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Full Paper

Development of ginger-flavoured soya milk ice cream : Comparison of data analysis methods

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Abstract: Sucrose at the concentration of 6 and 7% (w/w) and ginger extract at the concentration of 4 and 5% (w/w) were added to ginger-flavoured soya milk ice cream recipes to determine the consumer acceptablility. One hundred consumers were requested to taste four samples of ginger-flavoured soya milk ice cream and rate the intensity of ginger flavour, sweetness, richness and smoothness, together with their indication for ideal intensity of these attributes as well as their preference of each sample by using the 10 cm-line scale. Ideal ratio scores, principal component analysis and analysis of variance with mean comparison were used for data analysis. It was shown that the recipe with 7% sucrose and 4% ginger extract was close to the ideal product ($p>0.05$) and it had the highest preference mean score ($p\leq0.05$). Total phenolic content of this recipe was 91.6 $\pm$ 6.8 mg gallic acid equivalent per 100 grams and antioxidant capacity values including ferric reducing/antioxidative power (FRAP), 1,1-diphenyl-2-picryl-hydrazyl (DPPH) and 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid) (ABTS) were 37.9$\pm$3.7, 13.4$\pm$1.2 and 49.0$\pm$5.1 mg vitamin C equivalent per 100 grams respectively.

Key words: ice cream, ginger-flavoured ice cream, soya milk ice cream, principal component analysis

INTRODUCTION

Ice-cream is normally defined as a frozen mixture of milk components, sweeteners, stabilisers, flavourings and other ingredients [1]. There are a number of related products such as milk ice, water ice and sherbets, etc., which primarily differ in the relative quantities of ingredients. Ice cream ingredients, especially milk fat and milk solid, are used for product classification in accordance with legislation [1,

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2]. According to the Ministry of Public Health Announcements, Issue 222 and 257 (Thailand), there are 5 categories, viz. dairy ice cream, modified fat ice cream, mixed ice cream, ice cream in liquid or dried or powder forms, and sweet and cold ice cream from non-dairy products [3, 4]. Ice cream consumption by Thais is increasing and the market size is forecasted to be 15,000-16,500 million Baht in 2012 [5, 6].

Thai people are familiar with non-dairy ice cream. Coconut milk ice cream is well known and preferred by Thais and foreigners [7, 8]. Other kinds of non-dairy ice cream have been developed such as brown rice ice cream [9], Job's-tears ice cream [10] and soya milk ice cream [9, 11]. Soya milk can be used as a good dairy substitute for ice cream making because it is creamy but soya milk ice cream from the freezer may be hard and need about 15 minutes to soften before serving [12]. In addition, soya milk is a liquid extract of soya bean (*Glycine max* (L) Merrill), a good dietary source containing almost all components of soya bean which are beneficial to health, such as peptide and protein, lectin, trypsin inhibitor, dietary fibre, oligosaccharide, phytin, saponin, isoflavone, linoleic acid, α-linolenic acid, lecithin, tocopherol, plant sterol, vitamin K and magnesium [13, 14]. Several approaches have been undertaken to include more soya bean in the diet for better health of the people and new soya recipes have been developed.

A recipe for ginger-flavoured soya milk ice cream was first developed by Leelarattanakul and Hasun [15]. Ginger (*Zingiber officinale* Rosc.) is used as a cooking spice and herbal remedy. For therapeutic purposes, fresh ginger is used as antiemetic, antiussive, expectorant and is used to induce perspiration and dispel cold, whereas dried ginger is used for stomachache, vomiting and diarrhoea [16]. Fresh ginger is juicy, spicy, refreshing and slightly sweet and has lemon-like aroma and strong bite and it is more aromatic than dried ginger [17]. Ginger contains volatile essential oil and non-volatile compounds such as oleoresins (gingerol and shogaol, the pungent principles of ginger), and other usual organic and inorganic compounds found in food, especially vitamin C, manganese and iron [18].

This study is aimed to improve the ginger-flavoured soya milk ice cream of Leelarattanakul and Hasun [15] by varying the proportion of ginger extract and sucrose to make it more acceptable by consumers. Sensory rating was used to evaluate the products and data analysis was done by three different methods: ideal ratio scores, principal component analysis and analysis of variance, together with mean comparison. Total phenolic content and antioxidant capacity of the selected product were also determined.

MATERIALS AND METHODS

Ingredients and Ice Cream Mix Preparation

Soya bean (Aro brand), coconut milk (Chaokoh brand), tapioca flour (Pagoda brand), glucose (Pure Chem), sucrose (Mitr Phol brand) and mature fresh ginger were used as ingredients.

