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Original Research Paper

Development of physico-chemical standards for *Gulkand* as influenced by varying levels of sugar and sugar candy

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ABSTRACT

An experiment was carried out to develop physico-chemical standards of sugar and sugar candy levels for market product of Bourbon rose *gulkand* at ambient storage. Among physico-chemical changes, TSS, acidity, total sugar and reducing sugar showed an increasing trend, whereas, pH, ascorbic acid, phenolic content and total anthocyanin decreased at ambient storage from 0 to 120 days. The C_9-Bourbon rose petals + sugar candy (1.0 : 2.0 w/w) was found to be the best among all ingredient combinations with regard to TSS (76.20 °B), pH (4.81), acidity (0.32%), ascorbic acid (8.19 mg 100 g^{-1}), total sugar (67.11%), reducing sugar (10.65%), anthocyanin (162.36 mg 100 g^{-1}) and phenols (36.67 mg 100 g^{-1}) as compared to best market product C_{11} from *Rajsamund* (*Khamnore*), C_{12} from *Chittorgarh* (*Ghodakheda*) and C_1 check treatments at 120 days of ambient storage.

Keywords: Bourbon rose, *gulkand*, ph, total soluble solids, titratable acidity

INTRODUCTION

Processing of horticultural products is beneficial for decreasing post-harvest losses from 30-40%. During adverse conditions, like war and pandemic such as Covid-19, the per capita consumption of flowers decreases due to lack of social function and transport facilities in lockdown. *Gulkand* is a sweet rose petal preserve. It is good cure for acidity, memory and eyesight as well as good for blood purification. *Gulkand* has been used since ancient times as a cooling tonic to treat weakness, muscle aches, itching, biliousness and heat-related disorders. Ayurvedic doctors in India use it in combination with other specific herbs for various types of cancer patients undergoing radiation or chemotherapy to combat the negative effects of these therapies (Rudrawar & Singar, 2017). The rose 'Queen of Flowers' stands first in the international flower trade. *Rosa bourboniana, R. centifolia, R. chinensis, R.damascena, R. gallica* and *R. Pomifera* are suitable for *gulkand* preparation (Jat et al., 2018).

The major states of rose-growing in India are Maharashtra, Tamil Nadu, Karnataka and West Bengal. Roses are grown in an area of 29569 hectares in India (Anonymous, 2017). In Rajasthan, the total area under flower cultivation is 3493 hectares with 8057 MT productions out of which 1058 hectares roses are cultivated with an annual production of 3009 MT. The major rose producing districts are Ajmer, Nagaur, Jodhpur, Chittorgarh, Bundi, Sri-Gangangar, Rajsamand, Jhalawar, Sawai-Madhopur and Udaipur (Anonymous, 2024). The present study was undertaken as there is no physico-chemical standards are available for rose petals, sugar and sugar candy levels for available best market bourbon rose *gulkand* product and storage life at ambient condition.

MATERIALS AND METHODS

An experiment was conducted at Post Harvest Lab, Department of Horticulture, MPUAT, Udaipur from October 2020 to March 2022, which is located at 24°35' latitude, 73°42' Longitude and an elevation of 559.65 meters above the mean sea level. Bourbon rose flowers were procured from Mr. Parixit Singh a farmer's field at village Barodiya, District of Banswara, Rajasthan. Ingredients like sugar and sugar candy were purchased from the local market.

This experiment was laid out in completely randomized design with 12 treatments combinations replicated thrice, *viz.*, C_1- Bourbon rose petals + sugar (1.0:1.25 w/w- Check III), C_2- Bourbon rose petals +

sugar (1.0:1.50 w/w), C_3- Bourbon rose petals + sugar (1.0:1.75 w/w), C_4-Bourbon rose petals + sugar (1.0:2.00 w/w), C_5- Bourbon rose petals + sugar (1.0:2.25 w/w), C_6- Bourbon rose petals + sugar candy (1.0:1.25 w/w), C_7- Bourbon rose petals + sugar candy (1.0:1.50 w/w), C_8- Bourbon rose petals + sugar candy (1.0:1.75 w/w), C_9- Bourbon rose petals + sugar candy (1.0:2.00 w/w), C_{10}- Bourbon rose petals + sugar candy (1.0:2.25 w/w), C_{11}- Check I market product from *Rajsamund* (*Khamnore*) and C_{12}- Check II market product from *Chittorgarh* (*Ghodakheda*), Rajasthan, India.

