values for calcium and iron (mean values 155.20mg, 5.5m g/100 g) but showed lower value for phosphorous (37.20m g/100g). The wide variation in the mineral composition of carrots in the present study in comparison to other research studies may be attributed to application of natural or artificial fertilizers, climate, growing conditions, nature of soil and genetic variability.

The total carotene and beta carotene content of carrot germplasms are shown in the Table 5. The total carotene and beta carotene content of carrot germplasms which ranged from 4.35 – 13.74 mg/100 g and 0.91 – 4.16 mg/100 g respectively. The differences in mean values were significant ($p < 0.01$) among the germplasms. The highest total carotene was observed in the germpalsm UHSBC64 (13.74 mg/100 g) and beta carotene in the germplasm UHSBC101 (4.16 mg/100 g). Least level of total carotene and beta carotene was observed in the germplasm UHSBC59 (4.35 mg/100 g). The

total carotene values of the present study are in accordance with the findings reported by Gajewski *et al.* (2007) [8] and Matejkova *et al.* (2010) (0.20 – 14m g/100g). However Bender *et al.* (2009) and Bystricka *et al.* (2015) noted the higher values for beta carotene (2.45 – 12.42 mg/100g). The difference in the values of total carotene and beta carotene in the present study in comparison to other studies of carrots may be due to type of cultivar, colour of carrot, maturity at harvest, temperature during growing conditions, site of production and farming practices.

The phenolic content and antioxidant activity of the carrot germplasm is presented in the Figure 1 and 2. It ranged from 1.97 – 3.98 mg/ 100g and 24.15 – 32.21% respectively. The differences in mean values were significant at $p < 0.01$ level among the carrot germplasms. Highest level of phenols and antioxidant activity was observed in the germplasm UHSBC44-1 (3.98mg/100g and 32.21% respectively) and least in the germplasm UHSBC59 (1.97 mg/100g and 24.15% respectively). The study conducted by Sharma *et al* (2010) [7] and Gajewski *et al.* (2010) [7] reported lower values for phenols (1.26 – 2.66 mg/100 g). Bembem and Sadana (2014) and Moustafa *et al.* (2016) noted that different values for antioxidant activity which ranged from 7.96 – 40.90 %. The wide variation in the values of phenolic content and antioxidant activity of the present study in comparison to other research studies of carrots may be attributed to biosynthetic pathway during plant growth and development and environmental factors such as sunshine, temperature variation and climatic conditions within geographical location.

Conclusion

The nine newly identified high yielding carrot germplasms were good source of dietary fibre, minerals and antioxidant components. When carrot germplasms were compared with local carrot variety UHSBC101 had higher protein content (6.82g/100g) and germplasms UHSBC52, UHSBC53, UHSBC64 and UHSBC23-1 had higher total dietary fibre content (5.90-5.96g/100g). Local carrot variety was significantly high in total sugars (11.18g/100g) and iron content (3.17mg/100g) when compared to other carrot germplasms, All the carrot germplasms were significantly higher in calcium (88.76 -101.75mg/100g) and phosphorus content (59.90 – 64.60mg/100g) compared to local carrot variety. Germplasms UHSBC51, UHSBC53, UHSBC64 and UHSBC101 are significantly higher in total carotene and beta carotene content (11.40-13.74 mg/100g and 3.02-4.16 mg/100g respectively) compared to local carrot variety, All carrot germplasms except UHSBC59 had significantly higher phenolic content and antioxidant activity (2.56-3.98mg/100g and 27.04-32.21% respectively) when compared with local carrot variety. In conclusion the carrot germplasms *viz.* UHSBC53, UHSBC64, UHSBC101 and UHSBC44-1 were found to be best in terms of antioxidant components and antioxidant activity.

