International Food Research Journal 20(1): 403-407 (2013)
Journal homepage: *http://www.ifrj.upm.edu.my*

# Frying stability of rice bran oil and palm olein

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**Article history**

*Received: 7 March 2012*
*Received in revised form: 6 May 2012*
*Accepted: 7 May 2012*

**Keywords**

*Rice bran oil*
*palm olein*
*frying stability*

**Abstract**

A study to measure frying quality and stability of rice bran oil (RBO) compared to palm olein (PO) was conducted. The oils were used to fry French fries continuously for six hours a day up to five days at a temperature of 185 ± 5°C. Oil samples were collected and analyzed for free fatty acid (FFA), peroxide value (PV), smoke point, *p*-anisidine value (*p*-AV), iodine value (IV) and colour. At the end of the frying period for both oil samples, FFA, PV, colour and *p*-AV were increased whereas the IV and smoke point decreased. The rate of FFA formation of RBO was slightly lower which increased from 0.142% to 0.66% compared to PO which was from 0.079% to 0.93%. The PV of RBO showed consistent increased from 3.9 meq/kg to 13.4 meq/kg whereas PO with initial value at 3.4 meq/kg increased to 34.6 meq/kg on the fifth day. Smoke point of RBO and PO progressively dropped from 235°C to 188°C and 220°C to 178°C, respectively. The level of *p*-AV for RBO increased from 12.19 to 32.65 from the initial to the end of frying day whereas PO had higher rate of changes in *p*-AV which was from 10.45 to 60.75. The IV decreased over frying time where IV of RBO decreased from 94.5 to 66.5 while IV of PO decreased from 50.9 to 44.6. The colour of RBO showed increased in redness and yellowness but PO was darker at the end of the frying trial. In general, RBO showed better stability than the PO in deep frying of French fries.



## Introduction

Rice bran oil (RBO) is one of the most nutritious and healthful edible oils due to the presence of abundance natural bioactive phytoceuticals such as γ-oryzanol, tocopherols, tocotrienols (tocols) and play important roles in preventing some diseases (Rajam *et al*., 2005). RBO is more popular to be used as frying oil due to its high smoke point and stability and unique frying characteristics which required less oil in frying compared to other oils (Gunstone, 2006). Refined RBO plays important role as excellent salad and frying oil with high oxidative stability resulting from its high level of tocopherols and tocotrienols (~860ppm) (Gunstone, 2004).

Palm olein (PO) is often known as a heavy duty frying oils which normally used in fast food outlets due to its oxidative stability and presence of tocols and carotenoids composition (Nallusamy, 2006). Unsaturated and saturated fatty acid content of PO was found contributing to good flavor stability (Rayner *et al*., 1998). Bracco *et al*. (1981) reported that PO performed satisfactorily and produced fried foods with acceptable cooking qualities compared to other major commercial vegetable oils as frying media.

Deep fat frying is a process which involves immersing a food item in a large quantity of heated oil or fat. The frying time normally takes 5-10 min and normally conducted at temperatures of 175-195$^{0}$C (Aladedunye and Przybylski, 2009). The quality of the frying oil is of great importance with regard to quality of the fried food as it can contribute some unique organoleptic and sensory characteristics including flavour, texture and appearance (Kochhar, 2001; Aladedunye and Przybylski, 2009). During frying, the oil is subjected to physical and chemical reactions which will affect the oxidative degradation of the oil in the presence of air and moisture. The chemical reactions including oxidation (presence of air), hydrolysis (caused by the presence of water) and polymerization of unsaturated fatty acid that change the composition of the frying medium (Mariod *et al*., 2006).

The rate of decomposition of the oil depends on several factors such as temperature and length

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of frying, type of food fried, composition of the oil, continuous or intermittent frying and fresh oil replenishment. The decomposition of undesirable products also formed due to the interactions between the food ingredients and the oil which will affect the food products' taste, flavour, colour and shelf life. However, repeating using of frying oils can affect the food quality and promote the formation of compounds that can affect human health (Sanibal and Filho, 2004) and cause the fried foods to have rather limited shelf life due to the development of rancidity in the frying oil taken up by the products (Man and Irwandi, 2000). After the frying process, the consumers are concern about the oil quality from the aspects of the colour, smoke point and the degree of rancidity. Several parameters can be used to assess the oil quality such as free fatty acid (FFA), peroxide value (PV), colour of the frying oil, smoke point and fatty acid composition. The objective of this study was to determine and compare the frying stability via few physicochemical properties test on RBO and PO. PO was used in this study due to its major commercial role in frying. RBO was chosen in order to determine the frying stability in comparison with PO and further provide an alternative oil source as major commercial vegetable oils in deep fat frying.

