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Effect of various blanching pre-treatments on colour characteristics of carrots (*Daucus carota* L.)

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Abstract
The study has been undertaken to determine colour characteristics of carrots using different blanching treatments. The blanching methods used were hot water blanching, steam blanching and hot water blanching after 0.2% Pottasium metabisulfite (KMS) treatment. The colour of the product was analyzed for L, a, b, total colour difference (ΔE), chroma and hue factor using hunter colorimeter. The L (lightness) value was observed to be the maximum (34.8) when treated with hot water blanching after chemical treatment whereas, minimum (34.5) depicting a darker colour in untreated control sample. The 'a' value depicting the redness of the product was found to be highest (20.6) in, untreated and hot water blanching with KMS whereas the lowest value (20.4) was observed after steam blanching depicting lesser redness in product. Steam blanching recorded highest value of 'b' (5.3) showing more yellowness compared to untreated control sample recording value of 4.6. The total colour difference (ΔE) ranged from 0.24 to 0.75 in hot water blanching and steam blanching, respectively. The values of chroma varied from 21.05 to 21.22 with highest value of hot water blanching after chemical treatment. Steam blanching showed maximum hue angle (15.24) and untreated controlled sample showed lowest hue angle (13.02). Hot water blanching of carrot resulted in minimum change of colour among different treatments.

Keywords: carrot, hot water blanching, steam blanching, KMS, colour characteristics.

Introduction

Carrot (*Daucus carota* L.) is an important vegetable because of its large yield per unit area throughout the world and its increasing importance as human food [1, 2]. The major carrot growing states in India are Punjab, Uttar Pradesh, Karnataka, Tamilnadu and Andhra Pradesh. The total area under carrot in India is over 22,538 ha with an annual production of 4.14 lakh tonnes. In Punjab, the production of carrot is around 1, 00, 000 tonnes. It belongs to the family *Umbelliferae*. The carrot is believed to have originated in Asia and now under cultivation in many countries [3, 4]. It is orange-yellow in colour, which adds attractiveness to foods on a plate, and makes it rich in carotene, a precursor of vitamin A [5]. It contains abundant amounts of nutrients such as protein, carbohydrate, fiber, vitamin A, potassium, sodium, thiamine and riboflavin [1, 2, 3, 4], and is also high in sugar [6]. It is consumed fresh or cooked, either alone or with other vegetables, in the preparation of soups, stews, curries and pies. Fresh grated roots are used in salads and tender roots are pickled [7]. Its use increases resistance against the blood and eye diseases [3].

Blanching of fruit and vegetables is a processing step that is often preceding a thermal process like pasteurization or sterilization. On the one hand, blanching can be used to inactivate (quality related) enzymes that may be responsible for deterioration during storage. Blanching results in a more stable product prior to frozen storage or prior to canning and the product quality decline (in terms of flavour and colour) is reduced. In the case of carrots, the nutritional quality is mainly determined by the β- carotene content. This pigment is also responsible for the orange colour of carrots [8]. Next to the above mentioned effects of blanching, it must be taken into consideration that these short blanching treatments already influence the texture of fruit and vegetables, which is an important parameter for consumer acceptance [9, 10]. The desired objective was to study the colour attributes after different blanching treatments given to the carrots. The carrots were critically evaluated and analyzed for L value, a value, b value, hue angle, chroma value and total colour difference (ΔE).

Material and Methods

The studies on blanching of carrot (*Daucus carota* L.) were performed in the laboratories of the Department of Processing and Food Engineering, College of Agricultural Engineering and Technology, Punjab Agricultural University, Ludhiana. Fresh carrots of "Ujjwal Queen" variety were procured from local farms of village Baranhara near Ludhiana. Procured carrots washed in bulk and packed in gunny bag were stored in cold storage room in pilot plant of Department of Processing and Food Engineering (4-5°C). Carrots showing no sign of infection and infestation were selected thus removing any damaged carrots or a part of it. The selected carrots were thoroughly washed in running water to remove any adhering dirt. The tops of the carrots were removed using a stainless steel knife. Carrots were then manually peeled off with a stainless steel peeler. Then the carrots were cut by slicing each carrot in four parts longitudinally and then cutting it laterally into pieces of even size and shape. The prepared product was then collected in a vegetable tray.

