

Using Brown Rice Flour and Alternative Sweetener to Reduce Glycemic Index in Toddy Palm Cake

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Abstract

The objective of this study was to develop toddy palm cake with reduced glycemic index (GI) using brown rice flour (BRF) and a mixture of maltitol and sucralose (MS). The replacement of rice flour (RF) with BRF at the levels of 0 (control), 25, 50, 75 and 100% by weight of whole RF was carried out. The results showed that toddy palm cake at various level of BRF provided darker color, higher texture values in firmness and toughness. However, sensory score of toddy palm cake at 50% BRF was no significant different from that of control sample ($p>0.05$). The use of MS to replace sugar at 5 levels (0, 25, 50, 75 and 100% by weight of sugar) was further investigated. It was found that increasing amount of MS resulted in a lower color and higher firmness and toughness value of product. Toddy palm cake at 50% BRF and 50% MS was considered suitable for a final product preparation providing GI value of 50.22, which was 30.03% lower than that of original toddy palm cake ($GI = 71.78$). The results from the preference test from 100 consumers in Phetchaburi province showed that the developed product was not better than the original one ($p>0.05$).

Key Words: Toddy palm cake; Brown rice; Maltitol; Sucralose; Glycemic index

Introduction

Toddy palm cake is a traditional Thai dessert and widely made and eaten in Phetchaburi, which is major palm growing province. It is made by mixing rice flour with toddy palm flesh, sugar and coconut milk, then fermented and steamed to yield a soft and spongy product (Jangchud et al., 2004; Tassanaudom et al., 2010). Although toddy palm cake is popular among consumers, it is considered as high GI food which contributes to chronic diseases such as obesity, diabetes, coronary heart diseases and certain cancers. Rice is consumed by over half the world's population, ninety percent of which is in Asia (Nokkoull and Wichitparp, 2013). The major rice growing countries are Thailand,

China, India, Indonesia, Bangladesh, Burma, Vietnam, Japan and the Philippines (Wanyo et al., 2009). Brown rice (*Oryza sativa* L.) has higher nutritional components especially dietary fiber, vitamins, phenolic compounds and antioxidants than ordinary white rice grain (Pitiwiwattanakul et al., 2011). Brown rice has low GI value (50), while boiled white rice have moderate GI values ranging between 58 and 69 (Foster-Powell et al., 2002). According to the World Health Organization prevalence of diabetes affecting population is increasing worldwide, these populations can be benefitted by low GI food (Kumar and Prabhasankar, 2014). Generally, foods with a glycemic index (GI) of 70 or more are considered to have a high GI, whereas a GI of 56 to 69

inclusive is rated medium and foods with a GI of 55 or less are classified as low GI foods (Mulholland et al., 2009). Products made with sugar substitutes tasted like sugar with low GI have become more popular recently. Maltitol has a pleasant sweet taste remarkably similar to sucrose, and is about 90% as sweet as sugar (Limsuwan et al., 2014), while sucralose is about 600 times sweeter than sugar and is marketed for broad use in food and beverages in over 30 countries worldwide (Savitha et al., 2008). The GI of sucrose, maltitol, and sucralose with respect to glucose are 69, 35, and 0, respectively (Vosloo, 2005). Blends of sucralose with other sweeteners are often used to compensate for each sweetener's weakness to meet the original sucrose sweetness. The use of the artificial sweeteners, maltitol, sucralose and a combination of maltitol and sucralose for replacing sugar were found in many products such as ice cream (Limsuwan et al., 2014; Fuangpaiboon et al., 2013), frozen dessert (Pinto and Dharaiya, 2014) and muffin (Quilez et al., 2007).

Therefore, this research was designed to develop healthy toddy palm cake and study the effect of brown rice flour and maltitol and sucralose substitution on physical, nutritional and glycemic index, and sensory property of toddy palm cake.

