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The effect of using chinese water chestnut flour to partially replace wheat flour in steamed cake (Pui Fai)

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Abstract Chinese water chestnut flour is used to replace some of the wheat flour in steamed cake (Pui Fai) The ratios of Chinese water chestnut flour to wheat flour were varied 0:100, 10:90, 20:80, 30:70, 40:60 and 50:50 respectively. The mixture of Chinese water chestnut flour to wheat flour was 20:80 which showed the moisture content value of 39.57%, water activity (a_w) value of 0.90, oven spring value of 3.83% compared to the control , hardness value of30.36 N, brightness (L^* value) of 88.20, redness/greenness (a^* value) of -0.58, and yellowness/blueness (b^* value) of 14.13.The average score for consumers' quality evaluation was 7.10 for appearance, 7.32 for color, 6.88 for flavor, 6.53 for odor, 7.25 for texture, 7.13 for taste, and 7.32 for overall preference.

Keywords: Chinese water chestnut flour, Wheat flour, Steamed cake (Pui Fai), Physico-chemical properties, Sensory evaluation

Introduction

Around the world, baked goods cakes in particular are the most consumed products because of their delightful sensory attributes. Because it contains fat, sugar, eggs, wheat flour, and milk. In order to increase the nutritional content of many recipes, including those that lack fiber and protein, flour is now used in place of other components. Water chestnuts are a good source of raw materials for flour production because of their high starch content. Water chestnut starch is underutilized in the food industry because of a lack of understanding about its modifications and uses. Water chestnut starch is underutilized in the food industry because of a lack of understanding about its modifications and uses (Khrutsing and Thamaphiphol, 2017). Chinese water chestnuts are water-loving plants that resemble rice. At present, the Suphan Buri Province's Mueang District, Si Prachan District, and Sam Chuk District are major Chinese water chestnut growing areas. The benefits of water chestnut Thai desserts include

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Chinese water chestnuts, which are abundant in protein and resemble wheat flour because to their high carbohydrate content. One can turn it into flour. Flour made from water chestnut roots its characteristics are similar to those of sweet potato flour and cassava flour. Water chestnut flour has a good nutritional fat, and 4.55% fiber (Chenlo, 2011). While the average amount of carbohydrates in flour is 74.57-79.47%, the average protein percentage is 8.57-10.41%(Rujirapisit and Sukwilai, 2018). Both flour and water chestnut starch have a high amylose content. Likewise, it can be utilized to make a broad variety of products, such as food items like pasta, bread, cookies, noodles, film, and flour sheets. (Rujirapisit, 2006) reported on the outcomes of using water in the creation of flour sheets in an appropriate 1 to 4 ratio of Chinese water chestnut flour. Therefore, the objective was to develop a product that uses water chestnut flour instead of wheat flour in steamed cakes (Pui Fai), and to consider the product's physicochemical properties and potential market.

Materials and methods

Materials

The Chinese water chestnuts came from farmers in the Suphan Buri Province's Wang Yang Subdistrict, Si Prachan District, and Sam Chuk District. Peel, rinse with fresh water, and then rinse once more. Once the materials are placed in a container that is properly sealed, chill the mixture between 4 and 8 degrees Celsius.

Production of Chinese water chestnuts flour

Fresh Chinese water chestnuts are sliced into small pieces and then mixed with water until smooth (keep refrigerated). The flour precipitates and the water separates. The flour is roasted in a hot air oven at 60 to 65 degrees Celsius for five to eight hours. The water chestnut flour powder is stored in a bag that is vacuum-sealed.

Recipes and ingredients

Use Chinese water chestnut flour instead of wheat flour while making Pui Fai, a steamed cake. Utilize the following ratios: Chinese water chestnut flour and wheat flour have the following ratios: 0:100, 10:90, 20:80, 30:70, 40:60, and 50:50. Next, weigh the ingredients (wheat flour, Chinese water chestnut flour, baking powder, eggs, sugar, evaporated milk, water, and SP) for the steamed

cake (Pui Fai). With a food mixer, combine the ingredients. Add flour and stir for about 8 minutes. For the Pui Fai (steamed cake), thoroughly fill the cake form with the ingredients, then bake the cake with steam. The steaming process will take seven minutes. After that, the Pui Fai (steamed cake) needs to be taken out of the steamer and given time to cool before its quality is assessed.

