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Caloric Reduction in Mungbean Conserve Filling of Flaky Chinese Pastry

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ABSTRACT

This research aimed to develop reduced-calorie flaky Chinese pastry by reducing the oil and sugar contents. Inulin solution (I) was used as a fat replacer combined with sorbitol (Sor) or maltitol (Mal) solution as a sugar replacer in mungbean conserve filling. The factorial completely ramdomized design experiment involved reducing the oil (RF) level by 0, 25, 50 and 75% of the oil weight and sugar (RS) level was reduced by 0, 10, 20 and 30% of the sugar weight. The results showed that the scores for all characteristics tested except for the bean odor of RF25/RS0 (25% fat reduction combined with 0% sugar reduction) were not significantly different from RF0/RS0 ($P > 0.05$). Then, inulin solution at levels of 80, 90 and 100% (w/w) were combined with sorbitol or maltitol solution at levels of 10, 20 and 30% (w/w). These combinations respectively replaced the oil and sugar in the RF25/RS0 formula. The hardness of the pastry significantly increased as the level of replacement of the fat and sugar increased. However, the overall liking of the pastry from the I80/Mal10 formula was at the moderate level which was not significantly different from RF25/RS0 ($P > 0.05$). In addition, the fat and energy contents of the I80/Mal10 formula decreased by 69.44 and 25.51%, respectively from those of full-fat formula. Furthermore, the amounts of cholesterol and total saturated fat were 1.57 mg and 1.69 g per serving size (30 g). This product could be claimed to be "reduced-calorie", "reduced-fat" and "cholesterol-free".

Keywords: Chinese pastry, reduced-calorie, inulin, sorbitol, maltitol

INTRODUCTION

Flaky Chinese pastry (*pia*), is a preferred type of puff pastry in which the sweet filling is stuffed inside thin, soft layers of flaky crust (Thai Industrial Standards Institute, 2006). However, fat is a major ingredient in this product and fat is associated with several chronic diseases such as obesity, hypercholesterolemia and the causes of cancer, among others (Garrow *et al*., 2000; Veerotai, 2002). The recommended total daily fat intake should not be more than 30% of the total caloric intake and saturated fat should be less than 10% (Garrow *et al*., 2000; Calorie Control Council, 2004). Since the mungbean conserve filling is composed of high fat and sugar, to develop the reduced-caloric flaky Chinese pastry, the fat and sugar in this filling has to be reduced or substituted with a fat replacer such as inulin and a sugar replacer such as sorbitol or maltitol. Sorbitol

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and maltitol are sugar alcohols. Sorbitol provides 50–60% of the sweetness of sucrose and 2.6 kcal of energy/g. It also has humectant properties so that it retains moisture under certain conditions of relative humidity (Kanto, 2002). Maltitol is a sweetener used specifically in confectionary and bakery products (Calorie Control Council, 2005). Its sweetness value is 70–80% that of sugar and its energy content is only 2.1 kcal/g. Therefore, this research aimed to develop a formula for reduced-calorie, flaky Chinese pastry to achieve a minimum 25% caloric content reduction. Physical and sensory characteristics including the nutritional quality were determined in the study.

MATERIALS AND METHODS

Materials

All-purpose wheat flour (Kite), cake flour (Red lotus), shortening (Cream Topp), rice bran oil (King), cane sugar (Mitr phol), peeled mungbean (Raitip), egg yolk and fragrant candle (Thavorntanasarn) were used as ingredients for the flaky Chinese pastry. Inulin (Raftiline HP) was used as the fat replacer, while sorbitol and maltitol (Pure Chem Co. Ltd.) at solution levels of 70% were used as sugar replacers.

Preparation of fat replacer

The inulin solution used in the filling was prepared by dissolving inulin powder at 15% (w/w) in boiling water (modified from Vatanasuchart *et al*., 1998).

Production of flaky Chinese pastry

This product consisted of the crust and the filling (Table 1). The inner crust was prepared by mixing cake flour and shortening together using the low speed on a mixer (Kitchen Aid, Model 5KPM50) for 3 min. Then, this inner dough was divided into 3-gram pieces and rested for 10 min. The outer crust was prepared by mixing the ingredients listed in Table 1 at a medium mixer speed for 3 min. This dough was divided into

Table 1 Ingredients of flaky Chinese pastry (full fat formula and reduced-fat crust formula) and mungbean conserve.

