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RESEARCH ARTICLE

Development and quality evaluation of deep fried carrot chips during storage

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ABSTRACT

The objective of this study was to develop and evaluate the properties of deep fried carrot chips during storage. The carrot slices were blanched at 80°C for 4 min. followed by pre-treatments with NaCl (2%):T_1, $CaCl_2$ (2%):T_2, KMS (0.15%):T_3 and KMS (0.15%) + $CaCl_2$ (2%):T_4, and then partially dried at 60°C for 2 hr, fried and compared with control samples. The storage depicted significant increase in mean moisture content while there was a decreasing trend in the mean values of ash, protein, fat and ascorbic acid contents. The storage depicted the gradual decrease in the mean β-carotene values from 43.98 to 41.64 (mg/100g). The maximum retention of β-carotene was noticed in T_4 (43.65) while the minimum in T_0 (42.12). The color (L*, a*, b*) values of stored carrot chips showed a progressive decrease in all the treatments with maximum change noticed in T_0. The organoleptic evaluation showed that scores for color, taste, appearance and overall acceptability were highest for T_4, whereas the scores of crispness were highest in T_3.

Keywords: carrot chips; drying; storage; quality; sensory quality

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INTRODUCTION

Carrot (*Daucas carota*) is one of the most important seasonal root vegetable of *Apiaceae* (*Umbelliferae*) family, grown throughout the world and is the most important source of dietary carotenoids (Torronen *et al*., 1996). It is usually orange, red, purple, white or yellow in color, with a crisp texture when fresh. Carrot is an excellent source of β-carotene, a precursor of vitamin A, which protects cells from free radicals which may damage the basic cell structure of healthy cells (Demir *et al*., 2004; Yoon *et al*., 2005). It is also rich source of vitamin C, vitamin B-complex and minerals (Walde *et al*., 1992).

Recently carotenoids such as β-carotene have attracted considerable attention because of their possible protective effect against some types of cancers (Bast *et al*., 1996; Santo *et al*., 1996; Van, 1996). Carotenoids also are thought to have variety of different actions that are related to the decreased risk of some degenerative diseases (Dueik et al., 2010).

In recent years, fast food snacks industry has emerged as one of the important sectors for the modern consumers with a special desire for fried snack foods. Fried products are liked by all age groups and play an important role in consumer's diet because of their unique flavor and texture (Maity *et al*., 2014). Deep-frying is a method to produce dried food product where oil is heated above the boiling of water, which serves as the heat transfer medium. During frying oil migrates into the food, providing nutrients and flavor (Tarmizi and Niranjan, 2011). These deep frying conditions also leads to rapid cooking,

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browning, texture, and flavor development. Therefore, deep-fat frying is often selected as a method for creating unique flavors, colors, and textures in processed foods (Amany *et al.,* 2012). Various treatments including chemicals like sodium chloride, potassium metabisulphite and calcium chloride are used to enhance the quality attributes of friend snacks. Keeping in consideration the above facts the study was undertaken with the objective to study the effect of various treatments on the quality attributes of deep fried carrot chips.

MATERIALS AND METHODS

Raw materials

Fresh carrots devoid of any visible microbial infection or mechanical fissures, mustard oil and salt were procured from the local market of Pulwama.

Preparation of deep-fried carrot chips

Cleaning and trimming of procured fresh carrots was done manually. The carrots were then peeled and cut into 55 mm lengths, 7 mm thick slices using stainless steel knife. The carrot slices were steam-blanched by tying the carrot slices in a muslin cloth and dipping it into boiling water (80^{o}C) for 4 minutes. The samples were then cooled under running tap water to prevent over cooking and discoloration. Blanched and cooled carrot slices were then given treatments at different levels for 5 minutes.

