DOI: 10.15740/HAS/AU/12.TECHSEAR(1)2017/130-136
Agriculture Update
Volume **12** | TECHSEAR-1 | 2017 | 130-136
Visit us : *www.researchjournal.co.in*
e ISSN-0976-6847

RESEARCH ARTICLE :

Hunter color L*, a*, b* and sensory evaluation of raisins as influenced by storage temperatures and seedless varieties of grapes (*Vitis vinifera* L.)

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ARTICLE CHRONICLE :
Received :
05.07.2017;
Accepted :
22.07.2017

SUMMARY : The experiment was conducted to know the effect of storage temperatures (5±1°C, 18±1°C and ambient) on Hunter color L* (Lightness), a* (Hueness), b* (Brightness) as well as sensory evaluation of raisins prepared from five seedless grape varieties *viz*., Thompson Seedless, 2A Clone, Sonaka, Manik Chaman and Merbein Seedless. The raisins stored at 5±1°C in low density polythene (LDPE) bags were superior. The Hunter color L* and b* values decreased and a* values increased with increase of storage temperature as well as advancement of storage period. Raisins stored at 5±1°C recorded maximum L* and b* and minimum a* values. Significantly maximum sensory score was observed by Panelists in raisins stored at 5±1°C and lowest in ambient condition for color and appearance, texture, flavour, taste and overall acceptability. Regarding varieties, raisins prepared from Thompson Seedless and Manik Chaman were superior compared to others in terms of Hunter L*, a*, b* and sensory attributes like colour and appearance, texture, flavour, taste and overall acceptability. From this study, it can be concluded that the raisins prepared from Thompson Seedless or Manik Chaman and packed in 400 gauge LDPE bags and then stored at 5±1°C were superior to others.

KEY WORDS :
Hunter color L*, a*, b*, Sensory evaluation, Seedless grapes, Raisins

How to cite this article : Venkatram, A, Padmavathamma, A.S., Sankar, A. Siva, Manorama, K. and Vijaya, D. (2017). Hunter color *L*, a*, b** and sensory evaluation of raisins as influenced by storage temperatures and seedless varieties of grapes (*Vitis vinifera* L.). *Agric. Update*, **12**(TECHSEAR-1) **: 130-136; DOI: 10.15740/HAS/AU/12.TECHSEAR(1)2017/130-136.**

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BACKGROUND AND OBJECTIVES

Grape (*Vitis vinifera* L.) belongs to the family vitaceae, is an important commercial fruit crop of India. 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. Raisin is mostly produced from the variety Thompson Seedless and its clones *viz.*, Tas-A-Ganesh, Sonaka and Manik Chaman (Adsule *et al*., 2012). The largest producer of dried grapes in the world is USA and Turkey (DFTS, 2013). Telangana State falls under semi-arid tropical region wherein the major grape cultivation is confined to Ranga Reddy, Mahabubnagar and parts of Nalgonda district. 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.

Raisins are a good source of fibre, 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 like oleanolic acid, oleanolic aldehyde, botulin, betulinic acid, etc. (Carranza-Concha *et al*., 2012). 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 minute, and subsequent shade drying in open tier system (Adsule *et al*., 2012). Retention of color during storage and consumer preference is one of the major concerns in raisin production; hence, extensive research is necessary to find the effect of storage temperature on Hunter color L*, a*, b* as well as sensory evaluation of raisins prepared from seedless varieties of grapes.

