Available online at www.iseec2012.com

I-SEEC 2012

Proceeding - Science and Engineering (2013) 12–18

Proceeding
Science and Engineering

www.iseec2012.com

Science and Engineering Symposium
4th International Science, Social Science, Engineering and Energy Conference 2012

Effect of sorbitol substitution on physical, chemical and sensory properties of low-sugar mango jam

P. Kerdsup[a,*] , P. Naknean[a]

[a]Faculty of Agricultural Product Innovation and Technology, Srinakharinwirot University, Bangkok, 10110, Thailand

Abstract

Jam is a popular foodstuff because of its appealing taste and long shelf life. However, the high sucrose content typical of most preserves causes health problems for frequent consumers and limits recommended intakes for diabetes patients. The objective of this research was to study the production of low sugar mango jam using sweetener. Sorbitol was substituted for sucrose at extents varying from 20 to 100% in normal mango jam. Since high methoxy pectin gel plays an important role in texture of jam, the physical, chemical and sensory properties of the modified products were investigated. Full replacement of sucrose by sorbitol created a product that showed the same acceptability in color and flavor as normal jam ($p>0.05$). Moreover, texture, spreadability and overall acceptance of the mango jam were improved following substitution of sucrose by sorbitol. No differences were detected in color but hardness was significantly decreased when substituted sucrose with sorbitol. The chemical properties (total moisture, Aw, total acidity and pH) of the original and low sugar jams were not changed much. The results indicated that total acidity and hardness of the sorbitol replaced jam were maintained during storage over 6 weeks at room temperature, during which time no detectable growth of bacteria and fungi was observed. It was suggested that sorbitol is a suitable sweetener for production of low-sugar mango jam.

Keywords: mango, jam, sorbitol

1. Introduction

Jam is a generic term for mixture, with an intermediate moisture level, prepared by boiling fruit pulp or puree with sugar (sucrose), acid, and gelling agent to a reasonably thick consistency, firm enough to hold the fruit tissues and sugar in position [1]. Sugar constitutes more than 40% of total weight and 80% of total solid in jam that is important for physical, chemical, and microbiological properties. Because of high sucrose content in jam, this product has high calorific value and is not suitable for the diabetes. Hyperglycemia is caused by an excessive amount of glucose in blood (more than 180 mg/dl) resulting from too little insulin, insulin resistance, or increased food intake. Nowadays the dietary awareness of consumers has led to the growth of health food industry thus

* Corresponding author. *E-mail address:* paramapornk@swu.ac.th

alternative jams containing artificial sweeteners should be available. Because high intensity sweeteners provide only sweetness combining agents such as maltodextrin and sugar alcohols can provide the functional properties of sugar in food [2].

The physical gel in fruit jam refers to the three-dimensional network of high methoxyl pectin (HMP) and sugar makes gelation of possible pectin. The gelling mechanism of HMP is by hydrophobic interaction and hydrogen bonds in acidic condition ($pH < 3.4$) and low water activity (typically about 55% sugar content) which makes it suitable to be used in fruit jam [3]. Thus, the change of sugar content will affect the texture of the jam. In some diets the energetic value of sucrose is considered an undesirable feature. Substitution of sucrose by other sweeteners will affect the jam’s characteristics. Hyvonen and Torma [4] reported that sorbitol and xylitol strawberry jams and many of the jams containing some percentage of xylitol kept either better than of as well as the conventional sucrose jam. However, during the xylitol-maltodextrin jams became crystallized and were unfit for sensory evaluation. Moreover, Bakr [5] suggested that it was possible to prepare acceptable, high nutritional and low energy apricot, guava and strawberry jams by combinations of sweeteners using xylitol, sorbitol and aspartame.

The variation of ingredients or their content normally leads to change in gel structure of the jam that is often perceived by consumers through mouthfeel [1]. Texture of the product always influences the mouthfeel that is the sensory experience derived from the sensation in mouth after ingestion of food material. The panelist judges the quality when the food produces a physical sensation, such as fresh, tender, soft, in the mouth [6]. Jam is a viscoelastic food material that exhibits both requirement between mechanical stability when storage and handling and instability when spreading over a bread. Thus a development of new product like a low sugar jam in which the sucrose concentration is low has to be produced by controlling the sensory and texture perception [7]. Sorbitol is used as low caloric sweetener in both liquid and solid forms. The sweetness of sorbitol is 60-70% that of sucrose and the available energy value is 3 kcal/g. It is often used in variety of low sugar food because using in approximate amount of sucrose is technically possible to prepare food products that have textural characteristics and taste similar to the traditional products [8].