Ingredient	Amount (% w/w)	
	Full-fat formula (UFM Baking and Cooking School, 1995)	Reduced-fat crust (Chysirichote *et al*., 2011)
Crust		
- Inner crust		
Cake flour	27.45	28.77
Shortening	10.98	11.51
- Outer crust		
All-purpose flour	31.37	32.88
Shortening	10.20	2.94
Inulin gel	-	2.94
Sugar	6.27	6.57
Water	13.73	14.39
Filling (mungbean conserve)		
Peeled mungbean, steamed and mashed	51.28	-
Sugar	30.77	-
Rice bran oil	17.95	-

5-gram samples and rested for 15 min. Then, the inner dough was wrapped with the outer dough and the combined sample was rolled and three-folded twice. The mungbean conserve (15 g) was wrapped in the crust dough and baked in an electric oven (EKA, Model 648E) at 200 ^{o}C for 15 min. After baking, the pastries were removed from the tray, allowed to cool on a wire rack for 30 min at room temperature and kept in plastic boxes to prevent drying before being measured for physical properties and sensory evaluation within 18 hr.

Mungbean conserve was prepared by soaking dehulled mungbean in water for 2 hr and then steaming for 30 min before mashing finely. Finally, the conserve was mixed with sugar and rice bran oil and stirred in a pan at 80 ^{o}C for 20 min.

Reduction of oil and sugar in mungbean conserve filling

The reduced-fat crust (shell) recipe from Chysirichote *et al*. (2011) was used in the current study (Table 1). Based on the original recipe weights, four levels of reduction of the oil (0, 25, 50 and 75%) and four levels of reduction of the sugar (0, 10, 20 and 30%) in the filling were used in a factorial completely randomized design (CRD) with two replications of each treatment. The filling containing 0% reduced-oil and 0% reduced sugar (RF0/RS0) was used as the control. All treatments which provided a product suitable for manufacturing (having many thin layers of crust and being soft and having an unbroken surface) were selected for measurement of their physical qualities and sensory evaluation. The formula containing the greatest reduction in the amounts of oil and sugar and approaching the characteristics of the control was selected for further testing of fat and sugar replacement.

Water activity (a_w) was determined by a Water Activity Meter (Hygro Lab, Model Rotranic) at 25 ^{o}C. The samples in each treatment were chopped into small pieces and used to fill a plastic disposable cup to two-thirds capacity. Each sample was measured by placing the cup into the sample holder and taking a reading. Five replications were measured to obtain an average value for a_w. Texture profile analysis was determined to evaluate the texture of the pastries using a Texture Analyzer (Stable Micro System, Model TA-XT2i, England) with the 50 mm diameter cylinder probe (P/50) and conditions of 1.0 mm.s^{-1} test speed, 50% strain and 1.0 s test time were used to measure hardness, fracturability, springiness, cohesiveness and chewiness with the necessary calculations carried out using a Texture Exponent 32 software program (Stable Micro Systems LTD., UK). At least five measurements were taken to obtain an average value o f all texture parameters for each formulation.

The color of the crust and the filling of each sample were measured separately. The crust color was measured based on the whole crust. Then, the crust was peeled off to expose only the filling for color measurement. Color values were expressed as L*(lightness), a*(redness/greenness) and b*(yellowness/blueness) by a Chromameter (Ultra Scan, Model XE/IX7, USA). Five readings were made for all measurements and the mean values were calculated.

The size (diameter and height) of each sample was measured by vernier calipers. The specific volume of each sample was determined by sesame seed displacement (Lee *et al*., 1982). The product was weighed (W_0). The empty container was filled with sesame seed and the volume of the sesame seeds was determined using a graduated cylinder (V_1). The sample was placed in the container, which was filled with sesame seed and the seed volume then determined using a graduated cylinder (V_2). The difference between V_1 and V_2 was defined as the sample volume (V_0). The specific volume was calculated as the ratio of the volume to weight (V_0/W_0).

Sensory evaluation was conducted using a randomized complete block design and

descriptive analysis with 12 trained panelists. Panelists were selected from lecturers and staff who were teaching and working in the bakery field at the Suan Dusit School of Culinary Arts based on their ability to classify different samples using a triangle test. They were trained for the descriptive analysis with the development of terms to describe product attributes. They were trained to use a scale to define the Chinese pastry attributes (crust appearance, filling appearance, filling color, crust odor, bean odor, crust softness, filling softness, filling brittleness and sweetness) and also trained in defining sample intensity using a reference standard (full-fat formula, UFM baking and cooking school). The panelists were trained twice a week for four weeks. These attributes were rated on a 15 cm-line scale for all the characteristics mentioned above with the lines anchored from "not" to "very" for each attribute (applied from Leslie, 1999; Pimdit *et al*., 2008). For sample evaluation, each trained panelist was presented with individual samples (about 22 g per piece) which were placed on a tray in a plastic bag coded with a three-digit random number and served in a randomized order. A scorecard, napkin, pencil and a glass of room temperature water were provided together with samples. Drinking water was provided to minimize any residual effect before tasting the next sample. The descriptive analysis was conducted with two replications.

