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Effect of various pretreatments on quality of osmo-convectively dehydrated carrot shreds

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Abstract
Carrot is a very popular root crop grown all over the world for its delicious edible roots. Dehydration is most useful technique to prepare shelf stable products with longer shelf life. Osmotic dehydration is preferred over other drying methods due to its quality retention value in final product. Mass transfer phenomenon is affected due to different pre-treatments before osmosis. Therefore various pretreatments such as steam blanching, freezing and thawing were carried out before osmotic dehydration. Solid gain, water loss, texture and color were determined in order to evaluate effect of pretreatments on osmo-convectively dehydrated carrot shreds. Investigation of pretreatments on osmo-convectively dehydrated carrot shreds enhanced sugar gain and water loss before osmotic dehydration. Solid gain increased (34.34-40.66), while Water loss (20.30-27.39). Texture of osmo-convectively dehydrated shreds was found between 4.503 to 7.582 N. All sensory parameters were higher for steam blanching than other pre-treatment. Non-significant difference was observed for refrigerated and ambient thawing on the overall acceptability of carrot shreds.

Keywords: Osmatic dehydration, carrots, freezing, thawing, convective drying

Introduction
India is the second largest fruits and vegetable producer in the world. Fruits and vegetables has important role in daily human diet due to its good source of vitamins and minerals. Carrots are widely grown all over the world for its highly nutritious edible roots. The widely used orange carrot is high in α- and β-carotene hence is a rich source of provitamin A. (Selvakumar and Tiwari, 2018) [12, 13]. Being a perishable nature of carrot due to its high moisture content has very less shelf life. During the season there is glut in the market and prices falls down which results in monetary loss to farmers. Hence dehydration is most useful technique to prepare Ready-To-Eat and shelf stable products with longer shelf life. Osmotic dehydration is preferred over other drying methods due to its quality retention value in fruit and vegetable product. Osmatic dehydration of carrot shreds during the main growing season is one of the important alternatives for preservation. Osmotic dehydration is the phenomenon of removal of water from lower concentration of solute to higher concentration through semi permeable membrane results in the equilibrium condition in both sides of membrane (Tiwari 2005) [15]. Since osmotic dehydration results in quality improvement in terms of color, texture, flavor, product stability, nutrient retention and prevention from microbial spoilage. However, the quality of osmotically dehydrated product is affected by pretreatments like blanching, freezing and thawing. Therefore, the study aimed to assess the impact of various pretreatment on mass transfer parameters of the osmotically dehydrated carrot shreds. Additionally, quality attributes of the osmoconvectively dehydrated carrot shreds, focusing on other aspects such as color, texture, and sensory characteristics were also evaluated.

Materials and Methods
Sample preparation
Fresh, fully grown, firm and deep orange coloured carrots were purchased from the local market and peeled with hand peeler. Carrots shreds prepared using hand shredder were steam blanched for 2 minutes. (More and Khodke 2022) [10]. Pre-blanched carrot shreds were frozen at -25 °C for 3 hours. Ambient and refrigerated thawing were carried out at (30±2 °C) and (5±2 °C) respectively for four and eight hours (Kumavat *et al.*, 2023) [16].

Control (Without any pre-treatment) and all pre-treated carrot shreds were osmosed in a sugar solution of 50° Brix concentration for a duration of four hours using shreds to solution ratio of 1:4 (More *et al.*, 2020) [9]. During osmatic dehydration temperature of sugar solution was maintained as 50 °C and stirring was carried out manually at an interval of 15 minutes. Subsequently, all the osmosed samples were taken out from sugar solution and excess solution was wiped out with tissue paper. A small sample of carrot shreds after osmotic dehydration was taken out for moisture determination. Osmosed carrot shreds were subjected to convective drying at 60 °C until the moisture content reaches to 5±1%.

Quality assessment of osmo-convective dehydrated osmo-convectively dehydrated carrot shreds.

Mass transfer: The response variables water loss (WL) and solids gain (SG) were determined according to the following equations.

