



Yield, raisin recovery and biochemical characters of fresh and dried grapes (raisin) of Thompson Seedless grapes (*Vitis vinifera*) as influenced by different rootstocks

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ABSTRACT

Yield, raisin recovery and biochemical status of fresh grapes (*Vitis vinifera* L.) and raisins obtained from eight years old Thompson Seedless vines grafted on different rootstocks were studied. Higher yield (16.35 kg/vine) and raisin recovery (29.90%) was recorded in 110R rootstock and lowest in 1613-C rootstock (6.35 kg/vine). A higher total soluble solid of 21.53°Brix was recorded in 1613-C rootstock grafted vines. The fresh grapes of own rooted vines had higher protein (7.84 mg/g), total phenols (0.88 mg/g) and reducing sugars (2.26 mg/g) whereas higher amount of carbohydrate (82.25 mg/g) was recorded in 110-R and starch (3.44 mg/g) in 99-R rootstock grafted vines. The raisins of 99-R rootstock grafted vines had higher starch (15.30 mg/g) and reducing sugar (6.80 mg/g), whereas higher protein in raisin was recorded in SO4 (28.50 mg/g), total phenols in 1613-C (3.18 mg/g) and carbohydrate in 110-R grafted vines (285.36 mg/g). The rootstocks, 1103P was also equally good in raisin recovery (29.36 %), yield (13.17 kg/vine) and carbohydrate accumulation (291.14 mg/g). Biochemical analysis of fresh grapes and dried grapes showed that the major biochemical constituent, viz. carbohydrate, reducing sugar, protein and phenolics concentrated in the raisin making process.

Key words: Biochemical parameters, Quality, Raisin, Seedless, Thompson Rootstocks, Yield

Grape (*Vitis vinifera* L.) is one of the major important fruit crops of the country grown on an area of 111 000 ha with an annual production of 1 235 000 tonnes (Anonymous 2012). In India, 74.5 per cent of produced grape is available for table purpose, nearly 22.5 per cent is dried for raisin production, 1.5 per cent for winemaking and 0.5 per cent is used for juice making. The productivity of grape starts declining after few years of heavy fruiting, if planted on own roots. This is because of the gradual build up of salinity in soil, chlorides in irrigation water and also scarcity of water. To sustain the grape production under these adverse conditions, tolerant rootstocks are desired. Among the different rootstocks, Dog Ridge and 110-R are becoming popular and widely adopted since they have moderate tolerance to drought and vigor (Satisha *et al.* 2010). Rootstocks from *V. berlandieri* × *V. rupestris* were considered to be drought tolerant (Ezzahouani and Williams 1995). Due to the continuous drought prevailing in the region, dependence on only one rootstock may be risky for grape growing. Numerous reports have also proved that rootstocks affect vine growth, yield and fruit quality.

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Rootstocks affect photosynthesis and dry matter partitioning of scion cultivars, which influence vegetative growth and yield. During (1994) studied rootstock effects on scion photosynthesis and found that the rootstock effect on gas exchange is scion specific. Bica *et al.* (2000) found that the effect of rootstocks was significant on leaf area, chlorophyll content, stomatal conductance and quantum yield. Photosynthetic rates varied differently for *V. vinifera* 'Muller Thurgau' on different rootstocks (Candolfi-Vasconcelos *et al.* 1997). Rootstocks have a special value for fruit production as they can effectively control tree size, influence growth and development of cultivars grafted onto them and tolerate adverse soil conditions (Ferree *et al.* 2001, Lauri *et al.* 2006; Tworkoski and Miller 2007).

Raisin is mostly produced in the country from the varieties, viz. Thompson Seedless and its clones, viz. Tas-A-Ganesh, Sonaka and Manik Chaman. The quality of the dried products implies that several desirable changes (physical, chemical, and biochemical) must occur during the drying process. The physical characteristics of raisins from different countries are quite different, while chemical characteristics being fairly consistent. The physical characteristics found out are probably the result of cultivars, cultural, and processing differences (Bongers *et al.* 1990). Raisins acquire their dark brown colour from an accumulation of brown-black melanin

