Current Applied Science and Technology Vol. 18 No. 1 Jan.-Apr. 2018

Quality of Repeated Use of Oil for Frying Chinese Deep Fried Dough (Pa-Tong-Kho)

Chowladda Teangpook*, Urai Paosangtong, Yenjai Titatarn, Somchit Onhem and Winus Puminat

Institute of Food Research and Product Development, Kasetsart University, Bangkok, Thailand

Received: 12 July 2017, Revised: 23 March 2018, Accepted: 28 March 2018

Abstract

Thai people frequently consume Chinese deep fried dough and its quality is affected by frying conditions. An experiment was conducted using a 3 × 2 × 3 factorial randomized complete block design. The first factor was the three vegetable oils (palm olein oil (PO), rice bran oil (RO) and soybean oil (SO)). The second factor was the frying conditions (180 °C, 2 min and 160 °C, 4 min) and the third factor was the repeated frying cycle (4, 9, 16). The three factors did not interact. The color, viscosity, polar value (P) and trans fatty acids quantity (TA) of different types of oil were significant ($p \leq 0.05$) difference. The repeated frying oil showed darker color and higher values of the viscosity, P and TA. The color of fried PO and fried RO was not different but fried SO was a lighter yellow. The viscosity of PO was the highest value followed by RO and SO. Polar value of PO was the lowest (10.91 %), followed by RO (11.60 %) and SO (14.40 %). Trans fatty acids quantity of PO was the lowest (0.72 %) followed by SO (0.86 %) and RO (1.42 %). Frying conditions had no significant ($p > 0.05$) effect to color and viscosity while P and TA were significant ($p \leq 0.05$) difference. The higher temperature and shorter time frying resulted of higher P and higher TA of fried oil. However, the fried products were safe to consume because their polar was less than 25 %, and their T was low. PO was better than RO or SO for Chinese dough frying.

Keywords: Chinese dough, Pa-Tong-Kho, repeated frying, polar value, trans fatty acid

1. Introduction

Thai people frequently consume Chinese deep fried dough because the deep-fat frying process generates food with crispy texture and good flavor nevertheless the fried food quality. Quality of food depends on frying conditions including type of oil, temperature, time and repeated frying cycle. The big changes in chemical and physical properties include starch gelatinization, protein denaturation, water vaporization and crust formation [1] will lead to degrade frying oil such as darker color, increased viscosity, decreased smoke point, and increased foaming due to polymerization, oxidation, hydrolysis, and isomerization [2]. The measurements of degradation in frying oils can be determined by many methods such as viscosity measurement, [3], quantity of volatile decomposition products and nonvolatile decomposition products [4], free fatty acid [5], iodine value [6], nonurea-adduct forming ester [3], and total polar materials. Many researchers believe that these measurements are the best indicators for frying oil quality [7]. Paradis and Newar [8] stated that when 25-27 % of total polar materials has accumulated, the frying oil should be discarded.

*Corresponding author: Tel.: 660-29428629-35 ext 1614 Fax. : 660-29406455

E-mail: ifrcdt@ku.ac.th

Deep fat frying has also been considered as a source for the production of trans fatty acid (TA) [9] that has a relationship to the risk of cardiovascular disease [10]. TA is generally defined as unsaturated fatty acid that contains non-conjugated carbon-carbon double bonds in the trans configuration. TA in foods is derived from the chemical hydrogenation of vegetable and fish oils, the refinement process of edible oils from crude ones and microbial biohydrogenation in the digestive tract of ruminant animals. The main sources of TA for consumers are partially hydrogenated oils. The main objective of this study was to investigate the quality of Chinese dough (Pa-Tong-Kho) repeated frying oil from the different types of oils, frying conditions, and number of repeated frying cycles.

2. Materials and Methods

2.1 Materials for frying

Three refined, bleached and deodorized different vegetable oils, i.e. palm olein (PO), rice bran oil (RO) and soybean oil (SO) were purchased from a local supermarket in Thailand. All purpose wheat flour was purchased from a local supermarket in Thailand. Trans-6-petroselaidic methyl ester ($C_{18:1n6t}$) (Purity ≥ 99.00 %, Supelco), Trans -9-elaidic methyl ester ($C_{18:1n9t}$) (Purity ≥ 99.9, Supelco), Tricosanoic acid methyl ester ($C_{23:0}$) (Purity ≥ 99.8 %, Fluka) were used in this study.

