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Effect of Harvesting Dates on Yield, Color and Quality of Raisin Prepared from Seedless Grape (*Vitis vinifera*)

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Authors' contributions

This work was carried out in collaboration among all authors. Authors AV and ASP designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors BSR and DV managed the analyses of the study. All authors read and approved the final manuscript.

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ABSTRACT

Aims: To know the effect of harvesting dates on yield, color and quality of raisins prepared from seedless varieties of grapes viz., Thompson Seedless (TS), 2A Clone (2AC), Sonaka (SO), Manik Chaman (MC) and Merbein Seedless (MS).

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Study Design: Factorial completely randomized design.
Place and Duration of Study: The present investigation was conducted at Grape Research Station, Rajendranagar, Hyderabad, Ranga Reddy district, Dr. Y. S. R. Horticultural University, during 2012–13 and 2013–14.
Methodology: Selected grape varieties viz., TS, 2AC, SO, MC and MS were manually harvested on 9th, 12th, 14th, 17th and 21st March, respectively, chosen as first harvest date i.e. 20 days before local harvest. Succeeding harvests i.e. second, third, fourth and fifth was done with 10 days interval following the first harvest date and used for raisin making. The grape bunches were dried in ventilated rooms after pre-drying treatment with alkaline emulsion of ethyl oleate (2.4% K_2CO_3 plus 1.5% ethyl oleate) with ascorbic acid 1000 ppm.
Results: Well matured grapes, which are harvested between 19th April to 1st May (20 days after local harvest) recorded lowest brown and mixed colored raisins and correspondingly increased green colored raisins. The grapes dried early in variety MS and it takes only 13.27 days followed by 2AC, TS, MC and SO in order. Raisin yield, size, texture, color homogeneity, total soluble solids, and Hunter color *L**, *-a** (greenness) and *b** values increased with successive harvest dates. TS raisins were superior compared to others. The moisture content of raisins was lowest in fully matured (19th April to 1st May) grapes.
Conclusion: Raisins prepared from fully ripened grapes i.e. harvested between 9th to 19th April for Thompson Seedless and 17th to 27th April for Manik Chaman was superior regarding yield, retention of green color and quality.

Keywords: Drying time; raisin yield; green colored raisins; TSS; hunter color L; a* and b*.*

1. INTRODUCTION

Grape (*Vitis vinifera* L.) is an important commercial fruit crop in India, which grows in a wide range of climatic conditions. In India, about 78% of grape production is used for table purpose, nearly 17 to 20% is dried for raisin production, while 1.5% is used for juice and only 0.5% is used in manufacturing wine. The largest producer of dried grapes in the world is USA and Turkey. The raisin production in India is about 1,60,000 tonnes [1]. In India, raisin is mainly produced in Sangli, Solapur and Nasik districts of Maharashtra and Bijapur district of Karnataka state from the varieties viz., Thompson Seedless and its clones Tas-A-Ganesh, Sonaka and Manik Chaman [2].

Raisins are a good source of fiber, K, Fe, Ca and vitamin B and are free from fat and cholesterol. They contain only natural sugars as a source of energy. Green raisins are highly valued for their fresh, attractive green color, sweet flavour and sold for two to three times the price of sun-dried raisins. The technique of raisin production in India is mostly based on the dipping of the grape bunches in emulsion having 2.5% potassium carbonate and 1.5% ethyl oleate for a duration of 2 to 4 minutes, and subsequent shade drying in open tier system [3]. The dipping oil treatment alone induced soft texture, but it led to the development of brown rather greenish color.

The varied physical characteristics of raisins are probably the result of cultivars, cultural practice followed and processing differences. Telangana State falls under semi-arid tropical region wherein the major grape cultivation is confined to Ranga Reddy, Mahabubnagar and parts of Nalgonda district. Since the harvest period (February to May) is during summer with low relative humidity, it is excellent for raisin making. The different varieties of seedless grapes grown here are vigorous and highly productive. The physico-chemical qualities of these grapes are also highly suitable for raisin making. Green color is one of the major concerns in raisin production; hence, extensive research is necessary to find the effect of harvesting dates on green color retention, yield and quality of raisins prepared from seedless varieties of grapes [4].

