CHAPTER V
RESULTS

5.1 Fresh corn silk

Fresh corn silk was obtained from the corn milk processing facility of the National Corn and Sorghum Research Center in Nakhon Ratchasima Province.
It was stored in a refrigerator at 4^{o}C until used to extract dietary fiber. Physical properties i.e. color, moisture content and total dietary fiber of fresh corn silk were determined before the extraction. The results are shown in Table 5.1

Table 5.1 Physical and chemical properties of fresh corn silk[1, 2]

Property	Value
Moisture content (% w/w)	67.90 ± 0.54
Color value	
L*	24.75± 0.34
a*	+ 8.72 ± 0.06
b*	+14.90± 0.37
Dietary fiber contents (% w/w, wet basis)[2]	
TDF	17.23
IDF	12.65
SDF	4.58

[1]Results are mean ± SD of triplicate analysis.

[2]Results are duplicate analysis.

5.2 Extraction and yield of dietary fiber from fresh corn silk (FDF)

Fresh corn silk was boiled in water for about 3 h and then extracted twice with 95% ethanol, dried and ground to obtain dietary fiber (FDF). The yield of extraction for FDF was 22.07± 0.01% (wet basis) indicating that corn silk mainly consisted of fiber. The appearance of dietary fiber from fresh corn silk (FDF) is presented in Figure 5.1

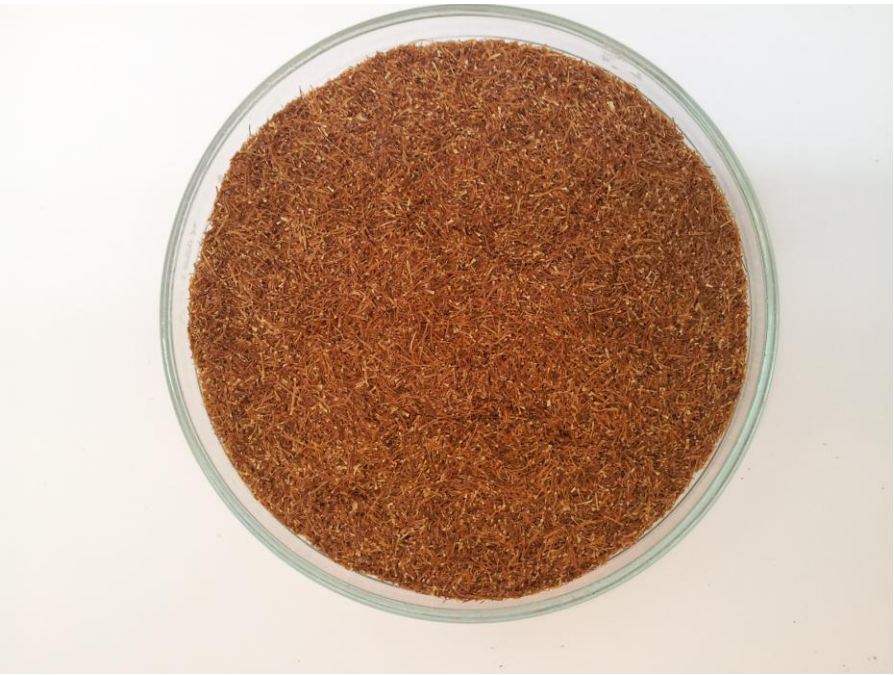

Figure 5.1 The appearance of dietary fiber from fresh corn silk (FDF)

5.3 Extraction and yield of dietary fiber from dried corn silk (DDF)

Dried corn silk was obtained by drying fresh corn silk at 50°C overnight then milled and extracted with 95% ethanol to obtain dietary fiber. The yield of DDF was 24.30± 0.90% (wet basis). The yield was close to the dietary fiber yield from fresh corn silk confirming that corn silk was mostly fiber. The appearance of dietary fiber from dried corn silk is presented in Figure 5.2

