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Quantifying color characteristics in sweet corn varieties after blanching under frozen storage

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Abstract
The study conducted at the Department of Food Science and Technology, College of Agriculture, JNKVV, Jabalpur, and Bhanu Farm Ltd., Jabalpur, aimed to assess various sweet corn varieties for their suitability in the frozen food industry and subsequent product development. Six sweet corn varieties were collected from different regions in Madhya Pradesh. The investigation involved blanching methods (hot water and steam) with varying durations, followed by air blast freezing. Color attributes were evaluated using the Hunter color measuring system and expressed as L*, a* and b* values. Statistical analysis using a factorial complete randomized design was employed to analyze the obtained data. Results revealed significant differences in brightness (L*), redness (a*), and yellowness (b*) among fresh sweet corn varieties. Throughout various stages (fresh, before and after freezing), blanching methods, and different time durations, substantial variations were observed in the color attributes. For instance, brightness values differed significantly among varieties, blanching methods, and durations across the freezing period (0, 30, 60, and 90 days). Redness and yellowness values also exhibited notable variations influenced by variety, blanching techniques, and freezing duration. The study highlights the influence of blanching methods and time on color attributes, crucial for determining the quality and sensory appeal of frozen sweet corn.

Keywords: Blanching, brightness (L*), redness (a*) and yellowness (b*)

Introduction

Sweet corn is a member of the Gramineae (grass family) along with barley, wheat and rice. This mutated grass is native to the tropical environments of the America. According to historical accounts, the origin of sweet corn dates back to 1779, when a member of the Sullivuan expedition against the six nations brought back a few ears of sweet corn, which was called papoon corn.

Maize (*Zea mays* L) is the most versatile crop with wider adaptability in varied agro-ecologies. It has highest genetic yield potential among the food grain crops. Globally, it is cultivated on nearly 150 m ha in about 160 countries having wider diversity of soil, climate, biodiversity and management practices that contributes 36% (782 m t) in the global grain production. The United States of America (USA) has the highest harvest of maize in the world that contributes nearly 20% of the total production in the world and is the driver of the US economy. The other major countries that contribute significantly to the global maize production are China, Brazil, Mexico, India and Indonesia.

The sweet corn is grown all over the world as one of the versatile and indispensable crops. The sweet corn is generally used in fresh, canned and frozen forms Vigneault *et al*., 2004 [1]. Higher respiration rate of sweet corn during storage, even at 0–10 °C, makes it perishable due to short shelf life. Sweetness and tenderness are two vital attributes found in fresh and processed sweet corn, which are very important during storage Azanza *et al*., 1994 [3]. The enzymatic reaction in sweet corn is generally accountable for adverse changes by losing original flavour, aroma, colour, texture and taste during storage. The blanching plays a crucial role by inactivating enzymes and slows down the reaction rate of detrimental changes. Blanching confers advantage of enhanced shelf life along with additional benefits of surface cleaning, colour perseverance and retention of vitamins. The improvement of product quality by blanching with hot water and steam, prior to processing, is well proven De-Corcuera *et al*., 2004 [4].

The blanching also reduces microbial load during intermediate processing and lower temperature storages and restricts decrease of vitamins in dried products too. Hot water blanching is common method to control post-harvest losses in fruits and vegetable, but the temperature and processing time usually have marked impact on colour, appearance and eating of products Lam *et al*., 1982 [5]. Hot water blanching has numerous benefits as it can delay the maturation and control the presence of insects. Heating may be used either by applying dry hot air or immersion in hot water Brecht *et al*., 2004 [6]. The add on of using hot water blanching is to control the diseases and remains monetarily effective being cheaper in investment McGuire *et al*., 2004 [7].

The influence of various blanching methods on sweet corn *viz*., microwave, steam and heated water blanching with respect to different time period was described by Kachhadiya *et al*., 2018 [8]. However, effect of temperature level in hot water blanching was not reported earlier, which is a major contributing factor and essentially needed to standardize the process parameters to obtain appropriate blanching to comprehend the effect on physical, chemical and sensory attributes. Therefore, the study was carried out to investigate the effect of hot water and steam blanching at various time levels for appropriate duration on enzymatic activity, physico-chemical attributes of sweet corn kernels.

The measurement of color in sweet corn varieties is a crucial parameter that determines its market value, shelf appeal, and consumer acceptance. Employing the Hunter color measuring system, the color attributes of sweet corn are expressed in terms of L*, a*, b*. These values represent distinct characteristics: L* signifies brightness on a scale from black (0) to white (100), while the a* value denotes the red-to-green color component, and the b* value indicates the yellow-to-blue color components. The L*, a*, b* representation facilitates a comprehensive evaluation of sweet corn varieties' color attributes, aiding in identifying distinct differences in brightness and color components among various cultivars.

In Madhya Pradesh total area under maize crop 1,43,4282 hectares with production 43,13,998 metric ton and average productivity is about 3008 kg/h. There is almost all the district of MP grow maize crop but chhindwara is leading in terms of cultivated area (3,68,200 h) and production (14,18,675 ton) and Barwani in terms of productivity is leading with 5648 kg/h.
(https://mpkrishi.mp.gov.in/hindisite_New/pdfs/201920_n.pdf)

Materials and Methods

The present investigation entitled, "Quantifying Color Characteristics in Sweet Corn Varieties after Blanching under Frozen Storage" was conducted in the Department of Food Science and Technology, College of Agriculture, JNKVV, Jabalpur (M.P.) and leading frozen food plant Bhanu Farm ldt, Jabalpur, (M.P.) during the year 2020-22. Six sweet corn varieties *viz*., Sugar 75, Sweet 1, KSCH 972, Rossy, Golden cob and Sweet heart were collected in fresh and mature state from AICRP on Maize, Zonal Agriculture Research Station, Chhindwara, JNKVV, Jabalpur and other regions of Chhindwara district, M.P.

