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Research Article

A STUDY ON THE EFFECTS OF DIFFERENT BLANCHING METHODS ON CARROT CUBES

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Abstract- This study investigated the effects of hot water and steam blanching on carrot cubes. Blanching has great effect on the moisture content, total soluble solids and ascorbic acid retention of carrot cubes. Fresh carrots were blanched in hot water and steam at different temperatures and time. The results were compared on the basis of product quality, *viz*. solid loss, moisture content and ascorbic acid content. The freshly cut carrot cubes weighing 20g, were subjected to hot water and steam blanching for six levels of exposure time (30, 60, 90, 120, 150 and180 seconds). Maximum solid loss (19.39 %) was observed in case of hot water blanching at 100°C and minimum (5.090 %) in case of steam blanching at 100°C for 3 minutes. In case hot water blanching as well as steam blanching moisture content was found to decrease initially up to 90s and increase in the latter stages. Higher loss of ascorbic acid was observed during hot water blanching. Steam blanching also resulted in loss of ascorbic acid, but at lower rates. The percentage retention of ascorbic acid after 3 minutes of steam blanching at 100°C, hot water blanching at 93°C and 100°C remained found to be 79.72 %, 71.67% and 69.88 % respectively.

Keywords- Carrot cubes, Blanching, Hot water, Steam, Effects.

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Introduction

Several pre-treatments are required to be performed during the production of processed products of horticultural produce. Blanching is one of the widely used pre-treatments in food processing industry. As a pre-freezing operation, blanching is the primarily method for inactivating undesirable enzymes present in the products and reducing the microbial load [1]. At the same time, blanching may also remove tissue gases, shrink the product, clean and stabilize color. Several standard-blanching techniques such as hot water blanching and steam blanching as well as fluidized bed blanching with steam-hot air mixture have been reported. Therefore, it is necessary to determine the proper blanching technique as well as its operating parameters for the development of the proposed product. Blanching is an essential step for processing of vegetables. This aims to inactivate the enzymes along with destruction of microorganisms so that the product is not deteriorated during dehydration [2]. Blanching has also proved to aid reconstitution and textural improvement in product [3]. Blanching involves a short and quick heat treatment to the material, for which usually either hot water or steam is used for uniformity of heating and higher heat transfer rate [2]. Although blanching is beneficial in many ways, it also has detrimental effects, particularly on the water-soluble nutrients [4]. Prolonged hot water blanching resulted in considerable loss of carbohydrate, protein and minerals [5]. It is required that blanching time should be kept minimum to prevent the high solid loss. Inactivation of peroxidase has been generally accepted as an index for blanching because it is supposed to be the most heat resistant of the enzymes [6]. Since complete inactivation of peroxidase to considerably long time resulting in heavy loss of nutrients and energy, Singh and Chen suggested 90% inactivation on peroxidase as sufficient to prevent any deterioration in the product and recommended the time required for the same as the optimum time for blanching [7]. Steam blanching results in minimum solid loss, although it proved to be comparatively uneconomical with no remarkable difference in blanching time. Moreover, steam blanching carried out in thick layers on moving belt often resulted in non-uniform blanching effect [8]. Uniform blanching can be achieved by IQB method where fluidized bed blanching is performed using steam as the medium. The loss of important nutrients during blanching is caused mainly by diffusion or leaching. These nutrients are mostly water soluble and as a result hot water blanching causes higher loss than that in steam blanching [9]. Selman observed that about 8% of tissues and 3% of total solids were lost after 10 min of hot water blanching of carrots at 70 °C [10].

