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Screening of Low Chill Peaches Grown under Indian Subtropics for Phenolic Compounds, Vitamins and Organic Acids

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ABSTRACT

Background: Peach [*Prunus persica* (L.) Batsch] fruits are good source of phenolic compounds, vitamins and organic acids. Low chill peach cultivars require low chilling hour for bud burst and growth.

Methods: Seven phenolic compounds, four vitamins and six organic acids were profiled in eight low chill peach cultivars at edible ripe stage using HPLC-PDA and evaluated using multivariate analysis.

Result: Gallic acid, chlorogenic acid and catechin were the most predominant phenolic components, ascorbic acid and niacin were the major vitamins and citric acid and malic acid were the prevalent organic acids in all peach cultivars. Though not a single low chill peach cultivar possessed all the nutraceuticals in good amount, Sharbati Surkha and Sharbati contained maximum amounts of total of identified phenolic components (1472.20 and 1306.89 µg/g, respectively), whilst Sharbati, Sharbati Surkha and Pant Peach-1 had maximum amounts of total of identified vitamins (368.22, 341.48 and 335.13 µg/g, respectively). Total of identified organic acids were recorded maximum in Pant Peach-1, Pratap, Shan-e-Punjab and Sharbati Surkha (21.12, 18.70, 18.56 and 17.66 mg/g, respectively). Sharbati Surkha was the best cultivar overall while other cultivars could be used either for fresh consumption or for imparting flavor in peach based processed products.

Key words: HPLC-PDA, Low chill peaches, Multivariate evaluation, Organic acids, Phenolic compounds, Vitamins.

INTRODUCTION

Peach [*Prunus persica* (L.) Batsch] is one of the important stone fruits grown in India. It belongs to family Rosaceae and sub-family Prunoidae. It was originated in China more than 4000 years ago and currently there are around 3000 peach cultivars available in the world (Faust and Timon, 1995). Peach fruits are nutritionally important as they contained antioxidant phenolic compounds, vitamins, minerals and organic acids. Phenolic compounds are large group of secondary plant metabolites found in almost all plant parts having the abilities to quench lipid peroxidation, prevent DNA oxidative damage, scavenge free radicals and check inhibition of cell communication (Cao and Cao, 1999). Ascorbic acid is a potent antioxidant with abilities to eliminate reactive oxygen species, keep the membrane-bound α-tocopherol in reduced state, acts as a cofactor for some enzymes and can play a role in stress resistance (Arrigoni and de Tullio, 2002). Organic acids are not only responsible for imparting flavor and aroma in fruits but also involved in digestion, stimulate the stomach and pancreas and increase intestine motor function (Drincovich *et al.*, 2016).

Recently characterization of phenolic compounds in various peach cultivars grown in different countries like USA (Gil *et al.*, 2002), Chile (Infante *et al.*, 2011), France (Mokrani *et al.*, 2016), Tunisia (Dabbou *et al.*, 2017), South Korea (Kim *et al.*, 2014), Pakistan (Manzoor *et al.*, 2012), China (Zhao *et al.*, 2015), *etc.* has been investigated. The available information on the estimation of B-vitamins and organic acids in peach cultivars is sporadic (Lima *et al.*, 2013). This information is not available in India, that too in low chill peaches. Low chill peach cultivars require low chilling hour (75-200 h) for bud burst and growth and mainly grown in sub-mountainous regions of Jammu and Kashmir, Himachal Pradesh, Punjab, Uttarakhand, Nilgiri Hills, Jharkhand and North-Eastern States (Josan *et al.*, 2009). In India, only ascorbic acid was estimated in some low chill peach cultivars (Jana, 2015; Chaurasiya and Mishra, 2017; Talang *et al.*, 2019). ICAR-CISH has recently introduced some low chill peach cultivars for subtropics of Lucknow to enhance farmers' income through crop diversity in traditional mango belt. The aim of the present investigation was, therefore, the evaluation and characterization of different phenolic compounds, organic acids and vitamins in some low chill peach cultivars grown in sub-tropics of Lucknow.

