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Development of Strawberry gummy jelly with reduced sugar content from Strawberry syrup

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Abstract The strawberry syrup from frozen strawberries industry was acidic and a red color. °Brix value of strawberry syrup was 26.77. It was used for preparation of strawberry gummy jellies. The suitable basic recipe of strawberry gummy jelly was selected.The result indicated that using 100% concentrated strawberry syrup in strawberry gummy jelly had the highest consumer acceptance. The sucrose was replaced by sucralose at the percentage of 0 25 50 75 and 100 (w/w). The result showed that using 50% sucralose for sucrose replacement in strawberry gummy jelly had the highest of consumer acceptance and lower calorie than control (sucrose). The replacement of sucrose by sucralose can be alternative ways of development of gummy jelly.

Keywords: Gummy jelly, Sucralose, Reduced sugar

Introduction

Strawberries are one of the most popular fruits in Thailand. Strawberries decay easily during transportation and storage. Freezing process is the alternative technology for extending shelf-life and preserving the juiciness and flavour of strawberries. Frozen strawberries are the most common starting raw material used in the manufacturing of strawberry juices, concentrates and jam. However, changes in qualities of strawberry occurred during freezing and thawing. Strawberries can be pre-treated by mixing them with dry sugar before freezing for increasing the sugar content, decreasing the textural degradation and improving the colour stability in strawberries (Oszmiański *et al.*, 2009). During the freezing–thawing process, the cell wall of strawberry was ruptured. So, strawberry syrup (juice and sugar) was generated from the manufacturing of frozen strawberries.

Confectionery are food items that are high sugar (sucrose and glucose syrup), gelling agents (starch, gelatin or pectin) and other ingredients (food acid, flavourings and colourings) (Jiamjariyatam, 2018). Gummy jelly is a confectionery product in a group of candy gel. Gummy jelly candy with a

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soft and sticky is popular product (Burey *et al.*, 2009). It is a product of herb, fruit or vegetable juice mixed with sweeteners and gelling agent. The major gelling agent of gummy jelly is gelatin. It is derived from collagen. Gelation process of gelatin is a thermoreversible formed in agueous phase through low the temperature (Djabourov, 1991). Gummy jelly is made by boiling of gel components and sugars at high temperatures. After boiling, the mixture was mixed with the food acid, flavor and color agents. The obtained mixture is poured into gummy molds. The gummy molds are placed in a cool and dry place (Hay, 2016). Gummy jelly products consist of high sucrose which negative effects on health. It has a high glycemic index and contributes to high blood sugar (Yudkin *et al.*, 1971). Moreover, excessive intake of high calorie, high glycemic food can result in exaggerated postprandial glucose and insulin levels (O'Keefe and Bell, 2007). At the present, consumer's behaviour and attitude of customer have moved towards health food products. Consumption of low-calorie sweeteners has increased, especially consumers with health issues. Sucralose is permitted for use in Thailand. Sucralose is a nonnutritive sweetener (600 times sweeter than sucrose) which created by the replacement of the three sucrose hydroxyl groups with three atoms of chlorine. Sucralose is noncarcinogenic and safe to ingest (Berry *et al.*, 2016). It is very stable at high temperatures and stability in low pH products (Barianni *et al.*, 2009). Additionally, sucralose does not have the bitter aftertaste (Wiet and Beyts, 1992). Thus, the aim of this study was produced strawberry gummy jelly and prepared with different levels of sucralose as sucrose replacement to reduce the sugar content without affecting the sensory properties.

Materials and methods

Strawberry syrup

Strawberry syrup was obtained from Lanna Agro Industry in Chiang Mai, Thailand. Frozen strawberry syrup was placed in polyethylene bag. The bag was imbedded in a polystyrene box containing dry ice and transported to the King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand. Insulated box containing samples and dry ice were kept at -20 ℃ until used. Pure refined sugar (Mitr Phol, Thailand), glucose syrup 43 DE (Fancy Craft, Thailand), gelatin A 240 Bloom (Mcgarrett, Thailand), ascorbic acid (Chemipan, Thailand) and sucralose (Chemipan, Thailand) were used as ingredients in formulation of gummy gelly.

