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Nutritional characteristics of different types of carrot

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Abstract
Carrots are the most common vegetable after potato. Among thirty-eight fruits and vegetables, carrot ranked tenth with respect to nutritional quality and seventh for its contribution to nutrition. It is often claimed to be the perfect health food. It is highly nutritious and functionally enriched vegetable. Carrots are particularly good source of beta-carotene, fiber, vitamins, minerals, ascorbic acid, antioxidants and polyphenols. Epidemiological and nutritional studies have exhibited that carrot phytochemical can play significant part in the prevention and degenerative disorders like diabetes, cancer and cardiovascular diseases. Carrots are found in many colours, including white, orange, red, purple and deep purple/ black. This paper includes the physical, chemical and functional properties of four types of carrot.

Keywords: Carrot, functional, nutritional

Introduction
Carrot (*Daucus carota* Sativus) is one of the most important seasonal root vegetable belonging to family *Apiaceae* (*Umbelliferae*) and is grown extensively in India during winter season for its edible taproot. It is considered to be native of Afghanistan (Banga, 1976) [4]. The earliest known mention of domesticated carrots dates back to the 10th century in Persia and Asia Minor; then it spreads to all Asia, Europe, North Africa and the Mediterranean region (Kalra *et al.*, 1987; Mazza, 1989) [12, 18]. Although it has been widely cultivated for many centuries, the use of carrot as a food dates only from the early twentieth century. According to botanical classification of carrot seeds, they are separated in two groups. The anthocyanin group (*Daucus carota* ssp. *Sativus* var. *Atrorubens Alef.*) and the carotene group (*Daucus carota* ssp. *Sativus* var.). Although orange colored carrot varieties are more common, consumption of black or purple carrots (*Daucus carota* L. ssp. *sativus* var. *atrorubens Alef.*) is currently increasing in world due to its health benefits. Black carrot has attracted the attention of the scientific community due to their phenolic compounds, vitamins and anthocyanins which are significantly related to its antioxidant capacity (Alasalvar *et al.*, 2001; Priya and Santhi, 2015) [1, 20]. Total area of the world is 13466 million hectares, India ranks seventh area wise (accounts for 329 million hectares i.e. 2.4%) after Russian Federation, Canada, USA, China, Brazil, and Australia. However, out of this (329 million hectares) only 159 million hectares is the arable land. Further, World's economically active population in agriculture is around 1310 million; 267 million (20.40%) of which is located in India. India's diverse climate ensures availability of all varieties of fresh fruits and vegetable throughout the year. Our presence in global market is significant and it is a matter of satisfaction that India is the second largest producer of vegetables and fruits. India has witnessed significant progress in horticulture production over the last few years. Over the last decade, the area under horticulture grew by 2.60 per cent per annum and annual production increased by 4.80 per cent during 2017-18. The world production of fruits and vegetable crops was 866.00 million tonnes and 1075.00 million tonnes, respectively. However, the production of vegetables has increased from 101.20 Million Tonnes to 184.40 Million Tonnes and production of fruits has increased from 50.90 Million Tonnes to 97.35 Million Tonnes since 2004-05 to 2017-18 in India.

According to recent estimate of crop-wise area and production of horticulture Crops for three years carrot accounts for 82, 86, 97 (000 Ha) and 1338, 1350 and 1648 (000MT) are and production in the year 2015-16, 2016-17 and 2017-18, respectively. Carrot is grown extensively throughout India as one of the major vegetable. Major carrot producing states are

Haryana, Punjab, Uttar Pradesh, Madhya Pradesh, Tamilnadu, Karnataka, Assam, Bihar, Andhra Pradesh, Jammu & Kashmir and Chattisgarh. In Himachal Pradesh total area under carrot was estimated to be 0.38 thousand hectare with an annual production of 7.67 thousand metric tonnes during the year 2017-2018 (NHB, 2019) [19].

Materials and Methods

Procurement of Raw Material: Carrots were procured from local fruit and vegetable market, Solan, Himachal Pradesh and brought immediately to the fruit processing unit of Department of Food Science and Technology for further studies.

Physical Analysis

The raw carrot roots (black, orange, purple and black) were analyzed for different parameters. The weight of roots was taken on electronic weighing scale and average root weight was expressed as gram per unit. While length, diameter and pith size of carrot roots was measured by using digital vernier caliper and expressed in millimeter. The visual colour was evaluated Royal Horticultural Society Colour Chart.