T_1 : Sodium Chloride (NaCl) 2%

T_2 : Calcium Chloride ($CaCl_2$) 2%

T_3 : Potassium metabisulphite (KMS) 0.15%

T_4 : Calcium chloride ($CaCl_2$) 2% + Potassium metabisulphite (KMS) 0.15%

After 5 minutes water was drained and carrot slices were spread in dehydrator trays for drying at 60°C for two hours. The dried slices (500g per batch) were deep-fried in deep pan at 150 °C for 4 minutes or until there were no bubbles due to residual water. The fried-carrot chips were drained on paper towels to remove excess oil and sprinkled with 1.0% salt (w/w). The carrot chip products were then packed (30g per batch) in HDPE pouches and then stored for further analysis.

Proximate composition

The samples were analyzed for moisture, ash, fat, protein content of deep-fried carrot chips was determined as per standard procedure of AOAC (2005).

Sensory evaluation

The sensory attributes in terms of color, appearance, crispness, taste and overall acceptability, were evaluated using a 5-point scale for likeness where 5= excellent, 4= good, 3= average, 2= fair and 1= poor. The carrot chips were deep-fried in mustard oil and served warm to a semi-trained panel of judges The coded samples were served to the panelists in random order. The nature of experiment was explained to the panelists without disclosing the identity of samples. Water was provided to rinse the mouth between the samples. The panelists judged the samples for color, appearance, crispness, taste and overall acceptability.

Texture Analysis

Texture measurements of the chips were performed by a computer assisted TA-HD Plus Texture Analyzer (Stable Micro Systems, UK) with a 5 kg load cell. Fried chips were mounted individually on a three- point pin support, at a distance maintained at 15mm with the punch diameter and the cross head speed being 2mm and 60mm/min respectively. Force versus distance curves was generated based on the puncture test and data was analyzed by using inbuilt software of the texture analyzer.

Ascorbic Acid

Vitamin C content of deep-fried carrot chips was determined by using the method developed by Ranganna (1992). For ascorbic acid determination 5 ml standard ascorbic acid solution was added with 5 ml of metaphosphoric acid (HPO_3) and titrated with the dye solution (2,6-dicholrophenol indophenol) until pink color appeared, which persisted for 15 seconds. Afterwards 10-20 ml of sample was taken and made upto 100 ml with 3% metaphosphoric acid (HPO_3) and then filtered and centrifuged. Later an aliquot (2-10 ml) of HPO_3 extract of the sample was titrated with the standard dye to a pink end point which persisted for at least 15 seconds.

$$\text{Ascorbic acid (mg/100g)} = \frac{\text{Titre Dye factor x volume make up}}{\text{Aliquot of extract taken for estimation x vol. of sample taken for estimation}} \times 100$$

β-carotene analysis

β-carotene content was determined using a method previously described by Amaya and Kimura (2004). Samples were prepared by crushing carrot chips and passing them through a sieve with 1.18 mm aperture. Carotenoids were then extracted by weighing 0.4 g of the homogeneous, representative sample from each of the treatments and transferred into a mortar containing a spatula full of hyflosupercel and ground with 50 ml of cold acetone. The mixture was filtered through a funnel fitted with glass wool. The mortar, pestle and residue were rinsed with acetone until the residues were free from colour. The carotenoids were extracted using petroleum ether (40-60°C), acetone and water. The absorbance of carotenoid ether extract was read at 450 nm in a cuvette with 1 cm light path. The total carotenoid content was calculated using the formula :

$$\beta\text{-carotene } (\mu g/g) = \frac{A \times \text{volume (ml)} \times 10^4}{A^{1\%}\ 1\ \text{cm} \times \text{sample wt. (g)}}$$

Where,

A = absorbance;

Volume = Total volume of extract (50 ml);

$A^{1\%}$ 1 cm = Absorbance at 450 nm of a 1% solution in a spectrophotometric cuvette with a 1 cm light path.

