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INFLUENCE OF COLD STORAGE ON FRUIT QUALITY AND MARKETABILITY OF SOME PEACH CULTIVARS

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ABSTRACT

This research was carried out in 2006 & 2007, on three peach cultivars, i.e., Flordaprince, Desert Red and Meet Ghamr to study the effect of cold storage on fruit quality and marketability. Weight loss, soluble solids content (SSC), and total sugars increased during cold storage and this increment was continuously observed during subsequent 4 days at 20^{o}C. Firmness, acidity and phenols behaved inverse trend and this trend remained during marketing period. Symptoms of decay were visible in fruits of all cultivars between 15 and 20 days of cold storage.

INTRODUCTION

Peach is one of the most popular fruit in the world because of it's high nutrient level and pleasant flavour and it's fruit is characterized by strong demand in different international markets (Wang, *et al;* 1998). In Egypt, according to the census of 2007, the area occupied with peach is about 83703 feddans. However, "Meet Ghamr" peach is a traditional specialty cultivar with a large demand to domestic market while, Flordaprince and Desert Red cvs. Are new cultivars imported by the Ministry of Agriculture and land Reclamation? In the past years, the production of local cultivars covers only a relatively short marketing season (about 2 months). Growers are interested in expanding peaches production and marketing season within and outside Egypt. In recent years, the production and commercialization of peach fruits have increased rapidly, mainly owing to the introduction of early and late new cultivars and improvements in fruit handling; the season is expanded to cover about 5 months, from April to August. In despite of, a gap within this period is existed. For this reason, cold storage must be used. Fruit firmness and acidity showed a significant decrease with storage time increase, either at cold storage or at ripening Ravaglia, *et al.,* (1995) El-Etreby (1996); Dundar, (1997); Akbudak and Eris (2003) and Serrano, *et al.* (2004), while weight loss and soluble solids content (SSC) were increase with increasing storage duration Kurnaze and Kazka (1993) and Vanoli *et al.*, (1995). The aim of this study was to determine fruit quality parameters during cold storage and marketing period.

MATERIALS AND METHODS

This Study was carried out in two successive seasons (2006 & 2007) on the peach trees grown in sandy soil in a commercial orchard at Abou Swair area, Ismailia Governorate. The studied cultivars were Flordaprince, Desert Red and Meet Ghamr. All the cultivars were budded on Nemagard rootstock,15-year-old, planted at 5×5 m apart and subjected to normal horticultural management of peach orchards. Thinning was practiced at the second week of February for Flordaprince, the third week of March for Desert

Red and the third week of May for Meet Ghamr by leaving a single fruit at 10-15 cm distance on the carrying shoots depending on the number of leaves on them. The time of full bloom was recorded when 85% of the total produced flowers had opened and the number of days between full bloom and harvesting date was estimated for each cultivar.

Maturity stage was determined according to the maturity indices of the three studied cultivars as described previously by El-Khoreiby *et. al.* (2010), the peach fruit of Flordaprince, Desert Red and Meet Ghamr were harvested after 91, 100 and 128 days from full bloom, respectively. A lot of 360 fruits were hand picked at random from the same height of the tree from each cultivar by using clipper and packed in two layers in plastic boxes, then transported immediately within one hour to postharvest laboratory of Horticulture Department, Faculty of Agriculture. Fruits were sorted to eliminate defect and selected for uniform color and size. Sound fruits were cleaned by using soft brush and packed in foam plates in one layer, covered with perforated polyethylene sheet (thickness 14 µ). All plates from each cultivar were divided into two groups and stored at 1^0C and 85-90 % RH.

Each plate of the first group contained 12 fruits formed a treatment unit, replicated 4 times and analyzed at harvest (zero time) and at five days intervals up to 20 days (12 fruits × 4 replicates × 5 periods). So, 240 fruits were used. Another plates (second group) contained 6 fruits per each formed a treatment unit, replicated 4 times, labeled , weighted at harvest time (zero time) and reweighted at five days intervals up to 20 days (6 fruits × 4 replicates × 5 periods).Thereby, 120 fruits were used. Therefore, the experiment was arranged in a complete randomize design with factorial arrangement of storage period and cultivar.

