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ASSESSMENT OF VARIABILITY IN FRUIT QUALITY PARAMETERS OF *PYRUS* GERMPLASM COLLECTED FROM AZAD JAMMU AND KASHMIR (PAKISTAN)

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Abstract

Five districts of the State of Azad Jammu & Kashmir (Pakistan) were explored for evaluation of 60 *Pyrus* accessions for their fruit quality. A considerable variability in organoleptic rating, chemical composition and post-harvest life was observed among the accessions. Fruits of all the accessions locally named as Frashishi and some ecotypes of Desi nashpati were distinguished as excellent for food quality, which was significantly better than those of other accessions. Five accessions locally called as Btangi remained at bottom in the evaluation criteria. Fruit samples of Frashishi accessions (MZ32, SD49, BG25 and SD40) had higher TSS and total sugar contents as compared to other accessions. The fruits of KT54 (Btangi) had the lowest TSS and total sugar contents. The maximum vitamin C content was recorded in RT11 (Glass) while the fruits of MZ33 and BG17 (both locally called as Btangi) had the minimum vitamin C content. The fruits of Kotharnul (BG21 and KT50) can be kept at room temperature for more than 21 days. However, most of the accessions locally referred as Frashishi possessed excellent and unique sensory properties but had comparatively less storability. The cluster dendrogram performed on the basis of studied parameters to assess pattern of diversity, differentiated accessions into four clusters and exhibited significant variability among the accessions. These results suggest that variability accounted for fruit quality was due to either genotypes or environmental conditions prevailing in the growing areas or interaction of both the factors.

Introduction

Pear stands 2nd after apples as the most frequently consumed fruit and the most economically important tree fruit in temperate zones of the world. Overall, world pear production reached to 19.5 million metric tonnes in 2005 (FAO, 2006). It belongs to the genus *Pyrus* which probably originated from Central Asia, the mountainous regions of western and southern China, from Asia Minor to India and further diversified and moved both in eastern and western directions from primary centre of origin (Watkins, 1976). Speciation has occurred mainly in eastern and central Asia in the Himalayas, Caucasus, Asia Minor and Eastern Europe. Challice & Westwood (1973) made detailed taxonomic studies of the genus *Pyrus* on the basis of both chemical and botanical characters and categorized 22 primary species. These primary species exist in all temperate regions in more than 50 countries. About 72% of all commercially cultivated species of the genus *Pyrus* are native to Asia. United States accommodates about 1,500 clones, 40% of these are Asian pear varieties (Nee *et al*., 2002). Pear fruits available in the world market belong either to *P. communis* or *P. pyrifolia* or hybrid group of these two species. The fruit constitutes an important part of the human diet, as it is excellent source of carbohydrates, sugars and dietary fibre (Blattny, 2003). Variability in taste and colour of fruits is mostly due to changes in contents and ratios of sugars (Doyon *et al*., 1991). Citric and malic acid ratios in pear fruit juice correlate the organoleptic evaluation of taste and quality criterion (Hudina & Stampar, 2000). The European and West Asian pears are relished for their buttery, juicy, fine texture and flavour, whereas East and North Asian pears for their crisp and sweet taste.

The genus *Pyrus* is highly diverse in phenological, physicochemical and organoleptical characteristics (Shen, 1980). The potential of *Pyrus* species remained largely unexplored in Asia. Pear genotypes show variation in fruit characteristics due to hybridization, natural seed based propagation, bud mutations and diverse agro-ecological conditions. Eating quality like aroma, flavour and texture are the most important traits that guide the consumer preferences for fruits (Daillant-Spinnler *et al*., 1996; Jaeger *et al*., 1998; Harker *et al*., 2002). Moreover, the cultivars chosen for their high vitamin C content could be of interest for fruit processing industries. Compositional quantification and sensory qualities have been evaluated in many fruits such as apples (Wu *et al*., 2007; Drogoudi *et al*., 2008; Vieira *et al*., 2009), grapes (Sato *et al*., 2000), mango (Akhtar *et al*., 2009) and peach (De Souza *et al*., 1998), and wide variations in the physicochemical properties have been reported among genotypes. Variability in fruit characteristics related to wild, primitive varieties of other temperate fruits have also been reported (Zaffar *et al*., 2004; Paganova, 2009). However, physico-chemical characteristics are influenced by genetic and environmental factors.

