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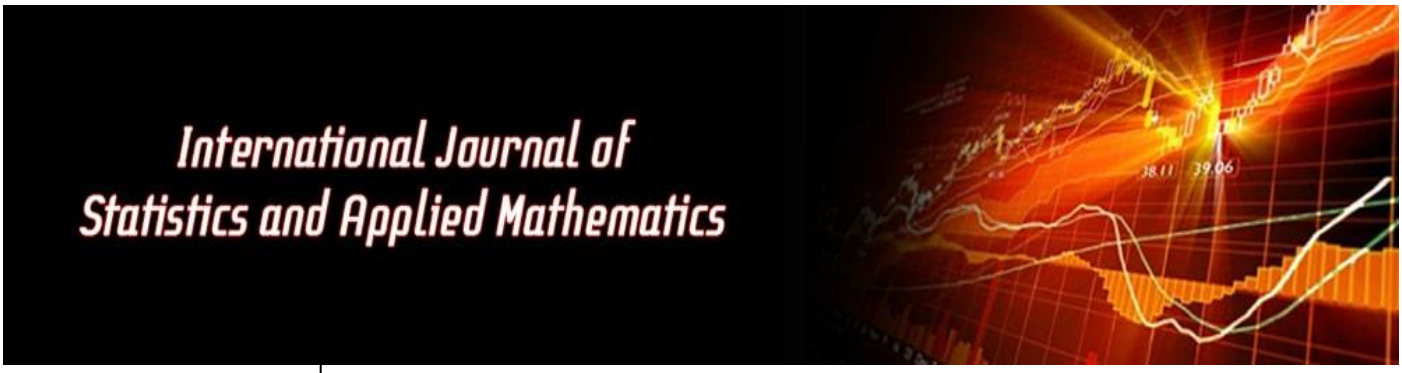

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Quality evaluation of beetroot tutti-frutti

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Abstract
Fruits and vegetables are high in vitamins and minerals. During the season, their production is high, and their perishable nature causes fruit spoilage. Beetroot is taproot portion of beet plant. Dark red-colored beet roots are very popular for human consumption, in the form of cooked and raw as salad or juice. Beetroot is widely used in the food industry as a natural food colourant and in a variety of value-added products. For preparation of beetroot tutti-frutti the experiment conducted in which various combination of sugar syrup temperature (40, 50 and 60 °C), concentration (50, 60 and 70° Brix) and duration of osmosis (60, 120 and 180 min) were taken. The results indicated that the quality observations affected by various treatments. As the temperature and concentration of the solution were increased the color and water activity decreased with increase in time.

Keywords: Beetroot, tutti-frutti, color, water activity, sensory evaluation

1. Introduction
The beetroot (*Beta vulgaris* L.) is the taproot (bulb) portion of the beet plant. It is grown in temperate countries and biennial plant. The beetroot and its juice are freely consumed for its great taste, nutritional benefit and flavour content. Beetroot juice contains a high level of biologically accessible antioxidants as well as many other health promoting compounds such as potassium, magnesium, folic acid, iron, zinc, calcium, phosphorus, sodium, niacin, biotin, B6 and soluble fibre. It contains vitamins A, B1, B2, B6 and C. It is also a good source of minerals like copper, phosphorus, sodium, calcium, magnesium, and iron (Neha *et al*., 2018) [3] The colouring pigments of beetroot: betaxanthin and betacyanin, are responsible to impart yellow and purple colour respectively, which is collectively known as betalains. (Vali *et al*., 2007) [4]. These betalains have the antioxidant capabilities in beetroot. (Georgiev *et al*., 2010) [2] Highest nitrate contents (>250 mg/100 g fresh weight) have also been reported in beetroot; (Kumar, 2016) [1]. Though beetroot is easily available at low cost in the local market but it is not liked by the consumers in raw form because of its peculiar after taste. Hence this restricts its consumption, thus limiting the scope of the benefits it can provide. Therefore, a need of processed beetroot product was greatly felt and its processing in the form of a candy was thought to be an effective way to include beetroot in the diets of humans of all age groups. Given its nutritional and medicinal value, beetroot should be included in the human diet. In addition, because it is available all year, beetroot can be processed into beetroot candies (Singh and Hathan, 2013) [5]. Beetroot candy is a healthy alternative to the artificially flavoured candy found in the local market (Fatma *et al*., 2016) [1].

