Journal of Applied Sciences Research, 9(3): 2205-2212, 2013
ISSN 1819-544X
This is a refereed journal and all articles are professionally screened and reviewed

ORIGINAL ARTICLES

Deep-fat-fried Edible Oil Blend Containing Omega 3, 6 , 9 and Natural Antioxidant Extracted from *Elaeocarpus hydrophilus* Kurz. Leaf

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ABSTRACT

The research aimed to develop edible oil blend from canola and palm olein oils for deep-fat frying at 180°C. *Elaeocarpus hydrophilus* Kurz.leaf extracts in varying concentration were used to improve frying stability, representing 0, 200, 400, 600 and 800 ppm. The physical and chemical properties including viscosity, color (L*, a*, b*), total polar materials, free fatty acid (FFA), peroxide value (PV) and p-anisidine value (AV) were determined. In the first part of the study, the most suitable ratio of mixed vegetable oil for deep-fat frying was selected based on physical and chemical properties. The oil blend (canola: palm olein) at the ratio of 25:75 (v/v) showed the highest frying stability which had the ratio of omega 6: omega 3 approximately 5.64:1. After that, the leaf extracts with different concentration were added to the selected edible oil blend. The result showed that the oil blend with the leaf extract at 800 ppm demonstrated the highest deep-fat frying stability. The measured values of total polar materials and AV in the fried oil were significantly different ($p \leq 0.05$) and showed the least change at the end of frying process.

Key words: Blended oil, Omega, Deep-fat frying, leaf extract

Introduction

Different oil contains various saturated and unsaturated fatty acids resulting in different physical and chemical properties. Omega 3 (alpha-linolenic acid; C18:3) and omega 6 (linoleic acid; C18:2) and omega 9 (oleic acid; C18:1) are the essential fatty acids found in edible oil. The American Heart Association recommended that the most suitable ratio of omega 6 and omega 3 for dietary intake should be between 2:1 and 5:1 (Flickinger, B.D., P.J. Huth, 2004). In order to obtain the most suitable ration of essential fatty acid intake, blending of vegetable oils is mostly used to modify the fatty acid composition and nutrition. Palm olein oil has been widely used in frying of food at high temperature due to its unique physical and chemical properties (Kubola, J., S. Siriamornpun, 2008). Canola oil contains the high content of omega 6 and 9 (10.7 % and 34.6 %, respectively) (Ravi, R., 2005). Proper omega 3 and 6 ratio of the oil blend can be achieved by optimizing the proportions of the mixed oils.

Deep-fat frying is probably one of the most dynamic processes in food processing. During heating, frying oils are subjected to various alterations such as hydrolysis and thermal oxidation, which generates volatile compounds such as carbonyls, keto acids and epoxy acids. These phenomena caused off-flavor and darken color in frying oil and the minor components such as vitamin in frying oils were oxidized, thereby affect to lost the nutrition of the fried oils. The oil blend between canola oil and palm olein oil contains high unsaturated fatty acids, which is rapid oxidized during frying at high temperature (Baux, A., 2008). Spanish plum or *Elaeocarpus hygrophilus* Kurz or Ma kok nam in Thai is inexpensive, safe and contains nutritional value. It is a local evergreen tree in ELAEOCARPACEAE family. It was found that Spanish plum had strong antioxidant activities and also has high total phenolic, flavonoids, and gallic acid contents. Therefore, the Spanish plum leave extract can be used as an alternative natural antioxidant in the oils to improve oil stability during frying (Farag, R.S., 2007).

The objective of this study was to determine the frying stability of oil blend between canola and palm olein oils with the adding of a natural antioxidant, Spanish plum leaf extract *Elaeocarpus hygrophilus* Kurz. Therefore, the most suitable ratio of oil blend containing omega 3, 6 and 9 with the highest deep-fat frying stability was developed in this study.

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Materials and Methods

1. Materials:

Palm olein and canola oils were purchased from Big C Supercenter Public Company Limited, Bangkok. Thailand. The oil sample was stored at 4°C until analysis. The Spanish plum leaves *Elaeocarpus hydrophilus* Kurz. were obtained from Jatujak market, Bangkok,Thailand.

