Development and Quality Evaluation of Sugar Beet (*Beta vulgaris* L) Jam

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Abstract

Sugar beet jam prepared from different sucrose concentrations of 45%, 55% and 68% was evaluated for physico chemical, sensory and microbial profiles. All the jam samples portrayed non-significant ($p \leq 0.01$) results in pH and acidity (%) whereas significantly different results were recorded in reducing sugars, non-reducing sugars (%) and sugar acid ratio in jam samples. The jam prepared from 55% sucrose on the whole was extremely liked by panelists owing to attractive color with quit ideal taste and texture. Besides the jam has outstanding consistency due to possessing moderate concentration of solids and is significantly superior to both 45 and 68% sugar jam samples. 45% sucrose concentration has also produced a good quality jam in terms of color, taste, texture, spreadability and overall acceptability. It was quite superior to 68% but was significantly inferior to jam samples prepared from 55% sugar. Jam prepared by 68% sugar has not attained a conspicuous rank in the study as compared to 55 and 45% sugar jams perhaps owing to quite tough/rigid jell structure (texture) and limited flow behavior (spreadability). Moreover 68% concentration has produced the jam with darkest color. 45 and 55% jams being significantly low in sucrose contents as compared to conventional jam, may be utilized by a vast group of consumers. Since the correct sugar content in a food hydro colloids plays a critical role in appropriate gel formation, rheology and storage/shelf life, therefore jam developed from 55 % solids had shown superior physico-chemical and sensory attributes as compared to 45 and 68% jams. No fungal and yeast counts were observed in any treatment of the developed product.

***Keywords*:** Sugar Beet Jam; Sucrose Concentrations; Physico-chemical; Microbial and Sensory Evaluation

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Introduction

Sugar beet (*Beta vulgaris* L) is the world's second largest source of sugar after sugar cane (Podlaski et al., 2017). Owing to higher concentration of sucrose and reduced water requirements it has been successfully produced on a large scale producing almost 30% of the world's sugar needs (Iqbal & Saleem, 2015; Bairagi et al., 2013) and a significant portion of Europe's sugar supply (Maitah et al., 2016; Tarkalson et al., 2014). Its value-added counterparts not only be beneficial for the industrialists but can also provide better return for the farmers as well as wider variety/choice for the consumers especially in the utilization of food concentrates like jam, jelly and marmalades.

The jam industry is generally centered on the production of conventional fruit preserves. Beetroot is quite ideal for preparation of jam due to its natural brown color with considerable quantity of sugars (Renna et al., 2013). Besides beet juice is a rich source of many other health promoting compounds as potassium, magnesium, folic acid, iron, zinc, calcium, phosphorus, sodium, niacin, biotin, vitamin B6, and soluble fiber (Tanumihardjo et al., 2016). In this perspective it can play a vital role in improving the existing quality and acceptability of conventional jam. Moreover, due to ever increasing cases of diabetes patients, modern consumer is very diet conscious especially about the intake of sugars. In this scenario, products developed from reduced quantity of sugars can play an efficient role by changing their eating lifestyle.

Furthermore, the re-crystallization of sugars in the conventional jam is regarded as a severe flaw due to excessive amount of sugar (Javanmard & Endan, 2010). It is important to select an appropriate amount of sugar with a lower potential for re-crystallization as well as equally liked by consumers. If an acceptable jam is prepared with low/desired sugar concentration required for jam (minimum standard i.e. 45% sucrose) the industry can initiate the processing of these valuable commodities from beet. Besides, the product will attract a lot of consumers who are sugar conscious/sensitive in addition to reducing/saving its lavish use as well as its cost. Keeping in view the above-mentioned facts present research project was initiated to prepare sugar beet jam from various sugar concentrations and evaluate it for physico chemical, microbial and sensory qualities.

Methodology

Sampling

Five beet roots of commercial variety (Beta vulgaris *L*.) were collected (in triplicate) from farmer’s field in March 2021 and was taken to the Laboratory of the Institute of Food Science & Nutrition, Gomal University, Dera Ismail Khan for jam preparation & its quality appraisal.

