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Website: www.aarf.asia **Email** : editor@aarf.asia , editoraarf@gmail.com

HOT PEPPER V: POSTHARVEST QUALITY ATTRIBUTES OF 12 ORNAMENTAL PEPPER LANDRACES DURING STORAGE AT REFRIGERATED AND NON-REFRIGERATED TEMPERATURES

Mohamed, M. E. S[a]; Mohammed, M[b]; Bridgemohan, P[a] and Baird, J[b].

[a]Centre for Biosciences, Agriculture and Food Technology, The University of Trinidad and Tobago, ECIAF Campus, Centeno, Trinidad.
[b]Department of Food Production, Faculty of Food and Agriculture, University of the West Indies, St. Augustine Campus, Trinidad.

ABSTRACT

Twelve ornamental pepper landraces were selected to determine quality characteristics, storage potential and relative sensitivity to chilling injury. For each landrace three replicates of seven fruits per landrace were evaluated prior to storage at refrigerated and non-refrigerated temperatures for fresh weight, shape, number of seed, placenta fresh weight, skin colour, fruit dimensions such as length, width and pericarp thickness, firmness, pH, total soluble solids (TTS), total titratable acidity (TTA), TSS:TTA. Measurements were also taken for fruits in each landrace that was sealed in low density polyethylene bags (LDPE) and stored for 15 days at 7^0C and 28^0C. These measurements included percentage fresh weight losses, percentage marketable fruits and percentage decayed fruits. Chilling injury symptoms were rated for all landraces after 15 days at 7^0C and upon subsequent transfer for an additional day at 28^0C. Quality attributes varied among the 12 landraces for all parameters listed above. However, landraces 3 and 4 accounted for the best shelf life with fruits securing marketable values of 67% and 62% respectively after 15 days at 7^0C which was almost two-folds greater compared to their counterparts stored at 28^0C. While the same two landraces were chilling tolerant after 15 days at 7^0C, they succumbed to severe chilling injury when transferred for 1 day at 28^0C.

Keywords: ornamental, chilling injury, fruit dimensions, pericarp thickness

Introduction

Growing peppers for edible and ornamental purposes is a new trend in many countries including consumer markets in the Caribbean. This genus of plants has the potential to provide a wide array of possibilities for the kitchen and the ornamental garden and sometimes both at once. Ornamental peppers have become a profitable crop for commercial growers and retailers. The ornamental plant market is worth nearly $5 billion in the United States each year and specialty peppers could capture a larger portion of those dollars (Kaplan, 2007). However, the commercial success of the cultivation of ornamental potted peppers depends on consumer appeal conferred by plant beauty, quality, vigour, colour, shape and size of leaves and fruits (Costa et. al. 2015). Ornamental peppers have three main types: potted types, cut stems and bedding and garden types (Hajheidari et. al. 2012). Cut stems are popular in Europe and are gaining prominence in the USA in recent years. This type of pepper produces clusters of fruits on long stems capable for use in flower arrangements. Other ornamental peppers which are heat and drought tolerant and prostrate are grown as bedding and garden plants. Some ornamental peppers are used for both ornamental and culinary purposes (Stommel and Bosland, 2006). A bonus of ornamental peppers in the home is the potential use of the fruits for making pepper sauce and flavoring food (Corley, 1967).

Ornamental peppers (*Capsicum annuum* L.) are morphologically diverse in fruit and leaf shape and size, as well as plant habit. Fruit softening and shrinkage, due to water loss and pathological decay, also affects the quality and acceptability of peppers during postharvest storage (Selahle et. al 2015). In view of the increasing interest and demand for ornamental peppers, the need arises for postharvest studies to optimize quality throughout the value chain. The objective of this investigation therefore was to determine the quality profile of 12 ornamental pepper landraces and to further investigate the shelf life of these fruits under refrigerated and non-refrigerated storage regimes.

Materials and Methods:

This study was conducted jointly between the University of the West Indies, St. Augustine Campus, and the Waterloo Research Campus, University of Trinidad and Tobago. Postharvest analyses were conducted in the former, and the agronomy and breeding in the latter. Both field and laboratory trials were undertaken during the period June 2014 to August 2016.