Blanching of Sweet Corn

In present investigation two types of blanching methods have been applied for blanching of cleaned and shelled kernels as hot water and steam for three different time duration. Hot water blanching was done in stainless steel utensil and then cool through cold water whereas steam blanch was done in perforated stainless steel utensil over steam boiling water when desirable temperature reached for definite time. After blanching, blanched kernels were applied to air blast freezing into Individual Quick Frozen for cease the all chemical and enzymatic activity and further store for frozen temperature at -18 °C. Preliminary studies were performed for the purpose of identifying the appropriate temperature with combination of different time range for inactivation of enzymatic activity of the kernels and accordingly different varieties kernels were blanched and by hot water and steam and applied air blast freezer. Different time-temperature combination was established through analysis of enzymatic activity (peroxidase), sensory and total soluble solids. Various acceptability attributes such as color & appearance, taste, aroma, texture and overall acceptability were considered as deciding factors by using the method described by (Amerine *et al*. 1965) [2].

Colour Analysis Sweet Corn

Color measurement of different sweet corn varieties was done by using a Hunter color measuring system and expressed in terms of L*, a*, b*, according to the CIE method (1976). L* represents the lightness from white (100) to black (0). Red (+) to green (-) color component was indicated by the a* values and yellow (+) to blue (-) color components were indicated by the b* values. These color observations have been observed in different intervals of frozen storage *viz*., 0, 30, 60 and 90 days.

Statistical analysis

The data obtained from various experiments were statistically analyzed. A factorial complete randomized design (FCRD) was adopted for statistical analysis of data by following the procedure as described by Panse and Sukhatme (1963) [13].

Result and Discussions

Herein, the result shows the color, brightness (L*), redness (a*), and yellowness (b*) parameters of sweet corn. The color of fresh, before frozen and after frozen sweet corn during blanching with different time period is important as it determines the quality and sensory attractiveness of the product. These color observations have been observed in different days *viz*., 0, 30, 60 and 90 days.

L* value of fresh kernels of different sweet corn varieties

Significant differences were found in the brightness (L*) of different varieties of sweet corn at fresh. The maximum and minimum values were found in Golden cob (72.86) and Sweet 1 (68.24) respectively.

L* value of different sweet corn varieties at 0 days of frozen storage

With respect to variety, blanching method and blanching time, significant difference was observed for brightness (L*) at 0 days. Sweetheart had the highest (66.33), whereas lowest value was observed in Rossy (61.59). Hot water blanching (90 °C) (B1) and 2 min Blanching time (T1) had the highest brightness (L*) of *i.e*., 64.47 and 64.55, while smallest values were observed in steam blanching (64.31) and 4 min time for blanching (64.23). The interaction between varieties and blanching methods were significant. The maximum brightness (L*) were found in sweetheart with hot water blanching (90 °C) (66.44) while, minimum was found in Rossy with steam blanching (100 °C) (61.48) as well as the interaction between varieties and blanching time were significant. The maximum brightness (L*) was reported in Sweetheart with 2 min blanching time (66.52) while minimum brightness (L*) was in Rossy with 4 min blanching time (61.45). Whereas, the interaction between blanching methods with respect to blanching time period was significant. The maximum and minimum brightness (L*) were found in hot water blanching (90 °C) with 2 min duration (64.58) and steam blanching (100 °C) with 4 min duration (64.08). Similarly, the interaction between varieties, blanching methods and time were also found to have significant differences. The maximum and minimum brightness (L*) were found in sweetheart with hot water blanching (90 °C) for two minutes (66.56) and Rossy with steam blanching (100 °C) for 4 minutes (61.26) respectively.

L* value of different sweet corn varieties at 30 days of frozen storage

With respect to variety, blanching method and blanching time, significant differences were observed for brightness (L*) at 30 days. Variety sweetheart (V6) had the highest brightness (L*) (66.20), whereas lowest brightness (L*) was observed in Rossy (V4) (61.51). Blanching method B1 and Blanching time T1 had the highest values i.e., 64.38 and 64.43, while smallest brightness (L*) was observed in B2 (64.22) and T3 (64.16). The interaction of varieties with blanching methods and blanching time revealed significant differences. The maximum brightness (L*) were found in sweetheart with hot water blanching (66.31) and sweetheart with 2 min. (V6T1) (66.35), while minimum brightness (L*) were found in Rossy with steam blanching (V4B2) (61.41) and Rossy with 4 min. (V4T3) (61.41). The interaction between blanching methods and time were found to have significant differences. The maximum and minimum brightness (L*) were found in hot water blanching with 2 min (64.44) and steam blanching with 4 min. (63.99). Similarly, the interaction between varieties, blanching methods and time were also found to have significant differences. The maximum and minimum brightness (L*) were found in sweet heart with hot water blanching for 2 min. (66.36) and Rossy with steam blanching for 4 min. (61.24) respectively.

