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Research Article

INVESTIGATION OF THE QUALITY AND QUANTITY CHARACTERISTICS OF ISFAHAN QUINCE FRUIT GENOTYPES DURING THE STORAGE PERIOD

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ABSTRACT
Iran ranked as the third quince producer in the world and the most quince genotypes belong to Isfahan. There is a little information about physical and chemical changes in fruits during storage. This study was conducted to investigate several parameters related to quince fruit quantitative and qualitative characteristics and physiochemical changes during storage period. Effect of 12 genotypes and five storage periods on quince fruit, was studied as a factorial experiment base on complete randomized design with four replications. Fruit firmness, flesh browning rate, total soluble solids, marketability, decay percentage and weight loss measured in fruit samples. The highest fruit firmness belong to NB1 (10.2 kgcm-2), NB4 (8.9 kgcm-2) and PH2 (8.2 kgcm-2) genotypes respectively. After four months of storage, the firmest samples belong to NB4 (6.9 kgcm-2), SVS2 (6.4 kgcm-2) and NB1 (6.2 kgcm-2) and the least firmness observed in KVD3 (5.1 kgcm-2) and KM1 (5 kgcm-2). SVS1 showed the lowest marketability. There were significant differences between genotypes and different storage periods in respect of total soluble solids and flesh browning percentage.

***Keywords**: Storage Period, Genotype, Quince Fruit, Quantitative, and Qualitative Characteristics*

INTRODUCTION
Quince *(Cydonia Oblonga* Mill.) belongs to Rosaceae family with a pome fruit (Rasoulzadegan, 1991). Iran is the origin of many fruit tree geniuses and a major fruit producer in the world (Maniee, 1994). Different varieties of quince cultivated in 47 countries around the world, base on FAO report (2010). The third rank of area harvested and forth rank of production amount of quince in the world belongs to Iran (FAO, 2010). There are more than 70 quince genotypes in the world. The most important varieties international of quince are Pineapple, Spahan, Ekmek, Botermo, Portugal, Morova, Meeh, Smyrna, Orage,Champion and Van Deman (Madi *et al.*, 1996). Iranian varieties of quince consist of Esfahan, Neyshabour, Beh Torsh (sour quince) and Mazaheri (Maniee, 1994). Esfahan is the major quince producer of Iran by about 1500 ha of harvested area and more than 14000 tone of fruit production (statistical handbook of agriculture, 2012). (Ghasemi, 2005) Investigated Isfahan genotypes of quince and studied their morphological and pomological characteristics base on quince tree descriptor. 135 characteristics like leaf, blossom and fruit shape investigated in each genotype. Cluster analysis was performed and 14 different genotypes introduced. Documented genotypes were SHA1, SVS1, SVS2, NB1, NB3, NB4, KVd1, KVd2, KVd3, KVd4, ET1, PH2, PK2 and KM1. KM1 was fast growth variety with early blossoming. KM2 was a medium growth variety with mid blossoming date and PK1, PK2 and PK3 were late to very late blossoming genotypes. There were significant differences between vegetative growths of different investigated genotypes. Fruit types were apple like, pear like and spherical and fruit color were yellow and golden yellow to yellowish green. Sherafatian (1982) stated that favorable condition for quince fruit storage is a zero degree of centigrade store with 85-90 percent of relative humidity. Turk and Mimaclo (1994) reported that storability; fruit browning percentage and qualitative traits of Esme variety of quince are affected by growing conditions (like altitude) and harvest time (e.g. early, mid and late). Testoni *et al.*, (1996) Investigated the effect of harvesting time and growth environmental condition fruit browning percentage of Gigant di Vrantia variety they investigated the effect of early, mid and late harvesting time and six month store duration and showed that browning