MATERIALS AND METHODS

Ten uniformly ripened and blemish-less fruits from eight low chill peach cultivars (Florda Prince, Shan-e-Punjab,

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Sharbati, Earligrande, Saharanpur Prabhat, Pratap, Pant Peach-1 and Sharbati Surkha) were harvested from the farm of ICAR–Central Institute for Subtropical Horticulture, Rehmankhera, Lucknow. Fruits were collected in two seasons (2017-18 and 2018-19) and pooled data was presented in this article. Required quantity of homogenized fruit sample for the estimation of three groups of nutraceuticals was collected in triplicate. Reference standards of different nutraceuticals were procured from Sigma-Aldrich India branch, Mumbai. HPLC grade solvents like methanol and water along with analytical grade reagents such as hexane sulphonic acid sodium salt and potassium dihydrogen orthophosphate were purchased from the local market. Stock solutions of 1000 µg/mL were prepared for each reference standard in methanol for phenolic compounds, in hexane sulphonic acid sodium salt buffer solution for B-vitamins and in phosphate buffer solution for organic acids and ascorbic acid. Extraction of phenolic compounds, organic acids and B-vitamins was done as per the methods described in literature (Bhattacherjee *et al.*, 2020; Bhattacherjee *et al.*, 2019). The characterization of nutraceuticals has been done in a HPLC system (Shimadzu LC20 AVP Series, Japan) as per the methods mentioned (Bhattacherjee *et al.*, 2011; Nour *et al.*, 2010; Bhattacherjee *et al.*, 2019).

The analysis of variance (ANOVA) was performed using completely randomized design with three replications by software Web agri stat package (WASP) version 2.0 by applying Student's t-test for comparison of means ($p \leq 0.05$). SPSS version 16 and SAS 9.3 statistical software were used for application of multivariate techniques- principal component analysis (PCA) and canonical discriminant function (CDF) analysis for exploring the relationship between the phenolic compounds, vitamins and organic acids of the fruits and to verify the presence of any difference between cultivars.

RESULTS AND DISCUSSION

Characterization of phenolic compounds in low chill peach cultivars

Among the seven phenolic compounds identified and quantified in eight low chill peach cultivars, gallic acid, chlorogenic acid and catechin were the major compounds estimated in all low chill peach cultivars and *p*-coumaric acid was the least quantified one. Maximum amounts of gallic acid (540.47 µg/g), chlorogenic acid (494.00 µg/g), catechin (225.60µg/g), ellagic acid (86.70 µg/g) and *p*-coumaric acid (32.08µg/g) were recorded in Sharbati Surkha which was also the richest source of total of identified phenolic compounds (1472.20 µg/g). Maximum amounts of epicatechin (167.63 µg/g) and caffeic acid (81.36 µg/g) were detected in Saharanpur Prabhat and Florda Prince, respectively (Table 1). Cultivars Sharbati (1306.89 µg/g), Florda Prince (1174.90 µg/g) and Saharanpur Prabhat (1147.63 µg/g) were the other good sources of phenolic compounds. In Chile, six phenolic compounds were detected in two peach cultivars using HPLC-DAD with Elegant Lady containing higher amount of total phenols than Carson (Infante *et al.*, 2011). The total phenolics content in three peach cultivars from Pakistan ranged between 711.7 (Shahpasand) to 881.3 (Golden) mg GAE/100 g (Manzoor *et al.*, 2012). In China, chlorogenic acid and catechin were the predominant components in both peel and pulp among nine phenolic compounds identified in seventeen peach cultivars (Zhao *et al.*, 2015). Total phenolic contents in seven Algerian peach cultivars ranged between 19.8 (cv. Romea) to 81.5 mg/g (cv. Spring Belle) where thirteen phenolic compounds were detected (Mokrani *et al.*, 2016). Dabbou *et al.* (2017) have also reported that chlorogenic acid and catechin were the predominant phenolic compounds in both flesh and peel of peach fruit grown in Tunisia. Highly significant variations in phenolic components among different peach cultivars suggested that they are genotypic characteristics depending on geographical locations.