Fresh bourbon rose flowers of *Rosa bourboniana* were chosen, washed and pre-cooled for overnight. During next morning rotted, off-coloured rose petals, pollen, anther, stigma, epicalyx and pedicel were separated and removed. For the preparation of *gulkand*, selected healthy rose petals were used. The weighed amounts of rose petals i.e. 1 kg and varied levels (1.25, 1.50, 1.75, 2.0, 2.25 kg) of sugar or sugar candy were mixed with the help of blender and transferred into wide mouth glass jars. The mouth of the *gulkand* fill-up jars were covered and bound with white muslin cloth, then kept in open sun light during day for one month to impregnation process. The prepared *gulkand* was packed in food grade plastic containers (500 g) leaving 2-3 cm headspace. The jars were then air tightly sealed with lids. They were then labelled as per treatment details and kept at ambient temperature for 0, 30, 60, 90 and 120 days of ambient storage for physico-chemical standards analysis.

Total soluble solids content of bourbon rose *gulkand* was measured by digital refractometer (0-85 °brix) at 20°C working on the base of light refraction. The pH of bourbon rose *gulkand* was measured by a pH meter. Twenty gram *gulkand* was dissolved in 40 mL distilled water and then placed on a shaker plate for 30 minutes to mix thoroughly. A buffer solution was used to calibrate the pH meter. The acidity of bourbon rose *gulkand* was calculated by diluting the known amount of *gulkand* product with distilled water and titrating with phenolphthalein as an indicator against the normal N/10 sodium hydroxide solution (A.O.A.C, 1995). The content of ascorbic acid in bourbon rose *gulkand* was determined using the volumetric method (Sadasivam & Balasubramanian, 1987). Total sugar, reducing sugar were measured as per methods defined by Ranganna (1986), anthocyanin content (Wrolstad et al., 2005) and total phenols were estimated using Folin-Ciocalteumethodas an oxidizing agent and gallic acid as per method described by Singleton & Rossi (1965). The data were analysed using completely randomized designed (Fisher, 1950).

RESULTS AND DISCUSSIONS

Total soluble solid (°Brix)

The TSS of bourbon rose *gulkand* increased significantly with advancement of storage and also atincreased levels of sugar and sugar candy (Fig. 1). It was observed in the range of (70.20 to 76.20 °B) under different combinations of bourbon rose petals + sugar and sugar candy during the observation period (0-120 days). The highest TSS trend was recorded from (74.20 to 76.20 °B) in C_9-Bourbon rose petals + sugar candy (1.0:2.00 w/w), while the lowest trend in C_1-Bourbon rose petals + sugar (1.0:1.25w/w) from (70.20 to 72.30°B). The C_9-Bourbon rose petals + sugar candy (1.0:2.00 w/w) and C_4-Bourbon rose petals + sugar (1.0:2.00 w/w), respectively were better over C_1, statistically at par with C_{11}-Check I best market product from Rajsamund (Khamnore) and C_{12}-Check II best market product from Chittorgarh (Ghodakheda) for TSS. The rise in the TSS content of bourbon rose *gulkand* over time was attributed to the conversion of starch (polysaccharides) into soluble sugar (monosaccharides). Similar findings were reported by Patel et al. (2016) in rose petal jam based on sapota, Rahman et al. (2018) in guava jam, Khan et al. (2020) in fig fruit jam. Pinandoyo & Siddiqui (2020) reported that TSS rises in papaya jam due to condensation of water at storage period and Rana et al. (2021) in mixed fruit jam.