Properties of strawberry syrup

Total soluble solid (°Brix) of strawberry syrup was determined by hand refractometer (Master-500, Atago, Tokyo, Japan). pH was measured

using a pH-meter (PB-10, Sartorius, Göttingen, Germany). Titratable acidity (TA) was determined by titrating with 0.1 N NaOH (AOAC, 2005). Vitamin C was estimated by titrating with 2, 6-dichlorophenol-indophenol dye solution as described by Babashahi-Kouhanestani *et al*. (2014). Total sugar content was determined according to the method of Dubois *et al*. (1956). The reducing sugar of the sample was determined following the procedure of Miller (1959). Color of sample was determined using a colorimeter (ColorFlex, Hunter Lab Reston, VA, USA).

Strawberry gummy jelly preparation

The strawberry syrup was subjected to preparation of strawberry gummy jelly by different formulations. The basic formulas of strawberry gummy jelly are showed in Table 1.

Table 1. Basic formulations of strawberry gummy jellies

Ingredients	Formulations		
	A[1] (%)	B[2] (%)	C[3] (%)
Strawberry syrup	40	43	40
Sugar	20	40	43
Gelatin powder	13	10	13
Glucose syrup	15	9	-
Ascorbic acid	0.4	1	0.4

[1]/ A formulation was modified from Ratmanee, *et al*. (2017)
[2]/ B formulation was modified from Commercial product
[3]/ C formulation was modified from Lichanporn *et al*. (2015)

The gummy jelly was made by pouring strawberry syrup into a pot and warmed up to 45 ℃ for 5 min. The mixture containing glucose syrup, sugar, ascorbic acid and gelatin powder were stirred well and boiled for 5 min to concentrate at 78 ± 0.01 °Brix. The mixture solution was poured into a gummy mold and cooled at room temperature for 24 hr. The jelly samples was removed from the mold and stored at 4 ℃ in an airtight polypropylene plastic container. Three gummy jellies formulations were subjected to sensory analysis.

Effect of strawberry syrup concentration on the sensory properties of strawberry gummy jelly

The gummy jelly formulation providing the highest sensory score was selected. Different ratios of strawberry syrup to water (40-100% (w/w)) were studied. The obtained strawberry gummy jellies were subjected to sensory analysis.

Effect of replacing sugar by sucralose on the qualities of strawberry gummy jelly

The strawberry syrup concentration in gummy jelly providing the highest sensory score was chosen. The sucrose was replaced by sucralose in gummy jelly at the percentage of 0-100 (w/w). Sucralose is 600 times sweeter than sucrose. The amounts of sucralose in gummy jelly were calculated to create the same sweetness. The obtained gummy jellies were subjected to analysis.

Analyses

The proximate analysis (moisture, protein, lipid, ash and fiber) of samples were determined by (AOAC, 2000). Carbohydrate was calculated as 100%-(%of moisture+ash+fat+protein). Total calorie contents were calculated from the results obtained in the proximate analysis of the energy component (protein, lipid and carbohydrate). Total sugar, reducing sugar, pH, TA and vitamin C of the samples were measured. Water activity (a_w) was evaluated using an Aqua-Lab Water Activity Meter (Series 3, Decagon Devices, Inc., Pullman, WA, USA). The texture of samples were determined using a texture analyzer (TA.XT II, Stable Micro Systems, Surrey, England). Colour of the strawberry gummy jellies was measured in a HunterLab colorimeter. For each sample was placed on glass cells. Results were expressed in terms of the CIELab scale parameters: L* [lightness, 0 = black, 100 = white], a* [greenness (−), redness (+)] and b* [blueness (−), yellowness (+)]. Sensory evaluation was performed using 50 untrained panellists. Panellists was to rank the products for appearance, colour, odour, texture, taste and overall likeness using a 9-point hedonic scale, in which a score of 1 = not like very much, 5 = neither like nor dislike and 9 = like extremely (Meilgaard *et al.,* 2006).

Statistical analysis

Descriptive statistic (mean and standard deviation, SD) was used to analyse the physical and chemical properties of strawberry syrup. A randomised complete block design was performed for the sensory analysis. Block was panellists, whereas treatments were divided into 3 parts: 1) formulations of gummy jellies (A, B and C), 2) syrup concentrations (40%, 60%, 80% and 100%) and 3) sucralose levels (0%, 25%, 50%, 75% and 100%). If the significant difference ($p<0.05$) from ANOVA was detected, Duncan's multiple range test was used to compare the difference of means. Independence t-test was used to compare the physical and chemical data between 0%sucralose and 50% sucralose gummy jellies. All analyses were performed using the Statistic software.