WL (%) = $(w_iX_i - w_fX_f)$ x 100 / wi

SG (%) = $(w_f(1\text{-}x_f/100) - wi\ (1\text{-}\ x_i/100)$ x 100 / w_i

Where

w_i and w_f are the initial and final weight (time t) of samples, respectively, (g);

X_i and X_f are the initial and final moisture content (time t) of samples, respectively, (g water/100 g initial wet).

Moisture content of carrot shreds after osmosis was determined by A.O.A.C. (1990). The textural property in term of hardness of osmo-convectively dehydrated carrot shreds were determined by measuring the force (Kg) needed to compress the osmo-convectively dehydrated carrot shreds using Texture Analzer (Model: TA-XT plus, Stable Micro System, UK) equipped with 50 kg load cell. The colour was evaluated using a Hunter Lab Colour Analyzer-Labscan-2 (Hunter Associates Laboratory, Inc. Virginia, USA) in terms of L*, a*, and b* values.

Result and Discussion

Water loss and solid gain of osmosed carrot shreds

Mass transfer parameters of osmosed carrot shreds were evaluated in terms of sugar gain and water loss. The quality attributes of the dried osmotically dehydrated shreds were evaluated in terms of color (L*, a* and b* Value), texture (hardness), and sensory characteristics using standard procedure.

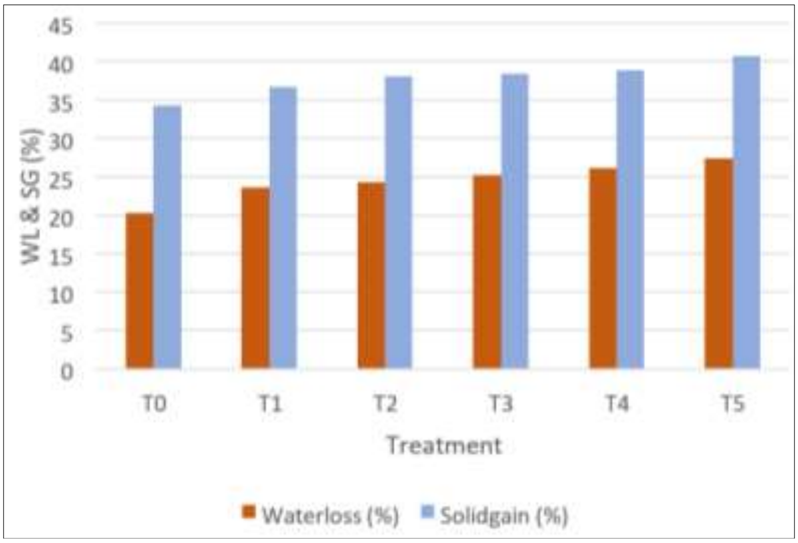

Fig 1: Effect of pretreatments on mass transport on osmo-convectively dehydrated carrot shreds

T_o	Control sample (without any pre-treatment)
T_1	2 min. Steam blanching.
T_2	4 hour refrigerated thawing of pre-blanched + pre-frozen carrot shreds.
T_3	8 hour refrigerated thawing of pre-blanched + pre-frozen carrot shreds.
T_4	4 hour ambient thawing of pre-blanched + pre-frozen carrot shreds.
T_5	8 hour ambient thawing of pre-blanched + pre-frozen carrot shreds at 8 hr.

WL & SG revealed the treatment T_5, involving ambient thawing of pre-blanched and pre-frozen carrot shreds for 8 hours duration resulted in the highest sugar gain of 40.66% and the water loss of 27.39%. In contrast, the control sample (T_o) which consisted of osmo-convectively dehydrated carrot shreds prepared without any pretreatment, exhibited the lowest sugar gain as 34.34% and the lowest water loss as 20.30%. All the pretreated samples attained higher value of sugar gain and water loss compared to the (T_o) control sample. This trend aligns with similar observations made by (Taiwo *et al.*, 2001) [14] in the context of osmotic dehydration of apple slices.