Soya beans were washed and soaked in water for 6 hours before blending with water at a ratio of 1:4 (soya bean:water). The blended mixture was filtered and the collected soya milk was boiled for 20 minutes before the addition of coconut milk, dispersed tapioca flour, glucose and varied amounts of sucrose and ginger extract (prepared from mature fresh ginger by a juice extractor) as shown in Table 1. The mixture was stirred and heated at 75°C for 15 minutes before rapid cooling and keeping overnight

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in the refrigerator. Ice cream was made by a compressor ice cream maker (JCS Technic Line Co., Ltd.) and it was packed in plastic boxes and kept in the freezer for at least 1 week [15].

Table 1. Composition of ice cream mix (gram (%w/w))

Recipe	Soya milk	Coconut milk	Tapioca flour	Glucose	**Sucrose**	**Ginger extract**
1	3,500 (61)	1,200 (21)	120 (2)	350 (6)	**350 (6)**	**250 (4)**
2	3,500 (60)	1,200 (21)	120 (2)	350 (6)	**400 (7)**	**250 (4)**
3	3,500 (60)	1,200 (21)	120 (2)	350 (6)	**350 (6)**	**300 (5)**
4	3,500 (60)	1,200 (20)	120 (2)	350 (6)	**400 (7)**	**300 (5)**

Sensory Measurement and Chemical Analysis of Selected Recipe

One hundred volunteers were requested to evaluate the flavour and texture, viz. ginger flavour, sweetness, richness [1] and smoothness [19], including their own ideal intensity of each attribute and their preference of each recipe by using the 10 cm-line scale (0 = least, 10 = most).

Total phenolic content was determined by Folin-Ciocalteau micro method [20] and antioxidant capacity of the selected recipe was evaluated by 3 different methods, namely ferric reducing/antioxidative power (FRAP) assay [21], 1,1-diphenyl-2-picryl-hydrazyl (DPPH) free radical scavenging activity [22] and improved 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid) (ABTS) radical cation decolourisation assay [23]. All analyses were done with some modifications [10].

Statistical Analysis

Sensory data was analysed by 3 different methods: ideal ratio scores, principal component analysis [24] and analysis of variance, by 2^2 factorial experiments with an ideal point [25] in randomised complete block design, together with mean comparison by Duncan's new multiple range test. All statistical analyses were done by SPSS 16.0 Family.

RESULTS AND DISCUSSION

Sensory attributes are the main key for consumers' acceptance of the product. For ice cream, rich and creamy, sweet, flavourful [1], smooth and velvety [19] products are desired. These sensory attributes were used for evaluating consumers' acceptance of ginger-flavoured soya milk ice cream. Consumers were requested to taste the products and rate the intensity of sensory attributes before being asked to express their ideal intensity compared to scores of tasted products. These ideal points would be the direction to improve the products.

Sensory Analysis

To calculate ideal ratio scores of each consumer, sample scores were divided by its ideal score for each attribute. The ideal ratio scale of 1.0 indicated that the intensity of the attribute was desired by

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that consumer. The attribute was too weak if the ideal ratio score was less than 1.0 and it was too strong if the ideal ratio score was more than 1.0. Mean ideal ratio scores of all consumers could be interpreted as relative or percentage changes from the ideal. However, mean ideal ratio scores could not be trusted if their standard deviation was higher than 0.5 [24]. The result of mean comparison for ideal ratio scores is shown in Table 2. Almost all of the standard deviation was lower than 0.5 and all distribution could be considered as normal curve which showed the agreement of consumers on the ideal.

For ginger flavour and sweetness, the mean ideal ratio scores of Recipes 2 and 4 were not significantly different ($p>0.05$) from 1.0, the ideal, whilst those of Recipes 1 and 3 were more than the ideal for ginger flavour but less than the ideal for sweetness. The mean ideal ratio score of richness of Recipe 2 was not significantly different ($p>0.05$) from the ideal whilst other recipes were less than the ideal. The mean ideal ratio scores of smoothness of all recipes were significantly lower ($p\leq0.05$) than the ideal. These results showed that Recipe 2 was closest to the ideal product because its intensity of ginger flavour, sweetness and richness were accepted by consumers. Only its degree of smoothness, which was less than the ideal, should be improved by specific ingredients such as emulsifiers and stabilisers and better freezing process [19].

