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Comparative studies on chromatic properties for refractance window, hot air tray and solar tunnel drying of carrot (*Daucus carota* subsp. *sativus*) puree

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Abstract
The value of L*, a*, b* and darkness factor of fresh carrot puree as well as dried carrot puree were recorded through hunter colorimeter and other chromatic properties *i.e.* change in brightness (ΔL) value, change in redness (Δa) and change in yellowness (Δb) were calculated. The mean values of L*, a*, b* and darkness factor of fresh carrots puree were found 52.23, 26.12, 42.87 and 1.64 respectively. The significant observation of L* values of dried carrot puree products were found between 43.11 and 55.51. The significantly maximum L* value 55.51 was observed for treatment T_7 and significantly minimum L* value 43.11 was observed for treatment T_{19}. The significant observation of a* values were found between 20.22 and 28.69. This means all dried samples indicates red in colour. The significantly maximum a* value 28.69 was observed for treatment T_7 and the significantly minimum a* value 20.22 was observed for treatment T_{19}. The significant observation of b* values were found between 36.03 and 44.21. The significantly maximum b* value 44.21 was observed for treatment T_7. This means all dried samples indicates yellow in colour. The significantly minimum b* value 36.03 was observed for treatment T_{19}. The significant observation of ΔL values were found between −9.12 and 3.28. The significantly maximum ΔL value 3.28 was observed for treatment T_7 and the significantly minimum ΔL value −9.12 was observed for treatment T_{19}. The significant observation of Δa values were found between -5.90 and 2.57. The significantly maximum Δa value 2.57 was observed for treatment T_7 and the significantly minimum Δa value -5.90 was observed for treatment T_{19}. The significant observation of Δb values were found between -6.84 and 1.34. The significantly maximum Δb value 1.34 was observed for treatment T_7 and the significantly minimum Δb value -6.84 was observed for treatment T_{19}.

Keywords: Chromatic properties, hunter colour values, L* a* b* values, darkness factor (b/a), comparative studies on chromatic properties

1. Introduction

Carrot (*Daucus carota* L.) is an essential root vegetable with carotenoids, flavonoids, vitamins and minerals that provide various nutritional and health benefits (da Silva Dias, 2014; Keskin *et al*., 2019) [9, 17]. It is a medicinal and industrial crop as it is an ample and economical source of minerals, vitamins and fiber. It is consumed fresh or used for the production of dried powders for soups and other food products. Drying reduces moisture content and lowers water activity in perishable products to safe levels, thereby prolonging shelf life and adding value. Although several commercial drying methods have been developed over time, none have previously been able to provide high quality yet economical products. Sun drying and hot air drying cause significant loss of color that make the product less appealing to consumers. Refractance window dryers produce high quality dehydrated products. Colour is an important property of food product for quality evaluation (Ordonez-Santos *et al*., 2014; Yang *et al*., 2018; Keskin *et al*., 2019) [27, 43, 17] and can be quantified by using a colorimeter (Pathare *et al*., 2013; Keskin *et al*., 2019) [29, 17]. The first quality judgment made by a consumer on food materials is their visual appearance, which is usually negatively affected by drying (Zielinska *et al*., 2005) [45]. The colour changes of thermally treated food materials occur because of chemical changes, such as pigment degradation (especially carotenoids and chlorophyll), browning reactions, such as Maillard condensation of hexoses and amino components, and finally oxidation of ascorbic acid (Zielinska and Markowski, 2012) [44].

Various studied were conducted on chromatic properties for RW dried products. These includes aloe vera gel (Miranda *et al*., 2009; Minjares-Fuentes *et al*., 2017; Ayala-Aponte *et al*., 2021) [21, 20, 3]; tomato powder (Castoldi *et al*., 2015; Qiu *et al*., 2019) [7, 33]; pumpkin layers (Ortiz-Jerez and Ochoa-Martínez, 2015) [28]; yogurt puree (Tontul *et al*., 2018) [38]; carrot