2.2 Frying experiment

The experiment was a 3 × 2 × 3 factorial randomized complete block design with the first factor of three vegetable oils (PO, RO, SO). The second factor was the frying conditions (180 ℃, 2 min and 160 ℃, 4 min) and the third factor was the repeated frying cycle (4, 9, 16). An open pan was filled with 1 liter of oil (using a thermometer for temperature control) and fermented Chinese dough (1.5 kgX. In each frying, the sample was fried repeatedly (16 frying cycles). Oil samples were collected every 4 , 9 and 16 cycl es. The collected samples of oil and fried Chinese dough were kept at-20 °C until further tests. The CIE color values were measured using a spectrophotometer (Spectraflash 60 0 plus, Datacolor International, USA) and recorded as L* = lightness (0 = black, 100 =white), a*(-a* = greenness, +a* = redness) b* (-b* =blueness, +b* = yellowness), Percent of free fatty acids (FFA) was calculated from acid value [11]. Viscosity (brookfield DV-III Rheometer V3.3 RV and TA were measured using polar value (Testo, Germany) and gas chromatograph, respectively [12]. The data was processed by analysis of variance and Duncan's New Multiple Range Test (DNMRT) for mean comparisons at the 0.05 significance level, using the SPSS statistical software program (SPSS for windows Ver. 12.0, now a part of IBM Corp.; White Plains, NY, USA).

2.3 GC of TA analysis

GC was performed in a CP 3800 Varian Gas Chromatograph fitted with a FID (GC-FID), the column, HP-88, with dimensions of 100 m × 0.250 mm × 0.20 um and Column flow (3.0 ml/min). The initial temperature was 90 °C (hold for 5 min); final temperature was 250 °C (hold for 20 min). The temperature of the detector, FID, was 260 °C. Helium was used as the carrier gas. Split ratio of 100:1 was used and 1 µl of sample was injected in GC for the analysis total trans fatty acid.

1. Percentage of fat $= (M_2 - M_1) \times 100/W$

M_2 = weight of Round Bottle Flask and Fat (g)

M_1 = weight of Round Bottle Flask (g)

W = weight of sample (g)

2. Area percentage of fatty acid $_x = \frac{100 \times A_x}{A_t - A_{ts}}$

A_x = area counts of fatty acid X
A_t = total area counts for the chromatogram
A_{ts} = area counts of the internal standard

3. Fatty acid, g/100g sample = $F_t \times F_c \times F_a /100$

F_t = total fat (g) in 100 g sample
F_c = correction factor for the conversion of data for fatty acid analyzed as percent of total fatty acid to grams per 100 g edible portion of food (soy bean = 0.93, rice bran = 0.92, palm = 0.956)
F_a = % area fatty acid

4. Total trans fatty acid

Total trans fatty acid $(C_{18}) = C_{18:2n9,\,12t} + C_{18:1n6t} + C_{18:1n9t} + C_{18:1n11t}$

3. Results and Discussion

3.1 Effect of types of frying oils

Due to the three factors were not interactions so the results were from the main factor only. The results of factor of types of oils were shown on Tables 1-3. Color change in frying oils is an indication of the deterioration of oil caused by oxidation led to the formation of nonvolatile decomposition products such as oxidized triacylglycerols and free fatty acids. Increasing viscosity caused by formation of high molecular weight polymers. The more viscous the frying oil, the higher the degree of deterioration. The changes in color or viscosity can be easily observed [13]. The color of fried oil of PO was the darkest followed with RO and SO. The viscosity of fried oil of PO was the highest value followed with RO and SO. Free Fatty Acids (FFA) are the result of the breakdown of oil. The FFA of fried oil of PO was the highest value followed with SO and RO. In most deep fat frying operations, the amount of FFA produced by hydrolysis is too small to affect the quality of the fried food compared oxidation of unsaturated fatty acids because the determination of FFA by titration does not differentiate between acids formed by oxidation and those by hydrolysis, the FFA is not good measure of frying fat deterioration if used alone, however, it can be a good indicator of the extent of fat abuse if used in conjunction with other methods.

P value of fried oil of PO was the lowest value followed with RO and SO. TA of fried oil of PO was the lowest value followed with SO and RO. However the P value of three oils was safe because it was lower than 25 % that is the criteria of Ministry of Public Health of Thailand (Notification of the Ministry of Public Health No. 283). For the color of fried Chinese dough on Table 3 was not significant ($p \leq 0.05$) difference but TA of PO was lowest followed with SO and RO.