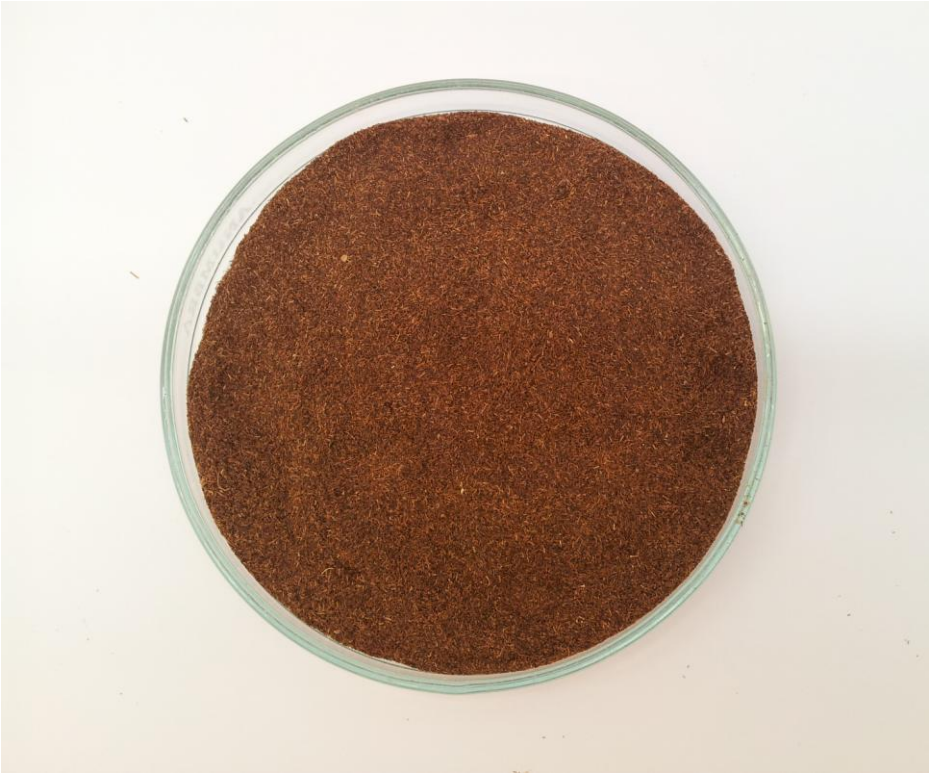

Figure 5.2 The appearance of dietary fiber from dried corn silk (DDF)

5.4 Bleaching experiment of dietary fiber from dried corn silk (DDF)

Bleaching experiment was performed on a small batch of DDF to observe whether alkaline hydrogen peroxide (AHP) treatment could improve the color properties of corn silk dietary fiber. The photograph of bleached DDF appears in Figure 5.3 while Figure 5.4 compares the fibers obtained from all 3 treatments. Bleaching yielded a slightly lighter color DDF than the non-bleached sample.

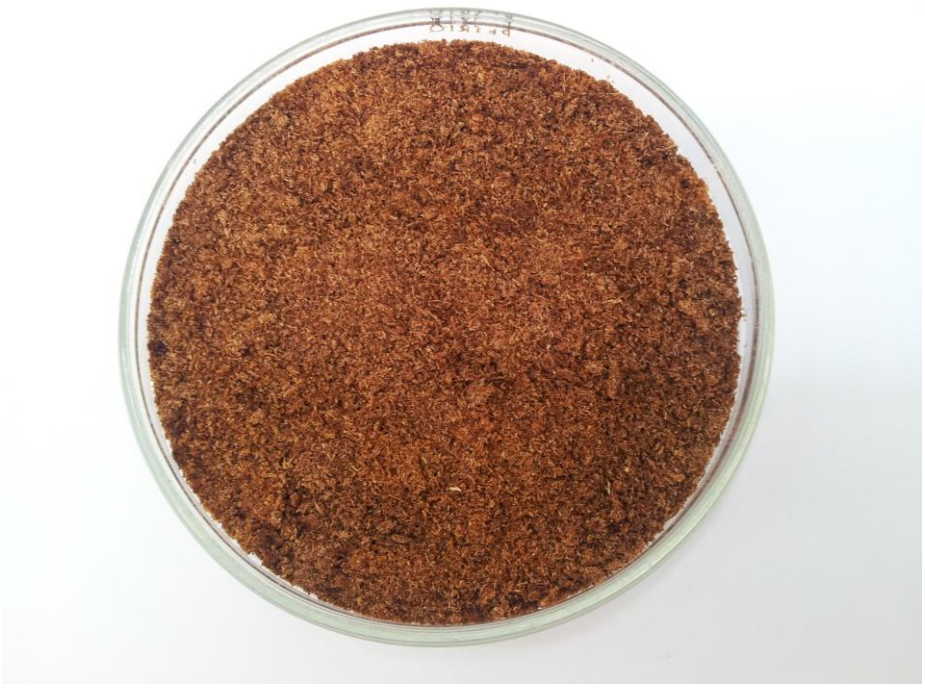

Figure 5.3 The appearance of bleached dietary fiber from dried corn silk (DDF)