Mango is highly popular fruit in Thailand. In the summer, amount of fresh mango is more than the market demand; thus, a lot of the mango must be rejected. This work was aimed to investigate the effect of sorbitol substitution on physical, chemical, and sensory properties of low calorie mango jam. The quality characteristics of the jam after storage were evaluated.

2. Material and Methods

2.1 Preparation of mango jam using sorbitol

Mango puree was produced using *Mangifera indica* Linn. The pH and total soluble solid of the puree was 3.7 and 13°Brix, respectively. Then the puree (500 g) was kept in each plastic bag and stored at -20°C.

For the mango jam manufacturing, the standard recipe of mango jam was modified from the traditional mango jam of Basu et al. (2010). The standard recipe contained 44% mango puree, 35% sucrose, 20% drinking water, and 1% pectin (high methoxy). The low sugar jam was prepared in duplicate using different sorbitol substitution of 6 levels; 0%, 20%, 40%, 60%, 80% and 100% of sucrose. All of the ingredients were placed into brass pan and stir continuously with medium heat. The total soluble solid (TSS) content was monitored during heating and the heat was stop when TSS reached 65 ± 1.0°Brix. The jam was quickly cooled down in an ice bath until the temperature dropped to 40°C then was poured into plastic bag and kept at 4°C until further use.

2.2 Storage assay

The best acceptable jam was remake in 3 batches and stored at room temperature (30°C) during 6 weeks. Samples were taken in duplicated physical and chemical analyses (hardness, pH and total acidity) were performed on 0, 2, 4 and 6 week of storage.

2.3 Physical measurements of mango jams

The color of sorbitol substituted mango jams were measured using a Minolta Color Analyses was performed by reflection on 2.5 mm thick sample placed over a white surface [9]. The results were expressed in the CIE L a b color space and were obtained using D65 standard illuminations (CIE 1931). Color determinations were made 3x10 times in each sample. The texture analysis was performed directly in the jar at the ambient temperature with a Texture analyser TA.XTplus (Stable Micro System, United Kingdom), using back extrusion procedure. On the basis of the preliminary work, the instrument working parameters were determined with the test mode compression, pretest speed at 1.0 mm/s, test speed at 1.0 mm/s, post-test speed at 10.0 mm/s, distance 10.0 mm, trigger force at 10.0 g and data acquisition rate at 200 pp. The data were analyzed using Texture expert Version 1.22 Software (Stable Micro System, United Kingdom) to measure the hardness in the samples. The measurements were done in triplicates.

2.4 Chemical measurements of mango jams

The pH was recorded on a Cyberscan pH meter (model 510, Singapore). Titratable acidity, moisture content and total soluble solid of final products were determined according to AOAC procedures [10].

2.5 Sensory Evaluation

The untrained panel consisted of 30 members of the faculty. The sensory evaluation was carried out one day after the sorbitol substituted jam manufacturing. The color, taste, texture, spreadability, and overall acceptability of the samples were evaluated following nine-point hedonic scale. In this context, nine meant extreme satisfaction and one meant extreme dissatisfaction. For determining outward appearance whole jams were presented and the panelists must be applied the jams on a piece of bread while test.

2.6 Microbiological analysis

Microbiological evaluation of the most acceptable mango jam stored at room temperature for 6 weeks and the sample was evaluated every week. The tests were performed for total viable counts, yeast and mold. The total counts were determined using pour plate method with plate count agar (PCA, Hymedia, India). Triplicate plates were prepared for each sample and incubated at 35°C for 48 hours. Yeast and mold were determined on potato dextrose agar (PDA, Hymedia, India). The triplicate plates were incubated at 30°C for 24 hours [11]. The results were reported in log colony forming unit per gram of sample (logCFU/g).

2.7 Statistical analysis

All sensory, physical and chemical data were analyzed using the one-way ANOVA with Duncan new multiple range test (SPSS software model 11.5, trail model). The significance level at $p \leq 0.05$ was used throughout the study.

3. Results and discussions

3.1 Effect of sorbitol substitution

The effect of using sorbitol instead of sugar in low sugar mango jam on chemical and physical properties of the product has shown in Table 1 and 2.

