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Effect of different pre-treatments on quality of carrot roundels

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Abstract
Carrot (*Daucus carota* L.) a root vegetable which is mainly consumed raw, converted to various products and cooked vegetable dish. Present studies were carried out to study quality characteristics of fresh carrot during the season for selection of best month for procurement of carrot and effect of different pretreatments on quality of carrot. As no work is carried out earlier to standardize the blanching time for this form of carrot i.e. roundels and effect of blanching time on quality of dried roundels. So steam blanching as pre-treatment for 3 minutes was found best to inhibit peroxidase activity of roundels. Further roundels were pretreated with additives like sulfur fumigation and KMS dipping treatments in different concentrations. On the basis of higher sensory characteristics like colour, texture, taste and overall acceptability. A pre-treatment comprising of steam blanching followed by 2000 ppm KMS dip for 60 minutes was found best for carrot roundels.

Keywords: Carrot (*Daucus carota* L.), steam blanching, peroxidase activity, sulphur, KMS

Introduction
Carrot (*Daucus carota* L.) is usually orange, purple, red or yellow in colour having crisp texture belongs to family Apiaceae. China is the largest producer of carrots in the world, which is followed by Russia, USA, Uzbekistan, Poland, Ukrain, UK, Turkey, Japan and France. India ranks 14th in the production of carrots among 125 countries that cultivate carrot. Major carrot producing states in India are Haryana, Andhra Pradesh, Uttar Pradesh, Assam, Karnataka, Punjab, and Tamil Nadu. It is a rich source of β-carotene and contains other vitamins, like thiamine, riboflavin, vitamin B-complex and minerals. It also contains significant amount of calcium, potassium, phosphorus and dietary fibres (Bao and Chang, 1994) [8]. Carrot is an excellent source of calcium pectate which is an extraordinary pectin fibre that has cholesterol reduction or lowering properties (Kumar and Kumar, 2011) [18]. It is a very good source of energy because of its high sucrose content and has tendency to lower the risk of many cancers especially prostate cancer. Being a rich source of both α and β carotene it acts as an antioxidant. It keeps the eyes healthy, nourishes epithelial tissues in lungs as well as skin. Carotenoids have been claimed to provide protection from heart diseases (Mayne *et al.*, 1992; Murakoshi *et al.*, 1992; Abbey *et al.*, 1995 [21, 22, 1]). Fresh carrot roots can be kept for few days under ambient conditions, whereas, dry products can be stored for months or even years without appreciable loss of nutrients with proper pretreatments before drying. Drying of vegetables also reduces the bulk weight thus facilitating ease of transportation (Gupta *et al.*, 2012) [12]. Use of pretreatments like blanching and additives in carrot roots before drying helps in inactivation of enzymes and increases the shelf life and maintains the quality of the carrot form. So, in the present studies efforts were made to study the variation in the quality of carrot during the carrot season available in the *local sabji* Mandi so that best quality carrot can be procured for processing and standardize the pretreatments for the further drying of carrot roundels.

Material and Methods
Procurement of raw material and preparation of carrot roundels
Carrot roots of uniform shape, size, colour and maturity were procured from local market of Solan in the first week of the month throughout the season starting from November to April for studying their quality characteristics. Ten no of samples were taken and their physico-chemical and sensory quality characteristics were conducted for the selection of best month for procurement of carrot for product development. Carrot roots procured in best selected month were washed peeled and were cut into one cm thick roundels.

Detail of steam blanching and additive dipping treatment

Pre-treatment like blanching time for the development of carrot roundels was standardized by estimating the peroxidase enzyme activity. The carrot roundels were subjected to steam blanching for varying time periods of 2, 2.5, 3, 3.5 and 4 minutes (Table 1). After standardizing the time of steam blanching for roundels they were further pre-treated with food additives like KMS and sulphur powder in different concentrations at different time intervals as T_1: Steam blanching (control), T_2: Steam blanching + 1000ppm KMS (30 min) dip, T_3: Steam blanching + 1000ppm KMS (60 min) dip, T_4: Steam blanching + 2000ppm KMS (30 min) dip, T_5: Steam blanching + 2000ppm KMS (60 min) dip, T_6: Steam blanching + 0.3% sulfur (30 min) fumigation, T_7: Steam blanching + 0.3% sulfur (60 min) fumigation, T_8: Steam blanching + 0.5% sulfur (30 min) fumigation, T_9: Steam blanching + 0.5% sulfur (60 min) fumigation.

