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Studies on Physico-Chemical, Sensory Quality of Sweet Orange Based RTS Blends under Refrigerated Storage

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The sweet orange based RTS blends using beet root and carrot juice were evaluated for their quality, acceptability throughout the period of storage. TSS (^{o}B) was significantly increased with increase in storage period, in all sweet orange based RTS blends. T_8 (S_2B_2) (15% sugar+5% beet root) recorded significantly highest TSS content. pH decreased with increase in storage period. Maximum pH was observed in T_8 (S_2B_2) (15% sugar+5% beet root). There was increase in titratable acidity throughout the storage period. T_8 (S_2B_2) (15% sugar+5% beet root) was found significantly higher. A significant retention of ascorbic acid was noticed in all the RTS blends. T_6 (S_2B_0) (15% sugar + no blend) showed highest ascorbic acid followed by T_1 (S_1B_0) and T_8 (S_2B_2). There was a slight increase in the total sugar (%) content in T_2 (S_1B_1) (10% sugar+2% beet root). Gradual increase was noticed in T_8 (S_2B_2) followed by T_7 (S_2B_1) which are on par with T_2.β-carotene was degraded during storage in all RTS blends. T_{10} (S_2B_4) (15% sugar+5% carrot) recorded high ß-carotene content during the storage period. Overall acceptability (OAA) decreased with increase in storage period in all RTS blends and all S_2 (15% sugar) based RTS blends (T_{10}, T_7 and T_6) recorded higher acceptable score.

Introduction

Sweet orange (*Citrus sinensis* L.) is one of the most important subtropical fruits of India and belongs to the family Rutaceae. It is widely consumed fruit juice by normal as well as sick people and is well known for its instant energy, vitamin C and potassium content. Sweet orange juice is refreshing after any hectic activity or on a dry, hot day to quench thirst. Similarly beet root and carrot are root vegetables, well known for their nutritive value. Beet root (*Beta vulgaris* L.) belongs to the family chenopodiaceae the swollen roots are eaten boiled or as a salad, also used for making pickles (Rana, 2008). Carrot (*Daucus carota* L.) belongs to the family umbelliferae. Carbohydrates can make up almost 75% of the dry matter of carrot roots. The main soluble sugars in carrots are glucose, fructose, and sucrose, with sucrose in major ratio. The most abundant carotenoid in orange carrots is β-carotene (45–80%), and there can be found smaller fractions of α-carotene and lutein (Mendelova *et al.*, 2016). An experiment was carried out at Post harvest technology

laboratory, college of horticulture, Anantharajupeta, during the year 2017-18, to standardize sweet orange based ready to serve beverages by blending beet root and carrot juice and to study their physico-chemical characters, sensory quality during storage under refrigerated conditions.

Fruit based beverages are easily digestible, highly refreshing, thirst quenching, appetizing and nutritionally far superior to many synthetic and aerated drinks. In tropical countries like India, they provide delicious cool drinks during the hot summer. Ready to serve (RTS) is a type of fruit beverage which contains at least 10% fruit juice and 10% total soluble solids besides about 0.3% acid. It is not diluted before serving, hence it is known as ready to serve (RTS) (Srivastava and Kumar, 2002).

Materials and Methods

Standard methods were followed for the preparation of various sweet orange based RTS blends and their storage behaviour was studied (Fig. 1).

Well matured and evenly ripe fruits of sweet orange and well matured, even coloured, and uniform size of beet root and carrot were procured from the local market, kodur, kadapa dist. It is used for extraction of juice and preparation of RTS blends as per the treatment schedule. Good quality food grade sugar was obtained for preparation of syrup.AR grade Sodium benzoate (SB) was used as preservative. Glass bottles (200 ml each) were used for filling up of RTS beverages.

