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Development of tomato glaced slices by using different sweetners

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Abstract

Tomato is a perishable crop and has high moisture content with lower shelf life. Postharvest treatments and practices are needed to extend shelf life. In current research different sweeteners were used to develop glace tomato slices, a value-added product of tomato. Tomato slices were immersed in sucrose, glucose, salt and CA (citric acid) solution at different concentration and stored at room temperature for 20hrs. Then drained out the excessive syrup and slices were placed in dryer for drying at 55 ^{o}C till a shelf stable state. Prepared glaced tomato slices were then placed in waterproof zip polythene bags and were evaluated for physicochemical and sensory attributes for storage period of six months. Results showed percent increase in pH (9.93- 14.35 %), moisture content (9.13- 12.94 %) and reducing sugar (24.29-33.57 %). Whereas percent decrease was observed in Acidity (21.02-24.64 %), Ascorbic acid (25.21-26.17 %), Non-Reducing sugar (19- 34.66 %), Color (25.29- 47.44 %), Texture (32.18- 48.10 %), Taste (25-31.25) and overall acceptability (37.50-46.25 %). Results also showed that physicochemical and sensory attributes of the glaced tomato slices was significantly affected by treatments and storage period. The Sample T3 (25% sucrose, 15% glucose, 0.2% citric acid and 0.2% salt) was found most satisfactory and acceptable in terms of quality and physicochemical characteristics. For diabetic patients, artificial sweetners may be used in future to check the acceptability.

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Introduction

Glacé fruit or peel is fruit that is drained from the sugar syrup and used as it is for eating or baking, whereas candied or crystallized fruit is air dried and then coated with sugar. Process for making candied fruit has been around since the 14th century when sugar became more widely available.

It involves placing whole fruit, smaller pieces of fruit, or pieces of peel, in heated sugar syrup, which absorbs the moisture from within the fruit and eventually preserves it. It is a bit more sophisticated than the ancient Roman process of just placing fruit in honey but both use the same scientific principle of osmosis *(*Jones, 2010). Osmotic process starts when water moves from low to high concentrated fruits and vegetables in osmotic solution. Surface or cell membrane of raw material works as semipermeable membrane (Khan, 2012).

Tomato (*Lycopersicon esculentum*) is considered an imperative vegetable crop. Tomato takes second position among major vegetables, growing in Pakistan (Mirza, 2007). Cultivated land under Tomato were 41 thousand/ha, during 2014-15 and aggregate production were 566.9 K tones, with 10522 Kilogram/ha yield (Agricultural Statistics of Pakistan, 2014-15). Tomatoes are the good source of vitamin A, C, lycopene and β-carotene in large amount which has a positive impact on human health. Composition of tomato is (91%) water, (5-7%) soluble and insoluble solids, citric acid, vitamins and minerals and other organic acids (Pedro and Ferreira, 2007). During summer tomato price is very high and available in large quantity with relatively low price during reaping period. As a seasonal fruit, tomato production rate is very low in its off season and common peoples do not reach to the price because the cost escalates and many peoples are not able to buy it. Another issue with tomatoes is that it is highly perishable fruit with lower shelf life. Development of candy from Tomato is one of the alternative methods to reduce tomato loss. Without any preservation system shelf life of tomato is 2-3 days; while tomato candies have up to six months shelf life. Consumer attraction would be more to tomato candy because it is very practical to consume in solid form.

Therefore, the current study was conducted to prepare a delicious, nutritious and stable product from raw fruit in order to minimize post-harvest losses and to indirectly uplift the farmer's economic status.

Materials and methods

The research was carried out in the laboratory of Food Science and Technology at Agricultural Research Institute Tarnab, Peshawar. Fresh tomatoes free from diseases, healthy and fully ripe with best colour were procured. Selection of tomato fruit was on the basis of uniform size, cleanliness and freshness. Tomatoes were colour sorted according to the standard method of (USDA 1991) for colour sorting.

Fruit was blanched at 80˚C in hot water for very short time. Tomatoes wee peeled and seeds were removed. Different slices of uniform sizes were made and dipped into different sucrose and glucose solution for 20 hours according to the plan of study.

