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Effect of Antioxidants on Drying, Yield, Hunter Color L*, a*, b* and Moisture Content of Dried-On-Vine Raisins Prepared from Seedless Varieties of Grape (*Vitis vinifera* L.)

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ABSTRACT

The study was conducted to know the various concentrations of antioxidants (ascorbic acid, 500, 750 and 1000 ppm and benzyl adenine, 50, 100 and 150 ppm) with 2.4% potassium carbonate and 1.5% ethyl oleate (i.e. alkaline emulsion of ethyl oleate, AEEO) as a pre-drying treatment on yield and quality of dried-on-vine raisins prepared from seedless varieties viz., Thompson Seedless, 2A Clone, Sonaka, Manik Chaman and Merbein Seedless. The grape bunches were dried on the vine after severing the fruit bearing canes and leaving the canes that will carry the next year's crop. Then canes are sprayed with drying emulsions and harvested raisins are finally dried in dehydrators. Among the various pre-treatments, AEEO plus ascorbic acid 1000 ppm showed significantly maximum raisin yield (4.84 kg/vine), average raisin weight and brix-acid ratio. The ascorbic acid 1000 ppm significantly retain maximum color of dried-on-vine raisins in terms of Hunter color L, a*, b* values and takes minimum drying time (20.87 days). Regarding varieties, dried-on-vine raisins prepared from varieties Manik Chaman and Thompson Seedless were superior to others.*

Key words: *Antioxidants, Dried-On-Vine Raisins, Hunter Color L*, a*, b*, Raisin Yield.*

INTRODUCTION

Grape (*Vitis vinifera* L.) is an important fruit crop of India. The fresh grape industry in the country is facing problems in marketing of the produce in both domestic and international market, as the quality standards stipulated by the regulatory bodies are becoming more and more stringent.

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Moreover, the maximum benefits from grape cultivation can only be derived by establishing processing industries for the production of value added products like good quality raisins[1,2]. 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[3].

Dried grapes, commonly known as raisins, are of a great economic importance. The word ‘raisin’ originates from the French word ‘racemes’, which means ‘a cluster of grapes or berries’. Raisins are 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. Raisins are a good source of fiber, potassium, iron, calcium and vitamin B and are free from fat and cholesterol. They contain only natural sugars as a source of energy. Besides sugars, essential amino acids and fatty acids, these are rich source of antioxidants[4].

There are many factors affecting the quality as well as yield of raisins. The physical characteristics of raisins from different countries are quite different, while chemical characteristics are fairly consistent[5]. 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[2]. The dipping oil treatment alone induced soft texture, but it led to the development of brown rather greenish color[6]. Application of antioxidants like ascorbic acid and benzyl adenine effectively reduced browning and increased the storage period of many fruits[7].

A new development in raisin production in Australia has been to dry the bunches on the vine (DOV) after severing the fruit bearing canes and leaving the canes that will carry the next year’s crop. The fruit bearing canes are then sprayed with drying emulsions and the run-off collected and reused. The harvested raisins are given a final drying in dehydrators. This technique works well using either Thompson seedless or Merbein seedless varieties. This technique may be applicable to Thompson seedless in Hyderabad area[8].

In India, raisins are mainly produced in Sangli, Solapur and Nasik districts of Maharashtra and Bijapur district of Karnataka state. 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 harvesting period in this region is during summer (February to May) with low relative humidity, it is excellent for raisin making[3]. 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. Therefore, the main objective of this study is to know the effect of various concentrations of antioxidants along with alkaline emulsion of ethyl oleate on drying, yield, Hunter color L*, a*, b* and moisture content of dried-on-vine (DOV) raisins prepared from seedless varieties of grape viz., Thompson Seedless, 2A Clone, Sonaka, Manik Chaman and Merbein Seedless.

MATERIALS AND METHODS

The experiment was conducted at Grape Research Station, Rajendranagar, Hyderabad, Ranga Reddy district, Telangana State during 2012-14. The Grape Research Station is located at 77^{o}85’ East longitude and 18^{o}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.

A solution containing 2.4% potassium carbonate plus 1.5% ethyloleate (*i.e.* alkaline emulsion of ethyl oleate, AEEO) was prepared in a plastic bucket. The pH of the solution was adjusted to 11 while adding potassium carbonate. Dipping solutions of 500 ppm, 750 ppm and 1000 ppm of ascorbic acid (AA) were prepared by dissolving 5 g, 7.5g and 10 g of AA respectively in 10 liters of AEEO. Similarly 50 ppm, 100 ppm and 150 ppm of benzyl adenine (BA) were prepared by dissolving 0.5 g, 1 g and 1.5 g of BA respectively in 10 liters of AEEO.