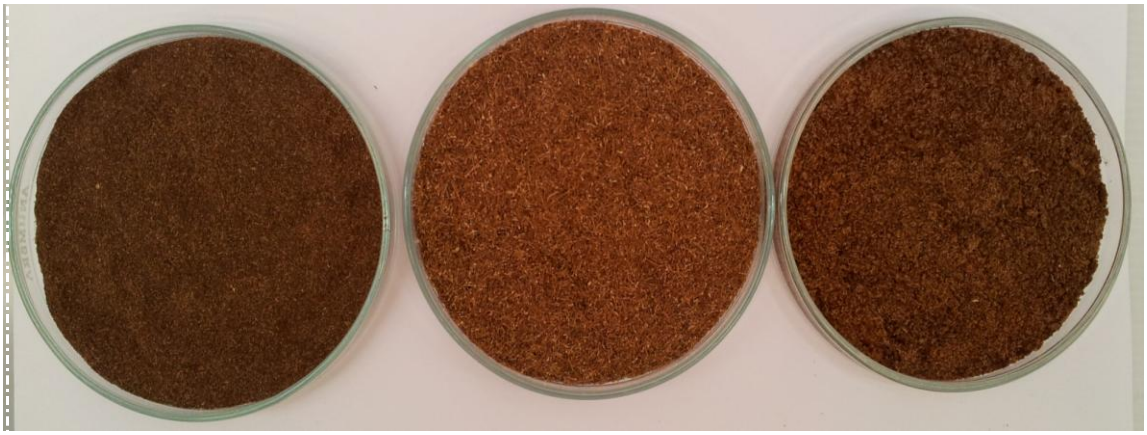

Figure 5.4 Comparing of DDF, FDF and Bleached DDF appearance after bleaching (from left to right)

5.5 Determination of properties of dietary fiber from fresh corn silk (FDF)

5.5.1 Particle size distribution

The particle size distribution of FDF was determined as the percentage of materials retained on a series of test sieves with different opening sizes. The results are shown in Table 5.2 The major portion of FDF corn silk fiber was retained on the 60 and 80 mesh screens (totaling around 70%).

Table 5.2 Particle size distribution of dietary fiber from fresh corn silk (FDF)[1]

Sieve size (mesh)	Sieve opening (mm)	% Retained
>35	> 0.500	0.80 ± 1.10
35-40	0.500-0.420	1.28 ± 0.53
40-60	0.420-0.250	48.69 ± 3.86
60-80	0.250-0.177	25.64 ± 0.82
80-100	0.177-0.149	11.07 ± 1.25
100-120	0.149-0.125	7.45 ± 1.57
120-140	0.125-0.105	3.62 ± 2.08
>140	>0.105	5.01 ± 4.34

[1]Results are mean ± SD of triplicate analyses.

[2]Values in the same column bearing different letters are significantly different ($p \leq 0.05$).

5.5.2 Physical and chemical properties of dietary fiber from fresh corn silk (FDF)

Water holding capacity, oil holding capacity, emulsifying activity, emulsion stability, total dietary fiber (TDF), insoluble dietary fiber (ISF), soluble dietary fiber (SF), water activity, moisture content and pH of FDF were determined. The results are summarized in Table 5.3

Table 5.3 Physical and chemical properties of dietary fiber from fresh corn silk (FDF)[1]

Property	Value
Color value	
L*	42.72 ± 3.42
a*	+ 6.32 ± 0.16
b*	+ 27.91 ± 3.30
Water holding capacity (g/g sample)	9.80 ± 0.69
Oil holding capacity (g/g sample)	5.41 ± 0.52
Emulsifying activity (%)	4.45 ± 0.61
Emulsion stability (%)	13.03 ± 2.17
Dietary fiber content[2] (%)	
TDF	76.94
IDF	65.04
SDF	11.90
Water activity	0.48 ± 0.07
Moisture content (%)	10.15± 2.33
pH	6.48 ± 0.11

[1]Results are mean ± SD of triplicate analyses.