2. Material and Methods
a. Beetroot tutti-frutti preparation
The slicing of fresh beetroot was done with the help of stainless steel knife to get 10 mm thick cubes. Syrup of desired sugar concentration (50 to 70º Brix) was prepared by disolving required amount of sugar in water. The prepared samples (beetroot cubes) were weighed approximately 40 g for each experiment and immersed in the sugar syrup (50, 60 and 70º Brix) contained in a 200 ml glass beaker. The beakers were placed inside the constant temperature water bath. Each beaker was removed from the water bath at the designated time 30, 60, 90, 120, 150 and 180 minutes and the samples were immediately rinsed with water and placed on tissue paper to remove the surface moisture.

b. Quality Evaluation

As quality is important in food processing, control should be practiced at every stage from pre-processing to drying, packing, storing, *etc*. Quality parameters *viz*. color, water activity and sensory evaluation of osmotically dried products were determined.

- **Colour measurement**

Colour is one of the most important qualities for acceptance of products, reflects sensation to the human eye. Colour is important to consumer as a means of identification, as a method of judging quality and for its basic aesthetic value. Product after drying gets darker in colour, but dark colour does not means better quality. Drying change the surface characteristics of a food and hence alters its reflectivity and color. This is prevented by blanching and treatment of fruits with ascorbic acid or sulphur dioxide. The colorimeter used in the present investigation was hunter lab colorimeter.

- **Water activity**

Water activity (a_w) is a measure of the availability of water for microbial, enzymatic or chemical activity that determine the shelf life of the product. Water activity can be defined as the ratio of the vapour pressure exerted by the food to the saturated vapour pressure of water at the same temperature. Water activity meter was used for tutti-frutti measurement.

$$a_w = \frac{P_A}{P_{A_{sat}}} \quad \ldots 1$$

Where,

a_w = Water activity

P_A = Vapour pressure of water exerted by food.

P_{Asat}= Saturated vapour pressure of water at the same temperature

- **Sensory Evaluation**

To the consumer, the most important quality attributes of a food are its sensory characterstics (texture, flavor, aroma, shape and colour).These determine the indivisual's preference for specific products. Sensory evaluation is important to assess the consumer's requirements. 9 point hedonic scale was used for it. The sensory evaluation was carried out for taste and over all acceptability.

3. Result and discussion

Water activity

The water activities of beetroot tutti-frutti with all combinations of temperatures and concentration were ranging from 0.741 to 0.602 (Table 1). As regards to individual effect of temperature, it revealed that as the temperature as well as concentration of syrup increased water activity decreased. As regards to individual effect of syrup temperature, it revealed that the lowest water activity 0.602 was found at high temperature–high concentration and highest at low temperature and low concentration. Optimization of water activity was done using RSM I-custom model, as shown in Table 2.

Table 1: Water activity of beetroot tutti -frutti at 40, 50 and 60 °C syrup temperature and 50, 60 and 70ºBrix syrup concentration

Temperature	Concentration	Water activity
40 °C	50ºBrix	0.741
	60ºBrix	0.728
	70ºBrix	0.712
50 °C	50ºBrix	0.705
	60ºBrix	0.656
	70ºBrix	0.693
60 °C	50ºBrix	0.641
	60 ºBrix	0.623
	70ºBrix	0.602

The ANOVA for water activity is presented in Table 3. From this table, it can be seen that the effect of drying temperature and syrup concentration on water activity were significant at 1 percent level of significance, and effect of their interactions on water activity was found not significant.

Table 2: Observed water activity under varying processing parameters

	Factor 1	Factor 2	Response
Run	A:temp (°C)	B: cons. (ºBrix)	water activity
1	50	60	0.65
2	40	50	0.741
3	50	70	0.693
4	50	60	0.686
5	60	60	0.623
6	60	60	0.623
7	60	50	0.641
8	40	60	0.728
9	50	70	0.693
10	50	60	0.686
11	40	60	0.728
12	40	70	0.715
13	50	50	0.705
14	40	50	0.745
15	60	60	0.623
16	50	50	0.705

Table 3: ANOVA showing the effect of temperature and concentration and their interaction on water activity