Treatments

Roots were washed, peeled, and sliced into 1cm to 2cm thick pieces/cubes using steel knife. These cubes were blanched at 100°C for 10 min, pulped is a blender/ juicer and are separately boiled in a pressure cooker for 15 minutes. The beet pulp was placed into separate steel pans and cooked for 15 minutes while adding sugar, until final brix value reached 45, 55, 68% w/w for jam as procedure adopted by Perumpuli et al. 2018. Whereas pectin and citric acid were added @ 0.6% and 0.25 % respectively in all the samples. Jam samples were hot filled (85°C) and separately packaged in pre-sterilized glass jars.

Physico-chemical Analysis

Total Soluble Solids (TSS) and pH: Total soluble solids (TSS) were determined by using Abbe-refractometer as described by Chen & Chou (1993). About 2-3 drops of filtered jam solution was poured on refractometer prism. TSS reading was noted. The pH was determined with pH meter (SES model 128, England) as described by (Halat et al., 1997)**.** Five grams of jam were mixed with 95 ml distilled water and blended using a blender. About twenty-five ml sample was placed in a 100 ml beaker in triplicate for each treatment. pH meter was calibrated with 4 and 7 buffer solutions. Sample reading was noted after dipping the electrodes in sample. The experiment was repeated thrice for each treatment.

Titratable Acidity (%): 10 ml of the prepared solution was taken in a conical flask in triplicate and added with 100 ml of distilled water. Acidity (%) was determined by titrating flask contents against NaOH solution (0.1 N) using phenolphthalein solution and reported as the percent citric acid (Halat et al., 1997). Volume of NaOH solution used was noted for each sample till the appearance of pink color.

Acidity (%) = (0.1 × Eq.wt of acid × Normality of alkli × volume of alkli used)/10

Reducing Sugars (%): Reducing sugars (%) was determined using Lane and Eynon method as described by Chen & Chou (1993). 2% solution of jam was prepared for various jams samples by dissolving 10 g of jam sample in small quantity of water and transferring it to 500 ml volumetric flasks by distilled water. The prepared solutions were used for the estimation of pH, acidity, reducing and total reducing sugars. Prepared solution was placed in a burette. About five ml of Fehling A and 5 ml of Fehling B were taken in a conical flask. Flask contents were heated to boiling in undisturbed condition. 2 to 3 drops of methylene blue solution were added. Prepared solution was taken in a burette and drop wise and added into conical flask until brick red color appearance.

Non-Reducing Sugars (%): Non reducing sugars of the developed jam were determined as the difference of Total reducing sugars (%) and free reducing sugars using Lane and Eynon method as described by Chen & Chou (1993).

Non reducing sugars (%) = Total reducing sugars (%) – free reducing sugars (%) * 342/360

Sugar Acid Ratio: Total sugars (%) and acidity (%) of the prepared jam samples are compared. The ratio is a better indicator of acceptability than either sugar or acid alone.

Microbial Analysis

*Total Yeast and Moulds Counts***:** Total yeasts and moulds counts were determined as described by Anon (2001).

Sensory Evaluation: Sensory evaluations were carried out to select the best jam/sucrose concentration by using post graduate students (11 panelists) of Institute of Food Science & Nutrition. The taste, texture, spread-ability, color and overall acceptance on each jam sample were evaluated with nine-point hedonic scale as described by Halat et al. (1997). Three samples (approximately 20 g) were presented to panelists on 3 glass plates using plastic spoon. Panelists were instructed to randomly evaluate samples and clean their tongue with water between samples. All samples were evaluated by each panelist three times (replications).

Statistical Analysis

The recorded data of the observed quality parameters of jam samples prepared from different sucrose concentration i.e. 45%, 55%, and 68% (with three replications) were statistically analyzed using SPSS (version 16) Means were separated by using post Hoc Duncan test at 0.01 level of significance.

Results and Discussion

Physico-chemical Quality

The physico-chemical quality parameters like pH, titratable acidity (%), reducing sugars (%), non-reducing sugars (%), total sugars (%) and sugar acid ratio of the beet jam are given in Table 1.

pH

The pH of sugar beet jam samples prepared from varying concentrations of 45%, 55%, and 68% sugar were analyzed as given in

Table 1. which ranged from 3.26 to 3.44 for different jam samples. pH value of 3.44, 3.26 and 3.33 was recorded in sugar beet jam prepared with 45, 55 and 68% sugar respectively. Statistically similar results were observed in this quality parameter in the jam samples (Table 1). Similar results values were noted by Perumpuli et al. (2018) they prepared a low sugar vegetable jam from different concentration of beetroot pulp (50%, 55%, and 60%) reporting similar results with respect to pH. Similarly, Wruss et al. (2015) prepared sugar beet juice from different cultivars of sugar beet and evaluated its quality and reported similar composition.