## Material and Methods

*Materials*

RBO and PO used for comparison in the frying were purchased from a local supermarket. French fries with shoestring size used in frying were purchased from a local supermarket. All reagents were of analytical grade and obtained from local suppliers.

*Initial oil analysis*

PORIM test methods (PORIM, 1995) were used to determine free fatty acid (FFA) and p-anisidine value (*p*-AV). While AOAC recommended methods (AOAC, 1999) were used to determine peroxide value (PV), iodine value (IV) and smoke point of the oil samples. Colour measurements of the oil samples was carried out using a HunterLab Colorflex (Maskan, 2003).

*Frying procedure*

The frying experiments of RBO was carried out using a stainless steel frying-pan. The frying test was carried out at 185 ± 5$^0$C with the frying time of 30 hours over five days. The frying test was started on first day by using a frying-pan in order to collect the fifth day frying oil. Another frying-pan was used on second day for frying test in order to collect the fourth day frying oil. There were total of six frying-pans used during the five days frying. For the first day of every frying test, the oil was conditioned by heating to 185 ± 5$^0$C and held for 30 min. About 166g of French fries were fried for each batch for six hours each day in 1kg oil. The food to oil ratio used was 1:6 (Normand *et al*., 2006). A total of 24 batches of French fries were fried each day. Each batch of the fries was fried for 15 min apart for the total of six hours in which the fries frying time was eight minutes while the break time between two successive frying was seven minutes (Rossi *et al*., 2007). The same frying process was carried out by using PO as frying medium.

*Sampling for oil analysis*

At the end of the frying experiment each day, the oil was left to cool overnight. On the second and consecutive frying days, the oil in each frying-pan was filtered to remove debris using separate filters before replenishment on each day. The oil was weighed prior to frying to determine the amount of fresh oil needed to replenish the oil to the initial weight of oil (1kg) in the frying pan (Petukhov *et al*., 1999). The 0 hour oil was collected after the oil conditioned for 30 min at 185 ± 5$^0$C. Six samples of oil were collected on the fifth day for 0 hour, day 1, 2, 3, 4 and 5 from six different frying-pans. The oil samples that collected was the last batch of the frying process for that particular day. The oil samples for analysis were taken on the fifth day after the oil had cooled to room temperature. An amount of 400ml frying oil was sampled in 500ml dark amber bottles, flushed in nitrogen and stored at -20$^0$C for physicochemical analysis (Tarmizi and Ismail, 2008). All the samples collected were analyzed using the same procedure used for the initial oil analysis. All testing and analysis were repeated three times to obtain an average reading.

*Statistical analysis*

Data was evaluated by analysis of variance by using Statistical Package for the Social Sciences (SPSS) version 16.0. Statistical significance was expressed at the $p<0.05$ level by using one way ANOVA. The data was analyzed by using Tukey test to determine the difference among the frying days.

## Results and Discussion

The initial quality of RBO and PO were shown in table 1. As overall, FFA, PV, *p*-AV, IV and smoke point of RBO were tested higher than PO. The FFA of PO at 0.079% was able to meet the standard trading specifications of 0.1% FFA maximum according to PORAM specification (PORAM, 2007). Meanwhile,

Table 1. Initial quality of rice bran oil and palm olein

| Determination | RBO | PO |
|---|---|---|
| FFA content (%) | 0.142 ± 0.007 | 0.079 ± 0.000 |
| PV (meq/kg) | 3.9 ± 0.007 | 3.4 ± 0.000 |
| Smoke Point ($^0$C) | 235 ± 1 | 220 ± 1 |
| *p*-AV | 12.19 ± 0.20 | 10.45 ± 0.15 |
| IV (g $I_2$/100 g of oil) | 94.5 ± 0.75 | 50.9 ± 2.10 |
| Colour [a(redness) / b(yellowness) / L(whiteness)] | - 0.60/4.07/30.10 | -1.68/7.60/34.99 |

*Mean Value ± Standard Deviation (n=2)

*FFA will be expressed to 3 decimal places for FFA below 0.15% and 2 decimal places for FFA above 0.15%.

