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Postharvest quality of green chilli (*Capsicum annuum*) cultivars under cold and ambient conditions

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ABSTRACT

The objective of the present investigation was to study the shelf-life of green chilli (*Capsicum annuum* L.) hybrid CH-52 and checks (CH-27 and *Veerji*) under cold storage and ambient conditions. The study was carried out at Punjab Horticultural Postharvest Technology Centre, Punjab Agricultural University during 2019–20. All the cultivars were packed in LDPE (Low Density Polyethylene) bags of 25 gauge thickness and were stored under cold store (4–7°C ± 1°C) and ambient (25–30°C) conditions. Significant differences were observed among genotypes for various physico-chemical characteristics under both the storage conditions. CH-52 recorded lowest weight loss and minimum spoilage. Higher antioxidant potential, chlorophyll and capsaicin were also retained in CH-52 at the end of storage period. Among other two genotypes CH-27 showed better shelf life than *Veerji*. Therefore, CH-52 could be recommended for commercial cultivation owing to its lowest spoilage index and higher shelf life as compared to checks.

Keywords: Chilli, Capsaicin, Carotenoids, Shelf life, Spoilage index

Chilli (*Capsicum annuum* L.) is one of the important vegetables cultivated in India belonging to family Solanaceae. It is one of the most widely consumed crops in its fresh form and is grown in tropical, sub-tropical and temperate regions of the world. In India, fresh green chillies are cultivated on 3646,000 hectare area with production of 3720000 MT (National Horticultural Board 2019). The pungent characteristic of chilli renders it a delicate flavour due to the presence of capsaicinoids group. Nutritionally, this crop is a rich source of vitamins, particularly vitamin C and minerals such as calcium, phosphorus, iron, potassium (Ajaykumar *et al*. 2012). After harvesting, chilli undergoes significant physiological and bio-chemical changes which deteriorate its quality. The presence of high moisture content results in desiccation and faster senescence. However, the most commonly faced problems during the postharvest handling of green chillies are chilling injury and shriveling due to loss in weight and change in color (Nyanjage *et al*. 2005) limiting its shelf life and marketable quality. Punjab Agricultural University, Ludhiana has developed multiple disease resistant hybrid CH-27 in the year 2015 which is now cultivated not only in many parts of the country but also covers more than 80% area of the state under chilli cultivation. The hybrid CH-27 was recommended for cultivation in summer (February-March transplanting) season. However, there was an immense need to develop a hybrid suitable for cultivation under low tunnel during the winter months of November-February. The transplanting of this crop not only gave early and higher returns to farmers but also fitted well in the Chilli-Basmati rotation. However, retention of fruit quality during winter months at both ambient and cool conditions is a major constraint observed in this crop. Therefore, new hybrid CH-52 was developed which is suitable for low tunnel cultivation. The present study was undertaken with the objective to evaluate the quality characteristics of different cultivars of fresh chilli, viz. CH-52, CH-27 and *Veerji* under cold store and ambient conditions.

MATERIALS AND METHODS

Fresh mature green chillies of three different cultivars, viz. CH-52, CH-27 and *Veerji* were procured from Vegetable Research Farm, Punjab Agricultural University, Ludhiana. The study was conducted at Punjab Horticultural Postharvest Technology Centre, Punjab Agricultural University during the year 2019–20. The produce was pre-cooled before packaging. All the chilli cultivars were packed in LDPE bags of 25 gauge thickness with three replications. The samples were stored under cold store (4-7°C ± 1°C and 90–95% RH) and ambient (25–30°C) conditions. The data were recorded for various physico-chemical parameters at an interval of 5 days and 2 days for cold store and ambient conditions, respectively, till acceptable quality.

Physiological loss in weight (PLW) and Spoilage: Chilli samples were assessed for PLW on initial weight

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basis followed by weight change with passing storage intervals and expressed as percentage loss in weight over the intial weight. For spoilage, 100 pieces per replicate for each cultivar packed in LDPE bags was kept at ambient and cold store conditions. Spoilage per cent was expressed as number of pieces spoiled over total number of pieces.

