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Quality evaluation and storage stability of carrot pomace powder

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Abstract
The experiment was conducted to develop dried carrot pomace powder of high quality and storage stability. The carrot pomace was given different blanching pre-treatments such as steam blanching expressed as (TSB), water blanching as (TWB), soaking in citric acid as (TCS) and citric acid blanching as (TCB). After different pre-treatments, the carrot pomace dried in a lab-scale cabinet tray drier at 60 °C and converted into powder. The prepared carrot pomace powder was packaged and analyzed for physico-chemical quality attributes and shelf stability at 30 days intervals. Among pretreatments, TCB (Citric acid blanching) samples had better results in retaining quality attributes than other treated samples. While observing color changes, it was noted that untreated (TC), steam blanched (TSB) and water blanched (TWB) carrot pomace powder showed a pale red colour. But, both the citric acid treated (TCS and TCB) samples retained their red colour during storage period that is most appealing and desirable than other ones.

Keywords: Carrot, carrot pomace, blanching, convective drying, physio-chemical attributes

Introduction
Carrot (*Daucus carota*) is an important root vegetable which is used commonly for juice production. The juice yield in carrots is about 60–70%, and the rest is lost as carrot pomace (Sharma *et al*., 2012) [12, 22]. Carrot pomace is a by- product of the carrot juice industry that does not find proper utilization and can become a source of environmental problem due to its high moisture content (about 88%). However, this carrot pomace contains large amounts of valuable compounds such as carotenoids, dietary fiber (Nocolle *et al*., 2003) [16], vitamins and minerals (Kumar *et al*., 2012) [13]. It contains both alcohol soluble (glucose, fructose, galactose, arabinose, cellopentaose, cellotetraose, cellotriose, cellobiose, galactotetraose and galactotriose) and alcohol insoluble (rhaminose, arabinose, mannose, galactose, glucose and xylose) dietary fibre (Yoon *et al*., 2005) [31]. Insoluble carrot fibre lowers serum triglyceride, serum total cholesterol and liver cholesterol and results in a higher HDL: total cholesterol ratio as well as higher levels of fecal lipids, cholesterol and bile acids (Hsu *et al*., 2006) [9]. Differently micronized insoluble carrot dietary fibre shows different functional properties (Chau *et al*., 2007a) [6] decreases caecal ammonia concentration, increases faecal output and moisture content and also reduces the activities of undesired b-Dglucosidase and b-D-glucuronidase in faeces (Chau *et al*., 2007b) [6].
Value addition to the carrot pomace helps to curtail the price of main product thus a direct benefit to the processors and consumers. Drying of carrot shreds with or without extracting juice could be one of the best alternatives to make carrot products available throughout the whole year. Drying or dehydration is the useful means to increase the shelf life of perishable food for further use (Roberts *et al*., 2008) [19].
Many different drying methods have been used to take out moisture from food. The applied methodology ought to give a dried product of the highest possible quality, i;e one characterized by only slight structure change, appropriate composition, high nutritive value and good sensory attributes To produce such a dried product, it is necessary to choose the best drying methodology and optimal drying conditions (Marabi *et al*., 2006; Perera, 2005; Ratti, 2001) [14, 17, 18]. Deterioration of quality proceeds because of high temperature, internal mass flow as well as water loss and shrinkage. Changes also take place due to the influence of the drying process on the physical properties of the dried material, such as apparent density, rehydration and hygroscopic properties (Stepien, 2008) [27].

Convective drying is the most frequently applied method for shelf life extension. In order to extend the shelf life of carrot pomace, it should be dried. The dried carrot pomace has carotene and ascorbic acid (9.87-11.57 mg and 13.53-22.95 mg per 100 g, respectively),and also a rich source of fibre (10-20%), antioxidants, minerals including calcium, copper, magnesium, potassium, phosphorus, iron and folic acid that exhibits health promoting effects (Upadhyay *et al.*, 2008) [29]. The dried carrot pomace can be used to enrich some foods including durum wheat pasta (Gull *et al*., 2015) [7] and wheat flour biscuits (Baljeet *et al*., 2014) [3], cookies (Nagarajaiah and Prakash, 2015), wheat rolls (Kohajdova *et al*., 2012) [11] and extruded products (Singh *et al*., 2006; Kumar *et al*., 2010) [24, 12]. Hence, fresh carrot pomace, if properly dried, packaged and stored, may increase availability for utilization in fiber rich products.
The present study was undertaken to prepare carrot pomace powder and evaluate the physio-chemical attributes and storage stability.

