**การใช้ซูคราโลสเป็นสารให้ความหวานในไอศกรีมจากตะลิงปลิงสูตรพลังงานต่ำ**

**USE OF SUCRALOSE AS SWEETENER IN LOW CALORIES ICE CREAM FROM BILIMBI (*Averrhoa bilimbi* Linn.)**

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**บทคัดย่อ:** ศึกษาการผลิตไอศกรีมจากตะลิงปลิงสูตรควบคุม โดยแปรปริมาณของผลสดตะลิงปลิงปั่นละเอียดเป็น 3 ระดับ คือ ร้อยละ 20, 30 และ 40 โดยน้ำหนัก พบว่าเมื่อเพิ่มปริมาณของผลสดตะลิงปลิงปั่นละเอียดสูงขึ้นมีผลทำให้ความหนืด ค่าปริมาณของแข็งที่ละลายน้ำได้ทั้งหมด และปริมาณกรดสูงขึ้น ในขณะที่ค่าร้อยละการขึ้นฟูและค่าความเป็นกรดด่างลดลง และเมื่อทดสอบทางประสาทสัมผัส พบว่าไอศกรีมที่มีปริมาณของผลสดตะลิงปลิงปั่นละเอียด ร้อยละ 30 ได้รับคะแนนการยอมรับสูงสุดในทุกด้าน จึงใช้เป็นสูตรควบคุม จากนั้นศึกษาปริมาณซูคราโลสที่เหมาะสม โดยแปรเป็น 3 ระดับ คือ ร้อยละ 0.1, 0.2 และ 0.3 โดยน้ำหนักและใช้มอลทิทอลเป็นสารให้เนื้อ พบว่าสมบัติทางเคมี กายภาพของไอศกรีมทั้ง 3 สูตรมีค่าแตกต่างกันเล็กน้อย แต่ไอศกรีมที่ใช้ซูคราโลส ร้อยละ 0.2 โดยน้ำหนักได้รับคะแนนการยอมรับทางด้านประสาทสัมผัสสูงสุดในทุกด้าน และเมื่อทดสอบเปรียบเทียบกับสูตรควบคุม พบว่าไม่มีความแตกต่างกันอย่างมีนัยสำคัญทางสถิติ ($p>0.05$) เมื่อวิเคราะห์องค์ประกอบทางเคมี พบว่าสูตรควบคุมและสูตรที่ใช้ซูคราโลสร้อยละ 0.2 โดยน้ำหนัก มีปริมาณไขมัน โปรตีน เส้นใย และเถ้า ไม่แตกต่างกันอย่างมีนัยสำคัญทางสถิติ ($p>0.05$) และมีค่าพลังงาน เท่ากับ 105.72 และ 39.10 กิโลแคลอรีต่อไอศกรีม 100 กรัม ตามลำดับ และเมื่อตรวจสอบทางด้านจุลชีววิทยา พบว่าจำนวนจุลินทรีย์ทั้งหมดและแบคทีเรียในกลุ่มโคลิฟอร์มต่ำกว่าเกณฑ์มาตรฐาน

**Abstract:** The production of ice cream from bilimbi fruit was studied. Three levels of blimbi pulp at 20, 30 and 40% (by wt) were used in the control formula. The results showed that viscosity, total soluble solids and % acid content increased while % overrun and pH decreased. Ice cream with bilimbi pulp at 30% (by wt.) had the highest overall acceptance scores and was subsequently used as the control formula. Maltitol as a bulking agent was used in concert with three levels of sucralose at 0.1, 0.2, and 0.3% (by wt.) in the control formula. The results showed that the chemical and physical properties of three formulas were slightly different. However, bilimbi ice cream with 0.2% sucralose had the highest acceptance scores. Comparison between bilimbi ice cream containing 0.2% (by wt.) sucralose and the control indicated no significant difference ($p > 0.05$) in terms of overall sensory acceptance. Proximate analysis of the control and bilimbi ice cream containing 0.2% (by wt.) sucralose were determined. The results revealed that lipids, protein, fiber and ash content were not significantly different ($p>0.05$). The calories content of the control and bilimbi ice cream containing 0.2% (by wt.) sucralose were 105.72 and 39.10 kcal/100 g ice creams, respectively.