Substitution of fat replacer and sugar replacer in filling

Using a factorial CRD with two replications for each treatment, three levels of inulin solution (80, 90 and 100%) were used to replace the oil weight in the reduced-oil formula and combined with three levels of sorbitol or maltitol solution (10, 20 and 30%) which replaced the sugar on a weight basis. These samples were brushed with egg yolk before baking and smoked with fragrant candle for 2 hr after baking and then cooled (Yodsirivichaikul, 2008), according to the suggestion of panelists in the previous experiment. This study was tested on the selected formula without substitution which was used as the control. The levels of substitution for the oil and sugar were determined based on practicability of measurement of the physical qualities and sensory evaluation.

Physical qualities (water activity, texture, crust and filling color, size and specific volume) were tested according to previously described methods.

For sensory evaluation, the descriptive analysis was performed using 12 trained panelists who were trained from the former experiment. They were trained to use a scale to define the Chinese pastry attributes in a similar manner as in the earlier experiment but with the additional attributes of crust color and fragrance from the candle smoke and their intensity using the full-fat formula (UFM Baking and Cooking School (1995) as the reference standard. The panelists were trained twice a week for two weeks. These attributes were rated on a 15 cm-line scale for all characteristics mentioned above. Moreover, 42 untrained panelists (students and staff of Suan Dusit Rajabhat University) were used to evaluate the affective test in the laboratory (Stone and Sidel, 1993). Each panelist was presented with individual samples (about 22 g per piece). These samples were prepared and served according to the previously described method. Panelists were asked to rate their liking of the quality attributes according to appearance, filling color, odor, crust softness, filling softness, filling brittleness, sweetness and overall liking of each sample using a 9-point hedonic scale (1=dislike extremely, 5=neither dislike nor like and 9=like extremely). The formula of the sample which received the highest score was selected for nutritional analysis.

Determination of nutritional quality

The nutritional qualities of the final product were determined for comparison with those of the full-fat formula of UFM (1995).

Standard methods of AOAC (2000) were used for proximate analysis and determination of the cholesterol, trans-fatty acid and total saturated fat.

Statistical analysis

Data obtained from this study were subjected to analysis of variance using the statistical package SPSS for Windows version 12.0 (SPSS (Thailand) Co., Ltd.) and significant effects of treatment means were tested at a level of $P \leq 0.05$ using Duncan's new multiple range test (Khuantham, 1999).

RESULTS AND DISCUSSION

Reduction of oil and sugar in mungbean conserve filling

The fillings with 75% oil reduction and either 20% or 30% sugar reduction were crumbly and not able to make a satisfactory product; therefore, those formulas were discarded. The other six filling formulas, in which the oil weight (RF) was reduced by levels of 0, 25 and 50% respectively, with a combination of sugar reduction (RS) by levels of either 0% or 10%, provided a smooth texture and could make a satisfactory product. This may be explained by the fact that oil is a lubricant and coats the sugar crystals to prevent the enlargement of crystals during heating. Increasing the concentration of sugar combined with decreasing the oil content caused the filling to be dry and crystallization occurred (Vaclavik and Elizabeth, 2008).

Table 2 shows the physical qualities of the six treatments with various reduced amounts of oil and sugar in the filling. Reducing either the oil or sugar in the filling formula resulted in significantly increased water activity. Hardness, cohesiveness and chewiness values increased significantly with decreased reduction in the amounts of oil and sugar. On the contrary, springiness decreased with the reduction rate in the amounts of oil and sugar. This may have been due to the humectant property

Table 2 Physical qualities of the products in which oil and sugar content in the filling were reduced (mean ± standard deviation).