Ascorbic acid: Ascorbic acid content was determined using 2,6, dichloroindophenol dye titrimetric method (Ranganna 2000). Five grams of sample was macerated with 0.4% oxalic acid and titrated against 0.04% 2,6-dichlorophenol indophenol dye. The results were expressed as mg/100 g fresh weight basis.

Chlorophyll content: Chlorophyll *a*, *b* and total cholorophyll content was determined using standard method as per Ranganna (2000). A requisite quantity of sample was extracted with acetone till the residue became colorless. Chlorophyll pigment was then transferred to petroleum ether using a separatory funnel followed by absorbance measurement at 660 and 642.5 nm (Specord 200, Analytik Jena, Germany) and results were expressed as mg/100 g.

Total carotenoids: Total carotenoids were determined by the standard method reported by Ranganna (2000). The extraction process was similar to that reported for chlorophyll extraction. The color intensity of the extract was measured at 452 nm (Specord 200, Analytik Jena, Germany) and results were expressed as mg/100 g against beta-carotene standard curve.

Antioxidant activity: The antioxidant activity was determined as per Brand William *et al*. (1995) using 2,2, di -phenyl picrylhydrazyl (DPPH) method. Methanolic extract of 5 g sample was taken for antioxidant activity analysis and % inhibition was calculated. The assay contained 0.5 ml extract, 0.5 ml tris buffer (50 mM) and 1 ml DPPH (0.1 mM). The reading was then noted at OD 517 nm at regular intervals till the samples became colorless and per cent antioxidant activity was calculated.

Capsaicin: Capsaicin estimation was done by colorimetric method (Sadasivam and Manickam 1996). Around 500 mg of chilli powder was used to extract capsacin by adding 10 ml of dry acetone for 3 h followed by centrifugation at 10,000 rpm for 10 min. Around 1 ml of supernatant was evaporated to dryness and residue was dissolved in 0.4% NaOH and 3% phosphomolybdic acid. The contents were allowed to stand for 1 h followed by absorbance measurement at 650 nm and results were expressed as % capsaicin against capsaicin standard curve.

RESULTS AND DISCUSSION

Physiological loss in weight (PLW): The physiological loss in weight for all the three chilli cultivars over the storage period at cold storage (Table 1) and ambient temperature (Table 2) was found to increase consistently. The decline in weight was significant (P<0.05) over the storage period and within the cultivars. Initially, up to 2% weight loss was recorded in all the cultivars of chilli after 10 days of cold storage. At ambient conditions, highest weight loss was noted for *Veerji* cultivar (4.64%) followed by CH-27 (2.36%)

Table 1 Physiological and biochemical attributes of green chilli cultivars under cold store conditions (4-7°C ± 1°C)