Table 2. Ideal ratio scores (mean $\pm$ standard deviation) of sensory attributes

Recipe	Ginger flavour	Sweetness	Richness	Smoothness
1 (S6, G4)	$1.13^{a} \pm 0.63$	$0.60^{b} \pm 0.17$	$0.60^{c} \pm 0.25$	$0.60^{c} \pm 0.20$
2 (S7, G4)	$\mathbf{0.91^{b}} \pm 0.24$	$\mathbf{1.03^{a}} \pm 0.21$	$\mathbf{0.97^{ab}} \pm 0.14$	$0.92^{b} \pm 0.20$
3 (S6, G5)	$1.17^{a} \pm 0.66$	$0.56^{b} \pm 0.18$	$0.61^{c} \pm 0.21$	$0.63^{c} \pm 0.21$
4 (S7, G5)	$\mathbf{0.95^{b}} \pm 0.28$	$\mathbf{1.03^{a}} \pm 0.23$	$0.93^{b} \pm 0.16$	$0.88^{b} \pm 0.24$
Ideal product	$\mathbf{1.00^{b}}$	$\mathbf{1.00^{a}}$	$\mathbf{1.00^{a}}$	$\mathbf{1.00^{a}}$

Note : S6 = 6%(w/w) sucrose; S7 = 7%(w/w) sucrose; G4 = 4%(w/w) ginger extract;
G5 = 5%(w/w) ginger extract
Means with different letters in the same column were significantly different ($p\leq0.05$).
(1 = ideal point, < 1 = too weak, > 1 = too strong)

The principal component analysis was used to reduce the sensory data of recipes to 2 principal components (PC) [24] with 82.7% variance explained. PC1 (57.7% variance explained) was a representative of sweetness, richness and smoothness, and PC2 (25.0% variance explained) was a representative of ginger flavour (Figure 1). The position of Recipes 1 and 3 on the principal component map (Figure 1) was close to each other but they were far from Recipes 2 and 4 and ideal product because of their stronger ginger flavour (PC1) and weaker sweetness, richness and smoothness (PC2), whilst Recipes 2 and 4 and ideal product were close to one another. The difference between Recipe 2 or 4 and ideal product was not obvious because of some information loss in this method.

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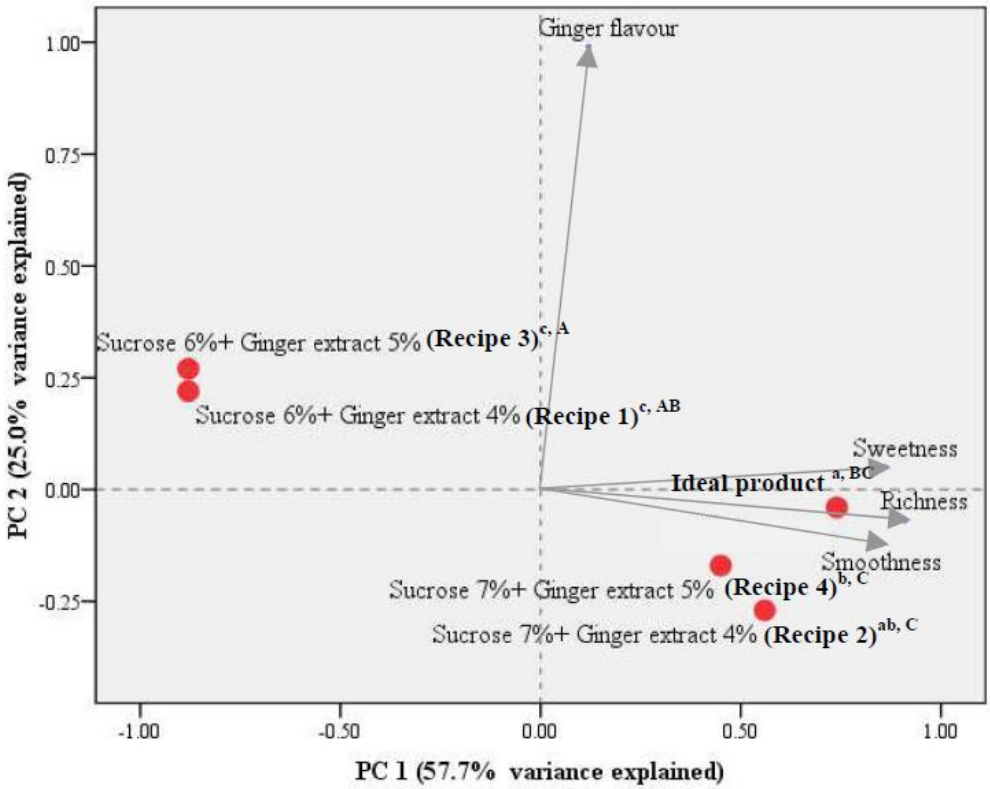

Figure 1. Principal component map of ginger-flavoured soya milk ice cream. Recipes with different letters (a, b, c for PC1 and A, B, C for PC2) were significantly different ($p \leq 0.05$).