Drying

The pre-treated carrot roundels were spread on the perforated aluminium trays of dimension 76 x 56 cm and dried at 60±2°C temperature inside a mechanical cabinet drier having internal dimensions 78 x 58 x 128 cm upto a constant weight.

Physico-chemical and Sensory analysis

Among the different chemical characteristics of fresh carrot and pretreated carrot roundels moisture content was estimated by drying the weighed samples to a constant weight in a hot air oven at 70±1°C. Loss in weight of carrot form after drying representing the moisture content and was expressed as per cent (W/W), whereas, total solids were estimated by subtracting moisture content from the fresh weight of the carrot roundels. Water activity of the carrot roundels was estimated by computer based digital water activity meter (HW3 model, Rotronic International, Switzerland), where direct measurements were taken at room temperature. The titratable acidity was determined by the method given by (AOAC, 1984) [7]. Sugars were estimated as per the standard procedure given by Lane and Eynon (1923) [19] in Ranganna (2009) [24]. The pH of fresh carrot and pretreated form was determined by using a digital pH meter (CRISON Instrument, Ltd, Spain). Carotenoids in fresh carrot and pretreated form were determined by Ranganna (2009) [24]. Antioxidant activity (Free radical scavenging activity) was measured as per the method of Brand-Williams *et al.* (1995) [9]. Crude fibre content was estimated by the method given by Gould (1978) [11]. The total phenols content was determined by the Folin-Ciocalteu procedure given by Singleton and Rossi (1965) [28]. Ash content was determined by using muffle furnace at temperature of 550°C as given by Ranganna (2009) [24]. Dehydration ratio was determined by Ranganna (2009) [24] Sensory analysis of fresh carrot and pretreated form was carried out by using nine point hedonic scale as described by the Amerine *et al.* (1965) [4]. The samples were evaluated for sensory qualities based on colour, texture, taste, aroma and overall acceptability. Sensory panel (10 numbers at a time) comprised of faculty members and postgraduate students of department of Food Science and Technology, UHF, Solan (HP) were selected randomly with the care to accommodate different sections and age groups to evaluate the sensory parameters.

Statistical Analysis

The data pertaining to the sensory evaluation fresh carrot roots and pretreated form of carrot replicated three times were analyzed by Randomized Block Design (RBD) as described by Mahony (1985) [20]. Whereas, the data pertaining to the physico-chemical characteristics was replicated three times and analysed using Completely Randomized Design (CRD) (Cochran and Cox, 1967) [10].

Results and Discussion

Physical Characteristics

Data in Figure 1 (graph a. and b.) show a gradual increase in physical parameters of the carrot roots from November to April. Increase in weight from 56.80 to 125.60, was observed from November to March and thereafter it decreased. However initially its weight was lowest (56.80 g) during November and maximum (125.60 g) during March. Increase in length was observed from 165.30 to 245.07 mm, minimum (165.30 mm) length was observed during November and maximum (245.07 mm) during April. Increase in diameter of roots from 23.43 to 44.41 mm was observed from November to March, minimum (23.43 mm) diameter was observed during November and maximum (44.41 mm) during March month and then it decreased. Visual colour of roots was observed as Grey Red (179 A) throughout the season upto March and Grey Red (179 B) during April. Increase in pith size of carrot from 8.93 to 28.87 mm was observed from November to April during the season. Rate of increase in pith size was slower upto January, thereafter it increased at faster rate. The results on above physical characteristics of carrot are near to the values reported earlier by (Anon, 2008; Anon, 2010 and Haq *et al.*, 2013) [5, 6, 13].