2. Methodology:

2.1 The oil blends between canola (CAO) and palm olein oil (POO) were prepared in the various ratios for 5 formulas as 25:75, 75:25, 20:80, 30:70 and 40:60 (v/v). The physical and chemical properties including viscosity (Brookfield model DV I, USA), color (Minolta Chroma Meter model CR-300, Japan) total polar materials (Testo 265, Germany), free fatty acid, peroxide value and p-anisidine value were determined.

2.2 Potatoes were peeled and sliced into pieces (30 mm. diameter x 1 mm. thickness). The fresh oil (2 L) was placed in 4-L capacity deep-fryer (Princess 2626 Deep Fryer, Netherland) and heated to 180°C. 300 g. per batch of potatoes slides was deep-fat fried at constant temperature. The batches were fried continuously at 1-min intervals for 60-min frying time. At the end of each 20-min frying time, 200 ml of frying oil was taken and stored at 4 °C until analyzed. The physical and chemical properties of the fresh and fried oils were determined (as described in 2.1).

2.3 Spanish plum leaves *Elaeocarpus hygrophilus* Kurz. were pruned. The leaves were cleaned and dried by hot air oven at 60 °C for 15 h and kept in desiccators for a day before extracted. Spanish plum leaves were mixed with 75% ethanol (1:8) and homogenized for 10 min (controlled at 5°C) and then ripened at 5 °C for 12 h. Then, the crude Spanish plum leaf extract were filtrated (Whatman no. 1) and evaporated by Rotary vacuum evaporator. The extracts were kept in a brown bottle at -20 °C until use.

2.4 The most suitable ratio of oil blend formula was selected (750 ml) and mixed with Spanish plum leaf extract in varying concentrations representing 0, 200, 400, 600 and 800 ppm. The stabilities of various oil samples were studied by using deep-fat frying process. Potatoes pieces (30 mm. diameter x 1 mm. thickness) in 300 g. batches were placed in oil samples (2 L) and fried at constant temperature (180°C). The batches were fried continuously at 1-min intervals for 60-min. The fried oil samples were taken at 0, 20, 40 and 60 min and analyzed physical properties including viscosity and color (as described in 2.1) and chemical properties including total polar materials (Testo 265, Germany), free fatty acid, peroxide value, p-anisidine value (AOCS, 1998), DPPH radical-scavenging activity (method of Kubola and Siriamornpun [6]) and polyphenol content (method of Gutfinger (Gutfinger, T., 1981)).

2.5 Statistical Analysis

All experiments were carried out in triplicate. The experimental design used in this study was the Completely Randomized Design (CRD). Analysis of Variance (ANOVA) was performed at 95% significant difference. Duncan's New Multiple Range Test (DNMRT) was applied to determine the significant differences between means.

Results and Discussion

1. Fatty acid composition of palm olein oil, canola oil and their blends:

The fatty acid composition indicates stability of oil during frying. Unsaturated fatty acids were oxidized rapidly resulting in lower stability of oil. The amount of unsaturated fatty acids of canola oil is higher than those in palm olein oil, then they may be oxidized and unstable for frying (Baux, A., 2008). However, canola oil had the suitable ratio of omega 6: omega 3 for consumption. Canola oil was selected to blend with palm olein oil, which had high oleic acid and stable for frying at high temperature. In this study, amount of omega 3, 6, and 9 of oil blend between canola and palm olein oils in various ratios of 5 formulas, representing 25:75, 75:25, 20:80, 30:70 and 40:60 (v/v) were shown in Table 1. The ratios of omega 6: Omegas 3 from 2:1 to 5:1 were obtained as shown in Table 1 (e.g. the blending POO: CAO at the ratio of 75:25, 30:70 and 40:60).

Table 1: Fatty acid composition of palm olein oil (POO), canola oil (CAO) and their blends.