Materials and Methods

Sample Preparation: Commercial variety of carrot was procured from local market at Jammu. Carrots were sorted for uniform size, color, physical damage and washed in running tap water to remove impurities. Carrots were manually peeled with knife and were properly washed with tap water followed by juice extraction using a juicer-mixer cum grinder. Carrot pomace obtained after the extraction of juice from carrots was collected for dehydration. Before dehydration carrot pomace was subjected to different blanching pretreatments. Carrot Pomace without any pre-treatment was expressed as control (TC), Carrot Pomace was given steam blanching for 3 minutes was expressed as (TSB), water blanching for 3 minutes was expressed as (TWB), soaking in citric acid (0.5gm in 100ml) for 3 minutes was expressed as (TCS) and citric acid blanching (0.5 gm in 100ml) for 3 minutes was expressed as (TCB).

Convective Drying: The convective drying was performed in a lab-scale cabinet tray drier. After different pre-treatments the carrot pomace to be dried was spread on the aluminium trays (27.94 × 21.59 cm^2) at 60 °C with drying bed thickness of 4 mm. Each treatment was replicated three times. The carrot pomace was turned up after a regular interval of 20 minutes. So, as to avoid sticking to the base of tray followed by proper dehydration. The drying was done up to a final moisture content of 4-5% (wet basis). The dried carrot pomace samples were grinded to powder in a Juicer Mixer-cum-Grinder and were packed in aluminium laminated packs and stored in refrigerated conditions (fig.1 and 2). The dried carrot pomace powder samples were then evaluated for their physico-chemical quality attributes and shelf stability.

Quality attributes: The developed samples were then evaluated for their physico-chemical quality properties such as moisture content, water activity, color profile, crude fibre and β-carotene. Also, compared with the values of a control sample (fresh carrot pomace) were determined by the procedure as given below:

Moisture content: The Moisture content was estimated by using an electronic moisture analyzer (Citizeon MB 50 C) at 105 ºC. Measurements were made in triplicates. A sample of about 2gm was spreaded on an aluminium sample holder and was placed in the analyzer. The sample was heated at 105 ºC and evaporative moisture losses were automatically reported as moisture content (%)

Water activity (a_w): The water activity was measured directly by using water activity meter (Aqua lab meter) at 25º C. Measurements were made in triplicates. Approximately 4 - 5gm was measured to determine water activity for the sample.

Crude Fibre: The crude fiber was estimated according to the procedure as outlined in (AOAC Official Methods, 2002). It was carried out by taking 3g of each fat free sample digested first with 1.25% H_2SO_4, washed with distilled water and filtered, repeated again this step. Then ignited sample residue by placing the digested samples in a muffle furnace maintained at temperature of 550-650 °C for 4 hours till grey ash was obtained. The percentage of crude fibre was calculated after igniting the samples according to the expression given below.

$$\text{Crude fiber (\%)} = \frac{\text{Weight loss on ignition}}{\text{Weight of flour sample}} \times 100$$

β-carotene: The β-carotene was estimated by spectrophotometric method based on the chromatographic separation using an adsorbent having varying affinities as per the standard method described (Srivastava and Kumar, 2002).

Colour profile (L*, a* and b*)
The colour profile was measured using a Hunter Lab Colorimeter (Color Flex Reston VA, USA). The equipment was calibrated using white and black standard ceramic tiles. In the Hunter's lab Colorimeter, the colour of a sample is denoted by the three dimensions L*, a* and b*. L* value is the brightness of the colour in the range of values from 0 (black) to 100 (white); the higher the values, the brighter the colour. The value of a* indicates the redness of sample namely - (green) to + (red). The b* value indicates the yellowness of the sample namely - (blue) to + (yellow).