The ornamental pepper crop was cultivated under greenhouse conditions (50% sunlight) and in mixture of peat moss and perlite in containers (0.70 m^3) using drip irrigation. The plants were 'fertigated' daily (2.0 $Kg.Ha^{-1}$.200 of water) with a N.P.K. nutrient mix (9:18:36 + 0.5 MgO + trace elements). Pest and diseases were controlled using a judicious spray program of Oberon 24 SC® and Consento 45 SC® at weekly intervals (Mohamed and Bridegemohan, 2014). Seeds were obtained from the sweet pepper *C. annuum* (cv California wonder) x purple ornamental pepper *C. frutescens* chilli type. The F_1 fruits were conical in shape with a tinge colour that was different from the original purple coloured parent. Seeds from the F_1 were sown in the greenhouse to obtain the F_2 population where segregation for many traits was visible.

To minimize individual plant-based differences in the evaluation of maturity-dependent variation, 10 to 15 individual fruits from each of the 12 landraces were hand harvested, placed and labelled accordingly in separate ventilated plastic containers. Fruits were room cooled at 18-20^0C, 85-90% relative humidity within 20 minutes of harvest, covered with a polyethylene sheet to minimize water stress and taken to the Food Biology Laboratory at the University of the West Indies within 40 minutes for further experimental procedures. Fruits of each landrace were selected to ensure that pedicels were green in colour and 2.5-3.5 cm in length and turgid with no discolouration. Only undamaged fruits at the same stage of maturity and free from obvious symptoms of diseases were used. Prior to the storage experiment measurements were taken on 3 fruits of each landrace and replicated 3 times for fresh weight, shape, number of seed, placenta fresh weight, skin colour, firmness, pH, total soluble solids (TTS), total titratable acidity (TTA), TSS:TTA and fruit dimensions such as length, width and pericarp thickness, according to methods previously described by Mohammed (1990, 2014) and Bridgemohan et. al. (2016).

In the storage experiment five fruits from each landrace were seal-packaged in 0.035 mm thick low density polyethylene bags (LDPE), and stored separately at 7^0C and 90-95% relative humidity (American Panel Thermorigid walk-in chill room equipped with a Copeland refrigeration system) and at 28^0C and 90-95% relative humidity up to 15 days and examined for percentage fresh weight losses, percentage marketable fruits and percentage decayed fruits. Chilling injury symptoms were rated for all landraces after 15 days at 7^0C and upon subsequent transfer for an additional day at 28^0C.

The weight of each fruit was taken before and after each storage interval for calculation of percentage fresh weight loss. Skin colour were obtained using a portable Tristimulus Minolta Chromameter (Model CR-200, Minolta, NJ) and chromaticity were measured in 'L', 'a', 'b' co-ordinates. Colour component 'L' represents the value (lightness) of colours and is larger for lighter colours; 'a' is negative for green and positive for red; 'b' is negative for blue and positive for yellow (Singha et. al. 1991). Measurements were taken at three locations chosen at random on the external peel surface. The severity of chilling injury and decay incidence were determined subjectively on a 5-point hedonic scale as previously described (Cabrera and Saltveit, 1990). The scoring system was 1 = no CI or decay (0% pitted, translucent, discoloured or decayed), 2 = slight (1%-5%), 3 = moderate (6%-15%), 4 = severe (16%-75%), 5 = very severe and complete breakdown (>75%). Fruits with a rating up to 3 were considered marketable while those above 3 (multiple infections of fruit tissue, > 75% translucency of flesh, stem end rot) were considered unmarketable and calculated as percentage decayed fruits. The CI index was determined for each fruit by summing the products of the number of fruits in each category and then dividing the sum by the total number of fruits assessed according to Pesis et. al (1994).

$$CI\ Index = \sum_{0}^{5} \frac{(injury\ level)\ x\ (number\ of\ fruits\ at\ this\ level)}{Total\ number\ of\ fruits}$$

The experiment consisted of a completely randomized design with a factorial arrangement of variables. Each treatment was replicated 3 times with each replicate consisting of 5 fruits. Significance of the data was tested by the F-test. Comparison of means and calculation of least significant difference (LSD) were also performed on the data.