The effect of blanching on moisture content of vegetables was studied by Kramer and Smith, who observed that regardless of temperature, short blanching period caused slight loss of moisture while prolonged treatment resulted in moisture gain [11]. This phenomenon was also observed by other researchers during hot water blanching of potato cubes [12, 13]. Ascorbic acid (vitamin- C) being an important nutritional parameter in vegetables including potatoes, its losses during conventional methods of blanching has been extensively studied in past [14, 15-16]. In an experiment it was described the ascorbic acid loss during hot water blanching as entirely a diffusion controlled phenomenon [17]. The authors determined the apparent diffusion coefficient of ascorbic acid in potato tissues and reported that it increased from 1.53×10^{-10} to 21.43×10^{-10} m^2/s as the temperature increased from 50 to 100 °C. It was estimated that ascorbic acid losses during various steps in processing of French fries and potato chips and observed that loss of ascorbic acid was highest during blanching for French fries and washing for potato chips [18]. Nevertheless, the products were reported to retain a substantial amount of ascorbic acid. It was also observed higher retention of ascorbic acid when potatoes were blanched in recycled water which also showed lower diffusivity than that in distilled water [19- 20]. The average value of heat transfer coefficient for hot water blanching of potatoes was reported to be 2.850 W/m^2 K.

In the present study, hot water blanching and steam blanching technique have been adopted for blanching of freshly cut carrot cubes for development of ready to eat dehydrated puffed product. Different parameters like total solid loss, moisture and nutrients content like ascorbic acid were compared with that obtained by traditional methods of blanching, i.e. hot water and steam blanching.

Materials and Methods

Preparation of sample: Fresh, highly colored, good commercial quality carrots (*Daucus carota* L.) of "*Pusa Kesar*" variety were procured from the local market in prior to each set of experiments. At first the carrots were washed in running tap water to remove dust, mud and other undesirable particles from the surface. After washing the carrots were sorted to remove the mechanically damaged or rotted carrots. Afterwards, the carrots were scraped very lightly and the tops removed with the help of a stainless steel knife. The scraped carrots were dipped in water to prevent the discoloration due to oxidation. The cortex portions of the carrots were cut into small pieces of dimensions 1x1x1cm. This size and shape was adopted for suitability for study of effect of blanching on carrot cubes.

Determination of moisture content: Moisture content of the sample was determined by the hot air oven method [21]. Weighed test sample (5 g approx.) was kept in hot air electric oven at temperature of 100 ± 2°C for 18 hours. After drying for 18 hours the sample was cooled in desiccator and reweighed. The moisture content was expressed either in percent (wet basis) or kg moisture/kg dry matter (dry basis). Mean of three replications was reported.

Moisture content on percent wet basis was determined by using the following formula:

$$m = \frac{Wm}{Wm+Wd} \times 100 \quad \text{... [1.0]}$$

Moisture content on percent dry basis was calculated by the following formula:

$$M = \frac{Wm}{Wd} \times 100 \quad \text{... [2.0]}$$

Where,

W_m = Weight of moisture

W_d = Weight of bone dry material

m_1, m_2 = Initial and final moisture contents respectively, per cent wet basis

M_1 , M_2 = Initial and final moisture contents respectively, per cent, dry basis

Blanching: The freshly cut carrot cubes each weighing 20g, were subjected to hot water blanching for six levels of exposure time (30, 60, 90, 120, 50 and180 seconds).

(i) **Hot water blanching**: Six samples of 20g, were kept in six beakers containing 160 ml of water equilibrated to the desired temperature level in a hot water bath. The temperature levels of 93 and 100°C were selected for study [22]. Samples were subjected to hot water blanching for predetermined time. After blanching the samples were reweighed and immediately kept into a refrigerator at 4°C to prevent any further change in quality.

(ii) **Steam blanching**: Steam blanching was carried out by subjecting the sample to an open steaming. Freshly cut, raw carrot cubes were weighed and approximately 20g sample was kept directly over a flow of steam ejecting from an autoclave, in a 10 gauge stainless steel wire mesh.

Ascorbic acid content: The ascorbic acid content of the samples was determined by visual titration method using 2, 6-dichlorophenol indophenol dye, which is blue in alkaline solution and red in acid solution, is reduced by ascorbic acid to a colorless form [23]. The reagents used for this experiment were 3% (w/v) HPO_3 (meta phosphoric acid) solution, ascorbic acid standard prepared by dissolving 100mg of L-ascorbic acid and made up to 100ml with 3% HPO_3 solution and diluting its 5ml to 50ml with 3% HPO_3 solution, dye solution (by dissolving 50mg of the salt of 2, 6-dichlorophenol indophenol in approximately 150ml of hot distilled water containing 42 mg of sodium bicarbonate).