Table 1: Physico-chemical parameters of the developed beet jam.

Quality parameters	T1 (45%)	T2 (55%)	T3 (68%)
pH	3.44	3.26	3.33
Titratable acidity (%)	0.69	0.69	0.75
Reducing sugars (%)	16.71c	15.46b	18.74a
Non reducing sugars (%)	28.13c	38.26b	45.36a
Total sugar (%)	44.84	53.72	64.10
Sugar acid ratio	64.98	85.1	85.46

Response of three replicates, different letters in a row indicate significant difference ($p \leq 0.01$).

Titratable Acidity (%)

Results regarding titratable acidity (%) of sugar beet jam are presented in (Table 1). Statistically titratable acidity (%) of 0.69 was recorded in jam prepared from 45 and 55% sugar while acidity (%) of 0.75 was found in jam prepared from 68% sugar. Statistically non-significant ($p \geq 0.01$) results were observed with respect to Titratable acidity of the jam samples (Table 1). Khan et al. (2017) reported similar results during development and quality evaluation of banana mushroom blended jam. These findings are supported by Shakir et al. (2008) during their work on physico-chemical analysis of apple and pear mixed fruit jam.

Reducing Sugars (%)

Statistical data regarding effect of sugar concentration on reducing sugar of beet jam is illustrated in Table 1. Recorded results showed that varying sugar concentration significantly affected reducing sugar (%) concentration of beet jam samples. The reducing sugar contents of the jam prepared from 45%, 55%, and 68% sugar ranges from 16.71% to 18.74% respectively. Highest reducing sugar content (18.74%) was observed in jam sample prepared with 65% sugar followed by jam sample prepared from 55% sugar (15.46%). Lowest reducing sugar contents of 16.71% were observed in jam sample prepared with 45% sugar. The varying yields of reducing sugars in the jam are probably added due to presence of reducing sugars from beet roots as well as inversion of sucrose contents during heating/ boiling process of the jam. Wruss et al. (2015) showed that reducing sugar increased from 15.46 to 18.74 % in sugar beet juice samples. These results are in line with Ruiz-Nieto et al. (1997) who observed an increase in glucose content in strawberry fruits during storage.

Non-Reducing Sugars (%)

Non reducing sugars (sucrose contents) of the developed beet root jam samples are shown in Table 1. The recorded data ranged 28.13 to 45.36 % non-reducing sugars in jam samples. Non reducing sugar (45.36%) was maximum in beet jam samples which were prepared from 68% sugar, closely followed by beet sample prepared from 55% sugar valuing (38.26%). Lowest non-reduction (28.13%) was recorded in samples prepared with 45% sugar (Table 1). Statistically significant ($p \leq 0.01$) results were observed in non-reducing sugars of jam samples. The results are in accordance with findings of Wruss et al. (2015).

Total Sugars (%)

Mixture of sugars, acids and other volatiles play a pivotal role in constituting food flavor. Sensory acceptance depends mainly on the sugars as well as organic acids and the balance between them. Moreover, sugars are simple ripening index of fruits and other sugar-based concentrates. Besides sugar have an established role in preservation of foods. Total sugars (%) of the developed jam samples are given in Table 1. Statistically significant ($p \leq 0.01$) results of 44.84, 53.72 and 62.10 % were recorded for total sugars (%) in prepared jam samples of 45, 55 and 68% sugar.