The State of Azad Jammu & Kashmir (Northern Pakistan) lies near the primary centre of diversity of genus *Pyrus* and other temperate fruits and its mountainous area is agro-ecologically very well suited for the production of these fruits**.** Due to geographical diversity, unevenness, naturalized population and inter-specific cross pollination, the region represents high degree of genetic diversity in fruit plants (Zaffar *et al*., 2004). The wide adaptation of the pear genotypes has great variability in their fruit quality. Therefore, characterization for all existing variation within genotypes is of vital importance. Fruit quality (chemical characteristics, organoleptic evaluation and storability) have not yet been fully characterised for the pear genotypes found in the region, which is important in assessing potential for their commercialization. The aim of the study was to characterise genetic diversity based on fruit quality parameters and screen out the plant material for horticultural interest. The promising genotypes can be promoted for nursery trade, fruit production for both fresh consumption and processing, and to use in breeding programmes.

Materials and Methods

Pear (*Pyrus* sp.) is widely distributed in the State of Azad Jammu and Kashmir, which is geographically situated in the mountainous region of Northern Pakistan. The topography of the area is mainly hilly and mountainous with valleys and stretches of plains. The climate is moist subtropical to cold temperate with an average rain fall varying from 800 to 1600 mm. The elevation ranges from 360 m from south to 6325 m in the north. In the present study, existing pear areas were explored in five districts i.e.

Rawalakot, Bagh, Muzaffarabad, Sudhnoti (Palandari) and some part of Kotli. Sixty accessions of *Pyrus* including two primitive varieties were selected at fruit maturity stage from 48 sites of these 5 districts for evaluation of their fruit quality. Thirty well ripe fruits per tree (90 fruits per accession) were picked randomly during two consecutive years (late June to late November) from all the sites. The fruits were evaluated for organoleptic parameters and analysed for their nutritional value (TSS, total sugars, vitamin C content) and post-harvest life at ordinary room temperature (26±2°C). The detail account of methods adapted is given in the following sections.

Organoleptic/sensory evaluation: Sensory or organoleptic evaluation for aroma, texture and flavour were carried out by a panel of ten members against a scale of 10 scoring points as described by Krum (1955). Ten fruits of each sample were presented to the panel for sensory parameters. Panellists were allowed to re-taste any sample if needed, and required to score the difference between samples by allotting a number from 1- 10 to each sample. The criteria followed was as poor (1.00-3.00), fair (3.01-5.50), good (5.51-8.00) and excellent (8.01-10.00).

Nutrition value (chemical analysis): Twelve fruits from each sample were cut into halves and seeds were removed from the flesh. Then juice was extracted by a blender and preserved in a glass beaker for each sample, separately. The juice was then analyzed for total soluble solid, sugars and ascorbic acid (vitamin C). Total soluble solids were determined using a hand refractrometer at room temperature. One drop of extracted juice from each sample was placed on absolutely dry refractrometer prism and readings were recorded in °Brix. Total sugars of the juice were estimated using the method described by Hortwitz (1960) and were expressed as percentage of juice. Ascorbic acid (vitamin C) was determined by the Indophenol's titration method (Ruck, 1963) and was expressed as (mg/100 ml juice).

Post-harvest life (days): Ten fruits collected from each accession were stored at ordinary room temperature (26±2°C) to evaluate their keeping behaviour. The fruit samples were assessed by making standard of 50% of samples maintaining eatable quality.

Data analysis: The quantitative data recorded were subjected to statistical analysis using MSTATC statistical computer package (Michigan State University, Estate Lancing, MI) following two ways analysis of variance based on years and accessions as factors. The effect of years was found non-significant. Means for the accessions were compared by using Duncan's Multiple Range Test at 5% probability level. The treatment means showing significant differences were separated by using the small letters a to z. As there were 60 accessions and alphabets are only 26, after z, means followed α, β and γ in descending order. Quality parameters were also analyzed by numerical taxonomic technique using cluster analysis (Sneath & Sokal, 1973). Means were standardized prior to cluster analysis using Z-scores. Estimates of Euclidean distance coefficients were made between all pairs of genotypes. Resulting Euclidean coefficients were used to evaluate the relationships between entries with cluster analysis (Rohlf, 2004).