Physicochemical quality measurement of chinese water chestnut flour

Chinese water chestnut flour was prepared using a sample, and the following parameters were measured: pH, color, protein, fat, ash, total carbohydrates, crude fiber, protein, and water absorption index (WAI and WSI) modified from the method of (Anderson *et al.*, 1969).

Chemical and physical quality measurement of steamed cake (Pui Fai) from Chinese water chestnut flour

The color of samples of steamed cake (Pui Fai) was measured by calculating the brightness (L*), redness (a*), and yellowness (b*). A texture profile analysis (TPA) was used to gauge the texture of the steamed cake, or Pui Fai. the aw values, moisture content, and chemical quality.

Specific bulk volume

Replace the specific bulk volume of the steamed cake (Pui Fai) with sesame seeds. Three measurements were taken when the material was cooled to room temperature.

Sensory evaluation

The sensory quality of Steamed cake (Pui Fai) product was evaluated using RCBD design with 9-Point Hedonic Scale by 50 untrained-panelists (1 means dislike the most and 9 means like the most) for appearance, color, flavor, water chestnut flavor, texture, taste and overall liking (Meilgaard *et al.*, 2006).

Statistical analysis

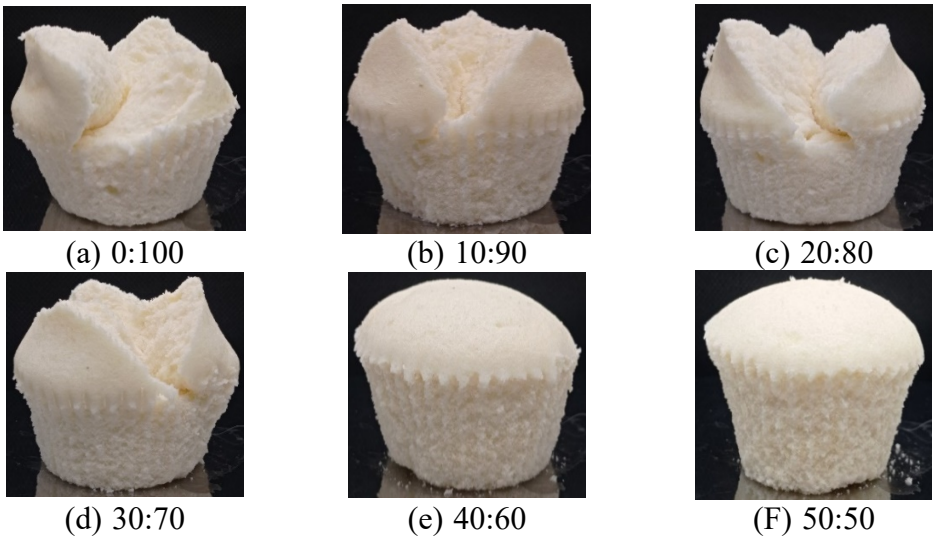
Using SPSS version 17, data analysis was performed via analysis of variance (ANOVA). We compared the means using Duncan's New Multiple Range.

Results

Chinese water chestnut flour's chemical makeup was determined to be 6.53% moisture, 9.39% protein, 0.68% fat, 6.67% crude fiber, 7.17% ash, and 69.56% total carbohydrates by dry weight. The flour's water solubility index was 4.16, its water holding index was 2.69, and its soluble solids content was 4.8 ° Brix. The experimental Chinese water chestnut samples had a comparatively high protein level.

