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Effect of dehydration on quality parameters of carrot (*Daucus carota* L.) germplasms

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Abstract
Present experiment was conducted with an objective to understand the effect of dehydration on quality of carrot germplasms and to select the best germplasm suited for dehydration. Ten carrot germplasms were dehydrated and rehydrated. Physico-chemical analysis reveals that the germplasm UHSBC-63 had maximum recovery per cent, reconstitution ratio, β-carotene and minimum moisture, water activity among all the germplasms. Whereas sensory evaluation revealed that maximum scores for colour and appearance, taste, texture and overall acceptability were recorded by the germplasm UHSBC-63 followed by UHSBC 40-3. However, minimum scores were recorded with the germplasm UHSBC-66 by the judges.

Keywords: carrot, germplasm, recovery, reconstitution, β-carotene, dry matter, water activity, non-enzymatic browning and sensory

Introduction
Carrot (*Daucus carota* L) is one of the popular root vegetables grown throughout the world and is the most important source of dietary carotenoids in western countries (Torronen *et al*. 1996) [17] In recent years, the consumption of carrot and its products have increased steadily due to their recognition as an important source of natural antioxidants besides, anticancer activity of β-carotene being a precursor of vitamin A. Apart from carrots being traditionally used in salad and preparation of curries in India, these could commercially be converted into nutritionally rich processed products like juice, concentrate, dried powder, canned, preserve, candy, pickle, and gazrailla.
Biochemically carrot is a rich source of β-carotene, fiber and many essential micro nutrients and functional ingredients. The presence of high concentrations of carotenoids, especially β-carotene in carrot roots makes them to inhibit cancers, free radical scavengers, anti-mutagenic and immune enhancers. Carrot being perishable and seasonal, it is not possible to readily make it available throughout the year. Dehydration of carrot during the main growing season is one of the important alternatives of preservation to further develop value added products throughout the year. Processing of carrots into products like canned slices, juice, concentrate, pickle, preserve, cake and halwa are some of the methods to make this important vegetable available throughout the year. Carrot pomace containing about 50% of the carotenoids and important fibers could profitably be utilized to develop value added products. Further, supplementation of foods like bread, cake, and biscuits with dried pomace is other alternatives to curtail the price of main products like juice and concentrate resulting in direct benefit to the consumers. To exploit the antioxidant properties and dietary fibers of carrot pomace, there is a need to develop products with optimal phytochemicals content without sacrificing taste or convenience (Sharma *et al*., 2012) [13].
Dehydrated carrots are produced by a process where moisture is removed in a drying chamber. The carrots are dehydrated to approximately 7% moisture. This process permits the carrots to maintain their natural orange colour and typical fresh carrot taste when rehydrated in water. The vitamin and nutrient qualities of fresh carrots are preserved so the taste is great and the nutritional food value is preserved. When rehydrated, it will maintain the texture and shape of fresh carrots with no shrinking or shriveling. Dehydrated carrots are an ideal product for long term food storage and emergency preparedness and will store for 10 to 15 years in a sealed can (oxygen absorber included) under ideal storage conditions (cool, dry place). Once opened, it has an average shelf life of 6 to 12 months.

Material and Methods
Materials
Ten germplasms of carrot, UHSBC-17, UHSBC 32-2, UHSBC 40-3, UHSBC 42-1, UHSBC 44-3, UHSBC-63, UHSBC-66, UHSBC-93, UHSBC-112 and UHSBC-117 were sown and harvested at optimum maturity from the Urgent nagar horticultural farm, operating at Regional

Horticulture Research and Extension Centre, Dharwad of Karnataka state.