[2]Results are mean of duplicate analyses.

5.6 Determination of properties of dietary fiber from dried corn silk (DDF)

5.6.1 Particle size distribution

The particle size distribution of DDF measured as the percentage of materials retained on a series of test sieves is shown in Table 5.4 The major portion of DDF was retained on 100 and 120 mesh screens (totally around 45%) with a considerable portion (about 24%) smaller than 140 mesh.

Table 5.4 Particle size distribution of dietary fiber from dried corn silk (DDF)[1]

Sieve size (mesh)	Sieve opening (mm)	% Retained
>35	> 0.500	0.37 ± 0.38
35-40	0.500-0.420	0.55 ± 0.62
40-60	0.420-0.250	1.56 ± 0.59
60-80	0.250-0.177	17.57 ± 9.30
80-100	0.177-0.149	21.84 ± 0.95
100-120	0.149-0.125	23.73 ± 3.36
120-140	0.125-0.105	13.40 ± 4.26
>140	>0.105	24.29 ± 13.10

[1]Results are mean ± SD of triplicate analyses.

5.6.2 Physical and chemical properties of dietary fiber from dried corn silk (DDF)

Water holding capacity, oil holding capacity, emulsifying activity, emulsion stability, total dietary fiber (TDF), insoluble dietary fiber (ISF), soluble dietary fiber (SF), water activity, moisture content and pH of FDF were determined. The results are summarized in Table 5.5

Table 5.5 Physical and chemical properties of dietary fiber from dried corn silk (DDF)[1]

Property	Value
Color value	
L*	37.81 ± 1.65
a*	+ 6.77 ± 0.32
b*	+ 18.6 ± 0.74
Water holding capacity (g/g sample)	4.94 ± 0.10
Oil holding capacity (g/g sample)	2.84 ± 0.11
Emulsifying activity (%)	2.08 ± 0.48
Emulsion stability (%)	4.59 ± 1.40
Dietary fiber content[2] (%)	
TDF	50.86
IDF	44.32
SDF	11.90
Water activity	0.14 ± 0.02
Moisture content (%)	4.54 ± 0.94
pH	6.71 ± 0.02

[1]Results are mean ± SD of triplicate analyses.

[2]Results are mean of duplicate analyses.

5.7 Color properties of bleached dietary fiber from dried corn silk compared with DDF and FDF corn silk fiber

Color values as L*, a* and b* of bleached DDF are shown in the Table 5.6 compared with the color of DDF and FDF**.** The color of bleached DDF was similar to the color of both non-bleached DDF and FDF.

Table 5.6 Color properties of bleached dietary fiber from dried corn silk compared with DDF and FDF corn silk fiber [1, 2]

Property	DDF[3]	FDF[4]	Bleached DDF[5]
Color value			
L*	37.81± 1.65[a]	42.72 ± 3.42[a]	40.25 ± 1.04[a]
a*	6.77 ± 0.32[a]	6.32 ± 0.16[a]	9.01± 0.47[b]
b*	18.60± 0.74[a]	27.91 ± 3.30[b]	25.42 ± 0.12[b]

[1]Results are mean ± SD of triplicate analysis.

[2]Results are duplicate analysis.

3 = Dietary fiber extracted from dried corn silk

4= Dietary fiber extracted from fresh corn silk

5= Bleached dietary fiber extracted from dried corn silk

5.8 Application of dietary fiber from fresh and dried corn silk (FDF, DDF) in food products

5.8.1 Cakes

In this study, FDF and DDF were added to cakes by partially substituting wheat flour with corn silk fiber at the levels of 15%. The other ingredients were kept constant to determine the effect of corn silk fiber addition on cakes characteristics compared with the control formula. The control formula used followed the formula reported by Prakongpan, 1999 (5). The cake samples were prepared according to the above treatments.

a. Quality determination

Compared to the control cake sample, 15% of wheat flour substitution by FDF and DDF caused obvious changes to the cake qualities. The characteristics evaluated include color, volume and water activity. The photographs of control, FDF and DDF-supplemented cakes are presented in Figure 5.5 The results of quality determination are shown in Table 5.7