All edible oils consist of triglycerides with a variety of fatty acids that differ in chain-length (number of carbon atoms in molecule), degree of saturation, position of double bond within the carbon chain, and geometry of each double bond (*cis* and *trans* isomers) [14]. PO has a composition of low polyunsaturated (9.1 %), 36.6 % monounsaturated and high saturated fatty acid (48.8 %) [15]. RO has a composition of 38 % monounsaturated, 37 % polyunsaturated, and 25 % saturated fatty acids [16] and SO has a composition of high polyunsaturated (58%), 23% monounsaturated and low saturated fatty acid (16 %) [17]. The oxidation rate of oil increased as the content of unsaturated fatty acids of frying oil increased [18-19]. Oleic acid is the most abundant monounsaturated fatty acid in all the common edible oils [14], is more stable to oxidation, compared with polyunsaturated fatty acids, modified oils containing high-oleic acid, low-linoleic and low-linolenic acids produced by various methods including genetic modification [20]. From P value and TA content, these explains why PO with less unsaturated fatty acid than RO or SO with more unsaturated fatty acids and high Oleic acid is a better frying oil than RO or SO. In addition, SO has a highest composition of 7 % linolenic acid while PO has hot found and 2.2 %. of RO. Linolenic acid is critical to the frying performance, the stability of oil, and the flavor of fried food [21-22]. Therefore, low linolenic acid oil by genetic modification was suggested to be a potential alternative to hydrogenated frying oil [23].

Table 1. The color of fried oils from the factor of types of oils (average ± standard deviation)

Oils	L*	a*	b*
PO	92.19±1.06^{b}	-1.89±0.33^{b}	24.24±4.16^{a}
SO	93.41±0.88^{a}	-1.07±0.26^{a}	17.36±4.40^{b}
RO	92.32±1.34^{b}	-1.75±0.64^{b}	24.04±5.13^{a}

Means of each treatment for each attribute (from column) with different letters were significantly different at p ≤0.05.

Table 2. Viscosity, P and TA of fried oils from the factor of types of oils (average ± standard deviation)

Oils	Viscosity (cp)	%FFA	P (%)	TA (%)
PO	67.87±1.62^{a}	0.69±0.05^{a}	10.91±1.77^{c}	0.72±0.60^{b}
SO	52.79±2.40^{c}	0.29±0.03^{b}	14.44±3.16^{a}	0.86±0.71^{b}
RO	64.83±2.14^{b}	0.25±0.02^{b}	11.66±2.58^{b}	1.42±0.66^{a}

Means of each treatment for each attribute (from column) with different letters were significantly different at p ≤0.05.

Table 3.The color of fried Chinese dough from the factor of types of oils (average ± standard deviation)

Oils	L*	a*	b*	TA (%)
PO	58.21±2.22^{a}	7.27±1.65^{a}	22.05±1.78^{a}	0.71±0.41^{b}
SO	58.63±3.30^{a}	7.80±2.02^{a}	22.34±2.99^{a}	0.80±0.19^{ab}
RO	55.09±2.94^{b}	8.26±1.77^{a}	20.93±2.36^{a}	1.01±0.34^{a}

Means of each treatment for each attribute (from column) with different letters were significantly different at p ≤0.05.

3.2 Effect of frying conditions

The results were shown on Tables 4-6. The color, viscosity and acid value of fried oils from factor of high and low temperature were not significant (p≤0.05) difference but P and TA of high temperature were higher than low temperature. The color and TA of fried Chinese dough (Table 6) were not significant (p≤0.05) difference. In line with TA of potatoes fried with commercially canola oil at 160, 180 and 200 °C by the tenth frying operation was increase with increasing temperature [24].

Table 4. The color of fried Chinese dough from the factor of the frying conditions (average ± standard deviation)

Frying conditions	L*ns	a*ns	b*ns
High temperature	92.77±1.35	-1.54±0.48	21.14±5.98
Low temperature	92.50±1.04	-1.60±0.65	22.62±5.04

Means of each treatment for each attribute (from column) with different letters were significantly different at p ≤0.05.

Table 5. Viscosity, Acid value, P and TA of fried oils from the factor of the frying conditions (Average ± standard deviation)

Frying conditions	Viscosity (cp) ns	% FFA ns	P (%)	TA (%)
High temperature	62.04±7.45	0.42±0.40	12.65±3.18 [a]	1.34±0.92[b]
Low temperature	61.62±6.52	0.41±0.47	12.02±2.71 [b]	0.66±0.36 [a]

Means of each treatment for each attribute (from column) with different letters were significantly different at p ≤0.05.

