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Arun Kishor

ICAR-CITH, Regional Station,
 Mukteshwar- 263 138, Nainital
 Uttarakhand, India

Raj Narayan

ICAR-CITH, Regional Station,
 Mukteshwar- 263 138, Nainital
 Uttarakhand, India

Manoj Brijwal

ICAR-CITH, Regional Station,
 Mukteshwar- 263 138, Nainital
 Uttarakhand, India

Brij Lal Attri

ICAR-CITH, Regional Station,
 Mukteshwar- 263 138, Nainital
 Uttarakhand, India

Anil Kumar

ICAR-CITH, Regional Station,
 Mukteshwar- 263 138, Nainital
 Uttarakhand, India

Sovan Debnath

ICAR-CITH, Regional Station,
 Mukteshwar- 263 138, Nainital
 Uttarakhand, India

Correspondence**Arun Kishor**

ICAR-CITH, Regional Station,
 Mukteshwar- 263 138, Nainital
 Uttarakhand, India

Studies on physico-chemical characteristics of different apple strains collected from Nainital district of Uttarakhand

Arun Kishor, Raj Narayan, Manoj Brijwal, Brij Lal Attri, Anil Kumar and Sovan Debnath

Abstract

A survey was conducted in Nainital district of Uttarakhand for evaluation of physico-chemical characteristics in sixteen apple strains. The highest fruit weight (304.37 g), fruit volume (300.00 cc), fruit length (8.08 cm) and fruit diameter (9.05 cm) were recorded in Collection-2 whereas highest T.S.S. was recorded in Collection-5 (13.97 °B), while lowest acidity was recorded in Collection-10 (0.90%) whereas the ascorbic acid content was found maximum in Collection-16 (10.42 mg/100 g). The Collection-12 exhibited highest total sugars (10.39%), reducing sugars (9.23%) and total anti-oxidant activity (40.70 mMTE/L). Among all the strains the highest carotene content was recorded in Collection-4 (137.31 µg/100 g). The Collection-1 was the most luminous ($L^*=85.20$), whereas the highest red colour was recorded in Collection-2 ($a^*=+42.26$). The yellow colour ($b^*=+68.25$) and Chroma ($C^*=68.89$) were found highest in Collection-6, while highest hue angle was recorded in Collection-8 ($h^\circ=91.40$). The most of the physico-chemical characteristics were found superior in Collection-2 and Collection-12 as compared to other apple collections.

Keywords: Apple strains, collection, evaluation, physico-chemical and quality

Introduction

Apple (*Malus x domestica* Borkh.) is the most important temperate fruit crop of the North-Western Himalayan region of the country. In India, the area under apple is 313.00 thousand hectares with approximate production of 2497.70 thousand metric tonnes having a productivity of 8.00 metric tonnes/hectare. Uttarakhand is the third largest producer of apple in India with an annual production of 77.50 thousand metric tonnes from an area of 30.00 thousand hectares with a productivity of 2.60 metric tonnes per hectare ^[1]. The leading apple variety in Nainital district of Uttarakhand is 'Red Delicious' and its over dominance in commercial plantation leads to a monoculture like situation and the farmers do not get remunerative price for their produce. To avoid gluts in the market and to meet ever changing consumer's preferences, there is a need to have varietal diversification in apple by bringing into cultivation genetically improved new cultivars ^[2]. The local strains are comparatively more tolerant against various abiotic and biotic stresses which have adapted under changing climate of the region. 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 ecotypes of apple, existing in the area on the basis of their physico-chemical traits and assess variability among the diverse population as the variability provide/offer the scope of improvement in the population through direct selection, hybridization and hybridization followed by selection procedures.

Materials and Methods

A survey was conducted in Nainital district of Uttarakhand (India) to study of physico-chemical characteristics of apple strains collected from different apple growing parts of the district. Formal and informal conversation with local farmers was adopted as a strategy to collect the information about the apple genotypes available in the area. In each village four to five 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 sixteen variants of apple were collected from different villages of Nainital district during fruit maturity stage in 2016 and assessed for their important physico-chemical traits as depicted in Table 1.