Methods of analysis used

Physico-chemical parameters including total soluble solids (TSS) of the RTS blends were determined by a digital refractometer, values expressed as ^{o}Brix. Acidity was determined by using Raganna (1986). Ascorbic acid content of the juice was estimated by 2,6-dichlorophenol-indophenol dye titration method Raganna (1986). Total sugars in the RTS blends were determined by the method of lane and Eynon procedure Raganna (1986).β-carotene was estimated by acetone method (Ranganna, 1986). To assess consumer preference, organoleptic quality of the RTS blends was tested by a panel of ten untrained judges using the 9 point hedonic scale (Amerine *et al.*, 1965). All estimations were carried out in triplicate, determinations were made for each attribute and data on physico-chemical, sensory quality were statistically analysed using completely randomized design Panse and Sukhatme (1985).

For all the treatments sweet orange juice 10% was used and was stored at 7^{o}C in refrigerator. Sampling was done at fortnight intervals upto 3 months.

Results and Discussion

TSS^{O}B

The TSS of sweet orange based RTS beverages prepared using different sugar levels and juice blends was given in Table 1.

The TSS increased with increase in storage period from 0 days to 90 DAS. There was significant difference among the interaction effect of sugar level and juice blends.

Among the interactions, S_2B_2 (15% sugar + 5% beet root) recorded significantly highest TSS content 15, and 15.867^{o}Brix at 0, and 90 DAS respectively followed by S_2B_4 (15% sugar + 5% carrot) with 15.9^{o}Brix at 90 days after storage.

The increase in TSS content during the storage of sweet orange RTS revealed a minimum biochemical changes takes place during

storage. The increase in TSS content of RTS which might be due to the hydrolysis of insoluble polysaccharides and organic acids into sugars. These results were also inconformity with Mishra and Sangma (2017), Balaji and Prasad (2014), Kumar *et al.,* 2013 and Bhavyasree (2010) in sweet orange RTS beverage.

Titrable acidity

The changes in titrable acidity of sweet orange based RTS with different sugar levels and juice blends was given in Table 2.

Titrable acidity increased with increase in storage period. Interaction effect of sugar level and juice blends S_2B_2 (15% sugar + 5% beet root) was found significantly higher with 0.339% of acidity followed by S_2B_1 (15% sugar+2% beet root) with 0.347% of acidity at 75th DAS. At 90thday of storage 15% sugar+ no blend showed higher acidity with 0.359%. The values were on par with each other from 0 to 90 DAS (Table 2).

The increase in titrable acidity might be due to the formation of organic acids by the degradation of ascorbic acid (Sharma *et al.,* 2008).

pH

The data pertaining to the changes in pH during the storage of sweet orange RTS blends was given in the Table 3.

pH was found to be significantly decreased throughout the storage. The interaction effects of different juice blends S_2B_2 (15% sugar+5% beet root) showed high pH 3.83, and 3.217 at 0 and 90 DAS respectively. The increase in acidity of the drink attributed to the increase in release of hydrogen ions during the storage. Therefore the corresponding decrease was noticed in pH (Akhtar *et al.,* 2013)

Ascorbic acid (mg/100ml)

There were significant differences in ascorbic acid content among the sugar level and juice blends interactions between them (4).

It was observed that the ascorbic acid content of RTS decreased significantly. Among the interaction effects of sugar level and juice blend shows significant decrease in ascorbic acid.S_2B_0 (15% sugar + no blend) showed highest ascorbic acid content 7.840 and 6.683 mg/100ml at 0 and 90 DAS respectively.

It was on par with S_1B_1 (10% sugar + 2% beet root) and S_1B_0 (10% sugar + no blend). Ascorbic acid is an important nutrient factor having natural antioxidant property. It was also noticed that the ascorbic acid content of the sweet orange RTS beverage was declined during the storage.