Chemical Analysis

The mature carrot roots were analyzed for different chemical parameters. Moisture content was determined by measuring the weight loss due to evaporation of water. Pre-weighed quantity of carrot roots was placed in hot air oven at 60 ± 5 ºC and dried until there was no change in the weight. Total Soluble Solids (TSS) was measured by hand refractometer of 0-32 °Brix. Titrable acidity was estimated by titrating known volume of sample against standard 0.1 N NaOH using phenolphthalein as an indicator (Ranganna, 2009) [21]. Lane and Eynon (1923) [15] method was followed for estimation of sugars. A digital pH meter (CRISON Instrument, Ltd Spain) was used to determine pH of the sample. The total ash content was determined gravimetrically by placing the sample in a muffle furnace at 550°C to obtain a carbon free white ash with a constant weight. Ascorbic acid content was determined using 2-6 dichlorophenol indophenols dye (AOAC, 2012) [3]. beta-carotene and anthocyanin were estimated as per the method described by Ranganna (2009) [21]. Total fibres content was estimated by the method given by Gould (1978). Total phenol content was determined by Folin-Ciocalteu procedure given by Singleton and Rossi (1965) and expressed as mg/100 g of GAE (Gallic Acid Equivalent). For estimation of antioxidant properties: One ml of sample was taken which was further dissolved in 10 ml of methanol and out of which 0.1 ml of methanolic extract was taken for the estimation. DPPH (2,2-diphenyl-1-picrylhydrazyl) was used as a source of free radical and free radical scavenging activity was measured as per the method of Brand-Williams *et al.* (1995) which was expressed as per cent.

Results and Discussion

Physical parameters

The results obtained for physical characteristics of raw carrot roots (black, orange, purple and red) are presented in Table 4.1. The maximum root length of 25.90 cm was reported in red carrot which was followed by black carrot (22.85 cm) purple carrot (20.76 cm) and orange carrot (16.53 cm). The findings are in compliance with the results of Chen *et al.* (2020) [7] and Singh *et al.* (2020) [25]. It was concluded that the highest root weight was noted in red carrot (96.84 g), while the minimum weight was observed in orange carrots (84.14 g). A similar range of root weight (92.81-113.34 g) was documented by Roshni *et al.* (2019) [22]. The visual colour of black, orange, purple and red carrot was found to be purple (79-A), greyed orange group (165-B), purple (79-B) and red group (45-A). The average pith size was 1.16 cm, 1.78 cm, 1.20 cm and 1.37 cm in black, orange, purple and red carrot, respectively. The results were in conformity with Haq *et al*, (2013) [11].

Table 1: Physical characteristics of carrot (Black, orange, purple and red)

Parameter*	Black Carrot (Mean ± SD)	Orange Carrot (Mean ± SD)	Purple Carrot (Mean ± SD)	Red Carrot (Mean ± SD)
Weight (g)	90.37 ± 3.47	84.14 ± 2.76	92.75 ± 3.19	96.84 ± 2.87
Length (cm)	22.85 ± 1.87	16.53 ± 1.53	20.76 ± 1.14	25.90 ± 1.23
Diameter (cm)	3.50 ± 0.15	4.26 ± 0.09	4.10 ± 1.06	3.59 ± 0.12
Colour** (visual)	Purple (79-A)	Greyed orange group (165-B)	Purple (79-A)	Grey red group (179-A)
Pith size (cm)	1.16 ± 0.08	1.78 ± 0.06	1.20 ± 0.03	1.37 ± 0.07

*Each value is average of 10 determinations; SD = standard deviation

**visual color value of different carrot roots was recorded by using color cards of Royal Horticulture Society, London

Chemical parameters

The data revealed a range of 84.14 to 92.75 per cent moisture content in carrot roots. Similar values of moisture content were reported by Gani and kumar (2013) [11], Borowska *et al.* (2017) [5] and Rubina *et al.* (2018) [23]. The average total soluble solids (TSS), total sugars, reducing sugar, titratable acidity, pH, fiber, ash, pectin and ascorbic acid in black carrot were recorded as 8.00 ºB, 4.97 per cent, 2.36 per cent, 0.25 per cent, 5.80, 1.02 per cent, 1.40 per cent, 0.17 per cent and 12.75 mg/100g, respectively. Whereas, total carotenoids, anthocyanins, total phenolic

Table 2: Chemical characteristics of carrot (Black, orange, purple and red)

Parameter*	Black Carrot (Mean ± SD)	Orange Carrot (Mean ± SD)	Purple Carrot (Mean ± SD)	Red Carrot (Mean ± SD)
Moisture (%)	89.70 ± 1.46	83.35 ± 1.50	91.50 ± 1.17	87.44 ± 1.28
TSS (°B)	8.00 ± 0.13	7.50 ± 0.10	7.80 ± 0.09	9.00 ± 0.12
Total sugars (%)	4.97 ± 0.07	4.25 ± 0.05	4.81 ± 0.08	5.60 ± 0.03
Reducing sugars (%)	2.36 ± 0.10	2.04 ± 0.07	2.10 ± 0.04	3.15 ± 0.03
Titratable acidity (%)	0.25 ± 0.03	0.09 ± 0.02	0.21 ± 0.01	0.15 ± 0.03
pH	5.80 ± 0.06	6.50 ± 0.08	5.92 ± 0.03	6.40 ± 0.05