If the sugar and sugar candy level are optimum set TSS (65°B) or above, will be helpful to draw the moisture/water through osmosis process. When a higher concentration of sugar enters in to the petal cell and the water activity is stopped. Hence, micro-organisms do not grow and ultimately, colony forming units of fungi, bacteria and actinomycetes decrease. Eventually, the shelf life of *gulkand* at ambient storage increases.

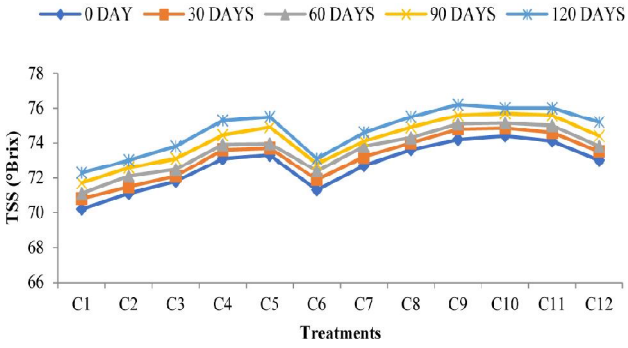

Fig. 1 : Effect of sugar and sugar candy levels on TSS (°B) of Bourbon rose *gulkand* at ambient storage

Active Acidity (pH)

The cumulative data recorded for pH of bourbon rose *gulkand* (Table 1) was declined significantly by different combinations of bourbon rose petals, sugar, sugar candy and also on advancement of ambient storage duration. The maximum pH (5.07) was observed for C_1-Bourbon rose petals + sugar (1.0:1.25 w/w), while, the minimum (4.79) was in C_{10}-Bourbon rose petals + sugar candy (1.0:2.25 w/w) at 120 days of storage. The best market products C_{11} and C_{12} (check I and II) were statistically at par with desirable trends of C_9-Bourbon rose petals + sugar candy (1.0:2.00 w/w) and C_4-Bourbon rose petals + sugar (1.0:2.00 w/w) respectively. Patel et al. (2016) concluded that the product's acidity increases during storage might be due to acid creation phenomenon during fermentation process that began when the sugar in the rose petals jam from sapota was impregnated. Changes in pH are connected directly to increase in acidity level of the jam. Since, the acidity of the jam increased during the storage period, the pH level was also reduced subsequently (Krishna et al., 2020). Present findings are in conformity with the results of Rahman et al. (2018) in guava jam and Ullah et al. (2018) in carrot + apple jam.

Table 1 : Effect of sugar and sugar candy levels on titratable acidity and pH content of Bourbon rose *gulkand* at ambient storage

Ambient storage (days) →	Titratable acidity (%)					pH				
Treatments (w/w) ↓	0	30	60	90	120	0	30	60	90	120
C_1- Bourbon rose petals + sugar (1.0:1.25 Check III)	0.25	0.29	0.33	0.36	0.40	5.23	5.18	5.16	5.11	5.07
C_2- Bourbon rose petals + sugar (1.0:1.50)	0.24	0.27	0.32	0.34	0.39	5.19	5.15	5.12	5.08	5.04
C_3- Bourbon rose petals + sugar (1.0:1.75)	0.21	0.24	0.27	0.31	0.36	5.15	5.12	5.08	5.03	5.00
C_4- Bourbon rose petals + sugar (1.0:2.00)	0.18	0.22	0.26	0.29	0.34	5.12	5.08	5.04	4.97	4.93
C_5- Bourbon rose petals + sugar (1.0:2.25)	0.17	0.21	0.25	0.28	0.31	5.10	5.06	4.98	4.95	4.90
C_6- Bourbon rose petals + sugar candy (1.0:1.25)	0.23	0.27	0.31	0.34	0.37	5.13	5.08	5.06	5.01	4.97
C_7- Bourbon rose petals + sugar candy (1.0:1.50)	0.21	0.24	0.29	0.33	0.35	5.08	5.04	5.00	4.98	4.94
C_8- Bourbon rose petals + sugar candy (1.0:1.75)	0.20	0.22	0.28	0.30	0.33	5.04	5.01	4.97	4.92	4.89
C_9- Bourbon rose petals + sugar candy (1.0:2.00)	0.16	0.18	0.21	0.25	0.32	5.00	4.96	4.93	4.87	4.81
C_{10}- Bourbon rose petals + sugar candy (1.0:2.25)	0.14	0.17	0.20	0.24	0.31	4.97	4.94	4.89	4.86	4.79
C_{11}- Check I market product from *Rajsamund* (*Khamnore*)	0.17	0.19	0.22	0.26	0.33	5.02	4.97	4.95	4.90	4.83
C_{12}- Check II market product from *Chittorgarh* (*Ghodakheda*)	0.19	0.23	0.27	0.30	0.35	5.13	5.09	5.06	5.02	4.94
SEm±	0.002	0.002	0.003	0.004	0.003	0.01	0.01	0.01	0.01	0.01
C.D. (P=0.01)	0.008	0.009	0.011	0.015	0.014	0.03	0.03	0.05	0.05	0.03