Selected grape bunches of varieties Thompson Seedless, 2A Clone, Sonaka, Manik Chaman and Merbein Seedless on fruit bearing canes were cut (cane severance) at fruit maturity of greater than 21 ^{o}Brix then the bunches were dipped in drying emulsion prepared for dipping viz., (A_1) AEEO + AA 500 ppm, (A_2) AEEO + AA 7500 ppm, (A_3) AEEO + AA 1000 ppm, (A_4) AEEO + BA 50 ppm, (A_5) AEEO + BA 100 ppm, (A_6) AEEO + BA 150 ppm and (A_7) AEEO as a control. Then, bunches were allowed to dry while hanging on fruiting canes from the trellis wires. The harvested raisins are given a final drying in dehydrators. Moisture testing was done frequently for a preserved level[6].

The acidity, ascorbic acid and sugar content (reducing, total and non-reducing) of fresh grapes was estimated by adopting the procedure given by Ranganna (1977)[9]. After the preparation of DOV raisins, the weight of 100 raisins was taken and calculated to obtain average weight of raisin. The weight of raisins of each replication was taken and calculated to obtain kilo gram of raisins per vine[10]. Moisture content was estimated by oven drying method[11]. The moisture was checked to 15% approximately while in drying. The Hunter color L* (Lightness), a* (Hueness), b* (Brightness) 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 (1985)[12]. Least significant differences (Fisher's protected LSD) were calculated following significant F-test (p=0.05).

RESULTS AND DISCISSIONS

The physico-chemical characteristics viz., color of berry, shape of berry, average weight of berry, berry length, berry diameter and average weight of bunch, total soluble solids, acidity, brix-acid ratio, total sugars, reducing sugars, non-reducing sugars and ascorbic acid content in seedless varieties of grapes were evaluated before imposition of pre-drying treatments (Table 1).

1. Physico-chemical characteristics of seedless varieties of grapes used for DOV raisin making

It was observed that color of berries was yellowish green in 2A Clone and Merbein Seedless and greenish yellow in Thompson Seedless, Sonaka and Manik Chaman, which may be a genotypic variation[13]. The shape of berries (Table 1) was observed to be ovoid in Thompson Seedless and 2A Clone, ovoid elongated in Manik Chaman, Sonaka and round in Merbein Seedless. These characteristic are in conformation with others[14]. The average weight of berry was significantly maximum in Thompson Seedless (2.60 g) which was comparable with Sonaka (2.57 g) and Manik Chaman (2.43 g) whereas it was minimum recorded in Merbein Seedless (2.12 g) which was comparable with 2A Clone (2.17 g). Significantly maximum berry length was recorded in Manik Chaman (19.71 mm) and lowest in Merbein Seedless (18.25 mm). Similarly, berry diameter was recorded highest in Sonaka (15.16 mm) and lowest in Manik Chaman (14.17 mm). Thompson Seedless (362.61 g) had maximum average bunch weight and minimum in Merbein Seedless (287.55 g) which was comparable with 2A Clone (298.45 g). This variation is due to varietal character, climate and soil condition of the locality as reported by[13]. Maximum total soluble solids, sugars (reducing, total and non-reducing) were recorded in Thompson Seedless whereas in Sonaka it was lowest. The ascorbic acid content of berries was maximum in Thompson Seedless whereas lowest was recorded in Sonaka (2.62 mg 100 g-1). Similarly, Adsule et al. (2008)[3] also reported that the suitability of grapes for raisin making is determined by total soluble solids and sugars.

2. Drying time (in days)

It was evident from Table 2 that there was significant difference observed among various concentrations of antioxidants with AEEO as well as in varieties on drying time of grapes. The lowest drying time was recorded in AEEO either with AA or BA irrespective of their concentration compared with control. The shorter drying time (20.87 days) was recorded in pre-drying treatment AEEO + AA 1000 ppm (A_3) which might be due to the ascorbic acid pre-treatment tends to loosen the water molecules[15]. Regarding varieties, shortest drying time (20.03 days) was claimed in Merbein Seedless followed by 2A Clone, Thompson Seedless, Manik Chaman and Sonaka in order. The differences among the grape varieties in terms of drying time which may be due to varied physico-chemical characters (Table 1) and epicuticular wax[16,17]. Once canes are cut, grape clusters supported by a trellis system dry into raisins in 4 to 8 weeks compared with 2 to 3 weeks needed to dry on trays[17,18,19]. The interaction effect on drying time between various concentrations of antioxidants with AEEO and varieties was not significant.

