Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

J P P Journal of Pharmacognosy and Phytochemistry

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; 7(1): 1968-1971
Received: 25-11-2017
Accepted: 27-12-2017

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Evaluation of traditional and exotic Sweet Cherry cultivars for horticultural and physico chemical traits under North Western Himalayas

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Abstract
The objective of this study was to determine main physical, chemical and yield characteristics of traditional and recently introduced sweet cherry (*Prunus avium* L.) cultivars. Compared to traditional cultivars highest mean fruit weight (8.15g), fruit set (37.10%) and fruit yield (8.31 kg/tree) was found in Sweet Heart cherry cultivar, whereas highest fruit length (25.69 mm) was found in cultivar Lapins. Traditional cultivar Misri was found to have highest firmness (396 g/mm) whereas, Makhmali cultivar was found to have least firmness (271 g/mm). Fruit stone ratio was highest in Stella (19.50) whereas lowest in Makhmali (12.18). Compared to traditional cultivars, Stella was earliest to mature (66 days from full bloom to maturity) whereas Misri showed late ripening (80 days from full bloom to maturity). The lowest content of TSS was found in cultivar Stella (17.98%) whereas highest TSS was recorded in Misri (22.50%). The content of acids ranged from 0.55% (Rainier) to 0.71% (Stella) and was found to be non-significant. Fruit size and fruit weight was found to be highly correlated with number of days from full bloom to maturity (NDFBM) (r=0.818) where as stone percentage was found to be negatively correlated. Principal component analysis (PCA) of six qualitative and nine quantitative parameters explain over 91.92% of total variability showing highest loadings on PC1 by fruit traits (days from full bloom to harvest, fruit length, fruit width, fruit weight) and on PC2 by stone traits (stone length, stone diameter and stone weight).

Keywords: Cherry, Prunus avium, Physio-chemical traits, Quality, Yield

Introduction
Sweet cherries of the genus *Prunus avium* (family *Rosaceae*) are non-climacteric stone fruit, mainly grown in temperate climate countries. In India, the state of Jammu and Kashmir, Himachal Pradesh and Uttarakhand are the main contributors of cherry production in which Jammu and Kashmir alone produces more than 95 per cent of the total production of commercial cherries. An area of 2816 ha is under cherry cultivation in J&K with an annual production of 10244 metric tonnes (Anonymous, 2015) [2]. Sweet cherry tree is a species with a great economic importance, due to the nutritional, technological and commercial value of its fruits (Pérez Sánchez *et al*., 2010) [10] Fruits of sweet cherry are refreshing, diuretic, energetic and anti–infective and it has the laxative and detoxifying effect. Concerning the fact that the demand for sweet cherry is increasing, there is an urgent need to increase the varietal spectrum of this crop. This can be achieved by introducing new varieties with different harvest windows and with wide range of valuable characteristics. Many studies have been conducted on the physical, chemical, pomological and nutritional properties of different sweet cherry (e.g., Naderiboldaji *et al*., 2008 and Radicevic *et al*., 2008) [9, 11]. Morphological analysis is quick and commonly used method to identify and characterize the germplasm through phenotyping. Large fruit (in both width and weight) are increasingly valued and is considered an important trait in the fresh-market group, fruit shape is very important for packaging and transportation, fruit size is very important for the canning industry and sugar content and total soluble solids content are very important for the food industry and all the traits are affected by a cultivar (Gozlekci, 2010) [6].

In recent years, new cultivars have been introduced in Kashmir, but there are no records of their phenology or fruit quality characteristics. The aim of this study was to characterize and compare some morpho-physico-chemical properties of these recently introduced six sweet cherry cultivars along with three traditional cherry grown varieties in the region. We also determined relationship between number of days from full bloom to maturity (NDFBM) and physico-chemical properties of fruit sweet cherry cultivars.