Variety (A)	CH-52						CH-27						*Veerji*						CD
parameter	0	5	10	15	20	Mean	0	5	10	15	20	Mean	0	5	10	15	20	Mean	(0.05)*
PLW (%)	ND	1.00 ± 0.06	1.00 ± 0.06	1.94 ± 0.10	2.74 ± 0.08	1.67	ND	1.00 ± 0.08	1.00 ± 0.04	2.10 ± 0.07	3.16 ± 0.06	1.81	ND	1.00 ± 0.04	1.00 ± 0.03	2.10 ± 0.07	3.30 ± 0.06	1.85	0.11
Ascorbic acid	130.12 ± 0.51	121.56 ± 0.86	110.26 ± 0.79	101.37 ± 0.49	92.46 ± 0.86	111.16	139.52 ± 0.63	125.24 ± 0.65	109.27 ± 0.75	99.42 ± 0.81	89.26 ± 0.83	112.62	111.24 ± 0.53	106.27 ± 0.90	98.56 ± 0.66	85.51 ± 0.91	78.89 ± 0.69	96.07	1.07
Cholorophyll a	21.52 ± 0.93	19.99 ± 0.38	18.53 ± 0.27	14.35 ± 0.48	10.48 ± 0.66	16.97	9.46 ± 0.35	7.44 ± 0.18	7.23 ± 0.14	4.28 ± 0.28	2.15 ± 0.07	6.11	9.88 ± 0.22	9.17 ± 0.24	8.50 ± 0.45	5.67 ± 0.14	3.66 ± 0.16	7.37	0.60
Cholorophyll b	8.88 ± 0.85	6.51 ± 0.34	5.97 ± 0.11	4.17 ± 0.14	3.71 ± 0.08	5.85	3.04 ± 0.08	2.96 ± 0.14	2.23 ± 0.04	1.96 ± 0.13	1.04 ± 0.08	2.25	3.52 ± 0.05	2.46 ± 0.08	2.03 ± 0.04	1.85 ± 0.08	1.55 ± 0.10	2.28	0.40
Total cholorophyll	30.4 ± 0.72	26.5 ± 0.68	24.5 ± 0.75	18.52 ± 0.61	14.19 ± 0.04	22.82	12.5 ± 0.34	10.4 ± 0.12	9.46 ± 0.12	6.24 ± 0.12	3.19 ± 0.02	8.36	13.4 ± 0.20	11.63 ± 0.18	10.53 ± 0.05	7.52 ± 0.07	5.21 ± 0.07	9.66	0.52
Total carotenoids	5.00 ± 0.11	11.24 ± 0.12	16.58 ± 0.28	18.6 ± 0.22	25.6 ± 0.47	15.40	1.72 ± 0.05	3.87 ± 0.12	5.92 ± 0.08	8.34 ± 0.09	10.34 ± 0.30	6.04	2.14 ± 0.95	5.17 ± 0.07	7.54 ± 0.09	10.12 ± 0.08	12.25 ± 0.08	7.44	0.21
Antioxidant activity	58.29 ± 0.43	68.63 ± 0.91	65.22 ± 0.88	58.63 ± 0.64	55.8 ± 0.648	61.33	57.61 ± 0.52	72.45 ± 0.51	61.52 ± 0.63	56.45 ± 0.63	52.48 ± 0.38	60.10	59.06 ± 0.30	68.82 ± 0.56	57.41 ± 0.64	54.82 ± 0.78	51.66 ± 0.81	58.35	0.74

*CD at P<0.05A (Variety) × B (Storage period) - Interaction effect; ND-Not Detected.

Table 2 Physiological and biochemical attributes of green chilli cultivars under ambient storage conditions (25–30°C)

Variety (A)	CH-52				CH-27				*Veerji*				CD
Parameter	0	2	4	Mean	0	2	4	Mean	0	2	4	Mean	(0.05)*
PLW (%)	ND	0.60 ± 0.04	1.40 ± 0.09	1.00	ND	1.36 ± 0.11	2.36 ± 0.11	1.86	ND	2.58 ± 0.08	4.64 ± 0.15	3.56	0.92
Ascorbic acid	130.12 ± 0.51	107.85 ± 0.38	95.63 ± 0.49	111.20	139.52 ± 0.63	106.59 ± 0.29	92.56 ± 0.87	112.89	111.24 ± 0.53	90.26 ± 0.87	75.63 ± 0.49	92.33	1.03
Cholorophyll a	21.52 ± 0.93	11.52 ± 0.48	4.54 ± 0.07	12.52	9.46 ± 0.35	4.63 ± 0.15	1.34 ± 0.06	5.14	9.88 ± 0.22	4.69 ± 0.17	0.85 ± 0.03	5.14	0.66
Cholorophyll b	8.88 ± 0.85	5.69 ± 0.03	4.93 ± 0.09	6.50	3.04 ± 0.08	2.96 ± 0.04	2.88 ± 0.02	2.96	3.52 ± 0.05	3.05 ± 0.04	2.44 ± 0.07	3.00	0.48
Total Cholorophyll	30.40 ± 0.72	17.21 ± 0.26	12.47 ± 0.10	20.03	12.5 ± 0.34	7.59 ± 0.16	4.22 ± 0.04	8.10	13.4 ± 0.20	7.74 ± 0.12	3.29 ± 0.10	8.14	0.39
Total carotenoids	5.00 ± 0.11	11.36 ± 0.10	18.25 ± 0.36	11.54	1.72 ± 0.05	6.58 ± 0.17	11.54 ± 0.12	6.61	2.14 ± 0.09	6.49 ± 0.12	10.15 ± 0.11	6.26	0.17
Antioxidant activity	58.29 ± 0.43	65.23 ± 0.55	56.71 ± 0.52	60.07	57.61 ± 0.52	61.23 ± 0.64	55.24 ± 0.24	58.02	59.06 ± 0.30	65.85 ± 0.59	52.71 ± 0.69	59.20	0.57