Crude fibres (%)	1.02 ± 0.02	1.95 ± 0.01	1.17 ± 0.02	1.76 ± 0.01
Ash (%)	1.40 ± 0.03	1.32 ± 0.07	1.43 ±0.05	1.27 ± 0.04
Pectin (%)	0.17 ± 0.01	0.35 ± 0.02	0.20 ± 0.02	0.24 ± 0.01
Ascorbic acid (mg/100g)	12.75 ± 0.28	15.43 ± 0.18	10.58 ± 0.09	10.43 ± 0.14
Carotenoids (mg/100g)	1.50 ± 0.05	12.30 ± 0.03	1.25 ± 0.04	8.68 ± 0.02
Anthocyanins (mg/100g)	249.32 ± 2.76	0.16 ± 0.01	235.17 ± 2.12	0.74 ± 0.02
Total phenols (mg/100g)	290.63 ± 2.54	25.78 ± 1.76	278.20 ± 2.81	34.07 ± 1.80
Antioxidant activity (% free radical scavenging activity)	80.25 ± 1.67	35.42 ± 0.76	73.69 ± 1.34	26.80 ± 0.52

*Each value is average of 10 determinations; SD = standard deviation

contents and antioxidant activity was found to be 1.50 mg/100g, 249.32 mg/100g, 290.63 mg/100g and 80.25 per cent free radical scavenging activity, respectively. Similar values of total soluble solids total soluble solids (7.80 ºB), total sugars (4.81%), reducing sugar (2.10%), titratable acidity (0.21), pH (5.92), fiber (1.17%), ash (1.43%), pectin (0.20%) ascorbic acid (10.58 mg/100g) and slightly lower values of anthocyanins (235.17 mg/100g), total phenolic content (278.20 mg/100g) and antioxidant activity (73.69% free radical scavenging activity) were estimated in purple carrot. The results were similar to those presented earlier by Kammerer *et al*, (2004) [14], Ersus and Yurdagel (2007) [9] and Cuevas *et al.* (2011) [8].

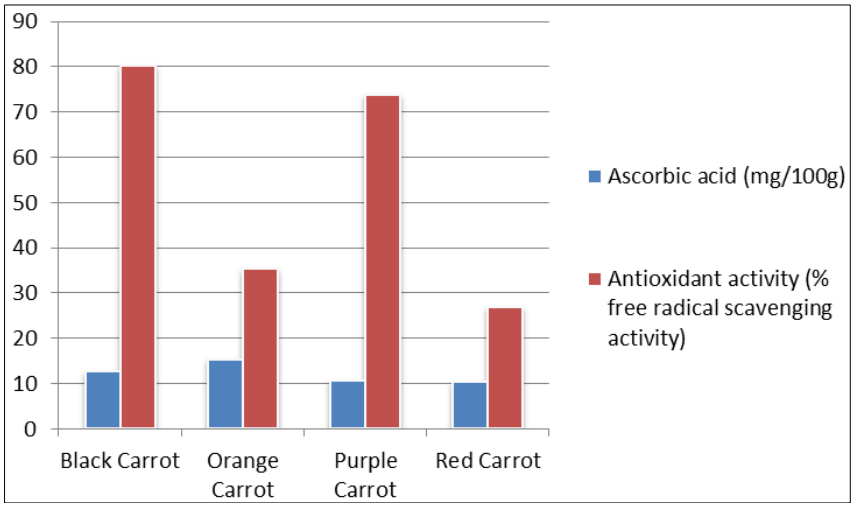

Fig 1: Ascorbic acid and antioxidant activity of different carrot types

Orange carrot contained 7.50 ºB total soluble solid, 4.25 per cent total sugar, 2.04 per cent reducing sugar, 0.09 per cent acidity, 6.50 pH, 1.95 per cent fibre, 1.35 per cent ash, 0.35 per cent pectin. Total carotenoids, total phenolic content and antioxidant activity was reported to be 12.30 mg/100g, 25.78 mg/100g and 35.42 per cent free radical scavenging activity. Red carrot roots were analyzed for various chemical characteristics and it was found that it contained 9.00 ºB total soluble solid, 5.60 per cent total sugar, 3.15 per cent reducing sugar, 0.15 per cent acidity, 6.40 pH, 1.76 per cent fibre, 1.27 per cent ash, 0.24 per cent pectin, 8.68 mg/100g total carotenoids, 34.07 mg/100g total phenolic content and 26.80 per cent free radical scavenging antioxidant activity. Similar results were shown by Leja *et al.* (2013) [17], Algarra *et al.* (2014) [2], Kamiloglu (2015) [13] and Singh *et al.* (2018) [4].

Conclusion

It can be concluded that carrots are fairly good source of phytochemicals and functional compounds. It comprises a broad spectrum of functional compounds including dietary fibre, carotenoids, flavonoids, phenolic acids, vitamins, minerals and polyphenols. Carrots are excellent source of vitamin A in the form of its precursor beta-carotene. Carrots can be a promising alternative not only to solve consumer starvation and provide health benefits by imparting the necessary nutrients, but also they can avert nutrient shortage related disorders. It can be used in fresh form, processed form and/ or for supplementation/fortification purpose as it retain most of its bioactive compounds in the added food product.

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