Also significantly higher solid gain (40.66) and water loss (27.39) was repoosmo-convectively dehydratedd for ambient thawing than refrigerated thawing condition for both 4 and 8 hour time duration. Similar higher rate of mass transfer was observed for room temperature thawing than refrigerated thawing by (More. 2021) [10] and (Kumavat., 2023) [16] for osmo-convectivetly dehydrated carrot slices. However non-significant difference was exhibited in solid gain and water loss for refrigerated thawing condition when thawing period increase from 4 to 8 hours. There was a significant difference in solid gain and water loss for ambient thawing condition when thawing period increase from 4 to 8 hours.

Hardness

The textural characteristics of osmo-convectively dehydrated carrot shreds were evaluated by measuring their hardness and presented in Fig.2. The variation in the hardness values for the different treatments was ranged from 4.503 to 7.582 N. The control sample (T_o), exhibited significantly higher hardness compared to all osmo-convectively dehydrated carrot shreds prepared by subjecting to various pretreatments *viz*, blanching, freezing and thawing. This observation aligns with the findings of (Albertos *et al*., 2016) [1], who reported that unfrozen carrot snacks were notably harder than frozen counterparts.

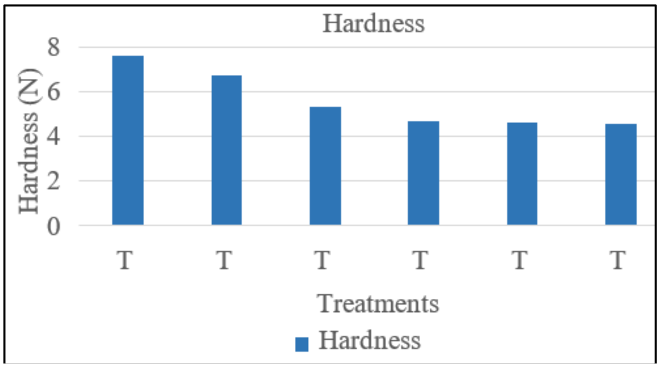

Fig 2: Effect of Pre-treatments on hardness on osmo-convectively dehydrated carrot shreds

Colour value L*, a*, b*.

Within the experimental range. The highest L* value (51.88) was observed in the control sample, while the lowest L* value (40.45) was recorded for the osmo-convectively dehydrated carrot shreds prepared with steam blanching for 2 min. From Fig. 3, the minor variations in L* values were observed between treatment T_1 and T_2 which may be attributed to less difference in solid gain during osmosis of carrot shreds. L* values were higher when ambient thawing was employed compared to refrigerated thawing. Furthermore, for both refrigerated and ambient thawing conditions, L* values were higher when the thawing time was extended to 8 hours as opposed to 4 hours. The a* values ranged from 28.32 to 34.14 for colour of all pretreated osmotically dehydrated carrot shreds. In comparison to the control sample, which underwent osmo-convective dehydration without any pretreatment had a lower a* value of 28.32. Furthermore, a* values were also lower for ambient thawing compared to refrigerated thawing condition for both 4 and 8 hour time duration for both refrigerated and ambient thawing conditions.

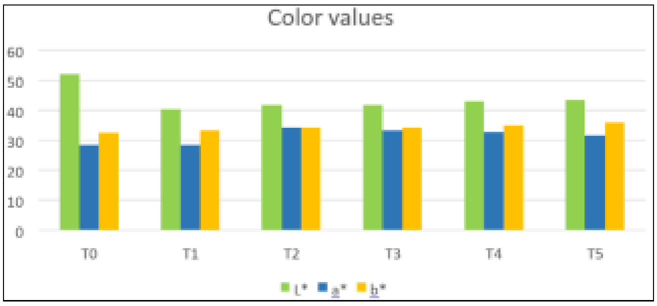

Fig 3: Effect of pretreatments on colour of osmo-convectively dehydrated carrot shreds