Table 1: Proximate composition of carrot germplasms

Carrot germplasm	Dry weight basis (%)					
	Moisture	Protein	Fat	Crude fiber	Ash	Carbohydrate
LC (Control)	7.29 ± 0.21^{c}	6.47 ± 0.17^{ab}	2.04 ± 0.09^{a}	9.22 ± 0.15^{b}	5.71 ± 0.07^{g}	69.26 ± 0.16^{c}
UHSBC 51	7.58 ± 0.07^{b}	5.78 ± 0.16^{b}	1.83 ± 0.10^{b}	10.34 ± 0.23^{a}	7.47 ± 0.07^{a}	66.98 ± 0.36^{e}
UHSBC 52	7.70 ± 0.10^{b}	5.82 ± 0.13^{b}	1.68 ± 0.07^{c}	10.07 ± 0.26^{a}	7.27 ± 0.10^{b}	67.45 ± 0.57^{de}
UHSBC 53	6.21 ± 0.10^{d}	5.78 ± 0.16^{b}	1.45 ± 0.05^{d}	10.24 ± 0.40^{a}	7.14 ± 0.09^{bc}	69.16 ± 0.66^{c}
UHSBC 59	6.08 ± 0.12^{e}	4.72 ± 0.17^{c}	1.40 ± 0.05^{d}	8.51 ± 0.07^{d}	5.28 ± 0.08^{i}	73.99 ± 0.34^{a}
UHSBC 64	6.39 ± 0.12^{d}	5.80 ± 0.17^{b}	1.66 ± 0.07^{c}	10.07 ± 0.11^{a}	7.01 ± 0.09^{c}	69.05 ± 0.68^{c}
UHSBC 101	7.92 ± 0.07^{a}	6.82 ± 0.16^{a}	1.66 ± 0.08^{c}	8.99 ± 0.11^{bc}	6.24 ± 0.09^{e}	68.36 ± 0.31^{cd}
UHSBC 23-1	7.78 ± 0.04^{ab}	6.47 ± 0.12^{ab}	1.65 ± 0.04^{c}	10.48 ± 036^{a}	6.09 ± 0.08^{f}	67.50 ± 0.10^{de}
UHSBC 34-1	7.21 ± 0.11^{c}	5.77 ± 0.17^{b}	1.46 ± 0.07^{d}	8.77 ± 0.13^{bcd}	6.44 ± 0.08^{d}	70.41 ± 0.28^{b}
UHSBC 44-1	7.29 ± 0.13^{c}	5.81 ± 0.16^{b}	1.73 ± 0.03^{bc}	8.69 ± 0.40^{cd}	5.54 ± 0.06^{h}	70.92 ± 0.52^{b}
Mean ± SD	7.13 ± 0.66	5.92 ± 0.64	1.65 ± 0.19	9.54 ± 0.77	6.42 ± 0.75	69.31 ± 1.05
F- value	96.09	6.06	21.10	26.97	272.90	40.87
S. Em. ±	0.06	0.23	0.04	0.14	0.04	0.32
C. D. @ 1% level	0.20^{**}	0.68^{**}	0.12^{**}	0.41^{**}	0.14^{**}	0.94^{**}

Note: Mean ± S.D; C.D – Critical Difference; S. Em. ± Standard Error mean; ** Significant at 0.01 percent level; Different superscript within a column indicate significant difference at 0.05 level by DMRT

Table 2: Dietary fibre content of carrot germplasms (g/100g)

Carrot germplasms	Dietary fibre (Fresh weight basis)		
	Insoluble dietary fibre	Soluble dietary fibre	Total dietary fibre
LC (Control)	4.10 ± 0.10^{c}	0.83 ± 0.05^{a}	4.93 ± 0.05^{b}
UHSBC 51	4.33 ± 0.15^{b}	0.76 ± 0.05^{ab}	5.10 ± 0.10^{b}
UHSBC 52	5.06 ± 0.05^{a}	0.83 ± 0.04^{a}	5.90 ± 0.10^{a}
UHSBC 53	5.13 ± 0.05^{a}	0.83 ± 0.05^{a}	5.96 ± 0.11^{a}
UHSBC 59	3.30 ± 0.10^{d}	0.63 ± 0.04^{c}	3.96 ± 0.11^{e}
UHSBC 64	5.06 ± 0.15^{a}	0.76 ± 0.06^{ab}	5.89 ± 0.11^{a}
UHSBC 101	3.40 ± 0.10^{d}	0.70 ± 0.10^{bc}	4.10 ± 0.10^{de}
UHSBC 23-1	5.06 ± 0.05^{a}	0.83 ± 0.05^{a}	5.90 ± 0.10^{a}
UHSBC 34-1	3.96 ± 0.05^{c}	0.73 ± 0.04^{abc}	4.70 ± 0.10^{c}
UHSBC 44-1	3.43 ± 0.05^{d}	0.74 ± 0.05^{abc}	4.16 ± 0.05^{d}
Mean ± SD	4.28 ± 0.73	0.76 ± 0.08	5.05 ± 0.79
F- value	184.61	3.51	207.59
S. Em. ±	0.05	0.03	0.05
C. D. @ 1% level	0.16^{**}	0.10^{**}	0.17^{**}

Note: Mean ± S.D; C.D – Critical Difference; S. Em. ± Standard Error mean; ** Significant at 0.01 percent level; Different superscript within a column indicate significant difference at 0.05 level by DMRT

