

Effect of Corn Silk Powder on Physical, Chemical and Antioxidant Properties of Chiffon Cake

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Abstract

Corn silk, the female flower stigma of maize (*Zea mays* L.), is considered as a waste in corn related processing food productions. This research aims to fortify the different levels (0, 10, 20 and 30% w/w) to chiffon cakes. The corn silk powder was prepared with minced the dried sweet corn silk with the hammer mill. The chiffon cakes were evaluated the physical and chemical properties. The viscosity and pH of cake batters were not significantly different. The pH of cake batter declined with an increase in corn silk powder level. Significant increasing of hardness, gumminess, chewiness were found when increasing the percentage of corn silk powder. The total phenolics compound of chiffon cake significantly increased with 10, 20 and 30% fortification with corn silk powder compared to the control. The highest amount of total phenolics compound was found in cake prepared with 30% fortification of cake flour with corn silk powder. These findings indicated that corn silk powder could be a potential source for health due to effective antioxidant properties.

Keywords: Chiffon cake, Corn, Corn silk, Antioxidant activity

1. Introduction

Corn is one of the mainly grown cereal crops in the world including Africa, America, Australia as well as Asia and has become one of five major crops in Thailand. In 2022, high corn production reached 450,358 ton/year for sweet corns (Office of Agricultural Economics, 2022). At present, Northern Thailand is the largest maize production region, following by the Northeast region and Central region. During the corn productions, there are many by-products including corn silks, husks and cobs. Cobs and husks can be utilised as animal feeds, charcoal, compost, handicraft as well as energy sources while corn silks can be used as valued-added products such as cosmetics, medicines, snacks etc (Senphan et al., 2019). Corn silk is the female flower

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stigma of maize (*Zea mays* L.) and considered as waste and discarded during corn production. In addition, corn silk has been utilised in ancient times as a traditional remedy and used in several regions to treat urological disorders, prostate problems, edema and gout (Nurhanan et al., 2012). Several studies have found that polyphenol compounds extracted from corn silk have strong free radical scavenging activity and contain many bioactive compounds including antioxidants (Sarepoua et al., 2015).

Baked food products are consumed all over the world and high consumption. Chiffon cake is a ready-to-eat and popular food appreciated by consumers all over the world (Mau et al., 2017). The main ingredients of chiffon cake are wheat flour, eggs, sugar, oil, seasoning, etc. They have potential as carriers of bioactive compounds. However, there is little information available regarding the effect of corn silk on quality characteristics of bakery products. Therefore, it would be beneficial to develop the formulation of chiffon cake production with corn silk powder.

2. Objectives of this study

The purpose of this study was to investigate the physical and chemical properties of chiffon cakes with 0, 10, 20 and 30% replacement of cake flour with corn silk powder.

3. Materials and Methods

3.1 Materials

Sweet corn (*Zea mays* L. *saccharata*) was purchased from the local market in Nakhon Sawan Province, Thailand. The ingredients used in the formula of chiffon cake were cake flour (United flour mill public., Ltd, Thailand), sucrose (Mitr Phol, Thailand), sodium chloride (Prung Thip, Thailand), soybean oil (Angoon, Thailand), fresh eggs (local market, Nakhon Sawan, Thailand), baking powder (McGarrett, Thailand), cream of tartar (McGarrett, Thailand) and nonfat dry milk powder (Dairy rich, Thailand).

3.2 Preparation of corn silk powder

Corn silk (500g) was cut into small pieces (2-3 centimeters) and dried in a hot air oven at 80°C until the moisture content was below 16%. Dried corn silk was ground into powder form with a hammer mill and was kept in a sealed bag at room temperature.

3.3 Preparation of chiffon cake

The formula of chiffon cakes was modified from the work of Lee and Lin (2008). Four different corn silk powder levels are shown in Table 1. The chiffon cake composes of 2 layer. The first layer contained cake flour, sucrose, dry milk powder, egg yolk, sodium chloride, soybean oil and baking powder. The egg yolk and sucrose were mixed with a whisk attachment in a mixer. The sifted cake flour, nonfat dry milk powder, sodium chloride and baking powder were poured into the bowl containing soybean oil. In the second layer preparation, the egg whites and cream of tartar were mixed and then sucrose was poured into the mixer. The foam was poured into the batter and mixed by hand with a plastic scraper until smooth. The cakes were baked at 160 °C for 40 min in a preheated oven, allowed to cool and packed in polypropylene bag at room temperature before further analysis.