The following determinations were carried out:-

1: Fresh weight loss was expressed as a percentage of weight loss of each plate was calculated in relation to its initial weight as follows:-

$$\text{Fresh weight loss}\,\% = \frac{\text{initial weight - sample weight}}{\text{initial weight}} \times 100$$

2: Fruit firmness (lb/in^2) of each fruit was measured with an 8 mm dip penetrometer (Magness Taylor,Japan) on two opposite sides of the equatorial region of the fruit.

3: Soluble solids content (SSC%) was measured with a hand refractometer (Atago,Tokyo,Japan) in juice pressed from the whole fruit.

4: Titratable acidity (%) was determined by titrating 2 ml of fruit juice with 0.1 N NaOH to PH 8 and calculating the result as malic acid equivalent.

5: Total sugars (%) were extracted twice by using 80% cold methanol for 24 hours. (El-Khoreiby and Salem, 1984) and colorimetrically determined by phenol sulphoric acid method according to Stewart (1974). A standard curve was prepared at the same time using glucose as a standard. The optical density was measured at 620 nm using a Spectro 22 spectrophotometer (Labomed Ince, USA).

6: Total phenolic compounds (%) were quantitatively determined by Folin and Ciocaltu colorimetric method (A.O.A.C., 1985) at 640 nm using a spectro 22

spectrophotometer (Labomed Ince. USA) and the concentration were calculated from a standard curve of pyrogallol (Coseteng and Lee, 1987).

7: Decayed fruits were separated and expressed as percentage in relation to number of fruit per replicate for each sample.

8: Marketability :- After a 20-day of cold storage, 40 fruits from each cultivar were separated and held in ambient temperature at 20±1^{o}C and 65% RH for a 4- days as ripening period and ensuring quality.

9: Consumer acceptance of each cultivar, on the basis of eating quality, was determined after marketing period by a panel of 12 tasters using the scale of 1= like slight , 2= like moderately and 3= like extremely Crisosto, *et al.* (2005).

Acceptance percentage was calculated as the number of fruit in like extremely category in relation to the total number of fruit. The following equation was used:-

$$\text{Acceptance \%} = \frac{\textbf{Number of fruit per each category}}{\textbf{Total number of fruit in each cultivar}} \times 100$$

Statistical analysis: The data were analyzed by two – way analysis of variance (ANOVA). A complete randomized design with a factorial arrangement of storage periods and cultivars was used (Steel and Torrie 1980). Analyses of variance and mean comparison (LSD at 5 %) were performed with Co-Stat program version 3.

RESULTS AND DISCUSSION

Physical and chemical changes during cold storage:

Fruit weight loss was significantly affected by peach fruit cultivars as shown in (Table1). Results showed that highest loss in weight was occurred in Flordaprince (3.5-3.1%) followed by Desert Red (2.5%) and Meet Ghamr (1.8-2.3%) with no significant difference between later two cultivars in both seasons. Weight loss is a consequence of fruit dehydration and leads to loss of quality. Zhang, *et al*. (1996) found that the average daily of whole fruit weight losses during 9 days of storage were 1.72 , 2.19 and 2.22 in three cultivars, Garnet Beauty, Red Haven and Sentiral, respectively. Fruit weight loss was significantly increased with increasing storage duration at 1^{o}C. Minimum weight loss was obtained during 5 and 10 days of storage and the highest weight loss was obtained from fruits stored up to 20 days in the two seasons. Kurnaze and Kazka, (1993) and Verstreken and Baerdemaeker, (1994) found that fruit weight loss was increased as storage time was increased. Similar results have been reported by Akbudak and Eris (2003) and Serrano, *et al.* (2004) who found that weight loss in normal condition was high in all analytical periods compared to peaches and nectarines stored in control atmosphere. A significant interaction between cultivars and storage period on fruit weight loss was detected during the two seasons. This indicated that under any cultivar, fruit weight loss increased with extending storage period. However, the highest values of weight loss was obtained by

Flordaprince after 20 days storage followed in descending order by Desert Red and Meet Ghamr in both seasons. Although, fruit weight loss increased with storage period was increased, Meet Ghamr cv. had the lowest fruit weight loss during progress of storage period when compared with the other two cultivars. This indicate that the "Meet Ghamr" cultivar act slowly with the other factor, storage period.