RESOURCES AND METHODS

The investigation was carried out 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. Selected grape bunches of five seedless varieties *viz*., Thompson Seedless, 2A Clone, Sonaka, Manik Chaman and Merbein Seedless were manually harvested, cleaned, washed in soap water followed by washing in pure water and dipped in solution containing 2.4% potassium carbonate, 1.5% ethyl oleate and ascorbic acid 1000 ppm for 3 minutes, and then kept for shade drying in trays. Under shade drying, the trays of pre-treated bunches were placed in well ventilated room at ambient condition. Moisture testing was done frequently for a preserved level (approximately 15%). Dried grapes were manually separated from the rachis and pedicels by twisting and gentle rubbing against the slotted surface of the trays. The prepared raisins were graded based on color. The color classes applied for grading was pale green, brown and mixed (the mixture in which the percentage of dominant color did not exceed 60%). Hundred grams of raisins were weighed and the separation was done according to the mentioned color classes (Arzani *et al*., 2009). Only the graded green color raisins prepared from varieties *viz*., (V_1) Thompson Seedless (TS), (V_2) 2A Clone (2AC), (V_3) Sonaka (SO), (V_4) Manik Chaman (MC) and (V_5) Merbein Seedless (MS) were packed in 400 gauge low density polyethylene (LDPE) film bags and stored in corrugated boxes at the respective temperatures *i.e.* (T_1) 5±1°C, (T_2) 18±1°C and (T_3) ambient condition in triplicate for a period of four months.

The Hunter L* (Lightness), a* (Hueness), b* (Brightness) 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. Similarly, positive *b** indicates yellow whereas negative b* is blue. The changes in Hunter color L*, a* and b* values of stored raisins were evaluated at monthly intervals. Sensory evaluation was done by panel of 15 personnel of both the genders (male and female) including students and staff of College of Horticulture and Grape Research Station for standard sensory attributes using the 5 point hedonic scale (Adsule and Banerjee, 2003). Score card contains various raisin quality attributes *viz*., color and appearance, flavour, texture, taste and overall acceptability. 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). Least significant differences (Fisher's protected LSD) were calculated following significant F-test (p=0.05).

OBSERVATIONS AND ANALYSIS

The results obtained from the present study as well as discussions have been summarized under following heads:

Hunter color L*, a*, b* values of raisins :

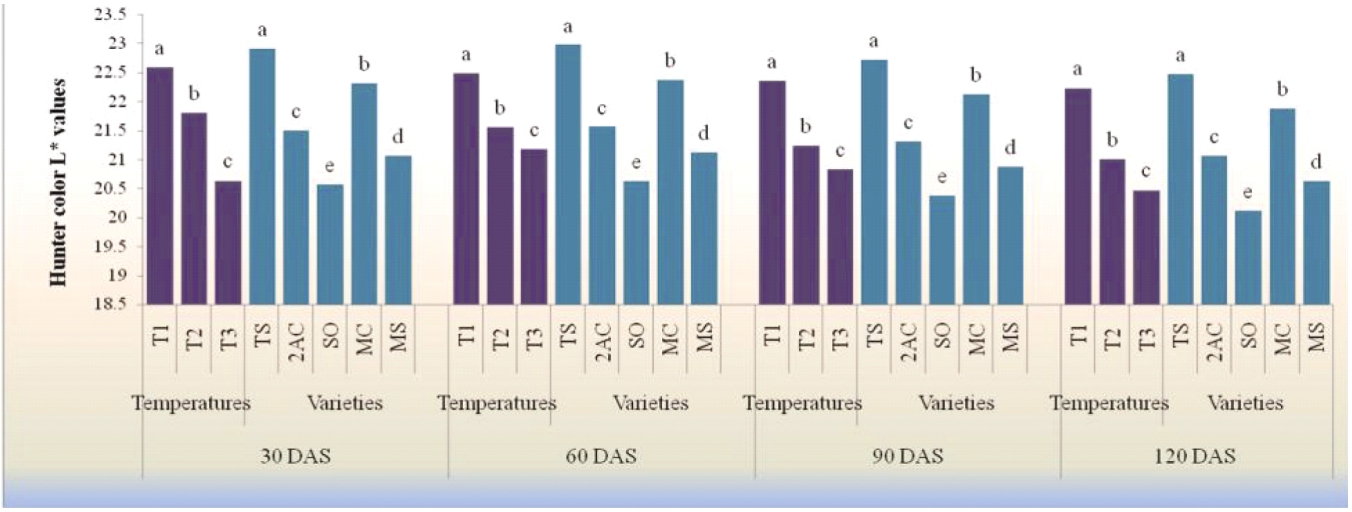
Hunter color L* (Lightness) values :

The Hunter color L* (lightness) values of raisins prepared from seedless varieties of grapes during 30, 60, 90 and 120 days of storage at 5±1°C, 18±1°C and ambient condition are illustrated in Fig. 1. There was significant difference observed among the storage temperature regarding to L* values on all the days after storage. The lightness values was significantly maximum in raisins stored at 5±1°C (22.58) and lowest recorded in ambient condition (20.63) on 30 days after storage.