Sugar Acid Ratio

Sugar and acidity are widely used as natural food preservatives. These are the most important components of fruits and their products and constitute an essential element for their flavor. Both quality parameters are normally used as consumer’s satisfactory indicators in many food products. As compared to assessing either sugar or acid alone, the ratio is a better index of acceptability. Flavor quality of citrus fruits and their products is strongly correlated with acidity and sweetness (Renna et al., 2013). The sweetness and acidities in these products are usually examined by the quantity and type of sugars and allied organic acid content as well as their sugar-acid ratio. The ratio reveals the relative amounts of sugars and acids, which is considered an important indicator for the flavor quality (Jribi et al., 2021). The sugar acid ratio of 66.07, 86.95 and 82.76 were found in prepared beet jam of 45%, 55%, and 68% sugar, respectively (Table 1). Statistically non-significant ($p \leq 0.01$) results were observed with respect to sugar acid ratio of the developed jam samples (Table 1). Wruss et al. (2015) observed that sugar acid ratio decreased from 97.79 to 80 during sixty days of storage in sugar beet juice due to increase in acidity (%) during storage. Similar results in sugar acid ratio were also reported by Gorini et al. (1987).

Sensory Evaluation of the Developed Jam

The effect of different sugar concentration on sensory evaluation of sugar beet jam in terms of color, taste, texture, spreadability and overall acceptability were studied, and the results are given in Table 2, and are discussed below:

Table 2: ***Sensory evaluation parameters* of the developed beet jam.***

Treatments	Color	Taste	Texture	Spreadability	Overall acceptability
T1 (45%)	7.1 b	6.9 b	7.4 b	7.3 b	7.1 b
T2 (55%)	7.5 a	7.3 a	7.8 a	7.7 a	7.5 a
T3 (68%)	6.8 c	6.6 c	7.1 c	7 c	6.8 c

*Response of three replicates, different letters in a row indicate significant difference ($p \leq 0.01$).

Color

Significantly ($p \leq 0.01$) different results with respect to color were found in sugar beet jam prepared from different sugar concentration. T2 (55%) ranked highest for color score (7.5), followed by T1 (45 %) sugar with 7.10 score whereas minimum color score of 6.80 was assigned to T3 (68%) sugar. Table 2 shows the effect of different sugar concentration on color score of sugar beet jam. Jam prepared from 68% sugar samples perhaps obtained minimum score due to much darker color which could not get/attract/appeal judges' attention. The results are due to significant high concentration of sucrose as incorporated in 68% sugar which resulted in the darker color in these samples produced during caramelization of sucrose in boiling/cooking process. Similarly, 45% sugar samples gained minimum score due to very fade/light color. Whereas 55% sugar jam samples grabbed maximum score due to its ideal color formed due to optimum concentration of sucrose with pleasant color formed during browning.

Taste

Table 2 shows the effect of different sugar concentrations on taste score of sugar beet jam. Statistically significant ($p \leq 0.01$) results were recorded in this quality parameter. From the data it can be observed that highest taste score of 7.30 was noted in T2 (55%) sugar followed by 6.90 in T1 (45%) sugar while lowest mean score of 6.60 was found in T3 (68%)

sugar. Perhaps minimum taste score was obtained by Jam prepared from 65% sugar samples due to extremely sweet taste which could not get enough attention of judges which may be due to significantly high concentration of sucrose as incorporated in 68% sugar resulting excessively highest sweetness, similarly 45% sugar samples gained minimum score due to very low sucrose contents. Whereas 55% sugar jam samples grabbed maximum score owing to quite ideal taste formed due to optimum concentration of sucrose with pleasing taste. Different workers (Wruss et al., 2015; Renna et al., 2013; Halat et al., 1997) observed that the sensory properties of food gels were significantly affected by sucrose levels.

Texture

The texture score of 7.80, 7.40, and 7.10 were found in jam samples prepared from different sucrose concentration of 45, 55 and 68% sugar respectively. The minimum texture value of 7.10 was noted in T3 (68%) sugar whereas maximum texture score of 7.80 was recorded for T2 (55%) sugar. Statistically significant ($p \leq 0.01$) results in texture were observed among the developed jam samples (Table 2). Jam prepared from 68% sugar samples perhaps obtained minimum score due to excessively hard texture which might have resulted from significant ($p \leq 0.01$) high concentration of sucrose which could not get significant judges' attention. Owing to runny texture, lowest texture score was given by jam samples as incorporated by 45% sugar as a result of possessing very low sucrose contents. Whereas quite ideal texture was formed in jam developed from 55% sugar due to optimum concentration of sucrose extremely liked by all the judges. Sucrose concentration has left a marked influence on the textural and rheological modifications of the developed food hydrocolloids (Bhople et al., 2019; Halat et al., 1997).