Color analysis of deep fried carrot chips (L*, a*, b* values)

Color analysis of deep-fried carrot chips was done by using Hunter Lab Colorimeter (Model SM-3001476 micro sensors New York) . The instrument was calibrated with user supplied black plate calibration standard that was used for zero setting, white calibration plates were used for white calibration settings. The instrument was placed at three different exposures at different places were conducted. Readings were displayed as L*, a* and b* color parameters. The a* value ranged from +100 (redness) to –100 (greeness), the b* values ranged from –100 (blueness) to + 100 (yellowness) while as L* value indicating the measure of lightness, ranged from 0 (black) to 100 (white).

Statistical analysis

The data generated were compiled and analyzed following the standard procedure (Snedecor and Cochran, 1995), for the analysis of variance (ANOVA) at 5% significance level for comparing the mean values to find the effect of treatments, storage periods and their interactions for various parameters in different experiments.

RESULTS AND DISCUSSION

Proximate composition of raw carrot

The data regarding the proximate composition of raw carrot presented in Table 1. The raw carrot contained 87.86% moisture, 1.1% ash, 0.2% fat, 0.85% protein and 3.6 mg/100g ascorbic acid and β -carotene (mg/g) .These results are in partial agreement with the findings of Sharma *et al*. (2012).

Organoleptic evaluation

The effect of different pre-treatments on the sensory characteristics of deep fried carrot chips is presented in Table 2. The sensory score for color ranged between 2.66-4.50. Highest score was noticed in T_4. The values of colour for T_1 and T_2 were comparable with each other but differed significantly ($p<0.05$) from T_0, T_3 and T_4. The score of taste ranged between 3.30-4.33. Highest score of taste was found in T_4. The scores of taste of T_1 and T_0 were comparable with each other and differed significantly ($p<0.05$) from T_3, T_2 and T_4. The results showed that score for crispness ranged from 3.16-4.33 with the highest found in T_2. The scores for appearance of T_1, T_2, T_3 were comparable to each other but differ significantly ($p<0.05$) from T_0 and T_4. Highest score for appearance was obtained for T_4. The overall acceptability score of pre-treated deep fried carrot chips ranged from 3.0-4.33. The values showed that treatment T_4 was found to be more acceptable by the sensory panelists followed in order by T_3, T_2, T_1 and T_0. The data showed that overall acceptability increased by the use of different pretreatments.

Texture analysis

In this study, the force required to break the chips was used to determine the crispness with lower breaking force (g) corresponding to higher crispness. The result delineates that the highest values of the texture were found in T_0 and lowest in that of T_2 followed in order by T_4, T_3 and T_1 and all the values differ significantly ($p<0.05$) from one another (Table 2). According to the obtained results of this study soaking of blanched carrot slices in NaCl, $CaCl_2$ and KMS solutions improve significantly the crispness of texture in fried carrot in comparison with control. The samples soaked in $CaCl_2$ solution had significantly the highest scores of crispness. This could be explained by the maintenance of texture probably due to Ca action

in stabilizing membranes and cell walls (Izumi and Watada, 1994). These results are in partial agreement with the findings of Bakhtiary (2014).

Proximate composition of fried product during storage

Moisture: Results showed that the mean values of moisture content of control and all the pretreated samples showed significantly increasing trend from 3.10-4.26% throughout the period of storage (Table 3). Highest mean moisture was recorded in T_1 (4.08%) while the lowest mean moisture in T_4 (3.34%). The highest moisture content found in T_1 may be attributed to the hygroscopic nature of NaCl. These results are in alignment with the findings Tumuhimbise *et al*., (2013). After 10^{th} day of storage there was a drastic increase in the mean moisture content of all the pretreated as well as the control samples from 3.55-4.08%. This significant increase in the moisture content in all the samples may be attributed to the fact that the carrot chips were stored in HDPE pouches at ambient temperature and high relative humidity that may have caused migration of water into the pouch, thus increasing the moisture content of the chips. These results are in line with the findings of Sulaeman *et al.*, (2003).