2. MATERIALS AND METHODS

The experiment was conducted at Grape Research Station, Rajendranagar, Hyderabad in Ranga Reddy district during 2012–14. The Grape Research Station is located at 77°85' East longitude and 18°45' North latitude and at an altitude of 542.6 m above mean sea level. The experimental location falls under semi-arid tropical climatic zone, having annual rainfall of 800 mm. Selected grape bunches of varieties Thompson Seedless (TS), 2A Clone (2AC), Sonaka (SO), Manik Chaman (MC) and Merbein

Seedless (MS) were manually harvested on 9th, 12th, 14th, 17th and 21st March, respectively as first harvest date (H_1) was chosen as simultaneous with the beginning of the 20 days before local harvest (20 DBLH). Succeeding harvests i.e. second (H_2: 10 DBLH), third (H_3: LH), fourth (H_4: 10 DALH) and fifth (H_5: 20 DALH) was done with 10 days interval following the first harvest date. The total soluble solids (TSS) of grapes were increased from 18.50 to 24.34, 18.22 to 24.04, 18.19 to 23.98, 18.24 to 24.05 and 18.22 to 24.00 ^{o}Brix from the first to fifth harvest with an average increase of 0.15, 0.15, 0.14, 0.15 and 0.14 ^{o}Brix per day for TS, 2AC, SO, MC and MS, respectively. The harvested bunches were cleaned, washed in soap water followed by washing in pure water and dipped in a solution containing 2.4% potassium carbonate, 1.5% ethyl oleate and ascorbic acid 1000 ppm for 3 minutes, and replicated thrice. The dipped bunches were placed in trays and kept for shade drying in well ventilated room at ambient condition. Moisture testing was done frequently for a preserved level (approximately 15%).

The prepared raisins were graded based on color i.e. pale green (consider as green in the entire experimentation), brown and mixed (the mixture in which the percentage of dominant color did not exceed 60%). 100 g of raisins was weighed and the separation of which was done according to the mentioned color classes. The number of raisins per 100 g was counted and three classes were ranked i.e. big (130 to 160), medium (160 to 190) and small (190 to 220). The surface texture of raisin was ranked into H (high), M (medium), and L (low) based on shrinkage. Color homogeneity observed visually and ranking was given for each treatment. Greater than equal to 95%, ≥90%, ≥85%, ≥80% and ≥75% color homogeneity ranked as first, second, third, fourth and fifth, respectively [4]. The moisture content of raisins was estimated by oven drying method (Model: Bajaj Microwave Oven, 2010 ETC) [5]. The moisture was checked to 15% approximately while in drying. The raisin TSS was determined by using digital hand refractometer and the values were corrected at 20°C with the help of temperature correction table [6]. The Hunter *L**, *a**, *b** color measured by spectrophotometer (Model: Colorflex, Hunter Lab, West Virginia, USA). The maximum for *L** is 100, which would be a perfect reflecting diffuser. The minimum *L** would be zero, which would be black. The *a** and *b** axes have no specific numerical limits. Positive a* is red whereas negative a* is green. Positive b* is yellow whereas negative b* is blue.

The experimental data were subjected to analysis of variance (ANOVA) using factorial completely randomized design as per the procedure out lined by Panse and Sukhatme [7]. Least significant differences (Fisher's protected LSD) were calculated following significant F-test (P = 0.05).

3. RESULTS AND DISCUSSION

3.1 Drying Time (Days)

It was evident from Table 3, significantly the lowest drying time recorded in late harvested (20 DALH) fruits i.e. 19th April to 1st May for all the varieties used for raisin making, which might be due to high water loss in delayed harvesting [4,8]. Drying time gradually decreased with the succeeding harvesting dates. The berries of MS were having thin skin, dried in a shorter time i.e. 13.27 days whereas SO took a maximum time of 14.73 days. The time taken for drying of TS (14.47 days) was comparable with MC (14.56 days). The difference among the varieties in drying time might be due to varied epicuticular wax and which was conformity with other report [9]. Similarly, another study reported that the grape varieties Diamond Muscat, Summer Muscat and Primus dried faster and it takes 7.7, 8.1 and 8.2 days, respectively whereas Thompson Seedless took more drying time and it takes 12.3 days [10]. The interaction effect on drying time between harvesting dates and varieties were not significant.

