Journal of Applied and Natural Science
14(2), 459 - 468 (2022)
ISSN : 0974-9411 (Print), 2231-5209 (Online)
journals.ansfoundation.org

Research Article

Sensory attributes, bioactive compounds, antioxidant activity and color values of jam and candy developed from Beetroot (*Beta vulgaris* L.)

Sehajveer Kaur*
Department of Food and Nutrition, Punjab Agricultural University, Ludhiana (Punjab), India
Navjot Kaur
Department of Food and Nutrition, Punjab Agricultural University, Ludhiana (Punjab), India
Poonam Aggarwal
Department of Food Science and Technology, Punjab Agricultural University, Ludhiana (Punjab), India
Kiran Grover
Department of Food and Nutrition, Punjab Agricultural University, Ludhiana (Punjab), India

*Corresponding author. Email: sehajdhin]dsa85@gmail.com

Article Info
https://doi.org/10.31018/jans.v14i2.3407
Received: March 27, 2022
Revised: May 23, 2022
Accepted: June 1, 2022

How to Cite
Kaur, S. *et al.* (2022). Sensory attributes, bioactive compounds, antioxidant activity and color values of jam and candy developed from Beetroot (*Beta vulgaris* L.). *Journal of Applied and Natural Science*, 14(2), 459 - 468. https://doi.org/10.31018/jans.v14i2.3407

Abstract
Beetroot is a root vegetable with abundant bioactive compounds like phenols, flavonoids and betalains that give the beetroot a characteristic colour. The present study was conducted to develop preserved functional foods from fresh beetroot and analyze sensory attributes, physico-chemical properties, nutritional parameters, bioactive compounds, antioxidant activity and color values. Total soluble solids and acidity contents of raw beetroot, beetroot jam and candy was found to be 10.72° Brix and 0.06 %, 69.03 °Brix and 0.72 % and 69.43° Brix and 0.12 %, respectively. The TSS content of jam and candy was found to be 55.77±0.09 and 66.50±0.19, respectively. Total phenols, flavonoids, betalains and antioxidant activity of jam and candy were found to be 82.58 and 98.94 mg GAE/100g, 47.85 and 45.51 mg QE/100 g, 267.73 and 357 mg/100g and 35.43 and 42.13 %, respectively. The L* value indicating the lightness of a product decreased for beetroot jam as opposed to L* value of beetroot candy, which increased compared to raw beetroot. The a* value revealing the redness of jam increased whereas redness of candy decreased compared to raw beetroot. The present study indicated that; beetroot could be used for the preparation of jam and candy with good sensorial quality, which has a high market potential.

Keywords: Antioxidant activity, Beetroot, Betalains, Flavonoids, Jam, Jelly, Phenols, Sensorial qualities

INTRODUCTION

Nowadays, there is considerable demand for fresh fruits and vegetables and their products because of the high level of biologically accessible phytonutrients and several other health-promoting components. The natural components possess anti-carcinogenic and other beneficial properties, so they are referred to as chemo preventives. They have been reported as vital sources for a wide array of phytochemicals that may benefit health individually or in combination. Therefore, fruits and vegetables have been conferred the status of ‘‘functional foods’’. Nevertheless, these commodities are seasonal and perishable due to a limited shelf life, so they must be processed to maintain quality attributes (Scibisz and Mitek, 2009).

The high moisture content of fruits and vegetables is a major factor in limiting their shelf life; therefore; the use of simple and inexpensive techniques like preservation can be used as an efficient tool to overcome this problem. Jam processing is considered one of the most common preservation methods for fruits. It is usually produced as a result of cooking fruits with sugar and other ingredients such as pectin, and citric acid. Similarly osmotic dehydration is such a technique of food processing and preservation where fruits and vegetable tissues are immersed in hypertonic solution containing concentrated sugar or salt. The fruit or vegetable cell membrane acts as a semi-permeable membrane that allows water to move from lower concentration to higher concentration i.e. candy preparation. The food industries commonly use these preservation methods and several studies have been conducted to study the effect of processing on the nutritional parameter of fruits (Tanwar *et al*., 2014).

During the last few years, the traditional jam market has been stable due to changes in consumption practices and the presence of alternative or new products in the market. Therefore, the jam industry needs to develop new products, such as vegetable jams to improve its competitiveness.

Beetroot, which is scientifically known as *Beta vulgaris* L. belongs to the Chenopodiaceae family and is well known for its antioxidant properties as well as nutritional benefits. Beetroot contains a high level of biologically accessible phytonutrients and several other health- promoting components such as anthocyanins, carotenoids, minerals like sodium, potassium, magnesium, calcium, phosphorus, zinc, and iron and fibre (Tiwari and Singh, 2019). Beetroot is rich in bioactive compounds like phenols, flavonoids, carotenoids and Betalains. Betalains are the water- soluble nitrogenous pigments that impart characteristic color to beetroot and add to its antioxidant potential. Despite its appreciable nutritional value, consumption of beetroot is not as much as other root crops. It does not find much consumer acceptance as a vegetable because of its earthy flavor due to compounds present in it called “pyrazine” and “geosmin”. Moreover, beetroot is consumed mostly as salad or juice. Keeping this in view, the aim of the present study was to develop beetroot jam and candy to improve the palatability of beetroot and analyze physico-chemical, nutritional, functional properties and color values of the developed products.

MATERIALS AND METHODS

Raw materials

Medium size, healthy and sound beetroot free from bruises and all the other required ingredients such as sugar, pectin, citric acid were procured from local market of Ludhiana, Punjab, India.

Sample processing and preparation of jam and candy

Jam

Beetroots free from defects were selected and washed under running tap water in order to render them free from any dirt or foreign materials and soil particles. Beetroots were then peeled and cut into pieces using a stainless steel knife. One kilogram of beetroots was homogenized using a Wonderchef blender to obtain the fine and homogenous beetroot pulp. The pulp was divided into 2 parts of 500 g each. Jam developed by using 1:1.5 ratio of beetroot pulp and sugar was coded as T1 and the one developed by using beetroot pulp and sugar in the ratio 1:1 was coded as T2. The pulp thus obtained was boiled in a stainless steel utensil prior to adding pectin (2% of pulp), sugar, and citric acid (2%). The mixture was stirred until pectin and sugar got dissolved. The mixture was boiled until desired Brix (69°Brix) was reached using a hand refractometer. Then the heat was turned off and the mixture was hot-filled into a sterilized glass container and allowed to cool at room temperature 28°C.