Titratable acidity (%)

The cumulative data as per Table 1 for titratable acidity of bourbon rose *gulkand* combinations increased significantly due to an advancement of ambient storage, whereas, it was decreased with the improved level of sugar and sugar candy combinations. The maximum increase in titratable acidity (0.40%) was recorded for C_1-Bourbon rose petals + sugar (1.0:1.25w/w), while, the minimum (0.31%) in C_{10}-Bourbon rose petals + sugar candy (1.0:2.25 w/w) at 120 days of storage. The desirable standards for titratable acidity were recorded for C_9-Bourbon rose petals + sugar candy (1.0:2.00w/w i.e. 0.16 to 0.32 %), C_4-Bourbon rose petals + sugar (1.0:2.00w/w i.e. 0.18 to 0.34 %) and these were found statistically at par with best market product C_{11}-Check I from Rajsamund (Khamnore) i.e. 0.17 to 0.33 % and C_{12}-Check II from Chittorgarh (Ghodakheda) i.e. 0.19 to 0.35 %. This rise in acidity content at ambient storage may be attributed to the start of fermentation of the bourbon rose *gulkand* via enzymatic activity and de-esterification of pectin molecules. Shah et al. (2015) reported that the rising trend of acidity in apple and olive blended jam might be due to the formation of various organic acids during carbohydrate breakdown and hydrolysis at storage duration. The gradual increment in acidity level at ambient storage has been also reported by Jat et al. (2022) in rose petal jam, Ullah et al. (2018) in carrot and apple blended jam, Krishna et al. (2020) in mango jam and Khan et al. (2020) in fig jam.

Ascorbic Acid (mg 100 g^{-1})

On addition of sugar and sugar candy quantity and advancement of ambient storage time, the ascorbic acid content of bourbon rose *gulkand* decreased significantly (Fig. 2). The highest amount of ascorbic acid was recorded for C_1-Bourbon rose petals + sugar (1.0:1.25 w/w) from (24.44 to 16.85 mg 100 g^{-1}) and the lowest amount for C_{10}-Bourbon rose petals + sugar candy (1.0:2.25 w/w) from (15.65 to 7.63 mg 100 g^{-1}). The lowest ascorbic acid standards of best market products C_{11} (16.35-8.13 mg 100 g^{-1}) and C_{12} (18.10-10.13 mg 100 g^{-1}) were statistically at par with best treatment combination C_8 -Bourbon rose petals + sugar candy (1.0:1.75 w/w) (19.25-10.25 mg100 g^{-1}), C_9-Bourbon rose petals + sugar candy (1.0:2.00 w/w) ranges 16.41-8.19 mg 100 g^{-1} and C_4-Bourbon rose petals + sugar (1.0:2.00 w/w) ranges 18.20-10.19 mg 100 g^{-1}, respectively at 0 to 120 days of storage. Vitamin-C, which is thermo-labile in nature and typically destroyed by oxidative processes triggered by light, heat, oxygen and peroxidase enzyme. The drop in ascorbic acid concentration is also likely related to the process of ascorbic acid oxidizing into de-hydro ascorbic acid by the enzyme ascorbinase (Patel et al., 2015). According to Rahman et al. (2018) the reduction in ascorbic acid concentration may be attributed to oxidation and catalytic reactions occurring inside the jam samples. The current findings are consistent with those of Patel et al. (2016) in *gulkand* based sapota jam, Jat et al. (2022) in *gulkand* and Pinandoyo & Siddiqui (2020) in papaya jam.