Subsequent microbiology tests demonstrated that total plate count and coliform count were lower than those of the required standard.

**Introduction:** Sucralose is produced by selectively replacing three hydroxy groups with chlorine atoms. Sucralose, which is 600 times sweeter than sucrose, was discovered during collaborative research between Queens Elizabeth College in London and a private company, Tate & Lyle, after an experiment involving chemical modification of sucrose conducted by the same collage in the 1970's. The Joint FAO/WHO Expert Committee on Food Additives (JECFA) evaluated the safety of sucralose. Sucralose is typically added to foods in very small quantities. Sucralose is used as a sweetening agent in more than 100 kinds of foods; e. g., drinks, desserts, and dressings. Sucralose products manufactured in the US for domestic consumption are commonly formulated by the addition of "bulking" ingredients (e.g. dextrose, maltodextrin) to give a degree of sweetness per unit weight comparable to sucrose, and to give some products an appearance similar to granular sugar. Some examples of these sweeteners are Splenda and SucraPlus [1]. The bilimbi, *Averrhoa bilimbi,* L., (Oxalidaceae), is closely allied to the carambola but quite different in appearance, manner of fruiting, flavor and uses. "Bilimbi" is the common name in India and has become widely used. The bilimbi is generally regarded as too acid for eating raw, but in Costa Rica, the green, uncooked fruits are prepared as a relish which is served with rice and beans. Sometimes it is an accompaniment for fish and meat. Ripe fruits are frequently added to curries in the Far East. They yield 44.2% juice having a pH of 4.47, and the juice is popular for making cooling beverages on the order of lemonade. Mainly, the bilimbi is used in place of mango to make chutney, and it is much preserved. To reduce acidity, it may be first pricked and soaked in water overnight, or soaked in salted water for a shorter time; then it is boiled with much sugar to make a jam or an acid jelly [2]. The objectives of this research were to produce bilimbi ice cream and develop low calorie ice cream by replacing sucrose with sucralose.

**Methodology:**

**Materials**

The ingredients used in this study were food grade as follow: Sucralose from Uching Co.Ltd. Maltitol syrup from Siam sorbitol Co.Ltd; medium egg (No.2); pasteurized milk; powdered sugar and guar gum.

**1. Preparation of bilimbi pulp**

Bilimbi fruit was washing, cutting and blended with blender which the ratio of bilimbi fruit : water = 1:1, separated with cheese cloth and filled in plastic boxes and storage at freeze temperature until use.

**2. Production of bilimbi ice cream**

Bilimbi ice cream was prepared using modified formulation as shown in Table 1. Ice cream mixes (3.2-L batch size) were pasteurized at 70°C for 30 min, homogenized at 11,000 rpm for 15 min and aged 24 h at 4°C. Ice creams were frozen in freezer (Siam University) for 20 min. Ice cream was filled in plastic boxes and hardened 24 h at -18°C. Three levels of blimbi pulp at 20, 30 and 40% (by wt) were used in the control formula. Chemical and physical properties of bilimbi ice cream were investigated. Viscosity measurements of ice cream mixes were determined using Brookfield viscometer. Overrun [3] and melting properties [4] were estimated. Acidity was determined by AOAC, 2000 method [5] and pH with pH meter. Sensory evaluation of each bilimbi ice cream were evaluated by 40 food technology students using 9-points hedonic scaling in terms of viscosity, texture, melting in

mouth and overall acceptability was investigated [6]. Data was analyzed using analysis of variance. Duncan's Multiple Range Test was employed to determine significant differences at the 5% level.