Candy

The selected whole beetroots with peel washed under running water were subjected to steam blanching for 8 minutes in a double vessel container. The stream blanched beetroots were kept refrigerated for cooling. Blanching was done with the method described by Ranganna (2007). Sugar syrup was prepared by boiling water and sugar together until syrup strength reached. Citric acid was added at the rate of 2 per cent of beetroot. Beetroot was then peeled and cut into evenly shaped cubes. Beetroot (500 g), sugar (500 g) and water (250 ml) were used in the ratio of 1:1: 0.5. The beetroot cubes were pricked with a fork and placed in the syrup and kept overnight. The next day syrup strength was increased and cubes were boiled in the sugar syrup. The process was repeated until desired syrup strength of 69° Brix was obtained. The syrup was then drained and the beetroot cubes were dried at 50°C for 6 hours. Dried candy was then stored in an air-tight glass container.

Determination of total soluble solids (TSS)

TSS content of raw beetroot as well as the products was determined by using a hand refractometer. The observations were expressed as ºBrix at 20º C.

Determination of titrable acidity

The titrable acidity was determined by titrating a known quantity of sample solution against standard 0.1 N NaOH solution to a faint pink colour in the presence of phenolphthalein indicator (Ranganna, 2007). One gram of sample was taken for estimation. Volume was made up to 100 ml with distilled water and filtered through Whatman filter paper no. 4. Ten ml aliquot was taken and after adding 1-2 drops of phenolphthalein indicator, it was titrated against 0.1 N NaOH to faint pink end point. The acidity was expressed was expressed as citric acid (equivalent weight-64) in terms of per cent.

Titrable Acidity (%) (as citric acid) =

$$\frac{\text{Titre value} \times 64 \times \text{Normality of NaOH} \times \text{Volume made up}}{\text{Weight of sample} \times \text{Volume of aliquot} \times 1000} \quad \text{Eq. 1}$$

Proximate analysis

Raw beetroot, beetroot jam and beetroot candy was analyzed for proximate composition (moisture, protein, fat, ash, carbohydrates and energy) using standard methods described by AOAC (2010).

Minerals

The mineral calcium, phosphorus, sodium, potassium, magnesium, iron and zinc were estimated using atomic absorption spectrophotometer (AAS, Varian model) after wet digestion (Piper, 1950).

Sugars estimation

Ethanol solution (80%) was used for the extraction of sugars. Protocol given by Dubois *et al*. (1956) was used for the estimation of total sugars. For the estimation of total sugars, sugar extract (0.2 ml) was added to distilled water (0.8 ml) and 5% phenol (1.0 ml) prior to the addition of 5.0 ml of concentrated sulphuric acid. Tubes were brought to room temperature by keeping them under running water. After 20 minutes, absorbance at 490 nm was read against the reagent blank. For estimation of reducing sugars, sugar extract (0.2 ml) was added with distilled water (0.8 ml) and alkaline copper tartrate (0.5 ml). The above made solution was heated for 10 minutes. Then all the tubes were cooled at room temperature and 0.5 ml of arsenomolybdic reagent was added to it. In the solution, 7.0 ml of water was added to make the final volume of 10 ml. The absorbance was read at 510 nm after 10 minutes. Results were expressed as mg glucose/100g (Somogyi, 1952).

Extraction of bioactive compounds

Phenols and flavonoids

One gram of sample was taken in a conical flask, to which 80% methanol was added for extraction in an orbital shaker at room temperature for two hours. The residue from the first extraction was then again extracted for one hour. Whatman no.1 filter paper was used for the filtration of the extract. Further volume was made to 100 ml using 80% methanol. The extract was then stored in a volumetric flask at a temperature of 20ºC for the determination of flavonoids and phenols.

Total phenols

The total phenolic content of the samples was obtained using protocol described by Singleton *et al*. (1999). 0.5 ml of the sample extract was taken in a test tube containing 5 ml Folin-Ciocalteau reagent and 0.5 ml 80% methanol. Five minutes later, 4 ml of 7.5% sodium carbonate was added and the mixture was agitated. Two hours after the incubation at 37 ºC, the absorbance color developed was measured at 765 nm using a UV-spectrophotometer against a blank.

Total flavonoids

The total flavonoid content in the samples was determined using the Aluminium chloride colorimetric method given by Zhishen *et al*. (1999). Sample extract (2ml) was mixed with 100µl of 10% $AlCl_3$, 100µl of 1 mol per litre potassium acetate and 2.8 ml water and were allowed to incubate for 30 minutes at room temperature. The absorbance of color developed was read at 415 nm using UV- spectrophotometer against a blank.

Anthocyanin

One gram of the crushed sample was placed inside a beaker with10 ml of 1% HCl (v/v) and kept overnight at 4ºC for the anthocyanin extraction. The absorbance of the extract obtained after filtration was read at 530 nm. The anthocyanin content was calculated by using the following formula (Rangana, 1977)

$$\text{Total OD/ 100 g} = \frac{\text{OD} \times \text{Vol. make up}}{\text{Weight of sample}} \times 100 \qquad \text{Eq. 2}$$

$$\text{Total anthocyanin (mg/100 g)} = \frac{\text{Total OD / 100 g}}{98.2} \qquad \text{Eq. 3}$$

Total carotenoids

The total carotenoids were estimated by using the method given by Ranganna (2007). A 5g of sample was extracted with 50ml acetone in a pestle and mortar using sodium sulphate until the residue was colorless. This extract was then transferred to a separatory funnel and 15 ml of petroleum ether was added. Pigments were transferred to the petroleum ether phase by diluting the acetone with 15ml of distilled water. Extraction of acetone phase with small volume of petroleum ether was repeated till colorless. Petroleum ether extract was filtered and transferred to 25 ml volumetric flask and the volume was made up to the mark (25 ml) with petroleum ether. The total carotenoids were estimated by measuring the O.D of the extract at 450 nm using petroleum ether as blank.