Results and Discussion:

There were variations in fresh weight, fruit shape, seed number per fruit and placenta fresh weight among the various ornamental landraces (Table 1) based on genetic factors according to Mohamed et. al. (2014). No consistent relationship existed between landraces with high fresh weights and placental fresh weights. Noteworthy was landrace 10 which had the highest seed number and highest placenta fresh weight but this was not consistent with landrace 2 which had the same fresh weight and shape and approximately similar seed number but with significantly ($P<0.05$) less placenta fresh weight (Table 1). In other studies, Kissinger et. al. (2005) examined physical properties of pepper and found that fruit fresh weight, pericarp thickness, initial water content were highly associated with each other, and varied significantly between pepper cultivars.

Fruit hues among the 12 landraces shown in Table 2 included a range of colours including red, orange, yellow, green, purple, bronze and creamy white. Genotypes 1, 2, 3, 11 and 12 had bright red colours with the ‘a’ value of 36.3 being the highest for landrace 11, and lowest for landrace 3 which was 17.3 (Table 2). Landrace 4 had a uniform yellow colour with ‘a’ value reading 32.3 and ‘b’ value of 23.2. Landraces 5 and 8 also had yellow colours but not as intense as landrace 4. Landraces 6 had a typical orange colour with L= 45.1, a = 27.4 and b = 23.4. Landrace 10 was the only selection with fruits showing a creamish–green colour (Table 2). However, all landraces in this experiment had fruits which initially appeared green or cream white which either turned yellow orange red or purple as the fruit matured. The diverse colour range of pigments in the landraces investigated in this study is significant in relation to the nutritional and medicinal values of ornamental peppers apart from their attractive glossy appearance and aesthetic appeal. Ornamental peppers are a rich source of ascorbic acid, flavonoids, phenolic acids and carotenoids, known as antioxidants (Castro, et. al. 2008). These compounds have been proven to prevent certain types of cancers, cardiovascular diseases, atherosclerosis and a delay in the ageing process (Simonne, et. al. 1997). Anthocyanins provide pigmentation, protect plants against damaging ultraviolet sunlight and function as antioxidants when consumed. Characterization of anthocyanins by Bridgemohan et. al. (2016) is a current investigation facilitating cooperative efforts with human nutritionists to track anthocyanins after consumption. Their research focuses on capturing the aesthetic and culinary appeal of ornamental peppers.

Fruit length ranged from 31.5 mm – 52.1mm while fruit width ranged from 31.5mm - 40.9mm. Landraces 4 and 12 had the thickest pericarp (3.5mm - 3.6 mm) while landrace 2 had the thinnest pericarp with 2.3 mm (Table 2). Pericarp thickness combined with fruit dimensions significantly influence fruit mass and yield. Furthermore, pericarp thickness contributed to the edible portion of the fruit since the nutritional and flavour components are embedded in the pericarp (Bridgemohan et. al. 2016). In a series of experiments conducted by Mohamed and Bridgemohan (2014), in their plant breeding and crop improvement program the overall goal of selecting ornamental peppers was to optimize their uses. To achieve this they transferred the colour of the ornamental pepper to a bell-shaped sweet pepper eventually producing a fruit with a conical shape with thicker pericarp than the parent ornamental. The original ornamental pepper being slightly pungent had the ability to transmit this trait to the progeny which were used in this investigation. Thus the reason for several genotypes listed in Table 1 with high placenta mass and large seed numbers.

In other studies, Weyszko-Chmielewska and Michaloje (2011) investigated the micromorphology of the epidermis as well as the anatomy of the pericarp of red peppers. They found that the pericarp consisted of an epidermis that had strong thickened outer walls, several layers of tangential and angular collenchyma as well as multi-layered parenchyma cells. Furthermore, they pronounced that these structural traits could provide adaptations to hot climatic zones as well as limit susceptibility to physical injuries during postharvest handling. Fisher and Fari (1983) in earlier investigations also drew attention to strong cutinization of the cell walls of the outer layers of the pericarp in red pepper fruits. The diverse intensity of colouration of the landraces shown in Table 2 could also be related to the presence of chromoplasts located in the epidermal and sub-epidermal cells of the fruits as described by Weyszko-Chmielewska and Michaloje (2011). It is also possible that the different colours of the chromoplasts which probably influenced the diverse fruit colours of the 12 landraces in this study could have been as a result of uneven maturation of the plastids and different contents of carotenoids in support of previous arguments reported by Weyszko-Chmielewska and Michaloje (2011).