Results

The chemical and physical properties of strawberry syrup are shown in Table 2. Total soluble solid (°Brix), pH, TA (%), vitamin C (%), total sugar (%) and reducing sugar (%) of strawberry syrup were 26.77, 3.22, 0.10, 8.10, 21.33 and 6.89, respectively. *L**, *a** and *b**-values of strawberry syrup were 13.68, 12.14 and 4.57, respectively.

Table 2. Chemical and physical properties of strawberry syrup

Chemical and physical properties	Strawberry syrup
Total soluble solid (°Brix)	26.77 ±1.05[1/]
pH	3.22 ±0.31
TA (%)	0.10 ±0.03
Vitamin C (%)	8.10 ±2.14
Total sugar (%)	21.33 ±0.82
Reducing sugar (%)	6.89 ±0.16
Color	
*L**	13.68 ±1.89
*a**	12.14 ±0.34
*b**	4.57 ±0.13

[1/]Data are expressed as mean ± SD (n = 3).

Selection of basic formulations of strawberry gummy jellies: Sensory properties of strawberry gummy jellies using strawberry syrup from different formulations are presented in Table 3. The highest likeness score of color showed in B gummy jelly ($p<0.05$). There was no difference in color between A and C gummy jellies ($p>0.05$). For the odor and overall likeness, C sample had no difference in likeness score, compared to A and B samples ($p>0.05$) However, odor and overall likeness of B sample was higher than A sample ($p<0.05$). Moreover, there were no differences in sourness, appearance and texture attributes among all samples ($p>0.05$). For the sweetness, A sample had lower likeness score in sweetness than other samples ($p<0.05$).

Table 3. Likeness score of strawberry gummy jelly from different formulations

Formulations	Likeness score						
	Color	Odor	Sourness	Sweetness	Appearance	Texture	Overall
A	6.73 ±1.55[1/b2/]	6.20 ±1.19[b]	6.40 ±1.48[a]	5.73 ±1.48[b]	6.33 ±177[a]	7.57 ±0.94[a]	6.53 ±1.41[b]
B	7.80 ±1.19[a]	6.67 ±1.09[a]	6.57 ±1.41[a]	6.63 ±1.19[a]	6.63 ±145[a]	7.63 ±0.93[a]	7.10 ±1.09[a]
C	7.13 ±1.38[b]	6.40 ±1.16[ab]	6.40 ±1.57[a]	6.47 ±1.83[a]	6.40 ±196[a]	7.53 ±1.11[a]	6.83 ±1.44[ab]

[1/]Data are expressed as mean ± SD (n = 3).
[2/]Different lowercase letters within the same column indicate significant difference ($p<0.05$).

Effect of strawberry syrup concentration on the sensory properties of strawberry gummy jelly in color, odor, sourness, sweetness, appearance, texture and overall of gummy jellies added with different concentrations of syrup were evaluated using a nine-point hedonic scale as shown in Table 4. There were no differences in likeness score of color, odor, sourness, sweetness and texture among all gummy jelly samples ($p>0.05$). Whereas, gummy jelly at 40% syrup was the lowest likeness score in appearance. In addition, gummy jelly produced from syrup with concentration of 100% (w/w) had the highest likeness score when compared with all samples ($p<0.05$). However, gummy jelly added with syrup at 60% showed similar likeness score when compared with those added with syrup at 40% and 80% ($p>0.05$). Thus, gummy jelly was produced using strawberry syrup at 100% yielded the highest likeness score which selected for further experiment.