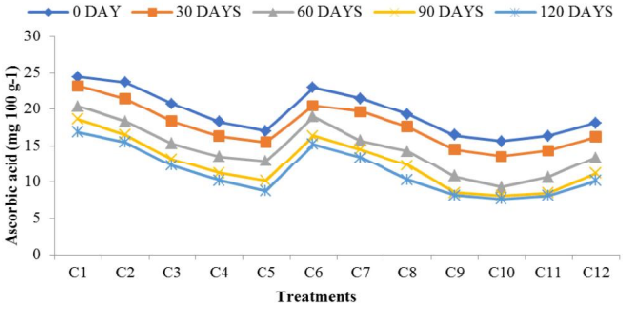

Fig. 2 : Effect of sugar and sugar candy on ascorbic acid content of Bourbon rose *gulkand* at ambient storage

Total sugar (%)

The data presented in Fig. 3 showed that changes in total sugar of bourbon rose *gulkand* increased significantly with various combinations of bourbon rose petals, sugar, sugar candy and on advancement of ambient storage (0-120 days). The maximum increase in total sugar was recorded from (64.57% to 67.32%) under C_{10}-Bourbon rose petals + sugar candy (1.0:2.25 w/w) followed by C_9-Bourbon rose petals + sugar candy (1.0:2.00 w/w) from (63.73% to 67.11%), while, the minimum was from (60% to 64.35%) under C_1-Bourbon rose petals + sugar (1.0:1.25 w/w) at 0 to 120 days of ambient storage. The desirable standards for total sugar was recorded in C_9-Bourbon rose petals + sugar candy (1.0:2.00 w/w) i.e. 63.73% to 65.56% and C_4-Bourbon rose petals + sugar (1.0:2.00 w/w) i.e. 63.22% to 66.32% , which were statistically at par with best market product C_{11}-Check I from *Rajsamund* (*Khamnore*) i.e. 63.69% to 67.04%, C_{12}-Check II from *Chittorgarh* (*Ghodakheda*) i.e. 63.17% to 66.26% and better over C_1 i.e. 60.0% to 64.35%, respectively. The increase in total sugar of bourbon rose *gulkand* could be due

to breakdown of polysaccharides into simple sugars. Pinandoyo & Siddiqui (2020) reported that total sugar content of jam was raised as the moisture content decreased during storage. These findings of the present study are consistent with the reports of Patel et al. (2016) in *gulkand* based sapota jam and Kanwal et al. (2017) in guava jam. The fungal and bacterial growth was increased in bourbon rose *gulkand* with the advancement of ambient storage duration and reduced with the addition of improved level of sugar and sugar candy.

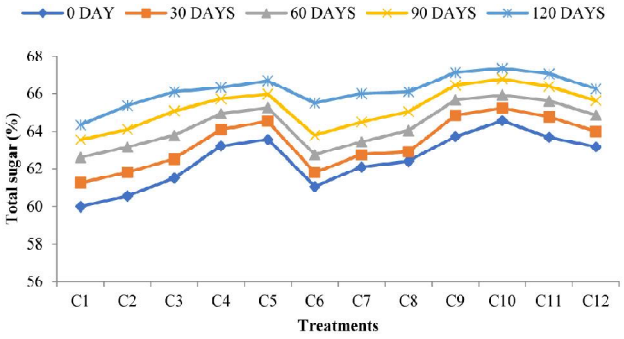

Fig. 3 : Effect of sugar and sugar candy levels on total sugar (%) of Bourbon rose *gulkand* at ambient storage

Reducing sugar (%)