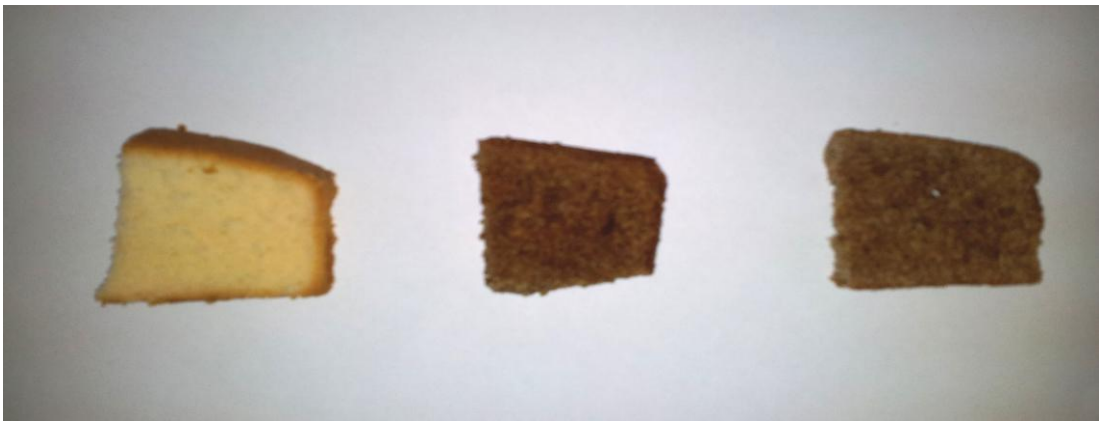

Figure 5.5 The appearance of cakes substituted by control, FDF and DDF at 15% in order from the left.

Table 5.7 Volume, Water Activity and Color (L*, a*, b*) of DDF and FDF-added cakes compares with Control[1, 2]

	Control, DDF and FDF- added cakes		
	0%	**15% DDF[3]**	**15% FDF[4]**
Volume	320.00 ± 34.64[a]	346.67± 23.09[a]	460.00 ± 34.64[b]
Water activity	0.92 ± 0.01[a]	0.91 ± 0.01[a]	0.91 ± 0.01[a]
Crust color			
L*	49.41 ± 2.37[a]	33.51 ± 1.81[b]	38.67 ± 3.34[b]
a*	13.22 ± 0.43[a]	9.81 ± 0.33[b]	10.50 ± 0.71[b]
b*	34.59 ± 3.22[a]	15.49 ± 2.28[b]	21.40 ± 3.27[b]
Crumb color			
L*	77.03 ± 2.98[a]	45.67 ± 1.27[b]	33.51 ± 1.81[c]
a*	-0.82 ± 0.30[a]	7.45 ± 0.17[b]	9.80 ± 0.33[c]
b*	24.70 ± 2.07[a]	19.50 ± 0.40[b]	15.49 ± 2.28[c]

1= Results are mean ± SD of triplicate analyses. Each of which consisted of 3 cakes.
2 = Values in the same row bearing different letters are significantly different ($p \leq 0.05$)
3 = Dietary fiber from dried corn silk substituted at 15% level
4 = Dietary fiber from fresh corn silk substituted at 15% level

According to the results, addition of FDF significantly ($p \leq 0.05$) increased the volume of the fiber- supplemented cake while addition of DDF did not cause any significant change ($p > 0.05$) in the cake volume compared to the control formula.

The crust color of cakes which were supplemented with FDF and DDF was significantly ($p \leq 0.05$) darker than that of the control formula with lower lightness (L*), redness (a*) and yellowness (b*) values.

In terms of crumb color, the L*, a* and b* values of the fiber-supplemented cakes (both with FDF and DDF) were markedly different ($p \leq 0.05$) from those of the control. The DDF cake was the darkest in color, followed by FDF and control cake, respectively.