The analysis of variance with mean comparison showed that the studied attributes of the developed recipes were close to the ideal point (Table 3). The ginger flavour of Recipes 1, 3 and 4 and ideal point was not significantly different ($p > 0.05$) whilst the sweetness of Recipes 2 and 4 and ideal point, and the richness of Recipe 2 and ideal point were not significantly different ($p > 0.05$). The smoothness of Recipes 2 and 4 were closer to ideal point than that of Recipes 1 and 3. In the case of preference, Recipe 2, with mildest ginger flavour, ideal sweetness, ideal richness and close-to-ideal smoothness, had the highest mean score. The second highest was Recipe 4, with ideal ginger flavour and sweetness, and close-to-ideal richness and smoothness. Recipes 1 and 3, with ideal ginger flavour but poor in sweetness, richness and smoothness, had lower mean preference scores ($p \leq 0.05$).

Table 3. Intensity (mean ± standard deviation) of sensory attributes

Recipe	Ginger flavour	Sweetness	Richness	Smoothness	Preference
1 (S6, G4)	$4.95^{a} \pm 2.19$	$3.44^{b} \pm 1.07$	$3.62^{c} \pm 1.46$	$3.94^{c} \pm 1.58$	$4.23^{c} \pm 1.88$
2 (S7, G4)	$4.30^{c} \pm 1.63$	$5.87^{a} \pm 1.29$	$5.87^{ab} \pm 1.30$	$5.98^{b} \pm 1.54$	$6.93^{a} \pm 1.63$
3 (S6, G5)	$5.11^{a} \pm 2.24$	$3.21^{b} \pm 1.06$	$3.66^{c} \pm 1.32$	$4.15^{c} \pm 1.54$	$4.19^{c} \pm 1.66$
4 (S7, G5)	$4.44^{bc} \pm 1.70$	$5.85^{a} \pm 1.27$	$5.65^{b} \pm 1.28$	$5.72^{b} \pm 1.57$	$6.46^{b} \pm 1.76$
Ideal product	$4.84^{ab} \pm 1.59$	$5.79^{a} \pm 1.10$	$6.11^{a} \pm 1.25$	$6.62^{a} \pm 1.34$	

Note : S6 = 6%(w/w) sucrose; S7 = 7%(w/w) sucrose; G4 = 4%(w/w) ginger extract; G5 = 5%(w/w) ginger extract
Means with different letters in the same column were significantly different ($p \leq 0.05$). (0 = least, 10 = most)

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This preference result accorded with both previous analyses because Recipe 2, which was closer to the ideal product, was more preferred by consumers. However, the mean ideal score of ginger flavour indicated that consumers preferred higher intensity of ginger flavour than that of Recipe 2 (Table 3). This requirement might be attributable to the difference in scale uses of consumers as well as to consumer awareness on the health benefits of ginger. In the first case, the difference in scale could be eliminated by transforming raw data to standardised or related scores. Therefore, this disagreement was not found in the ideal ratio scores. In the second case, ginger is a general spice and a Thai herb recommended for primary health care system [26]. Therefore, consumers tended to rate it high if the decision was made on ginger flavour only, because they wanted to have ginger for health benefit. In this case the ideal information provided by consumers did not correspond to the ideal product in terms of preference but to the ideal in terms of health benefit.

When consumers were asked to evaluate their preference of the products, the overall perception of the products would be considered and the impact of each perception on product preference was not similar. Normally, the satisfaction of overall flavour and texture of the products highly contributed to overall preference [27]. According to a preference estimation model [28], in this study it was: Preference = 1.365 – 0.105 (ginger flavour) + 0.546 (sweetness) + 0.387(smoothness). This model showed a lower impact of ginger flavour compared to sweetness and smoothness whilst the impact of richness was not significantly different ($p>0.05$) and the impact of ginger flavour was negative. Therefore, the intensity of ginger flavour should not be strong for the overall acceptance of product flavour.