**Table 1** Ingredients of bilimbi ice cream

| Ingredients | Formula 1: Sherbet (%) | Formula 2: Sorbet (%) |
|---|---|---|
| Powdered sugar | 13.50 | 30.00 |
| Pasteurized milk | 13.50 | 0.00 |
| Fruit pulp | 13.50 | 10.50 |
| Water | 56.20 | 59.20 |
| Egg white | 3.00 | 0.00 |
| Stabilizer (guar gum) | 0.30 | 0.30 |

**Note:** Formula 1 modified from http://icecream.icspace.net/sherbet.htm
Formula 2 modified from http://www.foodsci.uoguelph.ca/dairyedu/icecream.html

**3. Replacing sucrose with sucralose in bilimbi ice cream**

Sucralose was used to replace sucrose in selected bilimbi ice cream. 13.5% Maltitol as a bulking agent was used in concert with three levels of sucralose at 0.1, 0.2, and 0.3% (by wt.) in the control formula. The sucralose bilimbi ice cream was evaluated by 40 food technology students using 9-points hedonic scaling. Data was analyzed using analysis of variance. Duncan's Multiple Range Test was employed to determine significant differences at the 5% level [6]. The chemical and physical properties of ice cream were investigated. Viscosity measurements of ice cream mixes were determined using Brookfield viscometer. Overrun [3] and melting properties [4] were estimated. Acidity was determined by AOAC, 2000 method and pH with pH meter. Moisture, lipids, protein, ash, crude fiber, and carbohydrate content were determined by AOAC, 2000 method [5]. Microbiological quality was tested by the total plate and coliform count [7].

**Results, Discussion and Conclusion:**

**1. Production of bilimbi ice cream**

This study was conducted to produce control bilimbi ice cream. The result showed that viscosity and %overrun of sherbet were higher than sorbet. (Table 2) The meltdown rate of sherbet and sorbet ice cream was shown in Figure 1. The mean 9-point hedonic scaling of sherbet and sorbet ice cream was shown in Table 3. The results showed that sherbet ice cream had the most acceptable scores in term of color, texture, melting in mount and overall acceptability.

**Table 2** Physical and chemical properties of sherbet and sorbet bilimbi ice cream

| Properties | Type of ice cream | |
|---|---|---|
| | Formula 1: Sherbet | Formula 2: Sorbet |
| Viscosity (cP) | $720.00 \pm 0.55^{a}$ | $480.00 \pm 0.55^{b}$ |
| Total Soluble Solid (°Brix) | $19.16 \pm 0.25^{b}$ | $26.00 \pm 0.34^{a}$ |
| Overrun (%) | $32.80 \pm 0.05^{a}$ | $22.00 \pm 0.07^{b}$ |
| Acidity (%)$^{ns}$ | $0.23 \pm 0.03$ | $0.22 \pm 0.01$ |
| pH$^{ns}$ | $2.28 \pm 0.05$ | $2.20 \pm 0.07$ |

**Note:** Values with different letters in superscript in rows are significantly different ($p \leq 0.05$)
ns = not significantly different ($p>0.05$)
Mean ± standard deviation (SD)