Table 1: List of different apple germplasm collected during exploration

S. No.	Collection No.	Local Name	Collected from
1	Collection-1	Bhura Delicious	Supi
2	Collection-2	Bhura Delicious	Sunkiya
3	Collection-3	Bhura Delicious	Sunkiya
4	Collection-4	Bhura Delicious	Supi
5	Collection-5	Red Fuji	Ramgarh
6	Collection-6	Buckingham	Sunderkhal
7	Collection-7	Rymer	Dhanachuli
8	Collection-8	Golden Delicious	Ramgarh
9	Collection-9	Braeburn	Ramgarh
10	Collection-10	Rymer	Supi
11	Collection-11	Bhura Delicious	Sunderkhal
12	Collection-12	Kems Spur	Ramgarh
13	Collection-13	Bhura Delicious	Sunderkhal
14	Collection-14	Bhura Delicious	Sunkiya
15	Collection-15	Winter Banana	Supi
16	Collection-16	Bhura Delicious	Sunkiya

The physical properties of fruit in terms of weight (g), volume (cc), specific gravity (g/cc), size (cm) and fruit firmness (lb/in²) 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 colour values of different apples cultivars were obtained in terms of L*, a*, b*, C* and h° values using a Lovibond RT series reflectance tintometer. The 'L*' measures luminosity or lightness and varies from zero (black) to one hundred (perfect white). The chromaticity dimension 'a*' measures redness when positive, grey when zero, and greenness when negative. The 'b*' value measures yellowness when positive, grey when zero, and blueness when negative. The 'C*' describes the chroma (saturation) of the colour, a measure of how far from the grey tone the colour is. Hue angle (h°), describes the hue of the colour, i.e., colour tonalities (red, green, yellow etc.) [5]. The statistical analysis was done as per procedure described by [6].

Results and Discussion

A close perusal of data presented in table 2 exhibited significant variation in fruit physical characteristics of different apple collections. The highest fruit weight (304.37 g), fruit volume (300.00 cc), fruit length (8.08 cm) and fruit diameter (9.05 cm) was recorded in Collection-2, while the lowest fruit weight (103.87 g), fruit volume (106.67 cc), fruit length (5.51 cm) and fruit diameter (6.27 cm) was recorded in Collection-6. The variation in fruit size (length and diameter), weight and volume with respect to different apple strains is 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 in close conformity with the studies of [7, 8].

The highest specific gravity was recorded in Collection-9 (1.07 g/cc), while the lowest was recorded in Collection-1 (0.90 g/cc). 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. These findings are in agreement with the prior records of [9]. The highest fruit firmness was recorded in Collection-5 (9.10 lb/inch²), while lowest in Collection-11 (3.57 lb/inch²). A change in fruit firmness is primarily attributed to break down of insoluble protopectins to soluble pectin compounds, which ultimately affects 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 [7, 8].

The data pertaining to the chemical characteristics of fruits showed considerable variations among the different genotypes of apple. From perusal of the data presented in Table 3, the highest T.S.S. was recorded in Collection-5 (13.97 °B), while lowest in Collection-13 (10.50 °B). The appreciable differences with respect to T.S.S. among different apple 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 into simple metabolites. The highest acidity was recorded in Collection-10 (0.90%) and lowest in Collection-2 (0.28%). 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 [8, 10].

The highest ascorbic acid content was recorded in Collection-16 (10.42 mg/100 g), while lowest in Collection-6 (3.75 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 [11]. These findings are in agreement with the prior records of [12].

The highest total sugars (10.39%) and reducing sugars (9.23%) were recorded in Collection-12, while lowest total sugars (5.92%) and reducing sugars (5.17%) was observed in Collection-15. However, the highest non-reducing sugars were recorded in Collection-13 (1.94%) and lowest in Collection-1 (0.56%). Sugar is a vital constituent of fruits which is directly related with sweetness and is fundamental feature of fruit quality (aroma, flavour and texture). The extent of variation in sugars in different apple 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 is converted into sugar at fruit maturity. These results are in concurrence with the conclusion of [7].