*CD at P<0.05 A (Variety) × B (Storage period) - Interaction effect; ND-Not Detected.

and least for CH-52 (1.4%). The decline in PLW might be due to various ongoing physiological activities that involve moisture loss such as respiration and transevaporation resulting in shrinkage and shriveling of produce (Ezeocha and Ironkwe 2017) and can also be attributed to removal of carbon atom as a consequence of continued respiration (Kablan *et al*. 2008). With respect to storage temperature, all the three cultivars showed less weight loss at cold store conditions owing to slowing down of respiratory activities at low temperature. Weight loss per cent for *Veerji* and CH-27 was found to be at par (3.3% and 3.16%, respectively) and least in CH-52 (2.74%). During the 10th –15th day interval under cold store conditions, sharp increase in weight loss was found for CH-52 (1.96%) which however remained stable and lowest till the end of storage period whereas for CH-27 and *Veerji*, sharp decrease in weight was observed 15th day onwards. Overall, CH-52 showed comparatively less weight loss under ambient and cold store conditions than CH-27 and *Veerji* at the end of storage period. Similar findings were reported by Chitravathi *et al*. (2015) and Xing *et al*. (2011) in case of bell peppers for chillies packed with different polythene films and weight loss was reported up to 7% in case of LDPE packaging.

Total carotenoids and chlorophyll: The advancement in maturity leads to alterations in physiological processes thereby changing the proportion of different pigments. Chlorophyll pigment is responsible for green color in chillies; data pertaining to cholorphyll *a*, *b* and total chlorophyll content for all the cultivars at both storage conditions has been shown in Table 1 (cold store) and Table 2 (ambient condition). Among all the varieties, CH-52 had significantly higher total chlorophyll content (30.4 mg/100 g) followed by *Veerji* (13.4 mg/100 g) and CH-27 (12.5 mg/100 g). During the storage period, the total chlorophyll content declined significantly in all the cultivars. Chlorophyll *a* content was noted to be higher in all the cultivars as compared to chlorophyll *b*, being highest in CH-52 (21.52 mg/100 g) and lowest in CH-27 (9.46 mg/100 g). The degradation of chloroplast leads to formation of chromoplasts (Hortensteiner 2006) and with respect to this, capsicum undergoes *de novo* synthesis of carotenoid pigments i.e. capsanthin and capsorubin (Minguez-Mosquera and Hornero-Mendez 1994), subsequently, chlorophyll degradation leads to increase in carotenoid content. Among the cultivars, faster increase in carotenoid content was observed in CH-52 (Table 1 and Table 2), due to rapid degradation of chlorophyll owing to its higher cholorophyll content. Thus, at the end of cold storage period CH-52 had significantly higher carotenoid content (25.6 mg/100 g) as compared to *Veerji* (12.25 mg/100 g) and CH-27 (10.34 mg/100 g). Under cold store conditions, reduced respiration rate, might be responsible for higher retention of chlorophyll compared to ambient conditions. Overall, it was noticed that higher cholorophyll content in cultivar leads to parallel synthesis of carotenoid pigments because of the direct relationship between the two leading to colour change from green to red with passing storage interval. The parallel

