Research Article

Variability in Physico-chemical Characteristics of Plum Genotypes Collected from Kumaon Hills of Uttarakhand

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Abstract

A survey was conducted in Kumaon hills of Uttarakhand (India) for evaluation of physico-chemical characteristics in twelve plum genotypes. The physical characteristics of fruits were found superior in Collection-8. The highest T.S.S. (15.60 °B) and lowest acidity (0.90%) were recorded in Collection-5, while lowest T.S.S. (10.50 °B) and highest acidity (1.94%) were recorded in the Collection-12. The maximum ascorbic acid (13.33 mg/100 g) was recorded in Collection-1, while minimum ascorbic acid (5.42 mg/100 g) was recorded in Collection-6. The highest total sugars (4.16%), reducing sugars (3.03%) and carotene content (701.97) were recorded in Collection-2, while lowest total sugars (3.73%) and reducing sugars (2.13%) were recorded in the Collection-12. The maximum total anti-oxidant activity (37.35 mMTE/L) was recorded in Collection-3, while minimum total anti-oxidant activity (14.49 mMTE/L) was recorded in Collection-7. The most of the physico-chemical characteristics were found superior in Collection-8, Collection-2 and Collection-5. Theses collections could further be utilized in the breeding programme for the improvement of crop.

Keywords: Plum, collection, evaluation, physico-chemical and quality

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Introduction

Plum is one of the most important temperate deciduous fruit crops and it occupies a conspicuous and prominent position in the world. In India, the area under plum is 23 thousand hectares with approximate production of 76 thousand metric tonnes having a productivity of 3.30 metric tonnes/hectare. The area, production and productivity are found highest in Himachal Pradesh (8.56 thousand hectares), Uttarakhand (34.76 metric tonnes/hectare) and Punjab (17.54 metric tonnes/hectare), respectively [1]. The leading plum cultivar in Kumaon hills of Uttarakhand is 'Santa Rosa' and its over dominance in commercial plantation leads to a monoculture like situation and the farmers do not get remunerative price for their produce [2]. To avoid gluts in the market and to meet ever changing consumer's preferences, there is a need to have varietal diversification in plums by bringing into cultivation genetically improved new cultivars [2]. The local strains are comparatively more tolerant against various abiotic and biotic stresses, arises under changing climate. Hence, to sustain the production, productivity and quality of any crop in present trend of climate change, there is an urgent need to study the physico-chemical performance of locally existing germplasm and use them in breeding programme to develop desired ecotype(s) for the future. Therefore, the proposed study was envisaged to characterize various genotypes of plum (cultivated and wild), existing in the area on the basis of their physico-chemical traits and assess variability among the diverse population. The study will contribute to the knowledge about the genus *Prunus* and will be helpful in broadening the plum gene pool, which can be utilized in future plant breeding programs for the improvement of existing plum cultivars.

Materials and Methods

A survey was conducted in twelve different villages of Kumaon hills of Uttarakhand (India) for evaluation of physico-chemical characteristics in plum genotypes. Formal and informal conversation with local farmers was adopted as a strategy to collect the information about the plum genotypes available in the area. In each village four to five local farmers were consulted before identification of a genotype for collection. Variants were collected randomly at fruit maturity stage from different sites of the district and marked with durable label (aluminium sheet). During the survey, total twelve variants of plums were collected from different villages of Nainital district during 2016 and assessed for their important physico-chemical traits are depicted in **Table 1**.

Table 1 List of different plum genotypes collected during exploration

S. No.	Collection No.	Local Name	Collected from
1	Collection-1	Satsuma	Gehna
2	Collection-2	Satsuma	Dubakhar
3	Collection-3	Jitwa	Gehna
4	Collection-4	Jitwa	Sunkiya
5	Collection-5	Jitwa	Dubakhar
6	Collection-6	Santa Rosa	Dubakhar
7	Collection-7	Green Gauge	Mukteshwar
8	Collection-8	Satsuma	Mukteshwar
9	Collection-9	Kalegi	Mukteshwar
10	Collection-10	Santa Rosa	Gehna
11	Collection-11	Kalegi	Gehna
12	Collection-12	Late Plum	Mukteshwar

The fruit's physical properties in terms of weight (g), volume (cc), specific gravity (g/cc), size (cm) and fruit firmness (lb/in^2) were recorded by calculating the mean of ten fruits at final harvesting stage. The fruit firmness was measured with the help of a penetrometer (Model FT-327, Italy) using 8 mm stainless steel probe. The chemical characteristics of the fruits *viz*. T.S.S., acidity, ascorbic acid, total sugars, reducing sugars, non-reducing sugars and carotene content were recorded by using the methods described by [3] and total anti-oxidant activity was recorded by using the method described by [4]. The data were computed for statistical analysis following the procedure described by [5].