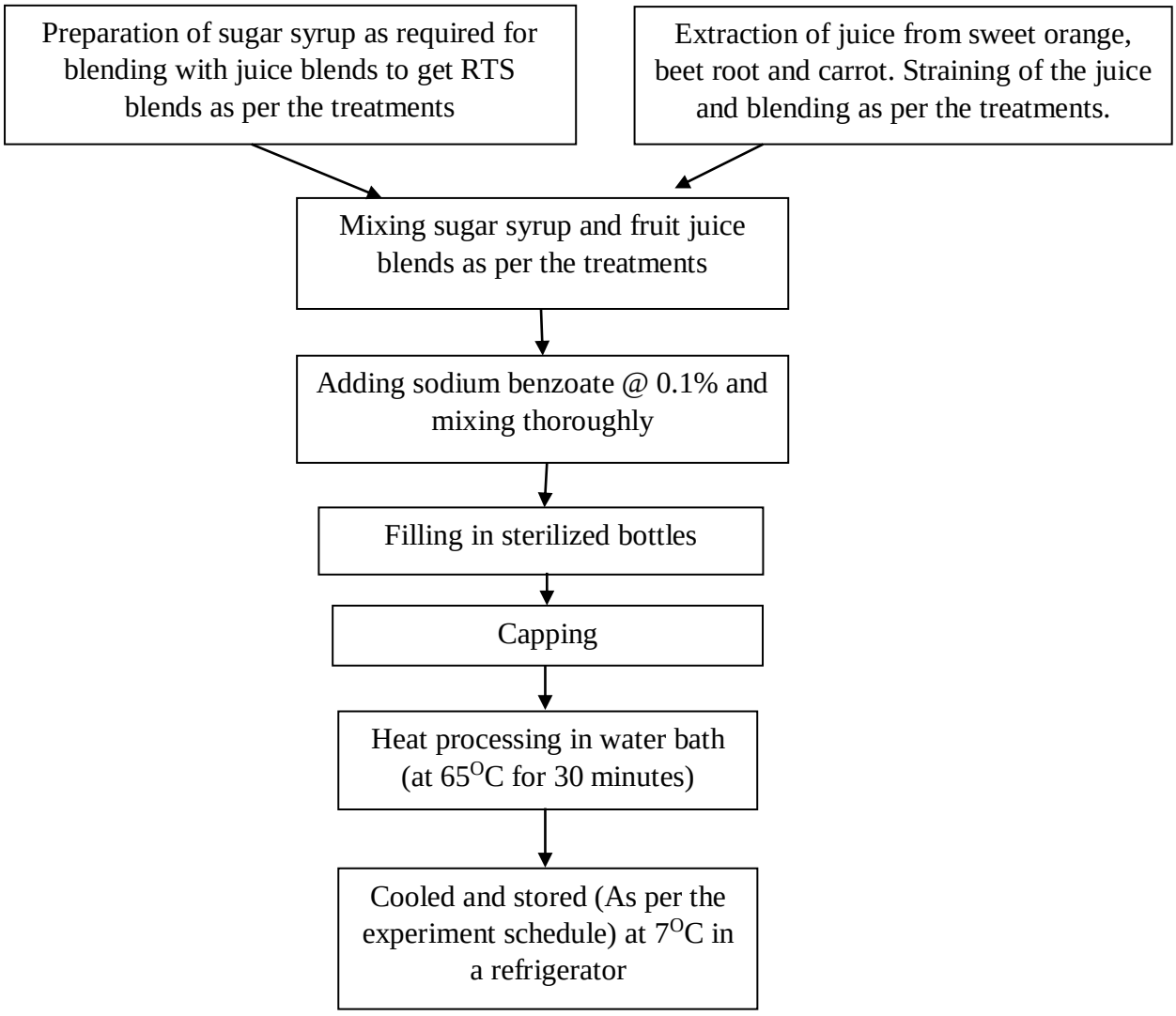
The loss of ascorbic acid is due to oxidation because it is very sensitive to light, oxygen and temperature.

During the storage the ascorbic acid is oxidized to dehydro-ascorbic acid, which is further oxidized to degraded product with no vitamin C activity. Similar results obtainted by Byanna and Gowda (2013) in sweet orange nectar.