Screening of vitamins in low chill peach cultivars

Among the four vitamins quantified in eight low chill peach cultivars, ascorbic acid was the highest quantified vitamin in fruit with less significant variation followed by niacin. Sharbati, Sharbati Surkha and Pant Peach-1 were found rich in ascorbic acid content (330, 310 and 300 µg/g, respectively). Cultivars Shan-e-Punjab (28.40 µg/g), Saharanpur Prabhat (28.23 µg/g) and Pant Peach-1 (27.23 µg/g) contained good amount of niacin. The richest source of riboflavin was Saharanpur Prabhat (15.43 µg/g) followed by Shan-e-Punjab (13.87 µg/g), Pratap (13.53 µg/g) and Sharbati (12.73µg/g) (Table 2). Similarly, Saharanpur Prabhat (3.42 µg/g), Sharbati (2.84 µg/g) and Earligrande (2.72 µg/g) were the good sources for thiamine. Overall cultivars Sharbati, Sharbati Surkha and Saharanpur Prabhat were the excellent sources of these identified vitamins. A study from USA has reported that raw peach fruit contained 0.024 mg of thiamine, 0.031 mg of riboflavin, 0.806 mg of niacin and 6.6 mg of ascorbic acid per 100 g (USDA, 2015). Leonel *et al.* (2014) in Brazil have reported that peach cultivars Marli and Dourado-2 possessed highest levels of ascorbic acid (16.9 and 16.5 mg/100 g). In India, Shan-e-Punjab recorded 174.33, 124.33 and 761.7 µg/g of ascorbic acid when grown under eastern plateau regions, northern hill zone of Chhattisgarh and lower hills of Nagaland, respectively (Jana, 2015; Chaurasiya and Mishra, 2017; Talang *et al.*, 2019). In five low chill peach cultivars grown under hilly regions of Uttarakhand, India, the ascorbic acid content ranged between 84.0 µg/g (Florda Prince) and 213.3 µg/g (Sharbati) (Singh *et al.*, 2016). The significantly higher ascorbic acid in Shan-e-Punjab might be due to the prolonged low temperature condition prevailing in Nagaland hill region which helped in retention of vitamin C. Significant variations in vitamins contents indicated that vitamins in low chill peaches not only varied from cultivar to cultivar but also depended on geographical locations and other environmental factors.

Profiling of organic acids in low chill peach cultivars

Among the six organic acids identified in eight low chill peach cultivars, citric acid and malic acid were the most abundant organic acids in peaches with all cultivars showed statistically significant differences for all detected organic acids. Earligrande contained maximum amount of citric acid (8.88 mg/g) closely followed by Pant Peach-1 (8.84 mg/g), whereas maximum amount of malic acid (7.77 mg/g) was noticed in Pant Peach-1 followed by Sharbati Surkha (7.37 mg/g) (Table 2). Shan-e-Punjab possessed maximum amounts of tartaric acid (2.68 mg/g) and fumaric acid (2.61 mg/g), while Pratap contained maximum concentrations of succinic acid (1.26 mg/g) and oxalic acid (1.03 mg/g). Pant Peach-1 possessed maximum amounts of total of detected organic acids (21.12 mg/g) followed by Pratap (18.70 mg/g), Shan-e-Punjab (18.56 mg/g) and Sharbati Surkha (17.66 mg/g) and these cultivars can be considered as good source of organic acids. Chapman and Horvat (1990) have observed that malic acid was the most abundant organic acid in mature peach fruit. In three peach cultivars grown in USA (Babygold 5, Babygold 7 and Cresthaven) the contents of malic acid, citric acid and quinic acid were recorded between 370-580, 200-350 and 180-280 mg/100 g (Wang *et al.*, 1993), which is almost at par with our report for malic acid but slightly lower for citric acid. Four organic acids (oxalic, tartaric, malic and lactic) were identified in unripe fruits of two peach cultivars from South Korea where oxalic acid and malic acid were predominant organic acids (Kim *et al.* 2014). Malic, quinic, citric and succinic acids were detected in bagged and non-bagged fruits of sixteen peach cultivars grown in Brazil where malic, quinic and citric acids were the predominant organic acids (Lima *et al.* 2013). The variable range of organic acid levels in low chill peach cultivars might be dependable on various factors like genotypical, environmental, soil type and cultivation practices. Higher levels of citric and malic acids in ripe fruits in the present study suggested that peach fruit could be a good source of these two organic acids.