(Abonyi *et al*., 2002; Zielinska *et al*., 2005; Zielinska and Markowski, 2012; Gong *et al*., 2015; Md Saleh *et al*., 2020) [1, 45, 46, 11, 19]; mango pulp (Shende and Datta, 2020) [35]; strawberry pulp (Abonyi *et al*., 2002 [1]; mango powder (Caparino *et al*., 2012) [16]; mango slices (Ochoa-Martínez *et al*., 2012) [26]; cranberry juice (Nindo *et al*., 2007) [24]; paprika cultivars (Topuz *et al*., 2009) [43]; apple (Baeghbali *et al*., 2019) [5]; asparagus (Nindo *et al*., 2003) [25]; blueberry (Nindo *et al*., 2006; Nemzer *et al*., 2018) [23, 22]; cheery (Nemzer *et al*., 2018) [22]; goldenberry pulp (Izli *et al*., 2014; Etzbach *et al*., 2019; Puente *et al*., 2020) [15, 10, 32]; physalis (Wen *et al*., 2019) [42]; kiwi fruits (Jafari *et al*., 2014) [16]; pomegranate juice (Baeghbali *et al*., 2016) [4]; acai juice (Pavan *et al*., 2012) [30].

The effectiveness of RW arisen from the rapid heat transfer by radiation and conduction. When the material contains water, the film allows the radiation by opening like a window, however, decreasing water content during drying closes the window and heat transfer only occurs by conduction. Therefore, RW drying prevents or limits the colour destruction (Hernandez-Santos *et al*., 2016; Tontul *et al*., 2018a) [12, 39]. The colour properties of RW dried samples were better than convective dried samples (Tontul *et al*., 2018a) [39]. Thus, the objective of this work was to comparing chromatic properties of the dried carrot puree powder products. The drying experiment of carrot puree were conducted by refractance window, hot air tray and solar tunnel dryer, by varying the operating temperature and puree bed thickness.

2. Materials and Methods

2.1 Treatment details

The experiments were planned to study the effect of independent variables viz. the different drying temperature and carrot puree bed thickness on chromatic properties of the dried products. The refractance window, hot air tray and solar tunnel dryer were selected to dry fresh carrot puree. Drying experiments were carried out, for each slice size with water temperatures of 75, 85, and 95 °C in the refractance window dryer. For hot air tray dryer the drying air temperature were selected 55, 65 and 75 °C and the carrot puree bed thickness 2, 4 and 6 mm were selected for both dryer. The details of treatment combinations are shown in Table 1.

Table 1: Treatment combinations

Treatments	Treatments Details		
	Types of Dryers	**Temp.**	**Bed thickness**
T_1	Refractance Window Dryer	Water Temp. 75 °C	2 mm
T_2			4 mm
T_3			6 mm
T_4		Water Temp. 85 °C	2 mm
T_5			4 mm
T_6			6 mm
T_7		Water Temp. 95 °C	2 mm
T_8			4 mm
T_9			6 mm
T_{10}	Hot Air Tray Drying	Drying Temp. 55 °C	2 mm
T_{11}			4 mm
T_{12}			6 mm
T_{13}		Drying Temp. 65 °C	2 mm
T_{14}			4 mm
T_{15}			6 mm
T_{16}		Drying Temp. 75 °C	2 mm
T_{17}			4 mm
T_{18}			6 mm
T_{19}	Solar Tunnel Drying	Drying Temp. of Solar Tunnel Dryer	4 mm

2.2 Materials and sample preparations

Fresh *Pusa Kesar* varieties of carrot having initial moisture content about (89% wb) were procured from the local market of Dediapada, Narmada District, Gujarat. The carrots were washed and soaked for 10 min in tap water to remove the dirt and soil residue. After that peeled the washed carrots and removed top and bottom inedible portion. The peeled carrots were cuts in small pieces into 10 × 10 ×10 mm cubes and then soaked in boiling water (temperature approx. 95 °C) for 2 minutes to prevent browning reaction and then immediate washed in cold water (temperature approx. 10 °C) for 5 minutes to cool the carrot. After water to be drained from the surface of cuts carrot, the puree products were prepared by mixer machine. The prepared carrot puree were used for drying by refractance window, hot air tray and solar tunnel dryer on different drying conditions.

2.3 Chromatic properties

The hunter lab L*, a*, b* and the modified CIE system called CIE LAB colour scale were opponents- type system commonly used in a food industry. The parameter a* takes positive value for reddish colour and negative value for the greenish ones, whereas b* takes positive value for yellowish colours and negative value for the bluish ones. L* is an approximate measurement of luminosity, which is the property according to which each colour can be considered as equivalent to a number of the greyscale, between black white.