In addition, incorporation of corn silk fiber did not cause any significant ($p > 0.05$) change in the water activity of the cakes indicating that the microbiological property of the fiber-supplemented cakes would be similar to the control one.

b. Sensory screening test

The sensory evaluation of FDF and DDF fiber-added cakes was performed to test whether these products containing corn silk fiber can be accepted by the consumers. The results are shown in Table 10. The addition of FDF and DDF significantly affected ($p \leq 0.05$) all sensory attributes (color, flavor, general appearance, overall acceptability, tastes and texture suitability) of the cakes in this study. All mean scores for the control cake were between like moderately and with 15% FDF had a mean sensory score of flavor and taste greater than 6 (like slightly) while the products added with 15% DDF had those scores around 5 (neither like nor dislike). All other mean scores for both FDF and DDF cakes were around 5. The sensory evaluation results, expressed as mean scores ± SD, suggested that the fiber-supplemented cakes were not quite acceptable to the consumers. Nevertheless, when the mode value was considered all scores were between 6 and 7. This implied that the fiber-supplemented cakes may still be accepted by a certain number of consumers while those who did not accept the products really dislike them. The values of mean, mode and median of all sensory scores appear in Appendix I.

Table 5.8 Sensory acceptability scores from the test of the DDF and FDF fiber-added cakes[1, 2]

Sample	General Appearance[4]	Overall Accpetability[4]	Color[5]	Flavor[5]	Texture[5]	Taste
Control	7.37 ± 0.81[a]	7.53 ± 0.90[a]	7.30±0.84[a]	7.30±1.15 [a]	6.93± 1.05[a]	7.70±0.80[a]
15% DDF	5.13 ± 1.85[b]	5.53 ± 1.61[b]	5.60±1.59[b]	5.00 ± 1.72[b]	4.87 ± 1.94[b]	5.37± 1.81[b]
15% FDF	5.60 ± 1.63[b]	5.40 ± 1.99[b]	5.50±1.61[b]	6.33 ±1.75[c]	5.23 ± 1.77[b]	6.17± 1.76[c]

[1] Results are mean ± SD, n= 30

[2] Values in the same row bearing different letters are significantly different ($p \leq 0.05$).

[3]DDF= Dietary fiber from dried corn silk, FDF = Dietary fiber from fresh corn silk

[4]Nine-point hedonic scale (9=like extremely, 5=neither like nor dislike, 1=dislike extremely).

d. Dietary fiber content of DDF and FDF fiber-added cake

FDF and DDF fiber-supplemented cakes (15% substitution of wheat flour) were analyzed for their TDF content. The total dietary fiber content of 15% DDF and FDF-supplemented cakes was 3.34 g/100g, and 3.36 g/100g, respectively.

6.2 Fried batter-coated chicken

The application of DDF and FDF corn silk fiber was tested in the batter-coated suspension prepared for deep fat frying of batter-coated chicken. The fiber was added at the level of 3% by weight of total batter suspension ingredients (all other ingredients were kept constant). FDF and DDF were added to batter suspension to increase technological yield, improve batter pick-up and reduce oil absorption after frying. The photographs of the control and fiber-supplemented fried batter-coated chicken pieces are presented in Figure 5.6

Figure 5.6 The appearance of control, fried batter-coated chicken added with dietary fiber from dried corn silk (DDF) and fried batter-coated chicken added with dietary fiber from dried corn silk (FDF).

a. Quality determination

Control, FDF and DDF-added fried batter-coated chicken pieces were weighed before and after coating with the batter to calculate batter pick-up. After frying, batter crust was removed and determined for their qualities including moisture

content, crude fat content and oil uptake. FDF and DDF-addition at 3% level in the batter-coated chicken pieces were determined for their quality including technological yield, and batter-pick up compared to the control formula. The results are shown in Table 5.9 and Table 5.10 The technological yield and batter pick-up of FDF and DDF-added samples were similar to the control with no significant changes ($p>0.05$). Addition of FDF and DDF to batter led to a higher moisture content in the final products when compared with the control formula. When calculated as moisture difference before and after frying, however, only FDF-supplemented batter showed a significantly greater amount ($p\leq0.05$) of water removed during frying. There were no significant differences ($p>0.05$) in the crude fat content, oil uptake and U_R among all samples.