Results and Discussion

A close perusal of data presented in **Table 2** exhibited significant variation in fruit physical characteristics of different plum collections. The highest fruit weight (72.71 g), fruit volume (69.33 cc), fruit length (5.25 cm), fruit diameter (5.04 cm) and pulp weight (68.32 g) were recorded in Collection-8, while the lowest fruit weight (13.08 g), fruit volume (12.33 cc), fruit length (2.74 cm), fruit diameter (2.68 cm) and pulp weight (11.24 g) were recorded in Collection-11. The variation in fruit size (length and diameter), weight and volume with respect to different plum genotypes are mainly attributed to the inter-varietal differences associated with genetic make-up of the genotypes and governed mainly by the cell size and intercellular spaces of the fruit tissues. The results obtained in the present investigation are found to be close conformity with the studies of [6, 7].

Table 2 Physical characteristics of plum genotype collected during exploration

Collection No.	Local Name	Fruit weight (g)	Fruit volume (cc)	Specific gravity (g/cc)	Fruit length (cm)	Fruit diameter (cm)	Fruit firmness ($lb/inch^2$)	Pulp weight (g)	Seed weight (g)	Pulp: stone ratio
Collection-1	Satsuma	40.29	39.67	1.03	4.20	3.85	1.83	38.51	1.78	21.75
Collection-2	Satsuma	41.80	41.00	1.03	4.11	3.85	1.47	39.87	1.93	20.93
Collection-3	Jitwa	26.78	25.67	1.05	3.27	3.44	1.40	25.78	1.01	25.63
Collection-4	Jitwa	33.90	31.33	1.08	3.87	3.63	3.17	31.65	2.26	14.57
Collection-5	Jitwa	24.32	24.67	0.99	3.34	3.25	2.43	22.83	1.49	15.99
Collection-6	Santa Rosa	56.93	54.33	1.04	4.56	4.36	5.53	54.39	2.54	21.46
Collection-7	Green Gauge	33.19	30.67	1.09	3.79	3.78	3.40	31.50	1.69	18.94
Collection-8	Satsuma	72.71	69.33	1.06	5.25	5.04	1.47	68.32	4.39	15.90
Collection-9	Kalegi	34.05	33.33	1.02	3.71	4.00	4.93	31.95	2.10	15.49
Collection-10	Santa Rosa	45.51	43.00	1.07	4.15	4.07	4.90	43.43	2.08	20.92
Collection-11	Kalegi	13.08	12.33	1.06	2.74	2.68	3.57	11.24	1.84	6.17
Collection-12	Late Plum	38.45	40.00	0.96	3.83	3.82	3.47	32.00	6.45	5.11
CD at 5%		9.18	11.43	NS	0.26	0.29	1.94	8.68	1.11	5.19
SEM±		3.13	3.90	0.05	0.09	0.10	0.66	2.96	0.38	1.77

The maximum specific gravity (1.09 g/cc) was recorded in Collection-7, while the minimum (0.96 g/cc) in Collection-12. The variation in specific gravity may probably be due to corresponding changes in fruit weight and volume. The increase in intercellular spaces in the fruit flesh, with the advancement of maturity affects the specific gravity of the fruits.

The highest fruit firmness (5.53 lb/inch^2) was recorded in Collection-6, while lowest (1.40 lb/inch^2) in Collection-3. A change in fruit firmness is primarily attributed to break down of insoluble protopectins to soluble pectin compounds, which ultimately affect the cell wall consistency and thus varied at different stages of fruit growth and ripeness. These findings are in agreement with the prior records of [2, 8].

The highest pulp: stone ratio (25.63) and lowest stone weight (1.01 g) was recorded in Collection-3, whereas lowest pulp: stone ratio (5.11) and highest stone weight (6.45 g) was recorded in Collection-12. A marked increase in pulp: stone ratio with advancement of maturity may be due to accumulation of metabolites thus increasing its weight, whereas reduction in stone weight resulted from the strong competition for assimilates between pericarp and stone in which stone was weaker competitor. As fruit approaches towards maturity, a gradual rise in pulp: stone ratio was observed. The differential behavior in the development of fruit pulp and stone accounted for gradual increase in pulp: stone ratio during fruit development and maturity [9]. These results elucidate the earlier findings of [9, 10] who also reported the pulp: stone ratio in different plum genotypes varies from 12.41 in Kabul Green Gage to 26.29 in Santa Rosa.

The data pertaining to the chemical characteristics of fruits showed considerable variations among the different genotypes of plum (**Table 3**). From perusal of the data presented in Table 3, the highest T.S.S. (15.60 °B) was recorded in Collection-5, while lowest was recorded in the Collection-12 (10.50 °B). The appreciable differences with respect to T.S.S. among different plum genotypes may be explained on the basis of genetic differences with respect to various genotypes, which subsequently affect the synthesis of photosynthates and their further breakdown in to simple metabolites. The results of the present study are in agreement with the findings of [9, 11] who also reported the T.S.S. content in different plum genotypes ranged from 12.19 °B (Red Beauty) to 15.43 °B (AU-Rosa). The maximum acidity (1.94%) was recorded in the Collection-12, while minimum in Collection-5 (0.90%). The differences in the acidity level of fruits are attributed to the presence of varying amount of organic acids in them. The results obtained in the present investigation are found to be in close conformity with the studies of [10, 12].