2.3.1 L* Value

Colour denotes the visual appearance of the product. The L* value of dried carrots puree products represents the brightness of the colour. L=0: indicate black colour and L =100: indicate white colour. L scale: Light vs. dark where a low number (0-50) indicates dark and a high number (51-100) indicates bright (Keskin *et al*., 2019) [17]. The Colorimeter (Figure 1), model CS-200 and make Hangzhou CHN Spec Technology, was used for the experiment for colour measurement. Ultra stable performance, display precision 0.01, repeatability precision AE's standard deviation 0.08, can measure whiteness or yellowness, measure at multiple spots for average, enhance the measure accuracy through white and black calibration. Measuring time 0.5 second and measuring source LED light. Power source four AA 1.5 V alkaline battery or nickel metal hydride battery exclusive 5V DC adapter. The fresh and dried carrot puree sample was kept on sample cylinder and the L* value was observed). Repeat the experiment triplicate and calculate average value.

2.3.2 a* Value
The scale of a* value: red vs. green, where $(+a)$ positive number indicates red and $(-a)$ negative number indicates green. The values of redness and greenness lies between $+60$ to -60 (Keskin *et al*., 2019) [17]. The Colorimeter, model CS-200 and make Hangzhou CHN Spec Technology, was used for the experiment for colour measurement. The fresh and dried carrot puree sample was kept on sample cylinder and the value a* was observed. Repeat the experiment triplicate and calculate average value.

2.3.3 b* Value
The b* scale: yellow vs. blue, where $(+b)$ positive number indicates yellow and $(-b)$ negative number indicates blue. The values of yellowness and blueness lies between $+60$ to -60 (Keskin *et al*., 2019) [17]. The Colorimeter, model CS-200 and make Hangzhou CHN Spec Technology, was used for the experiment for colour measurement. The fresh and dried carrot puree sample was kept on sample cylinder and the value b* was observed. Repeat the experiment triplicate and calculate average value.

2.3.4 Darkness factor (b/a)
A darkness factor b*/a* was also used to quantify possible discoloration as well as redness (a*) and blueness (b*) factors. The ratio of 'b' value of hunter colour to 'a' value of hunter colour is called darkness factor of the product. The darkness factor of carrot puree was expressed as under given equation 1.

$$\text{Darkness factor} = \frac{b}{a} \quad (1)$$

2.3.5 ΔL* Value
The delta L* values (ΔL) indicate how much a fresh samples and dried sample differ from one another in L value. The ΔL values are often used for quality control or formula adjustment. It was calculated as difference L* value of fresh carrot puree (L_0) and dried carrot puree (L) products and expressed as in equation 2.

$$\Delta L = L_0 - L \quad (2)$$

2.3.6 Δa* Value
The delta values (Δa) indicate how much a fresh samples and dried sample differ from one another in a*. The Δa values are often used for quality control or formula adjustment. It was calculated as difference a* value of fresh carrot puree (a_0) and dried carrot puree products $(\boldsymbol{a})$ and expressed as in equation 3.

$$\Delta a = a_0 - a \quad (3)$$

2.3.7 Δb* Value
The delta values (Δb) indicate how much a fresh samples and dried sample differ from one another in b*. It was calculated as difference b* value of fresh carrot puree (b_0) and dried carrot puree products (b) and expressed as in equation 4.

$$\Delta b = b_0 - b \quad (4)$$

Fig 1: Chromatic analysis of dried carrot puree products by colorimeter

3. Results and Discussions
The colour of the product is a very important quality parameter that plays a vital role in the acceptance and rejection of the product by the consumer. Colour characteristics were the most common parameter measured in dried food products as they are one of the first quality attributes that can be visualized by a consumer (Chua *et al*., 2000). Food colour is a major determinant of product quality and affects consumer preferences (Ahmed *et al*., 2002; Samia, 2014) and may be used as an indicator to predict the chemical and quality changes due to thermal processing. The evaluation of different chromatic properties *viz.* L*, a*, b*, ΔL, Δa, Δb and darkness factor (b/a) of the dried carrot puree products were studied and illustrated in tabulated and graphically in subsequent headings.

3.1 L* Value
Colour denotes the visual appearance of the product. The L* value of the dried carrots puree products represents the brightness of the colour. L =0: indicate black colour and L =100: indicate white colour. L scale: Light vs. dark where a low number (0 to 50) indicates dark and a high number (51 to 100) indicates bright (Keskin *et al*., 2019) [17].

The average L* value of the dried carrot puree products presented in Table 2 and graphically portrayed in Figure 2. The significant observation of L* values of the dried carrot puree products were found between 43.11 and 55.51. The significantly maximum L* value 55.51 was observed for treatment T_7 which was at par to 55.45 for treatment T_1 and T_3. The significantly minimum L* value 43.11 was observed for treatment T_{19}. The results shows that the L* value of the RW dried carrot puree product was higher than the HAT and solar tunnel drying carrot puree product, which indicated that the RW dried products were more vivid or brighter than HAT and solar dried products.