The treatments were given to the carrots along with the purpose of identifying the most apt method of blanching to retain the colour attributes of the carrots. The colour parameters *viz.* L value, a value, b value, hue angle, chroma value and total colour difference (ΔE) were checked after the treatments and the most suitable treatment was found out. The treatments provided are given below:

1. Hot water blanching
2. Steam blanching
3. KMS treatment + Hot water blanching
4. Untreated Control

Hot water blanching

Carrots were thoroughly washed and then sliced down to even thickness. A stainless steel vessel filled with about 5 l of water was used as the blanching medium. The water filled vessel was placed on a gas stove and the water in the vessel was allowed to attain its boiling point. The carrot slices to be blanched were tied in a clean and dry muslin cloth. When the water started boiling, the muslin containing the carrots was immersed into the vessel. Care was taken to assure that the whole lot of carrots was properly immersed in the blanching medium to attain even blanching treatment. The blanching time of carrots was 10 minutes whereas the temperature of the blanching medium was 95-100°C which was checked periodically during the experiment with a thermometer. A separate stainless steel container filled with ice cold water was taken. After 10 minutes the muslin containing carrots was taken out of water and the hot water boiled carrots were then quickly immersed in the ice cold water hence drastically lowering down the temperature of the carrots in a very short interval of time. The cooled carrots were then taken out of the vessel, the excess water was allowed to drain and the carrots were allowed to dry before they were frozen. The main objective of the hot water blanching was to result in a more uniform treatment, allowing processing at lower temperatures. Water blanching was observed to require longer processing times which resulted in increased leaching of minerals.

Steam blanching

The steam blanching of the carrots was done in an autoclave. Steam blanching is usually used for cut and small products, and requires less time than water blanching because the heat transfer coefficient of condensing steam is greater than that of hot water blanching. The temperature during steam blanching is higher than that of hot water blanching. It generally shows lesser leaching of minerals from the carrots. The fresh carrots were washed and cut into pieces of even thickness. Carrot pieces were then tied in a clean and dry muslin cloth. Autoclave consists of a cylindrical shell which has a stainless steel cylinder with perforated side walls of lesser diameter inside the shell. The cavity between the inner and outer cylinder is filled with water which is turned into steam when the process is taking place. The amount of water filled in the autoclave can be observed from the water level indicator provided on the exterior of the autoclave. The autoclave was tightly sealed to confirm no loss of pressure or any leakage from it. The pressure gauge of the autoclave was rotated to bring the pressure to 15 Kg/cm^2. The temperature inside the autoclave reaches well beyond 121°C. Pressure and temperature of the autoclave were maintained at constant by regulating from time to time. Excess pressure was released by opening the valve which lets the extra steam out. The carrots were steam blanched for 5 minutes and then pressure was brought down to zero by letting all the steam off from the valve. A separate stainless steel vessel was taken which was filled with ice cold water. The steam boiled carrots are then immersed in this ice cold water to drastically reduce down the temperature of the carrots in a very short time. Care was taken to immerse all the carrots fully in the vessel so that the whole product cools down rapidly and evenly. The carrots were then spread in a perforated tray. Excess water was drained and carrots were air dried before taking them further for freezing.

KMS treatment and hot water blanching

Pottasium metabisulfite (KMS) treatment was provided to the carrots with the objective of retention of the quality parameters (colour, texture and β-carotene) of the carrots while storage. Freshly cut carrots of even thickness were taken for this treatment. A stainless steel vessel of 5 l capacity was taken. To prepare 0.2% KMS solution 5 gm KMS was weighed and mixed thoroughly in 2.5 l of water by stirring it. Hence was prepared. Carrots were then immersed in the KMS solution for 5 minutes. The KMS solution from the vessel was then drained carefully to avoid loss of product and carrots were collected. Carrots were subjected to hot water blanching after KMS treatment. The procedure for the hot water blanching was followed as discussed earlier in this chapter.