The ascorbic acid content of the sample was calculated by using the following relation.

$$Ascorbic\ acid, \left({}^{mg}/_{100}\right) = \frac{Dye\ factor \times V2\ x\ 10000}{V1\ x\ W} \quad \text{... [3.0]}$$

Where,

V_2 = volume of dye required (ml)

V_1= volume of sample extract taken for dye titration (ml)

W= weight of sample taken for extraction with HPO_3 (g)

Total solids: The weights of the samples were accurately taken before and after blanching, removing the surface moisture with blotting paper. For the known moisture content, the total solid loss in the sample was determined.

Results & Discussion

Moisture content: Moisture contents of carrot cubes attained at various intervals of time and different blanching conditions were observed. The variation in moisture content can be observed in [Fig-1]. In of case hot water blanching as well as steam blanching, moisture content was found to decrease initially up to 90s and increase in the latter stages. Similar trend was observed by [24]. Since studies were not continued beyond 3 minutes, the validity of this observed trend could not be established for longer treatment periods. The observed data of moisture content when fitted was observed to be second order polynomial function of time in all the cases.

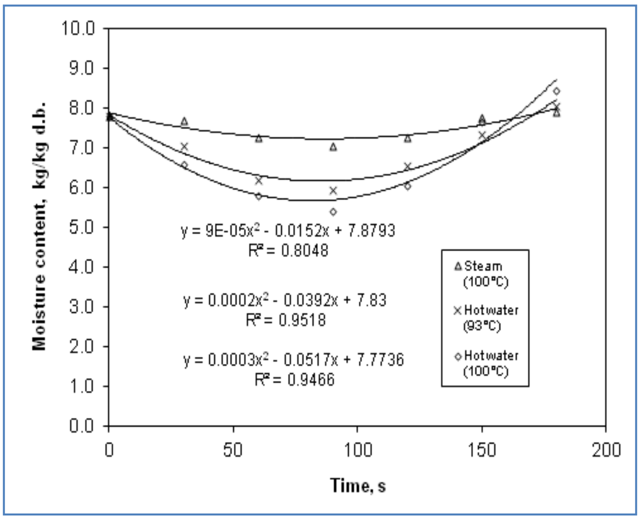

Fig-1 Variation in moisture content of carrot cubes with time during blanching

Ascorbic acid: Higher loss of ascorbic acid was observed during hot water blanching. Steam blanching also resulted in loss of ascorbic acid, but at lower rates. The percentage retention of ascorbic acid after 3 minutes of steam blanching at 100°C, hot water blanching at 93°C and 100°C was 79.72 %, 71.67% and 69.88 % respectively. The rate of loss was higher initially and decreasing gradually with time [Fig-2]. Similar results were also reported in case of vegetables like peas and beans and [25, 26-28] in case of potato.

Ascorbic acid content was found to be an exponential function of blanching time and the following general Arrhenius type relationship was observed:

$$\frac{Ca}{Ca0} = Ae^{-Kt} \quad \text{... [4.0]}$$

where, C_a and C_{ao} were ascorbic acid contents after blanching of time t and 0 seconds respectively. Similar observation was also made by [24, 26, 27], who further established that loss of ascorbic acid from potato during blanching was a diffusion based process. The coefficients A and K for the eqn.4.0, determined for all conditions of blanching are given in [Table-1]. Reasonably good fit was obtained in all the cases (R^2 > 0.97).