Also the L* values of the RW dried carrot products found higher as compared to fresh carrot puree (Table 2). It presented that the dried samples were more vivid or brighter than the fresh ones. While the L* values of the hot air tray and solar tunnel dried carrot puree products were lower as compared to the fresh carrot puree samples (Table 2). It presented that the dried carrot puree product were less vivid than the fresh ones. The differences in L∗ values were also dependent on the puree bed thickness, drying air temperature as well as drying time.

The highest values of L*of the RW dried sample concluded more saturated and more vivid colours. Carotenes present in the carrot responsible for its colour. During drying the carotenoids in the carrot start degradation this result in alteration of the product colour (Mahanty *et al.*, 2021) [18]. The minimum L* values (darker colour) of the of the solar tunnel and hot air tray dried carrot puree product was due to the high drying temperature and longer exposure time combinations. The higher temperature generated browning or Maillard reactions (Potter and Hotchkiss, 2012; Mahanty *et al.*, 2021) [31, 18]. The prolonged exposure of product to severe heat treatment causes sugar caramelization, non-enzymatic browning reactions, which bring forth the colour of the final product (Suna *et al.*, 2014; Tontul and Topuz, 2017) [37, 40].

Table 2: L*, a*, b* values for drying of carrot puree in different drying conditions

Treatment	L* value	a* value	b* value	Darkness factor (b/a)
Fresh carrot puree	52.23	26.12	42.87	1.64
T_1	54.45	27.51	43.67	1.59
T_2	54.91	28.04	43.91	1.57
T_3	55.45	28.31	44.12	1.56
T_4	53.89	27.22	43.29	1.59
T_5	54.19	27.42	43.47	1.59
T_6	54.67	27.65	43.64	1.58
T_7	55.51	28.69	44.21	1.54
T_8	55.12	28.28	43.92	1.55
T_9	54.78	27.83	43.67	1.57
T_{10}	50.40	25.41	40.71	1.60
T_{11}	50.05	25.10	40.37	1.61
T_{12}	49.88	24.79	40.09	1.62
T_{13}	50.23	25.86	41.12	1.59
T_{14}	50.40	25.48	40.88	1.60
T_{15}	49.86	24.28	40.48	1.67
T_{16}	47.43	23.64	39.03	1.65
T_{17}	47.83	24.22	39.66	1.64
T_{18}	48.33	24.84	39.96	1.61
T_{19}	43.11	20.22	36.03	1.78
Mean	51.60	26.04	41.70	1.61
S.Em. ±	0.0563	0.1138	0.0543	0.0093
C.D. at 5%	0.161304	0.32587	0.1554429	0.02655483
CV%	0.19	0.76	0.23	1.00

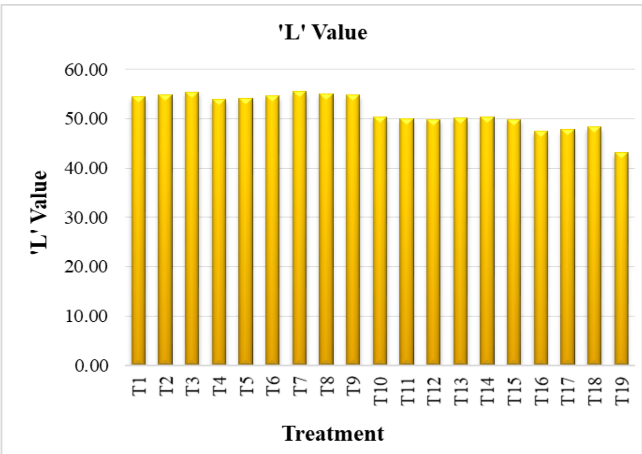

Fig 2: Variation in L* value for drying of carrot puree using different drying conditions

3.2 a* Value

The scale of a* value: red vs. green, where $(+a)$ positive number indicates red and $(-a)$ negative number indicates green. The values of redness and greenness lies between $+60$ to -60 (Keskin *et al.*, 2019) [17]. The average a* value of dried carrot products were obtainable in Table 2 and graphically represented in Figure 3. The significant observation of a* values were found between 20.22 and 28.69 which presented that all dried samples were red in colour. The significantly maximum a* value 28.69 was observed for treatment T_7 and it was at par to the value 28.31 for treatment T_3. The significantly, minimum a* value 20.22 was observed for treatment T_{19}. The results displayed that the a* value of the RW dried sample was higher than the HAT and solar tunnel drying technologies, which indicated that the RW dried samples had more redness colour than HAT and solar dried samples.