pigments produced by polyphenol oxidase activity and non-enzymatic reaction (Singleton *et al.* 1985 and Lozano-de-Gonzalez *et al.* 1993). It is well recognized that raisin quality is greatly influenced by the sugar (expressed as TSS) at harvest, rate of drying, drying conditions (temperature, humidity and exposure of drying grape to direct sunlight) etc. Different grape varieties express differently for the biochemical constituents or even the same variety grafted on different stock combination may differ for biochemical parameters. Similar information is, however, lacking for the raisins and the effect of raisin preparation process on the major biochemical constituents present in fresh grapes. An attempt was therefore made to study the effect of different rootstocks on yield, raisin recovery and biochemical parameters, viz. protein content, total phenols, carbohydrate, starch and reducing sugars in fresh grapes as well as raisins of Thompson Seedless grafted on different rootstocks.

MATERIALS AND METHODS

The study was conducted at the farm of National Research Centre for Grapes, Pune during the year 2008-09. Thompson Seedless was grafted on nine different rootstocks as well as own rooted vines during March 2001. The experimental site is situated in mid west Maharashtra at an altitude of 559 m; it lies on 18.32 °N latitude and 73.51 °E longitudes. Pune has a tropical wet and dry climate with average temperatures ranging between 20 to 28 °C. There are three distinct seasons: summer, monsoon and a mild autumn. Typical summer months are from March to May, with maximum temperatures ranging from 30 to 38 °C. The summers are hot. The monsoon begins in the month of June and continues up to September. The vines were trained as four cordons on a horizontally divided canopy trellis with vertical shoot positioning. The height of cordon from the ground surface was 1.20 m and was separated by 0.60 m wide cross arms. The distance from the fruiting wire to the top of foliage support wire was 0.60 m. The vines were planted at the spacing of 3.0 m between the rows and 1.83 m between the vines with the density of 1 815 vines/ha.

Since the region falls under tropical condition, double pruning and single cropping is followed. Hence, the vines were pruned twice in a year (once after the harvest of crop, i.e. back pruning and second for fruits, i.e. forward pruning). The experiment was laid out in a randomized block design with ten treatments and four replications. There were eight vines in each replication. Five vines having uniform shoots on each cordon and fruitful canes were tagged and labeled for data recording in each replication. All the standard recommended cultural practices were followed during the period of experiment. The observations on yield per vine were recorded after harvest. After the bunch harvest, 5.0 kg grapes from each treatment were treated with ethyl oleate and sodium carbonate and were kept for drying. After drying, the per cent raisin recovery was estimated. The samples from

the raisin prepared from Thompson Seedless grafted on different rootstocks were further taken for analysis of different biochemical parameters.

The total phenolic content was determined using the Folin-Ciocalteu method using 4-methylcatechol as the standard. The concentration of total phenolics was expressed as the catechol equivalent (mg/g) of the lyophilized sample. Reducing sugar was estimated by the dinitrosalicylic acid (DNSA) method and total carbohydrate was estimated by the Anthrone method using D-glucose as the standard. Protein was estimated by using the method described by Lowry *et al.* (1951) and total protein concentration was expressed as mg/g. The standard reference chemicals like D-glucose, 4-methylcatechol, Bovine serum albumin etc. used were obtained from the SD Fine Chemicals Ltd, Mumbai (India). All other buffers and chemicals were of AR grade and obtained from Merck Pvt Ltd.

The data recorded from three replicates were pooled together after passing normality test. Standard deviation was used as measure of variability. The overall significance of the treatments was determined by one-way-ANOVA test followed by Duncan's LSD comparison as a post-hoc test. The data analysis was carried out by using Sigma Stat 3.5 and Microsoft Excel 2003.

RESULTS AND DISCUSSION

Significant differences were recorded for yield per vine (Table 1). The vines grafted on 110-R rootstock recorded higher yield of 16.35 kg/vine compared to other rootstocks. The lowest yield (6.35 kg/vine) was recorded on 1613-C rootstock. Raisin recovery was highest in the vines grafted on 110R rootstock followed by 1103 P. This might be due to the inherent capacity of these rootstocks to produce higher fruit yield. Hedberg (1980) found that yields of all grafted

Table 1 Yield, quality and raisin recovery of Thompson Seedless grafted on different rootstock

