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Effect of Different Oils on Quality of Deep-fried Dough Stick

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***Abstract*—**The aim of this study was to determine the effect of oils on chemical, physical, and sensory properties of deep-fried dough stick. Five kinds of vegetable oil which were used for addition and frying consist of: palm oil, soybean oil, sunflower oil, rice bran oil, and canola oil. The results of this study showed that using different kinds of oil made significant difference in the quality of deep-fried dough stick. Deep-fried dough stick fried with the rice bran oil had the lowest moisture loss and oil absorption ($p \leq 0.05$), but it had some unsatisfactory physical properties (color, specific volume, density, and texture) and sensory characteristics. Nonetheless, deep-fried dough stick fried with the sunflower oil had moisture loss and oil absorption slightly more than the rice bran oil, but it had almost higher physical and sensory properties. Deep-fried dough sticks together with the sunflower oil did not have different sensory score from the palm oil, commonly used for production of deep-fried dough stick. These results indicated that addition and frying with the sunflower oil are appropriate for the production of deep-fried dough stick.

***Keywords*—**Deep-fried dough stick, palm oil, sunflower oil, rice bran oil.

I. Introduction

DEEP-FAT frying is a food processing that is a commonly used in food industry. This technique enhances sensory properties including flavor, color, taste, and texture of food products. During frying, chemical, and physical properties are changed [1]. Food is immersed in hot oil at temperature above the boiling point of water, 175-190 °C. Temperature above 175 °C induces the formation of acrylamide known to be a carcinogen [2]. Some deep-fat fried food contains the high level of fat content up to 40-45% of the total weight [3], and vacuum fried food have fat content 14-24 g/100g [4].

Frying oils that are popularly used are palm oil or its fractions, high-oleic sunflower oil, rapeseed oil, and soybean oil [5]. The vegetable oils used for frying vary in fatty acids content. The palm oil consists higher content monounsaturated fatty acid as oleic acid (C18:1) than the sunflower oil, and the soybean oil, (39.8, 30.2, and 27.8%, respectively) [5]. However, the sunflower oil and the soybean oil are higher level of polyunsaturated fatty acid as linoleic acid (C18:1) and linolenic acid (C18:2) [5]. The rice bran oil contains oleic acid, linoleic acid, and linolenic acid (43.90, 31.60, and 1.70%, respectively) [6].

Deep-fried dough sticks or Patongco (in Thai) is a popular breakfast snack food in Thailand. It is prepared from the dough of wheat flour adding with water, palm oil, egg, sugar, salt, yeast, and baking powder. The dough is cut into a stick and fried in the palm oil until it turns to golden yellow and then is removed from the oil. It contains large amount of oil (28.35% of total product) [7]. The aim of this study was to investigate the effect of addition and frying with different oils on physical, chemical and sensory characteristics of deep-fried dough stick.

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II. Materials and Methods

A. Materials

The commercial vegetable oils for this study consist of palm oil, soybean oil, sunflower oil, rice bran oil, and canola oil were purchased from a local super market in Bangkok, Thailand.

B. Preparation of Deep-Fried Dough Stick

Deep-fried dough stick was prepared from all-purpose wheat flour (500 g) obtained by adding yeast (2 g), baking powder (3 g), sugar (2 g), salt (3 g), vegetable oil (35 g), water (250g) and egg (50 g). All ingredients were mixed for 3 min. Each treatment was added with different types of five vegetable oil: palm oil, soybean oil, sunflower oil, rice bran oil, and canola oil. The dough was cut into 2.0×4.0×0.5 cm and fried with different types of vegetable oil at 170 °C for 30 sec on each side for a total of 1 min.

C. Analysis of Deep-Fried Dough Stick

Moisture and crude fat content of dough and deep-fried dough stick were measured according to AOAC methods [8]. Moisture loss of deep-fried dough stick was determined by the loss of moisture content after frying according to the following equation.

$$\text{Moisture loss (g/100g)} = M_oD - M_oDFDS$$

where M_oD is moisture content of dough (g/100g), and M_oDFDS is moisture content of deep-fried dough stick (g/100g).