Untreated control

A part of carrots was left untreated and were directly frozen. The untreated carrots were frozen so as to compare the effectiveness of other treatments with reference to the untreated.

Colour measurement

The colour of the samples was measured using a Hunter Lab colour meter (Konica minolta) fitted with a 2.5 cm diameter aperture. The instrument was calibrated using the black and white tiles provided. Carrot dices were covered with petri dishes and the aperture of the hunter colour lab meter was brought in contact with the glass of the petri dish to get the readings. Colour was expressed in Hunter Lab units L* (whiteness or brightness), a* (redness/greenness) and b* (yellowness/ blueness). Three replicate measurements were performed and results were averaged. In addition, colour intensity (chroma), total colour difference (ΔE) and hue angle were calculated using the following equations, where L_0, a_0 and b_0 are the control values for carrots.

$$\text{Hue angle} = \tan^{-1}(b^*/a^*) \quad (1)$$

$$\Delta E = [(L^* - L_0)^2 + (a^* - a_0)^2 + (b^* - b_0)^2]^{1/2} \quad (2)$$

$$\text{Chroma} = (a^{*2} + b^{*2})^{1/2} \quad (3)$$

Results and Discussion

The colour of the product was analyzed for L, a, b, ΔE, chroma and hue factor. The values of ΔE, chroma and hue factor were calculated from the formulas as discussed above. The factors 'L', 'a', 'b', hue and chroma depict the lightness, redness, yellowness, spatial distribution of colours and greyness of the product respectively. ΔE is a single value that takes into account the differences between the 'L', 'a' and 'b' of the sample and standard.

The L (lightness) value of 34.8 was observed to be as the maximum when treated with hot water blanching after chemical treatment (Table 1) and (Fig.1). This may be due to the effect of leaching which occurs while hot water blanching as well as during the treatment with KMS. The minimum value of 34.5 depicting a darker colour of the sample was found in untreated controlled sample. It is observed that initially the colour of the carrots gets lighter after the treatments are given as compared to untreated controlled carrots. Therefore, the 'L' variable was less for untreated control as there was no leaching effect and no colour was lost from the product. The 'a' value depicting the redness of the product was found to be highest in both, untreated controlled sample and hot water blanching after chemical treatment with a value of 20.6 whereas the lowest value thus observed was of 20.4 after steam blanching which depicts lesser redness of the product (Fig.2). The b value of steam blanching was found to be higher with a value of 5.3 showing more yellowness whereas the untreated controlled sample gave value of 4.6 (Fig.3). It can be deduced that the colour loss is found to be more significant with steam blanching as the results show lesser redness and more yellowness in steam blanching treatment. The total colour difference, ΔE was also calculated. The least change in the colour was observed to be 0.24 with hot water blanching and the maximum change in colour was observed to be 0.75 with steam blanching (Fig.4).

Table 1: Effect of treatments on colour parameters

Treatment	'L'	'a'	'b'	ΔE	Chroma value	Hue angle
Hot water blanching	34.6	20.5	4.8	0.24	21.05	13.68
Steam blanching	34.7	20.4	5.3	0.75	21.08	15.24
Hot water blanching+ KMS	34.8	20.6	5.1	0.58	21.22	14.49
Untreated control	34.5	20.6	4.6	0.00	21.107	13.02