L* value of different sweet corn varieties at 60 days of frozen storage

With respect to variety, blanching method and blanching time, significant differences were observed for brightness (L*) at 60 days. Variety sweetheart had the highest brightness (L*) (66.11), whereas lowest brightness (L*) was observed in rossy (61.42). Hot water blanching (90 °C) and Blanching time 2 min had the highest brightness (L*) *i.e*., 64.33 and 64.34, while smallest brightness (L*) was observed in steam blanching (64.14) and 4 min. (64.09). The interaction of varieties with blanching methods and blanching time revealed significant differences. The maximum brightness (L*) were found in treatment sweetheart with hot water blanching (66.26) and sweetheart with 2 min. (66.31), while minimum brightness (L*) were found in Rossy with steam blanching (61.29) and Rossy with 4 min blanching (61.31). The interaction between blanching methods and time were found to have significant differences. The maximum and minimum brightness (L*) were found in hot water blanching for 2 min (64.37) and steam blanching for 4 min. (63.92). Similarly, the interaction between varieties, blanching methods and time were also found to have significant differences. The maximum and minimum brightness (L*) were found in Sweetheart in hot water blanching for 2min (66.32) and Rossy in steam blanching for 4 min. (61.10) respectively.

L* value of different sweet corn varieties at 90 days of frozen storage

With respect to variety, blanching method and blanching time, significant differences were observed for brightness (L*) at 90 days. Variety Sweetheart (V6) had the highest brightness (L*) (65.88), whereas lowest brightness (L*) was observed in Rossy (V4) (61.27). Hot water blanching (B1) and blanching time 2 min. had the highest brightness (L*) *i.e*., 64.20 and 64.24, while smallest brightness (L*) was observed in steam blanching (B2,100 °C) (64.06) and 4 min. blanching time (63.99). The interaction of varieties with blanching methods and blanching time revealed significant differences. The maximum brightness (L*) were found in treatment V6B1 which is Sweetheart with hot water blanching (66.03) and V6T1 which is Sweetheart with 2 min. blanching time (66.10), while minimum brightness (L*) were found in V4B2 which is Rossy with steam blanching (61.25) and V4T3 which is Rossy with 4 min. blanching time (61.06). The interaction between blanching methods and time were found to have significant differences. The maximum and minimum brightness (L*) were found in hot water blanching for 2 min. (64.26) and steam blanching for 4 min. (63.83). Similarly, the interaction between varieties, blanching methods and time were also found to have significant differences. The maximum and minimum brightness (L*) were found in Sweetheart with hot water blanching for 2 min (66.12) and Rossy with steam blanching for 4 min. (60.97) respectively. Similar decrease in lightness with increase in blanching was reported by Ganjloo *et al*. 2009 [9]. This supports the sensory results for lightness of peas cooked by different methods reported by Schnepf and Driskell (1994) [11]. Brewer *et al*. (1994) [15] reported higher L* values and overall color values in most blanched treatments of green beans in comparison to unblanched green beans. Begum and Brewer (2001) [14] reported that all snow peas blanched by any method were greener than unblanched snow peas after frozen storage.

a* value of fresh kernels of different sweet corn varieties

Significant differences were found in the redness (a*) of different varieties of sweet corn at fresh. The maximum and minimum redness (a*) were found in Golden cob (11.14) and Rossy (7.35) respectively.

a* value of different sweet corn varieties at 0 days of frozen storage

With respect to variety, blanching method and blanching time, significant differences were observed for redness (a*) values at 0 days. Variety Golden cob had the highest redness (a*) (9.98), whereas lowest value was observed in Rossy (5.22). Steam blanching method (B2) and Blanching time 2 min. (T1) had the highest redness (a*) *i.e.*, 7.28 and 7.37, while smallest redness (a*) was observed in hot water blanching (B1) (7.25) and blanching time (T3) 4 min. (7.17). The interaction of varieties with blanching methods revealed significant differences. The interaction between blanching methods and time were found to have significant differences. The maximum and minimum redness (a*) were found in hot water blanching with 2 min. (7.39) and hot water blanching with 4 min. (7.15). On the other hand, the interaction of varieties with time was found to be non-significant. Similarly, the interaction between varieties, blanching methods and time were also found to have significant differences. The maximum and minimum redness (a*) were found in Golden cob with hot water blanching for 2 min. (10.13) and Rossy with hot water blanching for 4 min. (5.07) respectively.

a* value of different sweet corn varieties at 30 days of frozen storage

With respect to variety, blanching method and blanching time, significant differences were observed for redness (a*) at 30 days. Variety Golden cob (V5) had the highest redness (a*) (9.96), whereas lowest redness (a*) was observed in Rossy (V4) (5.17). Steam blanching method (B2) and Blanching time 2 min. (T1) had the highest redness (a*) *i.e.*, 7.22 and 7.29, while smallest redness (a*) was observed in hot water blanching (B1) (7.21) and blanching time (T3) 4 min. (7.15). The interaction of varieties with blanching methods and blanching time revealed significant differences. The maximum redness (a*) were found in treatment Golden cob with steam blanching (9.96) and Sweetheart with 2 min blanching time (10.05), while minimum redness (a*) were found in Rossy with hot water blanching (5.13) and Rossy with 4 min. blanching time (5.13). The interaction between blanching methods and time were found to have significant differences. The maximum and minimum redness (a*) were found in hot water blanching for 2 min. (7.32) and hot water blanching for 4 min. (7.13), respectively. Similarly, the interaction between varieties, blanching methods and time were also found to have significant differences. The maximum and minimum redness (a*) were found in treatments Golden cob variety with hot water blanching for 2 min. (10.12) and Golden cob with hot water blanching for 4 min. (5.04) respectively.