Tomatoes were then dried at 60˚C in mechanical dryer to obtain the moisture content of ≤18%. Prepared glaced tomato slices were then placed in polythene bags and kept in a room temperature for storage. Physicochemical and sensory analysis were performed for 180 days. The treatments were made according to the plan of work mentioned in table 1.

Statistical analysis

All the data concerning treatments and storage were analyzed using Completely Randomized Design with two factors (storage, treatment) using a statistical software Statistix 8.1. In case the data was found significant then least significant test was applied at 0.5% level of significance for mean comparison.

Results

Ascorbic acid significantly ($p<0.05$) decreased from 16.65 to 12.38 (Table 2.).

Table 1. Plan of work for development of tomato glaced slices.

Tomato	Sucrose	Glucose	Salt	Citric Acid
To = Tomato Slice	40%	No Glucose	0.2%	0.2%
T1 = Tomato Slice	35%	5%	0.2%	0.2%
T 2 = Tomato Slice	30%	10%	0.2%	0.2%
T 3 = Tomato Slice	25%	15%	0.2%	0.2%
T 4 = Tomato Slice	20%	20%	0.2%	0.2%
T 5 = Tomato Slice	15%	25%	0.2%	0.2%

The higher value of mean was observed in T_0 (14.84), while lower value was observed in sample T_5 (14.29). The maximum percent decline was observed in sample T_2 (26.17%) while minimum percent decrease was found in sample T_3 (25.21%). The pH values significantly ($p<0.05$) increase from 3.93 to 4.50. Maximum mean value for pH was recorded in sample T_0 (4.70), the lowest value for mean was noted in a T_3 (3.98). The highest percent increase was observed in the T_2 (14.35), while minimum decline was recorded in sample T_3 (9.93) (Table 3).

Table 2. Vitamin C (mg/100g) of glaced tomato slices stored at ambient temperature.

Treat	Storage interval							% Dec	Mean
	Initial	30	60	90	120	150	180		
					Vitamin C				
T_0	16.87	16.02	15.65	14.98	14.21	13.67	12.51	25.84	14.84a
T_1	16.57	15.87	15.21	14.64	13.78	13.11	12.34	25.53	14.50d
T_2	16.66	15.81	15.44	14.77	14	13.46	12.3	26.17	14.63bc
T_3	16.78	16.08	15.42	14.85	13.99	13.32	12.55	25.21	14.71b
T_4	16.68	15.98	15.32	14.75	13.89	13.22	12.45	25.36	14.61c
T_5	16.36	15.66	15	14.43	13.57	12.9	12.13	25.86	14.29e
Mean	16.65a	15.90b	15.34c	14.74d	13.91e	13.28f	12.38g		

Values followed by different small letters are statistically different ($p<0.05$).

Table 3. pH of glaced tomato slices stored at ambient temperature.

Treat	Storage interval							% Inc	Mean
	Initial	30	60	90	120	150	180		
					pH				
T_0	4.33	4.59	4.64	4.73	4.79	4.87	4.97	12.88	4.70a
T_1	3.93	3.98	4.06	4.13	4.24	4.37	4.49	12.47	4.17b
T_2	3.88	3.95	4.11	4.23	4.34	4.41	4.53	14.35	4.21b
T_3	3.81	3.82	3.89	3.95	4.04	4.12	4.23	9.93	3.98d
T_4	3.84	3.93	3.98	4.08	4.16	4.27	4.37	12.13	4.09c
T_5	3.8	3.89	3.97	4.09	4.18	4.26	4.38	13.24	4.08c
Mean	3.93g	4.03f	4.11e	4.20d	4.29c	4.38b	4.50a		

Values followed by different small letters are statistically different ($p<0.05$).

Percent acidity substantially ($p<0.05$) decreased from 0.63 to 0.48. Highest mean value was noted in experimental unit T_5 (0.62), while the minimum mean value was observed in a sample T_0 (0.50). The highest % decrease was noted in T_5 (24.64%) while lowest % decrease was T_3 (21.02%) (Table 4). Non-reducing sugar were substantially ($p<0.05$) decreased from 27.84 to 22.00.

Table 4. Percent Acidity of glaced tomato slices stored at ambient temperature.