Table 4. Likeness score of gummy jelly from different strawberry syrup concentration

Syrup concentration (%)	Likeness score						
	Color	Odor	Sourness	Sweetness	Appearance	Texture	Overall
40	7.17±1.05[1/a2/]	6.00±1.44[a]	5.60±1.61[a]	6.17±1.62[a]	5.97±1.47[b]	6.50±1.13[a]	5.10±1.03[c]
60	6.67±1.27[a]	6.07±1.30[a]	5.67±1.50[a]	6.07±1.72[a]	6.47±1.41[a]	6.00±1.40[a]	5.53±0.93[bc]
80	6.63±1.35[a]	5.80±1.30[a]	5.70±1.44[a]	6.07±1.30[a]	6.50±1.22[a]	6.43±1.36[a]	6.00±1.40[b]
100	6.80±1.54[a]	5.70±1.41[a]	5.3±1.50[a]	6.20±1.45[a]	6.90±1.10[a]	6.50±1.40[a]	6.80±1.10[a]

[1/]Data are expressed as mean ± SD (n = 3).
[2/]Different lowercase letters within the same column indicate significant difference ($p<0.05$).

Effect of replacing sucrose by sucralose on the qualities of strawberry gummy jelly, gummy jelly was replaced the sucrose with sucralose at various levels ranging from 0% (control) to 100%. There were no differences in color, sourness and texture likeness score ($p>0.05$) as shown in Table 5. However, gummy jelly containing 25 and 100% (w/w) sucralose substitution had the lowest odor likeness score, compared with the control ($p<0.05$). Likeness scores was slightly decreased with increasing sucralose levels up to 50% ($p<0.05$). It was found that the addition of sucralose up to 75% had no impact on overall likeness as similar in likeness score, compared with control sample. Gummy jelly with sucralose at 100% had lowest score in overall ($p<0.05$). From the result, the addition of sucralose at 50% had no impact on sensory properties of gummy jelly. Thus, gummy jelly with 50% sucralose replacer was selected for further study.

Table 5. Likeness score of gummy jelly at different sucralose levels

Sucralose levels	Likeness score						
	Color	Odor	Sourness	Sweetness	Appearance	Texture	Overall
0% (Control)	7.73±1.04[1/a2/]	6.90±1.61[a]	6.53±1.10[a]	6.97±1.90[a]	7.33±1.3[ab]	6.67±1.56[a]	7.47±1.15[a]
25%	7.20±1.3[ab]	5.93±1.60[b]	6.70±1.16[a]	6.37±1.804[ab]	7.30±1.41[ab]	6.53±1.6[a]	6.80±1.46[ab]
50%	7.07±1.36[ab]	6.07±1.43[ab]	6.36±1.57[a]	6.20±1.51[ab]	7.40±1.30[ab]	6.10±1.63[a]	6.73±1.07[ab]
75%	7.43±1.63[ab]	6.07±1.63[ab]	6.32±1.98[a]	5.93±1.75[b]	7.70±1.25[a]	6.23±2.10[a]	6.80±1.70[ab]
100%	7.37±1.50[ab]	5.90±1.83[b]	6.31±1.38[a]	5.67±1.52[b]	6.70±1.70[b]	5.97±2.17[a]	6.53±1.50[b]

[1/] Data are expressed as mean ± SD (n = 3).
[2/]Different lowercase letters within the same column indicate significant difference ($p<0.05$).

Chemical and physical properties of reduced sugar strawberry gummy jelly showed no different in moisture (20.78-23.06%), protein (8.20-8.71%), lipid (0.00-0.05%), ash (0.12-0.21%), fiber (0.37-0.74%), reducing sugar (1.56-1.88%), pH (3.63-4.85), TA (0.19-0.11%) and vitamin C (155.72-160.13%) between control and 50% sucralose samples ($p>0.05$) as seen in Table 6. The control sample had the significantly higher carbohydrate (70.55-68.43%), total sugar (3.81±0.70%), total calorie (315.46±0.62 calorie/100g), water activity (0.79±0.00) along with hardness, *a** and b*-values than 50% sucralose sample ($p<0.05$). For the *L**-value, this value ranged from 24.46±3.24 for control sample to 30.12±0.71 for gummy jelly sample with 50% sucralose.