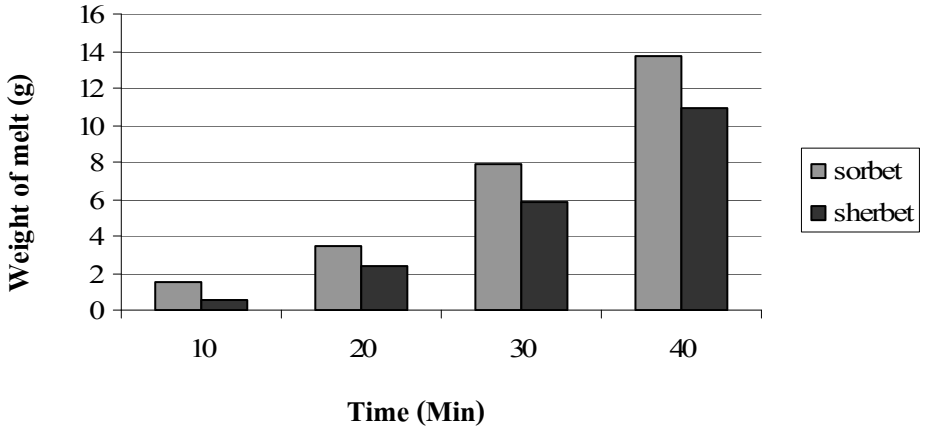


**Figure 1** Melting rate of sherbet and sorbet bilimbi ice cream

**Table 3** Means hedonic score of sensory evaluation of sherbet and sorbet bilimbi ice cream

| Attributes | Means hedonic score | |
|---|---|---|
| | Formula 1: Sherbet | Formula 2: Sorbet |
| Color | $6.40 \pm 1.22^{a}$ | $5.27 \pm 0.90^{b}$ |
| Flavor$^{ns}$ | $5.77 \pm 1.33$ | $5.20 \pm 1.16$ |
| Taste$^{ns}$ | $6.03 \pm 1.50$ | $5.57 \pm 1.07$ |
| Texture | $6.67 \pm 1.32^{a}$ | $5.57 \pm 0.94^{b}$ |
| Melting in mouth | $6.80 \pm 1.22^{a}$ | $5.90 \pm 0.66^{b}$ |
| Overall acceptability | $6.60 \pm 1.07^{a}$ | $5.90 \pm 1.03^{b}$ |

**Note:** Values with different letters in superscript in rows are significantly different ($p \leq 0.05$)
ns = not significantly different ($p>0.05$)
Mean ± standard deviation (SD)

Then, 3 levels at 20, 30 and 40% (by wt) of bilimbi pulp were varied. The results showed that viscosity, total soluble solid and %acid content increased while %overrun and pH decreased as the level of bilimbi pulp increased. (Table 4) Ice cream with 40% (by wt) of bilimbi pulp had the smallest meltdown rate (Figure 2). Sensory evaluation results showed that ice cream from bilimbi pulp at 30% (by wt) had the highest acceptance scores. (Table 5) Its was used as the control formula.

**Table 4** Physical and chemical properties of ice cream with 20, 30 and 40% (by wt) bilimbi pulp

| Properties | Amount of bilimbi pulp in ice cream | | |
|---|---|---|---|
| | 20% | 30% | 40% |
| Viscosity (cP) | $853.33 \pm 0.50^{c}$ | $1033.33 \pm 0.35^{b}$ | $1200.00 \pm 0.20^{a}$ |
| Total Soluble Solid (°Brix) | $18.33 \pm 0.05^{c}$ | $19.13 \pm 0.12^{b}$ | $20.07 \pm 0.12^{a}$ |
| Overrun (%) | $36.90 \pm 0.00^{a}$ | $36.66 \pm 0.00^{b}$ | $36.06 \pm 0.00^{c}$ |
| Acidity (%) | $0.23 \pm 0.01^{c}$ | $0.35 \pm 0.03^{b}$ | $0.39 \pm 0.12^{a}$ |
| pH | $2.54 \pm 0.03^{a}$ | $2.35 \pm 0.01^{b}$ | $2.19 \pm 0.12^{c}$ |

**Note:** Values with different letters in superscript in rows are significantly different ($p \leq 0.05$)
Mean ± standard deviation (SD)