Treat	Storage interval							% Dec	Mean
	Initial	30	60	90	120	150	180		
	Acidity								
T_0	0.575	0.555	0.535	0.495	0.475	0.445	0.435	24.35	0.50f
T_1	0.592	0.572	0.552	0.512	0.492	0.462	0.452	23.65	0.52e
T_2	0.611	0.591	0.571	0.531	0.511	0.481	0.471	22.91	0.54d
T_3	0.666	0.646	0.626	0.586	0.566	0.536	0.526	21.02	0.59b
T_4	0.634	0.614	0.594	0.554	0.534	0.504	0.494	22.08	0.56c
T_5	0.69	0.68	0.66	0.63	0.59	0.56	0.52	24.64	0.62a
Mean	0.63a	0.61b	0.59c	0.55d	0.53e	0.50f	0.48g		

Values followed by different small letters are statistically different ($p<0.05$).

Table 5. Percent Non reducing sugar of glaced tomato slices stored at ambient temperature.

Treat	Storage interval							% Dec	Mean
	Initial	30	60	90	120	150	180		
	Non -Reducing Sugar								
T_0	35.71	34.21	33.43	32.45	31.22	30.57	29.87	16.35	32.49a
T_1	33.62	32.12	31.34	30.36	29.13	28.48	27.78	17.37	30.40b
T_2	30.73	29.23	28.45	27.47	26.24	25.59	24.89	19	27.51c
T_3	27.5	26	25.22	24.24	23.01	22.36	21.66	21.24	24.28d
T_4	22.61	21.11	20.33	19.35	18.12	17.47	16.77	25.83	19.39e
T_5	16.85	15.35	14.57	13.59	12.36	11.71	11.01	34.66	13.63f
Mean	27.84a	26.34b	25.56c	24.58d	23.35e	22.70f	22.00g		

Values followed by different small letters are statistically different ($p<0.05$).

Maximum values were noted in sample T_0 (32.49) while minimum value was observed in sample T_5 (13.63). The highest % decrease was recorded T_5 (34.66%) while minimum decrease occur in T_0 (16.35%) (Table 5). Concentration of reducing sugar significantly ($p<0.05$) increased from 47.16 to 53.00. Highest mean value for treatments was recorded in sample T_5 (61.37), while minimum mean value was recorded in T_0 (42.51).

Table 6. Reducing sugar of glaced tomato slices stored at ambient temperature.

Treat	Storage interval							% Inc	Mean
	Initial	30 Day	60 Day	90 Day	120 Day	150 Day	180 Day		
	Reducing sugar								
T_0	39.3	40.8	41.6	42.6	43.8	44.4	45.1	12.94	42.51f
T_1	41.4	42.9	43.7	44.6	45.9	46.5	47.2	12.37	44.60e
T_2	44.3	45.8	46.6	47.5	48.8	49.4	50.1	11.65	47.49d
T_3	47.5	49	49.8	50.8	52	52.6	53.3	10.95	50.72c
T_4	52.4	53.9	54.7	55.7	56.9	57.5	58.2	10.03	55.61b
T_5	58.2	59.7	60.4	61.4	62.6	63.3	64	9.13	61.37a
Mean	47.16g	48.66f	49.44e	50.42d	51.65c	52.30b	53.00a		

Values followed by different small letters are statistically different ($p<0.05$).

The maximum percent increase was recorded in sample T_0 (12.94%) while minimum percent increase was recorded in sample T_5 (9.13%) (Table 6). Moisture content significantly ($p<0.05$) increased from 9.90 to 14.26. Highest mean value for treatments was recorded in T_5 (13.12), while the minimum mean value was recorded in T_1 (11.28). Maximum percent increased was recorded in sample T_2 (33.57%) while minimum percent increase was recorded T_0 (24.29%) (Table 6).

Table 7. Moisture content of glaced tomato slices stored at ambient temperature.