a* value of different sweet corn varieties at 60 days of frozen storage

With respect to variety, blanching method and blanching time, significant differences were observed for redness (a*) at 60 days. Variety Golden cob (V5) had the highest redness (a*) (9.91), whereas lowest redness (a*) was observed in Rossy (5.12). Steam blanching (B2) and Blanching time 2 min. (T1) had the highest redness (a*) *i.e.*, 7.16 and 7.17, while smallest redness (a*) was observed in hot water blanching (B1) (7.14) and 4 min. blanching time (7.12). The interaction of varieties with blanching methods and blanching time revealed significant differences. The maximum redness (a*) were found in Golden cob with steam blanching (9.90) and Sweetheart with 2 min. blanching time (9.94), while minimum redness (a*) were found in Rossy with hot water blanching (5.07) and with 4 min blanching time (5.09). The interaction between blanching methods and time were found to have significant differences. The maximum and minimum redness (a*) were found in hot water blanching for 2 min. (7.20) and hot water blanching for 4 min (7.11), respectively. Similarly, the interaction between varieties, blanching methods and time were also found to have significant differences. The maximum and minimum redness (a*) were found in golden cob with hot water blanching foe 2 min (10.01) and Rossy with hot water blanching for 4 min. (5.02) respectively.

a* value of different sweet corn varieties at 90 days of frozen storage

With respect to variety, blanching method and blanching time, significant differences were observed for redness (a*) at 90 days. Variety Golden cob (V5) had the highest value (9.76), whereas lowest redness (a*) was observed in Rossy (V4) (4.95). The redness (a*) of hot water blanching (7.01) was found to be greater than B2 (7.001). While the redness (a*) of 2 min. blanching time (7.04) was found to be greater than 4 min. blanching time (6.95). As shown in table no. 02, interaction of varieties with blanching methods and blanching time revealed significant differences. The maximum redness (a*) were found in Golden cob with steam blanching (9.77) and sweetheart with 2 min. blanching time (9.79), while minimum redness (a*) were found in Rossy with steam blanching (4.93) and Rossy with 4 min. blanching time (4.87). The interaction between blanching methods and time were found to have significant differences. The maximum and minimum redness (a*) were found in hot water blanching for 2 min. (7.06) and Hot water blanching for 4 min (6.94). Similarly, the interaction between varieties, blanching methods and time were also found to have significant differences. The maximum and minimum values were found in treatments Golden cob with hot water for 2 min (9.81) and Rossy with hot water blanching for 4 min. (4.84) respectively. Similar decrease in lightness with increase in blanching was reported by Ganjloo *et al*. 2009 [9]. This supports the sensory results for lightness of peas cooked by different methods reported by Schnepf and Driskell (1994) [11]. Brewer *et al*. (1994) [15] reported higher L* values and overall color values in most blanched treatments of green beans in comparison to unblanched green beans. Begum and Brewer (2001) [14] reported that all snow peas blanched by any method were greener than unblanched snow peas after frozen storage.

b* value of fresh kernels different sweet corn varieties

Significant differences were found in the yellowness (b*) values of different varieties of sweet corn at fresh. The maximum and minimum yellowness (b*) were found in Sugar 75 (49.32) and Rossy (36.71) respectively.

b* value of different sweet corn varieties at 0 days of frozen storage

With respect to variety, blanching method and blanching time, significant differences were observed for yellowness (b*) values at 0 days. Variety Sugar 75 had the highest yellowness (b*) (51.25), whereas lowest yellowness (b*) value was observed in Rossy (41.23). Hot water blanching and

Blanching time 4 min. had the highest yellowness (b*) *i.e*., 46.11 and 45.97, while smallest yellowness (b*) was observed in steam blanching (45.69) and blanching time 2 min. (45.86). The interaction of varieties with blanching methods and blanching time revealed significant differences. The maximum yellowness (b*) were found in Sugar 75 with hot water blanching (51.63) and Sugar 75 with 4 min. (51.48), while minimum yellowness (b*) were found in Sweetheart with steam blanching (41.13) and V4T1 (41.21). The interaction between blanching methods and time were found to have significant differences. The maximum and minimum values were found in hot water blanching with 4 min. (46.19) and steam blanching with 3 min. (45.62). Similarly, the interaction between varieties, blanching methods and time were also found to have significant differences. The maximum and minimum values were found in Golden cob with hot water blanching for 4 min. (50.05) and Sweetheart with steam blanching for 4 min. (41.09) respectively.

b* value of different sweet corn varieties at 30 days of frozen storage

With respect to variety, blanching method and blanching time, significant differences were observed for yellowness (b*) values at 30 days. Variety Sugar 75 had the highest yellowness (b*) (51.14), whereas lowest yellowness (b*) was observed in Rossy (41.19). Hot water blanching and Blanching time 4 min. had the highest yellowness (b*) *i.e*., 46.05 and 45.92, while smallest values was observed in steam blanching (45.65) and 2 min blanching time (45.80). The interaction of varieties with blanching methods and blanching time revealed significant differences. The maximum yellowness (b*) were found in Sugar 75 with hot water blanching (51.48) and Sugar 75 with 4 min blanching time (51.35), while minimum yellowness (b*) were found in Sweetheart with steam blanching (41.09) and Rossy with 2 min blanching time (41.15). The interaction between blanching methods and time were found to have significant differences. The maximum and minimum yellowness (b*) were found in hot water blanching with 4 min. (46.13) and steam blanching for 3 min. (45.59). Similarly, the interaction between varieties, blanching methods and time were also found to have significant differences. The maximum and minimum yellowness (b*) were found in Golden cob with hot water blanching for 4 min. (50.03) and Rossy with steam blanching for 4 min. (41.06) respectively.