Table 3: Sugar content of carrot germplasms (g/100g)

Carrot germplams	Sugars (Fresh weight basis)		
	Reducing sugar	Non-reducing sugar	Total sugar
LC (Control)	4.17 ± 0.08^{a}	6.66 ± 0.32^{a}	11.18 ± 0.42^{a}
UHSBC 51	3.33 ± 0.07^{de}	5.86 ± 0.36^{b}	9.50 ± 0.40^{d}
UHSBC 52	3.16 ± 0.08^{f}	4.95 ± 0.16^{c}	8.38 ± 0.24^{e}
UHSBC 53	4.00 ± 0.06^{b}	6.28 ± 0.16^{ab}	10.62 ± 0.26^{ab}
UHSBC 59	3.30 ± 0.08d^{e}	5.59 ± 0.24^{b}	9.22 ± 0.24^{d}
UHSBC 64	3.24 ± 0.07^{def}	5.94 ± 0.36^{b}	9.50 ± 0.42^{d}
UHSBC 101	3.22 ± 0.05^{ef}	5.83 ± 0.62^{b}	9.36 ± 0.64^{d}
UHSBC 23-1	3.49 ± 0.08^{c}	6.10 ± 0.48^{ab}	9.92 ± 0.42^{cd}
UHSBC 34-1	3.33 ± 0.08^{de}	6.66 ± 0.48^{a}	10.34 ± 0.40^{bc}
UHSBC 44-1	3.38 ± 0.46^{cd}	4.74 ± 0.27^{c}	8.38 ± 0.24^{e}
Mean ± SD	3.46 ± 033	5.86 ± 0.69	9.64 ± 0.93
F - value	58.83	8.68	16.06
S. Em. ±	0.04	0.21	0.22
C. D. @ 1% level	0.13**	0.63**	0.66**

Note: Mean ± S.D; C.D – Critical Difference; S. Em. ± Standard Error mean; ** Significant at 0.01 percent level; Different superscript within a column indicate significant difference at 0.05 level by DMRT

Table 4: Mineral content of carrot germplasms (mg/100g)

Carrot germplasm (Dry weight basis)	Calcium	Phosphorous	Iron
LC (Control)	84.68 ± 0.73^{g}	50.80 ± 0.56^{f}	3.17 ± 0.04^{a}
UHSBC 51	101.75 ± 0.77^{a}	62.20 ± 0.84^{cd}	3.12 ± 0.02^{a}
UHSBC 52	93.60 ± 0.59^{d}	62.60 ± 0.84^{bcd}	3.12 ± 0.03^{a}
UHSBC 53	98.58 ± 0.55^{b}	64.40 ± 0.56^{a}	3.04 ± 0.01^{b}
UHSBC 59	81.70 ± 0.64^{h}	59.90 ± 0.42^{e}	2.32 ± 0.02^{e}
UHSBC 64	95.74 ± 0.62^{c}	63.20 ± 0.56^{abc}	2.32 ± 0.02^{e}
UHSBC 101	91.62 ± 0.62^{e}	64.00 ± 0.56^{ab}	2.72 ± 0.01^{d}
UHSBC 23-1	81.59 ± 0.60^{h}	64.60 ± 0.28^{a}	3.04 ± 0.02^{b}
UHSBC 34-1	88.76 ± 0.84^{f}	62.80 ± 0.56^{bcd}	3.00 ± 0.02^{ab}
UHSBC 44-1	75.16 ± 0.65^{i}	61.60 ± 0.56^{d}	2.98 ± 0.02^{c}
Mean ± SD	89.17 ± 8.33	61.61 ± 3.96	2.87 ± 0.31
F- value	311.04	90.54	368.39
S. Em. ±	0.47	0.42	0.02
C. D. @ 1% level	1.49**	1.34**	0.07**

Note: Mean ± S.D; C.D – Critical Difference; S. Em. ± Standard Error mean; ** Significant at 0.01 percent level; Different superscript within a column indicate significant difference at 0.05 level by DMRT