Carotene content of fruits was found highest in Collection-4 (137.31 µg/100 g) while the lowest in Collection-5 (60.17 µg/100 g). The results obtained in the present investigation are found to be in close conformity with the studies of [13]. The highest total anti-oxidant activity was found in Collection-12 (40.70 mMTE/L), while lowest in Collection-11 (21.32 mMTE/L). The results obtained in the present investigation are found to be close conformity with the studies of [14]. 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 [14].

There were significant differences in colour parameters (L^* , a^* , b^* , C^* and h°) among the different apple collections (Table 4). The Collection-1 is the most luminous ($L^*=85.20$), while Collection-12 is the least luminous ($L^*=29.05$). The ground colour as well as blush depends on sunlight during ripening. Low value of ' L^* ' indicates a dark fruit skin. The ' a^* ' or red-green values showed a significant differences among the different germplasms studied. The Collection-2 showed the highest red colour ($a^*=+42.26$), while the lowest values were shown by Collection-8 ($a^*=+1.50$). The ' b^* ' or yellow-blue component values were found highest in Collection-6 ($b^*=+68.25$), whereas the lowest values were shown by Collection-12 ($b^*=+17.06$). The Chroma (C^*) values measure colour saturation or intensity, a measure of how far from the grey tone the colour is. The Collection-6 ($C^*=68.89$) showed the highest ' C^* ' value among the different genotypes, whereas the Collection-10 ($C^*=29.65$) showed the lowest ' C^* ' values. The hue angle (h°) that correlates with ' a^* ' and ' b^* ' values, was a good factor to assess changes of the characteristic colour in these cultivars. Lower h° values indicate a redder colour, as exemplified by the Collection-12 ($h^\circ=26.46$),

whereas the Collection-8 ($h^\circ=91.40$) showed the highest h° values. Colour is the most important indicator of maturity and quality in many fruit species. It is mainly influenced by the concentration and distribution of various anthocyanins in the skin, as well as by other factors, such as light, temperature, ethylene and cultural practices [15]. The results obtained in the present investigation are found to be close conformity with the studies of [5].

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. Thus, it can be inferred that the physico-chemical performance of Collection-2 and Collection-12 are better under changing climatic conditions of this region, hence would be popularized in the region. However, further evaluation with some more strains in multi-location trials is to be done. 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 of the Himalayan region.

Table 2: Physical characteristics of apple germplasm 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)
Collection-1	Bhura Delicious	144.34	160.00	0.90	5.77	7.18	3.83
Collection-2	Bhura Delicious	304.37	300.00	1.02	8.08	9.05	4.60
Collection-3	Bhura Delicious	146.01	153.33	0.95	5.88	7.14	6.60
Collection-4	Bhura Delicious	218.58	223.33	0.98	7.20	8.34	3.83
Collection-5	Red Fuji	188.86	196.67	0.96	7.56	7.82	9.10
Collection-6	Buckingham	103.87	106.67	0.97	5.51	6.27	5.73
Collection-7	Rymer	201.13	206.67	0.98	6.39	8.25	5.53
Collection-8	Golden Delicious	152.04	151.67	1.00	6.53	7.12	7.63
Collection-9	Braeburn	181.81	170.00	1.07	6.62	7.58	8.13
Collection-10	Rymer	235.00	253.33	0.93	6.90	9.01	7.83
Collection-11	Bhura Delicious	124.17	120.00	1.03	5.68	6.69	3.57
Collection-12	Kems Spur	194.00	183.33	1.06	6.80	8.22	7.53
Collection-13	Bhura Delicious	163.48	155.00	1.05	6.37	7.26	4.23
Collection-14	Bhura Delicious	193.45	183.33	1.05	6.90	7.87	5.87
Collection-15	Winter Banana	155.34	146.67	1.06	6.42	7.05	4.70
Collection-16	Bhura Delicious	243.00	236.67	1.03	7.03	8.37	3.87
SEM \pm		8.45	10.50	0.01	0.34	0.27	0.61
CD at 5%		24.41	30.32	0.04	0.99	0.78	1.76

Table 3: Chemical characteristics of apple germplasm collected during exploration

