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Standardization of pretreatments for red and black carrots on the basis of chemical and organoleptic quality evaluation

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Abstract
The present investigation was carried out to standardize the pretreatment for red and black carrots using 1% $CaCl_2$, 0.5% citric acid, 0.2% potassium metabisulphite and their combinations after blanching in hot water (95^{0}C) for 2 minutes. The slices were dipped in different chemical treatments for 10 minutes followed by chemical and organoleptic quality evaluation. The pretreated slices were studied for retention of total soluble solids, carotenoids, anthocyanins and decreased non-enzymatic browning. Pretreated slices were also subjected to organoleptic evaluation by semi-trained panelists using 9-point hedonic scale. 0.2% KMS + 1% $CaCl_2$ was found to be the best treatment for red carrots and 1% $CaCl_2$ + 0.5% cirtic acid showed best results for black carrots.

Keywords: red carrots, black carrots, Pretreatment, KMS, $CaCl_2$, citric acid, organoleptic evaluation

Introduction
Carrot (*Daucus carota* L.), an important root vegetable of Umbelliferae family, is cultivated throughout the World. The area under carrot in India was 68,000 ha during 2014-15 with an annual production of 10.92 lakh tonnes, Haryana being a leading producer (2.50 lakh tonnes) followed by Tamil Nadu, Punjab, Karnataka, Uttar Pradesh, Assam, Andhra Pradesh and Punjab (Anonymous, 2016) [1]. Carrots do not only supply a significant amount of calories to human diet, but also supply nutrition in the form of phytochemicals such as carotenoids, anthocyanins and other phenolic compounds. The greatest nutritional interest in carrots is due to its phytochemical content, but research work has also been focused on carrots as a source of fibre. The bioactive components are mainly concentrated towards the exterior side of root (cortex) and the presence of handsome amount of vitamins, bioactive components and minerals have led it to rank among top ten fruits and vegetables on the basis of nutrition (Alasalvar *et al*., 2001) [2]. Strong regional preference for specific coloured carrot has been observed in India. Red coloured carrot is typical to India (Leja *et al*., 2013) [3] and is predominantly cultivated in Northern India for preparation of traditional sweet dessert 'Halwa'. Anthocyanin rich black carrot variety cultivated in Northern India is used for preparation of traditional probiotic fermented beverage 'Kanji'. Black carrots (*Daucus carota* ssp. *sativus*) have been in focus due to its high anthocyanin content (1750 mg/kg) and extraordinary quality parameters (Kirca *et al*., 2006) [4]. In black carrots, the major anthocyanins are derived from acylation of cyanidins (Schwarz *et al*., 2004) [5]. Black carrot anthocyanins have higher colour stability at food pH than anthocyanins from other plants. These provide, especially, an excellent bright strawberry-red shade at acidic pH's (Downham and Collins, 2000) [6]. Anthocyanins have been found responsible for promoting health by reducing the risk of atherosclerosis, cancer, diabetes and neurodegenerative disorders (Wrolstad, 2004) [7]. These also contain high amount of nutraceutical components (Alasalvar *et al*., 2001) [2] and colouring of foods with black carrot juice may also provide health benefits. Drying and dehydration are most important operations that are widely practiced because of considerable saving in packaging, storage and significant reduction in shipping weights (Chavan and Amarowicz, 2012) [8]. Pretreatment or dipping in acid or alkaline solution prior to further processing helps in retaining quality prior to drying or dehydration. It has been reported that enzymatic browning of fruits and vegetables was prevented by dipping in 1.0% citric acid solution prior to osmotic dehydration (Sunkja and Raghavan, 2004) [9]. The present investigation was carried out with the objective to standardize the pretreatment on the basis of

retention of carotenoids, anthocyanins, total soluble solids, decreased non-enzymatic browning and highest sensory scores given by panelists for color & appearance, taste, mouthfeel, texture and overall acceptability.