Unsaturated fatty acid (%)	Canola oil	Palm olein oil	CAO:POO				
			25:75	75:25	20:80	30:70	40:60
C18:1(ω-9)	34.6	22.4	25.45	31.55	24.84	26.06	27.28
C18:2(ω-6)	10.7	4.7	6.2	9.2	5.9	6.5	7.1
C18:3(ω-3)	4.4	-	1.1	3.3	0.88	1.32	1.76
Ratio of ω-6: ω-3			5.64:1	2.79:1	6.7:1	4.92:1	4.03:1

2. Physical and chemical properties of palm olein oil, canola oil and their blends (before and after deep-fat frying):

2.1 Viscosity:

Changes in the viscosity of oil blends before and after frying at 180°C for 60 min were shown in Figure 1. The viscosity of oil blends at the initial stage of frying was significantly changed ($p \leq 0.05$) and increased during frying process. The polymerization reaction occurring during deep fat frying usually played the important role in increasing oil blends viscosity.

2.2 Color:

In the present study, the values of color indicated the quality of oils. Each oil has different color depending on its minor component. During frying process, the values of color including brightness (L*), red (a*), and yellow (b*) for oil blends were significantly different ($p \leq 0.05$). Values of L* and a* decreased while b* values increased. The possible cause that changed the oil color was oxidation reaction. The reaction of oxygen with double bond of edible oil composition (e.g. oil pigments) affected oil color.

2.3 Total polar materials:

Polar materials were generated from disintegration of unsaturated fatty acid in oils. Heated oil from cooking food was deteriorated easily due to the increasing of polar material. It has been reported that the polar materials cause the changes of oil color and rancid flavor. Their actions as promoters of carcinogenesis in rat were mentioned (Rangaswamy, B.L., 2005).

Figure 2 indicates significantly increased of the levels of total polar materials of oil blends during frying ($p \leq 0.05$). At the end of process, oil blend in the ratio 25:75 (v/v) showed the lowest total polar materials.

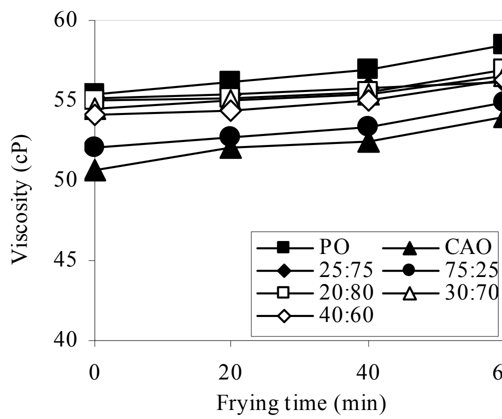

Fig. 1: Changes in the viscosity of palm olein oil, canola oil and their blends during frying (60 min).

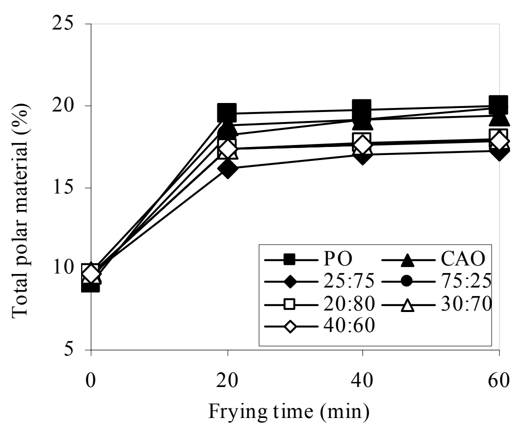

Fig. 2: Changes in total polar materials of palm olein oil, canola oil and their blends during frying (60 min).

2.4 Free fatty acids (FFA):

Free fatty acid indicated disintegration of triacylglycerol in oils. The data in Figure 3 demonstrated that free fatty acids in oil blends were significantly ($p \leq 0.05$) increased throughout the frying period. This indicated that the waters were transferred into the fried oil that affected the hydrolyzation of triacylglycerol to free fatty acid. This reaction was catalyzed by high temperature and presenting of oxygens.

2.5 Peroxide value (PV):

Peroxide value is the measurement of lipid oxidation and indicates oxidative rancidity in oils. During frying process, the levels of peroxide value of oil blends were significantly changed ($p \leq 0.05$) (Figure 4).