Rootstocks	TSS (°Brix)	Yield/vine (kg)	Raisin recovery (%)
Dog Ridge	21.20±0.20a	7.92±1.58d	27.47±5.22a
Salt Creek	21.07±0.23a	11.32±1.70bc	28.58±3.43a
St. George	20.20±0.35b	6.59±1.83e	27.44±3.84a
1613C	21.53±0.12a	6.35±1.70d	26.02±4.42a
110R	21.13±0.23a	16.35±2.13a	29.90±3.89a
B2/56	20.93±0.12ab	8.90±1.51cd	27.62±3.87a
99R	21.40±0.60a	11.02±1.98bc	28.50±4.85a
1103P	20.73±0.70ab	13.17±1.93b	29.36±5.28a
SO4	20.93±0.12ab	11.45±1.72bc	28.78±3.74a
Own root	21.27±0.90a	9.38±1.59cd	28.02±4.20a

Data are pooled means for three replications ±standard deviation. Letters indicates the rootstock-wise significant difference. Rootstocks followed by the same letter are not significantly different according to Duncan's multiple range test at P=0.05

cultivars were much higher than those of own-rooted vines, especially on Ramsey and Dog Ridge rootstocks. Ferree *et al.* (1996) reported increased yield of grafted Cabernet Franc and White Riesling than the own-rooted vines.

The data on biochemical constituents of raisins made from Thompson Seedless grapes grafted on different rootstocks is presented in Table 2. Among the different rootstocks studied, total phenolics content ranged from 2.27 mg/g to 3.18 mg/g. Vines grafted on 1613-C rootstock recorded highest content (3.18 mg/g) in St. George. Notably, raisins produced from all the grafted vines exhibited more phenolics concentration compared to the own rooted vines (2.27 mg/g). Based on the results obtained, it is found that compared to own rooted Thompson Seedless vines, 1613-C, Dog Ridge, SO4, 99R and B2/56 rootstocks accumulates higher phenolics. The rootstocks Salt Creek, 110R and 1103P were recorded as moderate and St. George, the least phenol accumulator. The accumulation of more phenol in the vine parts might also help in development of resistance against the pest and diseases (Evrenoso *et al.* 1999, Mohamed *et al.* 2007).

Significant differences were recorded for protein content in fresh grapes of Thompson Seedless obtained from different rootstocks. Higher amount of protein in fresh grapes was estimated in own rooted Thompson Seedless (7.84 mg/g), whereas among the rootstocks, minimum protein was recorded in St. George (4.99 mg/g) compared to highest amount in 1103 P grafted vines (6.05 mg/g). In general, the protein content in raisin was not same as in fresh grapes. Significant differences were recorded for protein content in the raisins made from Thompson Seedless grapes grafted on different rootstocks. Among the different rootstocks, the raisin obtained from SO4 showed more protein content (28.50 mg/g) compared to other rootstocks. The protein concentration in raisin was more in grafted vines than the own rooted vines. Based on the protein accumulation in raisin, the rootstocks 1613-C, 99-R, 110-R and SO4 were considered as higher protein accumulators and St George, B2/56 the medium protein accumulators, however, the rootstock 1103 P, Salt Creek and Dog Ridge were found in low protein accumulator group (Table 2). The variation in protein content in the raisins of Thompson Seedless vines might be due to the genetical differences available in the vines grafted on different rootstocks. These results are in accordance with the results obtained by Mazhan *et al.* (2002) who reported genetical variation in berry protein of Muscadine cultivars.

Significant differences were recorded for carbohydrate content in berries. In fresh grapes, higher amount of carbohydrate was recorded from St George rootstock (82.25 mg/g) followed by 1103-P (77.60 mg/g). However, the lowest carbohydrate was recorded in Salt Creek rootstock (55.99 mg/g). The carbohydrate accumulation in grapes obtained from different rootstocks might be due to the reaction of individual rootstock to the accumulation of carbohydrates that has resulted into variation in the concentration. Satisha *et al.*

Table 2 Changes in biochemical parameters of fresh grapes and raisins of Thompson Seedless grafted on different rootstocks