3.2 Drying Ratio (Grape: Raisin)

The results related to drying ratio (fresh grapes to obtained raisins) as influenced by harvesting dates in seedless grape varieties are depicted in Table 1. The drying ratio showed a significant decrease from the 20 DBLH to 20 DALH, so that in 20 DBLH, 1 kg of raisin was obtained from 4.73 kg of grapes while in 20 DALH, the same amount of raisin was obtained from only 3.98 kg of grapes. Drying ratio was significantly influenced by grape varieties, it was observed to be lowest in TS (4.01) and maximum in MS (4.55). The interaction between harvesting dates and varieties were also significant (P=.05) and a minimum drying ratio of 3.76:1 recorded in TS fruits harvested on 20 DALH i.e. 19th April whereas maximum in all the varieties harvested on 20 DBLH i.e. 9th to 21st March. It was lowest in late harvested fruits which might be due to high TSS and sugars accumulation in fresh berries as reported by Arzani et al. [4] and Winkler [11].

3.3 Raisin Color (%)

Raisin color is one of the important qualitative aspects and plays an important role in acceptance. Effect of harvesting dates on percentage of green, brown and mixed colored raisins prepared from seedless varieties of grapes are presented in Table 1. Significant difference was observed among the harvesting dates, varieties and their interaction on raisin color.

3.3.1 Green colored raisins

It was evident from data that the green colored raisins increased with each succeeding harvest date and it was highest (72.39%) recorded in late harvested i.e. 20 DALH (19th April) of TS which was comparable with 20 DALH of MC, 10 DALH of TS and MC whereas lowest in 20 DBLH and 10 DBLH of all the varieties as well as local harvest of SO.

3.3.2 Brown colored raisins

Significantly lowest (8.38%) brown colored raisins was noted in 20 DALH of TS which was comparable with 20 DALH of MC, 10 DALH of TS and MC; highest (15.25%) in 20 DBLH of SO which was on par with 20 DBLH of MS and 2AC, 10 DBLH of SO and MS.

3.3.3 Mixed colored raisins

10 DALH of TS and MC, 20 DALH of TS and MC and local harvest of MC were recorded significantly lower mixed colored raisins and comparable with others, whereas SO harvested on local harvest date, 10 and 20 DALH found highest.

Fully ripened or late harvested grapes between 10 and 20 DALH (i.e. 9th to 19th April for TS and 17th to 27th April for MC) recorded significantly lowest brown and mixed colored raisins, and correspondingly increased green colored raisins. Similarly, several authors revealed that the late harvest or fully ripened grapes resulting in improved and more homogeneous raisin color [4,12,13]. The formation of brown color in raisins can be ascribed to the accumulation of melanin produced by the activity of polyphenol oxidase and non-enzymatic reactions [14].

Table 1. Effect of harvesting dates on green, brown and mixed colored (%) and drying ratio (Grape: Raisin) of raisins prepared from seedless varieties of grapes

Harvesting dates (H)	Green colored raisins (%)	Brown colored raisins (%)	Mixed colored raisins (%)	Drying ratio (grape : raisin)
H_1: 20 days before local harvest	65.87 ^{c}	14.72 ^{e}	19.41 ^{d}	4.73 ^{e}
H_2: 10 days before local harvest	66.59 ^{c}	14.40 ^{d}	19.02 ^{c}	4.37 ^{d}
H_3: local harvest	69.62 ^{b}	11.54 ^{c}	18.85 ^{b}	4.26 ^{c}
H_4: 10 days after local harvest	71.92 ^{a}	9.47 ^{b}	18.62 ^{a}	4.06 ^{b}
H_5: 20 days after local harvest	72.39 ^{a}	9.03 ^{a}	18.58 ^{a}	3.98 ^{a}
Varieties (V)				
V_1: Thompson Seedless (TS)	71.33 ^{a}	11.03 ^{a}	17.61 ^{b}	4.01 ^{a}
V_2: 2A Clone (2AC)	68.62 ^{b}	11.87 ^{c}	19.50 ^{c}	4.32 ^{d}
V_3: Sonaka (SO)	66.92 ^{c}	12.72 ^{e}	20.36 ^{d}	4.26 ^{c}
V_4: Manik Chaman (MC)	71.27 ^{a}	11.31 ^{b}	17.42 ^{a}	4.20 ^{b}
V_5: Merbein Seedless (MS)	68.23 ^{b}	12.19 ^{d}	19.58 ^{c}	4.55 ^{e}
Interactions (H x V)				
H_1V_1	66.20 ^{g}	13.64 ^{k}	20.16 ^{i}	4.65 ^{kl}
H_1V_2	65.85 ^{g}	14.96 ^{no}	19.19 ^{e}	4.69 ^{l}
H_1V_3	65.30 ^{g}	15.25 ^{o}	19.45 ^{f}	4.69 ^{l}
H_1V_4	66.19 ^{g}	14.71 ^{mn}	19.10 ^{e}	4.68 ^{l}
H_1V_5	65.78 ^{g}	15.05 ^{no}	19.17 ^{e}	4.94 ^{lm}
H_2V_1	67.42 ^{fg}	13.97 ^{kl}	18.61 ^{c}	4.10 ^{de}
H_2V_2	66.20 ^{g}	14.25 ^{lm}	19.55 ^{fg}	4.44 ^{ij}
H_2V_3	65.84 ^{g}	14.96 ^{no}	19.20 ^{e}	4.36 ^{hi}
H_2V_4	67.32 ^{fg}	13.98 ^{kl}	18.70 ^{cd}	4.28 ^{gh}
H_2V_5	66.15 ^{g}	14.83 ^{no}	19.02 ^{de}	4.67 ^{kl}