Storage of each of the 12 landraces in separate sealed low density polyethylene bags (LDPE) at 7^0C and 28^0C respectively for 15 days resulted in development of a modified atmosphere (Table 3). Despite adopting the modified atmosphere packaging technique (MAP), percentage fresh weight losses after 15 days at 7^0C was between 3.1-5.6%. This accelerated almost two-folds for all landraces over the same period at 28^0C to between 7.0-11.1% (Table 3). Water loss is a critical factor in shortening the storage life and increasing deterioration of many fruit during storage (Ben-Yehoshua, 1979, Hardenburg et. al. 1986, Mohammed et. al. 2014). The results of fresh weight losses in this investigation are in support of similar studies conducted by Lim et. al. (2007). They also found that even with MAP, moisture loss could develop to critical levels which they attributed to the implications of storage temperature and fruit ripeness. As expected, during storage fresh fruit weight losses were consistently higher for each landrace at 28^0C than at 7^0C. Higher rates of respiration at 28^0C than at 7^0C would have contributed to this physiological occurrence. According to Peleg (1985) fruits and vegetables deteriorate when they lose more than 3% to 10% of their weight causing shriveling and softening to occur. After 15 days at either temperature fresh weight losses were always beyond 3% and at the higher temperature for genotypes 2 and 9 even above 10% (Table 3). Among the ornamental pepper landraces evaluated in this experiment, selections 1, 4, and 12 could be called low-water-loss fruit types, while selections 2, 6, 8, and 9 referred to as high-water-loss fruits, with the remaining selections as in between both extremes. Similar fruit classification was made by Kissinger et. al. (2005) in their pepper trials. Martinez-Romero et. al (2003) commented that the increase in vapour pressure at high temperatures could also account for the greater weight loss in fresh produce. Kissinger et. al. (2005), reported that the hollow nature of pepper fruits limits its water reservoir capacity. As such, small amounts of water loss as obtained for all landraces in this investigation could reduce fruit quality, shelf life, firmness, loss of peel glossy state, calyx browning and market value, resulting in loss of economic value and income. Lownds (1993), observed that water loss in relative water content of pepper fruit increased linearly with storage time, and differed for each cultivar examined which is in partial agreement with the data presented in Table 3. In a subsequent investigation Lownds (1994) provided additional arguments to support his findings by claiming that pepper fruits water loss rate correlated positively with initial water content and ratio of surface area to volume, but negatively correlated with surface area. In a more detailed analysis, Lownds (1994), provided data to show that a direct relationship existed between pepper fruit softening and water loss, since softening followed a pattern similar to water loss at each storage temperature which is also supported by the results in our study.

During the initial stages of our investigation, a small sample of peppers from each of the high-water-loss selections and the low-water-loss selections were coated with a commercial carnauba wax on the pericarp, stalk and calyx surfaces. It was discovered that most water loss from all selections occurred through the pericarp surface, with insignificant amounts of water loss occurring from the stalk or calyx as previously reported by Kissinger et. al. (2005). Peel gloss is associated with the natural deposition of wax on fruit skins. However, although the natural wax composition was neither quantified nor anatomically determined, it was noted that variation of skin or peel gloss existed among the selection of ornamental peppers investigated in this study, and further study is therefore warranted. Goodwin and Jenks (2005) described in detail the involvement of plant cuticle in drought tolerance, and reported that the lipoidal cuticle layer which is primarily composed of waxes and cutin which cover the fruit surface, is thought to provide a major hydrophobic barrier to fruit water loss. Elsewhere, Vega et. al. (1991), found no relationship between cuticle structural features and weight loss of blueberry fruit during storage. Notwithstanding, other studies provide evidence that certain characteristics of cuticular lipids play a major role in regulating postharvest water loss (Maalekuu et. al. 2003) via their interactions with polar diffusion pathways in the cutin framework of the cuticle membrane, and via their role in forming impermeable crystalline regions that resist water flux through the cuticle (Goodwin and Jenks, 2005). Similar investigations are currently being undertaken on the 12 ornamental pepper landraces used in this investigation.