ß-carotene (mg/100 ml)

The changes in ß-carotene content of sweet orange RTS beverage during storage was tabulated in Table 1 and 2. A significant variation was found in the total sugars of sweet orange RTS blends with respect to different factors. Among the Interaction effects recorded S_2B_4 (15% sugar+5% carrot) high ß-carotene content during the storage period, initially from 0.571 to 0.535 at 90 DAS. This is on par with S_1B_4 (10% sugar+5% carrot).

Fig.1 Different steps followed in preparation of different RTS blends is outlined in the flow chart mentioned above



Treatment Combinations

T_1	**S_1B_0 - 10% Sweet orange +10% sugar+ No blend**	**T_6**	**S_2B_0 - 10% Sweet orange + 15% sugar + No blend**
T_2	S_1B_1 - 10% Sweet orange + 10% Sugar + 2% Beet root	T_7	S_2B_1 - 10% Sweet orange + 15% Sugar + 2% Beet root
T_3	S_1B_2 - 10% Sweet orange + 10% Sugar + 5% Beet root	T_8	S_2B_2- 10% Sweet orange + 15% Sugar + 5% Beet root
T_4	S_1B_3 - 10% Sweet orange + 10% Sugar + 2% Carrot	T_9	S_2B_3 - 10% Sweet orange + 15% Sugar + 2% Carrot
T_5	S_1B_4 - 10% Sweet orange + 10% Sugar + 5% Carrot	T_{10}	S_2B_4- 10%Sweet orange+ 15% sugar + 5% Carrot

Table.1 Effect of sugar levels and juice blends on physico chemical quality of sweet orange based RTS blends at the time of processing before storage

	Parameter/ treatments	TSS°B	Acidity (%)	P^{H}	Ascorbic acid (mg/100ml)	B carotene (mg/100 ml)	Total sugars
Sugar level							
S_1	10% sugar	10.000	0.300	3.751	6.533	0.346	12.534
S_2	15% sugar	15.000	0.300	3.805	6.720	0.354	12.697
S.Em±		NS	**NS**	0.024	**0.177**	**NS**	**0.008**
CD (P=0.05)		NS	**NS**	0.070	**0.521**	**NS**	**0.024**
Juice blends							
B_0	No blend	12.500	0.300	3.702^{a}	13.475^{a}	0.103^{e}	13.455^{a}
B_1	2% Beet root	12.500	0.300	3.780^{a}	12.022^{e}	0.260^{d}	12.003^{e}
B_2	5% Beet root	12.500	0.300	3.820^{a}	12.063^{d}	0.360^{c}	12.042^{d}
B_3	2% carrot	12.500	0.300	3.768^{a}	12.712^{c}	0.459^{b}	12.652^{c}
B_4	5% carrot	12.500	0.300	3.818^{a}	12.993^{b}	0.567^{a}	12.925^{b}
S.Em±		**NS**	**NS**	0.04	**0.03**	**NS**	**0.01**
CD (P=0.05)		**NS**	**NS**	0.11	**0.09**	**NS**	**0.04**
Combination							
S_1B_0	10% sugar + no blend	10.000	0.300	3.640	7.560	0.099	13.340
S_1B_1	10% sugar + 2% beet root	10.000	0.300	3.767	6.440	0.256	11.963
S_1B_2	10% sugar + 5% beet root	10.000	0.300	3.810	6.813	0.356	12.020
S_1B_3	10% sugar + 2% carrot	10.000	0.300	3.737	5.693	0.455	12.527
S_1B_4	10% sugar + 5% carrot	10.000	0.300	3.800	6.160	0.563	12.820
S_2B_0	15% sugar + no blend	15.000	0.300	3.763	7.840	0.107	13.570
S_2B_1	15% sugar + 2% beet root	15.000	0.300	3.793	6.533	0.264	12.043
S_2B_2	15% sugar + 5% beet root	15.000	0.300	3.830	7.093	0.364	12.063
S_2B_3	15% sugar + 2% carrot	15.000	0.300	3.800	5.880	0.463	12.777
S_2B_4	15% sugar + 5% carrot	15.000	0.300	3.837	6.253	0.571	13.030
S.Em±		**NS**	**NS**	0.05	**0.39**	**NS**	**0.02**
CD (P=0.05)		**NS**	**NS**	0.16	**1.16**	**NS**	**0.05**