Table 1. Proximate composition of raw carrot

Parameters	Values
Moisture (%)	87.86±1.1
Ash (%	1.1±0.05
Fat (%)	0.2±0.12
Protein (%)	0.85±0.21
Ascorbic acid (mg/100g)	3.6±0.08
β -carotene (mg/g)	3.31±0.11

Values are mean of three replications ± standard deviation

Table 2. Mean scores of sensory attributes of freshly prepared deep fried carrot chips

Treatment	Colour	Taste	Crispiness	Appearance	Overall acceptability	Instrumental texture
T_0	2.66^{a}±0.5	3.33^{a}±0.57	3.16^{a}±0.28	2.83^{a}±0.28	3^{a}±0.5	494.60^{a}±0.2
T_1	3.16^{b}±0.28	3.33^{a}±0.57	3.33^{b}±0.57	3.16^{b}±0.28	3.16^{a}±0.28	489.84^{b}±0.08
T_2	3.16^{b}±0.28	3.50^{b}±0.5	4.33^{c}±0.28	3.33^{b}±0.57	3.16^{a}±0.28	334.64^{c}±0.06
T_3	3.33^{c}±0.57	3.83^{c}±0.28	3.33^{b}±0.57	3.16^{b}±0.28	3.33^{a}±0.57	468.20^{d} ±0.11
T_4	4.50^{d}±0.28	4.33^{d}±0.28	3.83^{d}±0.28	4.16^{c}±0.28	4.33^{c}±0.28	390.54^{e}±0.12

T_0 = without any treatment; T_1 = 2% NaCl; T_2 = 2% $CaCl_2$; T_3 = 0.15% KMS; T_4 = 0.15% KMS + 2% $CaCl_2$, Values are means of three replications±SD. Means in the row not followed by the same superscript are significantly ($p<0.05$) different

Ash: Results of ash content during storage are depicted in Table 3. The mean values for ash content of control and all the pretreated samples showed decreasing trend throughout the period of storage which ranged from 1.69-1.44%.The highest ash content was observed in T_4 while the lowest value was observed in T_0. On the 30^{th} day of storage the lowest ash content was found in T_1 followed in order by T_0, T_2, T_3 and T_4. The highest mean ash content (1.77%) observed in T_4 pretreated samples may be attributed to the fact that T_4 was found to have lowest moisture content throughout the storage period when compared with control and other pretreated samples. These results are in line with the findings of Izumi and Watada (1994).

Table 3. Effect of various pre-treatments on the composition of deep- fried carrot chips during storage.

Treatment	Moisture (%)				Treatment mean
	0day	10th day	20th day	30th day	
T_0	3.21	3.75	4.42	4.49	3.96
T_1	3.30	3.90	4.50	4.62	4.08
T_2	3.05	3.56	4.05	4.30	3.7
T_3	2.98	3.45	3.96	4.12	3.62
T_4	2.96	3.11	3.50	3.80	3.34
Storage mean	3.10	3.55	4.08	4.26	
Treatment	Ash (%)				Treatment mean
	0day	10th day	20th day	30th day	
T_0	1.57	1.47	1.38	1.33	1.43
T_1	1.62	1.45	1.37	1.29	1.43
T_2	1.69	1.60	1.53	1.46	1.57
T_3	1.74	1.66	1.57	1.50	1.61
T_4	1.93	1.81	1.72	1.65	1.77
Storage mean	1.69	1.59	1.51	1.44	
Treatment	Fat (%)				Treatment mean
	0day	10th day	20th day	30th day	
T_0	49.89	49.46	48.68	48.24	49.06
T_1	49.72	49.20	48.54	48.22	48.92
T_2	50.56	50.53	49.66	48.57	49.86
T_3	51.24	49.87	49.24	49.08	49.85
T_4	51.35	51.15	49.93	49.97	50.60
Storage mean	50.57	50.00	49.21	48.85	
Treatment	Protein (%)				Treatment mean
	0day	10th day	20th day	30th day	
T_0	0.72	0.67	0.63	0.54	0.66
T_1	0.67	0.63	0.60	0.52	0.62
T_2	0.74	0.69	0.65	0.58	0.70
T_3	0.76	0.70	0.66	0.59	0.65
T_4	0.80	0.78	0.76	0.74	0.77
Storage mean	0.72	0.71	0.68	0.65	