Carotenoid content was calculated using the following formula:

$$\text{Carotenoids content (µg/g)} = \frac{A \times V\,(\text{ml}) \times 10^4}{A1^{\%}{}_{cm} \times P\,(g)} \qquad \text{Eq. 4}$$

Where,

A = Absorbance

V = Total extract volume

P = Sample weight

$A^{1\%}{}_{cm}$ = 2592 (β-carotene Extinction Coefficient in petroleum ether)

Antioxidant activity

DPPH method described by Brand-William *et al*. (1995) was used to determine antioxidant activity of the samples. For the preparation of the DPPH solution, 15.77 mg of DPPH was dissolved in 200 mL of methanol and was stored at −20 °C until use. For sample analysis, sample extract (0.1 ml) was mixed with 2.9 ml of DPPH solution and vortexed for 30 seconds, followed by incubation at 37 º C. After 30 minutes, the absorbance of the sample was recorded at a wavelength of 517 nm. No sample extract was added to the DPPH solution and was considered as control sample. The scavenging activity was determined using the following formula:

DPPH radical−scavenging activity % = (A control - A sample) / A control × 100 Eq. 5
Where A is the absorbance at 517 nm

Betalains

Betalain content was estimated by the Spectrophotometric method described by Bucur *et al*. (2016). Five grams of the sample were weighed in a beaker and stirred for 10 minutes in 15 ml of distilled water followed by filtration into a 50 ml volumetric flask. This extraction was repeated 3 times and the stock solution was made up to 50 ml volume. Absorption was read at 25ºC ± 1 using solutions prepared from stock solution by dilution (1:2) with distilled water. Betalain content was calculated using the following equation.

Betacyanins/ Betaxanthins (mg/g) = $(A \times DF \times M_W \times V_d) / (\varepsilon \times L \times W)$ Eq. 6

where,
A= Absorption value
D= Dilution factor
V_d= Sample solution volume (ml)
L= Path length (1cm) of the cuvette
W= Weight of the sample (g)
Betacyanins (MW = 550 g/mol, ε = 60000L/ (mol*cm)
Betaxanthins (MW=308/mol, ε = 48000L/ (Mol*cm)

Color analysis

The color characteristics of raw beetroot, beetroot jam and candy was measured using Hunter lab colorimeter. Calibration of the instrument was done with standard black and white ceramic tile before taking the measurements. Values of L*, a* and b* were measured where L* indicates lightness read from 0 (opaque or black) to 100 (transparent or white), a positive a* denotes redness while a negative indicates greenness and a positive b* specifies yellowness whereas a negative b shows blueness of the sample. The data were evaluated based on L* a* b* values.

Sensory evaluation

Beetroot is an ideal vegetable for the development of jam because of its natural reddish-purple color. The sensory evaluation was assessed by using a 9-point hedonic scale (Amerine *et al*.,1965) with scores ranging from "extremely dislike-1" to "extreme like-9" by a semi-trained panel of 10 judges from the Department of Food and Nutrition and Department of Food Science and Technology, Punjab Agricultural, Ludhiana. Jam and candy were evaluated based on their appearance, color, texture, flavor, taste and overall acceptability.

Statistical analysis

For the analysis of data, SPSS software (version 23.0) was used. Mean values and standard error for different parameters were calculated. The significant difference between the sensory evaluation scores of jam was evaluated using Maan-Whitney U-test for comparison between two experimental samples. Independent sample t-test was used to compare the nutritional parameters between fresh beetroot and beetroot jam and candy.

RESULTS AND DISCUSSION

Physico-chemical properties

The effect of processing on the physico-chemical attributes of raw beetroot is presented in Table 1. Sensory attributes like taste, flavor and sweetness are directly influenced by the total sugar content and titrable acidity. TSS of jam and candy was found to be 69.03 and 69.43°Brix. Acidity value of jam is because of the organic acids present naturally. The acidity of fresh beetroot and jam was found to be 0.06 and 0.12 per cent, respectively. The acidity of jam and candy was significantly ($p<0.01$) higher than the acidity content of fresh beetroot as the addition of citric acid in jam contributed to the higher acidity observed. The increase in acidity may be due to acid formation, degradation of polysaccharides and oxidation of reducing sugars or by break down of pectin in to pectenic acid (Kanwal *et al*., 2017). Change in pH is directly related to changes in the acidity of samples. Similar values were reported for beetroot jam by Dobhal and Awasthi, (2019) with pH, TSS and titrable acidity of 4.96, 75 and 0.56, respectively.

Color values in Table 1 indicated that processing of raw beetroot to jam resulted in decreased L* value, i.e. 19.54, which means darker color as compared to raw beetroot whereas an increase in the L* value of beetroot candy (24.62) inferred that its color was lighter as compared to raw beetroot. Similarly, a* value (redness) of raw beetroot increased from 10.16 to 13.14 for beetroot jam and a* value decreased from 10.16 to 8.43 in beetroot candy. This was due to the leaching of water-soluble betalains into the sugar syrup which was drained prior to drying. The negative b* value indicating the blueness was found to be -1.61, -14.11 and -13.92 for raw beetroot, beetroot jam and beetroot candy, respectively.

Nutritional composition

The data presented in Table 2 illustrates the comparison between the raw beetroot and processed products like jam and candy developed from beetroot. The results revealed that the raw beetroot had significantly higher moisture, crude protein, crude fibre and total ash than the values obtained by jam and candy. In comparison, a non-significant decrease was observed for fat content in jam and candy in comparison to the raw beetroot. The significant decrease in the above mentioned parameters in the prepared jam and candy was due to the dilution of nutrients as only 50 per cent of beetroot is used for the development of jam and candy, remaining sugar contributes rest 50 per cent. Rickman *et al*. (2007) observed that fibre is lost during separation steps like peeling, filtration and during processing due to changes in moisture content. In addition, heating (thermal processing) leads to protein degradation and results in the formation of some other components. Aina *et al*. (2015) also observed that pineapple processing to jam leads to a decrease in the protein content. Carbohydrates and energy content of jam (53.72 % and 222.60 Kcal/100g) and candy (80.47 % and 327.72 Kcal/100g) significantly increased as compared to raw beetroot (7.15 % and 53.72 Kcal/100g). Baniwal and Hathan, (2015) also reported a decrease in dietary fibre in the sand pear candy as compared to the raw fruit. This might be attributed to the loss of soluble fibres which come out in the syrup during the candy making process. The increase in the carbohydrate content of jam and candy was attributed to the addition of sugar during the processing.