Parameter	Reduction of oil and sugar in the filling					
	RF0/RS0 (Control)	RF0/RS10	RF25/RS0	RF25/RS10	RF50/RS0	RF50/RS10
Water activity (a_w)	0.795 ±0.01^{e}	0.836 ±0.00^{b}	0.823 ±0.00^{d}	0.839 ±0.00^{b}	0.830 ±0.00^{c}	0.848 ±0.00^{a}
Texture						
Hardness (gf)	1888.56 ±1.93^{b}	1897.53 ±1.29^{b}	1919.04 ±1.53^{b}	1978.60 ±2.36^{b}	1982.37 ±3.63^{b}	2140.05 ±2.67^{a}
Fracturability^{ns} (gf)	1587.55 ±3.63	1587.65 ±2.21	1588.18 ±3.03	1598.83 ±2.04	1595.14 ±2.06	1617.05 ±2.74
Springiness (mm)	0.315±0.00^{a}	0.309±0.01^{ab}	0.309±0.00^{ab}	0.305±0.00^{abc}	0.297±0.01^{bc}	0.293±0.01^{c}
Cohesiveness	0.090±0.00^{d}	0.095±0.00^{d}	0.102±0.01^{c}	0.111±0.00^{b}	0.118±0.00^{a}	0.119±0.00^{a}
Chewiness (gf.mm)	76.20 ±2.62^{d}	76.50 ±0.54^{cd}	79.75 ±2.60^{bc}	80.51 ±1.01^{b}	80.95 ±1.29^{b}	85.65 ±1.95^{a}
Crust color value						
Lightness (L*)	71.03±0.83^{c}	75.33±2.42^{b}	77.14±0.51^{ab}	76.75±0.54^{ab}	77.85±0.64^{a}	78.27±0.42^{a}
Redness (a*)	1.85±0.09^{ab}	1.57±0.07^{ab}	1.86±0.11^{a}	1.55±0.10^{b}	1.60±0.34^{ab}	1.20±0.03^{c}
Yellowness (b*)	18.81±1.08^{a}	19.07±1.65^{a}	18.67±0.73^{a}	18.08±0.73^{ab}	16.82±0.15^{bc}	16.17±0.43^{c}
Filling color value						
Lightness (L*)	56.13±0.29^{e}	57.28±0.80^{de}	58.19±0.27^{cd}	58.90±0.73^{c}	61.75±1.20^{b}	63.13±0.84^{a}
Redness (a*)	9.96±0.26^{a}	9.30±0.22^{b}	9.87±0.12^{ab}	8.41±0.44^{c}	9.30±0.19^{b}	8.48±0.56^{c}
Yellowness (b*)	41.87±0.23^{c}	42.04±1.40^{c}	44.50±0.74^{b}	43.12±0.28^{c}	46.05±0.47^{a}	44.68±0.26^{b}
Size (cm.)						
Diameter^{ns}	3.68±0.03	3.70±0.05	3.70±0.05	3.68±0.03	3.68±0.03	3.65±0.03
Height	3.07±0.03^{b}	3.18±0.08^{a}	3.25±0.05^{a}	3.23±0.03^{a}	3.18±0.03^{a}	3.27±0.03^{a}
Specific volume ($cm^3.g^{-1}$)	1.25±0.02^{a}	1.17±0.03^{b}	1.16±0.03^{b}	1.15±0.05^{b}	1.15±0.04^{b}	1.14±0.03^{b}

$^{a, b, c, d, e}$ = Means within the same row are significantly different ($P \leq 0.05$).

^{ns} = Means within the same row are not significantly different ($P > 0.05$).

of sugar and the tenderizing property of fat. The lightness value (L*) of both the crust and filling significantly increased when the amounts of oil and sugar decreased. This was due to a reduction of pigments (particularly carotenoids) provided by the oil and in the brown color from caramelization and the Maillard reaction (Vaclavik and Elizabeth, 2008; Belitz *et al*., 2009). Furthermore, the diameters of the products were not significantly different, though there were significant differences in height and specific volume due to the reduction in the amounts of oil and sugar in the filling (Gisslen, 2005).

The sensory qualities of the six treatments assessed by the 12 trained panelists are shown in Table 3. Crust and filling appearance, filling color, bean odor and filling softness values gradually decreased while the crust odor and filling brittleness increased when the amounts of oil and sugar were reduced. All characteristic scores (except for bean odor in both treatments) with 0% oil reduction and 10% sugar reduction (RF0/RS10) and 25% oil reduction and 0% sugar reduction (RF25/RS0) were not significantly different from the control (RF0/RS0). However, oil contains 9 kcal.g^{-1}, whilst sugar contains less than 4 kcal.g^{-1}. Therefore, the caloric value in the product should be lower with lower amounts of fat (Garrow *et al*., 2000; Veerotai, 2002). Therefore, the RF25/RS0 formula was selected for further study.

Substitution of fat replacer and sugar replacer in filling

The filling formula of RF25/RS0 was compared with the filling with inulin solution as fat replacer and sorbitol solution or maltitol solution as sugar replacer. It was found that the products with increasing levels of fat and sugar replacer were more sticky and lighter. Substitution at a level of 100% fat replacement including 20% and 30% replacement with sorbitol or maltitol solution resulted in a dry and brittle filling; therefore, all of these treatments were excluded from the study.

Table 4 presents the physical properties of the treatments in which amounts by weight of the oil and sugar in RF25/RS0 were replaced by inulin solution (80% and 90%) combined with 10% sorbitol or maltitol solution. The formulas containing substituted fat and sugar were found to have higher values for a_w than the control (RF25/RS0) because the inulin solution contained more water. Additionally, the sorbitol solution produced

Table 3 Descriptive analysis of products in which oil and sugar content in the filling were reduced (mean ± standard deviation).