Apart from the rapid loss of fruit quality Kissinger et. al. (2005) reported that that pepper fruits with high water loss generally ripened earlier compared to those with low water loss. Akkaravessapong et. al (1996) found that higher rates of postharvest water loss in avocado fruit accelerated ripening and also altered the respiration rates in fruit. Fresh mass losses of 5% and higher promoted a shortening in pre-climacteric life of banana fruits and induced a decrease of maximal rates of respiration and ethylene production during climacteric ripening (Finger et. al 1995). Pre-climacteric ethylene production was stimulated by water stress; however, it did not induce chlorophyll degradation. Fruit exhibiting fresh mass loss of 20% showed an abnormal ripening with decreased pulp softening and excessive brown color of skin. Water deficit in plant tissues may stimulate ethylene production; as a consequence, there is an increase of tissue respiration (Yang and Pratt, 1978). Several authors found that water stress decreased the pre-climacteric life of fruits like banana, avocado, pear and plantain (Littmann, 1972b; George et al., 1982). Moreover, the anticipation of fruit ripening and concomitant increase of climacteric rise in respiration are accompanied by autocatalytic ethylene production. In addition, the increase in ethylene evolution might promote chlorophyll degradation in some green plant tissues. Our data in Tables 2 and 3 showed that only landrace 2 classified with a high water loss was consistent with this trend.

Percentages marketable and decayed fruits for each cultivar stored in sealed LDPE bags after 15 days at refrigerated and non-refrigerated temperatures are listed in Table 3. Only 3 selections had percentages marketable fruits above 50%. These were landrace 3 with 67%, landrace 4 with 62% and landrace 6 with 52% appeared to be tolerant to low temperature storage. Several landraces particularly 1, 2, 5, 9 and in particular 8 and 11 succumbed to chilling injury with symptoms of pitting, stem and calyx discoloration, seed darkening similar to symptoms described by Mohammed et. al. (2014). In these chilling sensitive landraces percentage fruit decay ranged from 73-86% (Table 3). Fruit decay was dominated with bacterial soft rot caused by *Erwinia species* but the majority of fruits more so landraces 8 and 11, multiple infections were observed. The enhancement and domination of bacterial soft rot in these landraces may be related to two factors: LDPE seal-packaging apparently increased the temperature of the sealed fruit by about 1-2^{0}C and secondly latent infection with pathogenic bacteria, particularly around the pedicel and calyx, which gradually extend around the shoulders of the fruits developed better in the water saturated micro-environment of the sealed LDPE bags accounting for fruits stored at 28^{0}C to exhibit rapid decay which was 100% for genotype 8 and 90% and above for landraces 1, 2, 5 and 11 (Table 3). The resulting decay frequently caused both pedicel and calyx to be completely decapped (Table 3). In these fruit samples decay was characterized with sunken, water-soaked, wrinkled, discoloured lesions, accompanied liquefaction and maceration of cells causing complete collapse of tissues similar to that described in previous investigations reported by Lund (1982) and Mohammed et. al. (2014).

Table 4 shows the biochemical analysis of the 12 ornamental pepper landraces. While our investigation is in agreement with Barrera et. al. (2005) data that no significant differences in pH for Amazonian pepper cultivars, our data indicate otherwise for percentage total soluble solid (TSS), total titratable acidity (TTA) and TSS:TTA. Landraces 1, 11 and 2 had TSS percentages of 9.5, 9.7 and 8.2 resulting in an average value of 9.1%. However, TSS of 50% of the landraces evaluated including 10, 5, 8, 6, 7 and 9 had values between 4.7-5.9 and a mean percentage of 5.4%. The TTA of selection 5 measured the highest level of 1.1, while selection 2 had the lowest TTA at 0.18. Due to the wide variations among the 12 ornamental pepper cultivars examined in this study, the TSS:TTA followed a similar trend (Table 4).