The results revealed that the mineral content significantly decreased when raw beetroot was subjected to processing for the development of jam and candy. Calcium, phosphorus, sodium, potassium, magnesium, iron and zinc content of raw beetroot decreased. Highest loss in beetroot jam was observed in iron content followed by calcium content. Similar results were reported by Tanwar *et al*. (2014) where the iron content of guava jam and guava nectar decreased significantly compared with the guava pulp due to the addition of sugar to the fruit pulp the processing of guava jam and guava nectar. Heating of tissues at temperatures 60 to 70°C causes disruption of membranes and decompartmentation of the cell constituents. Heat-induced firming is believed to start with damage to cell membranes that causes an increase in impermeability. This leads to the liberation of Ca^{2+} and its diffusion to the cell formation of Ca^{2+} and Mg^{2+} ionic cross-linkages between carboxyl groups of pectin (Tanwar *et al*., 2014). On the other hand, Bethke and Jansky (2008) observed that cubing, boiling and leaching resulted in a significant reduction in potatoes' phosphorus, magnesium, zinc, and iron content. The results for the reduction in mineral content of beetroot candy may also be explained by these processes followed for the development of candy.

The total sugar content of jam developed by beetroot was found to be 55.77 per cent which was significantly higher than raw beetroot (8.55 %). During processing, the added sugar, resulted in the increased sugar content seen in the beetroot jam. Sutwal *et al*. (2019) developed jam using stevia and observed sugar content of control jam and jam developed from stevia was 62.03 and 15.06 per cent respectively. Beetroot jam was found to have 14.49 percent reducing and 41.28 percent non-reducing sugar in contrast to 5.48 and 3.06 per cent reducing and non reducing sugars present in raw beetroot. This difference was expected as sugar concentration of beetroot is low and the addition of sugar will definitely result in an increased sugar content. The increase in non-reducing sugars as well as total sugars corresponded to the increase in total soluble solids (TSS) and a decrease in reducing sugars. The increased level of total sugars was probably due to the conversion of starch and pectin into simple sugars (Mahato *et al*., 2020). In a study conducted by Guiné *et al*. (2016), jam was developed by using apple as a base and enriched with beetroot extract obtained by boiling beetroot into water containing 31.9 % sucrose. Likewise, sugar content of candy was also significantly ($p<0.01$) higher than the raw beetroot. The total sugar content of beetroot candy was found to be 66.50 per cent in comparison to the raw beetroot with 8.55 % sugar. Reducing and non-reducing sugar in beetroot candy was found to be 15.74 and 50.75 per cent, respectively. The value of total sugar in beetroot jam was found to be more than 6 times and in beetroot candy was found to be more than 7 times higher than the raw beetroot. Dobhal and Awasthi, (2019) reported 48.11 per cent total sugars, 28.74 reducing and 19.36 per cent non-reducing sugars in candy developed from beetroot. The variation in sugar content was observed due to the absorption of sugars during osmosis. The higher reducing sugar content in both jam and candy was attributed to the addition of sugar which is simple sucrose sugar.

Bioactive compounds and antioxidant activity

Total phenols content in beetroot jam (82.58 mg GAE/100 g) was found to be 6 % higher as compared to raw beetroot (77.88 mg GAE/100 g) as shown in Fig. 1. Heating has been described as enhancing the release of bound compounds, leading to a higher content after processing when compared to raw beetroot. The increase might be due to the concentration of food matrix upon jam processing and disruption of cell walls resulting in the better extraction of the phenolic compounds. Kim and Padilla-Zakour, (2006) reported that raspberry had similar total phenolics after processing into jams indicating no considerable changes in concentration. Another reason for this increase might be related to the gradual release of ellagic acid due to the heating process, through ellagic tannins and the formation of amino reductones by the Maillard reaction. Similarly, flavonoid content in beetroot jam (47.85 mg QE/100 g) was higher as compared to raw beetroot (42.75 mg QE/100 g). The antioxidant activity of beetroot might be attributed to the bioactive components present in beetroot. Though a significant increase in total phenols and flavonoids was observed, overall the total antioxidant potential was affected due to the reduction of other bioactive components. The antioxidant