Table 1 Formulation of chiffon cakes

Ingredients (g)	Control	CS10	CS20	CS30
Layer 1				
Cake flour	200	180	160	140
Corn silk powder	0	20	40	60
Baking powder	8	8	8	8
Sucrose	150	150	150	150
Sodium chloride	4	4	4	4
Soybean oil	100	100	100	100
Egg yolk	100	100	100	100
Distilled water	130	130	130	130
Nonfat dry milk	16	16	16	16
Layer 2				
Egg white	200	200	200	200
Sucrose	120	120	120	120
Cream of tartar	1	1	1	1

Note: Control, CS10, CS 20, CS30: prepared with 0%, 10%, 20% and 30% replacement of cake flour with corn silk powder, respectively.

3.4 Physical characteristics of cake batter

The pH of the samples was directly determined with a pH meter (Sartorius, PB10, Germany). The viscosity was measured by Brookfield Viscometer (LV DV-I+, USA). Briefly, the 400 mL of cake batter was poured into a 500 mL beaker and its viscosity was measured at 30 rpm with a spindle L4 on a rotational viscometer.

3.5 Baked cake characteristics

3.5.1 Physical characteristics of chiffon cake

The volume of cake was determined by the rapeseed displacement method (Mau et al., 2015). Colorimeter measurement of chiffon cake was determined using a Hunter Colorimeter (Model. CQX 2934, USA) The CIE color values were recorded as L* (lightness), a* (redness) and b* (yellowness). The texture profile analysis (TPA) of cake samples from the midsection of the cake was determined using a texture analyser (TA-XT plus, Stable micro systems, Surrey, UK). The variance coefficient of a plunger (P/50, 5.08 cm diameter) compressing a sample of 50% of its original height at 0.8 mm/s. The texture parameters were recorded including hardness, cohesiveness, adhesiveness, springiness, resilience, gumminess and chewiness. The water activity of chiffon cake was measured by IR AQUA LAB (Series 3TE, USA).

3.5.2 Determination of antioxidant properties

The total polyphenol was determined according to a previous method of Lu et al., (2007). Five grams of sample with 100 ml of 80% acetone (v/v) was shaken in water bath shaker (110 rpm) at 25 °C for 16 hours. The solution was centrifuged at 10000xg for 10 minutes, the supernatant was collected for total phenolic determination. The total phenolic content was determined using the Folin-Ciocalteu spectrophotometric method. The extracted solution (0.5 ml) was mixed with 2.5 ml of 10-fold diluted Folin-Ciocalteu's phenol reagent and allowed for 5 minutes. After that, 2 ml of 7.5% Na₂CO₃ solution was added, the final volume was made up to 10 ml with deionized water and kept at room temperature for 1 hour. Then, the absorbance was measured at 760 nm and compared to a standard curve of prepared gallic acid (GA) solution. The antioxidant activity of chiffon cakes was determined using 2,2-diphenyl-1-picrylhydrazyl (DPPH) free radical scavenging following the method described previously (Aqil et al., 2006). Fifty microliters of the extract in methanol were mixed with 1 ml of 0.1 mM DPPH in methanol solution and 450 µl of 50 mM Tris-HCl buffer (pH 7.4). After 30 min of incubation at room temperature, the reduction in the number of DPPH free radicals was measured, the absorbance was measured at 517 nm. BHT and α -tocopherol were used as controls. The percent inhibition was calculated from the following equation:

$$\% \text{inhibition} = \frac{[\text{Absorbance of control} - \text{Absorbance of test sample}] \times 100}{\text{Absorbance of control}}$$

3.6 Statistical analysis

All analysis were done in triplicate. Statistical analysed were carried out with a Turkey's multiple test ($P < 0.05$) using SPSS statistical software (SPSS Inc., USA).

4. Results

4.1 Physical characteristics of cake batter and baked cake fortified with different corn silk powder

The physical characteristics are shown in Table 2. The viscosity and pH of cake batters were not significantly different.

Table 2 Physical characteristics of cake batter and baked cake fortified with different corn silk powder