percentage was less in early rather than late harvesting time. Akbari and Rahemi (2004) examined the effect of warming and different packing types on storability and qualitative characteristics of quince fruit. They reported that yellow color of fruit, acidity, *Beta*-carotene content and fruit decay percent increased by 72 hours of warming while fruit weight and flesh firmness decreased. Sakaldas (2008) studied the effect of harvesting time and packing type on Esme variety and reported that polystyrene packs with a cellophane wrapping results in highest fruit quality and least browning percentage. Isaakidis and Michailides (2004) Investigate 47 quince varieties at Imathia-Greec and declared a significant diversity between them in respect of pest susceptibility and yield. Different physiological abnormality levels observed between varieties after four month store. They showed that 11111, 11113, 11108, 11102, 11114, 11115 and 11103 were the most compatible varieties for studied environment. Kader, (1996) reported that 0-1 degree of centigrade with 85-90% RH is the best store condition for quince. Buyukkoca and Karacali (1991) collected and investigated Hungary varieties of quince and stated that Bereezki, Mezoturi, champion, Botermo, Angeris, Moldoya, Tinapoly and Konstan are the favorable varieties for Hungary environmental conditions. Madi, *et al.*, (1996) declared that the proper harvest time could be determine by fruit acidity, total soluble solids, flesh firmness, fruit peel flesh and seed color, respiration ratio and ethylene release amount. Kingstone, (1992) Physical, biochemical and physiological changes occur during fruit ripening. Physical changes include decrease in flesh firmness and peel chlorophyll content and increase in carotenes and xanthophylls content Chemical and physiological alternations consist of starch content, acidity and respiration rate decrease and sugar, soluble solid content and pectin increase are affected by genetic and environment (Ashari and Khosro Shahi, 2008). Ghasemi and Mosharef (2006) studied proper harvest date of Isfahan variety of quince during 2 years They affirmed that mid October harvest time (181 days after full blossoming) is the proper time for harvesting fruits in order to storage reported that fruit browning happen by poly phenol oxidase activity due to physical injuries. Phenolic compounds like chlorogenic acid change to unti-Quinone oxide by poly phenol oxidase activity. unti-Quinone polymerized and converts to melanin which results in fruit decay and browning (Anokpornm, *et al.*, 2008). Iran ranked as the third quince producer in the world and the most quince genotypes belong to Isfahan. Botanical and morphological information about Isfahan varieties are available but there is a little information about physical and chemical changes in fruits during storage. Thus the present study carried out to investigate quantitative and qualitative changes of different varieties fruit at storage duration and determining proper characteristics of each genotype for breeding programs.

MATERIALS AND METHODS

A factorial experiment base on complete randomized design with four replications carried out to investigate several parameters related to quince fruit quantitative and qualitative characteristics and physiochemical changes during storage period. 20 kg samples of 12 genotypes collected from Shahid Rabiee orchard of Mobarakeh -Esfahan. The station is located at 45 km south of Isfahan with 33° 36" N latitude and 52° 50" E longitude with 1120 m height. Maximum and minimum temperature of station is -10 °c in winters and 32 °c in summers with 128 mm of raining yearly precipitation. Samples gained from internal, upper and lower parts of tree crown. Harvest date determined base on needed days from full blossoming to ripening and starch test. Flesh firmness, browning percentage, total soluble solids, marketability and decay percentage and weight loss measured immediately after transferring samples to laboratory. Then fruits moved to a zero degree of centigrade store with 85-90 % relative humidity for 30, 60, 90 and 120 days. At the end of each storage interval, 10 fruits of each treatment brought to laboratory and the above characteristics measured again. The data were recorded. All collected data were subjected to analysis of variance. Duncan's multiple range tests were done to determine differences between means.

Flesh Firmness: Fruit firmness measured applying a penetrometer (Effigi, F.T. 327). Probe diameter and penetration length were 6.5 and 7 mm respectively. Penetration force was measured by inserting the probe into three peeled points of each fruit. Fruit firmness recorded and averaged for each fruit base on kgcm-2.

Total Soluble Solids: Total soluble solids (TSS) were measured with a refractometer (Bleeker- model 52436). TSS determined by extracting and mixing several drops of fruit juice and the result expressed as Brix.

***Marketability*:** Panel test performed to determining fruit qualitative traits. Eight experts score the samples from 1 to 5 (1 for worst and 5 for best quality). Fruit shape and texture, taste and flavor and palatability were examined.

Fruit Decay: Percent of decayed fruits in each treatment were examined visually and counted during storage and the percentage of decay was calculated as bellow: Decay (%) = (number of decayed fruits/total number of fruits)*100.

Weight Loss: The initial weight of each fruit was measured with a digital scale. The average loss of weight in all the treatments was calculated at 30 days intervals. The weight loss (%) was calculated as bellow: Weight loss (%) = ((Weight of fresh fruits – Weight after interval)/ Weight of fresh fruits)*100.