Results and Discussion

The nutritional status and quality of fruit is recognised by its composition such as contents of sugars, acids, minerals and other characteristics like aroma, texture and flavour. All these parameters depend on plant genotypes, environmental conditions, maturity and time of harvesting (Hudina & Stampar, 2005). However, pear fruit that have crispy, highly flavoured and sweet in taste are mostly liked by the consumers. Organoleptic parameter was assessed by a panel of judges on the basis of aroma, texture and flavour of fruits. The accessions were also ranked as poor, fair, good and excellent depending upon the score of organoleptic evaluation. The accessions RT13, BG25, MZ32, SD40 and SD49 (all locally called as Frashishi) had the maximum ratings, ranging from 9.37 to 9.75, with the excellent fruit quality. The rating of these samples was statistically at par with each other and significantly higher than rest of the samples. This was followed by BG14 (Desi nashpati), which although statistically differed from above mentioned accessions but also had excellent fruit quality as per rating scale. However, most of the accessions remained above optimum level and were rated as good. The minimum ratings range (2.0 to 2.25) was recorded in Btangi with accession names as RT9, BG17, MZ33, SD38 and KT54. These five accessions had poor fruit quality and differed significantly from all other accessions in the present study. Pathar nakh (RT4), Btung (RT8, BG15 and KT53) and Raj btung (MZ30, MZ31, MZ37 and KT55) were fair in organoleptic evaluation (Table 1). Btangi, Pathar nakh, Btung and Raj btung are mostly used as rootstocks in the region.

All the accessions locally called as Frashishi, showed excellent rating criteria in terms of aroma, texture and taste, also having the highest soluble solids and sugar contents. Fruit texture and flavour including sugars, acids and aroma are important traits of fruit quality (Daillant-Spinnler *et al*., 1996; Jaeger *et al*., 1998). Variation in organoleptic characters observed by the panel of judges was due to the influence of both genetic and environmental factors. Similar findings have also been reported in apricots (Brown & Walker, 1990), peaches and nectarines (Colaric *et al*., 2005). Chen *et al*. (2007) found that different pear cultivars have different chemical compositions and heritability of texture traits are often low to moderate, influenced by prevailing environmental conditions. Organoleptic evaluation of fruits always relies upon some elements of tasting by humans, which may vary from person to person. However, sensory evaluation technique by panel of judges has been reported by many apple researchers (King *et al*., 2000; Hampson *et al*., 2000). Therefore, in the present study, it was confidently assumed that panel of judges was not only able to perceive differences in flavour and texture attributes being considered but the panellists were also able to undertake this evaluation in an objective fashion and obtained results were appropriate.

Chemical aspects of fruits such as TSS, sugars and vitamin C contents may provide important information to the consumers in terms of recognising a more nutritious fruit (Drogoudi *et al*., 2008). The mean values for total soluble solids of fruits indicated significant differences among the accessions. The maximum TSS percentages were recorded in fruits of the accessions MZ32 and SD49, followed by the accessions BG25 and SD40 (all locally called as Frashishi). All these accessions were statistically at par with each other. On the other hand, a minimum TSS was recorded in KT54, followed by SD38 (both locally known as Btangi). These two accessions were statistically alike but former one differed significantly from rest of the accessions (Table 1).

Table1. Mean values for fruit quality evaluation (organoleptic rating, TSS, total sugars and vitamin C content and post-harvest life) and quality ranking of pear accessions.