b* value of different sweet corn varieties at 60 days of frozen storage

With respect to variety, blanching method and blanching time, significant differences were observed for yellowness (b*) values at 60 days. Variety Sugar 75 had the highest yellowness (b*) (51.09), whereas lowest yellowness (b*) was observed in Rossy (41.16). Hot water blanching method and Blanching time 4 min. had the highest yellowness (b*) *i.e*., 45.99 and 45.90, while smallest yellowness (b*) was observed in steam blanching (45.62) and 2 min blanching time (45.72). The interaction of varieties with blanching methods and blanching time revealed significant differences. The maximum yellowness (b*) were found in treatment Sugar 75 with hot water blanching (51.43) and Sugar 75 with 4 min. blanching time (51.32), while minimum yellowness (b*) were found in Sweetheart with steam blanching (41.07) and Rossy in 2 min. blanching (41.10). The interaction between blanching methods and time were found to have significant differences. The maximum and minimum yellowness (b*) were found in hot water blanching for 4 min. (46.09) and steam blanching for 3 min. (45.56). Similarly, the interaction between varieties, blanching methods and time were also found to have significant differences. The maximum and minimum yellowness (b*) were found in Golden cob with hot water blanching for 4 min. (50.01) and Sweetheart with steam blanching for 4 min. (41.06) respectively.

b* value of different sweet corn varieties at 90 days of frozen storage

With respect to variety, blanching method and blanching time, significant differences were observed for yellowness (b*) values at 90 days. Variety Sugar 75 had the highest yellowness (b*) (51.01), whereas lowest yellowness (b*) was observed in Rossy (41.10). Blanching method B1 and Blanching time 4 min. had the highest yellowness (b*) *i.e*., 45.90 and 45.81, while smallest yellowness (b*) was observed in steam blanching (45.51) and 2 min blanching time (45.62). The interaction of varieties with blanching methods and blanching time revealed significant differences. The maximum yellowness (b*) were found in Sugar 75 hot water blanching (51.35) and Sugar 75 in 4 min. blanching (51.24), while minimum yellowness (b*) were found in Sweetheart with steam blanching (41.01) and sweetheart with 2 min. (41.04). The interaction between blanching methods and time were found to have significant differences. The maximum and minimum yellowness (b*) were found in hot water blanching for 4 min. (46.02) and steam blanching for 3 min. duration (45.45). Similarly, the interaction between varieties, blanching methods and time were also found to have significant differences. The maximum and minimum values were found in Golden cob with hot water blanching for 4min. (49.98) and Rossy with steam blanching for 4 min. (40.94) respectively. Similar decrease in lightness with increase in blanching was reported by Ganjloo *et al*. 2009 [9]. This supports the sensory results for lightness of peas cooked by different methods reported by Schnepf and Driskell (1994) [11]. Brewer *et al*. (1994) [15] reported higher L* values and overall color values in most blanched treatments of green beans in comparison to unblanched green beans. Begum and Brewer (2001) [14] reported that all snow peas blanched by any method were greener than unblanched snow peas after frozen storage.

Table 1: L* value of different sweet corn varieties during before and after frozen storage

Treatments	L* Value				
	Fresh	0 Days	30 Days	60 days	90 Days
	Factor 1: Variety				
V1	69.92	64.72	64.65	64.63	64.57
V2	68.24	63.51	63.40	63.35	63.30
V3	71.17	64.58	64.53	64.47	64.37
V4	68.64	61.59	61.51	61.42	61.27
V5	72.86	65.61	65.51	65.43	65.38
V6	69.26	66.33	66.20	66.11	65.88
SEM	0.014	0.011	0.01	0.007	0.008
CD	0.044	0.03	0.029	0.02	0.023
Factor 2: Blanching Method					
B1	64.47		64.38	64.33	64.20
B2	64.31		64.22	64.14	64.06
SEM	0.006		0.006	0.004	0.005
CD	0.017		0.017	0.012	0.013
Factor 3: Blanching Time					
T1	64.55		64.43	64.34	64.24
T2	64.39		64.31	64.27	64.16
T3	64.23		64.16	64.09	63.99
SEM	0.008		0.007	0.005	0.006
CD	0.021		0.02	0.014	0.016
Interaction VXB					
V1B1	64.69		64.67	64.65	64.61
V1B2	64.75		64.64	64.62	64.54
V2B1	63.54		63.40	63.37	63.31
V2B2	63.47		63.40	63.32	63.29
V3B1	64.63		64.57	64.48	64.34
V3B2	64.53		64.49	64.46	64.41
V4B1	61.71		61.61	61.55	61.29
V4B2	61.48		61.41	61.29	61.25
V5B1	65.82		65.73	65.66	65.60
V5B2	65.40		65.29	65.19	65.16
V6B1	66.44		66.31	66.26	66.03
V6B2	66.23		66.09	65.96	65.72
SEM	0.015		0.014	0.01	0.012
CD	0.042		0.041	0.029	0.033
Interaction VXT					
V1T1	64.87		64.80	64.77	64.68
V1T2	64.62		64.58	64.56	64.52
V1T3	64.67		64.57	64.56	64.52
V2T1	63.57		63.47	63.37	63.30
V2T2	63.48		63.38	63.35	63.29
V2T3	63.47		63.36	63.32	63.30
V3T1	64.67		64.56	64.49	64.27
V3T2	64.57		64.53	64.49	64.45
V3T3	64.50		64.50	64.43	64.40
V4T1	61.74		61.61	61.49	61.46
V4T2	61.59		61.51	61.47	61.29
V4T3	61.45		61.41	61.31	61.06
V5T1	65.96		65.80	65.63	65.61
V5T2	65.65		65.59	65.55	65.50
V5T3	65.23		65.15	65.11	65.04
V6T1	66.52		66.35	66.31	66.10
V6T2	66.40		66.29	66.18	65.94