Materials and Methods

The research was carried out on nine sweet cherry cultivars in the cherry orchard at Zangam Fruit Nursery, Department of Horticulture, Pattan, Jammu and Kashmir, India. Three traditional cherry cultivars Bigarreau Noir Grossa (Misri), Bigarreau Napoleon (Double), Guigne Noir Hative (Makhmali) and six recently introduced Lapins, Sweet heart, Rainier, Regina, Bing, Stella cultivars were used for study. All the selected cultivars had Mazzard as the rootstock. The trees were trained to modified central leader system with a distance of 5 feet between the trees and 10 feet between the rows. The trail was laid out in RCBD with three replications. The trees were studied for various physical, chemical and yield characters such as :- number of days from full bloom to maturity, fruit length, fruit width, fruit weight, stone length, stone diameter, stone weight, stone percentage, fruit weight to stone weight ratio, total soluble solids, titratable acidity, TSS/acidity, fruit firmness, fruit set and fruit yield.

Flowering was recorded as per recommendations of the International working group for pollination (Wertheim, 1996) [13]. The date of full bloom was recorded – when 80% of flowers were open and the date of harvest was taken when cherries developed proper physiological maturity stage. Specific characteristics were determined on a sample of 30 fruits for each cultivar. The length of these selected fruits and extracted stones for each treatment was measured from distils to proximal end, diameter was measured from cheek to cheek and thickness of the selected fruits was measured from suture to suture with help of Vernier Calliper The weight of the fruits and stones extracted from the previously weighed fruit was measured with the help of Top Balance and the weight was recorded in grams. Proportion of the stone was calculated by using the formula: (weight of the stone/total weight of the fruit) ×100. The total soluble solid of the selected fruits was measured by Refractive meter and expressed as ºBrix. The total titrable acidity was determined by titration method. 10 grams of sample was crushed and mixed thoroughly with distilled water. The volume was made up to 100 ml and filtered through double layered cheese cloth. 10 ml sample solution was titrated against N/10 NaOH using phenolphthalein as an indicator. The total titrable acidity was determined in terms of malic acid on the basis of 1ml N/10 NaOH being equivalent to 0.067g anhydrous malic acid. The SSC: TA ratio was calculated in each sample by dividing the percentage of SSC with corresponding TA. Firmness was calculated using Texture Profile Analyzer TA HD PLUS with pre-test speed 1.5 mm/sec, post-test 10mm/sec, distance 2 mm and trigger force 25 g. Fruit set percentage was calculated as the number of fruits at harvest. date per total flowers at bloom (Alburquerque *et al.*, 2004) [1]. To determine average fruit yield/tree (kg) total fruits harvested from a tree were weighed and average yield per tree was calculated as: Fruit yield/tree = (Total fruit weight (kg)/ total no of trees) × 100. Relationships (R) between number of days from full bloom to maturity (NDFBM) and physico-chemical properties of fruit's sweet cherry cultivars was also studied. The significance of differences between mean values was determined by Duncan's multiple range test at P=0.05. The statistical analysis of the data including correlation and PCA was carried out by using SPSS 17.0 using MS Excel software.

Results and Discussion

Results showed significant differences in the various physical, chemical and yield characteristics of nine sweet cherry genotypes that were studied. Physincal characteristics and maturity of sweet cherry cultivars are presented in Table 1. The period from full bloom to maturity was from 66 to 76 days. The variety which ripened the earliest was 'Stella' followed by 'Bing'. Genotype Misri matured last (80 days). Regarding physical parameters Lapins had the highest mean fruit length (24.80 mm) followed by Misri (24.77 mm) and Sweet Heart (24.18 mm) while Stella (19.59 mm), Makhmali (20.16 mm) and Rainer (20.41 mm) had the lowest fruit length. Fruit width followed the same trend with Lapins having highest fruit width of 25.69 mm and Stella with lowest of 21.19 mm. Highest mean fruit weight (8.15 g) was recorded in fruits of cultivar Sweet Heart followed by Lapins (8.09 g), Misri (8.08 g), Reginia (7.96 g), Rainer (7.31 g) while lowest average fruit weight was observed in Makhmali (6.0 g), Double (6.60 g) and Stella (7.02 g). The observed data was in agreement with values reported in different studies (Martino *et al*., 2008) [7]. Varietal effect on stone length and stone diameter was found to be non significant. Makhmali exhibited highest stone percentage of 7.58% where as both Regina and Misri exhibited highest stone weight of 0.48 g. Fruit stone ratio was highest in Stella (19.50) whereas least in Makhmali (12.18). These findings are consistent with those of previously reported for different sweet cherries of Vursavu *et al*. (2005) Sweet cherries with lower weight of the stone have better value, as well as those having lower share of the stone in total weight of the fruit.