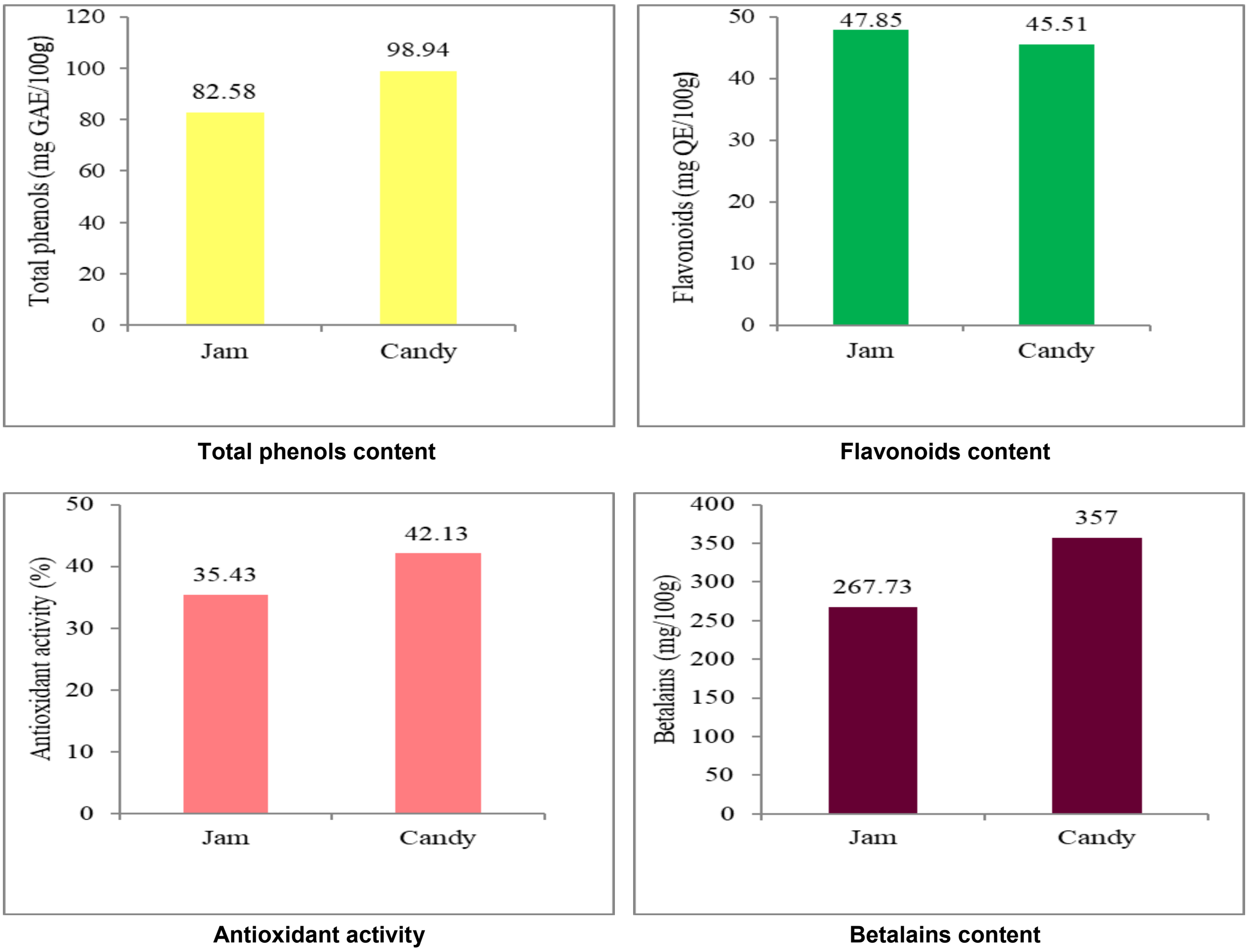

Fig. 1. *Total phenols, flavonoids, antioxidant activity and betalains content of jam and candy developed by utilizing raw beetroot*

activity of beetroot jam was found to be 35.43 per cent instead of raw beetroot, which showed antioxidant activity of 47.69 per cent. Kanabur and Daisy (2019) reported that beetroot jams provide an easier way of increasing antioxidant intake in daily life as beetroot jams are rich in antioxidants compared to regular jams. Lee *et al*. (2013) observed 92.3, 98.0 and 93.4 per cent retention of total phenols, total flavonoids and antioxidant activity of jam developed using miquel berry.

The total phenols content of beetroot candy (98.94 mg GAE/100 g) was increased significantly by 21.27 per cent as compared to raw beetroot (77.89 mg GAE/100 g). Flavonoids content of beetroot candy (45.51 mg QE/100 g) increased by 6.4 per cent as compared to that of raw beetroot (42.75 mg QE/100 g). Que *et al*. (2008) reported the formation of phenolic substances

Table 1. Effect of processing on physicochemical characteristics and color values of jam and candy

Parameter	Raw Beetroot	Beetroot Jam	t-value	Raw Beetroot	Beetroot Candy	t-value
TSS (°Brix)	10.72±0.65	69.03±0.16	138.81**	10.72±0.65	69.43±0.08	149.00**
Acidity (%)	0.06±0.01	0.72±0.05	78.08**	0.06±0.01	0.12±0.04	10.28**
L*	23.10±0.11	19.54±0.08	28.62**	23.10±0.11	21.62±0.15	10.53**
a*	10.16±0.07	13.14±0.27	18.26**	10.16±0.07	11.43±0.16	16.75**
b*	-1.61±0.01	-14.11±0.12	177.72**	-1.61±0.01	-13.92±0.33	64.46**

Values are expressed as Mean ± SE; ** Significant at 1% level of significance ($p<0.01$); Beetroot jam- 50 percent pulp and 50 percent sugar; Beetroot candy- 50 percent raw beetroot and 50 percent sugar during drying process at 70°C, mentioning that the formation of phenolic compounds might be due to the availability of precursors of phenolics by non-enzymatic inter-conversion between phenolic molecules; which could explain the increase recorded for candy. Similarly, Martínez *et al*. (2016) reported an increment of 22.5 per cent and 34.1 per cent in total phenols and total flavonoids when lime waste was dried compared to those of raw lime waste. The antioxidant activity also decreased from 47.69 to 41.41 per cent when beetroot was processed into candy. Muzzaffar *et al*. (2016) reported total phenolic content and antioxidant activity of pumpkin candy was found to be 40.11 mg GAE/300µL and 34.10 per cent, respectively.

Anthocyanins, a class of polyphenols have garnered recent interest from researchers because of their potential preventative and/or therapeutic effects on human health. The data presented in Table 2 indicated that the anthocyanin content of beetroot jam (7.86 mg/100 g) and candy (17.36 mg/100g) significantly ($p<0.0$) decreased as compared to raw beetroot (19.58 mg/100 g). The results for anthocyanins loss in a jam were affirmed by Kim and Padilla-Zakour (2006), who studied that anthocyanins in cherry, plum and raspberry significantly decreased when processed into jam. Anthocyanins degradation was due to heat treatment during processing. It was found that there was a 2.5- fold decrease in the anthocyanin content of jam developed from beetroot. With respect to candy, anthocyanins being water- soluble pigments would have lost as they tend to leach in sugar syrup during osmosis. Anthocyanins content of beetroot candy decreased by 12.78 % compared to the raw beetroot. A similar trend was followed by carotenoids where beetroot jam (0.14 mg/100 g) and candy (0.19 mg/100 g) contained significantly ($p<0.01$) lower carotenoids content in comparison to the raw beetroot (0.19 mg/100 g). There was nearly 26 and 19 per cent decline in the carotenoids content when raw beetroot was processed into jam and candy, respectively. The carotenoid's instability is mainly due to its oxidative degradation (Melendez-Martinez *et al*., 2004). In this sense, factors such as grinding, thermal treatments, light, oxygen exposition or pH can provoke important changes in these compounds. Thermal treatment can reduce carotenoids inducing structural changes in carotenoids, mainly isomerization, altering their solubility and consequently their micellarization. Carotenoids are susceptible to oxidation and can be lost during cooking by leaching into the cooking liquid. Raw beetroot contained significantly ($p<0.01$) higher betalains (676.46 mg/100 g) as opposed to beetroot jam (267.73 mg/100 g). Betacyanin content of raw beetroot was 404.25 mg/100 g whereas betaxanthin content was observed to be 273.09 mg/100 g which was found