Treat	Storage interval							% Inc	Mean
	Initial	30	60	90	120	150	180		
					Moisture				
T_0	9.88	10.28	10.88	11.31	11.97	12.51	13.05	24.29	11.41e
T_1	9.28	9.84	10.51	11.09	11.95	12.95	13.31	30.28	11.28e
T_2	9.38	10.18	10.97	11.95	12.75	13.64	14.12	33.57	11.86d
T_3	9.9	10.7	11.49	12.47	13.27	14.16	14.64	32.38	12.38c
T_4	10.32	11.12	11.91	12.89	13.69	14.58	15.06	31.47	12.80b
T_5	10.64	11.44	12.23	13.21	14.01	14.9	15.38	30.82	13.12a
Mean	9.90g	10.59f	11.33e	12.15d	12.94c	13.79b	14.26a		

Values followed by different small letters are statistically different ($p<0.05$).

Table 8. Color of glaced tomato slices stored at ambient temperature.

Treat	Storage interval							% Dec	Mean
	Initial	30	60	90	120	150	180		
					Color				
T_0	7.8	7.7	7.1	6.5	6	5.5	4.1	47.44	6.39d
T_1	7.6	7.2	7	6.2	5.9	5.6	4.6	39.47	6.30d
T_2	7.9	7.1	7	6.5	6.2	5.8	5.1	35.44	6.51d
T_3	8.7	8.5	7.8	7.6	7.4	6.9	6.5	25.29	7.63a
T_4	8.5	8.3	7.6	7.2	7	6.7	6.1	28.24	7.34b
T_5	8.3	8	7.2	6.7	6.5	5.8	5	39.76	6.79c
Mean	8.13a	7.80b	7.28c	6.78d	6.50d	6.05e	5.23f		

Values followed by different small letters are statistically different ($p<0.05$.

In term of sensory characteristics, T3 showed best results in term of color having a shiny appearance. Maximum value for mean was noted in sample T_3 (7.63), while minimum value for mean was noted in T_0 (6.30). Highest percent decline was noted in sample T_5 (39.76%), while lowest percent decline was noted in T_3 (25.29%) (Table 8). The overall mean points of judges for texture substantially ($p<0.05$) declined from 8.23 to 4.98. Highest value for mean was noted in sample T_3 (7.50) on the other hand lowest value was noted in sample T_0 (6.33). Highest percent decreased was noted in T_0 (48.10%), while lowest percent score was noted in sample T_3 (32.18%) (Table 9). The overall mean value of judges for taste substantially ($p<0.05$) declined from 7.97 to 5.65. Maximum value for mean was noted in T_3 (6.96), on the other hand lowest value for mean was seen and recorded in T_2 (6.70). Highest % decline was seen and recorded in T_0 and T_1 (31.25%), while minimum percent decrease was noted in sample T_3 (25.00%) (Table 10). Overall acceptability substantially ($p<0.05\%$) declined from 8.20 to 4.74. for treatments, highest value for mean was seen and recorded in T_3 (6.91), while minimum value for mean was recorded

in T_5 (6.39). Maximum percent decline was noted in T_5 (46.25%), while minimum percent decline was reported in T_2 (37.50%) (Table 11).

Discussion

The loss of vitamin C is believed due to a change in the structure of tissue of fruit. The higher the sugar solutions lead water molecules to diffuse reducing Vitamin C content.

During storage and processing loss in Vitamin C occurs as reported in previous studies. Ascorbic acid is a water-soluble vitamin C and may be destroyed by oxidation (Tamuno *et al.*, 2015).

Table 9. Texture of glaced tomato slices stored at ambient temperature.

Treat	Storage interval							% Dec	Mean
	Initial	30	60	90	120	150	180		
					Texture				
T_0	7.9	7.4	7	6.5	6.1	5.3	4.1	48.10	6.33d
T_1	8	7.8	7.3	6.8	6.3	5.5	4.5	43.75	6.60c
T_2	8.1	7.9	7.5	6.9	6.6	6	5.1	37.04	6.87b
T_3	8.7	8.2	7.9	7.8	7.3	6.7	5.9	32.18	7.50a
T_4	8.4	7.9	7.5	7	6.8	6.2	5.5	34.52	7.04b
T_5	8.3	7.8	7.1	6.6	6.2	5.3	4.8	42.17	6.59c
Mean	8.23a	7.83b	7.38c	6.93d	6.55e	5.83f	4.98g		

Values followed by different small letters are statistically different ($p<0.05$).

Table 10. Taste of glaced tomato slices stored at ambient temperature.