Materials and Methods

Preparation of brown rice flour

Local brown rice grains (Phetchaburi 1 brown rice) cultivated in Phetchaburi, Thailand were soaked in cold clean tap water in the ratio of 1:3 (grain to water) for 4 h at room temperature and then milled into flour at a local rice mill in Phetchaburi. Brown rice paste was separated and dried with a tray dryer at 50°C overnight to a moisture content of 13.0%. The brown rice flour (BRF) was grounded and sieved (70 mesh screens) and then packaged in labeled air-tight polythene bag.

Toddy palm cake preparation

The basic ingredients used were 27.20% rice flour (RF), 22.70% coconut milk (purchased from local market in Phetchaburi), 22.70% sugar, 9.07% toddy palm flesh (harvested locally in Phetchaburi), 18.15% water, and 0.18% baking powder (double acting type, Unilever, Bangkok, Thailand). Toddy palm cake was prepared by mixing and kneading rice flour, sugar, toddy palm flesh and water into consistency, followed by the addition of concentrate coconut milk. The batter was proofed for 3 h at 35±2°C. The baking powder was added to the batter and mixed to a homogenous mass. The batter was poured into a round cup (4 cm diameter) and steamed for 20 min. The prepared toddy palm cakes were cooled at room temperature (30±2°C) and packed in sealed polypropylene plastic bags for further quality evaluation. The physical properties including color and texture were determined. The color values of the samples were measured by colormeter (Konica Minolta Color Reader CR-10, Konica Minolta, Japan). The texture profile (firmness and toughness) was performed by using a TA-XT plus Texture Analyzer (Stable Micro Systems, Surrey, UK). The test speed was set at 2 mm/s with 50% deformation using a 2 mm diameter cylinder stainless probe. Sensory properties of toddy palm cake were tested on the basis of color, flavor, taste, texture and overall preferences with 5-point hedonic rating scales (1=dislike extremely, 3=neither like nor dislike, 5=like extremely) by 30 untrained panelists. The suitable samples were then used for further study. A combination of maltitol and sucralose (MS) was used to replace sugar which the relative sweetness of the maltitol-sucralose mixture is calculated to meet the original sweetness of sucrose. MS was added to replace sugar at the level of 0, 25, 50, 75 and 100% and evaluated for physical and sensory properties, as previously described.

Chemical analysis

Moisture, protein, fat and ash content of toddy palm cakes were determined following AOAC (2012) methods. Total carbohydrate (including dietary fiber) calculated by difference (100 - %moisture - %protein - %fat - %ash) according to AOAC (2005).

In vitro starch digestion and predicted glycemic index (pGI)

The samples of toddy palm cakes were analyzed for the *in vitro* digestibility base on glucometry method using a modified method of Sopade and Gidley (2009) and Mahasukhonthachat et al. (2010). A half-gram sample was treated with artificial saliva containing porcine α -amylase (Sigma A-3176) and pepsin (Acros Organics CAS: 9001-75-6, pH 2.0) was added after incubation at 37°C for 30 min in a reciprocating water bath. The digesta was neutralized with NaOH and pH was adjusted to 6.0 with sodium acetate buffer prior to an addition of pancreatin (Sigma A-1750) and AMG (Sigma A-9913). A small sample was taken from digesta at time intervals of 0, 30, 90, 120 and 180 min and the glucose concentration read from the glucometer (Accu-Check® Performa®, Roche Diagnostics GmbH, Mannheim, Germany). Starch digestibility was expressed as digested starch/100g dry starch (DS) by the following equation: $DS = (0.9 \times G_G \times 180 \times V) / (W \times S [100 - M])$, where G_G is the glucometer reading (mM/L), V is the volume of digesta (mL), 180 is the molecular weight of glucose, W is the weight of sample (g), S is the starch content of sample (g/100 g dry sample), M is the moisture content of sample (g/100 g sample), and 0.9 is the stoichiometric constant for starch from glucose contents. The digestogram (digested starch at a specific time period) of each sample was modeled and single-point measurements of starch digestion at 90 min in sample scan also be used to calculate GI (H_{90}). According to Goni et al. (1997), predicted glycemic index (pGI) was calculated by the following equation: $pGI = 39.21 + 0.803 (H_{90})$.