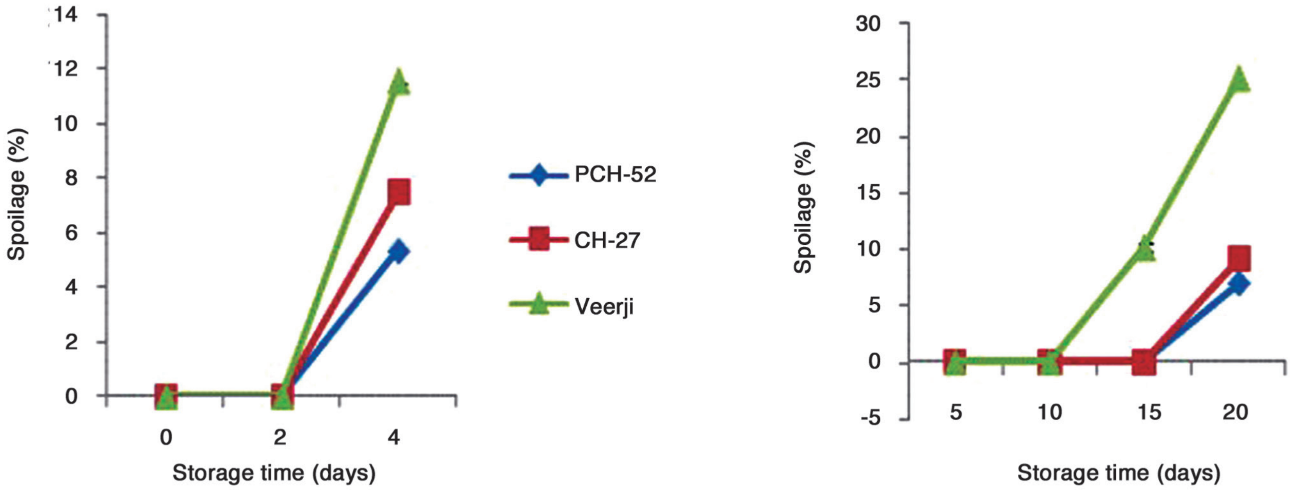

Fig 1 Spoilage index of green chilli cultivars at ambient (4 days) and cold store conditions (20 days).

relation between carotenoid and cholorophyll content was also reported by Deepa *et al*. (2007) in sweet peppers.

Ascorbic Acid: Continuous and significant ($P<0.05$) decline in ascorbic acid was noticed under both cold storage (Table 1) and ambient conditions (Table 2). With respect to cultivars, highest ascorbic acid was found in CH-27 variety (139.52 mg/100 g) followed by CH-52 (130.12 mg/100 g) and *Veerji* (111.24 mg/100 g). The decline was rapid under the ambient conditions as ascorbic acid is sensitive to light, oxygen and temperature (Plaza *et al*. 2006). Better retention of ascorbic acid throughout storage period was noticed in CH-52 (92.46 mg/100 g) as compared to CH-27 (89.26 mg/100 g) and *Veerji* (78.89 mg/100 g) variety at the end of cold store conditions. Similar trend of ascorbic acid reduction was noticed at ambient conditions. The results were corroborated by the findings of Deepa *et al*. (2007) and Ghasemnazhad *et al*. (2011) who reported the decline in ascorbic acid with maturity.

Antioxidant activity: The antioxidant activity increased in all the cultivars during storage till 5 days and thereafter reduced over storage period. The highest antioxidant activity was observed in CH-52 (55.88%) followed by CH-27 (52.48%) and *Veerji* (51.66%) at the end of storage period under cold store (Table 1). The same trend was also noticed among three cultivars under ambient storage with CH-52 (56.71%) retaining higher antioxidant activity than CH 27 (55.24%) and *Veerji* (52.71%) at the end of storage period (Table 2). The findings were in agreement with Saha *et al*. (2013) in chilli. The initial increase could be attributed to combined effect of increased phenol and carotenoids which overweighs decreased chlorophyll content. Further, the decreased total antioxidant activity during the storage was due to the reduced phenol concentration as strong correlation between phenols and antioxidant activity has been well documented by Orsavova *et al*. (2019).