Collection No.	Local name	TSS ($^\circ$ B)	Acidity (%)	Ascorbic acid (mg/100 g)	Total sugars (%)	Reducin g sugars (%)	Non-Reducing sugars (%)	Carotene content (μ g/100 g)	Total anti-oxidant activity (mMTE/L)
Collection-1	Bhura Delicious	11.73	0.68	4.17	8.13	7.54	0.56	74.05	30.77
Collection-2	Bhura Delicious	13.70	0.28	5.83	9.44	8.37	1.01	88.01	33.14
Collection-3	Bhura Delicious	13.23	0.49	6.67	7.86	7.17	0.66	87.94	27.24
Collection-4	Bhura Delicious	12.63	0.59	4.42	7.55	6.92	0.60	137.31	32.31
Collection-5	Red Fuji	13.97	0.44	5.00	8.35	7.59	0.72	60.17	35.09
Collection-6	Buckingham	12.77	0.43	3.75	8.60	7.07	1.45	70.61	27.90
Collection-7	Rymer	11.27	0.74	5.42	8.15	7.20	0.90	84.90	32.39
Collection-8	Golden Delicious	12.27	0.55	4.17	8.81	7.90	0.86	103.08	33.67
Collection-9	Braeburn	12.73	0.49	4.17	8.01	6.92	1.03	64.86	35.26
Collection-10	Rymer	11.50	0.90	5.00	7.84	6.87	0.92	80.11	30.25
Collection-11	Bhura Delicious	11.00	0.75	8.75	7.61	6.13	1.41	95.65	21.32
Collection-12	Kems Spur	12.03	0.54	6.67	10.39	9.23	1.10	118.80	40.70
Collection-13	Bhura Delicious	10.50	0.60	7.08	8.15	6.11	1.94	115.99	27.09
Collection-14	Bhura Delicious	13.13	0.54	6.67	7.92	6.06	1.76	80.35	34.29
Collection-15	Winter Banana	11.83	0.58	6.25	5.92	5.17	0.71	98.58	29.93
Collection-16	Bhura Delicious	12.73	0.52	10.42	8.89	8.19	0.67	83.38	35.99
SEM \pm		0.39	0.05	0.73	0.36	0.38	0.14	1.55	0.49
CD at 5%		1.12	0.16	2.12	1.03	1.11	0.42	4.50	1.43

Table 4: Fruit colour characteristics of apple germplasm collected during exploration

Collection No.	Local name	L*	a*	b*	Chroma (C*)	Hue angle (h°)
Collection-1	Bhura Delicious	85.20	+11.73	+50.66	52.00	76.97
Collection-2	Bhura Delicious	64.79	+42.26	+40.18	58.31	43.55
Collection-3	Bhura Delicious	60.25	+31.30	+38.90	50.12	50.91
Collection-4	Bhura Delicious	66.52	+18.53	+42.62	46.43	66.51
Collection-5	Red Fuji	51.02	+20.90	+22.21	30.50	46.74
Collection-6	Buckingham	84.01	+9.42	+68.25	68.89	84.14
Collection-7	Rymer	55.80	+18.46	+31.91	36.86	59.95
Collection-8	Golden Delicious	80.64	+1.50	+61.41	61.43	91.40
Collection-9	Braeburn	65.32	+16.39	+42.73	45.77	69.01
Collection-10	Rymer	55.12	+9.03	+28.24	29.65	72.27
Collection-11	Bhura Delicious	59.45	+34.32	+39.53	52.35	49.04
Collection-12	Kems Spur	29.05	+34.27	+17.06	38.28	26.46
Collection-13	Bhura Delicious	61.11	+21.75	+32.52	39.12	56.23
Collection-14	Bhura Delicious	56.42	+36.44	+29.80	47.07	39.27
Collection-15	Winter Banana	81.13	+10.91	+62.07	63.02	80.03
Collection-16	Bhura Delicious	64.26	+40.28	+39.57	45.21	37.79
SEM±		1.08	0.42	0.40	0.74	0.69
CD at 5%		3.14	1.23	1.17	2.13	2.01

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