Spreadability

The spread-ability results of beet jam prepared from different sugar concentration are shown in (Table 2). The spreadability values of 7.70, 7.30 and 7.0 were demonstrated for jam samples prepared from 45, 55 and 68%, respectively. The minimum spreadability score was noted to be 7.0 in T3 (68%) sugar while maximum spreadability score of 7.70 was shown in T2 (55%) sugar. The developed jam samples showed significantly different ($p \leq 0.01$) results in spreadability (Table 2).

Jam prepared from 68% sugar samples perhaps obtained minimum score due to excessively high viscosity/spreadability which might be resulted from significantly high concentration of sucrose which could not get significant judges' attention. Contrarily quite runny texture, lowest score was assigned to jam samples of 45% sugar incorporated with very low sucrose contents. Whereas quite ideal spread ability of the jam was observed in jam developed from 55% sugar possessing optimum concentration of sucrose extremely liked by all the judges. The presence of sucrose concentrations along with suitable thickening agents was studied by researchers all over the world (Bhople et al., 2019; Renna et al., 2013) for the development of a variety of jams with varying spreadability.

Overall Acceptability

The sugar beet jam prepared from 45% sugar showed overall acceptability value of 7.50 whereas, the jam prepared from 55% sugar showed overall acceptability value of 7.10. The overall acceptability of 6.80 was recorded in jam prepared from 68% sugar. Significantly different results ($p \leq 0.01$) were found with respect to overall acceptability in developed jam samples. On account of best performance with respect to color, taste, texture, appearance, spreadability and overall acceptability. The maximum overall acceptability values in 45% whereas, minimum over all acceptability values in 68%.

Sensory evaluation of the developed jam samples indicates strong, positive and significant correlation with each other among various sensory attributes. Taste has high positive correlation with texture, spread-ability and overall acceptability. Texture is also positively correlated with spreadability and overall acceptability. Similarly color of the jam samples is also positively correlated with other sensory parameters (Renna et al., 2013) as shown in Table 3.

Table 3: Pearson correlation coefficients between sensory quality attributes of sugar beet jam.

Trait	Color score	Taste score	Texture score	Spread-ability	Overall ability score
Color score	1	1.000**	1.000**	1.000**	1.000**
Taste score		1	1.000**	1.000**	1.000**
Texture score			1	1.000**	1.000**
Spreadability				1	1.000**
Overall ability score					1

** Correlation is significant at 0.01 level (2-tailed).

Microbial Quality

Microbial quality of the developed jam samples is shown in Table 4 above. Fresh samples of the developed jam revealed undetected quantity of moulds (cfu/g) and yeast counts (cfu/g) which shows the samples are quite safe for human consumption and, the developed product qualifies international quality standards.

***Table 4: Yeast* and mold counts* (cfu/g) in the developed jam samples*.**

Treatments	Yeast (cfu/g)	Moulds (cfu/g)
T1 (45%)	Undetected	Undetected
T2 (55%)	Undetected	Undetected
T3 (68%)	Undetected	Undetected

*Response of three replicates, different letters in a column indicate significant difference ($p \leq 0.01$).

Conclusion

The jam prepared from 55°Bx has outstanding consistency due to possessing moderate concentration of solids and is significantly superior to both 45 & 68% sugar jam samples. The concentration has resulted in a high-quality jam with a soft, uniform consistency, free of fruit bits, a vivid color, a strong taste, and a semi-jelled structure that is simple to spread. 45% sucrose concentration has also produced a good quality jam in terms of color, taste, texture, spreadability and overall acceptability. Jam was also liked by judges but was significantly inferior ($p \leq 0.01$)) to jam samples prepared from 55% sucrose. The prepared jam was runny as compared to 55% and 68% jams due to which it needs some incorporation of thickeners. Jam prepared by 68% sugar has not attained a conspicuous rank in the study as compared to 55 and 45% sugar jams perhaps owing to quite tough/rigid jell structure (texture) and limited flow behavior (spreadability). 45°Bx resulted in a runny mass while 68°Bx produced a stiff mass, and its higher sucrose may crystallize during storage and badly affect the texture of the final product. Jam prepared from 55% sucrose was extremely liked by consumers owing to its attractive color, desirable consistency and superior taste. No fungal & microbial colonies are found in all the prepared jam samples; therefore the prepared jam is quite wholesome for consumers.

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