Chemical Characteristics

Data in Figure 1 (graph c. d. e. f. g. and h.) shows significant changes in chemical characteristics of carrot with passage of time from November to April during the season. A decrease in moisture content of fresh carrot roots from 92.00 to 86.10 per cent was observed from November to April which reflects the increase in total solids from 8.00 to 13.90 per cent was observed during November to April. Increase in TSS from 7.00 to 8.0°B was observed during November to January thereafter it decreased and remained constant during February to April. Increase in reducing sugars from 3.47 to 3.55 per cent was observed during November to January and thereafter it decreased during February to April. Increase in total sugars from 6.10 to 6.39 per cent was observed during November to January and thereafter it decreased during February to April. Increase in titratable acidity from 0.12 to 0.18 per cent was observed during November to January and thereafter it decreased during February to April. Decrease in pH from 6.84 to 6.40 was observed during November to January and thereafter it increased during February to April. Increase in carotenoids from 4.10 to 4.52 mg/100g was observed during November to February and thereafter it decreased during March to April. Increase in total phenols from 12.31 to 13.18 mg/100g was observed during November to February and thereafter it decreased during March to April. Increase in ash content from 0.61 to 1.03 per cent was observed during November to April. Increase in crude fibre content from 0.44 to 1.40 per cent was observed during November to April. Increase in antioxidant activity from 6.21 to 8.87 per cent was observed during November to February and thereafter it decreased during March to April. Changes in physico-chemical characteristics of carrot occur as the production season of the carrot root varied because the temperature and the climacteric conditions becomes more suitable for the growth of the carrot roots and the concentration of major chemical constituents increased. But in the later phase of the production season as the temperature starts raising the climacteric conditions becomes less suitable for growth of the carrot roots and the carrots roots starts becoming over mature and the quality of the carrot roots decreases. Most of the physical and chemical characteristics of carrot increased upto January month thereafter they decreased because of the variation in soil temperature. Thereafter increase in temperature lead to the changes in the carrot characteristics which are not much suitable for drying or processing. More and more increase in pith size and crude fibres etc. lead to the non-acceptability of roots for processing after January month. So carrot roots procured in January month was selected best on the basis of physico-chemical and sensory quality characteristics for further processing

Sensory Characteristics

Figure 2 shows increase in appearance score from 6.60 to 8.50 during November to January and thereafter it decreased during February to April. Increase in texture score from 6.80 to 8.80 was observed during November to January and thereafter it decreased during February to April. Increase in taste score from 6.30 to 8.50was observed during November to January and thereafter it decreased during February to April. Increase in overall acceptability score from 6.50 to 8.50 was observed during November to January and thereafter it decreased during February to April**.** It was concluded that best period of selection of carrot roots for drying was January month during the season as most of the chemical characteristics were at its highest optimum value. The carrot roots had highest scores of sensory characteristics and also showed their superiority of the quality during the January month. So January month was adjudged to be the most suitable month for the selection of carrot roots for drying.

Standardization of pretreatments of drying process

Different pre-treatments like steam blanching followed by KMS as well as sulfur fumigation were standardized before drying of carrot roundels. The results obtained have been explained in the following heads:

Blanching Time

Data shows that peroxidase activity was positive for three samples as unblanched, steam blanching for 2 min and steam blanching for 2.5 min and negative for steam blanched samples for 3 min, 3.5 min and 4 min. Data shows that peroxidase activity was negative after 3 min of steam blanching in roundels. So roundels could be steam blanched for 3 min. More time taken for the blanching of roundels and sticks might be due to the larger size of the pieces which ultimately took more time for the penetration of heat upto their centre to inactivate the enzyme. Similar trend of results have been observed by Kidmose and Martens (1999) [16]; Karki (2009) [15]; Sra *et al.* (2011) [29] and Santos *et al.* (2012) [25] in the blanching of carrot.

Effect of pre drying treatments on the quality characteristics of carrot roundels

Data on the effect of pre drying treatments including blanching and additive treatment on quality characteristics of carrot roundels has been presented in Tables 1 elaborated under the following heads:

Roundels

Physico-chemical characteristics

Drying time, yield, dehydration ratio and colour

Perusal of the data in Table 1 shows that minimum time of 9.25 h to dry the carrot roundels was observed in pretreatment T_5, whereas, more time 9.60 h was taken to dry a given tray load in T_8 which was statistically at par with treatments T_1, T_2, T_6, T_7 and T_9. Further, the yield of dried carrot roundels was recorded maximum (16.00 %) in pretreatment T_1 and minimum (15.00 %) in pretreatment T_4 and T_5 which were statistically at par with T_7 and T_9. The data presented in same table shows the non-significant differences among all the treatments with respect to dehydration ratio of roundels. However highest dehydration ratio (1:0.160) was recorded in treatment T_1 and lowest (1:0.150) in T_4, T_5 and T_7. Data pertaining to the effect of pretreatments on the colour of carrot roundels indicates very little variation in colour in different pretreatments. The colour values were observed as Greyed Orange (176-D) in T_1, T_3 and T_9 treatment, whereas, in other pretreatments it was recorded as Greyed Orange (177-D) in T_2, (174-D) in T_4, (173-D) in T_5 and T_7, and Greyed Red (179-C) in T_6, T_8.

The lesser time taken for drying of given tray load in treatment T_5 might be due to combined effect of blanching and sulphiting, and continuous drying which reduced it by means of exposing the cells by rupturing their membrane, thus facilitating their plasmolysis due to heat. Similar trend of results of drying time have been reported by Karki (2009) [15] in steam blanched carrot pomace and Alam *et al.* (2013) [3] in citric acid blanched carrot pomace. The maximum yield recorded in pretreatment T_1 might be due to the more retention of moisture in this treatment as compared to others. Better retention of colour in pretreated samples was due to the effect of SO_2 which restricted the non-enzymatic browning reactions because of its antioxidant effect.

Moisture and Carotenoids

Data in Table 1 indicate that the moisture of dried carrot roundels was recorded minimum (10.63 %) in T_4 and T_7 which were statistically at par with T_5, T_6, T_8 and T_9 and maximum (11.10 %) in T_1 which was statistically at par withT_2. Data in the same table shows the non-significant differences among all the pretreatments with respect to carotenoids content of dried carrot roundels. However maximum (31.35 mg/100g) carotenoids were recorded in treatment T_7 and minimum (30.03 mg/100g) in T_3.

The minimum moisture content recorded in pretreatment T_4 might be due to the effect of blanching which lead to the better exposure of the cells by rupturing their membrane and facilitating proper plasmolysis of cells. Sra *et al.* (2011) [29] and Karki (2009) [15] have reported the similar trend of results of moisture retention in steam blanched slices/pomace of carrot.The degradation of carotenoids in all the pretreatments during drying might be attributed to their sensitivity to heat, light and oxygen (Sharma and Le Maguer, 1996) [27]. Sra *et al.* (2011) [29], Alam *et al.* (2013) [3] and Kapoor and Aggarwal (2014) [14] have also observed the degradation of carotenoids in carrot slices as well as in pomace during dehydration.

Total phenols and antioxidant activity

An elucidation of data presented in Table 1 shows thatmaximum (98.90 mg/100g) total phenols were recorded in treatment T_7 which was statistically at par with T_6, T_8 and T_9 and lowest (97.20 mg/100g) in treatment T_3 which was statistically at par with T_1, T_2 and T_5. Significant differences were observed among all the treatments with respect to total phenols and antioxidant activity in roundels. The maximum (54.57%) antioxidant activity (as free radical scavenging activity) in roundels was observed in pretreatment T_7 which was statistically at par with T_6, T_8 and T_9 and minimum (53.30%) in T_5 which was statistically at par with T_1, T_2, T_3 and T_4.

Maximum total phenols content observed in T_7 might be due to the antioxidant effect of SO_2 which prevented the oxidation of total phenols. Similar trend of results for total phenols have also been reported by Aggarwal *et al.* (2016) [2] in dried tomato slices. The maximum antioxidant activity observed in T_7 might be due to better retention of total phenols, carotenoids and ascorbic acid etc. The similar trends of results ofantioxidant activity have been observed by Kapoor and Aggarwal (2014) [14] in KMS pretreated carrot and Aggarwal *et al.* (2016) [2] in dried tomato slices.

Reducing and total sugars

The data presented in Table 1 indicate that significant differences were observed among all the treatments with respect to reducing and total sugars. Maximum (21.47 %) reducing sugars was recorded in treatment T_7 which was statistically at par with T_6 and T_9 and minimum 20.57 per cent in T_3 which was statistically at par with T_1, T_2 and T_5. Maximum (36.10 %) total sugars were recorded in treatment T_7 which was statistically at par with T_6 and T_9 and minimum 34.68 per cent in T_3 which was statistically at par with T_1, T_2 and T_5.