Table 6. Chemical and physical properties of reduced sugar strawberry gummy jellies

Properties	Gummy jellies	
	Control (0% sucralose)	50% sucralose
Moisture (%)	21.00±0.22[1/a2/]	22.72±0.34[a]
Protein (%)	8.35±0.15[a]	8.47±0.24[a]
Lipid (%)	0.02±0.02[a]	0.04±0.01[a]
Ash (%)	0.16±0.04[a]	0.18±0.03[a]
Carbohydrate (%)	70.47±0.08[a]	68.59±0.16[b]
Fiber (%)	0.52±0.15[a]	0.60±0.14[a]
Total calorie (kcal/100g)	315.46±0.62[a]	308.6±0.47[b]
Total sugar (%)	3.81±0.70[a]	1.81±0.14[b]
Reducing sugar (%)	1.65±0.00[a]	1.72±0.16[a]
pH	3.74±0.11[a]	3.72±0.07[a]
TA (%)	0.15±0.04[a]	0.13±0.04[a]
Vitamin C (%)	159.26±0.87[a]	157.14±1.42[a]
Water activity	0.79±0.00[a]	0.72±0.01[b]
Hardness (N)	37.44±1.50[*a]	29.50±2.11[b]
Color		
*L**	24.46±3.24[b]	30.12±0.71[a]
*a**	19.58±1.73[a]	15.12±1.31[b]
*b**	7.83±1.00[a]	5.74±0.74[b]

[1/] Data are expressed as mean ± SD (n = 3).
[2/]Different lowercase letters within the same column indicate significant difference ($p<0.05$).

Discussion

Strawberry syrup was obtained from frozen strawberries processing. As the results, strawberry syrup was acidic (pH varying from 2.91 to 3.53, TA 0.70 to 1.30% and ascorbic acid 5.96±10.24%), with high soluble solid content (from 25.72 to 27.82 °Brix) because of the high total sugar content (20.51±22.15%). The color expressed as *L**- (lightness), *a**- (redness) and *b**- (yellowness) values of the strawberry syrup. Strawberry syrup was red in color (*a**-value). Strawberry syrup were more likely due to the red color of anthocyanin (Cordenunsi *et al.,* 2003). Strawberry syrup was used to preparation of strawberry gummy jellies. The different formulations of gummy jellies were selected from preliminary study. Three formulations of gummy jelly in this study can produce a firm gel. B and C samples showed the higher likeness score than the A sample ($p<0.05$). B and C samples had a similar score in all attributes, except for color. High in color score of B sample was more likely associated with high amount of strawberry syrup in gummy jelly. Therefore, gummy jelly prepared from B formulation was selected for further studies. Gummy jellies produced from different concentrations of strawberry syrup showed similar result in sensory analysis. However, appearance and overall likeness of the gummy jelly were affected by the syrup concentration. Gummy jelly containing 100% strawberry syrup exhibited the highest likeness score. The overall, decreasing in likeness score with lower strawberry syrup concentration was found ($p<0.05$).

Physical and chemical properties of strawberry gummy jellies with and without 50% of sucralose replacement are shown in Table 6. The replacement of 50% sucrose by sucralose into the gummy jelly have a tendency to decrease carbohydrate, total calorie, total sugar, a_w, hardness, *a** and *b**- values. The result indicated that using sucarlose in gummy jelly can produce a less calorie gummy jelly. Lin *et al.* (2003) reported that the calories of 0%, 25%, 50%, 75%, and 100% erythritol cakes were 306.0, 281.1, 256.1, 231.3, and 206.3 kcal/100g, respectively. In general, gummy jellies contain low moisture (8–22%) and water activity (0.50-0.75) (Bussiere and Serpelloni, 1985). However, Periche *et al.* (2014) reported that the gummy added up of 30% isomaltulose and 70% fructose had 0.79 in water activity. From the result, water activity of the gummy jelly was lower than the control sample. This result indicated that sucralose was able to bind the free water resulting lower in the water activity. Gummy jelly containing gelatin as gelling agent could associated a three-dimensional network formation after its triple helix structure forms junction zones (Guo *et al.,* 2003). The sucralose replacement gummy jelly had lower hardness than the control samples. This result was similar with Periche *et al.* (2014) report.

The color of sucralose replacement gummy jelly were high in lightness (*L**), low in redness (*a**), and yellowness (*b**). The results may be due to sucralose is heat stable more than sucrose (Bannach *et al.*, 2009), and

it does not react with amino acids by Maillard reaction (Basu *et al.*, 2013). However, there were no impacts on the proximate composition ($p>0.05$).

Therefore, the addition of sucralose had impact on the gummy jelly quality and sensory properties. The use of 50% sucralose replacement in strawberry gummy jelly had the highest of consumer acceptance with lower calorie.

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