Accession No.	Local name	Organoleptic rating	TSS (ºBrix)	Total sugars (%)	Vitamin-C (mg/100ml)	Post-harvest life (days)	Quality ranking
RT1	Khurolli	5.75 e*	7.50 o-s	8.23 j-l	5.57 b	13.13 ijkl	Good
RT2	Bagugosha	7.50 bc	9.75 f-i	8.69 h-j	3.72 h-j	6.38 tu	Good
RT3	Glass	5.75 e	7.63 o-s	7.74 l-o	3.64 h-k	17.75 efg	Good
RT4	Pathar nakh	4.00 f	8.75 j-n	6.76 p-r	2.87 r-w	8.50 qrs	Fair
RT5	Kotharnul	6.00 e	8.38 l-o	7.45 no	4.51 c	18.88 cdef	Good
RT6	Khurolli	5.75 e	7.50 o-s	8.29 i-l	4.25 c-e	18.00 efg	Good
RT7	Desi nash	7.75 b	9.13 h-l	9.21 f-h	3.05 p-u	7.75 rstu	Good
RT8	Btung	4.00 f	7.38 p-t	6.01 st	2.10 z	13.00 ijkl	Fair
RT9	Btangi	2.13 g	6.88 st	6.30 rs	1.80 αβ	17.50 fg	Poor
RT10	Kashmiri nakh	6.00 e	9.25 g-k	7.60 m-o	2.71 vw	10.50 nop	Good
RT11	Glass	6.00 e	7.63 o-s	8.03 k-n	5.94 a	19.50 bcde	Good
RT12	Bagugosha	7.88 b	9.88 e-h	9.29 e-g	4.17 de	7.50 rstu	Good
RT13	Frashishi	9.63 a	11.25 bc	11.43 b	3.38 k-n	6.38 tu	Excellent
BG14	Desi nashpati	8.13 b	10.38 d-f	10.04 d	2.99 q-v	10.13 nopq	Excellent
BG15	Btung	3.75 f	7.38 p-t	5.55 tu	2.05 z α	13.75 ijk	Fair
BG16	Khurolli	6.25 e	7.75 o-s	8.16 j-m	3.79 f-i	20.00 abcd	Good
BG17	Btangi	2.00 g	7.25 q-t	5.14 uv	1.61 βγ	18.63 def	Poor
BG18	Kashmiri nakh	6.13 e	9.63 f-j	9.56 d-f	2.73 vw	12.88 jklm	Good
BG19	Kotharnul	6.00 e	7.75 o-s	8.34 i-k	5.63 b	20.50 abcd	Good
BG20	Desi nakh	7.50 bc	9.75 f-i	9.33 e-g	3.27 l-q	10.88 no	Good
BG21	Kotharnul	6.00 e	8.00 n-r	8.14 j-m	3.15 m-s	21.75 a	Good
BG22	Khurolli	6.25 e	7.63 o-s	7.95 k-n	4.42 cd	21.25 ab	Good
BG23	Kashmiri nakh	6.63 cde	9.63 f-j	9.33 e-g	3.14 m-t	12.88 jklm	Good
BG24	Bagugosha	7.75 b	11.00 cd	9.80 de	3.10 n-t	9.00 pqr	Good
BG25	Frashishi	9.38 a	12.00 ab	12.19 a	3.26 l-q	7.25 rstu	Excellent
MZ26	Kotharnul	5.88 e	8.38 k-o	8.11 k-m	3.06 o-t	21.38 ab	Good
MZ27	Desi nashpati	7.75 b	10.75 c-e	9.46 ef	3.17 m-r	11.50 lmno	Good
MZ28	Glass	6.00 e	8.88 i-n	7.90 k-n	3.02 p-v	20.00 abcd	Good
MZ29	Kashmiri nakh	6.00 e	9.00 h-m	9.25 e-g	3.26 l-q	11.88 klmn	Good