Effect of using Chinese water chestnut flour to replace wheat flour in Steamed cake (Pui Fai) products at different ratios

Chinese water chestnut flour was substituted for wheat flour in the ratios listed in the components for steamed cake (Pui Fai) goods as: 0:100, 10:90, 20:80, 30:70, 40:60, and 50:50. The experiment, it was found commonly observed that the addition of Chinese water chestnut flour reduces the product's rise when steaming at the same temperature. The statistical calculation of the rise value revealed that there is a statistical difference. The steamed cake (cotton fluff) rises when Chinese water chestnut flour is used instead of wheat flour in a mixture that consists of 30% water chestnut flour and 70% wheat flour.



(a) 0:100 (b) 10:90 (c) 20:80

(d) 30:70 (e) 40:60 (F) 50:50

Figure 1. Shape and rise of Steamed cake (Pui Fai) using different ratios of Chinese water chestnut flour and wheat flour

Results of chemical and physical quality measurement of Steamed cake (Pui Fai) products produced from Chinese water chestnut flour and wheat flour at different ratios

The following ratios of water chestnut flour to wheat flour are used to evaluate the brightness (L*), redness (a*), and yellowness (b*) of steamed cake (Pui Fai) items: wheat flour equal to 0:100, 10:90, 20:80, 30:70, 40:60, and 50:50. It was discovered that the product's color value decreased when the quantity of Chinese water chestnut flour rose. The a* and b* values rose while the L* value dropped. As a result, the product took on a darker appearance. The Pui Fai (steamed cakes) craze was discovered that the steamed cake (Pui Fai) had a higher moisture content when the quantity of Chinese water chestnut flour was increased. The rise of the product was mitigated. However, given the appearance of the approved product Put another way, it is possible to replace wheat flour with Chinese water chestnut flour 30:70. When the statistical analysis showed a significant statistical difference, as shown in Table 1.

Table 1. Physical characteristics and color values of steamed cake (Pui Fai) Using water chestnut flour instead of wheat flour

Formulation	Color			Moisture (%)	bulk density (g/cm^3)	Rising (%)
	*L**	*a**	*b**			
C:W 100: 0	91.38 ± 1.24^{a}	-0.40 ± 0.31^{c}	10.74 ± 0.30^{e}	37.74 ± 0.56^{c}	114.03 ± 0.47^{bc}	0.00 ± 0.41^{bc}
C:W 10 : 90	89.59 ±1.35^{ab}	-0.32 ± 0.17^{c}	10.16 ± 0.12^{d}	39.41 ± 0.41^{a}	115.32 ± 0.80^{ab}	1.23 ± 0.70^{ab}
C:W 20 : 80	88.20 ±2.55^{bc}	-0.58 ± 0.40^{bc}	14.13 ± 0.61^{a}	39.57 ± 0.86^{a}	118.40 ± 1.77^{a}	3.83 ± 1.55^{a}
C:W 30 : 70	87.92 ±1.54^{bc}	0.10 ± 0.08^{ab}	12.10 ± 0.51^{c}	38.47 ± 0.57^{b}	117.37 ± 2.13^{a}	2.93 ± 1.87^{a}
C:W 40 : 60	87.03 ± 1.69^{c}	0.30 ± 0.22^{a}	12.66 ± 0.57^{b}	39.73 ± 0.38^{a}	110.96 ± 0.71^{cd}	-2.69 ±0.62^{cd}
C:W 50 : 50	84.08 ± 0.84^{d}	0.29 ± 0.19^{a}	13.63 ± 0.42^{a}	39.58 ± 0.40^{a}	109.32 ± 0.83^{d}	-4.14 ± 0.73^{d}

***** C:W was Steamed cake (Pui Fai) prepared from Chinese water chestnut flour (C) :Wheat flour (W)
$^{a, b,}$ … Value in the same column with different letters are significant different ($p < 0.05$)

The textural qualities of the product (Hardness, Compressibility, Adhesiveness, Cohesiveness, Gumminess) reduced as the Chinese water chestnut flour content of the Steamed Cake (Pui Fai) increased. This resulted from the product's propensity to be drier, which enhanced flour adhesion and reinforced the firmness of the steamed cake (Pui Fai). The following ratios of water chestnut flour which is used to make steamed cakes, or Pui Fai can be used in place of wheat flour: 0:100, 10:90, 20:80, 30:70, 40:60, and 50:50.The porosity and

rising time of the steamed cake (Pui Fai) with unequal results after adding water chestnut flour are shown in Table 2 and Figure 2. It showed that the steamed cake (Pui Fai) with uneven results after adding water chestnut flour, showed the cake's porosity and rising time. The statistical significance analysis was significantly differed.