Consumer evaluation

The selected toddy palm cakes were evaluated by 100 consumers in Phetchaburi province and analyzed by mean of sensory acceptance/preference in terms of color, taste, flavor, texture and overall liking score using 5-point hedonic scale.

Statistical analysis

Three replications of each experiment were performed. The analyses of physical and chemical result were done using Completely Randomized Design (CRD). The analysis of sensory evaluation result was done using Randomized Complete Block Design (RCBD). All data were analyzed and tested by analysis of variance (ANOVA). Significant difference ($p \leq 0.05$) among various treatments was detected by using Duncan's multiple range tests.

Results and Discussion

Effect of substituting RF with BRF on quality of toddy palm cakes

Physical characteristics of toddy palm cakes substituted of RF with BRF are shown in Table 1. The results indicated that increasing BRF in toddy palm cakes resulted in decreasing L^* value. L^* is the luminosity, a^* is the position on the green (-) to red (+) axis, and b^* is the position on the blue (-) to yellow (+) axis (Girelli et al., 2004). The L^* value of toddy palm cakes at 25% and 50% BRF were similar to that of toddy palm cakes at 0% BRF (control) but significantly brighter than that of 75% and 100% ($p \leq 0.05$). The a^* and b^* values of toddy palm cakes substituted of RF with BRF were not significantly different from that of to control ($p > 0.05$). Majzoobi et al. (2013) determined the effect of rice bran properties (in flour level of 0, 5, 10, 15 and 20%) on the sponge cake and found that cake color became darker (lower L^* value), more reddish (higher a^* value) and less yellowish (lower b^* value) with inclusion of rice bran. For texture of toddy palm cakes, increasing BRF in

toddy palm cakes resulted in increasing firmness and toughness. Firmness is expressed as the maximum force needed to compress the sample. Low maximum force indicates soft texture (Korczyk-szabo and Lacko-bartosova, 2013). Toughness commonly describe the texture changes (tough and rubbery; samples are very resistant to bite) in reheated bakery product (Rogers et al., 1990). The firmness and toughness values of todody palm cakes at 25% and 50% BRF were lower than 75% and 100% BRF but significantly higher than those of control ($p \leq 0.05$). The firmness and toughness increase when increase

BRF. This might be because the fiber contained in todody palm cake restricting the expansion of gas cells. Imam et al. (2012) reported that the increase in the level of BRF in the formulation gave rise to the composite bread to have more compact texture which imparted to the increment of the bread hardness. Sodchit et al. (2013) studied the effect of dietary fiber from banana peel cellulose on butter cake quality and found that banana peel cellulose-added butter cake had significantly higher firmness than control.

Table 1 Physical characteristic of todody palm cakes at different levels of BRF substitution.

BRF substitution (%)	Color value			Texture	
	L*	a* ^{ns}	b* ^{ns}	Firmness (N)	Toughness (N.mm)
0 (control)	68.03±0.81 ^a	2.27±0.21	47.40±0.67	0.46±0.005 ^c	3.88±0.18 ^c
25	67.53±1.25 ^a	2.43±0.36	46.93±1.70	0.56±0.013 ^b	4.86±0.12 ^b
50	66.83±0.85 ^a	2.50±0.59	46.10±1.85	0.58±0.008 ^b	5.21±0.22 ^b
75	64.90±0.44 ^b	2.63±0.45	45.73±1.12	0.63±0.026 ^a	5.32±0.15 ^a
100	64.17±0.67 ^b	2.60±0.44	45.57±1.45	0.64±0.009 ^a	5.44±0.17 ^a

^{a-c} Means in same columns followed by different letter superscripts are significantly different ($p \leq 0.05$).

^{ns} No significant difference ($p > 0.05$).