Attribute	Reduction of oil and sugar in the filling					
	RF0/RS0 (Control)	RF0/RS10	RF25/RS0	RF25/RS10	RF50/RS0	RF50/RS10
Crust appearance	6.20±1.01^{a}	5.73±1.02^{ab}	6.06±1.01^{ab}	5.86±1.09^{ab}	4.86±0.88^{bc}	4.24±1.07^{c}
Filling appearance	7.04±1.34^{a}	6.84±1.00^{ab}	7.18±1.02^{a}	4.59±1.08^{c}	5.75±1.04^{b}	3.14±1.06^{d}
Filling color	6.83±1.21^{a}	6.33±1.08^{ab}	6.69±1.04^{a}	4.75±0.64^{c}	5.65±1.24^{bc}	2.66±1.05^{d}
Crust odor	3.92±1.00^{b}	4.14±0.96^{b}	4.67±1.39^{ab}	5.48±1.28^{a}	4.73±0.52^{ab}	5.61±1.02^{a}
Bean odor	5.08±0.57^{a}	3.89±1.08^{b}	3.68±1.33^{b}	3.93±1.51^{b}	4.33±1.28^{b}	3.58±1.04^{b}
Crust softness^{ns}	3.39±1.36	3.37±1.17	4.26±1.52	4.18±1.50	4.54±1.55	4.67±1.11
Filling softness	6.04±0.63^{a}	7.05±1.01^{a}	6.79±1.48^{a}	4.66±1.31^{b}	6.82±0.76^{a}	4.35±1.09^{b}
Filling brittleness	2.75±1.35^{c}	2.51±0.91^{c}	3.04±1.02^{c}	4.87±1.39^{b}	4.18±1.05^{b}	5.96±0.33^{a}
Sweetness	5.77±1.06^{a}	5.65±1.21^{a}	6.30±1.00^{a}	4.05±0.49^{b}	4.41±1.24^{b}	3.75±1.02^{b}

^{a,b,c} = Means within the same row are significantly different ($P \leq 0.05$).

^{ns} = Means within the same row are not significantly different ($P > 0.05$).

significantly higher values for a_w than the maltitol solution.

Hardness, cohesiveness and chewiness increased with the increased replacement of fat and sugar with the substitutes, while fracturability and springiness were not affected. Increasing the level of oil replacement with inulin solution seemed to significantly increase the chewiness value, perhaps because moisture in the inulin solution and the fat reduction resulted in a dense texture for the products (Kim *et al.,* 2001).

The color of the crust and the filling were measured separately. The lightness (L*) and redness (a*) values of crust from the products with fat and sugar replacers were significantly higher than those of RF25/RS0, whereas the redness (a*) values of filling from those products were significantly lower than that of RF25/RS0; however, their lightness (L*) values were similar to that of the crust. Similarly, the study of Hemtanont (2004) revealed that the L* values of steamed cassava dessert gradually increased with the addition of sorbitol. Moreover, this increase may have been due to the inulin solution being prepared by dissolving in water so that it was whiter, thicker and its moisture content was higher than that of oil (Kim *et al*., 2001). The yellowness (b*) values of the crust and filling from all treatments were not significantly different, owing to the xanthophyll pigment in the egg yolk which was brushed on the surface of products (Gisslen, 2005).

The diameters of products were not significantly different but the heights and specific volumes were significantly different from those of RF25/RS0 because of the water-holding property of inulin (Kim *et al*., 2001).

Table 4 Physical qualities of products containing fat replacer and sugar replacers in 25% reduced-oil filling (mean ± standard deviation).