T_0 = without any treatment; T_1 = 2% NaCl; T_2 = 2% $CaCl_2$; T_3 = 0.15% KMS; T_4 = 0.15% KMS + 2% $CaCl_2$

CD ($p<0.05$): Treatment (T) = 0.75; Storage (S) = 0.34; T x S = 0.25

Fat: The mean values of fat content in all the pretreated and control samples showed a decreasing trend which ranged from 50.57-48.85% throughout the period of storage (Table 3). The highest mean fat was observed in T_4 (50.60%) while the lowest mean fat was observed in T_1 (48.92%). The higher fat content of treatment T_4 could be due to higher moisture loss which resulted in considerable oil uptake during frying. These results are in alignment with the findings of Sulaeman *et al*. (2004). The fat degradation rate was lowest in T_4 treated samples because of its low moisture content. This decrease in the fat content

during storage may be attributed to the increased moisture content of the chips. These results are in alignment with the findings of Sulaeman *et al*., (2003).

Protein: The protein content of developed snacks during storage is shown in Table 3. The mean protein content values during storage in all the five samples of deep-fried carrot chips ranged from 0.72-0.65%. The highest mean value of protein was found in T_4 (0.77%) pretreated samples and lowest in that of T_1 (0.62%) at 30th day of storage. The protein content decreased as the storage period increased which could be due to increase in moisture content during storage due to poor moisture barrier properties of packaging materials. These results are in agreement with the findings of Amany *et al*., (2012).

Table 4. Effect of various pre-treatments and storage periods on the ascorbic acid content and β-carotene content of deep-fried carrot chips during storage.

Treatment	Ascorbic acid (mg/100g)				Treatment mean
	0 day	10th day	20th day	30th day	
T_0	2.09	1.73	1.15	0.90	1.46
T_1	2.13	1.78	1.20	0.93	1.51
T_2	2.20	1.86	1.22	0.98	1.56
T_3	2.35	2.20	2.03	1.95	2.13
T_4	2.27	2.01	1.70	1.52	1.87
Storage mean	2.20	1.91	1.46	1.25	
Treatment	β-carotene (mg/100g)				Treatment mean
	0 day	10th day	20th day	30th day	
T_0	43.98	42.26	42.09	40.16	42.12
T_1	43.98	42.36	41.17	40.42	42.52
T_2	43.98	42.42	42.21	42.05	42.66
T_3	43.98	42.72	42.51	42.39	42.90
T_4	43.98	43.80	43.60	43.21	43.65
Storage mean	43.98	42.71	42.32	41.64	

T_0 = without any treatment; T_1 = 2% NaCl; T_2 = 2% $CaCl_2$; T_3 = 0.15% KMS; T_4 = 0.15% KMS + 2% $CaCl_2$
CD ($p<0.05$): Treatment (T) = 0.63; Storage (S) = 0.41; T x S = 0.25

Ascorbic acid content: The ascorbic acid content varies among the different treatments with the highest observed in zero day (2.09 mg/100g) and lowest on 30 day storage (0.90 mg/100g) (Table 4). This difference may be attributed to the effect of different pre-treatments on the retention of ascorbic acid during frying which was more in T_3 and less in T_0. These results are in agreement with the findings of Sarabjeet *et al*. (2011). The results of ascorbic acid content of deep-fried carrot chips reveal that there was a drastic decrease in it after 10th day in all the treatments with maximum decrease recorded in T_0 while the minimum was recorded in T_3. This is because ascorbic acid is a very reactive compound and is particularly vulnerable to storage. Maximum retention of ascorbic acid (2.13 mg/100g) was noticed in KMS pretreated product while minimum in control (1.46 mg/100g). This might be due to higher retention of SO_2 in T_3 samples which minimize the oxidative loss of ascorbic acid by acting as reducing agents. These results are in line with the findings of Sarabjeet *et al*. (2011).