Table 2. Effect of using different amounts of water chestnut flour and wheat flour on textural characteristics of steamed cakes

Formulation	Hardness (N)	Compressibility (N.mm)	Adhesiveness (N.mm)	Cohesiveness	Gumminess (N)
C:W 100: 0	31.63 ± 3.39^{a}	113.7 ± 13.79^{ab}	0.78± 0.39^{b}	0.28 ± 0.21^{ab}	8.89 ± 0.72^{ab}
C:W 10 : 90	31.49 ± 2.04^{a}	96.06 ± 10.51^{c}	0.83± 0.20^{b}	0.29 ± 0.32^{a}	9.05 ± 0.66^{a}
C:W 20 : 80	30.36 ±1.28^{ab}	96.13 ± 5.20^{c}	0.65 ± 0.12^{b}	0.27 ± 0.29^{bc}	8.27 ± 0.37^{bc}
C:W 30 : 70	29.55 ±1.47^{ab}	99.24 ± 11.47^{c}	0.64 ± 0.11^{b}	0.26 ± 0.27^{c}	7.80 ± 0.40^{c}
C:W 40 : 60	29.24 ±1.45^{ab}	115.918 ± 6.46^{a}	0.98 ± 0.05^{a}	0.27 ± 0.17^{c}	7.81 ± 0.25^{c}
C:W 50 : 50	28.35 ± 1.35^{b}	101.69 ± 8.49^{bc}	0.58 ± 0.07^{b}	0.23 ± 0.20^{d}	6.43 ± 0.27^{d}

***** C:W was Steamed cake (Pui Fai) prepared from Chinese water chestnut flour (C) :Wheat flour (W)
$^{a, b,}$ … Value in the same column with different letters are significant different ($p < 0.05$)

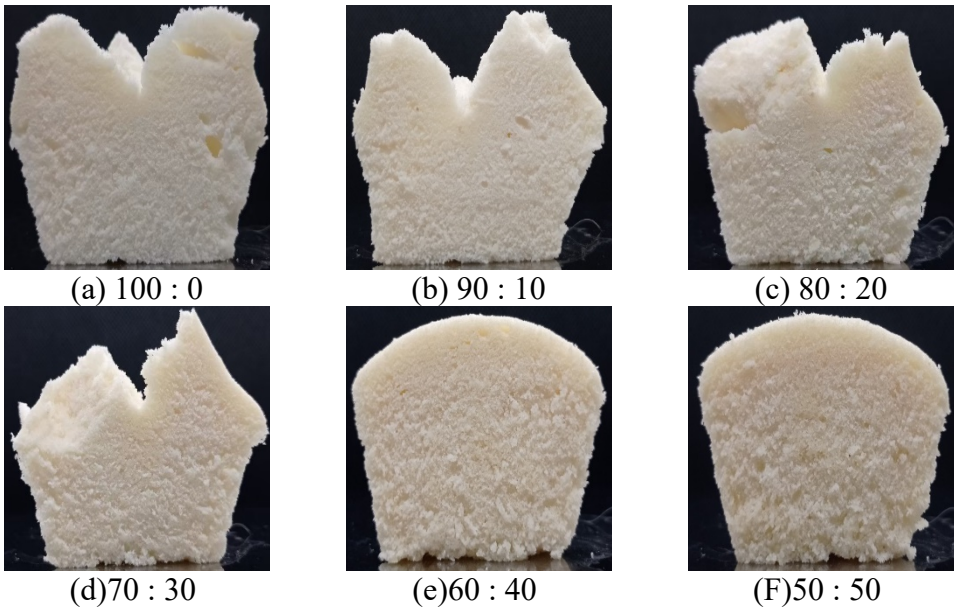


Figure 2. Characteristics of Steamed cake (Pui Fai) with different ratios of Chinese water chestnut flour and wheat flour