Treat	Storage interval							% Dec	Mean
	Initial	30	60	90	120	150	180		
					Taste				
T_0	8	7.8	7.2	6.7	6.1	5.9	5.5	31.25	6.74b
T_1	8	7.8	7.4	6.4	6.1	5.7	5.5	31.25	6.70b
T_2	7.9	7.6	7.3	6.8	6.1	5.8	5.6	29.11	6.73b
T_3	8	7.9	7.4	7	6.4	6	6	25	6.96a
T_4	7.9	7.7	7.1	6.5	6.2	5.9	5.7	27.85	6.71b
T_5	8	7.7	7.2	6.7	6.2	5.6	5.6	30	6.71b
Mean	7.97a	7.75b	7.27c	6.68d	6.18e	5.82f	5.65g		

Values followed by different small letters are statistically different ($p<0.05$).

The pH followed a slight increasing trend as the storage period was increased (3.93 to 4.50). The increase in moisture content cause decrease in acidity hence caused higher pH. The decrease in acidity might be due to the higher moisture gain due storage period. The osmotic solution causes organic acid of fruit to leach out from the fruit causing lowering in acidity. Similarly kumar *et al.* (2008) observed decreasing trend in acidity of osmo-vac dried mango slices. The decrease in non-reducing sugar during storage might be due to conversion to reducing sugar. Zia and Ayub (2012) observed similar results of decrease in non-reducing sugar of sucrose and glucose preserved melon cubes. The statistical analysis showed that reducing sugar of glaced tomato slices was significantly influenced by treatments and storage intervals. This might be due to the inversion of added sugar. Increasing trend of reducing sugar was reported in the effect of storage methods on sapota candy by Divya *et al.* (2014).

Table 11. Overall acceptability of glaced tomato slices stored at ambient temperature.

Treat	Storage interval							% Dec	Mean
	Initial	30	60	90	120	150	180		
	Overall acceptability								
T_0	7.90	7.77	7.13	6.80	6.10	5.50	4.40	44.30	6.51bc
T_1	8.30	7.78	7.57	6.50	6.23	5.70	4.65	43.98	6.68b
T_2	8.00	7.80	7.53	6.43	6.00	5.40	5.00	37.50	6.59bc
T_3	8.50	7.80	7.60	6.90	6.50	5.80	5.30	37.65	6.91a
T_4	8.50	7.90	7.47	6.32	5.91	5.80	4.80	43.53	6.67b
T_5	8.00	7.50	7.20	6.70	5.90	5.10	4.30	46.25	6.39c
Mean	8.20a	7.76b	7.42c	6.61d	6.11e	5.55f	4.74g		

Values followed by different small letters are statistically different ($p<0.05$).

The permitted moisture content of osmo dried food is maximum upto 25%. The higher moisture level in the environment might have caused the higher gain during storage period. Hasanuzzaman *et al.* (2014) observed increase in moisture content with 6 months of storage in tomato candy, attributed to moisture pickup from atmosphere. Color of many foods is important quality parameter in marketing. Important as related to consumer preferences based on appearance. The sugar solutions normally do not cause any damage to the Red color of tomato. Higher concentrations of sugar sometimes create caramelization and turn the products into red with dark red and even black. Tomato slices with 25% sucrose and 15% glucose solution were the most preferred product to the panelists; this is possible because the taste of tomatoes were still pleasant. The mean score for all sensory attribute decreased during storage which might be due to the environmental factor causing decrease in color. Moisture gain cause disruption in texture, while disturbance in acidity have caused taste disruption. Overall acceptability is a countenance of the individual sensory factors like color, texture, taste and other qualitative characters.

Conclusion

In the present study, glaced tomato slices was prepared by using different sweeteners (sucrose and glucose) with different concentrations. From this study, it was revealed that the sample treatment T_3 treated with (25% sucrose and 15% glucose) followed by T_4 (20% sucrose and 20% glucose) showed best results in both physicohemically and oraganoleptically.

It is also evident from the results that the physical and sensory properties of the glaced tomato slices have been significantly affected by the storage period. This study will help the food producer or the manufacturer of the confectionaries to select the appropriate concentration of sucrose and glucose solution to developed glaced tomato slices.

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