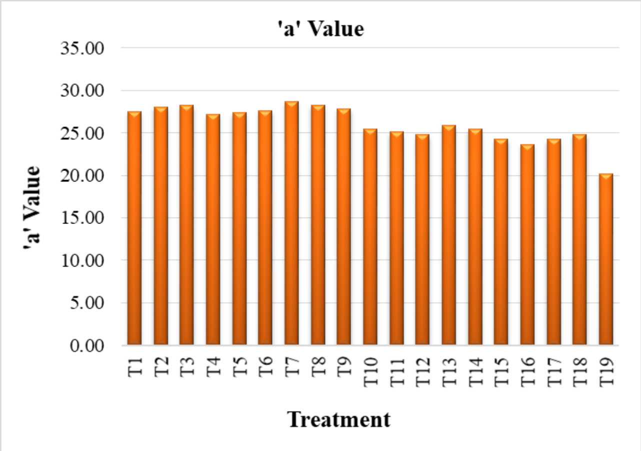

Fig 3: Variation in a* value for drying of carrot puree using different drying conditions

Similarly, the a* values of the RW dried carrot samples were found higher as compared to fresh carrot puree samples (Table 2) which signified that the dried samples had more redness colour than the fresh ones. While the a* values of the hot air tray and solar tunnel dried carrot samples were lower as compared to fresh carrot puree samples (Table 2). It indicated that the dried samples were less redness than the fresh ones. Abonyi *et al*., 2002 [1] also reported that the lower value of a* shows less intense red colour. The decrease in redness was probably due to the water removal, internal structure alterations and changes in surface texture and concentration of dry matter (Ibarz *et al*., 1999) [14]. The differences in a* (redness) obtained during the study might be due to the puree bed thickness, drying air temperature as well as drying time. The highest values of a* of the RW dried sample indicated more saturated and red colours. Carotenes present in the carrot responsible for its colour was also reported by Mahanty *et al*., 2021 [18]. During drying the carotenoids in the carrot start degradation which resulted in alteration of the product colour (Mahanty *et al*., 2021) [18]. The high temperature during the drying of carrot involved browning or Maillard reactions (Potter and Hotchkiss, 2012; Mahanty *et al*., 2021) [18].

3.3 b* Value

The b* scale: yellow vs. blue, where $(+b)$ positive number indicates yellow and $(-b)$ negative number indicates blue. The general range of b* values were of yellowness and blueness lies between $+60$ to -60 (Keskin *et al*., 2019) [17]. The average b* value of dried carrot products were presented in Table 2 and graphically represented in Figure 4. The significant observation of b* values were found between 36.03 and 44.21. The maximum b* value 44.21 was observed for treatment T_7 and it was at par to 44.12 for treatment T_3. The reported results indicated that all the dried samples were yellow in colour. The significantly minimum b* value 36.03 was observed for treatment T_{19}.

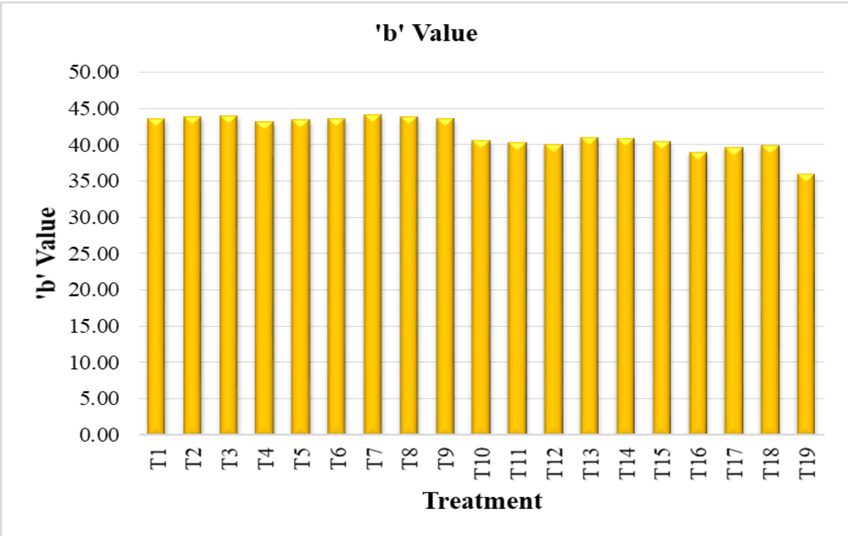

Fig 4: Variation in b* value for drying of carrot puree using different drying conditions