MZ30	Raj btung	4.13 f	7.50 o-s	6.59 qr	2.31 yz	16.25 gh	Fair
MZ31	Raj btung	4.13 f	8.00 n-r	6.90 pq	2.25 yz	13.75 ijk	Fair
MZ32	Frashishi	9.50 a	12.63 a	12.23 a	3.18 m-r	8.25 qrst	Excellent
MZ33	Btangi	2.00 g	6.88 st	4.93 v	1.46 γ	21.25 ab	Poor
MZ34	Pathar nakh	6.00 e	8.75 j-n	6.93 pq	2.93 r-v	12.88 jklm	Good
MZ35	Desi nakh	7.88 b	10.38 d-f	9.10 f-h	3.08 n-t	8.63 pqrs	Good
MZ36	Pathar nakh	6.00 e	8.38 l-o	6.63 qr	2.99 q-v	13.75 ijk	Good
MZ37	Raj btung	4.00 f	6.88 st	6.03 st	2.40 xy	13.88 ij	Fair
SD38	Btangi	2.25 g	6.50 tu	4.93 v	2.43 xy	20.88 ab	Poor
SD39	Desi nakh	8.00 b	9.50 f-j	8.83 g-i	2.85 s-w	7.25 rstu	Good
SD40	Frashishi	9.75 a	11.88 ab	12.34 a	3.09 n-t	6.00 u	Excellent
SD41	Desi nakh	8.00 b	10.13 d-g	9.34 e-g	2.82 t-w	8.75 pqrs	Good
SD42	Khurolli	6.25 e	8.25 l-p	7.88 k-n	5.66 b	20.75 abc	Good
SD43	Pathar nakh	6.25 e	8.25 l-p	6.48 q-s	2.93 r-v	11.88 klmn	Good
SD44	Bagugosha	8.00 b	10.38 d-f	9.68 d-f	3.01 p-v	8.25 qrst	Good
SD45	Kashmiri nakh	6.25 e	9.38 g-j	8.78 g-i	4.04 e-g	11.75 lmn	Good
SD46	Glass	6.25 e	7.75 o-s	7.71 l-o	3.66 h-k	21.00 ab	Good
SD47	Desi nakh	7.63 b	9.50 f-j	9.80 de	3.53 i-l	9.75 opq	Good
SD48	Nashpati	7.38 bcd	10.38 d-f	10.86 c	3.39 k-n	10.50 nop	Good
SD49	Frashishi	9.75 a	12.50 a	11.95 a	2.84 s-w	7.00 stu	Excellent
KT50	Kotharnul	6.25 e	8.13 m-q	7.51 no	4.06 ef	21.50 a	Good
KT51	Kashmiri nakh	6.00 e	9.63 f-j	8.16 j-m	3.32 l-p	11.00 mno	Good
KT52	Desi nakh	7.75 b	9.88 e-h	9.21 f-h	3.84 f-h	8.88 pqrs	Good
KT53	Btung	4.00 f	6.88 st	5.31 uv	2.59 wx	14.63 hij	Fair
KT54	Btangi	2.25 g	6.00 u	4.78 v	2.02 zα	20.00 abcd	Poor
KT55	Raj btung	4.00 f	7.13 r-t	6.03 st	2.30 yz	17.88 efg	Fair
KT56	Bagugosha	7.75 b	10.75 c-e	9.83 de	2.74 u-w	8.38 qrs	Good
KT57	Pathar nakh	6.25 e	8.13 m-q	7.81 k-n	3.85 f-h	11.38 lmno	Good
KT58	Khar nakh	6.50 de	10.13 e-g	7.23 op	3.45 j-m	18.88 cdef	Good
KT59	LeConte	7.75 b	9.75 f-i	7.51 no	3.37 k-o	14.88 hi	Good
KT60	Keiffer	8.00 b	9.88 e-h	8.10 k-m	3.76 g-i	20.38 abcd	Good