Table 6. The color and TA of fried Chinese dough from the factor of the frying conditions (Average ± standard deviation)

Frying conditions	L*ns	a*ns	b*ns	TA (%) ns
High temperature	56.41±3.31	8.10±1.70	22.22±2.60	0.48±0.16
Low temperature	58.21±2.91	7.45±1.91	21.33±2.25	0.69±0.39

Means of each treatment for each attribute (from column) with different letters were significantly different at p ≤0.05.

3.3 Effect of repeated frying cycle

The results were shown on Tables 7-9. The more cycles resulted the darker color, the increased viscosity, FFA, P (15.75 %) and TA (1.46 %) of fried oils but the color of fried Chinese dough (Table 9) was not significant (p≤0.05) difference but TA was increased, in accordance with the study of Abdulkarim [13], it was found that Moringa seed oil, canola oil, SO and PO were polar, increasing in duration and number of frying. Increasing of TA in accordace with TA of potatoes fried with commercially canola oil at 160, 180 and 200 °C by the tenth frying operation was 0.99-1.05 g/100 g lipids that was little impact [24].

Table 7. The color of fried oils from the factor of frying cycles. (average ± standard deviation)

Frying cycles	L*	a* ns	b*
4	93.45±0.64[a]	-1.60±0.72	18.71±4.14 [b]
9	93.03±0.65 [a]	-1.62±0.53	20.20±4.13[b]
16	91.43±1.19[b]	-1.5±0.44	26.74±4.73[a]

Means of each treatment for each attribute (from column) with different letters were significantly different at p ≤0.05.

Table 8. Viscosity, P and TA of fried oils from the factor of frying cycles. (average ± standard deviation)

Frying cycles	Viscosity (cp)	%FFA	P (%)	TA (%)
0	55.16±5.36[a]	0.10±0.35 [a]	9.96±1.03 [d]	0.26±0.29 [a]
4	60.23±7.37[b]	0.39±0.47[b]	10.88±1.88 [c]	0.54±0.39 [b]
9	61.23±6.33[c]	0.41±0.47 [b]	12.75±1.94[b]	0.97±0.27[c]
16	64.02±6.39[d]	0.44±0.32 [b]	15.75±2.69 [a]	1.46±0.25[d]

Means of each treatment for each attribute (from column) with different letters were significantly different at p ≤0.05.

Table 9. The color and TA of Chinese dough from the factor of frying cycles. (Average ± standard deviation)

Frying cycles	L*ns	a*ns	b*ns	TA (%)
4	58.19±3.61	7.01±1.41	21.58±2.20	0.375±0.12 [a]
9	57.05±3.39	8.27±1.79	22.24±3.11 [a]	-
16	56.7±2.61	8.05±2.07	21.50±2.01 [a]	0.69±0.32 [b]

Means of each treatment for each attribute (from column) with different letters were significantly different at $p \leq 0.05$.

4. Conclusions

Fried Chinese dough was safe from frying with PO, RO, and SO with the conditions of frying 180 ℃, 2 min and 160 ℃, 4 min and 16 frying cycles because P value of three fried oils was lower than 25 %. PO was better than RO or SO for Chinese dough frying. However, the taste of the products should be tested as well as the shelf life in case of long-term storage.

5. Acknowledgements

Financial support for this research was provided by the National Research Council of Thailand.

References

[1] Saguy, I.S. and Pinthus, E.J., **1995**. Oil uptake during deep-fat frying: Factors and mechanism. *Food Technol.*, 49(4), 142-145, 152.

[2] Moriera, R.G., Castell-Perez, M.E. and Barrufet, M.A. **1999**. *Deep-Fat Frying Fundamental and Applications*, Aspen Publication, Gaitherburg, MA. , pp. 33-74.

[3] Alim, H. and Morton, I.D., **1974**. Oxidation in foodstuffs fried in edible oils. In International Congress of Food Science and Technology, Madrid, Spain., 6, pp. 345-556.

[4] Melton, S.L., Jafar, S., Sykes, D. and Trigiano, M.K., **1994**. Review of stability measurements for frying oils and fried food flavor. *J. Am. Oil Chem. Soc.,* 71(12), 1301-1308.