Harvesting dates (H)	Green colored raisins (%)	Brown colored raisins (%)	Mixed colored raisins (%)	Drying ratio (grape : raisin)
H_3V_1	72.85 ^{bc}	10.41 ^{fg}	16.64 ^{b}	4.00 ^{cd}
H_3V_2	68.10 ^{ef}	11.63 ^{h}	20.27 ^{i}	4.32 ^{hi}
H_3V_3	66.25 ^{g}	12.75 ^{j}	21.00 ^{j}	4.25 ^{gh}
H_3V_4	72.84 ^{bc}	10.61 ^{g}	16.55 ^{ab}	4.17 ^{fg}
H_3V_5	68.05 ^{ef}	12.18 ^{i}	19.77 ^{g}	4.55 ^{jk}
H_4V_1	74.96 ^{ab}	8.77 ^{ab}	16.27 ^{a}	3.82 ^{ab}
H_4V_2	71.20 ^{cd}	9.53 ^{d}	19.27 ^{ef}	4.12 ^{ef}
H_4V_3	68.30 ^{ef}	10.56 ^{fg}	21.14 ^{j}	4.05 ^{de}
H_4V_4	74.88 ^{ab}	8.83 ^{ab}	16.29 ^{a}	3.98 ^{cd}
H_4V_5	70.24 ^{de}	9.64 ^{de}	20.12 ^{hi}	4.33 ^{hi}
H_5V_1	75.23 ^{a}	8.38 ^{a}	16.39 ^{ab}	3.76 ^{a}
H_5V_2	71.75 ^{cd}	9.01 ^{bc}	19.24 ^{ef}	4.04 ^{de}
H_5V_3	68.90 ^{ef}	10.08 ^{ef}	21.02 ^{j}	3.98 ^{cd}
H_5V_4	75.12 ^{ab}	8.44 ^{ab}	16.44 ^{ab}	3.91 ^{bc}
H_5V_5	70.95 ^{cd}	9.23 ^{cd}	19.82 ^{gh}	4.24 ^{fgh}

Mean separation with the same alphabets within harvesting dates (H), varieties (V) and their interactions (H x V) were not significantly different at P ≤ 0.05

3.4 Raisin Yield (kg/vine)

There was significant difference (*P* =0.05) found among the harvesting dates and varieties on raisin yield (Table 3). The highest raisin yield (4.73 to 4.82 kg/vine) was recorded in well matured or late harvested fruits i.e. 19th April (10 DALH) to 1st May (20 DALH) used for raisin making in our study, might be due to the TSS increase was found to be linear at about 0.15 ^{o}Brix per day for TS, 2AC and MC and 0.14 ^{o}Brix per day for SO and MS from 20 DBLH to 20 DALH. Similarly, Arzani et al. [4] and Christensen et al. [8] also found that increased raisin yield with delayed harvest date in varieties Thompson Seedless and Paycamy can be attributed to increased soluble solids. Raisins prepared from TS (5.10 kg/vine) and MC (4.92 kg/vine) showed highest yield in this study due to high TSS of fresh berries and corresponding increase in raisin yield [13]. The interaction between harvesting dates and varieties on raisin yield was not significant.