Source	Sum of Squares	df	Mean Square	F-value
Model	0.0256	5	0.0051	40.42**
A-temp	0.0159	1	0.0159	125.01**
B-cons	0.0002	1	0.0002	1.89**
AB	0.0001	1	0.0001	0.612ns
A^2	0.0002	1	0.0002	1.75
B^2	0.0008	1	0.0008	6.51
Lack of Fit	0.0004	2	0.0002	1.82ns
Pure Error	0.0009	8	0.0001	
Cor Total	0.0269	15		
Std. Dev.	0.0113			
Mean	0.6866			
C.V. %	1.64			
R^2	0.9529			
Adjusted R^2	0.9293			

**Significant at 1 percent level;*Significant at 5percent level, ns non-significant

Colour value

The colour of beetroot tutti-frutti was measured in terms of L-value (brightness/darkness), a* value and b* value which are shown in Table 4. Optimization of color value was done using RSM I-custom model.

Table 4: L*, a*, b* value at different temperature and concentration.

Temperature	Concentration	L*-value	a*-value	b*-value
	50ºBrix	76.74	60.20	48.87
40 °C	60ºBrix	76.66	60.01	48.79
	70ºBrix	76.52	59.91	48.70
	50ºBrix	75.95	58.74	47.54
50 °C	60ºBrix	75.82	58.66	47.42
	70ºBrix	75.74	58.34	47.30
	50ºBrix	74.52	57.24	46.61
60 °C	60 ºBrix	74.34	57.13	46.53
	70ºBrix	74.12	57.04	46.45

a* value

The a* value represents purple-red (positive a* value) and blue-green (negative a* value) colour scale of the product. This value of beetroot tutti-frutti varies according to various temperature-concentration combination. As regards to individual effect of temperature, it revealed that as the syrup temperature increased, the (+) a* value of colour decrease, due to the loss of the red pigment betaline present in the beetroot which is responsible for the redness of beetroot. Betaline is heat sensitive pigment, which is loss on high temperature. This value varies from 60.20 to 57.04 on 40 to 60 °C temperature. It shows the temperature dependence of product. It ranges 60.20, 60.01 and 59.91 at 50, 60 and 70ºBrix concentration at 40 °C. Similarly at 50 °C temperature it ranges 58.74, 58.66 and 58.34 at 50, 60 and 70ºBrix concentration, and at 60 °C temperature the a- value varies 57.24, 57.13 and 57.04 at 50,60 and 70ºBrix concentration.

Table 5: ANOVA showing effect of process variables on colour (a* value)

Source	Sum of Squares	df	Mean Square	F-value
Model	15.13	5	3.03	421.35**
A-temp	14.27	1	14.27	1987.05**
B-cons	0.1318	1	0.1318	18.35**
AB	0.0057	1	0.0057	0.7875*
A²	0.0081	1	0.0081	1.13*
B²	0.0193	1	0.0193	2.69
Lack of Fit	0.0438	3	0.0146	3.65ns
Pure Error	0.028	7	0.004	
Std. Dev.	0.0847			
Mean	58.58			
C.V. %	0.1447			
R²	0.9953			
Adjusted R²	0.9929			
Predicted R²	0.9802			

**Significant at 1 percent level; *Significant at 5 percent level; ns – Non significant

b* value

The b* value represents yellow (positive b* value) or blue (negative b* value) colour scale of the product. As regards to individual effect of temperature, it revealed that as the drying temperature increased, the b* value of colour decreased for beetroot tutti-frutti. The b-value varies from 48.87 to 46.45 on 40 to 60 °C temperature. It shows the temperature dependence of product. The b value ranges 48.87, 48.79 and 48.70 at 50, 60 and 70ºBrix concentration at 40 °C. Similarly at 50 °C temperature it ranges 47.54, 47.42 and 47.30 at 50, 60 and 70ºBrix concentration, and at 60 °C temperature the b- value varies 46.61, 46.53 and 46.45 at 50,60 and 70ºBrix concentration.