Table 5.9 Sensory acceptability scores from the test of the DDF and FDF fiber-added fried batter-coated chicken[1, 2]

Sample	Batter pick up (%)	Yield (%)	Moisture content (g/ 100g)		Crude fat content (g/100g)	
			Initial	Final	Initial	Final
Control	42.43 ± 1.46[a]	90.24 ± 2.68[a]	59.41±0.43[a]	19.18± 1.25[a]	0.86 ± 0.84[a]	29.66 ±5.20[a]
3% DDF[3]	46.43 ± 4.16[a]	94.43 ± 2.00[a]	60.15±3.61[a]	23.19 ± 1.19[b]	0.40 ± 0.13[a]	29.53 ±1.59[a]
3% FDF[3]	41.87 ± 4.16[a]	93.08 ± 2.64[a]	57.35±0.44[a]	25.92 ± 2.52[b]	0.42 ± 0.14[a]	28.57±2.17[a]

[1] Results are mean ± SD of triplicate analyses, Each of which consisted of 9 nuggets.

[2] Values in the same row bearing different letters are significantly different ($p \leq 0.05$).

[3]DDF= Dietary fiber from dried corn silk, FDF = Dietary fiber from fresh corn silk.

Table 5.10 Oil uptake, water removed and U_R value of DDF and FDF fiber-added frying batter compared with the control formula[1, 2, 3]

Sample	Oil uptake (g)	Water removed (g)	U_R[6]
Control	27.80 ± 4.73[a]	40.23 ± 1.53[a]	0.69 ± 0.14[a]
3% DDF[4]	29.14 ± 1.56 (+1.34)[a]	36.96 ± 2.83 (-3.27)[a]	0.79 ± 0.07 (-8.19)[a]
3% FDF[5]	28.16 ± 2.25(-0.36)[a]	31.43± 2.30 (8.80)[b]	0.90 ± 0.12 (-0.21)[a]

[1]Results are mean ± SD from triplicate analyses.

[2]The numbers in ( ) indicate percent difference from the control formula.

[3]Values in the same column bearing different letters are significantly different ($p \leq 0.05$).

[4]DDF = Batter crust removed of Dietary fiber from dried corn silk added-batter coated chicken

[5]FDF = Batter crust removed of Dietary fiber from fresh corn silk added-batter coated chicken

[6] U_R expresses the oil uptake ratio between the weight of oil uptake and the weight of water removed.

b. Sensory acceptability test

FDF and DDF-supplemented batter-coated chicken pieces were tested for the sensory acceptability in order to collect the information on the sensory quality of the products comparing with the control formula. The mean scores of sensory acceptability for each product formula are shown in Table 5.11 The results showed that there were no significant differences ($p>0.05$) on flavor, overall acceptability, taste and texture suitability between the control formula and both of the corn silk fiber-added samples. Significant differences ($p\leq0.05$) were found for the mean scores of general appearance and color where it was obvious that the color of the fried chicken markedly changed with the addition of 3% FDF or 3% DDF to the batter suspension for frying the products. The score of overall acceptability of the fiber-supplemented fried batter-coated chicken did not differ significantly ($p>0.05$) from that of the control. Since the scores were around 6 (like slightly), it may be assumed that the fiber-supplemented products were generally acceptable to the consumers. However, the general appearance and color of such products definitely needed to be improved.

Table 5.11 Sensory acceptability scores from the test of the DDF and FDF fiber-added fried batter coated chicken[1, 2]

Sample	General Appearance[4]	Overall Accpetability[4]	Color[4]	Flavor[4]	Texture[4]	Taste[4]
Control	7.47 ± 1.04[a]	6.67 ± 1.54[a]	7.30± 1.09[a]	6.20 ± 1.24[a]	6.40± 1.61[a]	6.07±1.76[a]
3% DDF[3]	4.90 ± 1.90[b]	5.97 ± 1.52[a]	4.73±1.64[b]	6.03 ± 1.87[a]	6.07 ± 1.55[a]	5.97± 1.58[a]
3% FDF[3]	5.71 ± 2.10[b]	5.40 ± 1.99[a]	5.40±2.04[b]	6.23 ± 1.50[a]	6.25 ± 1.52[a]	6.41± 1.39[a]

[1] Results are mean ± SD, n = 30

[2] Values in the same row bearing different letters are significantly different ($p \leq 0.05$).

[3]DDF= Dietary fiber from dried corn silk, FDF = Dietary fiber from fresh corn silk

[4]Nine-point hedonic scale (9= like extremely, 5= neither like nor dislike, 1= dislike extremely).