Result and Discussions

Evaluation of fresh Carrot pomace
The physico-chemical properties like moisture content, water activity, colour profile, crude fibre and β-carotene of fresh carrot pomace shown in Table 1. All of these physico-chemical properties of fresh carrot pomace were recorded before convective dehydration. The recorded values were moisture content 85.18 ± 0.37%, water activity (a_w) 0.95 ± 0.03, colour profile such as L* value 58.14 ± 0.42, a* value 18.27 ± 0.71, b* value 63.30 ± 0.30, crude fibre 1.05 ± 0.10% and β-carotene 31.26 ± 0.05 mg/100g. The results of these physico-chemical attributes such as moisture content (%), ash content and crude fibre are near to the values reported by Karki S (2009).

a) Comparative evaluation of fresh carrot pomace and dried carrot pomace
Moisture content: The data on physico-chemical analysis of dried carrot pomace powder showed that it contains less moisture content when compared with fresh carrot pomace due to dehydration. The moisture content was found as 4.00%, 4.22%, 4.41%, 4.43% and 4.58% for TC, TSB, TCS and TCB, respectively. Similar results have been reported for hot air drying of carrot pomace (Kumar *et al*., 2012) [13]. Less

moisture content of pomace powder is essential for the maintenance of better storage stability that prevents various deteriorative reactions (Sahni and Shere, 2017) [20, 21]. It has been suggested that dehydration of carrot shreds with or without extracting juice during the main growing season could be one of the best alternate to make carrot products available throughout the year (Sharma *et al*., 2012) [12, 22].

Water activity: Dehydration method also affected water activity. The water activity of dried carrot pomace powders was 0.32, 0.35, 0.36, 0.39, 0.41 for TC, TSB, TCS and TCB respectively. Water activity of a food sample is important factor that determines food safety. According to Alam *et al*. (2013) [1] carrot pomace convectively dried at 65 °C were found in the range of 0.351 to 0.444 (a_w). It has been reported that maximum oxidation and enzymatic reactions will be inhibited as water activity decreases, however non-enzymatic reactions will take place at intermediate a_w ranged from 0.4-0.65. Consequently, it is important to dry to an a_w of around 0.2-0.4 (Perera, 2005) [17].

Crude fibre: The study demonstrated an increase in crude fibre after drying. The recorded value of fresh content was 1.05 ± 0.10% and dried carrot pomace powder was 9.01%, 9.13%, 9.22%, 9.30% and 9.39% for TC, TSB, TCS and TCB, respectively. A significant effect of the drying method on changes in the content of fibre in carrot pomace was also demonstrated by Alam *et al*. (2013) [1], who found the highest fibre content in samples after convective drying (at 65 ºC) compared to sun drying and solar drying.

β-carotene: The pigment of carrot is known as beta-carotene, which is responsible for orange color in the carrots. In this study, we found that the β-carotene was affected by blanching and drying method. The recorded value of fresh carrot pomace was 31.26 ± 0.05 mg/100g and decreased in dried carrot pomace powder. It has been reported that due to thermal degradation of β- carotene during blanching resulted into decrease in β- carotene content (Chantaro *et al*., 2008) [4]. The β-carotene was affected by blanching pretreatment, drying method and their interaction (Alam *et al*., 2013) [1]. Reduction in β-carotene at high temperature drying could be due to increased oxidation rate of its highly unsaturated chemical structure. Earlier findings also supported the carotene behavior under drying in the present study (Upadhyay *et al*., 2008) [29].
Among pretreatments, TC (untreated) and TCB (Citric acid blanching) samples had better results than other treated samples. Also indicated that, acidulants, such as citric acid, prevented loss of β-carotene during thermal processing (Veda *et al*., 2008) [30]

b) Storage studies of dried carrot pomace
Moisture content: With the advancement in storage time, the moisture content increased as presented in table 2. After 90 days storage, the moisture content of TC increased from 4.00 to 4.33%, for TSB value increased from 4.22 to 4.61%, for TWB value increased from 4.41 to 4.77, for TCS value increased from 4.43 to 4.79% and TCB value increased from 4.58 to 4.80%. It has been found that the mean storage values greater than before i;e 4.32 to 4.66% that might be due to the hygroscopic nature of the product.

Water activity: The data pertaining to water activity of carrot pomace powder in table 2 showed that the water activity varied with the treatments and storage time. In the beginning of storage, highest water activity was observed in TCB (0.41) and lowest in TC (0.32). It was observed that, the recorded mean water activity value increased from 0.36 to 0.44 during 90 days storage. The effect of treatment, storage period and their interaction were found to be non-significant.