Flesh Browning: flesh browning fruits counted in each sample and relation between healthy and flesh browned fruits explained in percentage.

RESULTS

Firmness significantly affected by storage period (table 1). The highest flesh firmness belonged to harvest time and firmness diminished while storage time increased. The lowest firmness belonged to 120 month storage period (figure 1). The highest firmness at harvest time belonged to NB1 (10.2 kgcm-2), NB4 (8.9 kgcm-2), PH2 (8.2 kgcm-2) respectively. Firmness reduction in NB1 was higher compared with other genotypes during storage. The lowest firmness change observed in PH2. After 120 days of storage the fruit firmness was the highest in NB4 (6.9 kgcm-2), SVS2 (6.4 kgcm-2) and NB1 (6.2 kgcm-2). The lowest firmness belonged to KVD3 (5.1 kgcm-2), KM1 (5 kgcm-2) (figure 2).

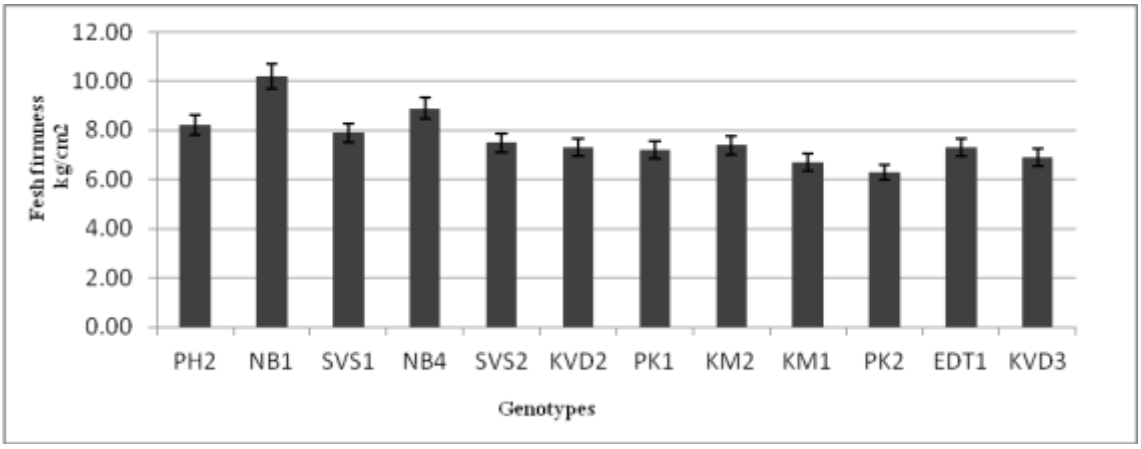

Figure 1: Effect of different genotypes on flesh firmness at harvesting time

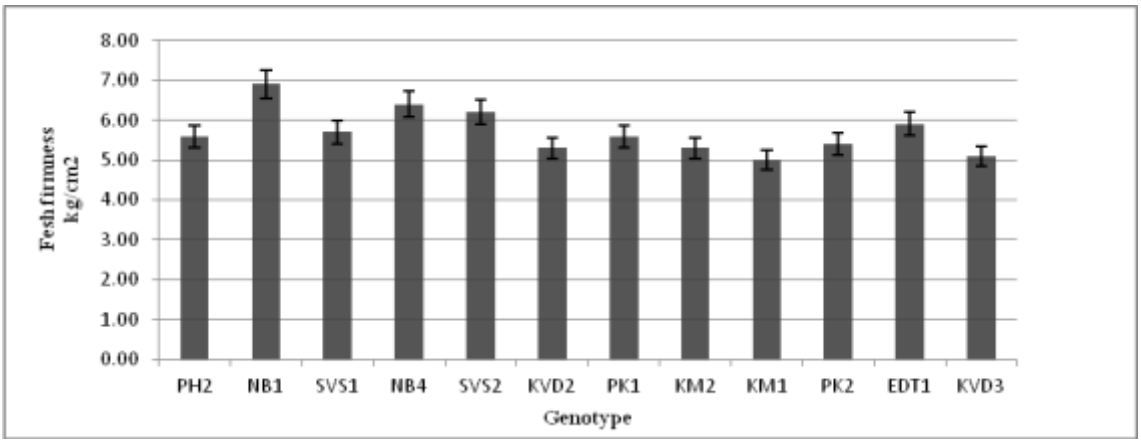

Figure 2: Effect of different genotypes on flesh firmness after 120 days of storage