Maximum sugars observed in T_7might be due to the protective effect of SO_2 towards hydrolysis and inversion of non-reducing to reducing sugars which helped in the retention of sugars. The similar trend of results have been observed in KMS pretreated carrot slices by Sra *et al.* (2011) [29].

Titratable Acidity

Data presented in Table 1 indicate that titratable acidity of roundels was recorded highest (0.88 %) in treatment T_7 which was statistically at par with T_9 and lowest (0.78 %) in T_3 which was statistically at par with T_1. Maximum acidity observed in T_7might be due to no leaching losses in this pretreatment as compared to dipping pretreatments where leaching losses of natural acids have occurred. Similar trend of results oftitratable acidity with different pretreatments has been reported by Sra *et al.* (2011) [29] and Karki (2009) [15] in carrot slices/pomace.

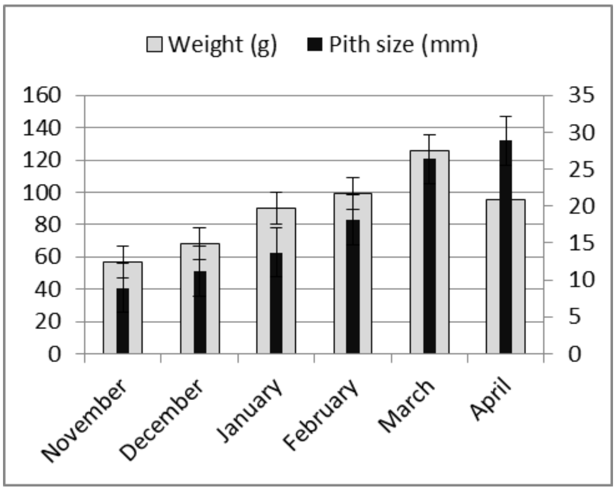
Sensory Characteristics

Data pertaining to the effect of treatment on the colour scores of dried carrot roundels indicate that maximum scores (8.50) were obtained in T_5 and minimum (5.75) in T_1 which was statistically at par with treatment T_2. Texture scores of dried carrot roundels were obtained highest (8.50) in treatment T_5 and lowest (6.50) in T_2 which was statistically at par with treatment T_1, T_3 and T_8. Data pertaining to the effect of treatment on the taste scores of dried carrot roundels indicate that the maximum taste scores (8.25) were recorded in T_5 and minimum (6.50) in T_2 which was statistically at par with treatment T_1, T_3, T_4 and T_8. Overall acceptability scores of dried carrot roundels were highest (8.50) in treatment T_5 and lowest (6.25) in T_1 which was statistically at par with treatment T_2.

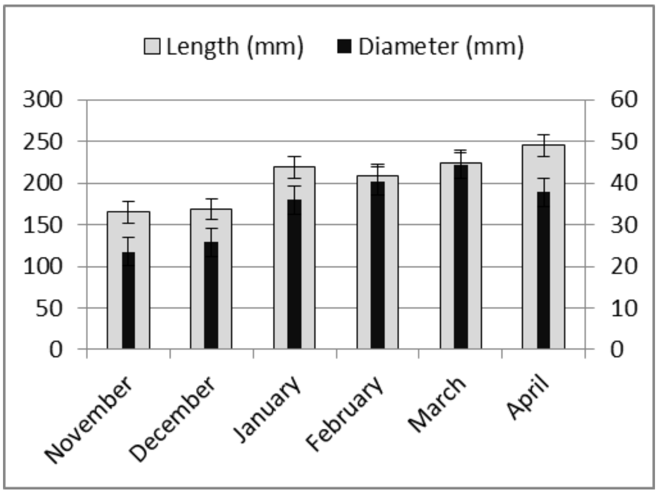
Although some chemical characteristics like carotenoids, total phenols, antioxidant activity, sugars and acidity were recorded higher in pretreatment T_7 but maximum scores of sensory characteristics like colour, texture, taste and overall acceptability were recorded in pretreatment T_5 which might be due to inhibition of non-enzymatic browning reaction by SO_2 which binds with the carbonyl group of reducing sugars and other compounds to retard the browning process resulting in bright colour and characteristic acceptable flavour of the product, while good texture and taste of the roundels might be due to its quick drying and lesser moisture retention in it thereby improving the overall acceptability (Take *et al.*, 2012) [30]. Nearly similar trend of results for sensory characteristics (colour, texture, taste and overall acceptability) in various pretreated carrot slices have been observed by Kukanoor *et al.*(2014) [14], Pritika (2015) [23] in SO_2 pretreated pumpkin cubes and slices and Sharma *et al.* (2015) [26] in bell pepper powder.