β- carotene content: All the samples showed a progressive decrease in β- carotene content throughout the period of storage Table 4. Increased moisture content during storage decreased the carotenoid content of the chips probably because of accelerated degradation due to the oxidation during storage. Among all the pretreated samples the lowest β-carotene content was observed in NaCl treated samples. This observation may be explained by the fact that salt has been reported to accelerate the rate of oxidation of carotenoids (Rodriguez and Kimura, 2004). It can be seen that all the pretreatments have

shown a good effect on carotene retention as compared to control samples with maximum retention in T_4 followed in order by T_3, T_2, T_1 and T_0. Combination of KMS and $CaCl_2$ had the best effect followed in order by T_3, T_2, T_1 and T_0. These results are in line with the findings of Sulaeman *et al*. (2003).

Color properties

The color changes of carrot snacks are shown in Table 5. The orange color of carrot chips was described by the lightness (L*), redness (a*) and yellowness (b*). The L*,a*,b* values of stored carrot chips showed a progressive decrease in all the treatments with maximum noticed in T_0 and minimum in T_4 followed in order by T_3, T_2 and T_1. The decreased color values seemed to be reflecting the degradation in carotenoid content of carrot chips during storage. As the color was influenced by the carotenoid content, the increased moisture content also significantly decreased the color values (L*, a*, b* values) of the stored carrot chips. The color of the carrot has been reported to be largely due to the presence of carotenes (Bao and Chang, 1994). These results are in close proximity with the findings of Sulaeman *et al*. (2003).

Table 5. Effect of various treatments and storage periods on the Colour values (Hunter L*, a*, b*) of deep-fried carrot chips during storage

Treatment	0day			10^{th} day			20^{th} day			30^{th} day			Treatment Mean		
	L*	a*	b*	L*	a*	b*	L*	a*	b*	L*	a*	b*	L*	a*	b*
T_0	37.60	24.60	21.80	36.02	19.16	20.16	34.02	18.04	19.18	34.00	17.06	17.00	35.41	19.71	19.53
T_1	37.60	24.60	21.80	36.17	21.10	21.00	34.60	20.10	20.40	34.20	18.60	19.90	35.64	21.10	20.77
T_2	37.60	24.60	21.80	36.70	21.25	21.05	34.90	20.40	20.55	34.40	18.60	20.02	35.90	21.21	20.85
T_3	37.60	24.6	21.80	36.90	22.17	21.10	35.20	22.1	20.75	34.95	20.2	20.51	36.16	22.26	21.04
T_4	37.60	24.60	21.80	37.00	22.70	21.21	35.70	22.20	21.05	35.16	21.07	20.95	36.36	22.64	21.25
Storage mean	37.60	24.60	21.80	36.55	21.27	20.90	34.88	20.56	20.38	34.54	19.10	19.67			

T_0 = without any treatment; T_1 = 2% NaCl; T_2 = 2% $CaCl_2$; T_3 = 0.15% KMS; T_4 = 0.15% KMS + 2% $CaCl_2$

CONCLUSION

Carrot is one of the most important seasonal root vegetable grown throughout the world and is the most important source of dietary carotenoids. Deep-fried carrot chips that are high in provitamin A carotenoids can be developed as an alternative for intervention programs in alleviating vitamin A deficiency as well as a healthful snack. Outcome of the present study resulted in the development of carrot chips with acceptable quality characteristics. In the world market, as potato chips remains popular, it is envisaged that carrot chips might also find its way as a healthy food snack. Future studies is warranted to develop appropriate methods and processes of blanching and frying to decrease oil content and uptake, along with studying the kinetics of texture development in the carrot chips.

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