Multivariate evaluation

Eight peach cultivars were compared over three variables as seven phenolic components (first variable), four vitamins (second variable) and six organic acids (third variable) through multivariate evaluation (PCA and CDF). PCA analysis suggested that chlorogenic acid (0.96) and catechin (0.94) had higher contribution in controlling variation through correlation with principal component 1 (PC1) which accounted for highest variance (61.97%) in 24×7 data matrix considering Eigen value (>1), whereas epicatechin (0.78) and caffeic acid (0.76) had higher loadings in principal

Table 1: The contents of various phenolic components in low chill peach cultivars.

Cultivars	Phenolic components* (µg/g)						
	Gallic acid	Chlorogenic acid	Catechin	Epicatechin	Caffeic acid	Ellagic acid	*p*-Coumaric acid
Florda Prince	345.23	357.	199.10	115.60	81.36	71.50	4.78
Shan-e-Punjab	300.70	330.07	150.67	134.40	48.23	69.90	9.79
Earligrande	276.90	174.73	132.30	107.83	19.95	23.67	3.78
Saharanpur Prabhat	437.17	304.83	172.80	167.63	50.62	11.09	3.49
Pant Peach-1	309.57	249.13	161.87	96.70	41.35	35.73	6.47
Pratap	255.23	213.07	134.90	125.00	30.94	35.66	3.24
Sharbati	399.00	417.77	201.77	164.13	55.84	59.76	8.62
Sharbati Surkha	540.47	494.00	225.60	49.53	43.82	86.70	32.08
CD ($p \leq 0.05$)	15.348	7.520	6.288	14.984	6.870	5.767	1.441

*Average of 3 replications.

Table 2: Profiling of different vitamins and organic acids in eight low chill peach cultivars.

Cultivars	Vitamins* (µg/g)				Organic acids* (mg/g)					
	Ascorbic acid	Thiamine	Riboflavin	Niacin	Oxalic	Citric	Tartaric	Malic	Succinic	Fumaric
Florda Prince	200.00	1.31	8.24	23.63	0.58	6.77	1.77	5.05	0.47	1.14
Shan-e-Punjab	190.00	2.56	13.87	28.40	0.78	6.87	2.68	5.08	0.54	2.61
Earligrande	210.00	2.72	8.39	21.33	0.79	8.88	2.43	2.24	1.06	0.90
Saharanpur Prabhat	200.00	3.42	15.43	28.23	0.54	2.84	2.29	2.34	0.49	0.20
Pant Peach-1	300.00	2.50	5.40	27.23	0.96	8.84	2.09	7.77	0.55	0.91
Pratap	150.00	1.63	13.53	22.00	1.03	6.97	1.57	6.77	1.26	1.10
Sharbati	330.00	2.84	12.73	22.65	0.57	4.28	2.26	2.71	0.91	2.02
Sharbati Surkha	310.00	1.06	6.19	24.23	0.77	6.89	1.74	7.37	0.52	0.37
CD ($p \leq 0.05$)	0.027	0.508	2.441	1.735	0.105	0.701	0.473	0.610	0.265	0.302

*Average of 3 replication.