Parameter	RF25/RS0	Replacement of fat replacer and sugar replacer in the filling			
	(Control)	I 80/Sor10	I 90/Sor10	I 80/Mal10	I 90/Mal10
Water activity (a_w)	0.832±0.00^{c}	0.852±0.00^{a}	0.854±0.00^{a}	0.842±0.00^{b}	0.843 ±0.00^{b}
Texture					
Hardness (gf)	2022.76 ±7.17^{b}	2069.79 ±5.04^{b}	2159.96 ±1.51^{a}	2041.55 ±5.64^{b}	2090.27 ±4.08^{ab}
Fracturability ^{ns} (gf)	1595.86 ±4.04	1596.59 ±5.19	1597.28 ±9.22	1587.79 ±5.34	1590.20 ±0.51
Springiness^{ns} (mm)	0.293±0.01	0.291±0.00	0.287±0.01	0.292±0.01	0.292±0.01
Cohesiveness	0.099±0.00^{c}	0.121±0.00^{b}	0.130±0.00^{a}	0.117±0.01^{b}	0.130±0.00^{a}
Chewiness (gf.mm)	82.62 ±2.65^{c}	87.55 ±1.70^{bc}	94.38 ±3.75^{a}	88.85 ±0.65^{b}	93.88 ±3.52^{a}
Crust color value					
Lightness (L*)	73.03±0.06^{b}	74.67±0.30^{a}	74.91±0.13^{a}	74.65±0.35^{a}	74.80±0.20^{a}
Redness (a*)	5.44±0.82^{b}	5.72±0.17^{a}	5.77±0.14^{a}	5.73±0.09^{a}	5.76±0.11^{a}
Yellowness (b*)^{ns}	38.15±0.32	38.61±0.57	38.41±0.69	38.69±1.90	38.56±0.43
Filling color value					
Lightness (L*)	58.20±0.22^{b}	68.78±2.22^{a}	69.43±0.68^{a}	69.67±1.51^{a}	70.58±1.57^{a}
Redness (a*)	9.91±0.13^{a}	5.61±0.57^{b}	5.79±0.48^{b}	5.23±0.45^{b}	5.36±0.33^{b}
Yellowness (b*)^{ns}	44.71±0.33	44.19±0.35	43.90±0.16	44.52±0.57	44.63±0.63
Size (cm)					
Diameter^{ns}	3.72±0.03	3.68±0.03	3.68±0.03	3.70±0.05	3.68±0.03
Height	3.22±0.03^{b}	3.32±0.03^{a}	3.35±0.00^{a}	3.35±0.00^{a}	3.35±0.00^{a}
Specific volume ($cm^3.g^{-1}$)	1.17±0.01^{b}	1.20±0.01^{a}	1.19±0.01^{a}	1.20±0.02^{a}	1.19±0.01^{a}

$^{a, b, c}$ = Means within the same row are significantly different ($P \leq 0.05$).

^{ns} = Means within the same row are not significantly different ($P > 0.05$).

The sensory qualities assessed by the descriptive analysis of five treatments by 12 trained panelists are shown in Table 5. There were no significant differences in crust appearance, crust odor and bean odor. On the contrary, filling appearance, crust and filling color, fragrance from candle smoke, crust and filling softness, filling brittleness and sweetness in the products containing the fat replacer and sugar replacers were significantly different from the control (RF25/RS0). Crusts were glossy and their color was moderately yellow because of the xanthophyll pigment and fat in the egg yolk (Gisslen, 2005). The score for odor from the smoke candle in the control was significantly higher than in the other products because the fragrance from the smoke candle could be dissolved in oil better than in the carbohydrate-based fat replacer (Calorie Control Council, 2004). There was a noticeable change in the sensory characteristics of the product caused by the inulin solution and sugar replacers (sorbitol or maltitol).

These five treatments were rated by 42 untrained panelists for degree of liking as shown in Table 6. There were significant differences in appearance, filling color, crust softness, filling softness and overall liking. In contrast, odor, filling brittleness and sweetness were not significantly different. The liking scores of all attributes were between the slight and moderate levels. This result may imply that the softness of the products decreased as the level of inulin increased. The liking scores with the exception of crust softness of the products with I80/Mal10 were not significantly different from the control and I90/Mal10. In addition, it was observed that the higher scores for all attributes with I80/Mal10 replacement resulted in an increase in the overall liking score more than in the products from other treatments. Therefore, this product was selected with a filling formulation consisting of 53.69% steamed and mashed peeled mungbean, 28.99% sugar, 3.22% maltitol solution, 2.82% rice bran oil and 11.28% inulin solution.

Nutritional quality of product

The nutritional qualities of the products from the full-fat formula (UFM Baking and Cooking School, 1995) and the developed product

Table 5 Descriptive analysis of products containing fat replacer and sugar replacers in 25% reduced-oil filling with egg wash and scented candle smoking (mean ± standard deviation).

Attribute	RF25/RS0 (Control)	Replacement of fat replacer and sugar replacer in the filling			
		I 80/Sor10	I 90/Sor10	I 80/Mal10	I 90/Mal10
Crust appearance^{ns}	6.41±0.80	6.93±0.84	6.76±1.05	6.78±0.90	6.71±0.87
Filling appearance	7.02±0.76^{a}	6.07±1.03^{b}	5.44±0.88^{c}	6.16±0.96^{b}	5.54±0.85^{c}
Crust color	6.26±0.93^{a}	5.84±0.82^{b}	5.75±0.76^{b}	5.84±0.82^{b}	5.80±0.80^{b}
Filling color	6.51±0.71^{a}	5.04±0.71^{bc}	4.43±0.88^{c}	5.38±0.72^{b}	5.18±0.81^{b}
Crust odor^{ns}	4.43±0.87	4.63±1.11	4.83±0.86	4.83±0.76	4.84±0.83
Bean odor^{ns}	3.62±0.79	4.11±0.94	3.66±0.72	4.03±0.76	3.74±0.48
Fragrant from candle smoke	7.04±0.84^{a}	6.25±0.78^{b}	5.67±0.78^{c}	6.25±0.78^{b}	5.71±0.81^{c}
Crust softness	5.73±0.81^{a}	5.30±0.79^{b}	4.99±0.66^{c}	5.31±0.74^{b}	5.03±0.61^{bc}
Filling softness	6.87±0.96^{a}	5.15±0.95^{bc}	4.29±0.71^{d}	5.51±0.54^{b}	4.78±0.93^{cd}
Filling brittleness	3.01±0.22^{c}	4.21±0.91^{ab}	4.90±0.88^{a}	4.12±0.84^{b}	4.71±1.02^{ab}
Sweetness	6.15±1.06^{a}	5.03±0.63^{b}	4.98±0.82^{b}	5.23±0.45^{b}	5.07±0.72^{b}