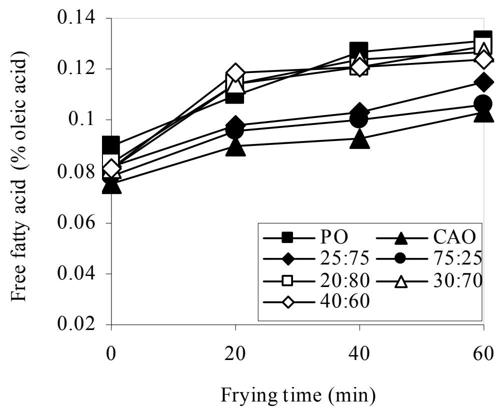

Fig. 3: Changes in free fatty acid (%oleic acid) of palm olein oil, canola oil and their blends during frying (60 min).

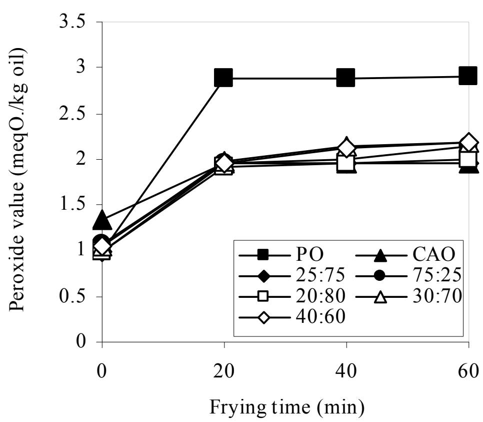

Fig. 4: Changes in peroxide value of palm olein oil, canola oil and their blends during frying (60 min).

2.6 p-anisidine value (AV):

The values of AV that used to measured level of carbonyl compounds, which were generated from peroxides and hydroperoxides. This reaction indicated oxidative stability and rancid flavor of oils. During frying, the reaction of oils with water were reacted, that affected to increase the levels of AV. Oil blend in the ratio 25:75 (v/v) induced the lowest change of AV at the end of frying process (Figure 5).

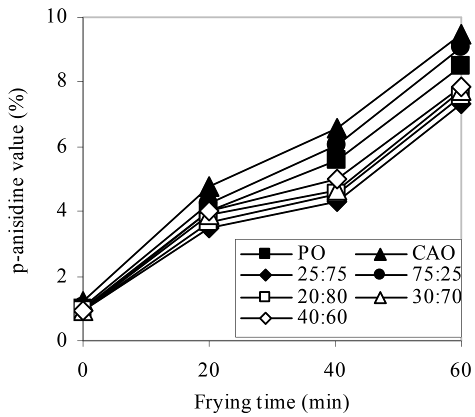

Fig. 5: Changes in p-anisidine value of palm olein oil, canola oil and their blends during frying (60 min).

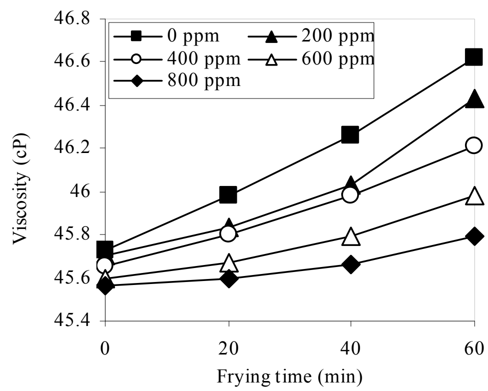

Fig. 6: Changes in the viscosity of oil blends during frying (60 min) mixed with different concentration of Spanish plum leaf extract.

3. Physical and chemical properties of oil blends mixed with various concentrations of Spanish plum leaf extract (before and after deep-fat frying):

3.1 Viscosity:

The initial viscosity of oil blends were not significantly different ($p\leq0.05$). The level of Spanish plum leaf extract was added to oil blends that induced the lowering in the viscosity values. During frying, the viscosity of oil blends was increased. However, the values of viscosity were not different significantly ($p\leq0.05$) at the end of frying process (Figure 6).