In the case of main effect analysis, only sucrose percentage significantly affected the intensity of the four sensory attributes ($p\leq0.05$) (Table 4). Ginger flavour was reduced whilst sweetness, richness and smoothness were increased by adding sucrose. For ginger flavour, it could be explained by taste-taste interaction in which a high intensity of sweetness tends to result in the suppression of other tastes [29]. For tactual properties, the sugar content could affect the consistency and texture of products [19]. Although sucrose and ginger extract significantly influenced consumer preference ($p\leq0.05$), the effect of sucrose content was significantly more pronounced (Table 4).

Table 4. Intensity (mean ± standard deviation) of sensory attributes at each level of sucrose and ginger extract

	Ginger flavour	Sweetness	Richness	Smoothness	Preference
Sucrose					
6% (w/w)	$5.03^{a} \pm 2.21$	$3.33^{b} \pm 1.07$	$3.64^{b} \pm 1.39$	$4.04^{b} \pm 1.56$	$4.21^{b} \pm 1.77$
7% (w/w)	$4.37^{b} \pm 1.67$	$5.86^{a} \pm 1.28$	$5.76^{a} \pm 1.29$	$5.85^{a} \pm 1.56$	$6.70^{a} \pm 1.70$
Ginger extract					
4% (w/w)	4.62 ± 1.95	4.66 ± 1.70	4.74 ± 1.78	4.96 ± 1.86	$5.58^{a} \pm 2.21$
5% (w/w)	4.78 ± 2.01	4.53 ± 1.77	4.65 ± 1.63	4.94 ± 1.74	$5.33^{b} \pm 2.05$

Note : Means with different letters in the same column were significantly different ($p\leq0.05$). (0 = least, 10 = most)

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Chemical Analysis of Selected Recipe

The most preferred recipe with 7%(w/w) sucrose and 4%(w/w) ginger extract was selected for chemical analysis. Its total phenolic content and antioxidant capacity values are shown in Table 5. The phenolic content of the product comes from soya milk and ginger extract. Examples of phenolic compounds found in soya bean are *p*-hydroxybenzoic acid, salicylic acid, *p*-coumaric acid, ferulic acid [30] and isoflavone [13, 14, 30] while in ginger, salicylic acid, cinnamic acid, catechin, rutin, quercetin, flavonoids, among others, are present [31]. The total phenolic content of this soya milk ice cream recipe is higher than that of Job's tears ice cream recipes (9.06-25.14 mg gallic acid equivalent per 100 grams of product) [10, 32] and tofu ice cream recipe (31 mg flavone per kilogram of product) [33]. As for milk ice cream, it contains trace amounts of phenolic compounds probably originated from the milk used but the formation of phenolic compounds by Maillard reaction could occur during pasteurisation of ice cream mixes [34].

Values of antioxidant capacity depend on the mechanism of the methods used [21-23]. However, all antioxidant capacity values which are more than 20% of the daily value (60 mg) of vitamin C [35] show antioxidant potential of this selected recipe owing to phenolic compounds and other antioxidant substances present in the raw materials used in the recipe.

Table 5. Total phenolic content and antioxidant capacity (mean $\pm$ standard deviation) of selected ginger-flavoured soya milk ice cream (3 replications)

	Recipe with 7%(w/w) sucrose and 4%(w/w) ginger extract
Total phenolic content (mg gallic acid equivalent per 100 grams of product)	91.6 + 6.8
Antioxidant capacity (mg vitamin C equivalent per 100 grams of product)	
FRAP	37.9 + 3.7
DPPH	13.4 + 1.2
ABTS	49.0 + 5.1

CONCLUSIONS

The overall results of ideal ratio scores, principal component analysis and analysis of variance, together with mean comparison in this study, were equivalent but the result of a single attribute such as ginger flavour might be misleading if analysis of variance was used only. The attributing ideal point showed that the intensity of ginger flavour should be high whereas the overall preference revealed that ginger flavour should be in the low level because it was more preferred. Since food was a complex matrix, many interactions could occur and the impact of each perception on consumer preference was not equal. Both the attribute and overall preference should be comparatively studied. This contradiction of ginger flavour was not found in the ideal ratio scores because dividing sample scores by ideal score diminished the difference of scale used for each consumer. Consumer disagreement on ideal ratio scores could be observed from a high standard deviation but it was not found for the selected sample in this study. For principal component analysis, it was found to be a good technique because the detail might be disregarded.

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