The changes in a* value might be due to the variation in solid gain. Similar trend of decrease in a* value was observed in osmo-treated apple slices by (Chauhan *et al*., 2011) [4]. Similar trend was reported by (Holzwarth *et al*., 2012) [7] for strawberry as a result of increased freezing and thawing temperature. The experimented, b* values of osmo-convectively dehydrated carrot shreds ranged from 32.54 to 35.90 with a significantly lower b* value for control sample. Moreover, in general, higher b* value was observed for ambient thawing compared to refrigerated thawing. Furthermore, the data revealed that there was a less difference in b* value, when the thawing time was increases from 4 to 8 hour for refrigerated thawing

Sensory evaluation of osmo-convectively dehydrated carrot shreds

The sensory properties of osmo-convectively dehydrated carrot shreds, prepared as per treatments, were assessed in terms of color and appearance, flavor, texture, taste, and overall acceptability using a 9-point Hedonic scale. The color and appearance scores for osmo-convectively dehydrated carrot shreds ranged from 6.0 to 8.9 within the various treatments. However, the highest score for color and appearance was observed in treatment T_1, in which the carrot shreds were steam-blanched for 2 minutes followed by osmotic and convective dehydration. Conversely, the lowest score was recorded for control treatment (T_o), which involved carrot shreds without any pre-treatment. Importantly, the data revealed that there was no significant difference in color and appearance scores when comparing thawing times of 4 hours and 8 hours for carrot shreds frozen for 3 hours. The highest mean score for flavour and taste was achieved for treatment T_1 instead of treatment T_o, representing the control sample subjected to osmotic dehydration without any pre-treatment, received the lowest score of 7.0. However very less difference was observed for refrigerated thawing for 4 and 8 hour time duration. Texture of osmo-convectively dehydrated carrot shreds is ranged from 7.1 to 8.9. Notably, the highest texture score was obtained in treatment T_1, where the carrot shreds were steam-blanched for 2 minutes and osmotically dehydrated for 4 hours in a 50 °Brix sugar syrup. In contrast, the lowest texture score was observed in treatment T_o, representing the control sample without any freezing and thawing treatment**.**

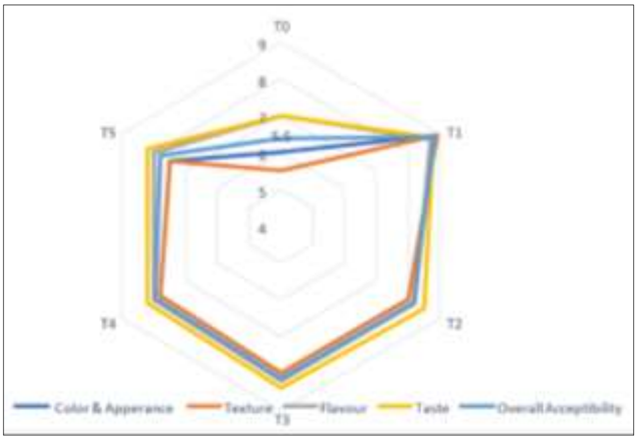

Fig 4: Effect of pre-treatments on sensory parameter on osmo-convectively dehydrated carrot shreds

The overall acceptability score serves as a comprehensive evaluation, taking into account all sensory parameters, including color and appearance, texture, taste, and flavour. Overall acceptability score, the average of all the scores obtained for these sensory attributes determined. From the Fig. 4., depicted that highest score of the overall was obtain for osmo-convectively dehydrated carrot shreds in which raw carrot shreds were steam blanched for 2 min. before osmosis process while the control sample i.e without any pre-treatment score lowest value of 6.37 for overall acceptability. It was also noted that similar or non-significant score was observed for refrigerated thawing of pre-frozen carrot shreds for 4 and 8 hours. Similar trend of no-significant score was followed by ambient thawing condition.

Conclusions

It is concluded that all pre-treatments such as steam blanching, freezing and thawing had significant influence on the mass transfer phenomenon of carrot shreds during osmotic dehydration. Retention of colour was more prominent in 2 min. steam blanching pretreatment than freezing and thawing. Two min. steam blanching produced the osmo-convectively dehydrated carrot shreds with appealing texture and desirable overall acceptability.

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