Table 1: Physico-chemical and sensory characteristics score of pretreated carrot roundels

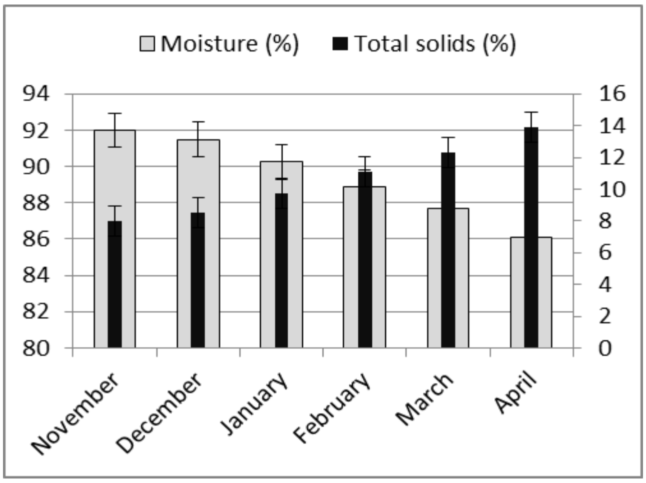
Characteristics\ Treatment	Yield (%)	Drying time (h)	Visual colour	Moisture (%)	Carotenoids (mg/100g)	Antioxidant activity (%)	Total phenols (mg/100g)	Reducing sugars (%)	Total sugars (%)	Titratable acidity (%)	Dehydration ratio	Sensory characteristics			
												Colour	Texture	Taste	OA
T_1	16.00	9.55	Greyed Orange (176-D)	11.10	30.05	53.41	97.30	20.65	34.73	0.79	1:0.160	5.75	6.75	6.55	6.25
T_2	15.50	9.50	Greyed Orange (177-D)	10.98	30.15	53.45	97.70	20.80	34.93	0.81	1:0.155	6.25	6.50	6.50	6.50
T_3	15.25	9.45	Greyed Orange (176-D)	10.77	30.03	53.38	97.20	20.57	34.68	0.78	1:0.152	7.10	6.75	6.75	7.10
T_4	15.00	9.40	Greyed Orange (174-D)	10.63	30.35	53.60	98.00	20.95	35.40	0.83	1:0.150	7.50	7.25	7.00	7.25
T_5	15.00	9.25	Greyed Orange (173-D)	10.68	30.10	53.30	97.50	20.70	34.80	0.80	1:0.150	8.50	8.50	8.25	8.50
T_6	15.25	9.55	Greyed Red (179-C)	10.75	31.20	54.25	98.50	21.15	35.89	0.86	1:0.152	7.10	7.00	6.75	7.25
T_7	15.05	9.50	Greyed Orange (173-D)	10.63	31.35	54.57	98.90	21.47	36.10	0.88	1:0.150	7.50	7.55	7.25	7.50
T_8	15.20	9.60	Greyed Red (179-C)	10.72	31.04	54.09	98.20	21.07	35.68	0.85	1:0.152	7.00	7.25	7.00	7.50
T_9	15.15	9.55	Greyed Orange (176-D)	10.70	31.25	54.39	98.70	21.28	35.97	0.87	1:0.151	7.50	7.75	7.50	7.75
$CD_{0.05}$	0.17	0.13	-	0.13	NS	0.51	0.77	0.36	0.41	0.01	NS	0.57	0.58	0.55	0.58