*The values are average of two years data. The means followed by similar letter(s) are statistically non-significant at $p \leq 0.05$.

Significant variability in total soluble solid among accessions was observed and all the accessions of Frashishi had the highest TSS with excellent quality of fruit, which was even higher than the established cultivars i.e. LeConte (KT59) and Keiffer (KT60). These results are at par with the findings of Janick (2006) who reported that pear cv. 'H2-169' had 13 to 15% TSS. Significant differences for the parameter have also been reported among quince clones (Guisado *et al*., 2009); higher TSS value has been observed in the mango fruit harvested at noon as compared to morning and evening (Amin *et al*., 2009). Some accessions locally referred as Btangi had the lower TSS values possibly due to their genetic make up. However, significant differences for total soluble solids were found in the accessions RT2, RT12, BG24, SD44, and KT56, all locally called as Bagugosha but grown at different environmental conditions. This variability in TSS might be due to variable climatic conditions mainly temperature and precipitation, as there is considerable variation in rainfall within the study area. Trees with high moisture availability showed less TSS compared to scarce water supply with higher TSS content in pears (Wang, 1982). This indicated that the variability in fruit characteristics especially in fruit composition was not only due to genetic factors but also influenced by climatic factors.

Sugar is basic ingredient of fruit quality and a source of carbohydrates. The mean values for total sugars revealed significant differences among the accessions. The accessions SD40, MZ32, BG25 and SD49 (all locally known as Frashishi) had the highest sugar level ranging from 11.95 to 12.34%. Total sugar percentages of these fruit samples were statistically at par with each other and significantly higher than fruit samples of the other accessions. The lowest range of total sugar percentage was 4.77 to 5.31, recorded in accessions KT54, MZ33, SD38, BG17 (all locally called as Btangi) and KT53 (Btung). Overall data obtained indicated that the fruit samples of Frashishi had the highest, while those of Btangi had the minimum sugar content (Table 1).

In the present investigation, significant differences were recorded among the accessions regarding total sugars, which ranged from 4.77 to 12.34%. Four accessions, locally called as Frashishi, remained at the top, while the accessions locally called as Btangi were at bottom in term of sugar percentage. Contrarily, the accessions RT10, BG18, BG23, MZ29, SD45 and KT51, all locally called as Kashmiri nakh but growing at different locations showed significant variation in sugar contents (7.60 to 9.56%). These differences among the accessions might be attributed to prevailing environmental conditions, harvesting of fruits at different time of maturity/ripening and variability in genotypes. All the accessions of local kind Frashishi were statistically similar showing genetically close relationship with each other. In the same fashion, all the accessions of locally called Btangi might have same genetic make up. These results are in line with the findings of Brown & Walker (1990) and Chen *et al*., (2007) who reported genotypic variations for fruit quality in apricots and pear cultivars, respectively. As far as the environment is concerned, prevailing temperatures and rainfall distribution over growing areas definitely affect growth and composition of fruits. Drought might have a stimulating effect and irrigation a depressing effect on fruit sugars. Behboudian *et al*., (1994) and Hudina & Stampar (2005) reported that excessive water supply decreased the sugar contents in pear fruits and *vice versa*.

The data pertinent to vitamin C content indicated significant differences among the accessions. The maximum vitamin C content was recorded in accession RT11 (Glass) which differed significantly from all the remaining accessions. This was followed by the fruit samples of accessions RT1 (Khurolli), BG19 (Kotharnul) and SD42 (Khurolli) and these three accessions were statistically alike. The minimum vitamin C content was recorded in the accession MZ33 (Btangi), followed by BG17 (Btangi) and both these accessions were statistically similar to each other (Table 1).

Mean values for vitamin C content ranged from 1.46 to 5.94 mg/100 ml of juice, indicating diversity in the pear accessions. The fruits of accession RT11 (Glass) growing at Charh location of district Rawalakot had the maximum vitamin C content and differed significantly from other accessions, including the accessions with same local name (RT3, MZ28 and SD46) but growing at other locations of same or other districts. The accession (RT11) had even higher vitamin C content than the established cultivars i.e., LeConte and Keiffer. The vitamin C content in fruits can be influenced by various factors such as genotypic difference, pre-harvest climatic factors, maturity and harvesting methods. Planchon *et al*., (2004) reported that old genotypes of apple contain three times more vitamin C contents as compared to commercial varieties. For the present study, fruit samples were collected from different geographical and ecological conditions at different intervals from variable age of trees. Fluctuation in day temperature at different localities might be responsible for variability in vitamin C contents. Moreover, fruits of high altitude with low temperature areas proved better in term of vitamin C than collected from low lying and warm localities. In fruits, temperature management is the pivotal to maintain vitamin C and losses are increased at higher temperatures (Lee & Kader, 2000). Ripening behaviour is also cause of fluctuation in vitamin C content in pear fruits likewise; fruits of some accessions were harvested at full maturity stage but not fully ripened because these accessions showed ripening at post-harvest stage. However, in some of the accessions fruit ripened when it was still on the tree. It would be possible that fully ripened fruits start decaying earlier resulting in decrease in vitamin C content. It was further noted that the fruit samples brought from remote areas with delay in transportation considerably affected the concentration of vitamin C. According to Kader (1988), maturity level, harvesting and post-harvest handling conditions also affect the vitamin C content of fruits and vegetables. However, variability in vitamin C content found in the present study could also be due to genetic make up of genotypes.