Fruit firmness was significantly varied among the peach fruit of the three cultivars as shown in (Table1). In the first season, fruit firmness of Flordaprince was significantly lower than that of Desert Red or Meet Ghamr. However, in the second season, Desert Red was the most softened cultivar. Ju, *et al* (2000) found that changes of fruit firmness varied according to cultivars. "Armking" fruit firmness decreased from 57 N at harvest to about 5 N after three days at 20^{o}C, while "Fantasia" fruit firmness decreased from 57 N at harvest to 40 N after three days at 20^{o}C and to 30 N after five days at 20^{o}C. Fruit firmness showed a significant decrease as storage time was increased. Generally, fruitfirmness decreased from (13.1-13.0 lb/in^{2}) at harvest to about (5.9-7.5 Ib/in^{2}) after 20 days of storage at 1^{o}C in the two seasons, respectively. In some studies (Ravaglia, *et al.,* 1995 and Dundar, 1997), when some cultivars of peach fruits were stored at room temperature or 0^{o}C, fruit firmness decreased with extending storage duration. But in another study (Wang, *et al.,* 1998), the fruit firmness was maintained very well during storage if fruit harvested at the green mature stage. In the two seasons, in each cultivar, fruit firmness was significantly decreased as storage time was increased. However, the lowest fruit firmness was obtained by Desert Red after 20 days of cold storage at 1^{o}C. This means that Desert Red fruit was more affected by cold storage than other two cultivars and could be stored for 15 days with good firmness.

Soluble solids content (SSC %) It could be seen that the values of SSC were generally higher in Meet Ghamr fruits than that of Flordaprince or Desert Red fruits in both seasons (Table 1). The significantly differences between the three considered cultivars were rather clear in the second season than in the first one particularly when Meet Ghamr and Flordaprince were compared. Depending on the peach cultivar, SSC either increased or decreased Kenawy (2001). Drake and El-Fving (2003) reported that cultivar and storage time had a strong influence on SSC of white – fleshed peaches. Changes in SSC percentage during cold storage in both seasons are presented in (Table1). In the first season, SSC was significantly increased till the end of storage period while, in the second season, no significant differences were detected between 15 and 20 days of storage. In addition, the maximum SSC was observed at the end of storage period in the two seasons. These results supported the previous findings of Kurnaze and Kazka (1993) and Vanoli, *et al.* (1995) who found that SSC increased with extending storage periods. Similar findings have been reported by El-Etrby (1996) on Florda Sun, Early Grand and Desert Gold and by Dundar (1997) on J.H. Hale peach cultivar. Soluble solids content was significantly affected by the interaction between cultivars and storage periods (Table 1). Where, in any cultivar, SSC was significantly increased with extending storage period in

both seasons. However, the minimum SSC was obtained by the cultivar Meet Ghamr after 20 days of cold storage when compared with the other cultivars.

Titratable acidity: Fruit acid content was significantly associated with cultivar as shown in (Table1). However, Meet Ghamr fruit had the lowest acid content as compared to Flordaprince or Desert Red in the two seasons. According to the peach cultivar, total acidity either increased or decreased. Kenawy (2001) and Drake and El Fving (2003) reported that cultivar and storage time had a strong influence on acid content of white-fleshed peaches. Total acidity was significantly decreased during the different periods of storage which showed the least acidity at the end of storage in both seasons. Among the metabolic reactions, respiration is an important process which may utilize organic acid as a substrate during the peak energy requirement of fruits, which usually coincides with ripening leading to a decrease in acidity during prolonged storage Sonkar and Ladaniya (1999). In similar studies, Kurnaze and Kazka (1993), Dundar (1997) and Akbudak and Eris (2003) stated that when some peach cultivars (Florda Sun , Early Grand , Desert Gold , J.H. Hale and Flordaprince) were stored at 0 ^{o}C and 90-95 % RH for 3-5 weeks , total acidity decreased and this reduction was associated with increase storage time. In general, the interaction failed to attain significantly effects with all possible combinations in both seasons. Nevertheless, it could be observed that fruit acid content tended to decrease in any cultivar as the storage time was increased. In addition, after 20 days of storage, Meet Ghamr fruit had the lowest acidity in either the first (0.30%) or the second (0.20%) season.

