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Development and storage study of Anthocyanin rich jelly from purple fleshed sweet potato (Variety Bhu-Krishna)

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Abstract
The objective of the study was to develop and storage study of Anthocyanin rich sweet potato jelly from purple fleshed sweet potato variety *Bhu-Krishna*. The proximate analysis of sweet potato jelly were recorded and analyzed. The prepared jelly filled in glass jar and stored at room temperature (30±2 ºC) as well as refrigerator (5±2 ºC) temperature conditions up to 90 days. During storage study of sweet potato jelly TSS, titratable acidity, total sugars were increased, where as moisture content, anthocynanin content and oraganoleptic quality was decreased with increased storage period. While microbial growth was slightly increased at both storage conditions and it was under the limit up to the 90 days of storage period. Hence, anthocyanin rich jelly from purple fleshed sweet potato exert their health benefits by helping to prevent lifestyle chronic diseases and may give an overall idea about preparation and storage of sweet potato jelly.

Keywords: Sweet potato, anthocyanin, jelly, microbial growth

Introduction
Sweet potato is a versatile root crop grown in many tropical countries. In India, the roots of this crop are consumed either as fresh vegetable or as boiled or baked products in the diet of rural and tribal people (Ray and Balagopalan, 1997) [10]. Sweet potato varieties contained colour pigments like anthocyanin, β-carotene and an unidentified flavonoid (Venkatman *et al*, 2019) [12]. Purple fleshed sweet potato (variety *Bhu-Krishna*) is rich in anthocyanin. Anthocynin is a natural, soluble food coloring pigment and responsible for the coloration of leaf, flower, stem and root. It is a soluble vacuolar pigment that may appear in red, purple or blue depending on the pH (Andersen *et al.*, 2001). Anthocyanin is a type of flavonoid a class of compounds with antioxidant effects. In addition to acting as antioxidants and fighting free radicals, anthocynins may offer anti-inflammatory, antiviral and anti-cancer benefits. Consumption of anthocynins may play a significant character in preventing lifestyle related diseases, such as cancer, hyperglycemia, cardiovascular and neurological disorder (Ashya *et al.* 2018) [3].
The development of value added products from purple fleshed sweet potato presents one of the most important key to the expended utilization of the crop. Jelly is an important class of preserved product and their preparation has been in use for a long time. Purple colored Jelly prepared from purple fleshed sweet potato variety *Bhu-Krishna* appears to represent an excellent appeal, gelling consistency and nutritive value.

Materials and Methods
The freshly harvested sweet potato tubers variety *Bhu-Krishna* was collected from the experimental farm of Regional Centre, ICAR-Central Tuber Crops Research Institute, Bhubaneswar. The major ingredients for the preparation of products were sugar, citric acid, pectin were purchased from local market of Bhubaneswar.

Process for strained extract
The peeled tubers were cut into thin slices and boiled in the equal quantity of water. The slices were heated gently for about 25-30 minutes till they become soft with occasional stirring. Then boiled extract was drained through coarse muslin cloth and the strained extract was used for preparation of purple fleshed sweet potato jelly.

Physico-chemical analysis of purple fleshed sweet potato jelly
Data were calculated for several physic-chemical (moisture, titratable acidity, total sugar, total

soluble solids and anthocynin content) parameters by following the standard procedure mentioned by Amerine and Ough (1980).

Formulation of sweet potato jelly

The purple colored sweet potato jelly prepared with different treatments was coded as: T_1, T_2, T_3, T_4 and T_5. The formulation of different treatments was mentioned in Table 1.

Methods used for preparation of sweet potato jelly

The clear purple coloured sweet potato extract was poured in a stainless steel pan and boiled, then required quantity of pectin was mixed with quantity sugar in stainless steel pot. The remaining sugar was mixed with sweet potato extract and mixture was boiled until the TSS become nearer to 55 ºBrix. Then sugar mixed pectin was added and continued the boiling until TSS becomes nearer to 58 ºBrix. The citric acid was added and continued the boiling till the desired consistency and TSS reaches to 67 ºBrix. Then the Sodium Benzoate was added the scum raised on the top of the boiling mass was removed occasionally with the help of ladle during preparation of sweet potato jelly.

Judging the end point of sweet potato jelly

When the jelly become sufficiently thick in consistency, the end point was judged by sheet test: A small portion of jelly was taken out during boiling, in a spoon. It was then allowed to drop. If the product falls off in the form of sheet or flakes instead of flowing in a continuous stream, was considered as the end point of jelly.