V6T3	66.07	65.96	65.84	65.60
SEM	0.018	0.018	0.012	0.014
CD	0.052	0.05	0.035	0.04
Interaction BXT				
B1T1	64.58	64.44	64.37	64.26
B1T2	64.46	64.38	64.34	64.19
B1T3	64.38	64.32	64.27	64.14
B2T1	64.53	64.42	64.31	64.22
B2T2	64.32	64.25	64.20	64.14
B2T3	64.08	63.99	63.92	63.83
SEM	0.011	0.01	0.007	0.008
CD	0.03	0.029	0.02	0.023
Interaction VXBXT				
V1B1T1	64.92	64.87	64.84	64.75
V1B1T2	64.58	64.58	64.56	64.53
V1B1T3	64.59	64.55	64.54	64.53
V1B2T1	64.83	64.74	64.70	64.60
V1B2T2	64.67	64.59	64.57	64.50
V1B2T3	64.76	64.59	64.58	64.51
V2B1T1	63.57	63.45	63.38	63.31
V2B1T2	63.53	63.40	63.39	63.29
V2B1T3	63.52	63.35	63.34	63.32
V2B2T1	63.56	63.48	63.36	63.30
V2B2T2	63.43	63.36	63.31	63.28
V2B2T3	63.42	63.37	63.29	63.28
V3B1T1	64.67	64.58	64.50	64.23
V3B1T2	64.61	64.54	64.48	64.38
V3B1T3	64.60	64.58	64.46	64.40
V3B2T1	64.66	64.53	64.49	64.31
V3B2T2	64.53	64.52	64.50	64.51
V3B2T3	64.40	64.42	64.39	64.40
V4B1T1	61.76	61.56	61.51	61.45
V4B1T2	61.72	61.67	61.62	61.27
V4B1T3	61.64	61.59	61.53	61.16
V4B2T1	61.72	61.65	61.47	61.47
V4B2T2	61.45	61.35	61.32	61.32
V4B2T3	61.26	61.24	61.10	60.97
V5B1T1	65.99	65.80	65.70	65.68
V5B1T2	65.74	65.71	65.65	65.58
V5B1T3	65.74	65.69	65.64	65.56
V5B2T1	65.93	65.79	65.55	65.53
V5B2T2	65.56	65.47	65.45	65.42
V5B2T3	64.71	64.61	64.57	64.52
V6B1T1	66.56	66.36	66.32	66.12
V6B1T2	66.54	66.38	66.33	66.10
V6B1T3	66.21	66.18	66.11	65.88
V6B2T1	66.49	66.34	66.30	66.07
V6B2T2	66.26	66.20	66.03	65.77
V6B2T3	65.93	65.73	65.56	65.32
SEM	0.026	0.025	0.018	0.02
CD	0.073	0.071	0.050	0.057

Table 2: a* value of different sweet corn varieties during before and after frozen storage

Treatments	a* Value				
	FRESH	**0 day**	**30 days**	**60 days**	**90 Days**
	Factor 1 : Variety				
V1	9.42	7.46	7.38	7.31	7.14
V2	10.25	9.49	9.42	9.36	9.17
V3	8.19	5.27	5.24	5.17	5.04
V4	7.35	5.22	5.17	5.12	4.95
V5	11.14	9.98	9.96	9.91	9.76
V6	8.47	6.20	6.15	6.07	5.96
SeM	0.013	0.009	0.008	0.004	0.007
CD	0.04	0.024	0.022	0.012	0.02
Factor 2 : Blanching Method					
B1		7.257	7.214	7.149	7.01
B2		7.284	7.226	7.16	7.001
SeM		0.005	0.004	0.003	0.004
CD		0.014	0.013	0.007	0.012
Factor 3 : BLANCHING TIME					
T1		7.372	7.292	7.178	7.04
T2		7.261	7.214	7.16	7.022
T3		7.177	7.155	7.126	6.954
SeM		0.006	0.005	0.003	0.005
CD		0.017	0.015	0.009	0.014
Interaction VXB					
V1B1		7.41	7.38	7.29	7.11
V1B2		7.50	7.37	7.33	7.17
V2B1		9.48	9.41	9.35	9.15
V2B2		9.50	9.42	9.37	9.20
V3B1		5.29	5.25	5.20	5.11
V3B2		5.26	5.23	5.14	4.98
V4B1		5.19	5.13	5.07	4.96
V4B2		5.26	5.22	5.16	4.93
V5B1		9.97	9.96	9.91	9.76
V5B2		9.98	9.96	9.90	9.77
V6B1		6.19	6.15	6.08	5.98
V6B2		6.20	6.15	6.06	5.95
SEM		0.012	0.011	0.006	0.01
CD		0.034	0.031	0.018	0.029
Interaction VXT					
V1T1		7.55	7.44	7.32	7.17
V1T2		7.46	7.35	7.28	7.13
V1T3		7.37	7.34	7.32	7.13
V2T1		9.62	9.53	9.42	9.23
V2T2		9.47	9.40	9.35	9.19
V2T3		9.38	9.33	9.31	9.10
V3T1		5.36	5.31	5.21	5.11
V3T2		5.29	5.26	5.18	5.05
V3T3		5.17	5.15	5.11	4.98
V4T1		5.32	5.22	5.10	4.97
V4T2		5.21	5.18	5.15	5.00
V4T3		5.15	5.13	5.09	4.87
V5T1		10.08	10.05	9.94	9.79
V5T2		9.95	9.93	9.89	9.75
V5T3		9.90	9.90	9.89	9.76
V6T1		6.30	6.20	6.08	5.98
V6T2		6.20	6.16	6.10	6.02