Physicochemical analysis of dehydrated carrot germplasm slices

Dehydrated carrot slices were analyzed for physicochemical parameters like recovery per cent (It is the ratio of weight of dried carrot slices to the weight of fresh carrot slices and per cent recovery of dried carrot slices was calculated),The dehydration ratio was calculated by dividing the fresh weight of carrot slices (after peeling) to the weight of finished dehydrated product and Rehydration of the dried sample was carried out by adding 80 ml distilled water to 5 g dried carrot slices in a 500 ml beaker. The beaker was covered with an aluminum plate and the contents were brought to boiling point within 3 min and the boiling was continued for 10 min. Excess water was removed by placing the sample on a stainless steel sieve and mass of the rehydrated sample was determined after drainage of excess water. Rehydration ratio was obtained by dividing mass of the rehydrated sample by the mass of dried sample. Reconstitution ratio calculated by dividing rehydration ratio by dehydration ratio of carrot slices. Moisture content was measured using moisture analyzer (Model: P1019319, A & D Company Limited, Japan). One gram of sample was placed in the sample dish and dried in the electric moisture analyzer until it automatically showed constant moisture in percentage and expressed in percentage. Water activity by digital water activity meter (Model: Novasia AG, Switzerland). β-carotene was measured using petroleum ether by spectrophotometer method (Ranganna, 2003) [11]. Sensory analysis of dehydrated and rehydrated carrot slices was carried out by a semi-trained panel of judges consisting of teachers and post-graduate students of Kittur Rani Channamma College of Horticulture, Arabhavi. The sensory characters like colour and appearance, texture, taste, flavour and overall acceptability were evaluated on a nine point hedonic scale (Ranganna, 2003) [10].

Statistical analysis

The data recorded on the physico-chemical and organoleptic parameters were subjected to statistical analysis using Web Agri. Stat. Package 2 developed by ICAR research complex, Goa. Interpretation of the data was carried out in accordance with Panse and Sukhatme (1985) [9]. The level of significance used in 'F' test was p=0.01. Critical difference values were calculated wherever 'F' test was significance.

Methodology for dehydration

The selected roots of ten carrot germplasms weighing one kg were cleaned by removing adhered soil particles by washing. Outer skin was removed by using hand peeler. Peeled carrots were sliced into uniform size of approximately five mm thickness using a motorized slicer. They were weighed and blanched for 2 min in boiling water. They were dried at 60 °C in air convection tray drier for 14 hours. The dehydrated slices were packed and further used for estimations. Dried slices and rehydrated slices were subjected to organoleptic/ sensory evaluation.

Results and Discussion

The data regarding recovery per cent of different carrot germplasms is presented in table 1. There was significant difference among the germplasms with respect recovery per cent of different dehydrated carrot germplasms. Significantly maximum recovery per cent was observed in germplasm UHSBC-63 (12.80 %) which was on par with UHSBC -17 (12.10 %) followed by UHSBC-117 (11.60 %) whereas, minimum per cent of recovery was found in UHSBC-112 (7.40 %). The possible reason might be due to high dry matter content, high soluble solids at maturity of the different germplasms but also affected by differences in peeling and trimming losses, size of roots and amount of bruising and decay. These results are in confirmation with findings reported by Alam *et al.* (2002) [1] in pea varieties, Javed *et al*. (1995) [6] in onion germplasms, Solmos *et al*. (1978) [15] in potato varieties and Caldwell *et al*. (1943) [3] in potato cultivars. Dehydration ratio was significantly different among all the germplasms. Among the germplasms, UHSBC-112 was recorded maximum dehydration ratio (13.52) followed by germplasm UHSBC 40-3 (11.91) and UHSBC 32-2 (11.64). However, UHSBC-63 carrot germplasm recorded significantly minimum dehydration ratio (7.81). Wherever the recovery was found higher, dehydration ratio was lower, which indicates the inverse relation between the per cent recovery and its dehydration ratio. The rehydration ratio of carrot slices was found maximum (3.75) in the germplasm UHSBC 112 and minimum (2.22) in UHSBC-66 (Table 1). This might be due to shape, size and cell wall composition of individual cultivars and capacity of dried cell to reabsorb water after rehydration. Similar results were also reported by Javed *et al*. (1995) [6] in onion, Srivastava and Nath (1985) [16] in cauliflower and Bawa and Saini (1986) [2] in cauliflower. The quick and high rehydration capacity of dried commodities indicated their better quality (Rajeshwari *et al*., 2011) [10] in case of leafy vegetables. Ratio of rehydration to dehydration is used as an index of reconstitutability. Significantly maximum reconstitution ratio was observed in UHSBC-63 (0.29) which was on par with UHSBC-17 (0.27). Whereas, minimum (0.21) rehydration ratio was found in UHSBC 32-2. Previous results as mentioned above, germplasm UHSBC-63 recorded maximum recovery and minimum dehydration ratio, that's why the germplasm showed the higher reconstitution ratio, similar results were also reported by Sardar and Chakraverty (2002) [12] in carrot. The maximum moisture content recorded in germplasm UHSBC-66 (4.90%) and minimum moisture (3.23%) content was found in UHSBC-63 (Table 1). Difference in moisture per cent among the germplasms was mainly associated with the specific surface area of the root (Shibairo *et al*., 1997) [14]. Similar results were also reported by the workers (Gupta and Shukla 2017 [5] in carrot and onion and Javed *et al*., 1995 [6] in onion varieties). Maximum water activity was found in germplasm UHSBC-66 (0.42) and minimum was recorded in UHSBC-63 (0.21) Table 1. Varietal difference with respect to water activity was attributed to lower moisture retention and enzymatic activities. Similar results were also recorded by Lavelli *et al*. (2007) [7]. Water activity plays an important role in the physical properties such as texture and shelf life of food and lower water activity was reported a longer shelf life of carrots (Goldman, 1983) [4]. There was a significant difference in amount of beta carotene content among the germplasms, UHSBC-93 recorded maximum amount of beta carotene (57.03 mg/100g). However minimum carotene content was found in UHSBC-66 (33.06 mg/100g) Table 1. The possible reason might be due to accumulation of chemical constituents with respect to varieties. Similar findings were also reported by Alam *et al*. (2002) [1] in pea cultivars, Negi *et al*. (2001) [8] in onion and suggested that the initial carotene content of dehydrated carrots was higher in blanched samples.