3. Average raisin weight (g)

The results related to an average weight of DOV raisin as influenced by various concentrations of antioxidants with AEEO as a pre-drying treatment in seedless grape varieties are depicted in Table 2. It was observed that there was no significant difference among the various concentrations of AA (500, 750 and 1000 ppm) as well as BA (50, 100 and 150 ppm) with AEEO. The highest raisin weight was recorded in pre-drying treatment AEEO + AA 1000 ppm (A_3) which may be due to highest water loss and concentration of soluble solids in the berries (Table 1) during drying period, which leads to higher raisin weight. Adsule et al. (2008)[3] also reported that the raisins prepared by dipping oil (AEEO) method in seedless grape varieties recorded raisin weight from 0.34 to 0.45 g. Regarding varieties, Sonaka and Manik Chaman recorded maximum (0.507 g) raisin weight whereas it was minimum in Merbein Seedless (0.438 g) in the present study which might be due to the high moisture content in DOV raisins[17]. The interaction effect was not significant.

4. Raisin yield (kg/vine)

It was evident from data, there was no significant difference observed among the various concentrations of AA (500, 750 and 1000 ppm) as well as BA (50, 100 and 150 ppm) with AEEO regarding to raisin yield. The DOV Raisins yield was significantly influenced by the seedless grape varieties used for raisin making. It was observed to be highest in Thompson Seedless (5.32 kg/vine) followed by Manik Chaman (5.11 kg/vine), Sonaka (4.75 kg/vine) and 2A Clone (4.54 kg/vine) whereas Merbein Seedless (3.67 kg/vine) recorded minimum. The DOV raisin yield among the various concentrations of antioxidants with AEEO and varieties ranged from 4.57 to 4.84 kg/vine and 3.67 to 5.32 kg/vine respectively. The highest raisin yield was recorded in pre-drying treatment AEEO + AA 1000 ppm (A_3) which may be due to the lowest raisin waste and highest average raisin weight was recorded in this treatment because the ascorbic acid play major role to terminate radical chain reactions ultimately leads to higher DOV raisin yield[20]. The highest raisin yield was recorded in Thompson Seedless which might be due to its high total soluble solids and sugars in fresh berries corresponding increase in DOV raisin yield. Obviously, Parpinello et al. (2012)[10] also reported that greater the rate of soluble solids in fresh grapes (Table 1) when cane severing, greater will be the DOV raisin yield, which may be relatively the same for present studied varieties. The interaction between various concentrations of antioxidants with AEEO and varieties was not significant with respect to DOV raisin yield.

5. Moisture content (%)

The raisin moisture content was low (15.21%) in pre-drying treatment AEEO + AA 1000 ppm (A_3) which could be due to the ascorbic acid pre-treatment affects fruit tissues, making it easier for the water to diffuse during drying[20,21]. The difference in DOV raisin moisture level among varieties which may be due to amount and type of wax in berry skin and size of berries, as in the case of Sonaka, which has thick skin and big sized berries and Merbein Seedless, which has thin skin and small sized berries in this study (Table 1)[10,16]. Ramming (2009)[17] also stated the Australian method uses an emulsion of potassium carbonate and drying oil to aid drying on vine (DOV) of Thompson Seedless fruit. Winkler (1962)[13] also stated that the changes and end points reached are varietal characteristics modified by environmental conditions. The interaction effect on moisture content between pre-treatments and varieties was not significant.

6. Brix-acid ratio

Influence of various concentrations of AA and BA with AEEO as a pre-drying treatment on brix-acid ratio of DOV raisins prepared from seedless grape varieties are depicted in Table 2. It was recorded to be highest (100.29) in pre-drying treatment AEEO + AA 1000 ppm (A_3) which may be due to highest water loss and concentration of soluble solids, which leads to higher brix-acid ratio[20]. Due to higher TSS and lower acidity of DOV raisins prepared from Thompson Seedless, showed higher brix-acid ratio compared to other varieties (Table 1)[22]. Winkler (1962)[13] also denoted that the brix-acid ratio of raisins is about the same as that assumed in fresh grapes. The interaction between various concentrations of antioxidants with AEEO and varieties was not significant.