Table 2. Effect of processing on nutritional composition of jam and candy

Parameter	Raw Beetroot	Beetroot Jam	t-value	Raw Beetroot	Beetroot Candy	t-value
Proximate (%)						
Moisture	87.48±0.08	42.90±0.82	54.04**	87.48±0.08	16.32±0.06	689.00**
Protein	2.06±0.26	1.71±0.01	11.93**	2.06±0.26	1.14±0.01	36.94*
Fat	0.33±0.08	0.09±0.00	2.70^{NS}	0.33±0.08	0.13±0.34	2.21^{NS}
Crude fibre	1.15±0.06	0.47±0.01	10.98*	1.15±0.06	0.67±0.01	7.56**
Total Ash	1.82±0.02	0.59±0.01	150.64**	1.82±0.02	1.24±0.01	29.66**
Carbohydrates	7.15±0.05	53.72±0.84	55.27**	7.15±0.05	80.47±0.07	758.03**
Energy (Kcal/100g)	39.86±0.53	222.60±3.21	56.04**	39.86±0.53	327.72±0.38	435.05**
Minerals (mg/100g)						
Calcium	18.24±1.05	10.26±0.06	7.57**	18.24±1.05	12.51±0.24	5.29**
Phosphorus	35.36±1.24	21.39±0.39	10.71**	35.36±1.24	29.19±0.32	4.80**
Sodium	76.85±0.39	44.79±0.54	47.76**	76.85±0.39	58.45±0.93	18.11**
Potassium	352.63±0.79	293.57±0.96	47.30**	352.63±0.79	303.96±1.09	35.91**
Magnesium	35.56±0.08	27.33±0.27	28.81**	35.56±0.08	23.12±0.40	30.22**
Iron	0.85±0.01	0.35±0.01	37.00**	0.85±0.01	0.59±0.01	15.92**
Zinc	0.34±0.01	0.21±0.01	11.25**	0.34±0.01	0.25±0.01	9.82**
Sugars (%)						
Total Sugars	8.55±0.08	55.77±0.09	359.85**	8.55±0.08	66.50±0.19	266.60**
Reducing sugars	5.48±0.21	14.49±0.13	35.65**	5.48±0.21	15.74±0.16	38.39**
Non-reducing sugars	3.06±0.29	41.28±0.04	129.39**	3.06±0.29	50.76±0.36	102.55**

Values are expressed as Mean ± SE ; ** Significant at 1% level of significance ($p<0.01$); Beetroot jam- 50 percent pulp and 50 percent sugar; Beetroot candy- 50 percent raw beetroot and 50 percent sugar to be higher than 267.73 mg/100 g and 165.56 and 102.17 mg/100 g of betacyanins and betaxanthins reported in beetroot jam. Betacyanins content represents the red pigment whereas betaxanthins symbolize the yellow hues. Hence the values observed signified that betacyanins were more than 1.5 times higher than the betaxanthins in the developed beetroot jam. Oksuz *et al*. (2015) observed that heat applied during the production of red beet jam betalains were converted into other forms such as betanidin and its degradation products like isobetanin, neobetanin and vulgaxanthin.

Beetroot candy contained 357.00, 233.93, 123.07 mg/100g of betalains, betacyanins and betaxanthins in contrast to value of 676.46, 404.25 and 273.09 mg/100 g obtained by raw beetroot. Betalains being hydrosoluble also leached out in the syrup and resulted in the significant decrease. Sawicki *et al*. (2019) also observed that processing applications like boiling, fermentation and microwave-vacuum treatment decreased the total betalain content in red beet products. Kumar *et al*. (2018) developed ginger candy using 12.07 % beetroot pomace extract and observed that betcyanins and betaxanthins content of the candy was 18.22 and 12.29 mg/kg. Despite of the significant losses beetroot jam and candy still contain good amounts of these bioactive compounds and pigments.

Sensory analysis

The calculated results from the sensory evaluation of beetroot jam are presented in Fig. 2. Results showed that there was a non-significant difference between all sensory attributes of beetroot jam with different pulp to sugar ratios. The higher scores of T2 for flavor and taste were due to a preference for moderate sugar in contrast to the more sugar present in T1. Overall acceptability of T2 was higher but no significant difference was found in their scores as both T1 and T2 were highly acceptable by all the panelists. Perumpuli *et al*. (2018) observed that jam with 60% beetroot pulp had higher scores for sensory evaluation followed by 50% and 55% beetroot pulp. The results of the present investigation for overall acceptability are in agreement

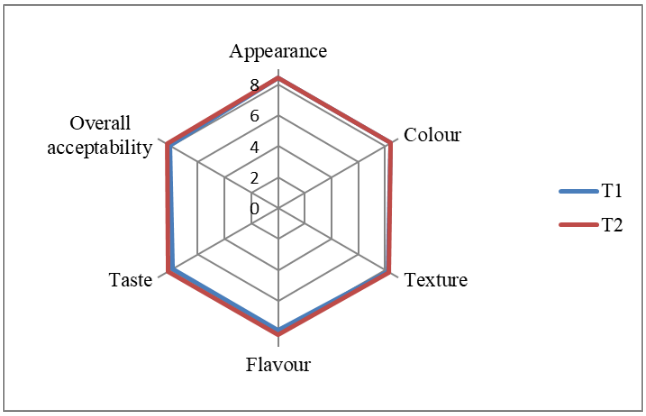

Fig. 2. *Sensory scores of jam developed from beetroot pulp (T1- 40 percent beetroot pulp and 60 percent sugar; T2- 50 percent beetroot pulp and 50 percent sugar)*