The data presented in Fig. 4 revealed that percentage of reducing sugar of bourbon rose *gulkand* was increased gradually with advancing days of ambient storage duration and also at increasing levels of sugar and sugar candy. This increase may be related to the inversion of non-reducing sugar to reducing sugar. The maximum increase in reducing sugar was observed for C_{10}-Bourbon rose petals + sugar candy (1.0:2.25w/w) i.e. from 4.12% to 10.70% followed by C_9-Bourbon rose petals + sugar candy (1.0:2.00 w/w) from 4.03% to 10.65%, while the minimum was from 3.64% to 10.05% under C_1-Bourbon rose petals + sugar (1.0:1.25 w/w) at 0 to 120 days ambient storage. The desirable standards for reducing sugar were recorded at C_9-Bourbon rose petals + sugar candy (1.0:2.00 w/w) i.e. 4.03% to 10.65% and C_4-Bourbon rose petals + sugar (1.0:2.00 w/w) i.e. 3.96 % to 10.50% and found statistically at par with best market product C_{11}-Check I Rajsamund (Khamnore) i.e. 4.0 to 10.63% and C_{12}-Check II Chittorgarh (Ghodakheda) i.e. 3.93% to 10.48%, respectively. Similar outcomes were also reported by Patel et al. (2015) in banana + pineapple blended jam, Khan et al. (2020) in fig fruit jam and Rana et al. (2021) in mixed fruit jam. The rise in reducing sugar of bourbon rose *gulkand* on advancement of days ambient storage results on hydrolysis of non-reducing sugars in to reducing sugar, increased acidity and decreased pH was confirmed by Kanwal et al. (2017).

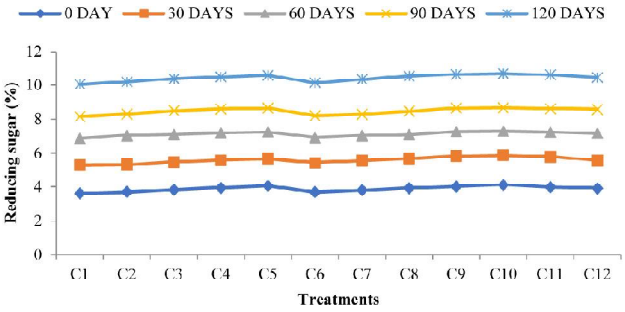

Fig. 4 : Effect of sugar and sugar candy levels on reducing sugar (%) of Bourbon rose *gulkand* at ambient storage

Anthocyanin and total phenols contents

Total anthocyanin and total phenolic contents of bourbon rose *gulkand* decreased gradually upon advancement of ambient storage and at increased levels of sugar and sugar candy (Fig. 5 & 6). The maximum declined in total anthocyanin and phenolic contents were recorded for C_6-Bourbon rose petals + sugar candy (1.0:1.25 w/w from 392.16 to 241.20 mg 100 g^{-1}, 89.14 to 50.17 mg 100 g^{-1}) and minimum contents were recorded for C_5-Bourbon rose petals + sugar (1.0:2.25 w/w from 265.88 to 135.16 mg 100 g^{-1}, 65.46 to 29.56 mg 100 g^{-1}), respectively at 0 to 120 days of ambient storage. Whereas, the desirable standards for total anthocyanin and phenolic contents were recorded for C_9-Bourbon rose petals + sugar candy (1.0:2.00 w/w) i.e. 295.27 to 162.36 mg 100 g^{-1}, 76.20 to 36.67 mg 100 g^{-1} and C_4-Bourbon rose petals + sugar (1.0:2.00 w/w) i.e. 289.17 to 159.20 mg 100 g^{-1}, 72.29 to 35.30 mg 100 g^{-1} respectively, which were found better as compared to best market product C_{11}-Check I from Rajsamund (Khamnore) i.e. 291.31 to 160.41 mg 100 g^{-1}, 76.15 to 35.55 mg 100 g^{-1} , C_{12}-Check II from Chittorgarh (Ghodakheda) 286.26 to 157.73 mg 100 g^{-1}, 72.15 to 34.87 mg 100 g^{-1} and C_1-Bourbon rose petals + sugar (1.0:1.25 w/w Check III), respectively. Agrawal & Kaur (2017) also reported slightly decrease in anthocyanin content of rose products at ambient storage and this might be due to ascorbic acid interaction with anthocyanins, which results in the degradation of both components via a condensation process. Similarly, Rababah et al.