7. Hunter color L*, a* and b* values

7.1 Hunter color L* values

The lightness (L*) values of DOV raisins was significantly maximum in A_3 (19.96) which was on par with A_2 (19.89) and lowest in control (17.06). Regarding varieties, it was observed to be highest in Manik Chaman (20.28) whereas minimum in Sonaka (17.93). The interaction between various concentrations of antioxidants with AEEO and varieties was not significant regarding to the Hunter color L* values of DOV raisins.

7.2 Hunter color a* values

There was significant difference was observed among the various concentrations of antioxidants with AEEO with respect to Hunter color a* values. The negative values of a* indicates the greenness and higher the negative value more in greenness of the raisins. It was recorded to be a significantly maximum negative value in A_3 (-0.43) which comparable par with A_2 (-0.31). The positive value of a* was noted in control (2.99) followed by A_4 (0.40) and this was on par with A_5 (0.28) which indicates the raisin color very nearer to the greenness or towards the redness.

There was significant difference among the varieties. It was observed to be significantly minimum in variety Manik Chaman (0.06) which was comparable with Thompson Seedless (0.12) and maximum in Sonaka (0.91) which was on par with Merbein Seedless. The interaction between various concentrations of antioxidants with AEEO and varieties was not significant on a* values of DOV raisins.

7.3 Hunter color b* values

Significant difference observed among the various concentrations of AA and BA with AEEO regarding to Hunter color b* values. The positive b* values indicates the yellowness of raisins. It was significantly maximum recorded in A_3 (8.26) whereas minimum in control (5.87). Hunter color b* values of raisins significantly increased with increase of various concentrations of BA (i.e. 50, 100 and 150 ppm) and AA (i.e. 500, 750 and 1000 ppm) with AEEO. With respect to varieties, significantly highest b* value was noted in Manik Chaman (7.18) which was comparable with Thompson Seedless (7.13). It was minimum reported in Sonaka (6.92) which was on par with Merbein Seedless (7.00). The interaction effect was not significant.

It was noted that the values of L* were less than 50 among the pre-drying treatments (17.06 to 19.96) and varieties (17.93 to 20.28), which indicate that the raisins are dark. The a* values were negative in treatments A_3 (-0.43) and A_2 (-0.31), indicating a predominance of green coloration over the red (positive a*) than other treatments (A_1, A_4, A_5, A_6 and A_7), and also positive values of b* among the various concentrations of antioxidants with AEEO (5.87 to 8.26) and varieties (6.92 to 7.18), 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 with increased of AA and BA concentrations with AEEO as a pre-drying treatment was found significant, and demonstrated effectiveness on saving the greenness of raisins[23]. Tray dried raisins, regardless of cultivar, had higher chroma values than did DOV raisins, indicating that the tray dried raisins were more vividly colored. This finding is consistent with other reports on drying of grapes[24].

Table 1: Physico-chemical characteristics of seedless grape varieties used for dried-on-vine raisin making

Physico-chemical characters	Varieties (V)					S.Em ±	CD at 5%
	TS	2AC	SO	MC	MS		
Color of berries	Greenish yellow	Yellowish green	Greenish yellow	Greenish yellow	Yellowish green	–	–
Shape of berry	Ovoid	Ovoid	Ovoid elongated	Ovoid elongated	Round	–	–
Average berry weight (g)	2.60^{a}	2.17^{b}	2.57^{a}	2.43^{a}	2.12^{b}	0.06	0.20
Berry length (mm)	18.95^{b}	18.98^{b}	19.65^{a}	19.71^{a}	18.25^{c}	0.05	0.15
Berry diameter (mm)	14.61^{b}	14.63^{b}	15.16^{a}	14.17^{c}	14.33^{c}	0.08	0.26
Average bunch weight (g)	362.61^{a}	298.45^{c}	325.36^{b}	323.63^{b}	287.55^{c}	4.23	13.52
Total soluble solids (^{o}Brix)	23.50^{a}	23.21^{b}	22.74^{c}	23.16^{b}	22.85^{c}	0.04	0.11
Acidity (%)	0.51^{a}	0.61^{b}	0.66^{d}	0.52^{a}	0.63^{c}	0.01	0.03
Brix-acid ratio	46.07^{a}	38.05^{bc}	34.45^{d}	41.36^{b}	36.27^{cd}	1.07	3.40
Total sugars (%)	21.11^{a}	20.35^{b}	19.63^{c}	20.84^{a}	19.73^{c}	0.14	0.45
Reducing sugars (%)	20.01^{a}	19.27^{c}	18.70^{d}	19.77^{b}	18.64^{d}	0.06	0.20
Non-reducing sugars (%)	1.10	1.08	0.93	1.07	1.09	0.08	NS
Ascorbic acid (mg 100 g^{-1})	3.52^{a}	3.08^{bc}	2.62^{d}	3.13^{b}	3.02^{c}	0.03	0.09

Figures with different alphabet within rows are significantly different at p≤0.05; NS–Not significant.