Table.2 Effect of sugar levels and juice blends on physico chemical quality of sweet orange based RTS blends after 90 Days of refrigerated storage (7+1°C)

Sugar level	Parameter/ treatments	TSS°B	Acidity (%)	P^{H}	Total sugars	Ascorbic acid (mg/100ml)	B carotene (mg/100 ml)
S_1	10% sugar	10.667	0.342	3.148	12.962	5.555	0.298
S_2	15% sugar	15.847	0.348	3.171	13.192	5.821	0.306
S.Em±		**0.016**	**0.002**	**0.009**	**0.026**	**0.082**	**0.001**
CD (P=0.05)		**0.048**	**0.006**	**0.028**	**0.076**	**0.241**	**0.004**
Juice blends							
B_0	No blend	13.100^{d}	0.354^{a}	3.105^{b}	13.947^{a}	6.560^{a}	0.062^{e}
B_1	2% Beet root	13.267^{bc}	0.344^{ab}	3.168^{a}	12.313^{d}	5.288^{c}	0.211^{d}
B_2	5% Beet root	13.317^{ab}	0.351^{a}	3.210^{a}	12.385^{d}	6.002^{b}	0.311^{c}
B_3	2% carrot	13.233^{c}	0.339^{b}	3.117^{b}	13.270^{c}	5.117^{c}	0.408^{b}
B_4	5% carrot	13.367^{a}	0.337^{b}	3.198^{a}	13.470^{b}	5.473^{c}	0.520^{a}
S.Em±		**0.03**	**0.00**	**0.01**	**0.04**	**0.13**	**0.02**
CD (P=0.05)		**0.08**	**0.01**	**0.04**	**0.12**	**0.38**	**0.01**
Combination							
S_1B_0	10% sugar + no blend	10.433	0.340	3.083	13.713	6.437	0.060
S_1B_1	10% sugar + 2% beet root	10.667	0.347	3.157	12.280	5.257	0.212
S_1B_2	10% sugar + 5% beet root	10.767	0.339	3.203	12.350	5.753	0.309
S_1B_3	10% sugar + 2% carrot	10.633	0.333	3.103	13.100	5.040	0.405
S_1B_4	10% sugar + 5% carrot	10833	0.359	3.193	13.367	5.287	0.505
S_2B_0	15% sugar + no blend	15.767	0.347	3.127	14.180	6.683	0.063
S_2B_1	15% sugar + 2% beet root	15.867	0.355	3.180	12.347	5.320	0.210
S_2B_2	15% sugar + 5% beet root	15.867	0.339	3.217	12.420	6.250	0.314
S_2B_3	15% sugar + 2% carrot	15.833	0.341	3.130	13.440	5.193	0.410
S_2B_4	15% sugar + 5% carrot	15.900	**0.00**	3.203	13.573	5.660	0.535
S.Em±		**0.03**	**0.01**	0.02	**0.06**	**0.18**	**0.01**
CD (P=0.05)		**0.08**	0.340	0.06	**0.17**	**0.54**	**0.01**

Table.3 Effect of sugar levels and juice blends on organoleptic quality of sweet orange based RTS blends at the time of processing before storage