Similar trend was also observed on 60, 90 and 120 days after storage. There was significant difference also observed among the varieties with respect to *L** values. It was observed to be significantly highest in variety Thompson Seedless (22.91, 22.90, 22.72 and 22.47, respectively) followed by Manik Chaman (22.31, 22.30, 22.12 and 21.87, respectively), 2A Clone (21.50, 21.50, 21.31 and 21.06, respectively) and Merbein Seedless (21.06, 21.04, 20.87 and 20.62, respectively) whereas minimum recorded in Sonaka (20.56, 20.54, 20.37 and 20.12, respectively) on 30, 60, 90 and 120 days after storage, respectively.

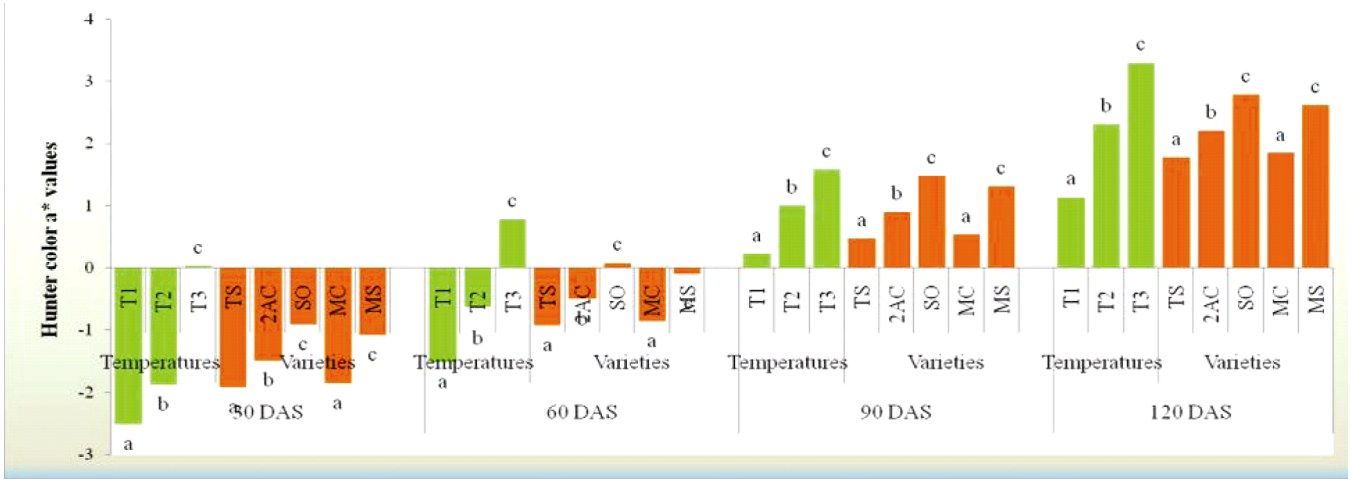
Hunter color a* (Hueness) values :

Hunter color a* (Hueness) values of raisins prepared from seedless varieties of grapes recorded during the study of the experiment after 30, 60, 90 and 120 days of storage at 5±1°C, 18±1°C and ambient



Bars labelled with the same alphabets within temperatures and varieties on each day after storage (DAS) were not significantly different at P≤0.05.
T_1 – 5±1ºC, T_2 – 18±1ºC, T_3 – Ambient
TS – Thompson Seedless, 2AC – 2A Clone, SO – Sonaka, MC – Manik Chaman, MS – Merbein Seedless

Fig. 1 : Hunter color L* values of raisins prepared from seedless varieties of grapes as influenced by storage temperatures at 30, 60, 90 and 120 days after storage (DAS)