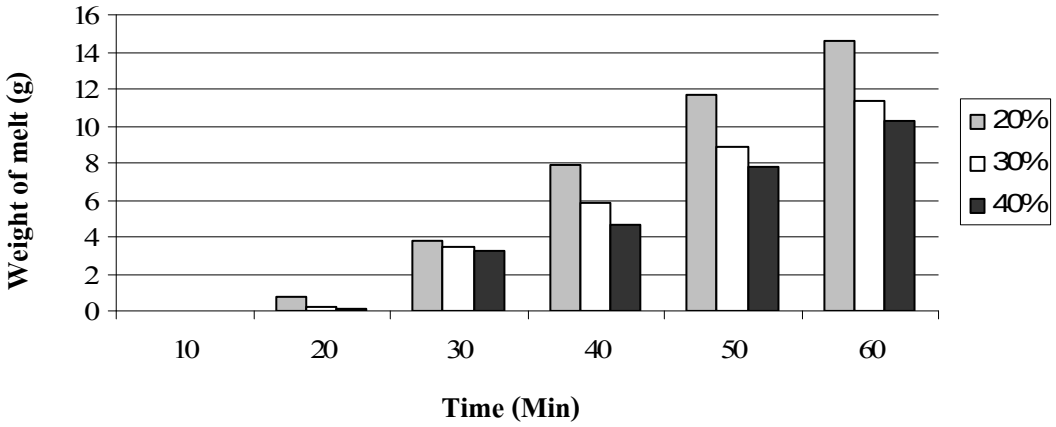


**Figure 2** Melting rate of ice cream with 20, 30 and 40% (by wt) bilimbi pulp

**Table 5** Means hedonic score of sensory evaluation of ice cream with 20, 30 and 40% (by wt) bilimbi pulp

| Attributes | Means hedonic score | | |
|---|---|---|---|
| | 20% | 30% | 40% |
| Color | $5.17 \pm 1.88^{b}$ | $6.70 \pm 1.88^{a}$ | $6.63 \pm 2.13^{a}$ |
| Flavor | $4.73 \pm 1.84^{b}$ | $6.07 \pm 1.36^{a}$ | $6.03 \pm 1.40^{a}$ |
| Taste | $4.87 \pm 1.87^{b}$ | $6.33 \pm 1.81^{a}$ | $6.13 \pm 2.30^{a}$ |
| Texture | $5.57 \pm 1.25^{b}$ | $6.60 \pm 1.67^{a}$ | $6.20 \pm 1.65^{ab}$ |
| Melting in mouth | $5.73 \pm 1.05^{b}$ | $6.47 \pm 1.59^{a}$ | $6.67 \pm 1.21^{a}$ |
| Overall acceptability | $5.23 \pm 1.41^{b}$ | $6.57 \pm 1.59^{a}$ | $6.43 \pm 1.65^{a}$ |

**Note:** Values with different letters in superscript in rows are significantly different ($p \leq 0.05$)
Mean ± standard deviation (SD)

**2. Replacing sucrose with sucralose in bilimbi ice cream**

Sucralose was used to replace sucrose in selected bilimbi ice cream and maltitol was also used as bulking agent at 13.5%. Sucralose were varied 3 levels at 0.1, 0.2, and 0.3% (by wt.). The results showed that the chemical and physical properties of three formulas were similar. (Data not showed) Sensory evaluation results showed that ice cream with 0.2% sucralose had the most acceptable scores. (Table 6) The chemical and physical properties of the control and bilimbi ice cream containing 0.2% sucralose are given in Table 7. In this experiment, maltilol was also used to combine with sweetener. Using of maltitol as bulking agent could contribute solids to system and improves texture qualities [8]. Bilimbi ice cream containing 0.2% sucralose had no significant difference ($p > 0.05$) in overall sensory acceptance as compared with control formula (sucrose). The proximate analysis of control and bilimbi ice cream containing 0.2% sucralose revealed that lipids, protein fiber and ash content were not significantly different ($p>0.05$). The calories content of control and bilimbi ice cream containing 0.2% (by wt.) were 105.72 and 39.10 kcal/100 g ice creams, respectively. The results revealed that ice cream with 0.2% sucralose decrease energy more than 36%. This result is similar to Chaumchaitrakun et al. (2007) [9] in that the energy of butter cake decrease more than 40% when using of sweetener. Microbiological quality tested by the total plate count were acceptable since microbial count was lower than standard of regulation. The results showed that coliform bacteria were not detected in the products.