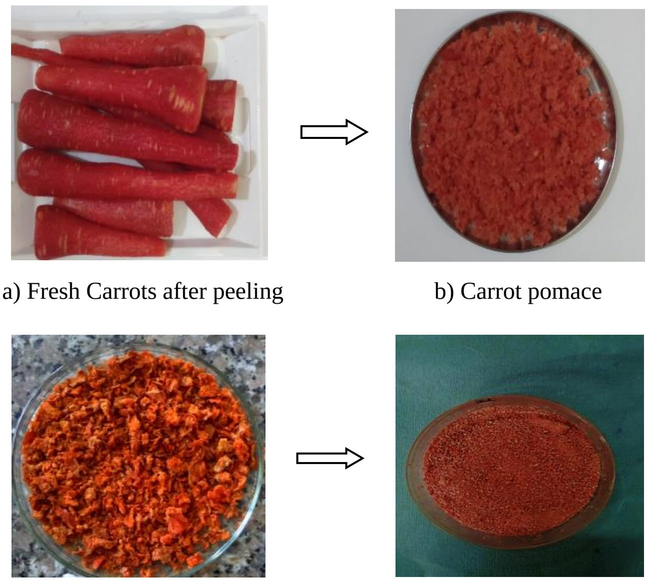
Crude fibre: The applied treatments and drying with respect to storage time significantly influenced the crude fibre content of carrot pomace powder. The mean crude fibre content decreased from 9.21 to 9.03% during storage period of 90 days (Table 3). Our findings are supported by Sharma *et al*. (2017) [23] who noticed the fiber content in dried pomace experienced decrease at all the storage intervals.

β-carotene: It has been noticed throughout storage of 90 days, β-carotene content decreased severely from 23.21 to 20.97mg/100g. Suman and Kumari (2002) [28] also evaluated loss of β- carotene in shreds followed by powder and chops during dehydration of carrot and three months storage. Another scientist also showed a gradual decrease of β-Carotene content in dehydrated carrot products with increased storage time (Singh *et al*., 2013) [25]

c) Effect on treatments and drying on colour attributes of carrot pomace powder
The color of the food product is the main quality parameter that imitates the sensory attractiveness and quality. The color profile in terms of L*, a* and b* values of carrot pomace powder showed significant differences during application of different treatments. It was observed that the L*, a* and b* values showed variation with different treatments (Figure 3).
According to experimental data, blanching and drying method affected the L* values. The highest Lightness (L*) value (62.56) was found in water blanching (TWB) and lowest value (48.52) was found in control (TC). Among the treated samples, highest a* value (25.32) was recorded in TCB while lowest (19.10) value in steam blanching (TSB). It might be due to the use of citric acid that act as a chelating agent and prevents browning reaction (Hiranvarachat *et al*., 2011) [8]. Our results are supported by Alam *et al*. (2013) [1]. For the colour b* values, TCB attained maximum (34.33) and TWB attained minimum (28.60) values.
While observing color changes, it has been investigated that untreated (TC), steam blanched and water blanched (TWB) carrot pomace powder showed a pale red colour. But, both the citric acid treated (TCS and TCB) retained red colour that is desirable than others.

Carrot
↓
Washing
↓
Peeling
↓
Grating
↓
Juice Extraction
↓
Carrot Pomace
↓
Pre-treatment
↓
Drying (60 ºC± 2 ºC)
↓
Dried carrot pomace flakes
↓
Grinding
↓
Powder
↓
Packaging in aluminium laminated packs
↓
Storage at 4 ± 2 ˚C

Fig 1: Schematic for preparation of carrot pomace powder.



a) Fresh Carrots after peeling

b) Carrot pomace

c) Dried Carrot pomace

d) Carrot pomace powder.

Fig 2: Picture representation.