Influence of dehydration on sensory attributes like colour and appearance, texture, taste and overall acceptability of dehydrated carrot germplasms were assessed by the 10 semi-panelists and the results are presented in Table 2. Maximum score for colour and appearance for dehydrated carrot was observed for UHSBC- 63 (8.16) which was on par with UHSBC 40-3 (7.83). Whereas, significantly minimum score for colour and appearance was found in UHSBC-66 (6.25). Maximum score for texture for dehydrated carrot germplasms was observed for UHSBC-63 (7.83) which was on par with UHSBC 40-3 (7.50) and UHSBC-112 (7.0). Whereas, significantly lowest texture score was found in germplasms UHSBC-66 (5.50). Maximum score for taste for dehydrated carrot germplasms was observed for UHSBC-63 (6.58) which was on par with UHSBC 40-3 (6.25).Whereas, significantly minimum taste score was found in germplasms UHSBC-66 (5.08). Maximum score for overall acceptability for dehydrated carrot was observed for UHSBC-63 (7.50) which was on par with UHSBC 40-3 (7.16). Whereas significantly lowest score was found in germplasms

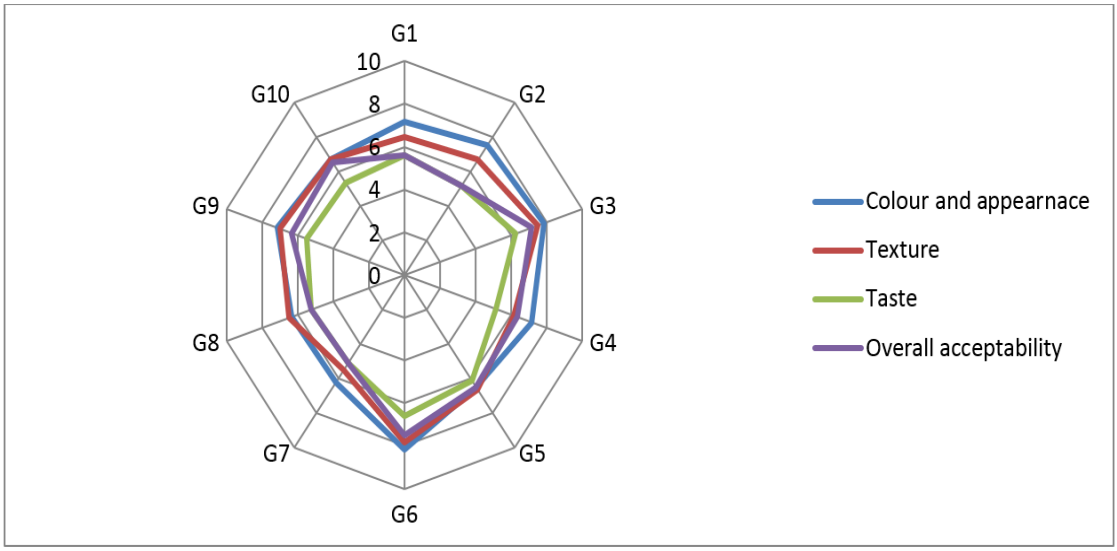
UHSBC-66 (5.08). Similar results were also recorded by Javed *et al*. (1995) [6] in dehydrated onion varieties.