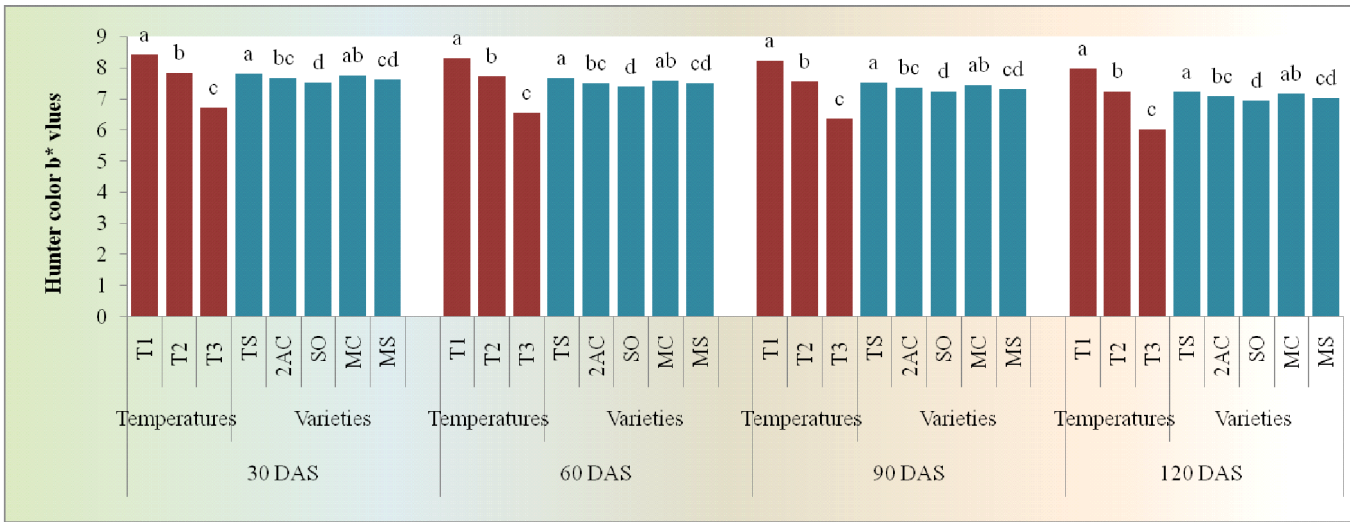
Bars labelled with the same alphabets within temperatures and varieties on each day after storage (DAS) were not significantly different at P≤0.05.
T_1 – 5±1ºC, T_2 – 18±1ºC, T_3 – Ambient
TS – Thompson Seedless, 2AC – 2A Clone, SO – Sonaka, MC – Manik Chaman, MS – Merbein Seedless

Fig. 2 : Hunter color *a values of raisins prepared from seedless varieties of grapes as influenced by storage temperatures at 30, 60, 90 and 120 days after storage (DAS)**

condition were presented in Fig. 2. There was significant difference observed among the storage temperature with respect to a* values of raisins. The negative values of a* indicates the greenness whereas positive a* is redness and higher the negative value more in greenness of the raisins. Significantly maximum negative value in raisins stored at 5±1°C (-2.51 and -1.52) was observed, followed by 18±1°C (-1.88 and -0.63) whereas lowest and positive value of a* was noted in raisins stored at ambient condition (0.03 and 0.78) which indicates the color of raisins towards the redness on 30 and 60 days after storage, respectively. On 90 and 120 days after storage, the a* values were positive on all the storage temperatures and it was recorded lowest in 5±1°C (0.23 and 1.14) whereas highest in ambient condition (1.59 and 3.30). The a* values on 30 and 60 days after storage was negative which indicates greenness whereas it was positive on 90 and 120 days after storage indicates redness of raisins (Fig. 2). There was significant difference were also observed among the varieties regarding a* values of raisins. It was observed to be significantly maximum in variety Thompson Seedless (-1.92, -0.92, 0.47 and 1.78, respectively) which was on par with Manik Chaman (-1.85, -0.86, 0.54 and 1.85, respectively) and minimum values was recorded in Sonaka (-0.91, 0.08, 1.48 and 2.79, respectively) which was on par with Merbein Seedless (-1.08, -0.09, 1.31 and 2.62, respectively) on 30, 60, 90 and 120 days after storage, respectively. The interaction between storage temperature and varieties were not significant on Hunter color a* values of raisins.