	Parameter/ treatments	Organoleptic score			
Sugar level		colour	flavour	taste	Over all acceptability
S_1	Sugar 10%	8.359	7.267	8.133	7.676
S_2	Sugar 15%	8.623	7.740	8.633	8.388
S.Em±		**0.105**	**0.096**	**0.118**	**0.374**
CD (P=0.05)		**0.310**	**0.283**	**0.348**	**1.105**
Juice blends					
B_0	No blend	8.430^{a}	7.333^{b}	8.083^{b}	8.150^{a}
B_1	2% Beet root	8.485^{a}	7.500^{b}	8.333^{ab}	8.110^{a}
B_2	5% Beet root	8.337^{a}	7.167^{b}	8.333^{ab}	7.740^{a}
B_3	2% carrot	8.443^{a}	7.517^{b}	8.417^{ab}	7.870^{a}
B_4	5% carrot	8.722^{a}	8.000^{a}	8.750^{a}	8.290^{a}
S.Em±		**0.17**	**0.15**	**0.19**	**0.59**
CD (P=0.05)		**0.49**	**0.45**	**0.55**	**1.75**
Combination					
S_1B_0	10% sugar + no blend	8.300	7.000	7.667	7.960
S_1B_1	10% sugar + 2% beet root	8.303	7.333	8.000	7.810
S_1B_2	10% sugar + 5% beet root	8.307	7.000	8.167	7.330
S_1B_3	10% sugar + 2% carrot	8.333	7.500	8.333	7.520
S_1B_4	10% sugar + 5% carrot	8.553	7.500	8.500	7.760
S_2B_0	15% sugar + no blend	8.560	7.667	8.500	8.340
S_2B_1	15% sugar + 2% beet root	8.667	7.667	8.667	8.410
S_2B_2	15% sugar + 5% beet root	8.447	7.333	8.500	8.150
S_2B_3	15% sugar + 2% carrot	8.553	7.533	8.500	8.220
S_2B_4	15% sugar + 5% carrot	8.890	8.500	9.000	8.820
S.Em±		**0.24**	**0.21**	**0.26**	**0.84**
CD (P=0.05)		**0.69**	**0.63**	**0.78**	**2.47**

Table.4 Effect of sugar levels and juice blends on organoleptic quality of sweet orange based RTS blends after 90 Days of refrigerated storage (7+1ºC)

	Parameter/ treatments				
Sugar level		colour	flavour	taste	Over all acceptability
S_1	Sugar 10%	8.091	6.055	6.200	6.534
S_2	Sugar 15%	8.383	6.487	7.133	7.588
S.Em±		**0.029**	**0.085**	**0.094**	**0.208**
CD (P=0.05)		**0.085**	**0.251**	**0.278**	**0.614**
Juice blends					
B_0	No blend	8.108^{c}	6.200^{a}	6.583^{a}	6.975^{a}
B_1	2% Beet root	8.200^{bc}	6.167^{a}	6.667^{a}	7.070^{a}
B_2	5% Beet root	8.250^{ab}	6.167^{a}	6.583^{a}	6.860^{a}
B_3	2% carrot	8.278^{ab}	6.237^{a}	6.667^{a}	7.045^{a}
B_4	5% carrot	8.350^{a}	6.583^{a}	6.833^{a}	7.355^{a}
S.Em±		**0.05**	**0.13**	**0.15**	**0.33**
CD (P=0.05)		**0.13**	**0.40**	**0.44**	**0.97**
Combination					
S_1B_0	10% sugar + no blend	7.950	5.967	6.000	6.430
S_1B_1	10% sugar + 2% beet root	7.950	6.000	6.167	6.510
S_1B_2	10% sugar + 5% beet root	8.200	6.000	6.167	6.330
S_1B_3	10% sugar + 2% carrot	8.157	6.140	6.333	6.640
S_1B_4	10% sugar + 5% carrot	8.200	6.167	6.333	6.760
S_2B_0	15% sugar + no blend	8.267	6.433	7.167	7.520
S_2B_1	15% sugar + 2% beet root	8.450	6.333	7.167	7.630
S_2B_2	15% sugar + 5% beet root	8.300	6.333	7.000	7.390
S_2B_3	15% sugar + 2% carrot	8.400	6.333	7.000	7.450
S_2B_4	15% sugar + 5% carrot	8.500	7.000	7.333	7.950
S.Em±		**0.06**	**0.19**	**0.21**	**0.47**
CD (P=0.05)		**0.19**	**0.56**	**0.62**	**1.37**

Total sugars (%)