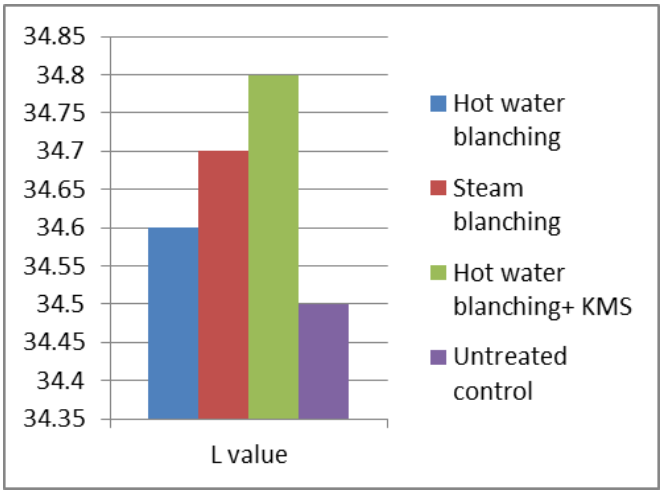

Fig 1: Effect of treatments on 'L' value of carrot slices

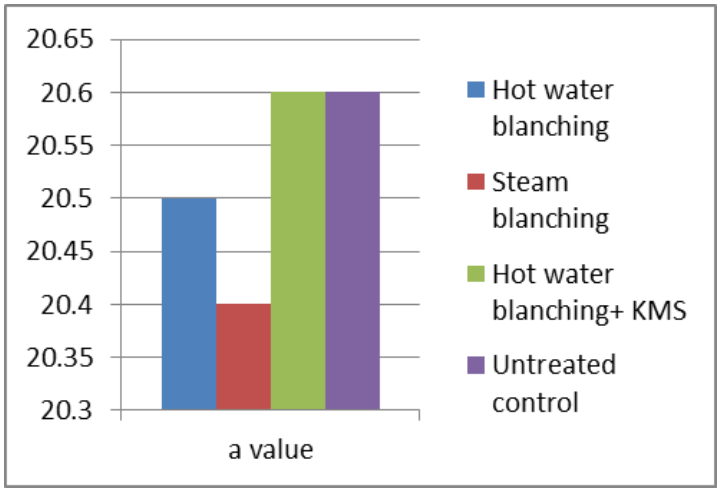

Fig 2: Effect of treatments on 'a' value of carrot slices

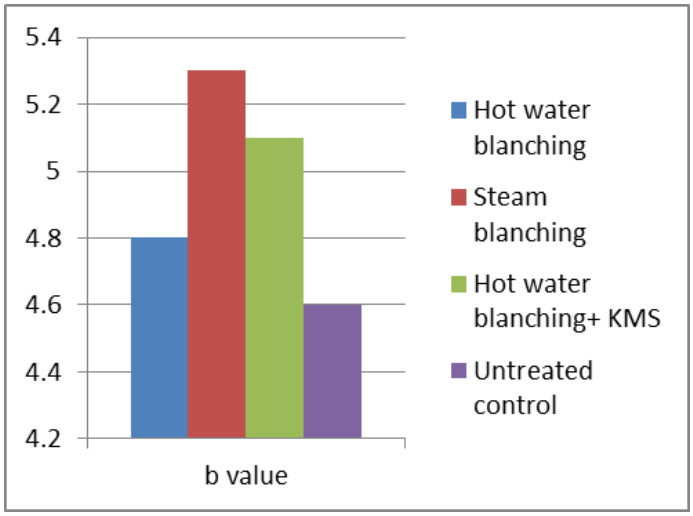

Fig 3: Effect of treatments on 'b' value of carrot slices

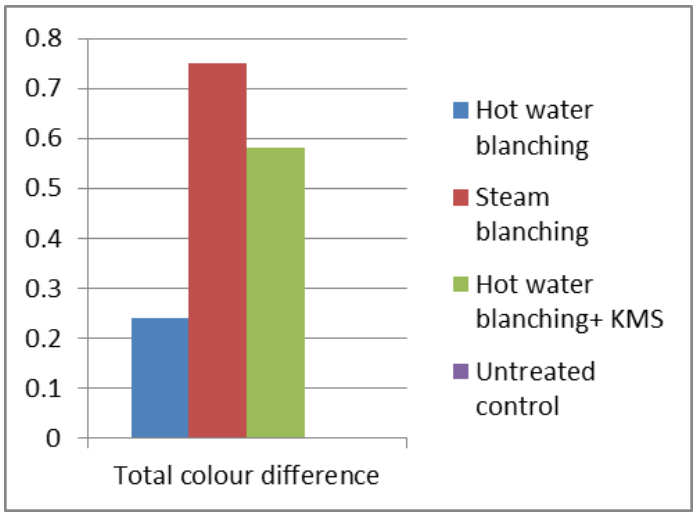

Fig 4: Effect of treatments on ΔE of carrot slices

Proportion of grey component characterizing colour is given by values of chroma. The values of chroma were found to be lesser significance with all the treatments giving a value between 21.05 and 21.22 (Fig.5). The highest value was that of hot water blanching after chemical treatment. Steam blanching showed maximum hue angle of 15.24 and untreated controlled sample showed lowest hue angle of 13.02 (Fig.6). Earlier, [11] also reported significant reduction in colour after blanching of carrots.

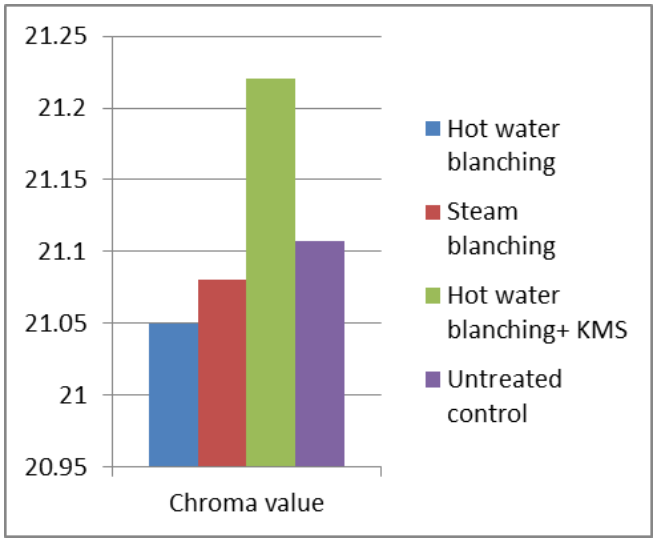

Fig 5: Effect of treatments on Chroma value of carrot slices