Hunter color b* (Brightness) values :

Influence of storage temperature on Hunter color b* (Brightness) values of raisins prepared from seedless grape varieties during 30, 60, 90 and 120 days of storage are presented in Fig. 3. Positive b* values indicates yellow color of raisins. Significantly maximum values were recorded in raisins stored at 5±1°C (8.42) followed by 18±1°C (7.84) and lowest values was recorded in ambient condition (6.71) on 30 days after storage. Similar trend was also observed on 60, 90 and 120 days after storage. There was significant difference observed among the varieties regarding to the Hunter color b* values of raisins. Significantly highest b* value was noted in Thompson Seedless (7.80, 7.65, 7.51 and 7.21, respectively) which was comparable Manik Chaman (7.74, 7.59, 7.45 and 7.16, respectively) and minimum in Sonaka (7.52, 7.38, 7.23 and 6.94, respectively) which was on par with Merbein Seedless (7.60, 7.49, 7.31 and 7.02, respectively) on 30, 60, 90 and 120 days after storage, respectively. On all the days after storage, the b* values of 2A Clone was comparable with Manik Chaman and Merbein Seedless. The interaction between



Bars labelled with the same alphabets within temperatures and varieties on each day after storage (DAS) were not significantly different at P≤0.05.
T_1 – 5±1ºC, T_2 – 18±1ºC, T_3 – Ambient
TS – Thompson Seedless, 2AC – 2A Clone, SO – Sonaka, MC – Manik Chaman, MS – Merbein Seedless

Fig. 3 : Hunter color *b values of raisins prepared from seedless varieties of grapes as influenced by storage temperatures at 30, 60, 90 and 120 days after storage**

storage temperature and varieties was not significant on Hunter color b* values of raisins.

The Hunter colour L* and b* values decreased and a* values increased with increase of storage temperature as well as advancement of storage. Raisins stored at 5±1°C recorded maximum L* and b* and minimum *a** values in the present study (Fig. 1, 2 and 3). Regarding varieties, it was recorded highest in Thompson Seedless and lowest in Sonaka. This study was in conformation with Mahmutoglu *et al.* (1996) that the raisins stored at 6°C recorded highest L* and b* values. Low storage temperature and low O_2 atmosphere in packaging of raisins maintained raisin color (L*, a* and b* values) over 84 days of storage as reported by Tarr and Clingeleffer (2005). During keeping time the highest L* value of raisins were reported when stored at 4°C and by increasing keeping temperature L* decreases and a* or b* increases (Bahaabad *et al*., 2013).

The change in L* and a* that occurred over the first month in the presence of O_2 is probably an indication of enzymatic browning, where polyphenol oxidase catalyses the oxidization of monophenolic compounds to stable brown compounds in the raisin flesh (Sapers, 1993). It is unlikely that the Maillard reaction would be a significant component of the darkening because it is typically slow, caused by a complex interaction of sugars and amino acids and not necessarily O_2 dependant (Namiki, 1988 and Sapers, 1993). The observed changes in L* and a* which were reduced in the low O_2 atmosphere when packaging in LDPE bags support this view in our study. The results demonstrate significant advantages of the low O_2 atmosphere, to minimize color changes in storage. Lower storage temperature in combination with packaging in LDPE bags (a low O_2 atmosphere) can improve preservation of raisin color compared to air storage in present study as supported by (Uhlig and Clingeleffer, 1998).

Sensory evaluation of raisins :

Sensory evaluation for color and appearance, texture, flavour, taste and overall acceptability (5 points scale) of raisins prepared from seedless varieties of grapes after 60, 90 and 120 days of storage at 5±1°C, 18±1°C and ambient condition were presented in Table 1.