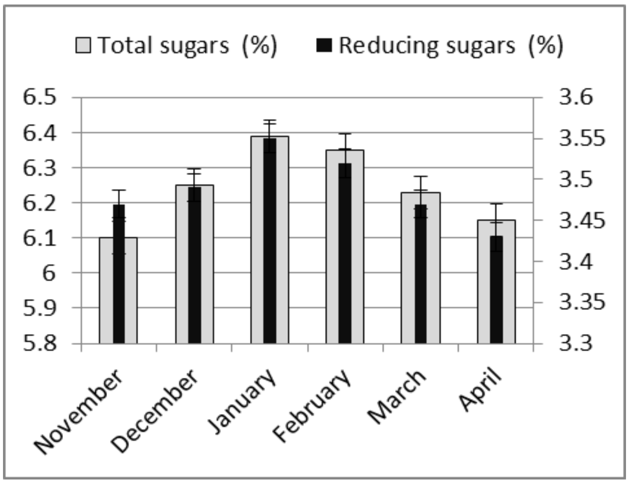
a. Weight and pith size



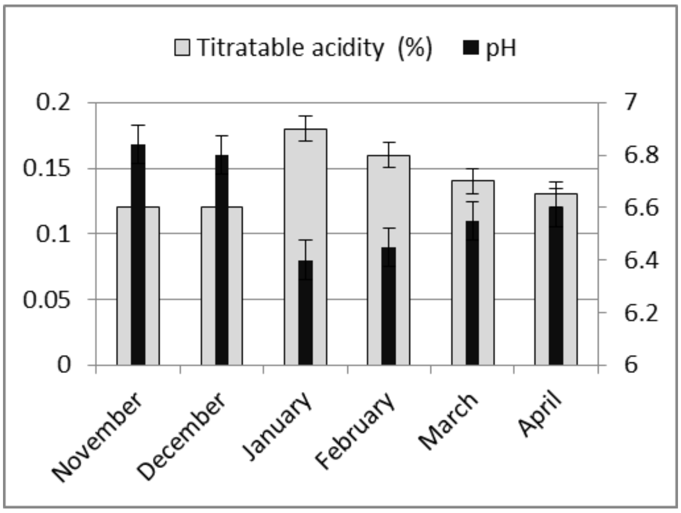
b. Length and diameter



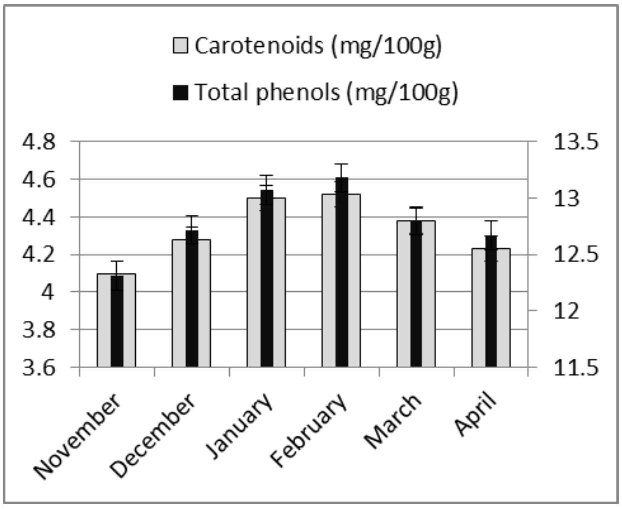
c. Moisture and total solids



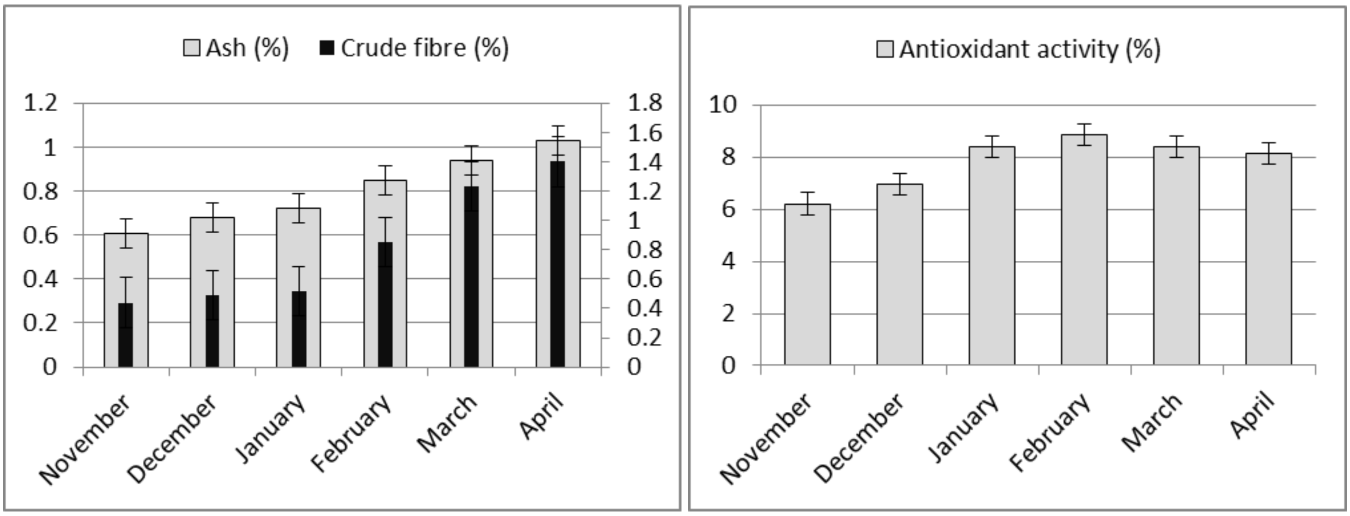
d. Reducing and total sugars



e. Titratable acidity and pH



f. Carotenoids and total phenols



g. Ash and crude fibre h. Antioxidant activity

Fig 1: Physico-chemical characteristics of fresh carrot during different months

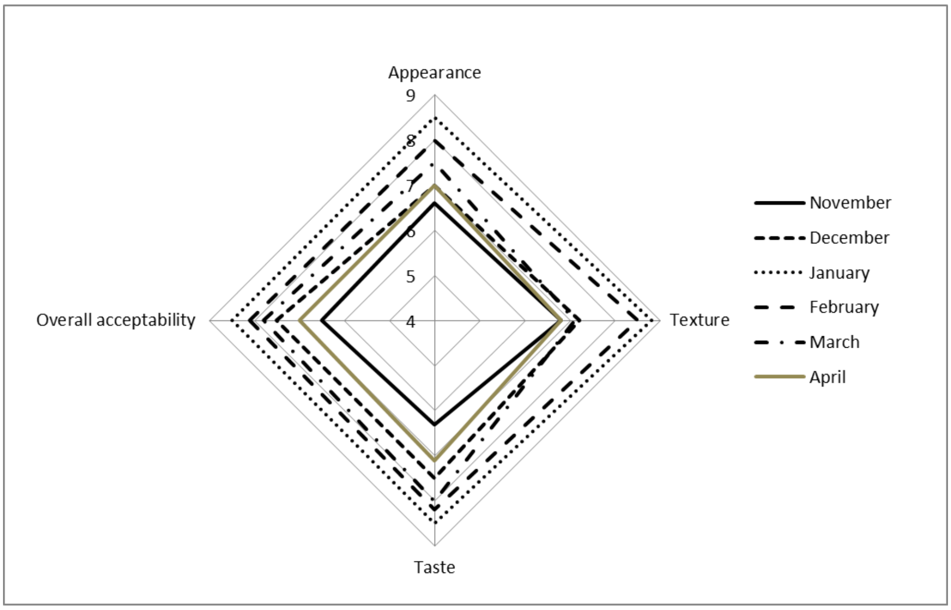


Fig 2: Sensory characteristics of fresh carrot during different months

Conclusion

As best month selected for carrot roots drying was January month during the season in that month most of the chemical characteristics were at its highest optimum value. The carrot roots had highest scores of sensory characteristics and also showed their superiority of the quality during the January month. So January month was adjudged to be the most suitable month for the selection of carrot roots for drying. Different pre-treatments like steam blanching followed by KMS as well as sulphur fumigation were standardized before drying of carrot roundels. So, on the basis of higher scores of sensory characteristics like colour (8.50), texture (8.50), taste (8.25) and overall acceptability (8.50) pretreatment T_5 steam blanching followed by 2000 ppm KMS dipping for 60 minutes was found to be the best pretreatment as compared to the other pretreatments.

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