Material and Methods

The study was carried out during 2014-15 at Centre of Food Science and Technology, CCSHAU, Hisar. Red carrots *cv. Hisar Gairic* was obtained from Experimental Farm, Department of Vegetable Science. Black carrots were obtained from local market. Fresh carrots were washed, peeled, sliced into 4-7mm thick pieces and then pricked using stainless steel fork. The pricked slices were subjected to hot water treatment (95^{0}C for 2 mins.) and then dipped for 10 minutes in following treatments: 1% $CaCl_2$ (T_1) 0.5% citric acid (T_2), 0.2% potassium metabisulphite (KMS) (T_3), 1% $CaCl_2$ + 0.5% cirtic acid (T_4), 0.5% citric acid + 0.2% KMS (T_5), 0.2% KMS + 1% $CaCl_2$ (T_6) and 1% $CaCl_2$ + 0.5% citric acid + 0.2% KMS (T_7). The ratio of carrot slices to dipping solution was taken as 1:2. The carrot slices after hot water treatment not followed by any pretreatment was treated as control. All trials were carried out in triplicates. The carrot slices after pretreatments were subjected to chemical and organoleptic quality evaluation. Best pretreatment for carrots was selected on the basis of retention of maximum carotenoids and anthocyanins, minimum browning and better overall acceptability. Fresh carrots were evaluated for TSS, total and reducing sugars, crude fibre, acidity, caortenoids, pectin, anthocyanins, non-enzymatic browning. Total soluble solids were estimated at ambient temperature using hand refractometer (0-32%) Erma, Japan and the values were expressed as per cent TSS after correcting at 20^{0}C temperature. Sugars were analyzed by the method of (Hulme and Narain, 1931) [10] using starch as an indicator. Crude fiber was estimated according to AOAC (2016) [11] by acid-alkali extractions. Titratable acidity was determined as per method given by AOAC (2016) [11]. 5 g sample was extracted with 50 ml boiling water and filtered. Suitable aliquot was titrated against 0.1N NaOH using phenolphthalein as indicator. Pectin was estimated as calcium pectate (Ranganna, 2014) [12]. Carotenoid was estimated by spectrometric method (Rodriguez-Amaya, 2004) [13]. Anthocyanins were estimated as total monomeric anthocyanin spectrophotometrically by pH differential method according to Askar and Treptow (1993) [14]. One aliquot of aqueous anthocyanin solution is adjusted to pH 1.0 and another to pH 4.5. The difference in absorbance at the wavelength of maximum absorption (between 520 and 700nm) is proportional to anthoycanin content. The browning of all samples was estimated by method of (Ranganna, 2014) [12]. The increase in absorbance of sample extract in ethanol at 440 nm was taken as a measure of nonenzymatic browning. The carrot slices were subjected to sensory evaluation by the semi-trained panel of 10 judges on a 9-point Hedonic scale (Ranganna, 2014) [12]. The experiments were conducted with 3 replications and completely randomized design (CRD) was adopted to calculate the statistical significance.

Results and Discussion

Fresh red and black carrots were analyzed for recovery, moisture content, specific gravity, total soluble solids, total sugars, reducing sugars, crude fibre, acidity, pectin, total carotenoids (for yellow carrots only), anthocyanins (for black carrots only) and non-enzymatic browning. The data as shown in table 1 reveal that recovery, moisture content, specific gravity, total soluble solids, total sugars, reducing sugars, crude fibre, acidity, pectin and non-enzymatic browning were 81.27, 86.33, 1.02, 9.30, 5.85, 2.23, 1.85, 0.13, 1.39% and 0.10 for red carrots and 82.59, 89.92, 1.04, 7.10, 4.50, 2.25, 0.25, 0.32, 0.88% and 0.49 for black carrots. Red carrots had 8.00 mg/100 g total carotenoids, while black carrots had 113 mg/l anthocyanins.

Table 1: Physico-chemical characteristics of fresh carrots*

Characteristics	Red carrots	Black carrots
Recovery (%)	81.27 $\pm$ 0.32	82.59 $\pm$ 0.16
Moisture content (%)	86.33 $\pm$ 0.29	89.92 $\pm$ 0.22
Specific gravity	1.02 $\pm$ 0.01	1.04 $\pm$ 0.01
Total soluble solids (ºBx)	9.30 $\pm$ 0.57	7.10 $\pm$ 0.28
Total sugars (%)	5.85 $\pm$ 0.78	4.50 $\pm$ 0.39
Reducing sugars (%)	2.23 $\pm$ 0.81	2.25 $\pm$ 0.78
Crude fibre (%)	1.85 $\pm$ 0.21	0.25 $\pm$ 0.03
Acidity as citric acid (%)	0.13 $\pm$ 0.03	0.32 $\pm$ 0.01
Total carotenoids (mg/100 g)	8.00 $\pm$ 0.32	-
Anthocyanins (mg/l)	-	113 $\pm$ 0.78
Pectin (%)	1.39 $\pm$ 0.10	0.88 $\pm$ 0.06
Non-enzymatic browning (O.D. at 440 nm)	0.10 $\pm$ 0.10	0.49 $\pm$ 0.18