The results revealed that the b* value of the RW dried carrot puree products was higher than the carrot products dried under HAT and solar tunnel dryer, which presented that the RW dried samples were more yellowness colour than HAT and solar dried samples. Similarly, the b* values of the RW dried carrot puree product were higher as compared to fresh carrot puree samples (Table 2) which also specified that the dried samples were more yellowness colour than the fresh ones. Even though, the b* values of the hot air tray and solar tunnel dried carrot samples were found lower as compared to fresh carrot puree samples (Table 2), which reflected that the dried samples were less yellowness than the fresh ones. The lower value of b* shows less intense yellow colour as compared to fresh carrot was also reported by Abonyi *et al*., 2002 [1]. The decrease in yellowness was probably due to the water removal, internal structure alterations, and changes in surface texture, and concentration of dry matter (Ibarz *et al*., 1999) [14].

3.4 Darkness factor (b/a)

The darkness factor is the ratio of b* value to a* value. Table 2 presented the average darkness factor (b/a) of dried carrot puree products and graphically portrayed in Figure 5. The significant observation of darkness factor (b/a) values were found between 1.54 and 1.78. The significantly minimum value 1.54 was found for treatment T_7 which was at par to 1.55 for treatment T_8. The significantly maximum value 1.78 was observed for treatment T_{19}.

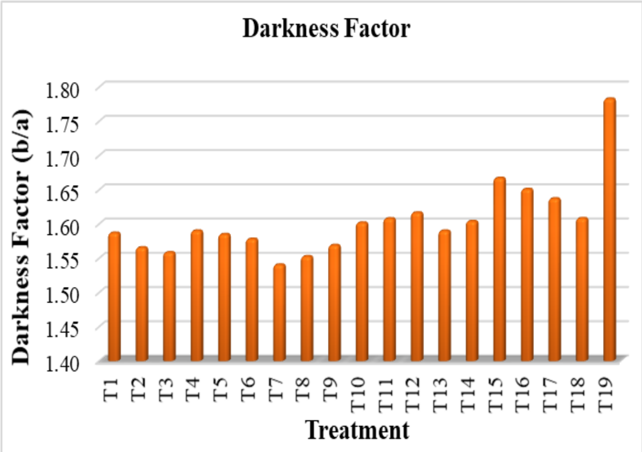

Fig 5: Variation in darkness factor (b/a) value for drying of carrot puree using different drying conditions

The darkness factor (b/a) of RW, HAT and solar tunnel dried carrot puree samples were compared with fresh carrot puree samples (Table 2). It was observed that the RW dried samples have found less darkness factor as compared to fresh whereas HAT and solar tunnel dried samples have found more darkness factor. The results revealed that the RW dried samples observed lighter and solar tunnel dried observed darker as compared to fresh samples.

3.5 Change in brightness (ΔL) value

The delta values (ΔL) indicate how much a fresh samples and dried sample differ from one another in L. The ΔL values are often used for quality control or formula adjustment. Tolerances may be set for the delta values. Delta values that were out of tolerance indicate that there was too much difference between the fresh and the dried samples (Hunter and Harold, 1987) [13]. Further the sign of the delta value is used to know that the dried samples are brighter than the fresh (Hunter and Harold, 1987) [13].

The value of change in brightness of the dried carrot material was evaluated using the chromatic aberration ΔL (Soysal *et al*., 2009) [36]. The average change in brightness ΔL value of dried carrot products with respect to fresh carrot puree samples presented in Table 3 and graphically depicted in Figure 6. The significant observation of ΔL values were found between −9.12 and 3.28. The maximum value 3.28 was observed for treatment T_7 and it was at par to 3.22 for treatment T_3. The significantly minimum value −9.12 was observed for treatment T_{19}.