This study assessed the sensory quality of steamed cake (Pui Fai) made with water chestnut flour rather than wheat flour in the following ratios: 0:100, 10:90, 20:80, 30:70, 40:60, and 50:50. The 50 consumers score the cake on a 9-point Hedonic Scale.The assessors of Pui Fai (steamed cake) were to rate the appearance, color, flavor, and texture as well as the flavor of the water chestnut. The liking scores for taste, were C:W(0:100) 7.28, C:W(0:100) 7.33, C:W(30:70) 6.92, C:W(30:70) 6.58, and C:W(20:80) 7.25 points (Table 3). These scores were in close proximity to the control formula and C:W (0:100) 7.17 points.

Table 3. Mean consumer acceptance scores of Steamed cake (Pui Fai)

Sample	Appearance	Color ^{ns}	Flavor ^{ns}	water chestnut flavor	Taste	Texture	Overall liking
C:W 100: 0	7.28 ± 1.31^{a}	7.33 ± 1.32	6.60 ± 1.66	6.03 ±1.51^{b}	7.22 ± 1.31^{a}	7.17 ± 1.40^{a}	7.35 ± 1.61^{a}
C:W 10 : 90	7.00 ± 1.21^{ab}	7.23 ± 1.22	6.78 ± 1.40	6.48 ±1.61^{a}	6.90 ± 1.64^{abc}	6.87 ±1.35^{ab}	7.18 ± 1.15^{ab}
C:W 20 : 80	7.10 ± 1.35^{ab}	7.32 ± 1.30	6.88 ± 1.31	6.53 ±1.35^{a}	7.25 ± 1.21^{a}	7.13 ±1.27^{ab}	7.32 ± 1.22^{a}
C:W 30 : 70	6.77 ± 1.58^{b}	7.17 ± 1.29	6.92 ± 1.31	6.58 ±1.27^{a}	7.12 ± 1.39^{ab}	7.07 ±1.08^{ab}	7.27 ± 1.01^{ab}
C:W 40 : 60	7.10 ± 1.42^{ab}	7.17 ± 1.20	6.75 ± 1.21	6.45 ±1.35^{ab}	6.72 ± 1.56^{bc}	7.15 ±1.22^{ab}	7.32 ± 1.04^{a}
C:W 50 : 50	6.78 ± 1.53^{b}	7.15 ± 1.29	6.65 ± 1.55	6.38 ±1.52^{ab}	6.62 ± 1.57^{c}	6.72 ± 1.65^{b}	6.92 ± 1.35^{b}

* C:W was Steamed cake (Pui Fai) prepared from Chinese water chestnut flour (C) :Wheat flour (W)
$^{a, b,}$ … Value in the same column with different letters are significant different ($p < 0.05$)

Discussion

The study of Steamed cake (Pui Fai) using water chestnut flour to partially replace wheat flour in different ratios, when compared with cotton candy with ratios of Chinese water chestnut flour to wheat flour of 0:100, 10:90, 20:80 and 30:70, found that the ratio of Chinese water chestnut flour to wheat flour (100:0) had the highest texture hardness and higher dough adhesion.

The pattern resembled that of (Saha *et al*., 2011), who investigated the impact of biscuits made from blended flours in 60:40 and 70:30 (w/w) sorghum to wheat ratios. The findings indicated that stronger biscuits were made with more wheat flour. The effects of temperature and water content on the flow

behavior of chestnut flour were demonstrated by (Correia *et al*., 2009).