Table 1: analysis of variance of fruit characteristics of 12 quince genotypes under different storage durations

SOV	df	Firmness	Acidity	TSS	PH	Fruit decay	GH	Weight loss
Rep	2	0.169**	0ns	0.064ns	0ns	0ns	0ns	12.717**
Genotype (G)	11	13.845**	-5.629**	85.049**	-3.32**	893.729**	510.567**	515.041**
Storage duration (SD)	4	3.525**	-0.99**	4.898**	-0.968**	22.127**	29.053**	15.079**
G*SD	24	1.654**	-0.102**	0.506ns	-0.221**	8.707**	8.202**	26.052**
Error	118	0.005	0	0.454	0	0	0	2.745

**, ** significant at 0.05 and 0.01 probability level and n. s no significant. In each column, means with the same letters are not significantly different S0, S1, S2, S3 and S4: harvest time, 30, 60, 90 and 120 day of storage*

Total soluble solids (TSS) significantly affected by genotypes at harvest time and each storage period (table 2). There was no significant difference between KM1, NB4, SVS2, NB1 and PH2 in respect of TSS (figure 3). TSS increased during storage period. After 120 days of storage the highest TSS

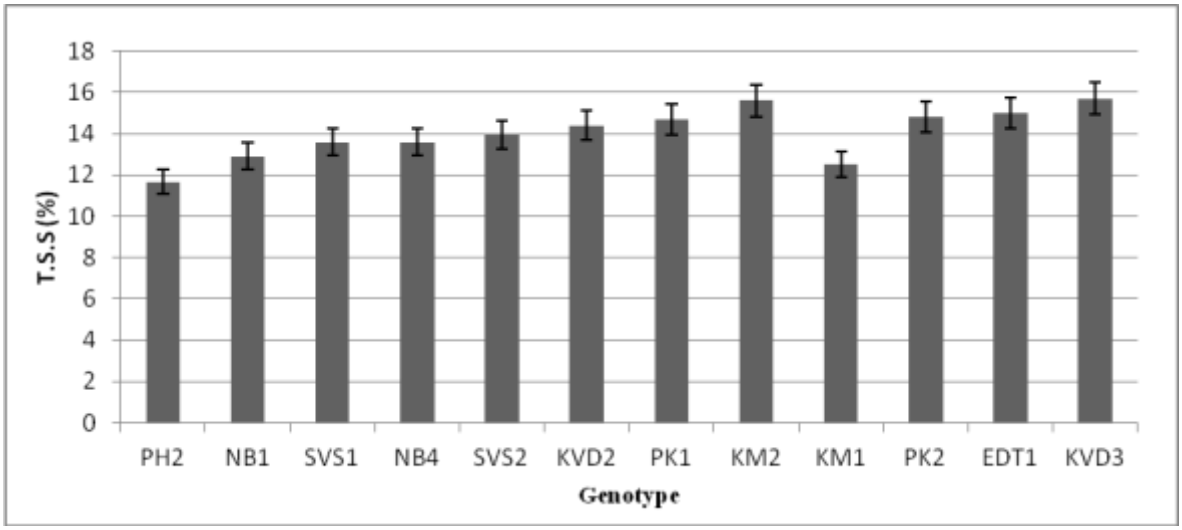

Figure 3: Effect of different genotypes on TSS at harvesting time

Belonged to ET1 and KVD3 (figure 4). The lowest TSS belonged to PH2 (11.67) at harvest time and KM1 (17.8) and NB1 (17.7) after 120 days of storage. Decay percentage was zero at harvesting time and after 30 days of storage. The highest and lowest decay percentage observed in NB4 (14%) and KM1 (5%) at 60 days storage treatment. A significant increase in decay percentage of fruit was recorded with increase in storage duration. In different storage periods, significant differences observed between genotypes in respect of decay percentage. After 120 days of storage the highest decay percentage observed in ET1 and KVD3 (13%). In all genotypes browning percentage was zero at harvest time. At 30 days storage duration, the lowest and highest browning percent belonged to KM1 (0 %) and PK1 (9 %) respectively. Browning percent enhanced when storage period increased. After 90 days of storage, the highest browning percent belonged to ET1 and KVD2. The highest and lowest browning percent belonged to NB4 (14%) and SVS1 (7%) after 120 days of storage.