Table 3 Chemical characteristics of plum genotype collected during exploration

Collection No.	Local Name	TSS (°B)	Acidity (%)	Ascorbic acid (mg/100 g)	Total sugars (%)	Reducing sugars (%)	Non-Reducing sugars (%)	Total anti-oxidant activity (mMTE/L)	Carotene content (μg/100 g)
Collection-1	Satsuma	12.40	1.57	13.33	5.85	4.11	1.65	26.35	660.83
Collection-2	Satsuma	12.07	1.56	10.42	7.63	5.44	2.08	36.33	701.97
Collection-3	Jitwa	12.87	1.32	9.17	4.74	3.90	0.79	37.35	161.99
Collection-4	Jitwa	14.10	1.24	10.83	5.98	4.96	0.97	35.36	298.27
Collection-5	Jitwa	15.60	0.90	9.17	5.00	4.12	0.84	36.53	429.41
Collection-6	Santarosa	14.40	1.22	5.42	5.69	4.15	1.47	27.27	653.12
Collection-7	Green Gauge	14.80	1.17	5.83	4.83	3.13	1.59	14.49	414.50
Collection-8	Satsuma	12.73	1.54	6.25	5.57	4.27	1.23	17.28	408.07
Collection-9	Kalegi	13.37	1.46	8.33	3.90	2.63	1.21	15.48	313.96
Collection-10	Santarosa	13.00	1.31	7.50	6.33	3.50	2.69	17.84	305.47
Collection-11	Kalegi	13.27	1.31	5.83	3.84	2.75	1.04	32.81	338.13
Collection-12	Late Plum	10.50	1.94	7.08	3.73	2.13	1.53	31.45	341.73
CD at 5%		1.80	0.44	3.58	1.33	0.96	1.06	6.69	25.15
SEM±		0.61	0.15	1.22	0.45	0.33	0.36	2.28	8.57

The results of present study revealed significant differences among the plum genotypes for their ascorbic acid content. The highest ascorbic acid (13.33 mg/100 g) was recorded in Collection-1, while lowest was recorded in Collection-6 (5.42 mg/100 g). The synthesis of ascorbic acid in the fruits depends on adequate supply of hexose sugar, which decline at ripening stage might be due to decrease in acidity, which could be attributed to oxidation of ascorbic acid [13]. The findings are in agreement with the prior records of [14] who also reported the ascorbic acid content in different plum genotypes varied from 3.8 mg/100 g in Grand Duke to 7.2 mg/100 g in Green Gauge, whereas [15] reported the ascorbic acid content in fresh fruits of five plum cultivars varied from 3 to 10 mg/100 g, respectively. The maximum total sugars (4.16%) and reducing sugars (3.03%) were recorded in Collection-2, while minimum total sugars (3.73%) and reducing sugars (2.13%) were recorded in the Collection-12. The highest non-reducing sugar (1.65%) was recorded in Collection-1, while lowest in Collection-5 (0.84%). Sugar is a vital constituent of fruits which directly related with sweetness and is fundamental feature of fruit quality (aroma, flavour and texture). The extent of variation in sugars in different plum genotypes may be explained on the basis of leaf: fruit ratio and subsequently on the synthesis of more photosynthates and variable amount of starch in young fruits, which in turn converted into sugar at fruit maturity. These results are in concurrence with the conclusion of [9, 16].

The maximum carotene content (701.97 µg/100 g) recorded in Collection-2, while the minimum was recorded in Collection-3 (161.99 µg/100 g). The results obtained in the present investigation are found to be close conformity with the studies of [14] who also recorded the carotene content in different plum genotypes varied from 300 µg/100 g in Warwick to 850 µg/100 g in Santa Rosa. The highest total anti-oxidant activity (37.35 mMTE/L) was recorded in Collection-3, while lowest total anti-oxidant activity (14.49 mMTE/L) was recorded in Collection-7. The antioxidants are mainly scavengers that reduce the various free radicals and serving in the avoidance of cellular injury and other disease. Likewise, fruit antioxidants have ability to produce resistance in tissues against disease and stress conditions. However, plant genotypes may differ in their antioxidant capacity [17]. The results obtained in the present investigation are found to be in close conformity with the studies of [12, 18].

The variability in various chemical characteristics of fruits may be due to environmental conditions, harvesting of fruits at different time of maturity/ripening and genetic variability in genotypes.

Conclusion

From the present study, it can be inferred that the physico-chemical performance of Collection-8, Collection-2 and Collection-5 are better under changing climatic conditions of this region, hence would be popularized in the future. However, further evaluation with some more strains in multi-location trials is to be done for verification of the results. Moreover, these strains could also be used for further breeding/improvement programme for achieving better yield and quality and to harness plant potential in fullest under the changing climatic conditions in the Himalayan region.

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Publication History

Received 04th Mar 2017

Revised 15th Mar 2017

Accepted 15th Mar 2017

Online 30th Mar 2017