Sixty days after storage :

On 60 days after storage, significantly maximum sensory score was observed by Panelists in raisins stored at 5±1°C (4.03, 4.02, 3.76 and 3.97, respectively) which was at par with 18±1°C (3.97, 3.96, 3.70 and 3.91, respectively) whereas it was lower in ambient condition (3.89, 3.87, 3.63 and 3.83, respectively) for colour and appearance, texture, flavour and overall acceptability, respectively. Taste of raisins stored at 5±1°C (4.06) recorded maximum followed by 18±1°C (4.00) and lowest in ambient condition (3.92). Regarding varieties, significantly highest score was observed in raisins

Table 1 : Effect of storage temperature on sensory evaluation of raisins (5 points scale) prepared from seedless varieties of grapes

Temperatures (T)	Color and appearance			Texture			Flavour			Taste			Overall acceptability		
	Days after storage			Days after storage			Days after storage			Days after storage			Days after storage		
	60	90	120	60	90	120	60	90	120	60	90	120	60	90	120
T_1 – 5±1ºC	4.03^{a}	4.00^{a}	3.96^{a}	4.02^{a}	4.00^{a}	3.99^{a}	3.76^{a}	3.70^{a}	3.68^{a}	4.06^{a}	4.03^{a}	3.99^{a}	3.97^{a}	3.93^{a}	3.91^{a}
T_2 – 18±1ºC	3.97^{ab}	3.94^{b}	3.90^{b}	3.96^{ab}	3.93^{b}	3.92^{a}	3.70^{ab}	3.64^{b}	3.62^{ab}	4.00^{b}	3.97^{a}	3.92^{a}	3.91^{a}	3.87^{a}	3.85^{a}
T_3 – Ambient	3.89^{b}	3.83^{c}	3.78^{c}	3.87^{b}	3.82^{c}	3.81^{b}	3.63^{b}	3.57^{c}	3.55^{b}	3.92^{c}	3.89^{b}	3.81^{b}	3.83^{b}	3.79^{b}	3.77^{b}
S.E.±	0.03	0.03	0.03	0.02	0.01	0.03	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.02
C.D. (P=0.05)	0.10	0.10	0.10	0.07	0.04	0.08	0.07	0.05	0.07	0.05	0.06	0.08	0.07	0.06	0.07
Varieties (V)															
V_1 – Thompson Seedless	4.02^{a}	3.98^{a}	3.94^{a}	4.01^{ab}	3.98^{a}	3.97^{a}	3.76^{ab}	3.70^{ab}	3.68^{ab}	4.05^{ab}	4.01^{ab}	3.97^{a}	3.96^{ab}	3.92^{ab}	3.90^{ab}
V_2 – 2A Clone	3.96^{ab}	3.90^{ab}	3.88^{ab}	3.95^{bc}	3.92^{b}	3.91^{ab}	3.69^{bc}	3.64^{bc}	3.62^{bc}	3.99^{bc}	3.95^{bc}	3.91^{ab}	3.90^{bc}	3.86^{bc}	3.84^{bc}
V_3 – Sonaka	3.87^{b}	3.81^{b}	3.79^{b}	3.86^{d}	3.83^{c}	3.82^{b}	3.60^{d}	3.55^{d}	3.53^{d}	3.90^{d}	3.86^{d}	3.82^{b}	3.81^{d}	3.77^{d}	3.75^{d}
V_4 – Manik Chaman	4.06^{a}	4.02^{a}	3.98^{a}	4.05^{a}	4.02^{a}	4.01^{a}	3.79^{a}	3.74^{a}	3.72^{a}	4.09^{a}	4.05^{a}	4.01^{a}	4.00^{a}	3.96^{a}	3.94^{a}
V_5 – Merbein Seedless	3.91^{b}	3.87^{b}	3.83^{b}	3.90^{cd}	3.87^{bc}	3.86^{b}	3.65^{cd}	3.59^{cd}	3.57^{cd}	3.94^{cd}	3.93^{cd}	3.86^{b}	3.85^{cd}	3.82^{cd}	3.80^{cd}
S.E.±	0.04	0.04	0.05	0.03	0.02	0.04	0.03	0.02	0.03	0.02	0.03	0.04	0.03	0.02	0.03
C.D. (P=0.05)	0.12	0.12	0.13	0.09	0.05	0.11	0.09	0.07	0.09	0.07	0.08	0.10	0.09	0.07	0.09
Interaction (T x V)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Figure with different alphabet within temperatures (T) and varieties (V) are significantly different at $p \leq 0.05$; NS=Non-significant