Table 1: Treatment details

Treatments	Sweet potato Extract (ml)	Sugar (gm)	Citric acid (%)	Pectin (gm)
T1	1000	500	0.5	10
T2	1000	550	0.5	11
T3	1000	600	0.5	12
T4	1000	650	0.5	13
T5	1000	700	0.5	14

Hot filling in glass jars and cooling

After judging the end point of sweet potato jelly, the finished hot jelly was cooled down and then filled in clean and dried wide mouth glass jars which were previously pasteurized in hot water (60 ºC for 30 min). The glass jars were cooled and sealed.

Sensory evaluation of sweet potato jelly

The sensory evaluation of purple fleshed sweet potato jelly samples were carried out according to the standard method of Amerine *et al.* (1965) [1] on 9 point Hedonic scale. The mean score of minimum 20 semi trained judges for each quality parameter *viz*., colour and appearance, taste, flavour, consistency, transparency and overall acceptability was recorded.

Storage of sweet potato jelly

The glass bottles containing sweet potato jelly after cooling were stored for 90 days at both ambient (30±2 ºC) and refrigerated temperature (5±2 ºC). The biochemical analysis and organoleptic evaluation of stored sweet potato jelly were carried out at an interval of 0, 30, 60 and 90 day's storage.

Microbiological analysis of jelly (yeast and mould count)

The microbial contamination and growth were determined by standard plate count method using potato dextrose agar (PDA). The sterile distilled water was used in control and the counting was done after increasing the plate at 38ºC for 48 hours (Ranganna, 2010) [8].

Results and Discussion

The results of various experiments conducted during the study period are summarized below;

Proximate composition of purple fleshed sweet potato juice

The data on proximate of purple fleshed sweet potato juice such as moisture content, TSS, total sugars, titratable acidity and anthocynin contents recorded in Table 2. The results obtained are in good agreement with Ray *et al*. (2005) [11].

Table 2: Proximate composition of purple fleshed sweet potato juice

Sr. no	Parameters	Mean value
1	Moisture (%)	86.27
2	TSS (º Brix)	12.18
3	Titratable acidity (%)	0.54
4	Total sugar (g per 100 gm)	3.27
5	Anthocynin (mg per 100gm)	54.21

Standardization of recipe

The sensory score for different treatments were presented in Table 3 on 9 point hedonic scale. The score for colour and appearance, flavour, taste, consistency and overall acceptability was highest for T3 (1000 ml sweet potato extract+600 gm sugar + 0.5% citric acid + 12 gm pectin) and it was 8.72 while minimum score was recorded in T5 (1000 ml sweet potato extract+700 gm sugar + 0.5% citric acid + 14 gm pectin). The minimum sensory scores for the recipe blends T1 and T2 might be due to the amount of sugar added may not be sufficient to give fine consistency and flavour. The remaining samples T4 & T5 were not liked by the panel of judges may be due to poor settings and higher quantity of sugar. On the other hand, T3 sample gave sharp edges when cut with a stainless steel knife and best mouth feel with transparent colour. So, the treatment T3 was used for storage studies.

Table 3: Sensory score of purple fleshed sweet potato jelly

Treatments	Colour & appearance	Flavour	Taste	Consistency	Transparency	Overall Acceptability
T1	8.54±0.03	8.51±0.02	8.53±0.02	8.62±0.07	8.67±0.01	8.56±0.03
T2	8.60±0.06	8.69±0.05	8.57±0.06	8.64±0.05	8.68±0.06	8.65±0.03
T3	8.81±0.03	8.85±0.01	8.64±0.03	8.72±0.02	8.77±0.03	8.72±0.02
T4	8.61±0.03	8.65±0.01	8.54±0.03	8.66±0.02	8.61±0.06	8.63±0.02
T5	8.44±0.02	8.54±0.03	8.51±0.02	8.47±0.01	8.55±0.02	8.52±0.01

±Standard deviation

Physico-chemical changes of purple fleshed sweet potato jelly during storage

The data on chemical composition of purple fleshed sweet potato jelly during storage are depicted in Table 4 and Table 5. The jelly stored in ambient as well as refrigerated condition were analyzed for moisture, TSS, titratable acidity, total sugars, anthocyanin content and microbial growth at 0,30,60 and 90 days interval during storage study.