Development of chilling injury symptoms mentioned earlier became more apparent with varying degrees of sensitivity among landraces after 15 days at 7^{0}C and upon subsequent exposure for 1 day at 28^{0}C (Figure 1) in keeping with fundamental role of genetic and chilling susceptibility as postulated by Wang (2010), Saltveit and Morris (1990). Severe CI occurred with genotypes 8, 9 and 11 with a CI rating of 4.2 and above indicative of almost complete breakdown of cellular organelles. Only landraces 3 and 4 with CI ratings of 2.6 and 2.1 respectively were below the limit to marketability (Figure 1). However, although the aesthetic quality of these two CI tolerant landraces was compromised by visible evidence of surface pitting, which typically appeared as sheet pitting they remained marketable based on their culinary properties. The remaining landraces differed in their susceptibility to CI but all had CI ratings above 3 and designated unmarketable. These fruits had a combination of aggravated and intense sheet pitting which were dominant on the fruit shoulders which coalesced to form deeper peel depressions randomly dispersed throughout the fruit pericarp. All landraces transferred after 15 days at 7^0C for a day at 28^0C had CI ratings above 4 and likewise were considered as unmarketable fruits (Figure 1). Secondary infections, seed, stem and calyx darkening were observed in all landraces with CI ratings above 3 and consistent with similar findings in previous studies (Mohammed, 1990, Mohammed et. al. 2014, Bridgemohan et. al. 2016).

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Table: 1 General quality attributes of 12 landraces of ornamental pepper crosses.

Landraces SD40F4	General Quality Attributes			
	Fresh wt.(g)	Shape	No. of Seeds	Placenta wt. (g)
1	3.3	Elongate	84	0.48
2	5.6	Triangular	87	0.77
3	4.3	Triangular	58	0.46
4	3.1	Bell-Shape	99	0.82
5	3.5	Bell-Shape	115	0.98
6	4.9	Elongate	44	0.93
7	4.1	Blocky	89	0.77
8	4.7	Bell-Shape	130	0.90
9	5.6	Triangular	91	1.10
10	4.2	Bell-Shape	140	1.39
11	4.3	Triangular	77	1.20
12	3.6	Blocky	92	0.76
$LSD_{(0.05)}$	**1.9**		**40.5**	**0.4**

Table 2. Colour, dimensions and firmness of 12 landraces of ornamental pepper crosses.

Landraces	Physical quality attributes						
	Colour			Dimensions (mm)			
SD40F4	L	a	b	Length	Width	Pericarp Thickness	Firmness (g/force)
1	32.8	28.5	13.3	52.1	35.2	3.0	695.0
2	35.2	25.4	13.1	32.9	31.5	2.3	667.5
3	40.1	17.3	17.4	43.7	34.7	3.1	712.5
4	44.5	32.3	23.2	44.9	37.9	3.6	785.0
5	41.1	12.9	17.7	47.6	36.6	3.3	747.5
6	45.1	27.4	23.4	40.3	35.0	3.1	647.5
7	39.9	12	10.7	51.7	33.0	3.1	562.5
8	34.3	15.5	7.7	39.0	29.8	3.2	685.0
9	35.7	21.5	10.9	44.3	34.1	2.8	605.0
10	62.1	-4.1	27.3	46.8	31.8	2.8	660.0
11	36.3	36.3	17.6	42.9	34.0	3.3	772.5
12	33.2	26.1	12.3	50.8	40.9	3.5	690.0
LSD $_{(0.05)}$	**8.3**	**18**	**17.3**	**18.7**	**8.3**	**1.3**	**35.8**

Table 3. Fresh weight losses, marketable and decay incidence of 12 landraces of ornamental pepper crosses after 15 days of storage at 7^0C and 28^0C.

Landraces	Storage after 15 days					
	% Fresh Wt. losses		% Marketable Fruit		% Fruit Decay	
SD40F4	7 °C	28°C	7 °C	28°C	7 °C	28°C
1	3.3	8.5	22	0.5	78	95
2	5.6	10.2	24	0.5	76	95
3	4.3	7.6	67	31	33	69
4	3.1	7.8	62	28	38	72
5	3.5	6.9	22	10	78	90
6	4.9	8.9	52	46	48	54
7	4.1	7.0	44	49	56	51
8	4.7	8.7	14	0.0	86	0.0
9	5.5	11.1	27	12	73	88
10	4.2	7.4	42	51	58	49
11	4.3	7.6	18	6.0	82	94
12	3.6	6.6	42	54	58	46
LSD $_{(0.05)}$	**1.3**	**2.9**	**15.8**	**15.8**	**14.0**	**20.5**

Table 4. Chemical quality attributes of 12 landraces of ornamental pepper crosses.