Table-1 *Coefficients of eqn.4 between retention of ascorbic acid C_a / C_{ao} and blanching time*

Blanching condition	Coefficients		Coeff. of correl.
	A	K	(R2)
Steam (100°C)	0.9802	0.0012	0.9763
Water (93°C)	0.9787	0.0019	0.9847
Water (100°C)	0.9761	0.0019	0.9761

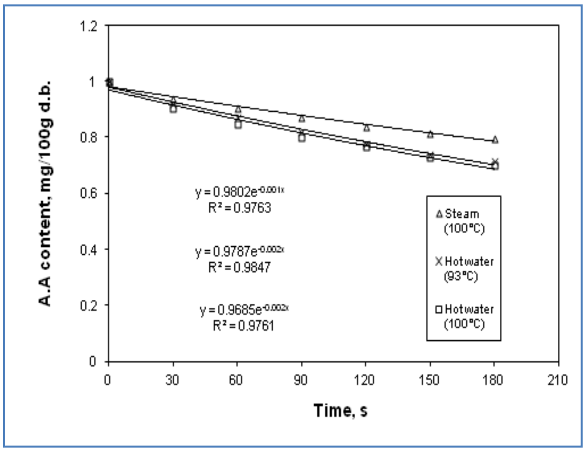

Fig-2 Effect of blanching time on ascorbic acid content of carrot cubes

Total soluble solid loss: Total solid loss (%) was estimated for different intervals of time and temperatures. It was observed that the maximum solid loss (19.39 %) was in case of hot water blanching at 100°C and minimum (5.09 %) in case of steam blanching at 100°C for 3 minutes. From [Fig-3] it was observed that the rate of solid loss was initially higher and decreased with time. The observed data on solid loss, when fitted was found to be second order polynomial function of blanching time (in seconds).

$$TSL = A + B + Ct^2 \ldots [5.0]$$

Where,
TSL = Total solid loss, (%) at time t seconds
A, B, C = constants
Reasonably good fit was obtained (R> 0.98) for all the conditions used for blanching. The coefficients of the equation 5.0, corresponding to various blanching conditions is presented in the following [Table-2].

Table-2 *Coefficients of equation 5 between solid loss (%) and time of blanching*

Blanching condition	Coefficients			Coeff. of
	A	C	B	correl. (R^2)
Steam (100°C)	0.2103	0.0487	-0.0001	0.9895
Water (93°C)	0.1597	0.1596	-0.0003	0.9827
Water (100°C)	0.8745	0.2011	-0.0006	0.9861

The observed data also indicated that solid loss in case of steam blanching at 100°C was considerably lower than that of hot water blanching. It suggested that solid loss during blanching was mainly due to the leaching effect.

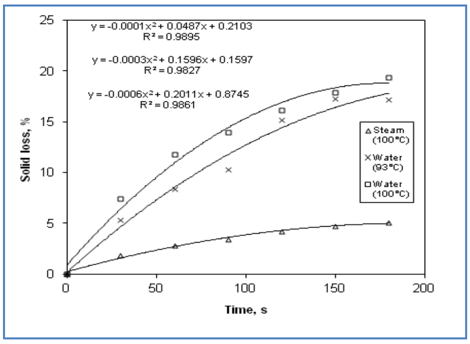

Fig-3 Variation in solid loss of carrot cubes with time during blanching

Conclusion

Maximum solid loss (19.39 %) was observed in case of hot water blanching at 100°C and minimum (5.09 %) in case of steam blanching at 100°C for 3 minutes. In case hot water blanching as well as steam blanching moisture content was found to decrease initially up to 90s and increase in the latter stages. Higher loss of ascorbic acid was observed during water blanching. Steam blanching also resulted in loss of ascorbic acid, but at lower rates. The percentage retention of ascorbic acid after 3 minutes of steam blanching at 100°C, hot water blanching at 93°C and 100°C was 79.72 %, 71.67% and 69.88 % respectively.

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Authors' contribution: All author equally contributed

Abbreviations:
g: Gram
W: Watt
m: Meter
K: Kelvin
cm: Centimeter
^{o}C: Degree centigrade
ml: Milliliter
kg: Kilogram
s: Second
d.b.: Dry basis
t: Time
TSL: Total solid loss

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.

Conflict of Interest: None declared

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