Oil absorption of deep-fried dough stick was calculated by fat content increase after frying with the following equation:

$$\text{Oil absorption (g/100g)} = FDFDS - FD$$

where FDFDS is fat content of deep-fried dough stick (g/100g), and FD is fat content of dough (g/100g).

Color of deep-fried dough stick crumb and crust were measured by using a spectrophotometer (Hunter Lab, Color Quest XE, USA) equipped with a light source illuminant D65

and 10° for observation. CIELAB system; L* (lightness-darkness), a* (redness-greenness), and b* (yellowness-blueness) values were measured.

The specific volume (cm^3/g) of deep-fried dough stick was calculated by dividing the volume by the mass. The volume of deep-fried dough stick was determined by seed replacement method [9]. The bulk density of deep-fried dough stick (g/cm^3) was determined as dividing weight by volume.

Dough and deep-fried dough stick were measured by using a texture analyzer (Lloyd Instrument, TA plus, UK) equipped with a 50 N load cell and cylinder probe (5 cm diameter). The texture profile analysis (TPA) of samples was comprised to 50% of original height at the test speed of 3 mm/s. The parameters were obtained hardness (N), cohesiveness, springiness, gumminess (kgf), and chewiness (kgf).

The sensory evaluation of deep-fried dough stick was performed by 30 panelists, who were students and staff members of Suan Sunandha Rajabhat University. Seven sensory attributes were evaluated (color, appearance, odor, texture, Oiliness, taste, and overall acceptability) by using a 9-point hedonic scale (1=extremely poor and 9=excellent).

D. Statistical Analysis

All experiments and analytical measurements were done in triplicate. The data were processed by analysis of variance (ANOVA). The level of the statistical significance is $p \leq 0.05$.

III. Results and Discussion

A. Moisture and Fat Content of Deep-Fried Dough Stick

The moisture and fat contents of deep-fried dough stick with different kinds of vegetable oils are shown in Table I. The results showed that deep-fried dough stick fried with the soybean oil and the sunflower oil had the highest moisture content. Deep-fried dough stick using palm oil, soybean oil, and canola oil had the higher fat level than using sunflower oil and rice bran oil. The sample fried with the rice bran oil had the lowest moisture and fat content.

TABLE I
Moisture and Fat Content of Deep-Fried Dough Stick

Oils	Moisture content (g/100 g)	Fat content (g/100 g)
Palm oil	25.67^{c}	18.02^{a}
Soybean oil	28.27^{a}	16.70^{a}
Sunflower oil	28.38^{a}	13.62^{b}
Rice bran oil	25.44^{c}	10.43^{c}
Canola oil	26.95^{b}	18.05^{a}

Mean in the same column with different letters are significantly different ($p \leq 0.05$)

Table II shows the levels of moisture loss and oil absorption of deep-fried dough stick during frying with different frying oils. Deep-fried dough sticks were fried with the palm oil had the highest moisture loss and oil absorption. The lowest moisture loss and oil absorption was deep-fried dough stick fried with rice bran oil. The water content or moisture loss in any fried food product has a major impact on oil uptake during the deep fat frying [3]. These results indicated adding and frying with rice bran oil enhanced the water holding and reduced oil uptake of deep-fried dough stick.

TABLE II
Moisture Loss and Oil Absorption of Deep-Fried Dough Stick

Oils	Moisture loss (g/100 g)	Oil absorption (g/100 g)
Palm oil	13.40^{a}	9.69^{a}
Soybean oil	12.32^{ab}	8.74^{b}
Sunflower oil	11.28^{bc}	6.71^{d}
Rice bran oil	9.67^{c}	5.03^{e}
Canola oil	11.74^{ab}	7.78^{c}

Mean in the same column with different letters are significantly different ($p \leq 0.05$)

B. Color of Deep-Fried Dough Stick

The values of color, lightness (L*), redness (a*) and yellowness (b*) were measured in the deep-fried dough stick crumb and crust as shown in Table III. The results show that L* and b* values of crumb were significantly ($p \leq 0.05$) affected by oil addition and frying oil. However, addition and frying with different oils did not differ significantly the redness value of crumb. The crumb of deep-fried dough stick and fried with the rice bran oil had the highest L* value.