Table 1. Chemical properties of sorbitol substituted mango jam

Sorbitol (%)	Moisture content (%)	Water activity (A_w)	Total acidity (as citric acid, g/l)	pH
0 (control)	33.24^{a}	0.56^{ab}	7.04^{b}	3.71^{b}
20	28.68^{ab}	0.53^{c}	7.81^{a}	3.72^{b}
40	28.64^{ab}	0.54^{bc}	6.75^{b}	3.73^{ab}
60	26.53^{b}	0.53^{c}	6.91^{b}	3.73^{ab}
80	26.84^{b}	0.58^{a}	7.68^{a}	3.74^{a}
100	25.40^{b}	0.58^{a}	6.72^{b}	3.73^{ab}

Means in columns not followed by the same superscripts are significantly different *($p \leq 0.05$)*

Table 2. Physical properties of sorbitol substituted mango jam

Sorbitol (%)	Hardness (g)	Color		
		L	a	b
0 (control)	$150.45^{a} \pm 2.11$	51.90^{a}	2.14^{a}	5.86^{ab}
20	$142.66^{b} \pm 1.65$	51.15^{a}	2.37^{a}	7.19^{a}
40	$137.76^{c} \pm 2.41$	50.46^{a}	2.43^{a}	3.88^{c}
60	$125.33^{d} \pm 2.45$	49.94^{a}	2.30^{a}	6.11^{ab}
80	$113.48^{e} \pm 2.21$	50.90^{a}	3.24^{a}	4.40^{bc}
100	$102.78^{f} \pm 1.56$	50.94^{a}	3.98^{a}	4.72^{abc}

Means in columns not followed by the same superscripts are significantly different *($p \leq 0.05$)*

From Table 1, the substituted mango jam with sorbitol shows that total acidity and pH values are not significantly different compared to the standard recipe. Water activity (A_w) of low sugar mango jam in some treatments was significantly different from the control. However, the A_w values were between 0.53 and 0.58 that was in the range of microorganisms very hard to grow, which desired in jam. Replacement of sugar with sorbitol was lower the hardness of jam significantly and the 100% substituted showed the lowest hardness value (Table 2). The decrease in hardness as a result of hydrogen bonding patterns between sorbitol and water that can be achieved more than sucrose [12]. Therefore, number of hydrogen bonding with water was higher in sorbitol in jam. Number of junction zones formed by pectin was therefore less and the network formation by pectin was much weak in the jam prepared with sorbitol. Thus increased concentration of sorbitol results in less stable pectin network structure formation in the final product [7].

The color of the low sugar jam did not differ significantly in terms of lightness (L), and redness (a), but there was significant difference in the yellowness (b). These happened during the heating process because the standard of jam production preserves the total solid content not less than 62% and the low sugar mango jams were produced under the total solid control (65%) without time control. When the mango has been heated in the different period, carotenoid and carotenoid ester, the major coloring group of ripe mango, will not have to be changed in some pattern. The previous research indicated that canned mango fruit slices showed significantly different pattern with beta-carotene, the main carotenoid component (90%). Large differences in Hunter color values were observed between fresh and canned mango slices [13].

Table 3 shows the sensory score for the effect of sorbitol substitution on mango jam. The addition of sorbitol in the recipes did not affect on the color and taste of the final product changes compared to the normal jam. However, texture, spreadability and overall acceptability of the jam had changed significantly at $p<0.05$. It was found that the increased percentage of sorbitol resulted in more liking score of the product in term of texture, spreadability and overall acceptability and the 100% sorbitol substituted recipe also had the highest scores. The results were in agreement with Hyvonen and Torma [4] that reported the acceptability of low sugar strawberry jam using sorbitol and xylitol. However, Ragab [14] reported the use of saccharin and xylitol as sweetener for production of apricot jam. It was found that the use of the both sweeteners affected the lower score compared to the standard recipe but no differences in color was detected in the low sugar jam. Thus production of low sugar jam with different type of fruit and sweetener should be studied for the best product acceptability.

Table 3. Average sensory scores of sorbitol substituted mango jam

sorbitol (%)	colour	taste	texture	spreadability	Overall acceptability
0 (control)	6.05^{ab}	5.67^{a}	4.22^{c}	3.32^{c}	5.55^{b}
20	5.78^{b}	5.77^{a}	4.44^{c}	4.42^{b}	5.73^{b}
40	6.17^{a}	6.03^{a}	5.76^{b}	4.36^{b}	6.03^{a}
60	6.33^{a}	6.11^{a}	6.03^{a}	5.67^{a}	6.22^{a}
80	6.26^{a}	5.98^{a}	6.15^{a}	5.32^{a}	6.33^{a}
100	6.67^{a}	6.32^{a}	6.33^{a}	5.89^{a}	6.41^{a}

Means in columns not followed by the same superscripts are significantly different $(p \leq 0.05)$

The results indicated that the acceptability score of 100% sorbitol substituted mango jam was not different compared to that of the replaced by 80% and 60% sorbitol. However, due to the natural sugar has been found in the ripe mango, the 100% substituted product is better for the consumer health. Thus the 100% sorbitol substituted jam was selected to study the change during storage.