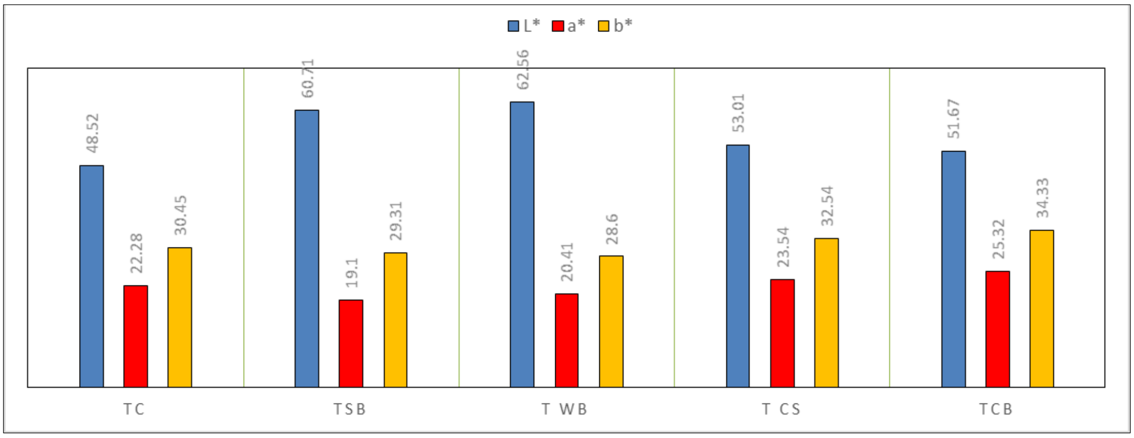


Fig 3: Effect on treatments and drying on colour attributes of carrot pomace powder

Table 1: Physico-chemical analysis of fresh carrot pomace

Parameters	Fresh carrot pomace
Moisture content (%)	85.18 ± 0.37
Water activity (a_w)	0.95 ± 0.03
Color values	
L*	58.14 ± 0.42
a*	18.27 ± 0.71
b*	63.30 ± 0.30
Crude fibre (%)	1.05 ± 0.10
β-carotene (mg/100g)	31.26 ± 0.05

Table 2: Effect of treatment and storage on moisture content (%) and water activity (a_w) of carrot pomace powder

Treatments	Moisture Content Storage period (months)					Water activity Storage period (months)				
	0	1	2	3	Mean	0	1	2	3	Mean
TC	4.00	4.10	4.29	4.33	4.18	0.32	0.34	0.35	0.38	0.34
TSB	4.22	4.37	4.52	4.61	4.43	0.35	0.38	0.42	0.44	0.39
T WB	4.41	4.55	4.69	4.77	4.603	0.36	0.40	0.43	0.46	0.41
T CS	4.43	4.62	4.70	4.79	4.635	0.39	0.42	0.45	0.47	0.43
TCB	4.58	4.65	4.71	4.80	4.685	0.41	0.43	0.47	0.48	0.44
Mean	4.32	4.45	4.58	4.66		0.36	0.39	0.42	0.44	
CD ($P \leq 0.05$)										
Treatments		0.03							0.02	
Storage		0.02							0.01	
Treatments X Storage 0.05							N/S			
TC: Control	TSB: Steam blanching			TWB: Water blanching		TCS: Citric acid soaking		TCB: Citric acid blanching		

Table 3: Effect of treatment and storage on crude fibre (%) and β-carotene (mg/100gm) of carrot pomace powder

Treatments	Crude fibre Storage period (months)					β-carotene Storage period (months)				
	0	1	2	3	Mean	0	1	2	3	Mean
TC	9.01	8.92	8.87	8.72	8.88	28.28	26.05	25.31	24.52	26.04
TSB	9.13	9.09	9.01	8.95	9.04	22.21	21.45	21.17	20.05	21.22
T WB	9.22	9.19	9.14	9.10	9.16	21.39	20.01	19.82	19.61	20.20
T CS	9.30	9.28	9.22	9.19	9.24	19.68	18.17	17.91	17.68	18.36
TCB	9.39	9.30	9.26	9.21	9.29	24.52	23.12	22.85	22.99	23.37
Mean	9.21	9.15	9.10	9.03		23.21	21.76	21.41	20.97	
CD ($P \leq 0.05$)										
Treatments			0.02				0.02			
Storage			0.02				0.01			
Treatments x Storage			0.03				0.03			
TC: Control	TSB: Steam blanching			TWB: Water blanching		TCS: Citric acid soaking		TCB: Citric acid blanching		

Conclusion

The findings of the study indicate that carrot pomace can be dehydrated successfully for the preparation of carrot pomace powder. Preserving nutrient levels for the dehydrated product is a difficult task, so appropriate method should be developed. Given the importance of colour in consumer food choices and preference, and the increasing consumer demand for internal quality attributes of food products including nutrients, there is opportunity for the usage of non-destructive methods associated with nutritional value. Likewise, in the drying stage, all the particles may have exposed to heat resulting in loss of nutritional as well as colour characteristics, so drying at low temperature, blanching and pre-treatments before processing will be succeeding alternative. Moreover, efforts have been made to proper utilize carrot pomace powder supplementation in foods such as bread, cake, dressings, pickle, fortified wheat bread, high fibre biscuits and extruded products etc. So, that it can be used as a good source of fibre and β -carotene for the valorization of food products.

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