3.5 Raisin Wastes (g)

The raisin wastes (grams decayed raisins from 3 kg of fresh grapes) were lowest in 20 DBLH (57.50 g); among the varieties it was observed to be minimum in TS (84.46 g) whereas MS (92.06 g) recorded highest. The increase in raisin waste from 20 DBLH to 20 DALH (Table 3) in this finding may be explained by the increase in the amount of decayed berries with successive harvesting date [4]. This study was consistent with Christensen et al. [12] in dried grapes. The interaction between harvesting dates and varieties was not significant.

3.6 Size, Texture and Color Homogeneity

It was observed that the harvesting dates and varieties influenced the size, surface texture and color homogeneity of raisins (Table 2). The raisin size (number of raisins in 100 g) on 20 DBLH and 10 DBLH was small (190–220) and in local harvest date it was medium (160–190) in all the varieties, whereas big (130–160) in 20 DALH in all varieties except MS. In our study, increase in soluble solids and decrease in water content by progression of ripening stage, may be the cause for raisin size improvement [8]. The size of a single raisin is directly related to size of fresh grape berry. Bolder or smaller berry size is directly contributed by regional factors, vineyard soil type, grape variety itself and crop load on a vine [15]. The surface texture of raisins prepared after 20 and 10 DBLH were classified as high shrinkage (H) and local harvest as medium shrinkage (M) whereas on 10 and 20 DALH it was low shrinkage (L) on all the varieties of grapes based on number of wrinkles or shrinkage of raisin. Skin thickness of berry influences the fineness of the wrinkles on raisins and fine wrinkled raisins are more desirable [10]. The highest color homogeneity of raisins was observed in all the varieties on 20 DALH whereas lowest on 20 DBLH; with respect to the varieties, MC and TS raisins were more homogeneous in color followed by 2AC and MS and least homogeneous was observed in SO raisins. When the fruit was more fully ripened,

the resulting raisin color improved and a more homogenous color was obtained [4].

3.7 Moisture (%)

The moisture content (Table 3) of raisins significantly decreased from 15.66% (20 DBLH) to 15.03% (20 DALH) with the successive harvesting dates which can be attributed to decreased drying rates and increased soluble solids with delayed harvest as reported by Christensen et al. [8] and Arzani et al. [4]. Similarly, Adsule and Banerjee [16] also found that the moisture level of 15 to 16.5% is considered an appropriate range and will have a better mouth feel. It was significantly lowest (14.61%) in MS raisins and highest (15.67%) in SO raisins. The difference in raisin moisture level among varieties may be due to amount and type of wax in berry skin and size of berries, as in the case of SO, which has thick skin and big sized berries and MS, which has thin skin and small sized berries in this study [9]. The interaction effect on moisture content of raisins between harvesting dates and varieties was not significant.

Table 2. Effect of harvesting dates on size (number of raisins in 100 g), texture and color homogeneity of raisins prepared from seedless varieties of grapes

	Varieties				
	TS	**2AC**	**SO**	**MC**	**MS**
Harvesting dates	**Size (number of raisins in 100 g)**				
H_1 : 20 days before local harvest	Small	Small	Small	Small	Small
H_2 : 10 days before local harvest	Small	Small	Small	Small	Small
H_3 : local harvest	Medium	Medium	Medium	Medium	Medium
H_4 : 10 days after local harvest	Medium	Medium	Big	Big	Medium
H_5 : 20 days after local harvest	Big	Big	Big	Big	Medium
Harvesting dates	**Texture**				
H_1: 20 days before local harvest	H	H	H	H	H
H_2: 10 days before local harvest	H	H	H	H	H
H_3: local harvest	M	M	M	M	M
H_4: 10 days after local harvest	L	L	L	L	L
H_5: 20 days after local harvest	L	L	L	L	L
Harvesting dates	**Color homogeneity**				
H_1: 20 days before local harvest	Rank 5	Rank 5	Rank 5	Rank 5	Rank 5
H_2: 10 days before local harvest	Rank 4	Rank 4	Rank 5	Rank 4	Rank 4
H_3: local harvest	Rank 3	Rank 3	Rank 4	Rank 3	Rank 3
H_4: 10 days after local harvest	Rank 2	Rank 3	Rank 4	Rank 2	Rank 3
H_5: 20 days after local harvest	Rank 2	Rank 3	Rank 3	Rank 1	Rank 3

Table 3. Effect of harvesting dates on drying time (days), yield (kg/vine), wastes (g decayed raisins from 3 kg of grapes) and moisture (%) of raisins prepared from seedless varieties of grapes