Moreover, L*, a* and b* values of crust were significantly ($p \leq 0.05$) affected by oil addition and frying oil. The results showed that deep-fried dough stick fried with the palm oil had L* value higher than the soybean oil, sunflower oil, rice bran oil and canola oil, respectively. The sample with the palm oil had the highest value of L* and less value of a*, which means that the addition and frying with the palm oil resulted a golden yellow color product as desired. On the other hand, the sample with the canola oil had the lowest value of L* and the highest value of a* that resulted in the dark brown color, which is undesired from the consumers. Most people may like golden yellow fried food, whereas the dark brown product is not welcome [10].

TABLE III
Crumb and Crust Color of Deep-Fried Dough Stick

Oils	Color		
	L*	a*	b*
	Crumb		
Palm oil	68.39^{c}	1.90^{ns}	22.44^{bc}
Soybean oil	72.75^{ab}	1.44^{ns}	24.56^{ab}
Sunflower oil	64.48^{d}	1.46^{ns}	19.71^{c}
Rice bran oil	73.62^{a}	1.95^{ns}	20.17^{c}
Canola oil	69.09^{bc}	2.07^{ns}	26.89^{a}
	Crust		
Palm oil	62.20^{a}	8.51^{c}	29.20^{ab}
Soybean oil	60.06^{b}	8.38^{c}	29.88^{a}
Sunflower oil	56.58^{c}	10.57^{b}	26.26^{cd}
Rice bran oil	55.72^{c}	12.68^{a}	25.38^{d}
Canola oil	53.26^{d}	12.61^{a}	28.01^{bc}

Mean in the same column with different letters are significantly different ($p \leq 0.05$)
^{ns} = no significant difference ($p > 0.05$)

C. Specific Volume and Bulk Density of Deep-Fried Dough Stick

The effect of addition and frying oils on specific volume and bulk density of deep-fried dough stick are shown in Table IV. Deep-fried dough stick fired with the soybean oil and the palm oil gave higher specific volume than other vegetable oils. Bulk density of deep-fried dough stick with the rice bran oil is at the highest level, but with the palm oil and the soybean oil are at the lowest level. Bulk density and specific volume decreased during frying, whereas density and porosity increased [11].

TABLE IV
SPECIFIC VOLUME AND BULK DENSITY OF DEEP-FRIED DOUGH STICK

Oils	Specific volume (cm^3/g)	Bulk density (g/cm^3)
Palm oil	1.97^{a}	0.52^{c}
Soybean oil	2.14^{a}	0.47^{c}
Sunflower oil	1.14^{b}	0.87^{b}
Rice bran oil	0.23^{c}	4.27^{a}
Canola oil	1.03^{b}	0.97^{b}

Mean in the same column with different letters are significantly different ($p \leq 0.05$).

D. Texture Profile Analysis of Dough and Deep-Fried Dough Stick

The effect of different of oils on textural properties of dough and deep-fried dough stick are shown in Table V. Texture profile analysis of dough shows that dough fried with the bran oil had the highest hardness compared to the other vegetable oils. Moreover, dough fried with the canola oil had the highest of cohesiveness, springiness, and chewiness. Texture profile analysis of deep-fried dough stick reveals that samples fried with the rice bran oil had the highest hardness, whereas soybean oil and sunflower oil had the lowest hardness value. These results indicated the high level of hardness in deep-fried dough stick gave high bulk density; however, it had lower value of softness and specific volume. Deep-fried dough stick fried with the sunflower oil had the highest value of cohesiveness following with the soybean oil, canola oil, palm oil, and rice bran oil, respectively. Deep-fried dough stick fried with the rice bran oil had the lowest value of springiness when comparing with the other vegetable oils. However, gumminess of both dough and deep-fried dough stick did not have statistical difference significantly ($p>0.05$).