prepared from variety Manik Chaman (4.06, 4.05, 3.79, 4.09 and 4.00, respectively), which was on par with Thompson Seedless (4.02, 4.01, 3.76, 4.05 and 3.96, respectively) whereas lowest recorded in Sonaka (3.87, 3.86, 3.60, 3.90 and 3.81, respectively) which was comparable with Merbein Seedless (3.91, 3.90, 3.65, 3.94 and 3.85, respectively) for color and appearance, texture, flavour, taste and overall acceptability, respectively on 60 days after storage. The interaction between storage temperature and varieties was not significant for studied sensory attributes (Table 1).

Ninety days after storage :

Significantly maximum sensory score was recorded by Panelists in raisins stored at 5±1°C (4.00, 4.00, 3.70, 4.03 and 3.93, respectively) and minimum in ambient condition (3.83, 3.82, 3.57, 3.89 and 3.79, respectively) for color and appearance, texture, flavour, taste and overall acceptability, respectively. With respect to varieties, significantly highest score was observed in raisins of Manik Chaman (4.02, 4.02, 3.74, 4.05 and 3.96, respectively), which was at par with Thompson Seedless (3.98, 3.98, 3.70, 4.01 and 3.92, respectively) whereas it was lowest recorded in Sonaka (3.81, 3.83, 3.55, 3.86 and 3.77, respectively) which was comparable with Merbein Seedless (3.87, 3.87, 3.59, 3.93 and 3.82, respectively) for color and appearance, texture, flavour, taste and overall acceptability, respectively on 90 days after storage (Table 1). The interaction between storage temperature and varieties were not significant for studied organoleptic attributes.

Hundred and twenty days after storage :

On 120 days after storage, significantly maximum sensory score was observed by Panelists in raisins stored at 5±1°C (3.96, 3.99, 3.68, 3.99 and 3.91, respectively) and lowest in ambient condition (3.78, 3.81, 3.55, 3.81 and 3.77, respectively) for color and appearance, texture, flavour and overall acceptability, respectively. With respect to varieties, significantly highest score was observed in raisins of Manik Chaman (3.98, 4.01, 3.72, 4.01 and 3.94, respectively), which was at par with Thompson Seedless (3.94, 3.97, 3.68, 3.97 and 3.90, respectively) whereas lowest recorded in Sonaka (3.79, 3.82, 3.53, 3.82 and 3.75, respectively) which was comparable with Merbein Seedless (3.83, 3.86, 3.57, 3.86 and 3.80, respectively) for color and appearance, texture, flavour, taste and overall acceptability, respectively on 120 days after storage. The interaction between storage temperature and varieties was not significant for studied sensory attributes.

The raisins prepared from variety Manik Chaman had brighter color and appearance and was superior to others from 60 to 120 days, whereas Sonaka scored less. This may be due to the genetic difference in skin phenol content and pigmentation. A similar observation was also reported by Angulo *et al*. (2007). The raisins prepared from Manik Chaman also recorded high score for texture, flavour and taste from 60 to 120 days followed by Thompson Seedless and this may be due to proper sugar acid ratio in raisins. Analytically high acceptance was acquired by Manik Chaman followed by Thompson Seedless, 2A Clone, Merbein Seedless and Sonaka. The raisins prepared by 0.5% olive oil and 4% potassium carbonate recorded the highest sensory score during the entire storage period as reported by Jadhav *et al*. (2010).

Acknowledgement :

Thanks to University Grants Commission, Government of India for financial assistance and advisory committee for technical advice.

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