Characteristics	Control	CS10	CS20	CS30
Cake batter				
Viscosity (cp) ^{ns}	175.27 ± 8.20	175.07 ± 3.85	183.37 ± 4.80	177.67 ± 1.52
pH ^{ns}	5.06 ± 0.01	5.12 ± 0.06	5.13 ± 0.05	4.88 ± 0.04
Baked cake				
Volume (ml)	995 ^a ± 0.00	920 ^b ± 0.00	820 ^c ± 0.00	780 ^d ± 0.00
Water activity	0.89 ^a ± 0.00	0.87 ^{ab} ± 0.01	0.86 ^{ab} ± 0.02	0.85 ^b ± 0.02
L *	64.39 ^a ± 3.21	46.54 ^b ± 3.33	42.51 ^b ± 4.42	47.29 ^b ± 2.93
a*	0.19 ^b ± 0.17	9.52 ^a ± 1.92	9.86 ^a ± 0.77	8.68 ^a ± 1.93
b* ^{ns}	20.31 ± 0.37	21.55 ± 7.10	23.43 ± 7.14	23.34 ± 8.05
Hardness (g)	249.4 ^d ± 32.5	460.9 ^c ± 55.7	640.5 ^b ± 20.7	928.7 ^a ± 18.0
Springiness ^{ns}	0.857 ± 0.06	0.872 ± 0.07	0.757 ± 0.14	0.811 ± 0.01
Cohesiveness	0.824 ^a ± 0.01	0.837 ^a ± 0.01	0.797 ^b ± 0.01	0.719 ^c ± 0.01
Adhesiveness (g/s) ^{ns}	-0.78 ± 0.95	-1.31 ± 0.70	-2.21 ± 2.68	-3.98 ± 1.96
Gumminess (g)	205.6 ^c ± 25.4	385.9 ^b ± 45.0	508.5 ^b ± 15.5	668.7 ^a ± 13.7
Chewiness (g)	173.1 ^c ± 34.1	337.6 ^b ± 56.2	391.5 ^b ± 36.7	541.4 ^a ± 30.9
Resilience	0.45 ^b ± 0.01	0.49 ^a ± 0.01	0.42 ^c ± 0.01	0.35 ^d ± 0.01

Note: Control, CS10, CS 20, CS30: prepared with 0%, 10%, 20% and 30% replacement of cake flour with corn silk powder, respectively.

Each value expressed as mean ± SD. Mean with different capital letter within a row are significantly different ($P < 0.05$).

4.2 Baked cake characteristics

Baked cake characteristics are shown in Table 2. A decreased in cake volume was found with an increase of corn silk powder. The color of chiffon cake was represented by Hunter L*, a* and b* values. Table 2 shows that the replacement of corn silk powder was affected the color of chiffon cake. As the corn silk powder level increased, the color of chiffon cake became darker and redder. The appearance of baked chiffon cakes produced with corn silk powders was shown in Figure 1.

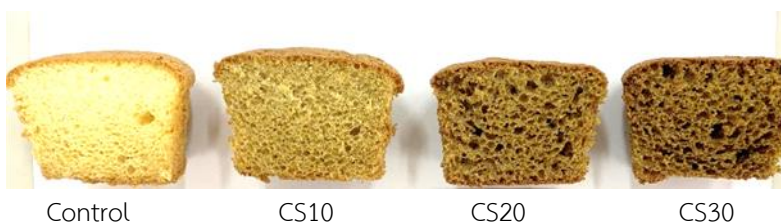


Figure 1 The appearance of corn silk chiffon cakes. Control, CS10, CS20, CS 30: Chiffon cakes fortified with 0%, 10%, 20% and 30% (w/w) corn silk (CS) powder, respectively.

In texture analysis, the baked chiffon cake with the increased level of corn silk powder become harder than control. The study found that the hardness was mainly related to the volume of the cake. The results indicated that a significant decrease in the cohesiveness of caked with added corn silk powder added. Adhesiveness is defined as the ability of cake to stick to the teeth when chewed and it is the negative force area between the first and second bite. A cake adhesiveness decreased with increased level of corn silk powder. Gumminess is determined by hardness multiplied by cohesiveness. Chewiness is indicated by gumminess multiplied by springness and represents the amount of energy needed to disintegrate a food for swallowing (Pasukamonset et al., 2018).

The antioxidant properties of baked chiffon cake are shown in Table 3. The results were expressed as total phenolic compound and the effectiveness in scavenging ability on DPPH radicals.

Table 3 The total phenolics compound and the antioxidant activity of chiffon cakes prepared by different corn silk powder fortification

	Control	CS10	CS20	CS30
Total Phenolics Compound (mg GAE/g)	0.11 ^d ± 0.01	0.15 ^c ± 0.01	0.23 ^b ± 0.01	0.27 ^a ± 0.01
% inhibition	53.83 ^b ± 2.89	57.28 ^b ± 1.14	67.95 ^a ± 1.95	68.73 ^a ± 2.21

Note: Control, CS10, CS 20, CS30: prepared with 0%, 10%, 20% and 30% replacement of cake flour with corn silk powder, respectively.

Each value expressed as mean ± SD. Mean with different capital letter within a row are significantly different (P<0.05).