3.2 Effect of storage

After storage for 6 week, the sorbitol substituted mango jam had not significantly been different in term of physical (hardness) and chemical (total acidity) properties compared to the original mango jam (Table 4). Moreover, the microbiological results showed that no bacteria, fungi and yeast had been detected in the final product over 6 week of storage (Table 5).

Physical and chemical properties of jam during storage can be changed such as the synerisis and changing of total acid content in the product. From the exiting researches, using the varieties of sweetener substitution did not significantly affect on stability of the jam. For example, production of low sugar blackcurrant jams using neohesperidine as sweetener. The result clearly indicated that there were no detectable differences in sweetness quality, intensity of flavor profiles between the test samples of the control recipe throughout the 18 months of storage [15].

Table 4. Physical and chemical properties of sorbitol substituted mango jam during storage

Storage time (week)	Hardness (g)	Total acidity (g/l)
0	$102.70^{a} \pm 1.56$	$6.83^{a} \pm 0.74$
2	$101.66^{a} \pm 1.45$	$7.16^{a} \pm 0.67$
4	$103.76^{a} \pm 2.92$	$6.83^{a} \pm 0.37$
6	$102.33^{a} \pm 2.67$	$6.83^{a} \pm 0.74$

Means in columns not followed by the same superscripts are significantly different *($p \leq 0.05$)*

Table 5. Microbiological properties of sorbitol substituted mango jam during storage

Storage time (week)	Total plate count (logCFU/g)	Yeast and mold (logCFU/g)
0	0	0
2	0	0
4	0	0
6	0	0

4. Conclusion

Production of low sugar mango jam using sorbitol as a sweetener can be done with 100% substitution without effect on sensory quality. However, hardness decreased with increasing sorbitol concentration because of weaker junction zones in pectin gel network. The results demonstrated that chemical properties remained similar for sucrose or sorbitol used during jam manufacturing. No negative effect on physical, chemical and microbiological properties of the jam during storage at room temperature had been detected.

Acknowledgements

This study was financially supported by the research scholarship of Faculty of Agricultural Product Innovation and Technology, Srinakharinwirot University, Thailand.

References

[1] Basu S, Shivhare US. Rheological, texture, micro-structural and sensory properties of mango jam. J Food Eng 2010; 100: 357-65.
[2] Manisha G, Soumya C, Indrani D. Studies on interaction between stevioside, liquid sorbitol, hydrocolloids and emulsifiers for replacement of sugar in cakes. Food Hydrocolloids 2012; 29: 363-73.
[3] Lofgren C, Walkenstrom P, Hermansson A-M. Microstructure and rheological behavior of pure and mixed pectin gel. Biomacromolecules 2002; 7(1): 1144-53.
[4] Hyvonen L, Torma R. Examination of sugar, sugar alcohols, and artificial sweeteners are substitutes for sucrose in strawberry jam, keeping quality tests. J. Food Sci 2006; 48(1): 186-92.
[5] Bakr AA. Application potential for some sugar substitutes in some low energy and diabetic foods. Molecular Nutri Food Res; 41(3): 170-5.
[6] Kokini JL, Plutchok GJ. Viscoelastic properties of semisolid foods and their biopolymers components. Food Technol 1998; 41(3): 89-95.
[7] Basu S, Shivhare US, Singh TV, Beniwal VS. Rheological, texture and spectral characteristics of sorbitol substituted mango jam. J Food Eng 2011; 105: 503-12.
[8] Matsukubo T, Takazoe I. Sucrose substitutes and their role in caries prevention. Inter Dent J. 2008; 56: 119-30.
[9] Melgarejo P, Martinez R, Hernandez F, Martinez JJ, Lequa P. Anthocyanin content and colour development of pomegranate jam. Food Bioproducts Process. 2011; 89: 477-481.

[10] A.O.A.C. Official Methods of Analysis of the Association of Official Chemists International. 16th ed. The Association of Official Analytical Chemists International. Gaithersburg. 2000.
[11] Benson HJ. Microbiological applications, In: A laboratory manual in general microbiology. W.C. Brown. Iowa. 1985.
[12] Bayarri S, Duran L Costell E. Influence of sweeteners on the viscoelasticity of hydrocolloids gelled systems. Food Hydrocolloids 2004; 18(4): 611-9.
[13] Cano MP, de Ancos B. Carotenoid and carotenoid ester composition in mango fruit as influenced by processing method. J Agri Food Chem 1994; 42: 2737-42.
[14] Ragab M. Characteristics of apricot jam sweetened with saccharin and xylitol. Food Chem 1987; 23(1): 55-64.
[15] Tomas-Barberan FA, Borrego F, Ferreres F, Lindley MG. Stability of the intense sweetener neohesperidine dihydrochalcone in blackcurrant jams. Food Chem 1995; 52: 263-5.