V6T3	6.10	6.09	6.04	5.90
SEM	0.015	0.013	0.008	0.012
CD	N/A	0.038	0.022	0.035
Interaction BXT				
B1T1	7.39	7.32	7.20	7.06
B1T2	7.22	7.20	7.14	7.03
B1T3	7.15	7.13	7.11	6.94
B2T1	7.35	7.26	7.16	7.02
B2T2	7.30	7.23	7.18	7.01
B2T3	7.20	7.18	7.15	6.97
SEM	0.009	0.008	0.004	0.007
CD	0.024	0.022	0.012	0.02
Interaction VXBXT				
V1B1T1	7.53	7.49	7.32	7.12
V1B1T2	7.38	7.34	7.25	7.11
V1B1T3	7.33	7.32	7.30	7.11
V1B2T1	7.57	7.39	7.33	7.21
V1B2T2	7.53	7.36	7.31	7.15
V1B2T3	7.41	7.36	7.34	7.15
V2B1T1	9.62	9.53	9.39	9.19
V2B1T2	9.41	9.39	9.35	9.19
V2B1T3	9.40	9.32	9.31	9.06
V2B2T1	9.63	9.54	9.44	9.26
V2B2T2	9.52	9.41	9.35	9.19
V2B2T3	9.36	9.33	9.32	9.13
V3B1T1	5.39	5.32	5.26	5.17
V3B1T2	5.30	5.26	5.22	5.11
V3B1T3	5.18	5.17	5.12	5.04
V3B2T1	5.33	5.30	5.16	5.05
V3B2T2	5.29	5.27	5.15	4.98
V3B2T3	5.16	5.13	5.10	4.91
V4B1T1	5.35	5.21	5.09	5.00
V4B1T2	5.16	5.13	5.10	5.03
V4B1T3	5.07	5.04	5.02	4.84
V4B2T1	5.29	5.22	5.12	4.93
V4B2T2	5.25	5.22	5.19	4.97
V4B2T3	5.23	5.22	5.16	4.90
V5B1T1	10.13	10.12	10.01	9.81
V5B1T2	9.90	9.88	9.83	9.73
V5B1T3	9.89	9.88	9.88	9.73
V5B2T1	10.03	9.99	9.86	9.77
V5B2T2	10.01	9.98	9.96	9.77
V5B2T3	9.91	9.92	9.89	9.78
V6B1T1	6.33	6.25	6.12	6.04
V6B1T2	6.19	6.17	6.11	6.02
V6B1T3	6.06	6.04	6.02	5.87
V6B2T1	6.26	6.15	6.04	5.91
V6B2T2	6.20	6.16	6.09	6.02
V6B2T3	6.14	6.14	6.05	5.93
SEM	0.021	0.019	0.011	0.018
CD	0.059	0.053	0.03	0.05

Table 3: b* value of different sweet corn varieties during before and after frozen storage