Table 6: ANOVA showing effect of process variables on colour (b*-value)

Source	Sum of Squares	df	Mean Square	F-value
Model	10.66	5	2.13	932.4**
A-temp	9.85	1	9.85	4308.15**
B-cons	0.0514	1	0.0514	22.48**
AB	0.0025	1	0.0025	1.09ns
A²	0.1915	1	0.1915	83.78
B²	0.0006	1	0.0006	0.2734
Lack of Fit	0.0062	3	0.0021	0.8747ns
Pure Error	0.0166	7	0.0024	
Cor Total	10.68	15		
Std. Dev.	0.0478			
Mean	47.53			
C.V. %	0.1006			
R²	0.9979			
Adjusted R²	0.9968			
Predicted R²	0.9927			

**Significant at 1percent level; ns -non significant

L-value

L* value represents lightness index of the product, which are represented in Table 4.15. The L-values of beetroot tutti-frutti at various experimental conditions were ranged from 76.74 to 74.12. As regards to individual effect of temperature, it revealed that as the drying temperature increased, the L-value of colour (darkness) decreased significantly. The L- value varies 76.74 to 76.52 at 40 °C temperature from 50 to 70ºBrix concentration. Similarly at 50 °C temperature it varies 75.95 to 75.74 from 50 to 70º Brix concentration, also at 60 °C it varies 74.52 to 74.12 from 50 to 70º Brix concentration.

Table 7: ANOVA showing the effect of syrup temperature and concentration and their interaction on colour (L-value)

Source	Sum of Squares	df	Mean Square	F-value
Model	11.81	5	2.36	257.91**
A-temp	10.68	1	10.68	1165.97**
B-cons	0.0733	1	0.0733	81
AB	0.0003	1	0.0003	0.0334*
A²	0.5379	1	0.5379	58.72*
B²	0.0006	1	0.0006	0.0682*
Lack of Fit	0.0105	3	0.0035	0.3015ns
Pure Error	0.0811	7	0.0116	
Cor Total	11.9	15		
Std. Dev.	0.0957			
Mean	75.64			
C.V. %	0.1265			
R²	0.9923			
Adjusted R²	0.9885			
Predicted R²	0.9752			

**Significant at 1 percent level; *Significant at 5percent level; ns-non significant

Sensory evaluation

The main aim of dehydration process is to reduce the moisture content as high as possible. So higher the water loss, better is the dehydration process. However, at the same time due to semi-permeability of the membrane sugar gain also takes place and high sugar gain affects quality and sensory characteristics of final product. High levels of sugar gain during the osmotic dehydration may hamper sensory attributes significantly and final product may present a taste

that is not acceptable by the consumers. Thus considering the importance of the sugar gain in product quality, this factor was mainly used for optimization of the input process parameters. It is required to fix the level of sugar gain in the final product, so that it is acceptable by the consumers. Twenty judges were given the beetroot tutti-frutti samples having the various levels of sugar gain ranging from 6.20 to 13.07 percent. The judges were asked to taste the samples and give the marks according to their liking ranging from like extremely (Score-9) to dislike extremely (Score-1). The details of the mean sensory score for the sweetness of the product as well as the result of these tests are presented in Table 8.

It can be observed from the Table 9 that as the sugar gain increased from 6.20 to 9.80 percent; the mean sensory scores was initially increased for 9.80 percent of sugar gain then decrease for 13.07 percent sugar gain. From the analysis of variance, it could be seen that the coefficient of variance among the different judges was 4.02 percent, which is less than 10 percent indicating coherence amongst the score attributed by the judges. The F value was significant at 1percent level and the SD at 1percent indicated that the product with 9.80 percent sugar gain was most liked by the judges.

Table 8: Effect of salt gain in osmo-dehydrated beetroot samples on mean sensory score

Product code	Sugar gain, percent	Mean score	t-test	Remark given by consumer panel
01	6.20	7.6 ^{b}		Liked moderately
02	8.66	8.18 ^{a}	6.38**	Liked moderately
03	9.80	8.97 ^{b}	0.54^{ns}	Liked very much
04	13.07	7.38 ^{c}	0.80^{ns}	Liked moderately

**The values superscripted by similar letters are significantly different from each other

4. Conclusion

As the temperature and concentration of the solution were increased the color and water activity decreased with increase in time. Colour value of tutti-frutti significantly decrease with the increase in temperature of the syrup. The l*, a* and b* value decrease as the concentration of the sugar syrup increases. Taste, colour, texture and overall acceptability of osmotically prepared tutti-frutti at 62^{o}C syrup temperature, 50^{o}Brix syrup concentration was highly appreciable.

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