Spoilage: The spoilage or decay involved the count of chillies which were rotted or shrivelled. Significant ($P<0.05$) spoilage was found over the storage intervals under both cold store and ambient conditions (Fig 1). No decay was observed till 15 days in case of CH-52 and till 10 days for CH-27 and *Veerji* under cold store conditions. Thereafter, there was a sudden rise in spoilage in case of *Veerji* cultivar. The decay percentage was lowest in CH-52 (6.9%) followed by CH-27

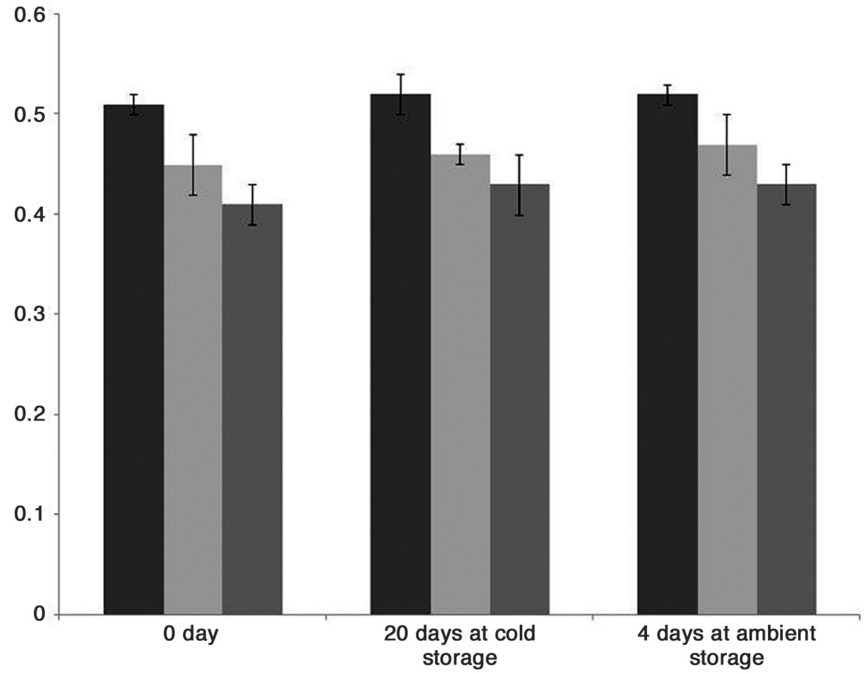

Fig 2 Capsaicin content (%) of green chilli cultivars at the end of storage period.

(9.08%) and *Veerji* (25.14%) under cold storage for 20 days. Under the ambient conditions, the decay percentage was also noted lowest for CH-52 (5.36%), followed by CH-27 (7.43%) and highest for *Veerji* (11.53%). Under ambient conditions, fungal infection was noticed in chilli cultivars after 4 days whereas the cultivars were free from fungal infestation even after 20 days under refrigerated conditions. The finding was corroborated by the report of Xing *et al.* (2011) reporting a decay percentage up to 34% in case of uncoated chillies.

Capsaicin: Capsaicin is the pungent principle compound in chilli responsible for its pungency which imparts unique flavor and anti-carcinogenic properties. The varieties vary with respect to capsaicin percentage wherein, CH -52 (0.51%) had highest pungency followed by CH-27 (0.45%) and *Veerji* (0.41%) at the time of harvest (Fig 2). During storage non-significant ($P<0.05$) increase was observed in all the cultivars under cold store and ambient conditions at the end of storage period. This increase could be due to senescence leading to color break stage (green to yellowish) (Chitravathi *et al*. 2015).

The present study revealed that the cultivar CH-52 performed better under both cold store and ambient conditions with minimum spoilage and lower PLW changes. With respect to bioactive compounds, higher retention of ascorbic acid, carotenoids, antioxidant activity and total chlorophyll at the end of storage period was also observed in CH-52 with shelf life of 20 days and 4 days under cold store and ambient conditions, respectively. Among other two cultivars, CH-27 resulted in higher retention of bioactive compounds with better shelf life than *Veerji*. The research experiment was conducted in collaboration with Department of Vegetable Science and among all the varieties studied, CH-52 variety has been recommended by Punjab Agricultural University for commercial purpose owing to its better shelf life, biochemical attributes and minimum spoilage.

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