Treatment	b* Value				
	FRESH	**0 day**	**30 days**	**60 days**	**90 Days**
	Factor 1 : Variety				
V1	49.32	51.25	51.14	51.09	51.01
V2	54.38	47.89	47.84	47.76	47.67
V3	38.89	44.33	44.30	44.24	44.03
V4	36.71	41.23	41.19	41.16	41.10
V5	44.51	49.43	49.42	49.39	49.32
V6	43.37	41.26	41.23	41.19	41.12
SeM	0.021	0.011	0.008	0.006	0.007
CD	0.066	0.03	0.024	0.017	0.019
Factor 2 : Blanching Method					
B1	46.11		46.05	45.99	45.90
B2	45.69		45.65	45.62	45.51
SeM	0.006		0.005	0.004	0.004
CD	0.017		0.014	0.01	0.011
Factor 3 : Blanching TIME					
T1	45.86		45.80	45.72	45.62
T2	45.87		45.83	45.79	45.69
T3	45.97		45.92	45.90	45.81
SeM	0.007		0.006	0.004	0.005
CD	0.021		0.017	0.012	0.014
Interaction VXB					
V1B1	51.63		51.48	51.43	51.35
V1B2	50.86		50.79	50.76	50.67
V2B1	47.96		47.90	47.80	47.71
V2B2	47.82		47.78	47.71	47.63
V3B1	44.38		44.33	44.23	44.09
V3B2	44.27		44.26	44.24	43.97
V4B1	41.31		41.26	41.21	41.15
V4B2	41.15		41.11	41.11	41.05
V5B1	49.97		49.95	49.93	49.89
V5B2	48.89		48.88	48.86	48.75
V6B1	41.40		41.36	41.31	41.24
V6B2	41.13		41.09	41.07	41.01
SEM	0.015		0.012	0.009	0.01
CD	0.042		0.034	0.025	0.028
Interaction VXT					
V1T1	51.11		51.00	50.92	50.82
V1T2	51.15		51.07	51.05	50.98
V1T3	51.48		51.35	51.32	51.24
V2T1	47.81		47.76	47.66	47.58
V2T2	47.84		47.80	47.71	47.66
V2T3	48.01		47.94	47.90	47.77
V3T1	44.37		44.33	44.23	43.97
V3T2	44.32		44.30	44.23	43.94
V3T3	44.29		44.26	44.25	44.18
V4T1	41.21		41.15	41.10	41.06
V4T2	41.23		41.21	41.20	41.13
V4T3	41.25		41.21	41.19	41.12
V5T1	49.41		49.37	49.35	49.28
V5T2	49.36		49.35	49.33	49.27
V5T3	49.52		49.52	49.51	49.42
V6T1	41.25		41.17	41.11	41.04
V6T2	41.29		41.25	41.21	41.16
V6T3	41.26		41.26	41.24	41.16
SEM	0.018		0.015	0.011	0.012
CD	0.052		0.041	0.03	0.034
Interaction BXT					
B1T1	46.02		45.94	45.85	45.77
B1T2	46.11		46.07	46.01	45.93
B1T3	46.19		46.13	46.09	46.02
B2T1	45.70		45.66	45.59	45.48
B2T2	45.62		45.59	45.56	45.45
B2T3	45.74		45.71	45.71	45.61

SEM	0.011	0.008	0.006	0.007
CD	0.03	0.024	0.017	0.019
	Interaction VXBXT			
V1B1T1	51.56	51.42	51.32	51.24
V1B1T2	51.54	51.49	51.46	51.40
V1B1T3	51.79	51.54	51.52	51.42
V1B2T1	50.66	50.58	50.51	50.39
V1B2T2	50.76	50.65	50.63	50.56
V1B2T3	51.16	51.15	51.12	51.06
V2B1T1	47.81	47.73	47.63	47.52
V2B1T2	47.97	47.91	47.81	47.75
V2B1T3	48.09	48.04	47.98	47.86
V2B2T1	47.81	47.79	47.69	47.64
V2B2T2	47.71	47.70	47.62	47.58
V2B2T3	47.94	47.84	47.81	47.67
V3B1T1	44.32	44.26	44.13	43.98
V3B1T2	44.40	44.37	44.24	44.05
V3B1T3	44.41	44.37	44.32	44.22
V3B2T1	44.43	44.40	44.32	43.96
V3B2T2	44.23	44.23	44.22	43.82
V3B2T3	44.16	44.15	44.19	44.13
V4B1T1	41.21	41.14	41.08	41.02
V4B1T2	41.31	41.29	41.26	41.19
V4B1T3	41.40	41.35	41.29	41.23
V4B2T1	41.20	41.16	41.11	41.09
V4B2T2	41.14	41.12	41.13	41.06
V4B2T3	41.10	41.06	41.08	41.01
V5B1T1	49.93	49.87	49.86	49.82
V5B1T2	49.95	49.93	49.91	49.87
V5B1T3	50.05	50.03	50.01	49.98
V5B2T1	48.88	48.87	48.83	48.73
V5B2T2	48.77	48.77	48.74	48.67
V5B2T3	49.00	49.01	49.00	48.86
V6B1T1	41.28	41.20	41.11	41.02
V6B1T2	41.49	41.44	41.39	41.30
V6B1T3	41.42	41.45	41.42	41.39
V6B2T1	41.21	41.14	41.10	41.06
V6B2T2	41.09	41.06	41.04	41.02
V6B2T3	41.09	41.07	41.06	40.94
SEM	0.026	0.021	0.015	0.017
CD	0.073	0.059	0.043	0.048

Conclusions

The study concluded significant diversity in color attributes (brightness - L*, redness - a*, and yellowness - b*) among different sweet corn varieties across various stages. Varieties distinctly varied in these color parameters, signifying inherent genetic differences in their visual characteristics. Blanching methods (hot water, steam) and durations notably affected sweet corn's color attributes, altering its visual appeal. Variations in L*, a*, and b* values highlighted the impact of different blanching techniques on the color properties of sweet corn. The duration of freezing exhibited changes in color parameters (L*, a*, and b*) over time (0, 30, 60, and 90 days), indicating alterations in color attributes during storage. Additionally, specific sweet corn varieties showed unique responses to distinct blanching methods and durations, causing variability in color attributes. Overall, a consistent trend of decreasing brightness (L*) and changes in redness (a*) and yellowness (b*) values were noted with increased blanching time and freezing duration. This trend aligns with previous research on similar vegetables, emphasizing the consistency of color changes during processing and storage. In short, the study underscores the significance of genetic diversity in sweet corn varieties' color attributes and highlights the influence of blanching methods, durations, and freezing time on these visual characteristics, crucial for understanding and maintaining product quality in the frozen food industry.

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