Chemical properties like TSS and TSS/Acidity for all genotypes differed significantly whereas stone length, stone diameter and acidity were found to be non-significant (Table 2). The lowest content of TSS was found in cultivar Stella (17.98%) whereas highest TSS was recorded in variety Misri (22.50%). Lower content of TSS in Stella may be due to the less number of days taken by this variety to reach harvest stage from full bloom and is in accordance with the results of Milatovic *et al*. (2011) [8]. Similar results have been reported earlier by Martinez-Romero *et al*., 2006 which showed that TSS in sweet cherry fruit ranges between 11 and 25%. The content of acids in the study ranged from 0.55% (Rainier) to 0.71% (Stella) and was found to be non-significant. Ercisli *et al*., 2006 [4] also recorded acidity between 0.55 - 0.98% in sweet cherry cultivars. Firmness is one of the most important attributes of sweet cherries and is often used to assess fruit quality (Esti *et al*., 2002) [5]. Firmness of Misri variety was found to be significantly higher (396 g/mm) than other varieties, whereas Makhmali recorded least firmness values of 271 g/mm. Regarding fruit set Sweet Heart recorded the highest set (37.10%) and fruit yield (8.31 kg/tree) where as lowest yield and fruit set was recorded in Regina variety. Amongst traditional varieties Bigarreau Napolean recorded highest fruit set (30.90%) and yield (7.58 kg/tree) (Table 2)

Fruit size and fruit weight was found to be highly correlated with number of days from full bloom to maturity (NDFBM) (r=0.818) (Table 4), whereas stone percentage was found to be negatively correlated. TSS was found to be positively correlated with number of days from full bloom to maturity (NDFBM) whereas, with fruit acidity, it was found to be negatively correlated. Our results of firmness being highly correlated with number of days from full bloom to maturity (r=0.878) (Table 4) are justified in the light of findings of Christensen, (1995) [3] who found that late cultivars were firm, while early cultivars were generally much softer. Principal component analysis (PCA) of six qualitative and nine quantitative parameters explain over 91.92% of total variability in the first four axes (eight values for each was larger than 1). It was observed that significant variation was

recorded for different morpho-physiological traits of the cultivars examined. The distribution of cultivars based on the PC-1 and PC-2 shows the phenotypic variation among the cultivars and how widely dispersed they are (Table-3). The highest loadings on PC1 were shown by fruit traits (days from full bloom to harvest, fruit length, fruit width, fruit weight) and on PC2 by stone traits (stone length, stone diameter and stone weight).

Conclusion

Results of the research work showed large variability in the physical, chemical and yield characteristics of nine sweet cherry cultivars under North Western Himalayan conditions. Statistically, significant differences were observed in number of days from full bloom to maturity, fruit length, fruit width, fruit weight, stone weight, stone percentage, fruit weight to stone weight ratio, total soluble solids, TSS/acidity, fruit firmness, fruit set and fruit yield. Thus the tested cultivars can serve also as the valuable parent cultivars for breeding programmes under cherry improvement programs.

Table 1: Physical characteristics of sweet cherry cultivars under North Western Himalayan conditions