Total sugars content: Fruit of the three considered cultivars had different content of total sugar (Table 1) which the highest values were obtained from fruit of Meet Ghamr followed in descending order by Flordaprince and Desert Red in both seasons. Concerning the effect of storage period, it could be seen that total sugars significantly increased as the time of storage was increased which reached a maximum values at the end of storage period. The increase in sugar contents may be due to the higher loss in weight of these fruits, as a result of water loss which may lead to an increase in the concentration of sugars. Akbudak and Eris (2003) stated that the increase in total sugars content observed in peach fruits having minute quantities of starch mainly, resulted from the conversion of polysaccharides in the cell walls to sugar. An increase in total sugars content during cold storage of peach has been reported by Vanoli , *et al.* (1995) and Sonkar and Ladaniya (1999). With respect to interaction, two significantly responses were observed with a fixed trend could be recognized in both seasons. The first reveals that Meet Ghamr fruits becomes more effective on increasing total sugars as the storage period was increased. The second shows no sizable differences between Flordaprince and Desert Red under the different periods of storage. Furthermore, after 20 days of cold storage, the highest total sugar contents were obtained from fruit of cv. Meet Ghamr (7.7 and 7.5) when compared with Flordaprince cv. (7.1 and 7.1) or Desert Red cv. (7.0 and 6.8) in two second seasons, respectively.

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Total phenols content: A significantly higher in phenols content was detected in fruit of Meet Ghamr cultivar than other two cultivars in both seasons (Table1). A gradual decline in total phenols was observed with the advancement of storage period. The faster rate of decline in total phenols was in the first 5 days of storage then, the changes were slower till the end of storage period in the two seasons. This reduction may be due to polyphenoloxidase oxidize total phenols in peach fruit during cold storage (Cheng and Crisosto, 1995). The significant interaction between cultivars and storage period showed that under all studied cultivars, total phenols decreased as storage time progressed. However, the total phenol values of the three cultivars showed a similar trend where total phenol contents attained the minimum values after 20 days of cold storage.

Decay percentage: The results concerning decay percentage during cold storage in both seasons are shown in (Table 2). During the first 10 days of cold storage, no decay incidence was detected, while symptoms of decay in fruits were visible in all cultivars between 15 and 20 days of storage. Moreover, at the end of storage period, Meet Ghamr cultivar had significant lower decay value (14.5 and 14.0) in comparison with Flordaprince cv. (16.0 and 15.5) or Desert Red cv. (16.8 and 16.4) in the first and second seasons, respectively. The reduction in decay value in Meet Ghamr fruit may be due to the large amount of phenols detected in Meet Ghamr cv. (Table 1). Recently, Mohammadi and Kazemi (2002) found that polyphenoloxidase oxidize phenols to form more toxic quinines , which directly influence invading pathogens in plant- pathogen interactions.

5- Fruit behaviour during marketing period: Fruit behaviour parameters during marketing period for 4 days at 20±1^{o}C and 65% RH after removal from cold storage at 1^{o}C are shown in (Table 3). The obtained results show that, in all cultivars, weight loss , SSC , SSC / acid ratio and total sugars content increased during cold storage and this increase was continuously and significantly during subsequent 4 days at 20^{o}C as marketing period. On the other hand, firmness, acidity and total phenols behaved inverse trend and had remained the same trend during marketing period. However, Meet Ghamr fruit gave significant lower weight loss, acidity and in the same time it had significant higher firmness, SSC, SSC / acid ratio , total sugar and phenols as compared with other two cultivars. Similar results were observed in several studies (Brash, 1990; Robertson, *et al.,* 1990; Mclaren, *et al.,* 1994; Vanoli, *et al.,* 1995; Dundar, 1997 and Valero, *et al.,* 1997) they reported that weight loss and SSC increased but fruit firmness and acidity decreased when fruit of peach cultivars stored at 0^{o}C for 3-4 weeks followed by 2-4 days at 20^{o}C. Recently, Girandi, *et al.* (2005) found that peach fruit with 11.30% of SSC at harvest showed an increase to 13.0% after 35 days of cold storage. After a further 5 days at 22±3^{o}C the SSC significantly increased in the fruit reaching 13.5%, while the titratable acidity behaved a converse trend. In this way, fruits of Meet Ghamr showed high eating quality which in turn to high consumer acceptance. In this respect, Parker, *et al.* (1991) found that high consumer acceptance was associated with high SSC in peaches.