Table 2: Effect of different genotypes and storage period on measured characteristics

	Flesh firmness (kg/cm2)					TSS (%)					Decay percent			Flesh Browning (%)				Weight loss (%)				Marketability	
genotype	**S0**	**S1**	**S2**	**S3**	**S4**	**S0**	**S1**	**S2**	**S3**	**S4**	**S2**	**S3**	**S4**	**S1**	**S2**	**S3**	**S4**	**S1**	**S2**	**S3**	**S4**	**S0**	**S4**
PH2	8.2d	7.4hij	6.3tuv	5.9yz	5.6z	11.67x	13.3uvw	13.45tuvw	13.67stuvw	14.3opqr	7h	8g	8g	5j	8f	10d	8f	10de	11.6cd	3hij	2ij	Very good	good
NB1	10.2a	9.3b	7.8ef	7.6f	6.9no	12.9vw	12.75w	12.9vw	13.7stuvw	13.9rstuv	6i	8g	9f	3k	5i	7g	8f	17.3a	5ghi	2ij	4n	good	medium
SVS1	7.9e	7.4ghi	7.1m	6.8op	5.7z	13.6tuvw	14.6pqrs	14.6pqrs	14.45opqr	15nopqr	6i	7h	9f	6h	7g	7g	7g	10de	4n	7efg	3hij	poor	poor
NB4	8.9c	7.9e	7.5gh	6.9n	6.4r	13.6tuv	14.2rst	14.6pqrs	14.6pqrs	14.5opqr	15b	16a	8g	9e	10d	9e	14a	3hij	10de	5ghi	5gh	Very good	good
SvS2	7.5gh	7.4ghi	7.3jkl	6.4r	6.2tuv	13.9qrst	14.2rst	15lopq	15.5klmn	15.33jklm	10e	9f	8g	8f	7g	8f	9e	5ghi	16a	2ij	2ij	medium	medium
Kvd2	7.3klm	6.3tuv	6.2tuv	6.1uv	5.3z	14.4nopq	14.55pqr	15.1lmno	15.45klmn	15.7ghij	10e	10e	12d	6h	8f	12b	12b	5ghi	4n	2ij	2ij	good	medium
Pk1	7.2lm	6.4rs	6.3tuv	6.1uv	5.6z	14.7nopq	15.23klmn	15.6hijk	116.1defg	16.47cdef	7h	7h	9f	8f	9e	10d	8f	9.3de	15.3ab	3hij	2ij	Very good	good
KM2	7.4ij	6.4rs	6.2tuv	5.7yz	5.3z	15.6hijk	16.2def	16.6bcde	16.73bcde	/716.7bcde	10e	10e	12d	4j	7g	8f	12b	9.3de	10de	2ij	3hij	Very good	good
KM1	6.7p	6.1w	6xy	5.2z	5z	12.5vw	12.75w	13.2vw	13.7stuvw	13.9rstuv	5j	6i	8g	0m	3k	5i	8f	13bc	4n	5ghi	4n	good	good
Pk2	6.3tuv	6.1w	5.9yz	5.7yz	5.4z	14.85pqr	16.27fghi	17.2abc	17.57hijk	17.7ab	7h	8g	8g	5i	8f	10d	8f	10de	11.6cd	3hij	2ij	Very good	good
ET1	7.3jkl	7.1m	6.3tuv	6.1vw	5.9yz	15mnop	16.4defg	17.1bcde	17.4abc	17.8a	6i	8g	9f	3k	5i	7g	8f	17.3	5ghi	2ij	4n	good	medium
Kvd3	6.9no	6.6q	6.3tuv	5.7yz	5.1z	15.7ghij	16.3efgh	16.9bcde	17.3abc	17.8a	6i	7h	9f	6h	7g	7g	7g	10de	4n	7efg	3hij	poor	poor
KM2	7.4ij	6.4rs	6.2tuv	5.7yz	5.1z	15.6hijk	16.2def	16.6bcde	16.73bcde	16.7bcde	10e	10e	12d	4j	7g	8f	12b	9.3de	10de	2ij	3hij	Very good	good
KM1	6.7p	6.1w	6xy	5.2z	5z	12.5vw	12.75w	13.2vw	13.7stuvw	13.9rstuv	5j	6i	8g	0m	3k	5i	8f	13bc	4n	5ghi	4n	good	good
Pk2	6.3tuv	6.1w	5.9yz	5.7yz	5.4z	14.8opqr	16.27fghi	17.2abcd	17.57hijk	17.7ab	7h	8g	8g	5i	8f	10d	8f	10de	11.6cd	3hij	2ij	Very good	good
ET1	7.3jkl	7.1m	6.3tuv	6.1vw	5.9yz	15mnop	16.4defg	17.1bcde	17.4abc	17.8a	6i	8g	9f	3k	5i	7g	8f	17.3	5ghi	2ij	4n	good	medium
Kvd3	6.9no	6.6q	6.3tuv	5.7yz	5.1z	15.7ghij	16.3efgh	16.9bcde	17.3abc	17.8a	6i	7h	9f	6h	7g	7g	7g	10de	4n	7efg	3hij	poor	poor