Table 5: Total carotene and beta-carotene content of carrot germplasms

Carrot germplams	Carotenoids (mg/100g)	
	Total carotene	Beta carotene
LC (Control)	9.36 ± 0.25^{e}	2.50 ± 0.16^{d}
UHSBC 51	12.47 ± 0.26^{c}	3.57 ± 0.26^{b}
UHSBC 52	8.53 ± 0.21^{f}	2.34 ± 0.30^{d}
UHSBC 53	11.40 ± 0.32^{d}	3.02 ± 0.05^{c}
UHSBC 59	4.35 ± 0.25^{h}	0.91 ± 0.05^{e}
UHSBC 64	13.74 ± 0.19^{a}	4.12 ± 0.11^{a}
UHSBC 101	13.23 ± 0.24^{b}	4.16 ± 0.22^{a}
UHSBC 23-1	9.16 ± 0.16^{e}	2.50 ± 0.16^{d}
UHSBC 34-1	8.74 ± 0.21^{f}	2.19 ± 0.16^{d}
UHSBC 44-1	8.11 ± 0.18^{g}	2.28 ± 0.11^{d}
Mean ± SD	9.51 ± 2.82	2.66 ± 0.98
F- value	436.99	91.18
S. Em. ±	0.12	0.10
C. D. @ 1% level	0.38**	0.29**

Note: Mean ± S.D; C.D – Critical Difference; S. Em. ± Standard Error mean; ** Significant at 0.01 percent level; Different superscript within a column indicate significant difference at 0.05 level by DMRT

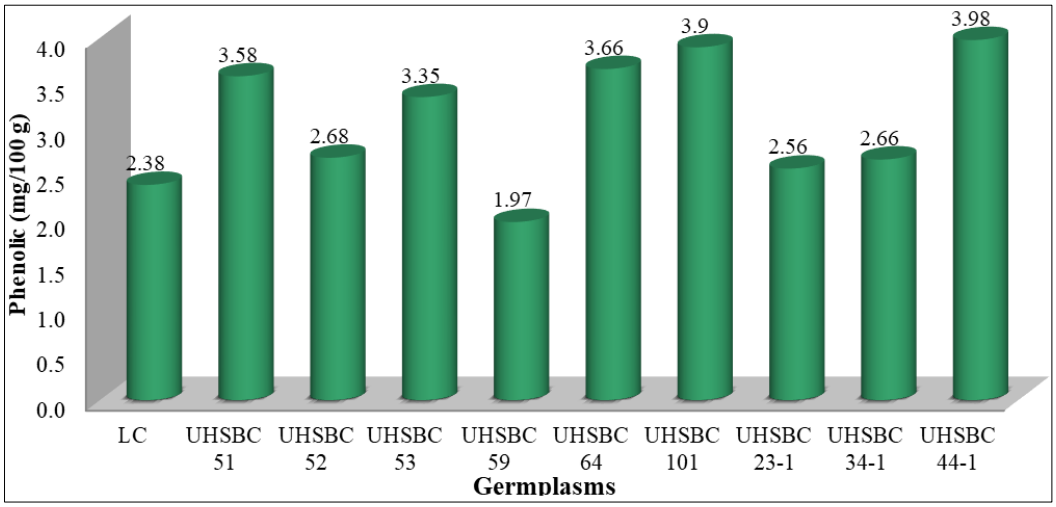

Fig 1: Phenolic content of carrot germplasms

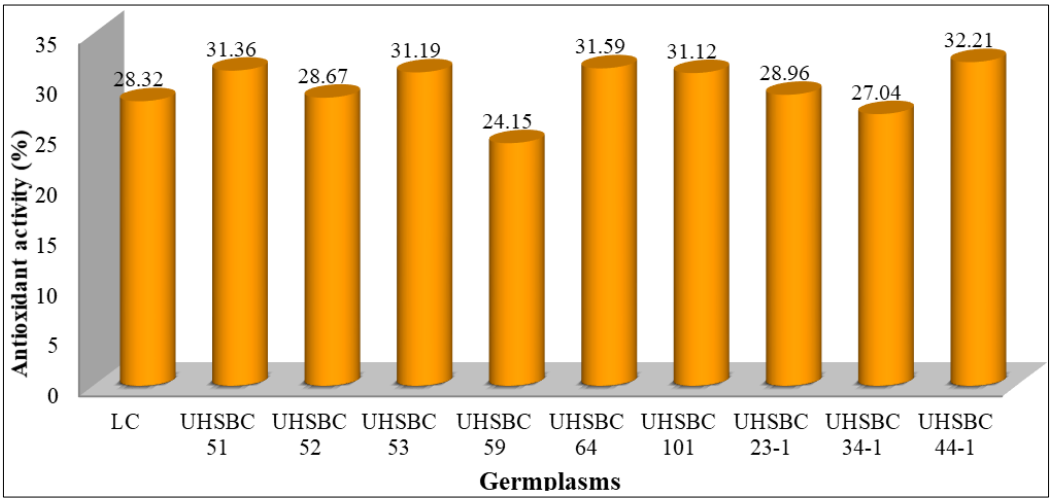

Fig 2: Antioxidant activity of carrot germplasms

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