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Crisosto, *et al.* (2005) reported that consumer acceptance expressed as degree of liking and / or percentage acceptance was related to ripe soluble solids concentration (RSSC) or RSSC/ripe titratable acidity (RTA), but depended on the cultivar, which have different RSSC and different consumer acceptance. It appears that low acidity in white or yellow flesh fruit cultivars has a higher consumer acceptance. On the other hand, to maintain the high eating quality of the cultivar Meet Ghamr, the maximum limit of storage should not exceed 20 days at 1^{o}C plus 4 days at 20^{o}C as marketing period.

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تأثير التخزين المبرد على صفات الجودة و القدرة التسويقية لثمار بعض أصناف الخوخ

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أجريت هذه الدراسة خلال موسمي ٢٠٠٦ – ٢٠٠٧م على ثمار ثلاث أصناف خوخ هي فلوردا برنس و دزرت رد و ميت غمر بهدف دراسة تأثير التخزين المبرد على صفات الجودة و القدرة التسويقية لثمار كل صنف. بالنسبة لتأثير التخزين المبرد على الثمار فقد ظهر زيادة في الفقد في الوزن و المواد الصلبة الذائبة و النسبة بين المواد الصلبة الذائبة إلى الحموضة و السكريات الكلية مع زيادة فترة التخزين و استمرت هذه الزيادة خلال فترة نضج الثمار على درجة ٢٠^{0}م. أما صلابة الثمار والحموضة والفينولات فسلكت سلوكاً معاكساً و ظل هذا السلوك خلال فترة التسويق. ظهرت أعراض التلف على ثمار جميع الأصناف في الفترة ما بين ١٥-٢٠ يوم من التخزين المبرد.

قام بتحكيم البحث

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Table (1): Effect of some peach cultivars, cold storage period and their interaction on some fruit parameters in 2006 &2007 seasons

(a) Effect of cultivars:

Cultivars	Season 2006						Season 2007					
	Weight loss%	Firmness lb/in^2	SSC%	Acidity%	Total sugars%	Total phenols%	Weight loss%	Firmness lb/in^2	SSC%	Acidity%	Total sugars%	Total phenols%
Flordaprince	3.5 a	8.8 c	11.8 b	0.85 a	6.5 b	60.4 b	3.1 a	10.0 b	11.9 c	0.95 a	6.6 b	62.0 b
Desert Red	2.5 b	9.1 b	11.9 b	0.77 a	6.6 b	56.6 c	2.5 b	9.6 c	12.5 b	0.82 b	6.1 c	56.2 c
Meet Ghamr	1.8 b	10.3 a	13.6 a	0.45 b	7.0 a	77.6 a	2.3 b	10.6 a	13.6 a	0.38 c	7.0 a	79.4 a

(b) Effect of cold storage period:

Storage period in days	Season 2006						Season 2007					
	Weight loss%	Firmness lb/in^2	SSC%	Acidity %	Total sugars%	Total phenols%	Weight loss%	Firmness lb/in^2	SSC%	Acidity%	Total sugars%	Total phenols%
0	0.00 e	13.1 a	10.7 e	0.88 a	5.9 d	71 a	0.00 e	13 a	11.3 d	0.93 a	5.9 d	73.3 a
5	1.3 d	11.2 b	11.9 d	0.73 ab	6.4 c	68 b	1.2 d	11.3 b	11.8 c	0.81 ab	6.3 c	69.3 b
10	2.3 c	9.3 c	12.4 c	0.7 bc	6.8 b	64 c	2.4 c	9.3 c	12.9 b	0.71 bc	6.5 b	65 c
15	4.2 b	7.5 d	12.7 b	0.6 bc	7.1 b	61.7 d	3.9 b	7.5 d	13.6 a	0.59 cd	6.9 a	61.8 d
20	5.3 a	5.9 e	13.5 a	0.5 c	7.3 a	59.7 e	5.6 a	5.9 e	13.8 a	0.53 d	7.1 a	61.8 e

(c) Effect of the interaction between cultivars and storage period:

Cultivars	Storage period in days	Season 2006						Season 2007					
		Weight loss%	Firmness lb/in^2	SSC %	Acidity %	Total sugars%	Total phenols%	Weight loss%	Firmness lb/in^2	SSC%	Acidity %	Total sugars%	Total phenols%
Flordaprince	0	0.0	12.2	10.6	1.1	5.9	65	0.0	13.0	10.8	1.3	6.0	62
	5	2.0	11.2	11.2	0.9	6.4	64	1.8	10.8	11.4	1.0	6.4	66
	10	3.3	8.6	12.0	0.8	6.8	60	2.8	10	12.4	0.95	6.6	62
	15	5.8	6.8	12.4	0.75	7.0	58	4.6	8.5	13.1	0.77	7.0	58
	20	6.4	5.4	12.8	0.7	7.1	55	6.3	7.6	13.4	0.65	7.0	56
Desert Red	0	0.0	13.7	10.4	1.0	5.5	66	0.0	12.8	10.6	1.0	5.4	64
	5	1.2	11.0	11.4	0.8	6.1	60	1.1	11.0	11.2	0.85	5.8	60
	10	2.0	8.8	11.8	0.8	6.6	55	2.3	9.8	13.4	0.8	6.0	55
	15	4.1	6.6	12.6	0.65	7.0	52	3.8	7.6	13.5	0.7	6.5	52
	20	5.3	5.2	13.2	0.6	7.1	50	5.5	6.6	13.8	0.75	6.8	50
Meet Ghamr	0	0.0	13.4	12.4	0.55	6.3	82	0.0	13.2	12.4	0.5	6.5	88
	5	0.7	11.5	13.2	0.5	6.6	80	0.8	12.0	12.8	0.5	6.8	82
	10	1.5	10.4	13.4	0.5	6.9	77	2.1	10.5	14.0	0.4	6.9	78
	15	2.8	9.2	14.4	0.4	7.4	75	3.4	9.0	14.0	0.3	7.2	75
	20	4.2	7.2	14.6	0.3	7.7	74	5.1	8.2	14.8	0.2	7.5	74
LSD: 0.05		0.27	0.78	0.63	ns	0.36	0.61	0.35	0.56	0.55	ns	0.47	0.64	

Table (2): Decay percentage of some peach fruit cultivars during cold storage at 1°C in 2006 & 2007 seasons

Cultivars	Season 2006					Season 2007				
	Storage period in day (A)					Storage period in day (A)				
	0*	5	10	15	20	0*	5	10	15	20
Flordaprince	0.00	0.00	0.00	10.8 b	16.0 b	0.00	0.00	0.00	11.0 a	15.5 b
Desert Red	0.00	0.00	0.00	12.2 a	16.8 a	0.00	0.00	0.00	11.9 a	16.4 a
Meet Ghamr	0.00	0.00	0.00	10.6 b	14.5 c	0.00	0.00	0.00	10.8 a	14.0 c

*** Initial values at harvest, prior to storage.**
Values followed by the same letter (s) in each column are not significantly different at 5% level.

Table (3): Quality parameters of some peach fruit cultivars stored at 1°C for 20 days and placed for 4 days at 20°C to determine marketability and consumer acceptance in 2006 & 2007 seasons

Cultivars	Season 2006							
	Weight loss(%)	Firmness (lb/in^2)	SSC (%)	Acidity(%)	SSC/Acid ratio	Total sugars*	Total phenols*	Consumer acceptance (%)
Flordaprince	8.2 a	3.2 b	14.2 b	0.6 a	23.67 b	8.4 b	48.6 b	95 b
Desert Red	8.5 a	3.5 b	13.6 b	0.5 a	27.20 b	8.8 ab	45.3 b	98 ab
Meet Ghamr	6.4 b	5.6 a	15.4 a	0.3 b	51.33 a	9.3 a	66.1 a	100 a
Season 2007								
Flordaprince	8.0 a	3.0 b	14.0 b	0.6 a	23.33 b	8.4 b	46.2 b	97 b
Desert Red	7.7 a	3.5 b	14.6 b	0.6 a	24.33 b	8.8 ab	44.4 b	95 b
Meet Ghamr	6.2 b	5.3 a	16.0 a	0.2 b	80.00 a	9.5 a	63.3 a	100 a

Values followed by the same (s) in each column are not significantly different at 5% level.