In each column, means with the same letters are not significantly different. S0, S1, S2, S3 and S4: harvest time, 30, 60, 90 and 120 day of storage

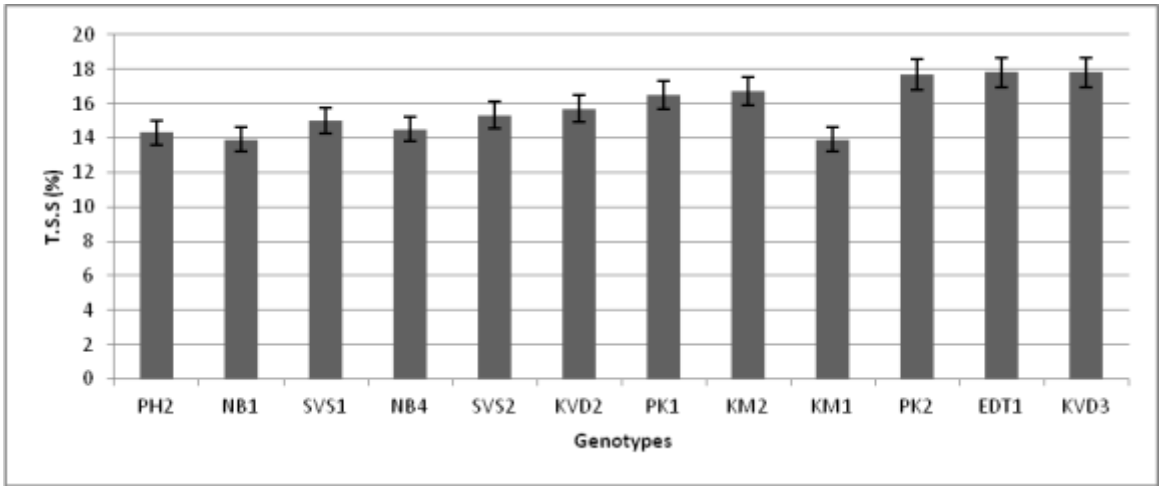

Figure 4: Effect of different genotypes on TSS after 120 days of storage

Weight loss percent significantly affected by genotypes and storage period (table 2). The highest and lowest weight loss percentage at 30 days storage treatment belonged to NB4 (15.3) and KDV2 (3) respectively. After 90 days of storage there were not significant changes in fruit weight of different genotypes. Fruit weight reach to a stable amount after 90 days of storage. Marketability determined by panel test base on fruit shape, taste and flavor (figure 5). Genotypes PH2, NB4, PK1, KM2, PK2, ET1 and KVD3 considered as very marketable ones at harvest time. SVS1 had a poor marketability at harvest time. After 120 days of storage, genotypes KVD2-ET1-PK2-KM1-KM2-PK1-NB4 and PH2 were very marketable, NB1, SVS2 and KVD2 were acceptable and SVS1 show a poor marketability (table 2).