(2014) also noted declining trend in anthocyanin content in different fruit jam, Oancea & Calin (2016) in blackberry, raspberry and wild cherry jam and Moreira et al. (2019) in mixed jams of rose petals + apples. Sharma et al. (2019) also reported a significant decrease in total phenols of bael-mango jam during storage because total phenols are highly volatile and oxidised, their concentration dropped in sample when they were exposed to light. The cell structure was disrupted during processing and the materials were susceptible to non-enzymatic oxidation, which might be primary causes of the total phenol loss. Vinokur et al. (2006) reported a total phenols content in rose tea ranging from 50.7 to 119.5 mg gallic acid equivalents (GAE) per gram of dry matter. The decrease in total phenolic content might be attributed to disruptions in structure of fruit cells during processing by Rababah et al. (2014). Present findings are in conformity with Agrawal & Kaur (2017) in different rose products, and Jat et al. (2022) in rose petal jam.

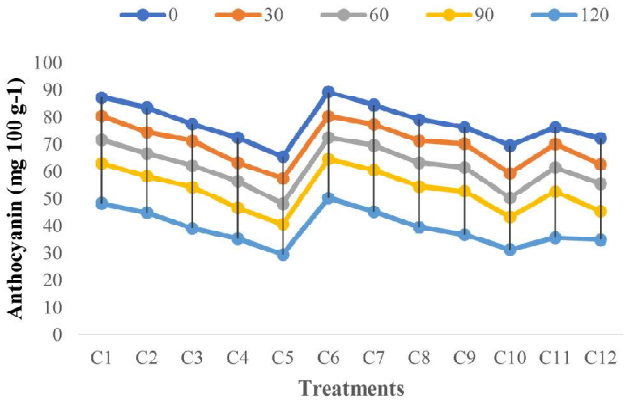

Fig. 5 : Effect of sugar and sugar candy levels on Anthocyanin (mg 100 g-^{1}) of Bourbon rose *gulkand* at ambient storage

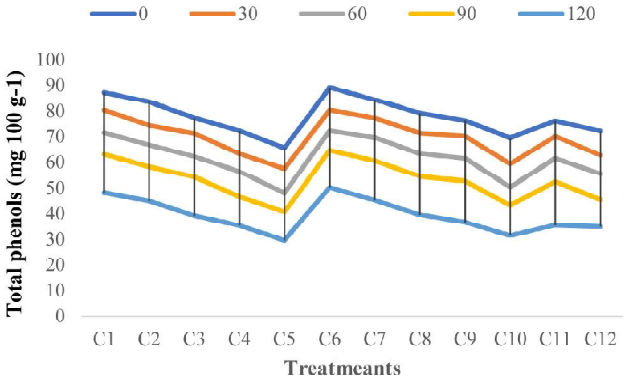

Fig. 6 : Effect of sugar and sugar candy levels on Total phenols (mg 100 g-1)of Bourbon rose *gulkand* at ambient storage

CONCLUSION

On the basis of two years of study, it is concluded that C_9-Bourbon rose petals + sugar candy (1.0:2.00 w/w) was found to be statistically at par with regard to TSS (76.20 °B), pH (4.81), acidity (0.32), ascorbic acid (8.19% mg 100 g^{-1}), total sugar (67.11%), reducing sugar (10.65%), anthocyanin (162.36 mg 100 g^{-1}) and total phenols (36.67 mg 100 g^{-1}) as compared to best market product C_{11}-Check I from *Rajsamund* (*Khamnore*), C_{12}-Check II from *Chittorgarh* (*Ghodakheda*) and C_1-Check.

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