The sensory scores for color, flavor, taste, texture and overall liking of todody palm cakes are shown in Table 2. The average scores of all sensory parameters were in the range of 3.43-4.47 which fell between neither like or dislike and like moderately. The mean taste score was the highest for control, while the color score was the lowest in todody palm cakes at 100% BRF substitution. Increasing replacement RF with BRF could be cumulative effect of sensory properties. Cho et al. (2014) studied sensory characteristics of Seolgitteok (Korean traditional rice cake) with varying added levels of BRF and found that flavor- and texture-related attributes were more associated with the added

amounts of brown rice flour. Salehi and Bibalan (2012) determined the effect of full fat stabilized rice bran (in four levels 0, 10, 20 and 30%) on muffin cake and found that characteristic color properties of muffin cakes was increased with the addition of rice bran flour compared to the control cakes. The overall liking scores of todody palm cakes at 50% BRF, ranging from 3.97-4.17 which define as like moderately were not significantly different from those of control and todody palm cakes at 25% BRF substitution ($p > 0.05$) but significantly higher than others ($p \leq 0.05$). In this study, the optimal RF to BRF ratio was 50:50, which was chosen for the subsequent part of the study.

Table 2 Sensory attributes of toddy palm cakes at different levels of BRF substitution.

BRF substitution (%)	Sensory liking scores				
	Color	Taste	Flavor	Texture	Overall liking
0 (control)	4.47±0.63 ^a	4.37±0.72 ^a	4.33±0.57 ^a	4.40±0.37 ^a	4.37±0.89 ^a
25	4.23±0.82 ^a	3.90±0.91 ^{bc}	4.10±0.57 ^a	4.00±0.89 ^{bc}	4.17±0.80 ^a
50	4.03±0.75 ^b	4.17±0.85 ^{ab}	3.97±0.67 ^b	4.17±0.90 ^{ab}	4.07±0.85 ^a
75	4.07±0.65 ^b	3.57±0.56 ^{cd}	3.60±0.63 ^b	3.70±0.64 ^{cd}	3.63±0.55 ^b
100	3.50±0.40 ^c	3.47±0.67 ^d	3.43±0.89 ^c	3.50±0.89 ^d	3.47±0.62 ^b

^{a-d} Means in same columns followed by different letter superscripts are significantly different ($p \leq 0.05$).

Effect of substituting sugar with MS on quality of toddy palm cakes

Physical characteristic of toddy palm cakes substituted by sugar with MS are show in Table 3. The results indicated that increasing MS in toddy palm cakes resulted in increasing L* and b* value, but decreasing a* value. Toddy palm cakes at 50% MS substitution had significantly higher L* and b* and lower a* value than others ($p \leq 0.05$). The brightness slightly increased when increasing amount of MS in toddy palm cakes. This might be due to the lack of aldo and keto groups, maltitol, therefore, it does not participate in 'Maillard' browning reactions in the presence of amino acids (Ghosh and Sudha, 2012). The firmness of the toddy palm cakes varied from 0.54 to 0.63 N and the toughness

varied from 4.89 to 5.32 N.mm. The firmness and toughness values of toddy palm cakes at 50% MS was similar to that of toddy palm cakes at 25% MS, but significantly lower than that of toddy palm cakes at 100% MS substitution ($p \leq 0.05$). Increasing MS in toddy palm cakes resulted in increasing firmness and toughness. The humectants is a substance that promotes retention of water and helps keep a confection moist (Ergun et al., 2010). The increment of moisture content was possibly leads the cellular pores of bread experiencing undue expansion and bread become denser, eventually (Amir et al., 2013). Garcia-Serna et al. (2014) reported that the use of maltitol as a sugar replacement shown slightly higher moisture content and hardness of the biscuits ($p > 0.05$).

Table 3 Physical characteristic of toddy palm cakes at different levels of MS substitution.