Variety	Days from Full Bloom to Harvest	Fruit Length (mm)	Fruit Width (mm)	Fruit Weight (g)	Stone Length (mm)	Stone Diameter (mm)	Stone Weight (g)	Stone Percentage
Lapins	78±18	24.80±0.57	25.69±0.83	8.09±0.49	10.51±0.54	7.28±0.54	0.41±0.007	5.09±0.19
Sweat Heart	77±18	24.18±0.88	25.29±0.51	8.15±1.13	11.02±0.56	8.00±0.57	0.44±0.013	5.46±0.15
Rainier	71±17	20.41±0.94	22.48±0.43	7.31±0.50	10.48±1.11	6.95±0.48	0.42±0.014	5.75±0.21
Regina	75±17	23.86±0.71	24.21±0.51	7.96±0.56	11.15±0.56	7.87±0.38	0.48±0.044	6.05±0.56
Bing	70±16	21.18±0.66	22.64±0.54	7.06±0.57	10.17±0.53	6.98±0.43	0.36±0.008	5.15±0.56
Stella	66±14	19.59±0.56	21.19±0.50	7.02±0.43	10.33±0.54	6.86±0.32	0.34±0.017	4.90±0.49
Misri	80±19	24.77±0.32	24.11±0.53	8.08±0.52	11.26±0.08	7.53±0.49	0.48±0.010	5.94±0.32
Double	72±17	20.92±0.64	22.81±0.43	6.60±0.83	11.40±0.10	7.28±0.56	0.40±0.009	5.81±0.26
Makhmali	69±17	20.16±0.79	22.60±0.47	6.00±0.57	11.33±0.55	7.25±0.51	0.45±0.017	7.58±0.16
C.D. (p=0.05)	4.72	1.09	0.36	1.02	N.S	N.S	0.060	1.09
SEM	1.56	0.40	0.12	0.38	0.46	0.48	0.020	0.36

Table 2: Quality and yield characters of sweet cherry cultivars under North Western Himalayan conditions

Variety	Fruit stone ratio	TSS (%)	Acidity (%)	TSS/Acidity	Firmness (g/mm)	Fruit Set (%)	Fruit Yield (kg/tree)
Lapins	18.63±0.24	19.28±0.55	0.60±0.008	32.13±0.54	319±1.15	32.33±0.57	7.34±0.56
Sweat heart	17.31±0.57	21.20±0.56	0.58±0.07	36.55±0.13	367±1.15	37.10±0.46	8.31±0.50
Rainier	16.36±0.54	19.80±0.26	0.55±0.009	36.66±0.56	302±1.15	33.90±0.11	7.82±0.12
Regina	15.51±0.14	20.10±0.50	0.61±0.035	32.95±0.12	342±1.15	21.96±0.29	4.83±0.06
Bing	18.39±0.54	18.90±0.20	0.70±0.046	27.00±0.57	296±1.15	26.50±0.52	6.62±0.57
Stella	19.50±0.55	17.98±0.31	0.71±0.046	25.32±0.55	278±1.15	28.10±0.40	6.87±0.12
Misri	16.83±0.19	22.50±0.54	0.56±0.040	40.17±0.54	396±1.15	27.00±0.57	6.64±0.08
Double	16.20±0.53	19.40±0.12	0.60±0.040	32.33±0.56	288±1.52	30.90±0.11	7.58±0.57
Makhmali	12.18±0.57	18.20±0.50	0.60±0.029	25.63±0.12	271±1.15	29.70±0.17	7.02±0.50
C.D. (p=0.05)	0.54	1.28	N.S	1.38	3.59	1.22	0.71
SEM	0.18	0.42	0.04	0.46	1.20	0.40	0.23

Table 3: Component weights in Principal Component Analysis using physical and chemical traits of various sweet cherry cultivars.

	Principal components						
Components	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Eigen values	5.704	4.496	2.488	1.101	0.672	0.286	0.253
Percent of variance	38.026	29.970	16.584	7.338	4.482	1.909	1.690

Table 4: Relationships (R) between number of days from full bloom to maturity (NDFBM) and physico-chemical properties of fruit's sweet cherry cultivars. The testing of correlation coefficient significance was done by *F*- test; NS = Non-significant,

Physical properties	R	Chemical properties	R
Fruit Length	0.959**	TSS	0.843**
Fruit Width	0.896**	Acidity	-0.632
Fruit Weight	0.818**	Tss/acidity	0.796*
Stone length	NS	Firmness	0.878**
Stone diameter	0.698*	Fruit set	NS
Stone weight	0.668*		
Stone percentage	-0.073		
Fruit stone ratio	NS		

**. Correlation is significant at p<= 0.01 level

*. Correlation is significant at p<= 0.05 level

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