3.2 Color:

The values of color (L*, a* and b*) were not different significantly ($p\leq0.05$). The values of brightness (L*) were decreased but redness (a*) and yellow (b*) were increased. Mixing oil blends with Spanish plum leaf extract at 800 ppm indicated the least change of color at the end of frying process.

3.3 Total polar materials:

During frying process, the total polar materials of fried oil were significantly increased ($p\leq0.05$) (Figure 7). Total polar materials at the end of frying process for oil blends were about 0.78, 0.71, 0.61 and 0.44, for oil blends mixed with 200, 400, 600 and 800 ppm, respectively.

3.4 Free fatty acids (FFA) and Peroxide value (PV):

The data illustrated in Figure 8 and 9 indicated that FFA and PV increased during frying. The oil blend mixed with Spanish plum leaf extract at 800 ppm induced the least change of FFA and PV about 0.25 and 0.93, respectively.

3.5 p-anisidine value (AV):

Changes in p-anisidine value (AV) of oil blend mixed with various concentrations of Spanish plum leaf extract shown in Figure 10. The AV of oil blend were significantly ($p \leq 0.05$) increased during frying process. The levels of AV of oil blends mixed with Spanish plum leaf extract at 800 ppm were about 1.45 lower than the oil blend without Spanish plum leaf extract.

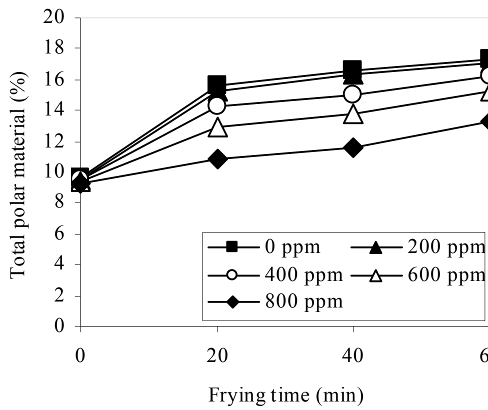

Fig. 7: Changes in total polar materials of oil blends during frying (60 min) mixed with different concentration of Spanish plum leaf extract.

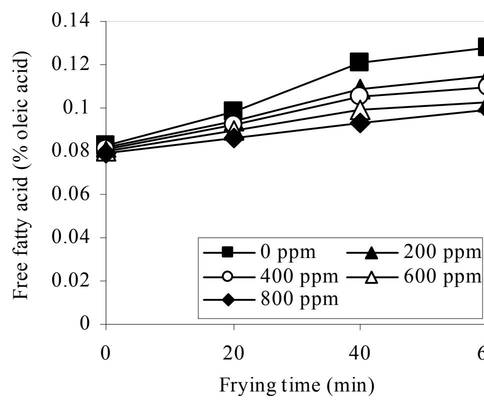

Fig. 8: Changes in free fatty acid (%oleic acid) of oil blends during frying (60 min) mixed with different concentration of Spanish plum leaf extract.

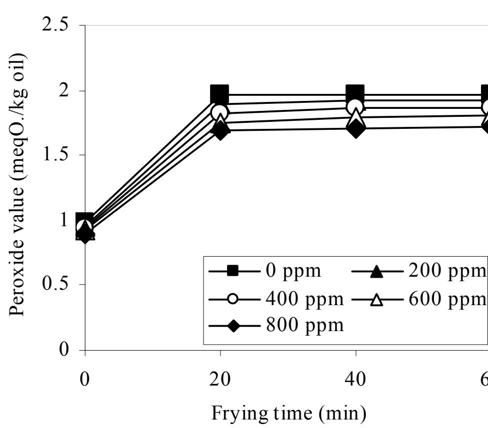

Fig. 9: Changes in peroxide value of oil blends during frying (60 min) mixed with different concentration of Spanish plum leaf extract .

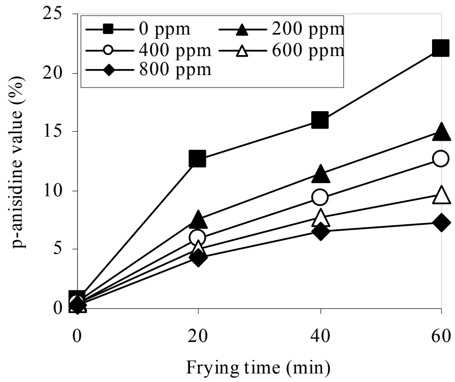

Fig. 10: Changes in p-anisidine value of oil blends during frying (60 min) mixed with different concentration of Spanish plum leaf extract.