MS substitution (%)	Color value			Texture	
	L*	a*	b*	Firmness (N)	Toughness (N.mm)
0	65.07±0.85 ^c	3.13±0.35 ^a	46.10±0.78 ^{cd}	0.57±0.010 ^b	5.21±0.12 ^{bc}
25	67.13±0.65 ^b	2.87±0.06 ^{ab}	47.83±0.67 ^b	0.55±0.011 ^c	4.89±0.10 ^a
50	69.47±0.45 ^a	2.23±0.25 ^c	49.50±0.96 ^a	0.54±0.005 ^c	4.81±0.19 ^a
75	67.57±0.57 ^b	2.47±0.12 ^{bc}	47.47±1.27 ^{bc}	0.58±0.022 ^b	5.19±0.12 ^{ab}
100	67.00±0.20 ^b	2.37±0.47 ^{bc}	45.73±0.95 ^d	0.63±0.009 ^a	5.32±0.17 ^c

^{a-d} Means in same columns followed by different letter superscripts are significantly different ($p \leq 0.05$).

The sensory scores for color, flavor, taste, texture and overall preferences of toddy palm cakes substituted of sugar with MS are shown in Table 4. Color, flavor and overall liking scores of toddy palm cakes with 50% MS substitution were not significantly different

from those of toddy palm cakes at 0% and 25% MS substitution ($p>0.05$) but significantly higher than those of others ($p\leq0.05$). Thus, the optimal S to MS ratio was 50:50, thus chosen for the subsequent study.

Table 4 Sensory attributes of toddy palm cakes at different levels of MS substitution.

MS substitution (%)	Sensory liking scores				
	Color	Taste	Flavor	Texture	Overall liking
0	4.23±0.82 ^a	4.07±0.64 ^{ab}	4.20±0.41 ^a	4.03±0.72 ^{ab}	4.27±0.52 ^a
25	4.13±0.68 ^a	4.27±0.45 ^a	4.27±0.58 ^a	3.87±0.68 ^{bc}	3.93±0.85 ^a
50	4.30±0.47 ^a	4.33±0.55 ^a	4.00±0.59 ^a	4.30±0.60 ^a	4.13±0.63 ^a
75	3.97±0.81 ^b	3.83±0.59 ^b	3.53±0.63 ^b	3.57±0.73 ^{cd}	3.50±0.73 ^b
100	3.67±0.78 ^b	3.40±0.89 ^b	3.23±0.63 ^c	3.27±0.83 ^c	3.30±0.79 ^b

^{a-c} Means in same columns followed by different letter superscripts are significantly different ($p\leq0.05$).

Nutrition and Glycemic Index

Nutrient contents in terms of moisture, protein, fat, ash, and carbohydrate of original toddy palm cake (control) and developed toddy palm cake (toddy palm

cake with 50% BRF and 50% MS substitution) are shown in Table 5. The proximate values including moisture, protein and ash of developed toddy palm cake were higher than those of original toddy palm cake.

Table 5 Nutritive value and predicted glycemic index (pGI) of original toddy palm cake and developed toddy palm cake

Nutritive value	Original toddy palm cake	Developed toddy palm cake
Moisture, %	45.28	45.54
Protein, %	2.97	2.85
Fat, %	7.89	6.88
Ash, %	0.75	0.77
Total carbohydrate, %	43.11	43.96
Predicted glycemic index (pGI)	71.78	50.22

Starch digestibility of toddy palm cake is shown in Figure 1. The original toddy palm cake was digested more rapidly than the developed toddy palm cake. The predicted glycemic index (pGI) of developed toddy

palm cake was 50.22, which was 30.03 % lower than that of original toddy palm cake (GI = 71.78). The levels of pGI were lower in developed toddy palm cake than the original toddy palm cake which could