Table 4: Biochemical changes during storage of purple fleshed sweet potato jelly at ambient temperature

Storage period (days)	Moisture (%)	TSS (ºBrix)	Titratable acidity (%)	Total sugar (%)	Anthocyanin Content (mg/100g)	Microbial Growth 10^3 cfu/ml
0	28.36±0.03	67.21±0.04	0.50±0.07	65.12±0.05	21.10±0.02	0.25±0.01
30	28.30±0.02	67.40±0.03	0.53±0.03	65.51±0.03	21.10±0.06	2.00±0.01
60	27.55±0.02	67.52±0.09	0.58±0.04	65.54±0.04	21.05±0.09	2.00±0.03
90	27.21±0.05	67.69±0.02	0.61±0.09	65.63±0.04	21.02±0.25	3.00±0.04

±Standard deviation

Table 5: Biochemical changes during storage of purple fleshed sweet potato jelly at refrigerated temperature

Storage period (days)	Moisture (%)	TSS (ºBrix)	Titratable acidity (%)	Total sugar (%)	Anthocyanin Content (mg/100g)	Microbial Growth 10^3 cfu/ml
0	28.36±0.04	67.21±0.02	0.50±0.06	65.12±0.03	21.10±0.04	0.25±0.02
30	28.33±0.06	67.43±0.05	0.51±0.06	65.58±0.04	21.10±0.02	1.00±0.02
60	27.65±0.07	67.58±0.05	0.53±0.02	65.63±0.04	21.07±0.09	1.00±0.05
90	27.47±0.04	67.71±0.06	0.57±0.05	65.67±0.30	21.06±0.04	2.00±0.03

±Standard deviation

Moisture

The data shows that the moisture content was decreased from 28.36% to 27.21% within 90 days of storage at ambient temperature. However, slight decrease in moisture content of purple fleshed sweet potato jelly stored at the refrigerated temperature i.e.28.36% to 27.47% was observed. The decrease in moisture content from 28.90% to 27.15% was observed in Dragon fruit jelly during storage (Panchal *et al*., 2018) [7]. This decrease in moisture content may be due to frequently opening of lid of bottle during storage for analysis.

Total soluble solids

The data shows that the TSS increased from 67.21 ºBrix to 67.69 ºBrix at ambient temperature while, at the refrigerated temperature it increased from 67.21 ºBrix to 67.71 ºBrix. The increased total soluble solid from 67.26 ºBrix to 68.16 ºBrix was reported in Dragon fruit jelly with increase of storage period (Panchal *et al*, 2018) [7]. The increased total soluble solids might be due to the conversion of polysaccharides in to sugars in the presence of organic acids (Kumar and Deen, 2017) [6].

Titratable acidity

The data indicated that the acidity increased from 0.50% to 0.61% at ambient temperature while from 0.50% to 0.57% at refrigerated temperature. The increase of acidity was slightly higher in case of ambient temperature compared with refrigerated temperature. The results are good agreement with Kotecha and Kadam 2002 [5]. They reported that the gradual increase in titratable acidity of tamarind jelly stored at room temperature as well as refrigerated temperature for 180 days.

Total sugars

The data shows that the total sugar was increased from 65.12% to 65.63% at ambient temperature while at refrigerated temperature it increased from 65.12% to 65.67%. The increase in total sugars might be due to loss of moisture content during storage. The results are similar with Raut, 2015. He reported that the total sugars increased from 64.63% to 67.29% in pomegranate and sapota mixed jelly.

Anthocyanin content

The data indicated that the anthocynin content was slightly decreased from 21.10 mg/100gm to 21.02 mg/100g at ambient temperature while at refrigerated temperature it decreased from 21.10 mg/100g to 21.06 mg/100g. The decrease of anthocynin content was slightly higher at ambient temperature compared with refrigerated temperature. The decrease in anthocynin content might be due to increased acidity (lower pH) of jelly during storage. Ira Mulyawanti *et al*. 2018, reported that the stability of anthocynin in purple fleshed sweet potato extract was the pH value rather than temperature during processing and storage of food products.

Microbial quality

The microbial counts of purple fleshed sweet potato jelly stored at ambient and refrigerated condition were 0.25×10^3 cfu/g at zero days. The microbial count was increased slightly from 2×10^3 cfu/g to 3×10^3 cfu/g at ambient temperature and from 1×10^3 cfu/g to 2×10^3 cfu/g at refrigerated storage temperature. It showed that, refrigerated storage condition helped for controlling microbial growth. Ranganna (2010) [8] reported that the microbial count should not exceed to 10^3 per ml or g of jelly. In present findings, the microbial count had not exceeded this limit up till jelly remained acceptable organoleptically.