TS – Thompson Seedless 2AC – 2A Clone SO – Sonaka MC – Manik Chaman MS – Merbein Seedless

Table 2: Effect of various concentrations of antioxidants with alkaline emulsion of ethyl oleate (AEEO) as a pre-drying treatment on drying time, average weight, yield, moisture, brix-acid ratio and Hunter color L*, a* and b* values of dried-on-vine raisins prepared from seedless varieties of grapes.

Pre-drying treatments (A)	Drying time (days)	Average raisin weight (g)	Raisin yield (kg/vine)	Moisture content (%)	Brix-acid ratio	Hunter color		
						L*	a*	b*
A_1 – AEEO + AA 500 ppm	20.99^{ab}	0.476^{ab}	4.73^{ab}	15.42^{bc}	93.69^{bc}	19.47^{b}	0.07^{b}	7.10^{c}
A_2 – AEEO + AA 750 ppm	20.92^{ab}	0.480^{ab}	4.74^{ab}	15.38^{ab}	100.29^{ab}	19.89^{a}	-0.31^{a}	7.94^{b}
A_3 – AEEO + AA 1000 ppm	20.87^{a}	0.481^{a}	4.84^{a}	15.21^{a}	106.22^{a}	19.96^{a}	-0.43^{a}	8.26^{a}
A_4 – AEEO + BA 50 ppm	21.12^{b}	0.473^{bc}	4.62^{bc}	15.69^{ef}	78.78^{ef}	18.76^{d}	0.40^{d}	6.61^{e}
A_5 – AEEO + BA 100 ppm	21.09^{b}	0.473^{bc}	4.63^{bc}	15.58^{de}	81.50^{de}	18.96^{cd}	0.28^{cd}	6.76^{d}
A_6 – AEEO + BA 150 ppm	21.02^{ab}	0.476^{abc}	4.64^{bc}	15.49^{cd}	87.28^{cd}	19.18^{c}	0.18^{bc}	6.83^{d}
A_7 – AEEO (Control)	22.21^{c}	0.470^{c}	4.57^{c}	15.80^{f}	73.52^{f}	17.06^{e}	2.99^{e}	5.87^{f}
S.Em±	0.07	0.07	0.06	0.05	2.93	0.09	0.06	0.04
CD at 5%	0.21	0.02	0.16	0.15	8.27	0.24	0.18	0.12
Varieties (V)								
V_1 – Thompson Seedless	21.37^{c}	0.471^{b}	5.32^{a}	15.67^{c}	100.65^{a}	19.68^{b}	0.12^{a}	7.18^{a}
V_2 – 2A Clone	20.62^{b}	0.455^{c}	4.54^{d}	15.28^{b}	88.00^{b}	18.87^{c}	0.42^{b}	7.04^{b}
V_3 – Sonaka	21.69^{d}	0.507^{a}	4.75^{c}	15.73^{c}	76.25^{c}	17.93^{e}	0.91^{c}	6.92^{c}
V_4 – Manik Chaman	21.42^{c}	0.507^{a}	5.11^{b}	15.72^{c}	98.36^{a}	20.28^{a}	0.06^{a}	7.13^{a}
V_5 – Merbein Seedless	20.03^{a}	0.438^{d}	3.67^{e}	15.13^{a}	80.51^{c}	18.43^{d}	0.77^{c}	7.00^{bc}
S.Em±	0.06	0.02	0.05	0.04	2.48	0.07	0.05	0.03
CD at 5%	0.18	0.06	0.14	0.13	6.99	0.20	0.15	0.10
Interactions (A x V)	NS	NS	NS	NS	NS	NS	NS	NS

Figures with different alphabet within pre-drying treatments and varieties are significantly different at p≤0.05; NS – Not significant. ‘ – ‘ values indicate pale green color of raisins

AA – Ascorbic acid
BA – Benzyl adenine

CONCLUSION

The dried-on-vine raisins prepared from seedless varieties of Manik Chaman and Thompson Seedless by using alkaline emulsion of ethyl oleate (i.e. 2.4% potassium carbonate and 1.5% ethyl oleate) with ascorbic acid 1000 ppm as pre-drying treatment were significantly superior in drying time, raisin yield and quality in terms of Hunter color L*, a*, b*, brix-acid ratio and average raisin weight.

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