Landraces	Chemical quality attributes			
SD40F4	pH	TSS (%)	TTA	TSS:TTA
1	5.2	9.5	0.46	20.7
2	5.2	8.2	0.18	45.6
3	5.3	6.8	0.34	20.0
4	4.8	7.4	0.35	21.1
5	4.9	5.2	1.10	4.70
6	4.7	5.5	0.29	18.9
7	5.7	5.6	0.26	21.5
8	5.6	5.4	0.27	20.0
9	4.9	5.9	0.57	10.4
10	5.2	4.7	0.27	17.4
11	5.1	9.7	0.44	22.0
12	4.8	7.7	0.36	21.4
LSD $_{(0.05)}$	**0.14**	**4.7**	**0.87**	**20.31**

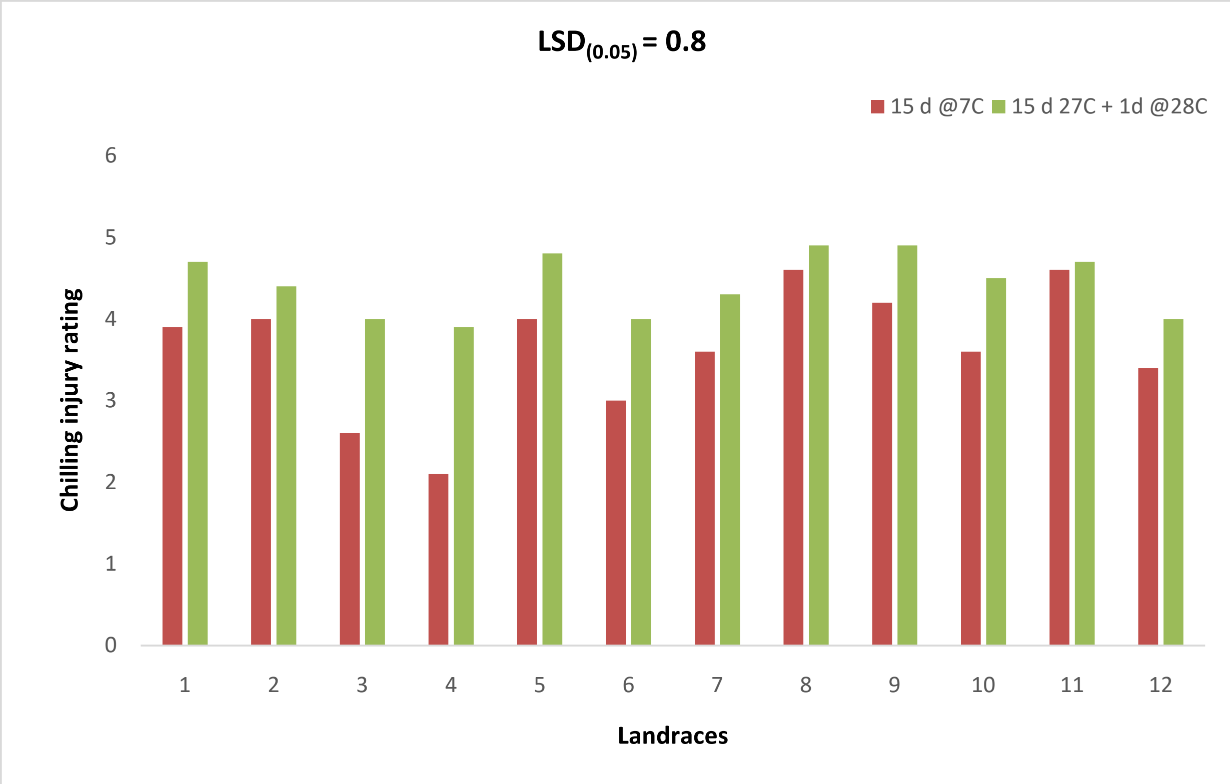

Figure 1. Incidence of chilling injury of 12 landraces of ornamental pepper crosses after 15 days at 7^0C and upon subsequent transfer for an additional day at 28^0C.