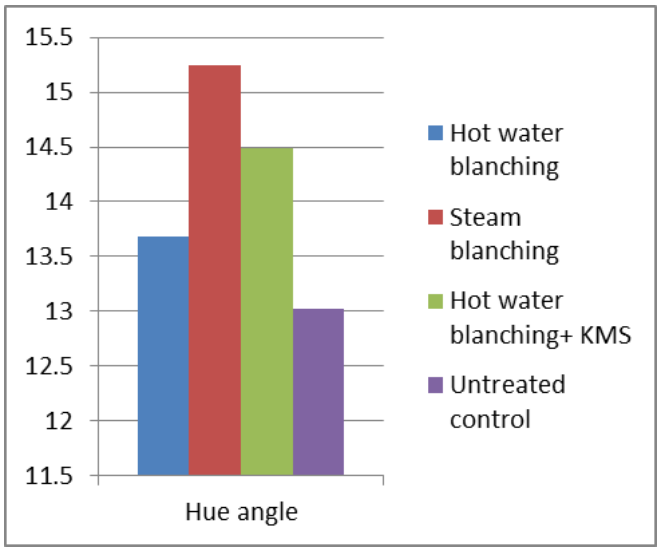

Fig 6: Effect of treatments on Hue angle of carrot slices

The study indicated that after the treatments 'L' parameter gave lowest values (more dark) after hot water blanching and 'a' parameter gave highest value (more red) after hot water blanching after chemical treatment. For 'b' variable, hot water blanching gave lowest value (less yellow). The overall change in the total colour difference (ΔE) was observed to be minimal in case of hot water blanching before storage. The change in hue angle after pre-treatments before the storage period was found to be minimum after hot water blanching and chroma value was found to be best in hot water blanching after chemical treatment. Overall, the hot water blanching as a treatment is found to be the most apt as compared to other treatments significantly for colour retaining with minimum change in the total colour of the carrots.

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