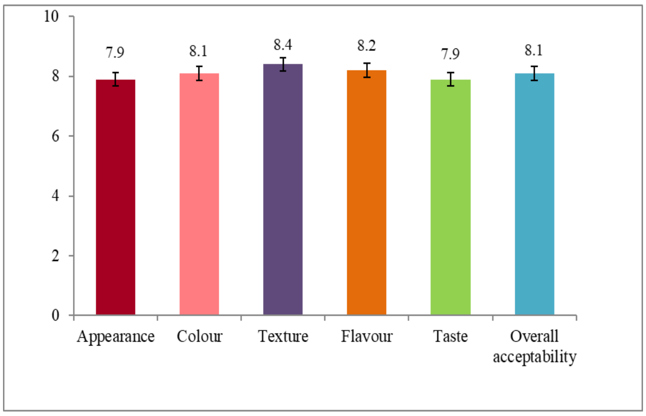

Fig. 3. *Sensory scores of candy developed from raw beetroot (Beetroot candy: 50 percent raw beetroot and 50 percent sugar)*

T1- 40 percent beetroot pulp and 60 percent sugar

T2- 50 percent beetroot pulp and 50 percent sugar

50 percent beetroot and 50 percent sugar

Jam

Candy

Fig. 4. *Jam and candy developed from beetroot*

with a study conducted by Bhople *et al*. (2016). They reported mean scores of 8.4 for overall acceptability for jam prepared with beetroot pulp.

Sensory scores of beetroot candy developed using beetroot and sugar in the ratio of 1:1 have been illustrated in Fig. 3. Mean scores of beetroot candy for appearance, color, texture, flavor, taste were 7.9, 8.1, 8.4, 8.2 and 8.1, respectively. Beetroot candy was highly acceptable by all the panelists. Dobhal and Awasthi, (2019) reported similar results where steam-blanched candy had overall acceptability of 8.1 out of a maximum score of 10 using score card method.

Conclusion

Beetroot is rich in many bioactive components especially betalains but its earthy flavour limits its consumption. In the present study, beetroot was processed into jam and candy as a result of which its palatability was enhanced by the processing. In sensory evaluation, both jam and candy were highly acceptable. Although TSS and acidity of jam and candy increased along with the bioactive compounds like total phenols and flavonoids but antioxidant activity and betalains decreased when fresh beetroot was processed to jam and candy. The redness of jam increased after processing whereas it decreased in candy. It was concluded that beetroot jam and candy could act as a promising tool that can be relished by people of all ages and enhance their antioxidant potential.

Conflict of interest

The authors declare that they have no conflict of interest.

REFERENCES

1. Aina, V.O., Ibrahim, M.B., Peter, M., Waziri-Adewumi, A.A. & Abdulsalami, M.S. (2015). Nutrient and anti-nutritional composition of jam prepared from pineapple ananas comosus. *Journal of Natural Sciences Research* 5 (2), 96-100.
2. Amerine, M.A., Pangborn, R.M. & Roessler, E.B. (1965). Laboratory studies: Quantity-Quality Evaluation in Principles of Sensory Evaluation of Foods Academic Press, New York, pp: 349-397.
3. AOAC. (2010). Official Methods of Analysis of AOAC International, 18th Ed. Washington DC, USA.
4. Baniwal, P. & Hathan, B.S. (2015). Process parameter optimization for the development of ready-to-eat instant sand pear candy using response surface methodology. *Journal of Food Processing and Preservation,* 39 (6), 3098-3109. https://doi.org/10.1111/jfpp.12575
5. Bethke, P.C. & Jansky, S.H. (2008). The effects of boiling and leaching on the content of potassium and other minerals in potatoes. *Journal of Food Science,* 73 (5), H80-H85.https://doi.org/10.1111/j.1750-3841.2008.00782.x
6. Bhople, S.G., Ingle, M.P. & Bornare, D.T. (2016). Studies on standardization of beetroot jam by using date paste and effect on organoleptic properties of jam during storage. *The Pharma Innova*tion *Journal*, 8 (9), 64-67.
7. Brand-Williams, W., Cuvelier, M.E. & Berset, C.L. (1995). Use of a free radical method to evaluate antioxidant activity. *LWT-Food Science Technology,* 28 (1), 25-30. https://doi.org/10.1016/S0023-6438(95)80008-5
8. Bucur, L., Taralunga, G.H. & Schroder, V. (2016). The betalains content and antioxidant capacity of red beet (Beta vulgaris L. subsp. vulgaris) root. *Farmacia*, 64 (2), 198-201.
9. Dobhal, A. & Awasthi, P. (2019). Formulation of beetroot candy using simple processing techniques and quality evaluation. *Journal of Pharmacognosy and Phytochemistry* 8 (4), 913-916.
10. Dubois, M., Gilles, K. A., Hamilton, J. K., Rebers, P. T. & Smith F (1956). Colorimetric method for determination of sugars and related substances. *Analytical Chemistry* 28 (3), 350-56. https://doi.org/10.1021/ac60111a017
11. Esparza-Martínez, F.J., Miranda-López, R. & Guzman-Maldonado, S.H. (2016). Effect of air-drying temperature on extractable and non-extractable phenolics and antioxidant capacity of lime wastes. *Industrial Crops and Products,* 84, 1-6. https://doi.org/10.1016/j.indcrop.2016.01.043
12. Guiné, R., Roque, A.R., Gonçalves, F. & Correia, P. (2016). Development of an innovative jam based on beetroot. *Journal of Food Science Research,* 1 (2), 49-53
13. Kanabur, V. & Daisy, D.M. (2019). Development and evaluation of a healthy jam. *International Journal of Engineering Science and Research,* 6 (1), 216-223.
14. Kanwal, N., Randhawa, M.A. & Iqbal, Z. (2017). Influence of processing methods and storage on physico-chemical and antioxidant properties of guava jam. *International Food Research Journal,* 24 (5), 2017-2020.
15. Kim, D. O. & Padilla-Zakour, O. I. (2004). Jam processing effect on phenolics and antioxidant capacity in anthocyanin-rich fruits: Cherry, plum, and raspberry. *Journal of Food Sci*ence 69 (9), 01-06. https://doi.org/10.1111/j.1365-2621.2004.tb09956.x
16. Kumar, V., Kushwaha, R., Goyal, A., Tanwar, B. & Kaur, J. (2018). Process optimization for the preparation of antioxidant rich ginger candy using beetroot pomace extract. *Food Chemistry*, 245,168-177. https://doi.org/10.1016/j.foodchem.2017.10.089