Table 3: Change in brightness (ΔL), redness (Δa) and yellowness (Δb) values for drying of carrot puree using different drying conditions

Treatment	Change in brightness (ΔL)	Change in redness (Δa)	Change in yellowness (Δb)
T_1	2.22	1.39	0.80
T_2	2.68	1.92	1.04
T_3	3.22	2.19	1.25
T_4	1.66	1.10	0.42
T_5	1.96	1.30	0.60
T_6	2.44	1.53	0.77
T_7	3.28	2.57	1.34
T_8	2.89	2.16	1.05
T_9	2.55	1.71	0.80
T_{10}	-1.83	-0.71	-2.16
T_{11}	-2.18	-1.02	-2.50
T_{12}	-2.35	-1.33	-2.78
T_{13}	-2.00	-0.26	-1.75
T_{14}	-1.83	-0.64	-1.99
T_{15}	-2.37	-1.84	-2.39
T_{16}	-4.80	-2.48	-3.84
T_{17}	-4.40	-1.90	-3.21
T_{18}	-3.90	-1.28	-2.91
T_{19}	-9.12	-5.90	-6.84
Mean	-0.63	-0.08	-1.17
S.Em. ±	0.064	0.1132	0.0669
C.D. at 5%	0.18343	0.3241	0.19149
CV%	-17.74	-253.33	-9.87

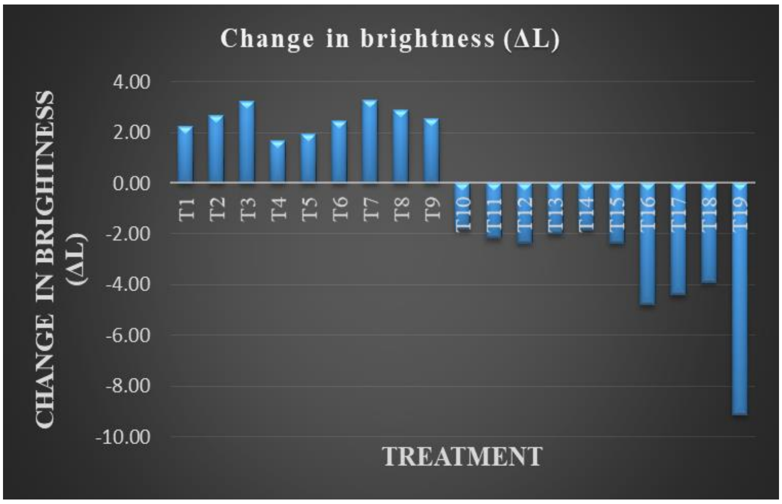

Fig 6: Variation in change in brightness (ΔL) value for drying of carrot puree using different drying conditions

The minimum positive ΔL values 1.66 were found for treatment T_4 and it was at par to 1.96 for treatment T_5. Similarly, the minimum negative ΔL values −1.83 were found for treatment T_{10}, T_{14} and at par to −2.00 for treatment T_{13}. The maximum positive and negative ΔL values were found 3.28 and −9.12 for treatment T_7 and T_{19} respectively. The above reported results showed that the treatment T_4 and T_{10} provided minimum positive and negative (ΔL) change in brightness values. It was also observed that the dried carrot puree samples were nearer to fresh carrot puree samples for the ΔL values.

3.6 Change in redness (Δa)

The delta values (Δa) indicate how much a fresh samples and dried sample differ from one another in a*. The Δa values are often used for quality control or formula adjustment. Delta values that are out of tolerance indicate that there is too much difference between the fresh and the dried samples (Hunter and Harold, 1987) [13]. The sign of the Δa value indicated the redness or greenness of the studied samples as compare to fresh carrot (Hunter and Harold, 1987) [13].

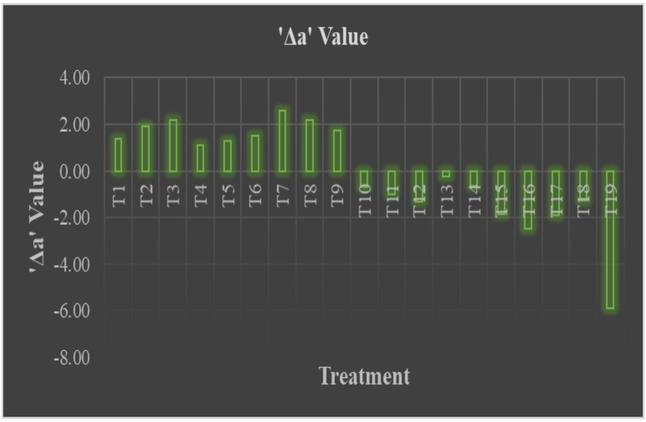

Fig 7: Variation in change in redness (Δa) value for drying of carrot puree using different drying conditions