$^{a, b, c, d}$ = Means within the same row are significantly different ($P \leq 0.05$).

^{ns} = Means within the same row are not significantly different ($P > 0.05$).

(I80/Mal10) are shown in Table 7. According to nutrition labeling, food which is reduced by at least 25% of the caloric value of the regular product can be claimed as "reduced-calorie" and food which is reduced by at least 25% of the fat of the regular product can be claim as "reduced-fat", while food containing less than 2 mg cholesterol and 2 g or less saturated fat per reference serving size (30 g) can be claimed as "cholesterol-free" (Calorie Control Council, 2004). The fat and total energy contents of the final developed product were less than those of the full-fat formula by 69.44 and 25.51%, respectively. Additionally, the cholesterol and total saturated fat contents of the final product were 1.57 mg and 1.69 g per reference serving size (30 g), respectively; therefore, this product can be declared as "reduced-calorie", "reduced-fat" and "cholesterol-free" flaky Chinese pastry.

CONCLUSION

The study aimed to develop reduced-

Table 6 Means 9-point hedonic scores of products containing fat replacer and sugar replacers in 25% reduced-oil filling with egg wash and scented candle smoking (mean ± standard deviation).

Attribute	RF25/RS0 (Control)	Replacement of fat replacer and sugar replacer in the filling			
		I 80/Sor 10	I 90/Sor 10	I 80/Mal 10	I 90/Mal 10
Appearance	7.03±0.51^{a}	6.63±0.81^{ab}	6.34±1.33^{b}	7.03±0.86^{a}	6.59±0.51^{ab}
Filling color	7.25±0.52^{a}	6.22±0.31^{c}	6.09±0.52^{c}	6.91±0.96^{ab}	6.59±0.91^{bc}
Odor^{ns}	6.28±0.64	6.47±0.41	6.25±0.21	6.56±0.84	6.38±1.00
Crust softness	6.78±1.01^{b}	6.59±1.04^{b}	6.63±0.94^{b}	7.31±1.00^{a}	6.91±0.96^{ab}
Filling softness	7.06±0.84^{a}	6.09±0.33^{bc}	5.94±0.50^{c}	6.81±0.81^{a}	6.56±0.80^{ab}
Filling brittleness^{ns}	6.50±0.81	6.25±0.30	6.00±0.43	6.75±0.42	6.22±0.43
Sweetness^{ns}	6.94±0.86	6.53±0.73	6.28±0.30	6.78±0.21	6.38±0.61
Overall liking	7.03±0.64^{a}	6.28±0.22^{b}	6.25±0.20^{b}	6.91±0.51^{a}	6.75±0.95^{ab}

$^{a, b, c}$ = Means within the same row are significantly different ($P \leq 0.05$).

^{ns} = Means within the same row are not significantly different ($P > 0.05$).

Table 7 Nutritional qualities of flaky Chinese pastry which contained 45% reduced fat with 50% inulin gel replacement in the crust, which was stuffed with 25% reduced oil with 80% inulin solution and 10% maltitol solution (developed product) and standard full-fat formula (control).

Nutritional quality	Full-fat formula	Developed product
Moisture (%)	15.44	21.97
Protein (%)	7.30	8.44
Fat (%)	25.56	7.81
Ash (%)	0.73	0.63
Fiber (%)	1.37	1.94
Carbohydrate (%)	49.60	59.21
Total Calories (kcal per100g)*	457.64	340.89
Cholesterol (mg per100 g)	6.43	5.23
Total saturated fat (g per 100g)	6.15	5.62
Trans fatty acid (g per100g)	0.07	0.00

* Calorific value by calculation.