17. Lee, D.J., Lee, H., Lee, S.H., Lee, C.Y. & Kim, D.O. (2013). Effects of jam processing on anthocyanins and antioxidant capacities of Rubus coreanus Miquel berry. *Food Science and Biotechnology,* 22 (6), 1607-1612. https://doi.org/10.1007/s10068-013-0257-8
18. Mahato, A., Chakraborty, I. & Baidya, B.K. (2020). Preparation and evaluation of fruit candy from unripe mango. *International Journal of Chemical Studies,* 8 (1), 2727-2731. https://doi.org/10.22271/chemi.2020.v8.i1ao.8682
19. Martínez, F.J., Miranda-López, R. & Guzman-Maldonado, S.H. (2016). Effect of air-drying temperature on extractable and non-extractable phenolics and antioxidant capacity of lime wastes. *Industrial Crops and Products*, 84, 1-6. https://doi.org/10.1016/j.indcrop.2016.01.043
20. Melendez-Martinez, A.J., Vicario, I.M. & Heredia, F.J. (2004). Nutritional importance of carotenoid pigments. *Archivos Latinoamericanos de Nutricion,* 54 (2), 149–154.
21. Muzzaffar, S., Baba, W.N., Nazir, N., Masoodi, F.A., Bhat, M.M. & Bazaz, R. (2016). Effect of storage on physicochemical, microbial and antioxidant properties of pumpkin (Cucurbita moschata) candy. *Cogent Food & Agriculture*, 2 (1), 01-31. https://doi.org/10.1080/23311932.2016.1163650
22. Oksuz, T., Surek, E., Tacer-Caba, Z. & Nilufer-Erdil, D. (2015). Phenolic contents and antioxidant activities of persimmon and red beet jams produced by sucrose impregnation. *Food Science and Technology,* 3 (1), 1-8. DOI: 10.13189/fst.2015.030101
23. Perumpuli, P.A., Fernando, G.S.N., Kaumal, M.N., Arandara, M. & Silva, S.W.M. (2018). Development of Low Sugar Vegetable Jam from Beetroot (Beta *vulgaris* L.), Studies on Physicochemical Sensory and Nutritional Properties. *International Journal of Theoretical and Applied Sciences,* 10 (2), 22-27.
24. Piper, C.S. (1950). Soil and plant analysis. Pp.212. Scientific Publication Inc, New York.
25. Que, F., Mao, L., Fang, X. & Wu, T. (2008). Comparison of hot air-drying and freeze-drying on the physicochemical properties and antioxidant activities of pumpkin (*Cucurbita moschata Duch.)* flours. *International Journal of Food Science and Technology,* 43 (7), 1195-1201. https://doi.org/10.1111/j.1365-2621.2007.01590.x
26. Ranganna, S. (1997). Manual of analysis of fruits and vegetables product. Tata McGraw-Hill Pub Co. Ltd New Delhi, India.
27. Ranganna, S. (2007). Handbook of analysis and quality control for fruit and vegetable products. Tata McGraw Hill Pub Co. Ltd. New Delhi, India.
28. Rickman, J.C., Bruhn, C.M. & Barrett, D.M. (2007). Nutritional comparison of fresh, frozen, and canned fruits and vegetables II. Vitamin A and carotenoids, vitamin E, minerals and fiber. *Journal of the Science of Food and Agriculture,* 87 (7), 1185-1196. https://doi.org/10.1002/jsfa.2824
29. Sawicki, T., Martinez-Villaluenga, C., Frias, J., Wiczkowski, W., Peñas, E., Bączek, N. & Zieliński, H. (2019). The effect of processing and in vitro digestion on the betalain profile and ACE inhibition activity of red beetroot products. *Journal of Functional Foods,* 55, 229-237. https://doi.org/10.1016/j.jff.2019.01.053
30. Scibisz, I. & Mitek, M. (2009). Effect of processing and storage conditions on phenolic compounds and antioxidant capacity of high bush blueberry jams. *Polish Journal of Food and Nutrition Sciences,* 59 (1), 45–52.
31. Singleton, V.L., Orthofer, R. & Lamuela-Raventós, R.M. (1999). Analysis of total phenols and other oxidation substrates and antioxidants by means of folin-ciocalteu reagent. In: Methods in Enzymology (Vol. 299, pp. 152-178). Academic press. https://doi.org/10.1016/S0076-6879(99)99017-1
32. Somogyi, J. (1952). Note on sugar determination. *Journal of Biological Chemistry,* 195, 19-23.
33. Sutwal, R., Dhankhar, J., Kindu, P. & Mehla, R. (2019). Development of low calorie jam by replacement of sugar with natural sweetener stevia. *International Journal of Current Research and Review,* 11 (4), 09-16. DOI: http://dx.doi.org/10.31782/IJCRR.2019.11402
34. Tanwar, B., Andallu, B. & Chandel, S. (2014). Influence of processing on physicochemical and nutritional composition of Psidium Guajava L.(Guava) products. *International Journal of Agriculture and Food Science Technology*, 5 (2), 47-54.
35. Tiwari, V. & Singh, N. (2019). Organoleptic properties and the utilization of carrot and beetroot. *Journal of Pharmacognosy and Phytochemistry*, 8 (1), 1619-1621.
36. Zhishen, J., Mengcheng, T. & Jianming, W. (1999). The determination of flavonoid contents in mulberry and their scavenging effects on superoxide radicals. *Food Chemistry,* 64 (4), 555-559. https://doi.org/10.1016/S0308-8146(98)00102-2