The contents of total phenolics compound in the cake ranged from 0.11 ± 0.01 to 0.27 ± 0.01 mg GAE/g. This result showed that the total phenolics compound of chiffon cake significantly increased when replaced by 10, 20 and 30% corn silk powder. The highest amount of total phenolics compound was found in cake fortified with 30% corn silk powder.

5. Discussion

5.1 Physical characteristics of cake batter

The viscosity and pH of cake batters were not significantly different. The results are in agreement with the findings of previous study (Mau et al., 2017), which reported the viscosity of cake batter did not significantly change with increased black rice powder. According to the previous work (Kawila, 2022), the pH of corn silk powder dried at 80 °C was 6.06 and the nutrition composition of corn silk powder had 10.01% moisture content, 16.22% protein, 0.72% fat, 5.13% ash, 15.04% crude fiber and 52.8% carbohydrate. However, the pH of wheat flour ranged from 6.71-6.75 (Popovska, 2022). Lu et al., (2010) reported that the viscosity of cake batters increased significantly with the increasing of green tea powder level. The previous study also found green tea cake decrease in pH value with increased tea powder level (Mau et al., 2015).

5.2 Physical characteristics of baked cake

A decreased in cake volume was found with an increase of corn silk powder. Lee and Lin (2008) reported that cake volume decreased with increasing GABA tea powder in chiffon cake. In this study, the cake volume decreased may be due to the increasing of corn silk powder cellulose. The cellulose may minimize the gluten matrix which is responsible for retaining gases in cake (Lu et al., 2010).

As the corn silk powder level increased, the color of chiffon cake became darker and redder. It might be associated with corn silk pigments and polyphenol compounds become oxidation during processing. These observations indicate that a loss in brightness of cake caused by corn silk powder due to the result of carotenoid pigments of corn silk (Aukkanit et al., 2015).

The study found that the hardness was mainly related to the volume of the cake. The results agree with the findings of previous studies of Mau et al. 2017, Lee and Lin 2008, Lu et al. 2010, which reported that the chiffon cake hardness when increased tea powder. Cohesiveness represents the internal resistance of cake structure (Mau et al., 2017). The results indicated a significant decrease in the cohesiveness of caked with added corn silk powder. This reduction indicated that the cakes formulated with corn silk powder have low ability to resist before the cake structure deformed under the teeth. A cake adhesiveness decreased with an increased level of corn silk powder. Our results are consistent with a previous study of sponge cakes fortified with *Clitoria ternatea* extract (Pasukamonset et al., 2018). Gumminess is determined by hardness multiplied by cohesiveness. Chewiness is indicated by gumminess multiplied by springness and represents the amount of energy needed to disintegrate a food for swallowing (Pasukamonset et al., 2018). This study found an increase in gumminess and chewiness with increased level of corn silk powder. These overall results are in agreement with the previous studies, the sponge cakes fortified with *Clitoria ternatea* extract (Pasukamonset et al., 2018), green tea (Lu et al., 2010), cheonnyuncho powder (Kim et al., 2012) and tea powder (Mau et al., 2015) caused an increased in hardness, adhesiveness, gumminess and chewiness and a decreased in cohesiveness, springness and resilience. The decreased in cohesiveness and resilience of cakes can be due to the less elastic gluten structure of the cakes (Pasukamonset et al., 2018). However, sensory evaluation should be performed for further research.

5.3 Total phenolic compound of baked cake fortified with different corn silk powder level

The highest amount of total phenolics compound was found in cake fortified with 30% corn silk powder. This result agrees with the previous studies, the total phenols contents of chiffon cakes fortified with tea powders, black rice, and pomace were increased proportionally with the level of compound (Mau et al., 2015; Şeker et al., 2016, Mau et al., 2017). The scavenging ability on DPPH radicals assayed was expressed as percent inhibition. This result showed that supplemented corn silk enhanced antioxidant activity of chiffon cakes. Total phenolic contents showed a good correlation with % inhibition ($y = 101.33x + 42.69$, $R^2 = 0.9652$). Hasanudin et al., (2012) also found that corn silk is rich in phenolic compounds particularly flavonoids and flavonoids are

the major phenolic compounds present in corn silk (Maksimovic et al., 2005). Thus, these results indicated that total phenolic in corn silk chiffon cake possessed strong antioxidant activity.

In conclusion, corn silk is a good source of total phenolic compounds and antioxidant activity. Chiffon cake formulated with partial replacement up to 30% of cake flour increased the total phenolics compounds and the scavenging ability as compared to cake prepared with 100% cake flour. Corn silk chiffon cake exhibited antioxidant activity. It would be an alternative and possible source of development of cakes as a functional food. However, sensory evaluation should be the subject of further research

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7. References

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