The results indicated significant differences among the accessions for storability of their fruits at ordinary room temperature (26±2ºC). The maximum post-harvest life (more than 21 days) was recorded in the accessions BG21 and KT50 (both locally named as Kotharnul) and these two accessions were statistically alike. This was followed by fruits of the accessions MZ26 (Kotharnul), BG22 (Khurolli), MZ33 (Btangi), SD46 (Glass), SD38 (Btangi), SD42 Khurolli), BG19 (Kotharnul), KT60 (Keiffer), BG16 (Khurolli), MZ28 (Glass) and KT54 (Btangi). All these accessions were statistically at par with each other and also with former two accessions. Post-harvest life of these accessions ranged from 20 to 21.38 days at normal room temperature. On the other hand, SD40 (Frashishi) showed poor post-harvest life (only 6 days) and stood at par with RT2 (Bagugosha), RT13 (Frashishi), SD49 (Frashishi), BG25 (Frashishi), SD39 (Desi nakh), RT12 (Bagugosha), and RT7 (Desi nash). These results indicated that the fruits of Kotharnul can be kept longer on ordinary room temperature, while those of Frashishi can be stored for only a few days (Table 1).

Post-harvest life of fruits at ordinary temperature corresponds with consumer's choice, marketing system and economical return to the growers. Present investigations regarding this parameter showed significant differences among the accessions. Post-harvest life of the fruits ranged from 6 to 21.75 days. According to Elgar *et al*., (1997) 'Buerre Bosc' and Doyenne du Comice' maintained their eating quality up to 4 weeks at room temperature. The fruits probably have more shelf life when harvested at maturity than at ripening stage. The accessions which ripened off the tree were Kotharnul (18.88 to 21.75 days), Glass (17.75 to 21 days) and Khurolli (13.13 to 21.25 days). All these maintained their eating quality and had comparatively long storability at ambient temperature. On the other hand, all accessions of Frashishi ripened on the tree, had the minimum range of storability (6.00 to 8.62 days) or with the shortest shelf life. It was also noted that these accessions are very perishable, generally consumed by local inhabitants within 10 days. It is interesting to note that some accessions MZ33, SD38 and KT54, locally called as Btangi also showed better storability when harvested at ripening stage. However, their fruit is not eatable as these are wild genotypes mostly used as rootstock by the local farmers. Collection of fruit samples from remote areas was delayed due to difficulties in access and poor transport facilities. Delay in harvesting resulted in low shelf life of fruits with deteriorated keeping quality. Similar findings have also been reported by Chen & Mellenthin (1981). Earlier harvested fruits had low decay incidence and long shelf life but poor quality, whereas late harvested fruits had highest incidence of decaying and shorter storage life (Boonyakiat *et al*., 1987). Additionally, factors like kind and variety of fruits, maturity stage, prevailing temperature and cultural practices adapted also affect enormously on the firmness and shelf life of temperate fruits (Bourne, 1979).

To assess the variability for these quality parameters, a dendrogram was constructed on the basis of mean values of two years data by using Euclidean Distance method. Mean, minimum and maximum values and coefficient of variance for each parameter in each cluster is given in Table 2. The dendrogram illustrated variability among clusters based on mean values and coefficient of variance and relatedness among the accessions which fell within same cluster. All the 60 accessions were grouped into four clusters (Fig. 1). The names of the accessions in each cluster are given in the dendrogram. Seventeen accessions fell in cluster I, 26 in cluster II, 12 in cluster III and only 5 in cluster IV. All the accessions locally known as Frashishi, having excellent fruit quality but poor keeping quality fell in one cluster (cluster IV) indicating its variability from the accessions of the rest of clusters. The accessions locally called Btangi, Btung and Raj btung which are mostly used as rootstocks in the area, had the fair to poor fruit quality and were grouped in cluster III. All the accession which had almost good fruit quality fell in cluster I and cluster II. However, fruits of the accessions grouped in cluster I had lower organoleptic rating and more post-harvest life as compared to those in cluster II.