[5] Johnson, O.C. and Kummerow, F.A., **1957**. Chemical changes which take place in an edible oil during thermal oxidation. *J. Am. Oil chem. Soc.*, 34, 407-411.

[6] Waltking, A.E. and Zmachinski, H., **1970**. Fatty acid methology for heated oils. *J. Am. Oil Chem. Soc.,* 47, 530-134.

[7] Innawong, B., **2001**. Improving Fried Product and Frying Oil Quality Using Nitrogen Gas in A Pressure Frying System, Dissertation , Faculty of Virginia Polytechnic Institute and State University, goo.gl/dXK3lf (10 June 2017)

[8] Paradis, A.J. and Nawar, W.W., **1981**. Evaluation of new methods for the assessment of used frying oils. *J. Food Sci.,* 46, 449-451.

[9] Moreno, M., Olivares, D.M., Lopez, F.J.A., Adelantado, J.V.G. and Reig, F.B., **1999**. Determination of unsaturation grade and trans isomers generated during thermal oxidation of edible oils and fats by FTIR. *Journal of Molecular Structure*, 482-483, 551-556.

[10] Mozaffarian, D., Pischon, T., Hankinson, S.E., Rifai, N., Joshipura, K., Willett, W.C. and Rimm, E.B., **2004**. Dietary intake of trans fatty acids and systemic inflammation in women. *Am J Clin Nutr.,* 79(4), 606-612.

[11] AOCS. **1993**. Sampling and Analysis of Commercial Fats and Oils: Acid Valve AOCS Official Method. *Official Methods and Recommended Practices of the American Oil Chemists Society*, 4^{th} edn., AOCS Press, Champaign, pp. Aa 4-38, Aa 6-38, Ce 1-62.

[12] *Compendium of Methods for Food Analysis*. **2003**. *Food Composition and Nutrition Labelling:2.20* Fatty acid in Food, Gas - Liquid Chomatographic Method. First Edition p.2-39.

[13] Abdulkarim, S.M., Long, K., Lai, O.M., Muhammad, S.K.S. and Ghazali, H.M., **2007**. Frying quality and stability of high-oleic *Moringa oleifera* seed oil in comparison with other vegetableoils. *Food Chemistry,* 93, 1389-1382.

[14] Gunstone, D., **2000**. Composition and properties of edible oils. **In:** W. Hamm, R.J. Hamilton (Eds.), *Edible oil processing*, Sheffield Academic Press, England, pp. 3-5.

[15] Oil, vegetable, palm per 100 g; Fats and fatty acids. Conde Nast for the USDA National Nutrient Database, Release SR-21. **2014**. http://nutritiondata.self.com/facts/fats-and-oils/510/2(10 June 2017)

[16] Orthoefer, F.T., **2005**. Rice Bran Oil. In Shahidi, F. *Bailey's Industrial Oil and Fat Products*. 2 (6 ed.). John Wiley & Sons, Inc. p. 465.

[17] Poth, U., **2001**. *Drying Oils and Related Products*. Ullmann's Encyclopedia of Industrial Chemistry.

[18] Stevenson, S.G., Vaisey-Genser, M. and Eskin, N.A.M., **1984**. Quality control in the use of deep frying oils. *J. Am. Oil Chem. Soc.,* 61*,* 1102-1108.

[19] Warner, K., Orr, P., Parrott, L. and Glynn, M., **1994**. Effects of frying oil composition on potato chip stability. *J. Am. Oil Chem. Soc.,* 71*,* 1117-11121.

[20] Anon. **1998**. *US grower plant mid-oleic sunflower*. *Inform.* 9, p. 92

[21] Liu, H-R. and White, P.J., **1992**. High-temperature stability of soybean oils with altered fattyacid compositions. *J. Am. Oil Chem. Soc.* 69*,* 533-537.

[22] XuX-Q, Tran, V.H., Palmer, M., White, K. and Salisbury, P., **1999**. Chemical and physical analyses and sensory evaluation of six deep-frying oils. *J. Am. Oil Chem. Soc.,* 76*,* 1091-1099.

[23] Mounts, T.L., Warner, K., List, G.R., Neff, W.E. and Wilson, R.F., **1994**. Low-linolenic acid Soybean oils-alternatives to frying. *J. Am. Oil Chem. Soc.,* 77*,* 223-229.

[24] Tsuzuki, W., Matsuoka, A. and Ushida, K., **2010**. Formation of trans fatty acids in edible oils during the frying and heating process. *Food Chemistry,* 123(4), 976-982.