Table 1: Effect of dehydration on recovery per cent, dehydration, rehydration, reconstitution ratio, moisture and water activity of carrot germplasms.

Germplasms	Recovery (%)	Dehydration ratio	Rehydration ratio	Reconstitution ratio	Moisture (%)	Water activity (a_w)	β-carotene (mg/100g)
UHSBC 17	12.10	8.26	2.26	0.27	4.50	0.35	46.23
UHSBC 32-2	8.60	11.64	2.86	0.21	4.60	0.37	50.04
UHSBC 40-3	8.40	11.91	2.66	0.22	3.50	0.23	41.41
UHSBC 42-1	9.00	10.42	2.56	0.24	4.63	0.40	52.40
UHSBC 44-3	9.36	9.70	2.42	0.22	3.60	0.25	56.11
UHSBC 63	12.80	7.81	2.27	0.29	3.23	0.21	53.52
UHSBC 66	10.63	9.40	2.22	0.23	4.90	0.42	33.06
UHSBC 93	10.33	9.67	2.47	0.25	3.90	0.28	57.03
UHSBC 112	7.40	13.52	3.75	0.23	4.30	0.31	36.86
UHSBC 117	11.60	8.62	2.27	0.26	4.10	0.29	42.73
Mean	10.02	10.09	2.57	0.24	4.12	0.31	46.93
S.Em±	0.17	0.33	0.03	0.01	0.07	0.01	0.67
CD @1%	0.79	1.34	0.17	0.07	0.26	0.05	2.73

Table 2: Effect of dehydration on organoleptic evaluation of carrot germplasms (9 Point Hedonic scale)

Germplasms	Colour and appearance	Texture	Taste	Overall acceptability
	Scores			
UHSBC 17	7.16	6.45	5.58	5.58
UHSBC 32-2	7.50	6.66	5.16	5.16
UHSBC 40-3	7.83	7.50	6.25	7.16
UHSBC 42-1	7.16	6.16	5.13	6.33
UHSBC 44-3	6.50	6.66	6.13	6.50
UHSBC 63	8.16	7.83	6.58	7.50
UHSBC 66	6.25	5.50	5.08	5.08
UHSBC 93	6.33	6.50	5.25	5.25
UHSBC 112	7.16	7.00	5.50	6.33
UHSBC 117	6.66	6.66	5.33	6.50
Mean	7.17	6.69	5.49	6.21
S. Em ±	0.28	0.26	0.14	0.25
CD @1%	1.19	1.19	0.69	1.05



G1: UHSBC-17 G2: UHSBC 32-2 G3: UHSBC 40-3 G4: UHSBC 42-1 G5: UHSBC 44-3
G6: UHSBC-63 G7: UHSBC 66 G8: UHSBC 93 G9: UHSBC 112 G10: UHSBC 117

Fig 1: Effect of dehydration on organoleptic evaluation (9 point hedonic scale) of dehydrated carrot slices

Conclusion

Based on all the observations it can be concluded that germplasm UHSBC-63 retained maximum nutrients after dehydration and organoleptically accepted by the panelists. The germplasms UHSBC-63 and UHSBC 40-3 are better suited for dehydration.

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