be explained by increasing replacement of BRF and maltitol content. Partial substitution of RF with BRF cause an increase in fiber in toddy palm cake, which delays the glycemic response (Vosloo, 2005). Pirasath et al. (2012) reported that the cooked brown rice contained more soluble dietary fiber (0.21%), insoluble dietary fiber (1.88%) and total dietary fiber (2.09%) than the cooked white rice (trace, 1.21 and 1.21%), so the cooked brown rice gave lower GI value when compared with cooked white rice. Imam et al. (2012) reported that white rice possess high glycemic index worsened glycemic control in type 2 diabetic rats while brown rice produced better glycemic levels. Maltitol is slowly absorbed; therefore, the insulin response associated with the ingestion of glucose is significantly reduced (Grembecka, 2015). It has been reported that the final product combined low GI starch and sugar substitute may have produced a synergistically lower GI compared to original product. Phantu Wong et al. (2010) developed the steamed stuffed bun (Sa-La-Pao) with low GI using BRF and palatyne (isomaltulose) and found that final product could substitute 40% BRF for wheat flour and replaced 40% (by weight of sugar) palatyne for all amount of sugar in the original formula and developed product could be decreased 33.23% of GI from the original product. Quilez et al. (2007) reported that the low-calorie muffins, replaced of sugar with maltitol, and partially replaced of wheat flour with high-amylose corn starch, exhibited lower in GI as compared to plain muffin (control). Their GI values were 37.4 and 46.1. According to Mulholland et al. (2009), foods with GI of ≤ 55 , 56-69 and ≥ 70 are classified as low, medium, and high GI, respectively. It demonstrated that developed toddy palm cake

with substitution of 50% BRF and 50% MS was considered as a low GI food.

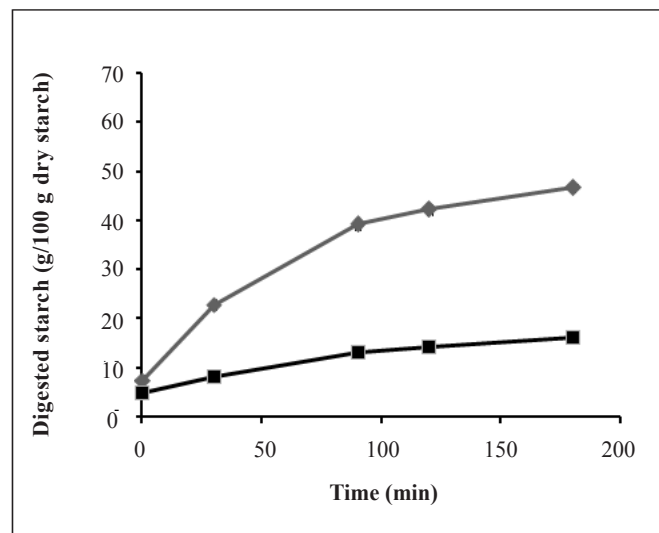


Figure 1 Digestogram plot of toddy palm cake sample; original toddy palm cake (♦), and developed toddy palm cake (■)

Consumer acceptance of developed toddy palm cakes

Most of consumers were female, age between 21-40 years old with education level of bachelor degree, married, having income between 15,001 – 20,000 bath per month. The sensory liking scores for color, flavor, taste, texture and overall liking of developed toddy palm cakes compared to original toddy palm cake are shown in Table 6. The liking score for color and texture of developed toddy palm cake was slightly higher than those of original toddy palm cake ($p > 0.05$). The overall liking score of the developed product was not significantly different from that of the original product ($p > 0.05$). Ninety-two percent of tested consumer accepted and eighty-six percent would buy developed toddy palm cakes.

Table 6 Sensory attributes of developed toddy palm cakes

	Sensory attributes liking scores				
	Color ^{ns}	Taste ^{ns}	Flavor ^{ns}	Texture ^{ns}	Overall liking ^{ns}
Original toddypalm cakes	4.18±0.70	4.21±0.75	4.12±0.76	4.14±0.72	4.18±0.75
Developed toddy palm cakes	4.22±0.70	4.20±0.77	4.08±0.93	4.20±0.60	4.14±0.73

^{ns} No significant difference (p>0.05).

Conclusion

The low GI products are increasingly of interest by consumers concerning with health or suffering from diabetes or obesity in term of mitigating many chronic diseases. The obtained results indicated that it is possible to use BRF and sweetener (MS) to partially substitute RF and sugar, and may be useful for developing of new Thai dessert products with improved nutrition and reduction GI.

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