*Values are mean ± SD of three replicates

The data depicting the effect of different pretreatments on total soluble solids, total carotenoids, anthocyanins and non-enzymatic browning on red and black carrots have been shown in Table 2. The results express that pretreatments had significant effect on TSS, total carotenoids, anthocyanins and non-enzymatic browning of fresh carrots. Treatment (T_6) showed maximum TSS (8.3 and 6.9^{0}Bx) in red and black carrots. In red carrots, maximum carotenoid retention (7.8 mg/100 g) was in treatment (T_6). However, treatment (T_4) showed maximum anthocyanin retention (102 mg/100 g) in black carrots. Non-enzymatic browning was observed minimum (0.02 and 0.61) in treatment (T_7) for red and black carrots. After pretreatments, fresh carrots were subjected to sensory evaluation. The data (Table 3) reveal that maximum scores for colour and appearance, taste, mouthfeel, texture and overall acceptability were observed for treatment (T_6) in red carrots. For black carrots, (T_4) scored highest in terms of different sensory attributes. On the basis of above chemical and sensory evaluation studies, (T_6) was selected as the best pretreatment for red carrots and (T_4) for black carrots. TSS were higher in $CaCl_2$ along with KMS treated dried slices as reported by Mozumder *et al.* (2012) [15] in pretreated tomato slices. Total carotenoids decreased during hot water treatment given alone and in combination with chemicals in apricot

(Sharma *et al.*, 2000) [16]. KMS and KMS + $CaCl_2$ treated samples showed higher carotenoids over control. This might be due to prevention of oxidation by KMS. Similar findings were reported in carrot slices by Sra *et al.* (2011) [17]. It has also been reported that browning is inhibited by KMS in dried apricots (Mir *et al.*, 2009) [18] and $CaCl_2$ can also be used to reduce or prevent browning and to act by blocking the amino group, thereby restraining them from entering into browning reaction (Porntewabancha and Siriwongwilaichat, 2010) [19].

Table 2: Effect of different pretreatments on physico-chemical characteristics of fresh carrots

Treatments	TSS (^{0}Bx)		Total carotenoids/anthocyanins^a (mg/100 g)		Browning (O.D. at 440 nm)	
	R	B	R	B	R	B
T_1	7.9	6.7	6.9	98	0.09	0.74
T_2	7.5	6.5	6.5	93	0.08	0.77
T_3	7.9	6.7	6.6	90	0.07	0.70
T_4	8.1	6.5	6.0	102	0.06	0.71
T_5	7.8	6.3	6.9	99	0.06	0.68
T_6	8.3	6.9	7.8	95	0.05	0.66
T_7	7.4	6.6	6.3	96	0.02	0.61
T_0	8.9	7.0	7.9	106	0.09	0.82
CD at 5%	0.40	0.20	0.45	0.89	0.04	0.05

T_1=1% $CaCl_2$; T_2=0.5% citric acid; T_3=0.2% KMS; T_4=1% $CaCl_2$ + 0.5% citric acid; T_5=0.5% citric acid + 0.2% KMS; T_6=0.2% KMS + 1% $CaCl_2$; T_7= 1% $CaCl_2$ + 0.5% citric acid + 0.2% KMS; T_0= control
R=Red carrots; B=Black carrots; a=Anthocyanins (mg/l) for black carrots only

Table 3: Effect of diffèrent prétraitements on sensory quality (mean scores out of 9) of fresh carrots

Treatments	Colour and appearance		Taste		Mouth feel		Texture		Overall acceptability	
	R	B	R	B	R	B	R	B	R	B
T_1	6.5	6.6	7.8	7.6	8.4	8.3	8.3	8.1	7.7	7.7
T_2	6.6	6.8	7.0	7.3	7.3	7.3	7.1	7.5	7.0	7.2
T_3	7.6	6.4	7.0	7.0	6.8	7.5	7.0	7.5	7.1	7.0
T_4	6.6	7.8	7.5	8.0	8.5	8.3	8.1	8.1	7.7	8.0
T_5	6.3	6.4	7.3	7.4	8.0	7.0	8.0	6.8	7.4	6.9
T_6	7.8	6.6	7.8	7.3	8.5	8.5	8.3	8.1	8.1	7.6
T_7	6.3	6.5	7.1	7.0	6.3	6.6	6.2	6.5	6.4	6.6
T_0	7.6	7.4	8.0	8.1	6.3	6.6	6.3	6.6	7.0	7.2

T_1=1% $CaCl_2$; T_2=0.5% citric acid; T_3=0.2% KMS; T_4=1% $CaCl_2$ + 0.5% citric acid; T_5=0.5% citric acid + 0.2% KMS; T_6=0.2% KMS + 1% $CaCl_2$; T_7= 1% $CaCl_2$ + 0.5% citric acid + 0.2% KMS; T_0= control
R=Red carrots; B=Black carrots

Conclusion

There are many evidences of improvement in quality of fruits and vegetables if pretreated prior to processing. These pretreatments may prevent browning thus increasing the shelf life and improving colour and appearance of processed fruits and vegetables during storage. Till now, there is no literature available regarding the effect of pretreatments using chemicals in carrots after blanching as mentioned in this paper. The results may escalate the use of such pretreatments prior to drying or osmodehydration for improved quality products based on carrots by industries.

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