Cluster analysis for estimation of variability among the accessions based on the parameters studied exhibited diversity/relatedness. Dendrogram illustrated variability at different levels between the accessions of different clusters and relatedness among the accessions within the same cluster. All the accessions were grouped into four clusters according to their similarity in these characters indicating a narrow genetic base, further, most of the accessions showed relationship in chemical composition also called with same local names. Whereas, some accessions called with different names and collected from diverse geographical locations exhibited low genetic variation in cluster analysis. However, the accessions of cluster IV contained of only five accessions, all locally called as Frashishi. This group was entirely diverse from all the accessions for all the parameters studied. The mean ranges estimated, seem to vary greatly among the all studied parameters, however, there is no convincing evidence whether the observed variation was caused by environmental or by genetic factors. However, coefficient of variance of examined traits, showed the variation among each other. The fruit quality of pear genotypes thus seems to vary greatly among the ecotypes grown under variable agro-ecological conditions. Genetic variability in *Pyrus* species is probably due to heterogeneity, diversity in environments and hybrid progeny (Katayama & Uematsu, 2006). The obtained evidences as a result of the present study indicated prospects of some accessions to exploit for commercialization and use in breeding programmes for improvement of existing and evolution of new cultivars.

Table 2. Mean, range (minimum to maximum) and coefficient of variation (CV) for organoleptic evaluation, chemical characteristics and post-harvest life (days) of *Pyrus* accessions in various clusters.

Cluster	No. of accessions	Values	Organoleptic rating	TSS (ºBrix)	Total sugars (%)	Vitamin-C (mg/100 ml juice)	Post-harvest life (days)
I	17	Mean	6.3	8.3	7.9	4.2	19.4
		Minimum	5.8	7.5	7.2	3.0	13.1
		Maximum	8.0	10.1	8.3	5.9	21.8
		CV	10.2	10.4	4.1	23.4	12.2
II	26	Mean	7.0	9.6	8.8	3.21	10.1
		Minimum	4.0	8.1	6.4	2.71	6.3
		Maximum	8.1	11.0	10.8	4.17	13.7
		CV	14.6	8.11	12.9	12.8	19.8
III	12	Mean	3.2	7.1	5.7	2.1	16.8
		Minimum	2.0	6.0	4.8	1.5	13.0
		Maximum	4.1	8.0	6.9	2.6	21.2
		CV	30.2	7.3	12.3	16.2	17.8
IV	05	Mean	9.6	12.1	12.0	3.2	7.0
		Minimum	9.4	11.3	11.4	2.8	6.0
		Maximum	9.8	12.6	12.3	3.4	8.3
		CV	1.7	4.6	3.0	6.5	12.4

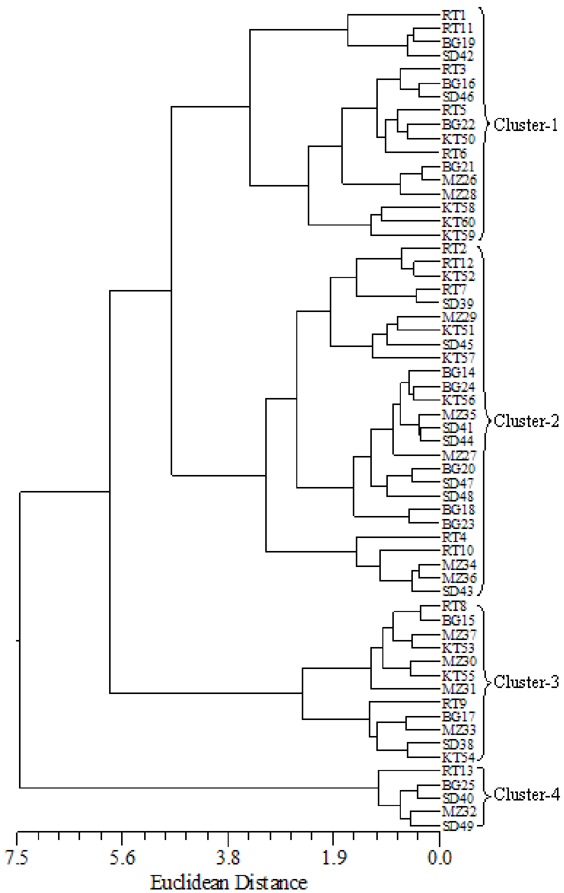

Fig. 1. Cluster analysis showing the relationship between *Pyrus* germplasm from AJK based on fruit quality traits.

Conclusion

Pyrus germplasm found in the region is of diverse nature. The genotypes being self-incompatible and many are hybrid, resulting from natural crossing among *Pyrus* species and seed base propagation had various forms with different fruit composition. Some accessions locally named as Frashishi and Desi nashpati had excellent fruit quality, offer a scope for selecting promising genotypes for commercialization and exploitation for breeding/crop improvement.

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