3.6 DPPH radical-scavenging activity:

The DPPH method has been widely applied for estimating antioxidant activity in recent years. The stable free radical diphenylpicrylhydrazyl (DPPH) is characterized as a stable free radical by virtue of the delocalization of the spare electron. The delocalization also gives rise to the deep violet color, characterized by an absorption band in ethanol solution centered at about 517 nm. When a solution of DPPH is mixed with that of a substance that can donate a hydrogen atom, then this gives rise to the reduced form with the loss of this violet color to be a pale yellow color. In generally, vegetable oils had a natural antioxidant but it was not enough to preventing oxidation in oils. The present study was entailed on the direct use of Spanish plum leaf extract. Consequently, the polyphenol content present in Spanish plum leaf extract were added in oil blends at various level in an attempt to increase the oil stability and prevent to rancid flavor during frying.

The data in Figure 11 indicated that the DPPH values were significantly ($p \leq 0.05$) increased with higher concentration of Spanish plum leaf extract. However, heating at high temperature affected the decrease of antioxidant activity in the fried oils. The mixed oil blends with Spanish plum leaf extract at 800 ppm showed the highest antioxidant activity which was higher than that the oil blend without Spanish plum leaf extract about 23.52% in the end of frying process.

3.7 Polyphenol content:

Polyphenol generally found in fruit and vegetable. It is antioxidant that prevented oxidation in oils but it can be destroyed at high temperature. The antioxidant effect of Spanish plum leaf extract on oil stability was entirely dependent on their suitable concentration of polyphenol.

Figure 12 indicated that the polyphenol content were significantly decreased ($p \leq 0.05$). At the end of frying process (60 min), the lost amount of polyphenol content were 24.49%, 20.87%, 18.75% and 18.03% for oil blends mixed with the leaf extract 200, 400, 600 and 800 ppm, respectively

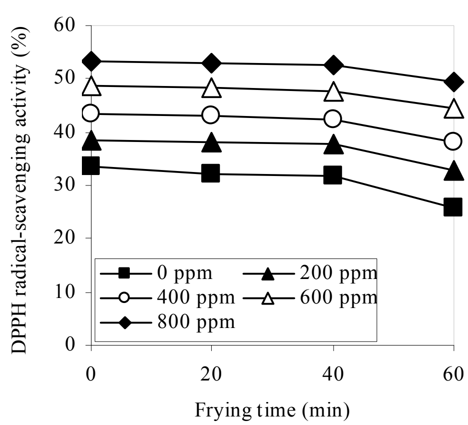

Fig. 11: Changes in DPPH radical-scavenging activity of oil blends during frying (60min) mixed with different concentration of Spanish plum leaf extract.

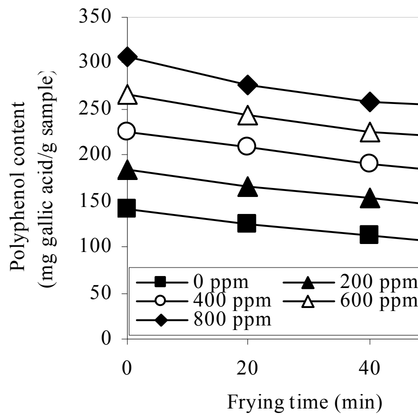

Fig. 12: Changes in polyphenol content of oil blends during frying (60 min) mixed with different concentration of Spanish plum leaf extract.

Conclusion:

In the present study, the ratio of oil blend at 25:75 (v/v) mixed with Spanish plum leaf extract at 800 ppm showed the highest frying stability that was selected based on physical and chemical properties. This oil blend had the lowest change of polar materials and p-anisidine value. This oil blend can be use as alternative edible oil for deep-fat frying. It is good for dietary intake since it contains optimum ratio of omega 3, 6, and 9.

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