calorie, flaky Chinese pastry by using fat replacer and sugar replacers. The trained panelists preferred the pastry with 25% reduced oil but with no reduced-sugar filling. The pastries with inulin and sorbitol solution were harder than those with maltitol solution as sugar replacer. Moreover, untrained panelists liked at the moderate level the pastry which had 80% inulin solution and 10% maltitol solution, respectively replacing the oil and sugar weight in 25% reduced-oil filling. The inner crust formula consisted of 28.77% cake flour with 11.51% shortening, and the outer crust was composed of 32.88% all-purpose flour, 2.94% shortening, 2.94% inulin gel, 6.57% sugar and 14.39% water. The filling formula consisted of 53.69% steamed and mashed peeled mungbean, 28.99% sugar, 3.22% maltitol solution, 2.82% rice bran oil and 11.28% inulin solution. According to the nutritional values of this formula, fat and total calories could be reduced by 69.44 and 25.51%, respectively. The cholesterol and total saturated fat contents were 1.57 mg and 1.69 g per serving size (30 g). Thus, this product could be claimed as "reduced-calorie", "reduced-fat" and "cholesterol-free".

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LITERATURE CITED

AOAC. 2000. **Official Methods of Analysis.** 17th ed. Association of Official Analytical Chemists. Washington D.C.

Belitz, H.-D., W. Grosch and P. Schieberle. 2009. **Food Chemistry.** 4th ed. (revised and extended), Springer-Verlag Berlin Heidelberg. 1070 pp.

Calorie Control Council. 2004. **Fat replacers: Food ingredients for healthy eating.** [Available from: http://www.caloriecontrol.org/fatreprint.htm]. [Cited: 26 January 2006].

_____. 2005. **Polyols in sugar free and reduced calorie food and beverages.** [Available from: http://www.caloriecontrol.org/redcalqa.htm]. [Cited: 18 August 2006].

Chysirichote, T., A. Utaipatanacheep and W. Varanyanond. 2011. Effect of reducing fat and using fat replacers in the crust of flaky Chinese pastry. **Kasetsart J. (Nat. Sci.)** 45(1): 120–127.

Garrow, J.S., W.P.T. James and A. Ralph. 2000. **Human Nutrition and Dietetics.** 10th ed., Elsevier, Philadelphia, PA, USA. 901 pp.

Gisslen, W. 2005. **Professional Baking.** 4th ed., John Wiley & Sons, Hoboken, NJ, USA. 701 pp.

Hemtanont, P. 2004. **Development of Steamed Cassava Dessert from Cassava Flour KU-50 Variety.** MSc.thesis. Kasetsart University, Bangkok.

Kanto, P. 2002. **Shelf Life Extension of Khanom Pia (Chinese Cake) by Using Humectant and Packaging,** [in Thai]. MSc.thesis. Kasetsart University, Bangkok.

Khuantham, A. 1999. **Principle of Experimental Design**, [In Thai]**.** Kasetsart University, Bangkok. 348 pp.

Kim,Y., M.N. Faqih and S.S. Wang. 2001. Factors affecting gel formation of inulin. **Carbohydr. Polym.** 46: 135–145.

Lee, C.C., R.C. Hoseney and E.Varriano-Marston. 1982. Development of a laboratory scale single stage cake mix. **Cereal Chem.** 59(2): 389–392.

Leslie, L.A. 1999. **Evaluation of a Maltodextrin Gel as Partial Replacement for Fat in a High-Ratio White-Layer Cake Formulation.** MSc.thesis, Virginia Polytechnic Institute and State University. VA, USA.

Pimdit, K., N. Therdthai and K. Jangchud. 2008. Effects of fat replacers on the physical,

chemical and sensory characteristics of puff pastry. **Kasetsart J. (Nat. Sci.)** 42(4): 739–746.

Stone, H. and J.L. Sidel. 1993. **Sensory Evaluation Practices.** 2nd ed., Academic Press, San Diego CA, USA. 338 pp.

Thai Industrial Standards Institute. 2006. **Standard of Community Product-Chinese Cake (Kha Nom Pia),** [in Thai]. 115/2549. Ministry of industry, Bangkok.

UFM Baking and Cooking School. 1995. **Training Document for Course of Chinese Pastry,** [In Thai]. UFM Food Center Co.Ltd., Bangkok.

Vaclavik, A.V. and W.C. Elizabeth. 2008. **Essentials of Food Science.** 3rd ed., Springer Science±Business Media, New York. 571 pp.

Vatanasuchart, N., P. Tangkanakul, P. Auttaviboonkul, D. Hengsawadi and S.Maneepun. 1998. Fat substitute, oatrim-5, use in bakery products and Thai desserts, [in Thai]. **J. Food** 28(2): 97–110.

Veerotai, M. 2002. **Technology of Healthful Food Products,** [in Thai]. Institute of Academic Development (IAD), Bangkok. 260 pp.

Yodsirivichaikul, S. 2008. **Chong Tang Tum Gin,** [in Thai]. "Daily news" newspaper. 2 November 2008. p 23.