The findings demonstrated that adding various Chinese water chestnut flour ingredients changed the steamed cake's (Pui Fai) texture, hardness, and stickiness. The product's rise was reduced with an increase in Chinese water chestnut flour, which is in line with the findings of (Hussain *et al.,* 2019). Because BF has a lot of fiber and water, adding it to the muffin made it heavier. (Krishnaiya *et al.,* 2016) noted that adding WCF in place of wheat flour made the muffin heavier. With the popularity of Steamed Cake (Pui Fai) products growing, it was discovered that adding more Chinese water chestnut flour to the product changed its moisture content and raised its value.Steamed cake (Pui Fai) product is produced when Chinese water chestnut flour is used to replace wheat flour at a ratio of 30:70. The brightness (L*), redness (a*), and yellowness (b*) values of the steamed cake (Pui Fai) product indicated that an increase in the quantity of Chinese water chestnut flour in the product had an impact on its color value. While the a* and b* values rose, the L* value fell. As a result, the product's look darkened. due to increase flour adhesion, the texture value was measured by the parameters of hardness, compressibility, adhesiveness, cohesiveness, and gumminess decreased, giving the steamed cake (Pui Fai) a tighter texture. This aligns with the findings of (Hruskova *et al.*, 2019). Dietary fiber content increased twofold from the control level when wheat flour was substituted with barley flour, water chestnut flour, and oak flour. Moreover, non-glutenous protein was elevated. With the Falling Number and Zeleny Test values sharply declined due to the ingredient changed. This had an impact on the foaming and rising of the steamed cake (Pui Fai), indicating inconsistent results when additional water chestnut flour was added.

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Conflicts of interest

The authors declare no conflict of interest.

References

Anderson, R. A. (1969). Gelatinization of corn grits by roll- and extrusion-cooking. Journal of Cereal Science, 14:4-7.

Chenlo, F., Moreira, R., Prieto, D. M. and Torres, M. D. (2011). Desorption isotherms and net isosteric heat of chestnut flour and starch. Food and Bioprocess Technology, 4:1497-1504.

Correia, P., Leitão, A. and Beirão-da-Costa, M. L. (2009). The effect of drying temperatures on morphological and chemical properties of dried chestnuts flours. Journal of Food Engineering, 90:325-332.

Hrušková, M., Švec, I. and Kadlčíková, I. (2019). Effect of chestnut and acorn flour on wheat/wheat-barley flour properties and bread quality. International Journal of Food Studies, 8:41-57.

Hussain, S. Z., Beigh, M. A., Naseer, B., Amin, T. and Naik, H. R. (2019). Characteristics of resistant starch in water chestnut flour as improved by preconditioning process. International Journal of Food Properties, 22:449-461.

Hussain, S. Z., Beigh, M. A., Qadri, T., Naseer, B. and Zargar, I. (2019). Development of low glycemic index muffins using water chestnut and barley flour. Journal of Food Processing and Preservation, 43:14-49.

Krishnaiya, R., Kasar, C. and Gupta, S. (2016). Influence of water chestnut (*Trapa natans*) on chemical, rheological, sensory and nutritional characteristics of muffins. Journal of Food Measurement and Characterization, 10:210-219.

Krutsing, P. and Thamaphiphol, S. (2017). Environment and management system of water chestnut cultivation of farmers in Suphan Buri Province. Veridian E-Journal, Silpakorn University (Humanities, Social Sciences and Arts), 10:1828–1842.

Meilgaard, M. C., Carr, B. T. and Civille, G. V. (1999). Sensory evaluation techniques. CRC Press.

Rujirapisit, P. (2006). Chemical composition and physicochemical properties of flour and starch from Chinese water chestnut. (Master's thesis). University of the Thai Chamber of Commerce Institutional Repository, Thailand.

Rujirapisit, P. and Sukwilai, A. (2018). Effect of substituting Chinese water chestnut flour for wheat flour in the production of dense batter cakes. Journal of Science and Technology, University of the Thai Chamber of Commerce, 49:45-48.

Saha, S., Gupta, A., Singh, S. R. K., Bharti, N., Singh, K. P., Mahajan, V. and Gupta, H. S. (2011). Compositional and varietal influence of finger millet flour on rheological

properties of dough and quality of biscuit. LWT-Food Science and Technology, 44:616-621.

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