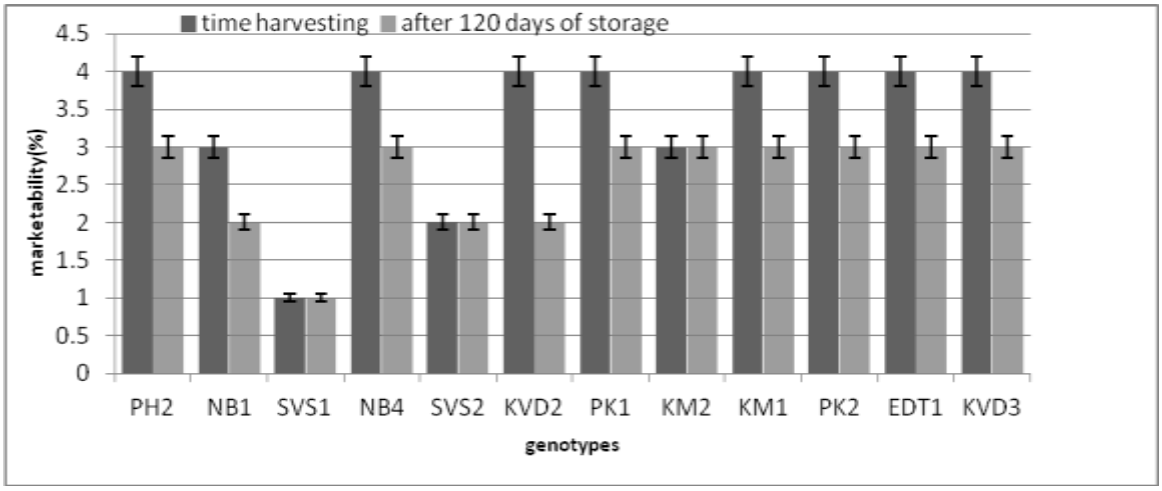

Figure 5: Effect of storage and genotype on marketability

DISCUSSION

Comparison between means showed that flesh firmness significantly affected by storage period. Polygalacturonase is an effective enzyme in fruit ripening which destroy pectin cell walls and results in fruit softening. There is correlation between flesh firmness and fruit texture of each genotype. The most soft and juicy texture the less firmness. Flesh firmness affect by inherent ability of each genotype in absorbance and collecting Ca in cell walls, ethylene production amount, respiration ratio and stage of maturity. The results were in agreement by Kingstone (1992), Turk and Mimaclo (1994), Isaakidis and Michailides (2004) and Akbari and Rahemi (2004) which reported that flesh firmness decrease during storage. TSS significantly varied between different storage periods. Physical and chemical changes in

quince fruit is slower that apple and pear because of its special characteristics Buyukkoca and Karacali (1991). Fruit maturity enhances during cold storage due to enhancing TSS and starch conversion to sugar. TSS increase because of starch conversion to starch. Starch is the main fruit storage substance and break down to fruit sugars (fructose, glucose, sucrose and Sorbitol) before maturity (Rahemi, 1998). Results were in agreement with Ghasemi and Mosharef (2005) and Turk and Mimaclo (1994) which stated that TSS and other fruit qualitative traits affected by harvesting time and storage period. Dry matter decrease, metabolic activities, respiration and transpiration results in weight loss. Respiration ratio increase in climacteric fruits by fruit maturity which results in weight loss (Ashari and Khosro, 2008). Weight loss affected by cold storage conditions such as temperature and RH%, skin fuzz percent and density, skin thickness, mineral ingredients of fruit and surface to volume percent of fruit (Anokpornm *et al.*, 2008). The same results reported by Akbari and Rahemi (2004) and Sakaldas (2008). Fruit bruising is an important physiological damage in fruits. The high amount of phenol compounds in quince makes it susceptible to browning. Flesh browning percent depends on phenol compounds type and amount and the activity of poly phenol oxidase, peroxidase and Phenylalanine ammonia-lyase. Pre and post harvest factors such as variety inherent traits, phenol amount of fruit at harvest time, storage temperature and period, mechanical damages during harvest and transport are effective on browning percent (Fang *et al.*, 2009; Testoni *et al.*, 1992). Different genotypes showed different susceptibility to browning which is related to decomposed phenol compounds. The results is in agreement with Akbari and Rahemi (2004) Sakaldas (2008), Fang, *et al.*, (2009) and Anokpornm, *et al.*, (2008).

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