**Table 6** Means hedonic score of sensory evaluation of bilimbi ice cream with 0.1, 0.2, and 0.3% sucralose

| Attributes | Means hedonic score | | |
|---|---|---|---|
| | 0.1% Sucralose | 0.2% Sucralose | 0.3% Sucralose |
| Color | $6.20 \pm 1.58^{b}$ | $7.20 \pm 0.48^{a}$ | $6.67 \pm 0.95^{ab}$ |
| Flavor | $5.83 \pm 1.17^{b}$ | $6.93 \pm 0.90^{a}$ | $6.27 \pm 0.90^{b}$ |
| Taste | $4.63 \pm 1.13^{c}$ | $7.57 \pm 0.72^{a}$ | $6.27 \pm 1.36^{b}$ |
| Texture | $5.90 \pm 1.29^{b}$ | $6.90 \pm 1.09^{a}$ | $6.46 \pm 1.22^{ab}$ |
| Melting in mouth | $5.60 \pm 1.61^{b}$ | $7.10 \pm 0.88^{a}$ | $6.80 \pm 1.12^{a}$ |
| Overall acceptability | $5.40 \pm 1.47^{c}$ | $7.86 \pm 0.73^{a}$ | $6.73 \pm 1.23^{b}$ |

**Note:** Values with different letters in superscript in rows are significantly different ($p \leq 0.05$)
Mean ± standard deviation (SD)

**Table 7** Physical and chemical properties of control (sucrose) and bilimbi ice cream with 0.2% sucralose

| Properties | Type of Sweetener | |
|---|---|---|
| | Sucrose (control) | Sucralose |
| Viscosity (cP)$^{ns}$ | 786.40 ± 1.14 | 788.60 ± 8.26 |
| Total Soluble Solid (°Brix) | $16.24 \pm 0.08^{a}$ | $15.86 \pm 0.26^{b}$ |
| Overrun (%) | $35.45 \pm 0.00^{b}$ | $39.35 \pm 0.00^{a}$ |
| Acidity (%)$^{ns}$ | 0.36 ± 0.02 | 0.36 ± 0.01 |
| pH$^{ns}$ | 2.34 ± 0.01 | 2.37 ± 0.01 |

**Note:** Values with different letters in superscript in rows are significantly different ($p \leq 0.05$)
ns = not significantly different ($p>0.05$)
Mean ± standard deviation (SD)

**References:**


1. Wikipedia Organization. 2009. Sucralose Available from: http://en.wikipedia.org/wiki/ Sucralose Accessed June 10, 2009.
2. http://www.hort.purdue.edu/newcrop/morton/bilimbi.html
3. H. D. Goff, 1995. *Dairy Science and Technology Education*, University of Guelph, Canada, Retrieved September 6, 2006, from www.foodsci.uoguelph.ca/dairyedu/home. html
4. W. G. Geilman, and D. E. Schmidt, *J. Dairy Sci*. 1992, 75, 2670-2675.
5. A.O.A.C. 2000. Official Method of Analysis. (17th ed.). The Association of Official Analytical Chemists, Washington, D.C.
6. M. Meilgaard, G.V. Civille, and T. Carr, 1999. *Sensory Evaluation Technigues* . (3rd ed.) CRC Press LLC , New York, p. 242-247.
7. W.F. Harrigan, 1998. *Laboratory Methods in Food Microbiology.* (3rd ed.). London. WBC Book Manufacturers.
8. M. Kroger, K. Meister and R. Kava 2006. *Low-calorie sweeteners and other sugar substitutes: A Review of safety issue.* Comprehensive reviews in food science and food safety 5:35-47.
9. http://iat.sut.ac.th/food/FIA2007/FIA2007/paper/P4-39-NC.pdf



**Keywords:** ice cream, bilimbi fruit, sweetener, maltitol, sucralose

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