E. Sensory Evaluation of Deep-Fried Dough Stick

Table VI presents the sensory scores for color appearance, odor, texture, oiliness, taste and overall acceptability of deep-fried dough stick fried with different types of oil. The results show that deep-fried dough stick with the soybean oil, sunflower oil, and palm oil had higher sensory score in overall acceptability than the canola oil and the rice bran oil. Deep-fried dough stick fried with the rice bran oil had the lowest sensory score in all attributes.

TABLE V
TEXTURE PROFILE ANALYSIS OF DOUGH AND DEEP-FRIED DOUGH STICK

Oils	Hardness (N)	Cohesiveness	Springiness	Gumminess (kgf)	Chewiness (kgf)
			Dough		
Palm oil	5.545^{b}	0.158^{ab}	0.218^{bc}	0.089^{ns}	0.215^{b}
Soybean oil	5.613^{b}	0.191^{a}	0.375^{ab}	0.108^{ns}	0.298^{ab}
Sunflower oil	5.392^{b}	0.157^{ab}	0.326^{abc}	0.086^{ns}	0.300^{ab}
Rice bran oil	8.248^{a}	0.119^{b}	0.160^{c}	0.099^{ns}	0.251^{ab}
Canola oil	5.446^{b}	0.189^{a}	0.403^{a}	0.104^{ns}	0.456^{a}
			Deep-fried Dough Stick		
Palm oil	18.068^{b}	0.313^{c}	0.786^{a}	0.578^{ns}	4.216^{b}
Soybean oil	11.821^{c}	0.385^{ab}	0.775^{a}	0.457^{ns}	3.799^{b}
Sunflower oil	10.380^{c}	0.441^{a}	0.785^{a}	0.527^{ns}	4.395^{b}
Rice bran oil	27.884^{a}	0.217^{d}	0.536^{b}	0.602^{ns}	5.895^{a}
Canola oil	16.677^{b}	0.356^{bc}	0.779^{a}	0.592^{ns}	5.075^{ab}

Mean in the same column with different letters are significantly different ($p \leq 0.05$)
^{ns} = no significant difference ($p>0.05$)

TABLE VI
SENSORY EVALUATION OF DEEP-FRIED DOUGH STICK

Oils	Sensory evaluation						
	Color	Appearance	Odor	Texture	Oiliness	Taste	Overall acceptability
Palm oil	7.83^{a}	7.45^{ab}	7.08^{a}	5.87^{b}	6.16^{ab}	6.37^{a}	7.00^{a}
Soybean oil	8.04^{a}	7.91^{a}	6.41^{a}	7.41^{a}	6.62^{a}	6.95^{a}	7.41^{a}
Sunflower oil	7.87^{a}	7.54^{ab}	6.54^{a}	6.04^{b}	5.66^{ab}	6.70^{a}	7.04^{a}
Rice bran oil	6.08^{b}	5.33^{c}	5.37^{b}	3.58^{c}	5.29^{b}	4.20^{b}	4.71^{c}
Canola oil	6.79^{b}	6.87^{b}	6.33^{a}	5.62^{b}	6.16^{ab}	6.33^{a}	6.45^{b}

Mean in the same column with different letters are significantly different ($p \leq 0.05$)
Mean values based on 9-point scale where 1=extremely poor and 9=excellent

IV. Conclusion

In conclusion, addition and frying with different oil types affected the quality of deep-fried dough stick. The usage of rice bran oil for adding and frying deep-fried dough stick gave the lowest moisture loss and oil uptake. However, this addition and frying with the rice bran oil had poor physical properties (color, specific volume, density, and texture) and lowest sensory score in all attributes. On the other hand, deep-fried dough stick fried with the sunflower oil had moisture loss and oil absorption more than the rice bran oil, but it had higher in all physical properties and sensory score. Deep-fried dough stick fried with the sunflower oil did not have different sensory score in color, appearance, odor, softness, oiliness, taste, and overall acceptability when compared it to palm oil that is widely used for the production of deep-fried dough stick. Therefore, using sunflower oil is suitable for healthy deep-fried dough stick production.

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