Harvesting dates (H)	**Drying time (days)**	**Yield (kg/vine)**	**Wastes (g)**	**Moisture (%)**
H_1: 20 days before local harvest	14.43 ^{c}	4.05 ^{c}	57.50 ^{a}	15.66 ^{c}
H_2: 10 days before local harvest	14.31 ^{bc}	4.40 ^{b}	69.73 ^{b}	15.40 ^{bc}
H_3: local harvest	14.19 ^{bc}	4.51 ^{b}	87.00 ^{c}	15.22 ^{ab}
H_4: 10 days after local harvest	14.08 ^{ab}	4.73 ^{a}	100.50 ^{d}	15.11 ^{ab}
H_5: 20 days after local harvest	13.91 ^{a}	4.82 ^{a}	126.28 ^{e}	15.03 ^{a}
Varieties (V)				
V_1: Thompson Seedless (TS)	14.47 ^{c}	5.10 ^{a}	84.46 ^{a}	15.55 ^{b}
V_2: 2A Clone (2AC)	13.89 ^{b}	4.39 ^{c}	90.46 ^{c}	14.95 ^{a}
V_3: Sonaka (SO)	14.73 ^{d}	4.59 ^{b}	87.91 ^{b}	15.67 ^{b}
V_4: Manik Chaman (MC)	14.56 ^{cd}	4.92 ^{a}	86.12 ^{b}	15.64 ^{b}
V_5: Merbein Seedless (MS)	13.27 ^{a}	3.51 ^{d}	92.06 ^{d}	14.61 ^{a}
Interactions (H x V)	NS	NS	NS	NS

Mean separation with the same alphabets within harvesting dates & varieties were not significantly different at P ≤ 0.05. NS – Not significant

3.8 Total Soluble Solids (°Brix)

The TSS of raisins gradually increased with each successive harvesting dates and a maximum of 81.73 °Brix was recorded in 20 DALH (19th April to 1st May) and lowest in 20 DBLH (65.45 °Brix). The TSS increased while the berries are continuing to grow and expand due to the influx of water. Thereafter, increase in soluble solids concentration may be due to the loss of water from the berries and the concentration of solids already present in the berries. During this time, TSS increased from 18.50 to 24.34 °Brix in TS, 18.22 to 24.04 °Brix in 2AC, 18.24 to 24.05 °Brix in MC, 18.19 to 23.98 °Brix in SO and 18.22 to 24.00 °Brix in MS in our study. From the 20 DBLH to 20 DALH corresponding increase in TSS of raisins with delayed harvesting was observed. It was recorded a maximum of 74.94 °Brix in TS raisins whereas SO raisins recorded a minimum of 72.43 °Brix. This study is conformity with Winkler [11]. Mane et al. [17] also reported that raisin TSS in different varieties ranged from 71.5 to 82.6 °Brix. The interaction between harvesting dates and varieties was not significant with respect to TSS of raisins.

3.9 Hunter Color *L**, *a** and *b**Values

There was significant difference (P=0.05) observed among the harvesting dates and varieties on Hunter color *L**, *a** and *b** values of raisins (Table 4). The interaction between harvesting dates and varieties were not significant on Hunter color *L**, *a** and *b** values.

3.9.1 *L** (Lightness)

Significantly maximum *L** value was recorded in 20 DALH (23.32); among varieties TS (23.34) raisins are brighter followed by MC, 2AC and MS whereas minimum in SO (20.99) raisins are darker.

3.9.2 *-a** (Greenness)

The negative values of *a** indicates the greenness of the raisins, and higher the negative value more in greenness. The negative a* value of raisins gradually increased with each successive date of harvesting. Significantly maximum and on par negative *a** value was recorded in 20 DALH (-2.78) and 10 DALH (-2.66) whereas lowest in 20 DBLH (-2.05). Raisins prepared from TS were observed to be more greenness (-2.88) than other varieties.

3.9.3 *b** (Yellowness)

The Hunter color *b** values of raisins showed a significant increase from 20 DBLH (6.09) to 20 DALH (8.66). TS raisins (7.39) showed higher *b** value than others varieties.