The changes in total sugars content of sweet orange RTS beverage during storage was tabulated in 1 and 2. Sugar level of S_2 (15% sugar) recorded with 12.697 and 13.192 % at 0 and 90 DAS respectively. Among the juice blends, no blend showed a highest total sugars content, B_0 with 13.455and 13.947 at 0 and 90 DAS respectively. Among the interaction effect of sugar level and juice blend, S_2B_0 (15% sugar + no blend) recorded higher sugars (13.570%) at the initial day. Gradual increase was noticed from 13.570 and 14.180at 0 and 90 DAS respectively. The increasing trend in total sugars was observed by earlier workers and was ascribed due to inversion of sugars and hydrolysis of polysaccharides into simple sugars (Sonai *et al.*, 2010).

Sensory evaluation

Colour (score)

The data on sensory score pertaining to colour of sweet orange based RTS blends was tabularized in Table 3 and 4. There was a decrease in score given to the colour of sweet orange based RTS beverages during the storage period. Colour score was found to be highest in S_2 (15% sugar) 8.388 and 7.588 at 0and 90 DAS storage respectively.

In case of juice blends B_4 (5% carrot), recorded higher score of 8.290 and 7.355 at 0 and 90 DAS respectively. It was on par with B_0 (no blend), B_1 (2% beet root), B_2 (5% beet root), B_3 (2% carrot). In the interaction effects S_2B_4 (15% sugar+ 5% carrot) showed highest mean score for colour 8.890 and 8.500 at 0, and 90 DAS respectively.

The decrease in colour parameter was expected due to the changes in biological properties of the sweet orange RTS during storage and as the colour was influenced by ß carotene content and there is a slight decrease during the storage. The colour decreases. Similar reports observed by Kumar *et al.*, (2013).

Taste (score)

The data on in sensory score pertaining to taste of sweet orange based RTS blends was tabularized. The sensory score of Sweet orange based RTS blends for taste decreased from initial day to 90 DAS. With regard to the sugar level S_2 (15% sugar) recorded highest score 8.633 and 7.133 at 0and 90 DAS respectively. Whereas in juice blends significantly highest score obtained in B_4 (5% carrot) 8.750 and 6.833 at 0 and 90 DAS respectively. Among interaction effects between sugar and juice blends S_2B_4 showed highest score 9 and 7.333 at 0and 90 DAS respectively with regard to taste.

The decrease in score for taste might be due to degradation in biochemical constituents during storage.

Flavour (score)

The data on sensory score pertaining to flavor of sweet orange based RTS blends was tabularized in the Table 3 and 4. Among the sugar level high score obtained in S_2 (15% sugar) 7.740 and 6.487 at 0, and 90 DAS respectively. Among juice blends B_4 (5% carrot) showed significant highest score 8 and 6.583 at 0and 90 DAS respectively. Interaction between sugar level and juice blends highest score obtained in S_2B_4 (15% sugar + 5% carrot) 8.500and 7.000 at 0 and 90 DAS respectively.

The decrease in organoleptic score of flavour might be due to degradation in biochemical constituents and of RTS during storage which leads to development of off-flavours.

Overall acceptability (score)

The data on sensory score pertaining to overall acceptability of sweet orange based RTS blends was tabularized in the Table 3 and 4.

There was a significant decrease in the score given to the overall acceptability of sweet orange RTS during storage period. Overall acceptability score was high in S_2 (15% sugar) with a score of 8.388and 7.588 at 0and 90 DAS respectively. Among juice blends highest score obtained in B_4 (5% carrot) 8.290and 7.355 at 0and 90 DAS respectively. The values are on par with each other. Interaction between sugar levels and juice blends S_2B_4 (15% sugar+ 5% carrot) recorded highest score 8.820 and 7.950 at 0and 90 DAS respectively.

The decrease in score of overall acceptability might be due to degradation in biochemical constituents during storage. The consumer acceptance of sweet orange RTS blends is influenced by its colour, flavour, taste, aroma and textural properties. Reduction in overall acceptability score was observed by Bhavyasree (2010) in sweet orange RTS beverages prepared by blending with pomegranate and ginger.

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