Table 3: PCA data regarding evaluation of eight peach cultivars for three types of nutraceuticals.

Phenolic compounds			Vitamins			Organic acids			
Phenolics	PC1	PC2	Vitamins	PC1	PC2	Acids	PC1	PC2	PC3
Gallic acid	0.84	0.02	Thiamine	0.73	0.44	Oxalic	0.93	0.16	-0.14
Chlorogenic acid	0.96	0.19	Riboflavin	0.85	-0.28	Tartaric	-0.48	0.62	0.33
Caffeic acid	0.49	0.76	Niacin	0.54	0.58	Citric	0.73	0.15	0.29
Catechin	0.94	0.23	Ascorbic acid	-0.52	0.75	Malic	0.77	-0.38	0.36
Epicatechin	-0.44	0.78				Succinic	0.34	0.53	-0.72
Ellagic acid	0.81	-0.04				Fumaric	-0.06	0.72	0.42
p-Coumaric acid	0.86	-0.48							
Variance (%)	61.97	21.56		45.52	29.40		39.73	20.58	14.54
Cumulative variance (%)	61.97	83.53		45.52	74.92		39.73	60.31	74.85

component 2 (PC2) (21.56% variance) for phenolic compounds. In case of vitamins, riboflavin (0.85) and thiamine (0.73) showed considerably higher loadings in PC1 (45.52% variance), while ascorbic acid (0.75) showed significantly higher loading in PC2 (29.40% variance) in 24 × 4 data matrix. For organic acids, oxalic (0.93), malic (0.77) and citric acid (0.73) showed higher contributions in PC1 (39.73% variance), while fumaric acid (0.72) and succinic acid (0.72) showed higher contributions in PC2 (20.58% variance) and PC3 (14.54% variance), respectively, in 24 × 6 data matrix (Table 3). These nutraceuticals played significant role in cultivar identification. The CDF analysis revealed that two significant functions (F1 and F2), significant as Wilks' Lambda tested by Chi-square test (p=0.05), controlled 79.45, 13.01 per cent variation (cumulative 92.64%) in phenolic compounds, 57.01, 22.48 per cent variation (cumulative 79.49%) in vitamins and 73.21, 11.86 per cent variation (cumulative 85.07%) in organic acids. The CDF analysis also indicated that Sharbati Surkha and Sharbati were the distinctly significant cultivars containing antioxidant phenolic compounds. In case of vitamins, the discriminant scores showed the display of eight cultivars in three clusters as (Pant Peach-1, Pratap and Sharbati Surkha), (Saharanpur Prabhat and Shan-e-Punjab) and (Earligrande, Florda Prince and Sharbati) showing some similarity, while for organic acids, six cultivars were found distinct except Pant Peach-1 and Pratap which were similar. The multivariate statistical methods can be used to study fruit crops for understanding of characters playing significant role in controlling variation as reported in evaluation of variability in jamun varieties, bio-chemical profiling of aonla, simultaneous determination of phenolic bioactive compounds in guava and characterization of ascorbic acid and phenolic compounds in aonla (Singh *et al.*, 2007; Pandey *et al.*, 2016; dos Santos *et al.*, 2017; Bhattacherjee *et al.*, 2020).

CONCLUSION

The concentrations of phenolic compounds, vitamins and organic acids varied considerably among low chill peach cultivars at edible ripe stage and depended mainly on genetic and environmental factors. Cultivars Sharbati Surkha, Sharbati, Florda Prince and Saharanpur Prabhat were ideal for fresh consumption. Cultivars Sharbati, Sharbati Surkha and Pant Peach-1 were rich source of immune-enhancing vitamins and Pant Peach-1, Pratap, Shan-e-Punjab and Sharbati Surkha stood out for flavor-imparting organic acids. Overall, Sharbati Surkha was found the best cultivar as it contained all three groups of nutraceuticals in relatively sufficient amounts that could take care of per capita nutrition requirements when consumed fresh.

Conflict of interest: None.

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