The value of change in redness of the dried carrot samples was evaluated by using the chromatic aberration Δa (Soysal *et al*., 2009) [36]. The average Δa value of dried carrot products were reported in Table 3 and graphically showed in Figure 7. The significant values of Δa were found in between -5.90 and 2.57. The maximum value 2.57 was observed for treatment T_7 which was at par to 2.19 for treatment T_3. The significantly minimum value -5.90 was observed for treatment T_{19}. The minimum positive Δa values 1.10 were found for treatment T_4 which was at par to 1.30 for treatment T_5. Similarly, the minimum negative Δa values −0.26 were found for treatment T_{13} and it was at par to −0.64 for treatment T_{14}. The maximum positive and negative Δa values were observed 2.57 and −5.90 for treatment T_7 and T_{19} respectively. The above discussed results indicated that the treatment T_4 and T_{13} resulted minimum positive and negative (Δa) change in redness colour values of studied dried carrot puree samples. The value of Δa of treatment T_4 treatment T_4 dried carrot puree samples was found close to the fresh carrot puree samples.

3.7 Change in yellowness (Δb)

The delta values (Δb) indicate how much the fresh samples and dried sample differ from one another in b*. The Δb values are often used for quality control or formula adjustment. The yellowness or blueness of the dried samples as compared to fresh designated by the sign of Δb value.

The value of change in yellowness of the dried carrot material was evaluated by using the chromatic aberration Δb (Soysal *et al*., 2009) [36]. The average Δb value of dried carrot products presented in Table 3 and graphically illustrated in Figure 8. The significant observation of Δb values were found in between -6.84 and 1.34. The maximum value 1.34 was observed for treatment T_7 which was at par to 1.25 for treatment T_3 and the minimum value -6.84 was observed for treatment T_{19}.

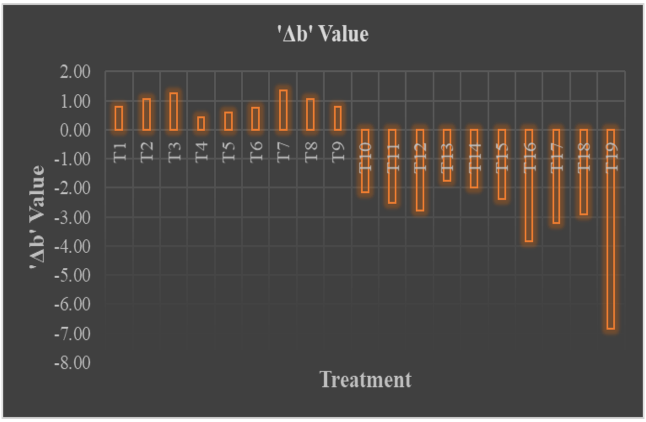

Fig 8: Variation in change in yellowness (Δb) value for drying of carrot puree using different drying conditions

The minimum positive Δb values 0.42 were found for treatment T_4 which was at par to 0.60 for treatment T_5. Similarly, the minimum negative Δb values −1.75 were found for treatment T_{13} which was at par to −1.99 for treatment T_{14}. The maximum positive and negative Δb values were 1.34 and −6.84 for treatment T_7 and T_{19} respectively. The above discussed results presented that, the treatment T_4 and T_{13} resulted minimum positive and negative (Δb) change in yellowness colour values. The obtained values of change in yellowness of the dried carrot material was found nearer to fresh carrot puree samples.

4. Conclusions

The effect of carrot puree bed thickness and drying temperature on quality characteristics of dried carrot puree in terms of chromatic properties i.e L*, a*, b*, b/a, ΔL, Δa and Δb were determined. The mean values of L*, a*, b* and darkness factor of fresh carrots puree were found 52.23, 26.12, 42.87 and 1.64 respectively. The maximum L* value 55.51 was observed for treatment T_7 and minimum L* value 43.11 was observed for treatment T_{19}. The observation of a* values were found between 20.22 and 28.69. This means all dried samples indicates red in colour. The maximum a* value 28.69 was observed for treatment T_7 and the minimum a* value 20.22 was observed for treatment T_{19}. The maximum b* value 44.21 was observed for treatment T_7. The minimum b* value 36.03 was observed for treatment T_{19}. The observation of ΔL values were found between −9.12 and 3.28. The observation of Δa values were found between -5.90 and 2.57. The observation of Δb values were found between -6.84 and 1.34. Thus the refractance window dried carrot puree products were found better colour quality.

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6. References

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