Changes in sensory quality of jelly during storage

The data on sensory score of purple fleshed sweet potato jelly during storage for parameters like colour and appearance, flavour, taste, consistency, transparency and overall acceptability of jelly samples are mentioned in Table 6 and 7.

Table 6: Sensory quality of purple fleshed sweet potato jelly after 90 days of storage at ambient temperature

Storage period (days)	Colour & appearance	Flavour	Taste	Consistency	Transparency	Overall Acceptability
0	8.72±0.05	8.85±0.02	8.90±0.07	8.72±0.04	8.90±0.08	8.75±0.04
30	8.69±0.02	8.81±0.06	8.88±0.02	8.68±0.01	8.75±0.02	8.71±0.03
60	8.63±0.04	8.70±0.02	8.86±0.04	8.61±0.07	8.72±0.07	8.65±0.02
90	8.55±0.02	8.61±0.04	8.72±0.01	8.40±0.06	8.45±0.05	8.52±0.04

±Standard deviation

Table 7: Sensory quality of purple fleshed sweet potato jelly after 90 days of storage at refrigerated temperature

Storage period (days)	Colour & appearance	Flavour	Taste	Consistency	Transparency	Overall Acceptability
0	8.80±0.05	8.85±0.01	8.87±0.04	8.72±0.02	8.90±0.01	8.82±0.01
30	8.76±0.02	8.83±0.07	8.85±0.04	8.69±0.01	8.86±0.04	8.78±0.06
60	8.68±0.02	8.75±0.04	8.82±0.06	8.63±0.07	8.78±0.07	8.67±0.07
90	8.60±0.03	8.66±0.02	8.75±0.01	8.52±0.04	8.54±0.04	8.63±0.06

±Standard deviation

Colour and Appearance

The data shows that score for colour and appearance of jelly were decreased from 8.72 to 8.55 at ambient temperature and from 8.80 to 8.60 at refrigerated temperature during storage period of 90 days. The decrease in colour and appearance score from 8.93 to 8.65, 8.92 to 8.55 respectively were observed in dragon fruit jelly (Panchal *et al*, 2018) [7].

Flavour

The data shows that score for flavour of jelly samples decreased from 8.85 to 8.61 at ambient temperature and 8.85 to 8.66 at refrigerated temperature during storage study of 90 days. The loss of flavour was reported from 8.89 to 8.48, 8.91 to 8.53 respectively were observed in dragon fruit jelly (Panchal *et al*, 2018) [7].

Taste

The data shows that score for taste of jelly samples decreased from 8.90 to 8.72 at ambient temperature and 8.87 to 8.75 at refrigerated temperature during storage study of 90 days. The sensory score for taste at ambient temperature is better than refrigerated temperature.

Consistency

The data indicate that score for consistency of jelly samples decreased from 8.72 to 8.40 at ambient temperature and 8.72 to 8.52 at refrigerated temperature during storage study of 90 days. The samples stored at refrigerated temperature were liked most by the judges.

Transparency

The data shows that score for transparency of jelly samples decreased from 8.90 to 8.45 at ambient temperature and 8.90 to 8.54 at refrigerated temperature during storage period of 90 days. The similar results found by Kumar and Deen, 2017 [6]. They reported that there was decrease in transparency from 8.63 to 8.03 during storage of wood apple jelly.

Overall acceptability

The data shows that the overall acceptability score decreased from 8.75 to 8.52 at ambient temperature while from 8.82 to 8.63 at refrigerated temperature. The decrease in overall acceptability score was due to undesirable change in jelly. The results are good agreement with Kotecha and Kadam 2002 [5]. They reputed that the overall acceptability score decrease from 8.00 to 6.86 at ambient temperature while from 8.00 to 7.15 at refrigerated temperature was reported in tamarind jelly.

Conclusion

It can be concluded from the present investigation that the better quality of anthocyanin rich purple fleshed sweet potato jelly prepared using 1000 ml sweet potato extract, 600g of sugar and 12g of pectin with better organoleptic properties as well as chemical composition and good storage stability at both storage (ambient and refrigerated) conditions up to 90 days storage period. Thus, prepared anthocynin rich jelly from purple fleshed sweet potato exert their health benefits by helping to prevent lifestyle chronic diseases.

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