Rootstocks	Protein (mg/g)		Total phenols (mg/g)		Carbohydrate (mg/g)		Starch (mg/g)		Reducing sugar (mg/g)	
	Fresh grapes	Raisins	Fresh grapes	Raisins	Fresh grapes	Raisins	Fresh grapes	Raisins	Fresh grapes	Raisins
Dog Ridge	5.58±0.06c	22.69±2.23cd	0.79±0.02f	2.88±0.07b	66.80±0.18f	284.56±9.54ab	3.25±0.08d	14.03±1.20ab	1.82±0.08e	3.53±0.06f
Salt Creek	5.09±0.06de	21.45±1.63de	0.63±0.02e	2.75±0.05b	55.99±0.24g	263.33±4.16d	2.93±0.09e	9.32±0.24e	1.63±0.05f	4.42±0.22e
St George	4.99±0.15e	23.44±1.64cd	0.77±0.04e	2.42±0.13c	82.25±0.25a	273.65±8.12bcd	2.93±0.06e	10.61±0.35de	1.89±0.05de	4.83±0.21de
1613C	5.94±0.18b	26.70±0.86ab	0.65±0.03e	3.18±0.19a	73.55±0.25c	261.45±7.84d	3.44±0.07c	7.13±0.22f	1.91±0.04de	4.95±0.45d
110R	5.29±0.18d	27.46±1.76ab	0.65±0.03e	2.67±0.22b	72.58±0.28d	285.36±10.80ab	4.02±0.08b	14.59±0.97ab	2.06±0.06c	6.12±0.20bc
B2/56	5.13±0.16de	24.89±0.81bc	0.67±0.02d	2.79±0.14b	70.54±0.13e	263.91±9.88d	2.69±0.05f	11.42±0.31cd	2.17±0.05b	5.76±0.16c
99R	5.11±0.12de	27.36±1.76ab	0.67±0.02cd	2.87±0.12b	72.37±0.09d	280.17±10.36abc	3.44±0.06c	15.30±0.71a	1.89±0.03de	6.80±0.28a
1103P	6.05±0.10b	21.01±1.60de	0.87±0.03bc	2.74±0.09b	77.60±0.30b	291.14±2.53a	3.52±0.06c	12.66±2.57bc	1.96±0.07d	5.16±0.55d
SO4	5.60±0.09c	28.50±1.52a	0.83±0.06ab	2.88±0.14b	72.61±0.22d	267.93±5.67cd	3.21±0.05d	13.12±1.82bc	1.93±0.05d	6.30±0.09b
Own root	7.84±0.30a	19.78±0.87e	0.88±0.01a	2.27±0.12c	70.62±0.10e	283.97±10.76ab	3.02±0.12g	7.04±0.16f	2.26±0.06a	5.14±0.08d

Data are pooled means for three replications ±standard deviation. Letters indicates the rootstock-wise significant difference. Rootstocks followed by the same letter are not significantly different according to Duncan's multiple range test at P=0.05

(2008) also reported variation in carbohydrate content in cuttings of different grape rootstocks. The significant differences were also recorded for carbohydrates in raisins. The vines grafted on 1103-P rootstock recorded highest (291.14 mg/g) carbohydrate followed by 110 R (285.36 mg/g) and least in 1613-C rootstock (261.45 mg/g). Preparation of raisin from fresh grapes is the process of drying in which the berries loose water. This helps in accumulating the carbohydrates in dried berries. Grape berries, as typical sink organs depend on the use of available carbohydrate resources produced by photosynthesis to support their growth and development. The transport and allocation of sugars between the photosynthetic source tissue and the heterotrophic sink tissue is known as assimilate partitioning and is a major determination of plant growth and productivity (Kingston-Smith 2001). Grape berries as a typical sink organ rely on the use of available carbohydrate resources produced by photosynthesis to support their growth and development (Conde *et al.* 2007). Variation in starch contents among the different rootstocks was also recorded. The raisins obtained from 99R rootstock had higher amount of starch (15.30 mg/g) followed by 110R (14.59 mg/g), whereas the lowest starch content was recorded in the raisins from own rooted vines (7.04 mg/g).

Although the study not involved the estimation and measurement of glucose: fructose ratio, the class to which they belongs, i e reducing sugars, was estimated for per gram of raisins. In viticulture, measurement of TSS (total soluble solids) is one of the major parameter to assess the grape ripeness. Since reducing sugars are mostly monosaccharides and disaccharides that impart sweetness in fresh grapes, based on the findings of experiment, it can be hypothesized that the availability of TSS can be indirectly related with the concentration of reducing sugars in dry grapes or vice versa.

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