It was noted that the values of *L** were less than 50 among the harvesting dates (20.41 to 23.32) and varieties (20.99 to 23.34), which indicate that the raisins are dark. The *a** values were negative among the harvesting dates (-2.05 to -2.78) and varieties (-1.87 to -2.88), indicating a predominance of green coloration over the red (positive a*), and also positive values of b*

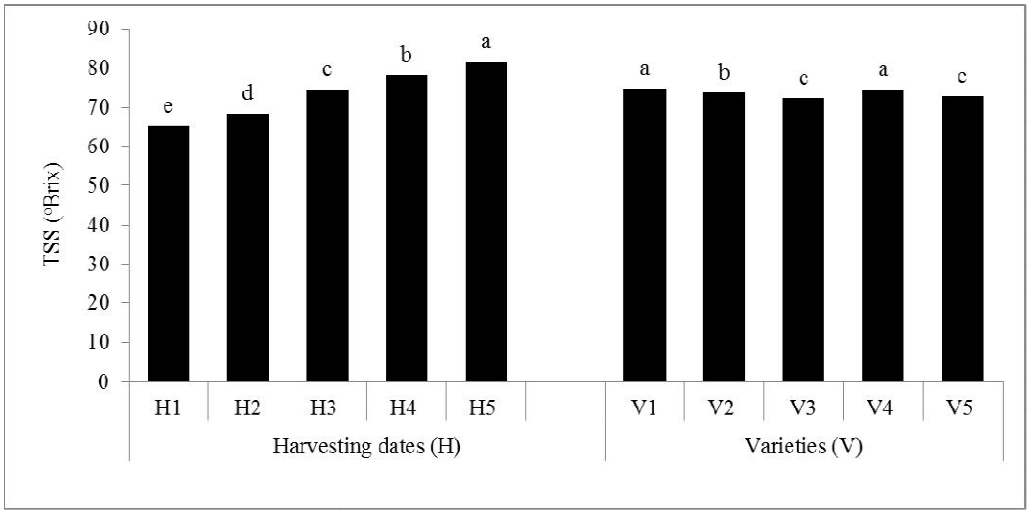

Fig. 1. TSS (°Brix) of raisins prepared from seedless grape varieties as affected by harvesting dates

Table 4. Effect of harvesting dates on Hunter color *L, *a** and *b** values of raisins prepared from seedless varieties of grapes**

Harvesting dates (H)	*L**	*a**	*b**
H_1: 20 days before local harvest	20.41 ^{e}	-2.05 ^{c}	6.09 ^{d}
H_2: 10 days before local harvest	21.51 ^{d}	-2.26 ^{b}	6.18 ^{d}
H_3: local harvest	22.32 ^{c}	-2.32 ^{b}	7.14 ^{c}
H_4: 10 days after local harvest	22.92 ^{b}	-2.66 ^{a}	8.29 ^{b}
H_5: 20 days after local harvest	23.32 ^{a}	-2.78 ^{a}	8.66 ^{a}
Varieties (V)			
V_1: Thompson Seedless (TS)	23.34 ^{a}	-2.88 ^{a}	7.39 ^{a}
V_2: 2A Clone (2AC)	21.93 ^{c}	-2.88 ^{a}	7.26 ^{bc}
V_3: Sonaka (SO)	20.99 ^{e}	-1.87 ^{c}	7.15 ^{d}
V_4: Manik Chaman (MC)	22.74 ^{b}	-2.81 ^{a}	7.34 ^{ab}
V_5: Merbein Seedless (MS)	21.49 ^{d}	-2.04 ^{c}	7.23 ^{cd}
Interactions (H x V)	NS	NS	NS

Mean separation with the same alphabets within harvesting dates & varieties were not significantly different at P ≤ 0.05. NS – Not significant. '-' values indicate green color

among the harvesting dates (6.09 to 8.66) and varieties (7.15 to 7.39), which are indicators of the predominance of yellow coloration over the blue (negative *b**). In this study, the increase of greenness (negative *a**), brightness (*L**) and yellowness (*b**) of raisins on each successive harvesting date was found significant, and late harvests (i.e. 19th April to 1st May for all varieties) demonstrated effectiveness on saving the greenness of raisins [18]. Our finding was consistent with Bahaabad et al. [19] on drying of grapes.

4. CONCLUSIONS

Our results indicate that raisins prepared from fully ripened grapes i.e. harvested on 19th April to 1st May (10 to 20 days after local harvest) in all the seedless varieties among which Thompson Seedless harvested on 9th to 19th April and Manik Chaman on 17th to 27th April were superior for yield, green color retention and quality of raisins.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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