* +a = red, -a=green, +b=yellow, -b=blue, L, 0=black, 100=white

Table 2. Changes in FFA, PV, *p*-AV, IV and smoke point in oils during

| Determination | Day | RBO | PO |
|---|---|---|---|
| FFA content (%) | 0 | $0.14 \pm 0.01^{fB}$ | $0.16 \pm 0.00^{fA}$ |
| | 1 | $0.22 \pm 0.00^{eB}$ | $0.24 \pm 0.01^{eA}$ |
| | 2 | $0.37 \pm 0.00^{dB}$ | $0.48 \pm 0.02^{dA}$ |
| | 3 | $0.50 \pm 0.01^{cB}$ | $0.70 \pm 0.01^{cA}$ |
| | 4 | $0.56 \pm 0.01^{bB}$ | $0.81 \pm 0.03^{bA}$ |
| | 5 | $0.66 \pm 0.00^{aB}$ | $0.93 \pm 0.01^{aA}$ |
| PV (meq/kg) | 0 | $8.60 \pm 0.28^{cA}$ | $6.80 \pm 0.28^{eB}$ |
| | 1 | $11.25 \pm 0.07^{bB}$ | $44.85 \pm 0.92^{aA}$ |
| | 2 | $9.40 \pm 0.57^{cB}$ | $20.70 \pm 1.98^{dA}$ |
| | 3 | $11.05 \pm 0.21^{bB}$ | $25.20 \pm 2.26^{dA}$ |
| | 4 | $12.75 \pm 0.21^{aB}$ | $38.70 \pm 0.57^{bA}$ |
| | 5 | $13.35 \pm 0.21^{aB}$ | $34.55 \pm 1.48^{cA}$ |
| Smoke point ($^0$C) | 0 | $225.0 \pm 1.4^{aA}$ | $212.0 \pm 0.0^{aB}$ |
| | 1 | $219.5 \pm 0.7^{bA}$ | $209.0 \pm 1.4^{aB}$ |
| | 2 | $211.0 \pm 1.4^{cA}$ | $197.0 \pm 1.4^{bB}$ |
| | 3 | $207.0 \pm 1.4^{cA}$ | $188.5 \pm 0.7^{cB}$ |
| | 4 | $190.0 \pm 0.0^{dA}$ | $180.5 \pm 0.7^{dB}$ |
| | 5 | $187.5 \pm 0.7^{dA}$ | $177.5 \pm 0.7^{dB}$ |
| *p*-AV | 0 | $16.06 \pm 1.16^{dB}$ | $21.30 \pm 0.46^{dA}$ |
| | 1 | $20.46 \pm 0.96^{cB}$ | $48.99 \pm 0.72^{cA}$ |
| | 2 | $24.33 \pm 1.44^{bB}$ | $56.47 \pm 1.61^{bA}$ |
| | 3 | $26.76 \pm 0.06^{bB}$ | $60.85 \pm 0.54^{aA}$ |
| | 4 | $27.95 \pm 0.07^{bB}$ | $60.91 \pm 0.31^{aA}$ |
| | 5 | $32.65 \pm 1.06^{aB}$ | $60.75 \pm 0.19^{aA}$ |
| IV (g $I_2$/100 g of oil) | 0 | $92.5 \pm 1.06^{aA}$ | $51.2 \pm 1.70^{aB}$ |
| | 1 | $84.7 \pm 0.57^{bA}$ | $49.9 \pm 1.20^{abB}$ |
| | 2 | $76.4 \pm 0.85^{cA}$ | $48.4 \pm 0.35^{abcB}$ |
| | 3 | $69.4 \pm 1.13^{dA}$ | $47.0 \pm 1.00^{bcB}$ |
| | 4 | $67.4 \pm 1.00^{dA}$ | $46.9 \pm 0.28^{bcB}$ |
| | 5 | $66.5 \pm 1.27^{dA}$ | $44.6 \pm 0.14^{cB}$ |

*FFA value will be expressed to 3 decimal places for FFA below 0.15% and 2 decimal places for FFA above 0.15%.

*Mean value ± standard deviation (n=2). Mean values within each column followed different letters (a, b, c, etc.) are significantly (p<0.05) different. Mean values within each row followed by different letters (A, B, C, etc.) are significantly (p<0.05) different.

Table 3. Hunter Lab values of rice bran oil and palm olein

| | RBO | | | PO | | |
|---|---|---|---|---|---|---|
| Hunter Lab | a | b | L | a | b | L |
| Fresh Oil | -0.60 | 4.07 | 30.10 | -1.68 | 7.60 | 34.99 |
| Day 0 | -1.20 | 6.82 | 33.97 | -1.62 | 9.89 | 37.50 |
| Day 1 | -1.76 | 10.13 | 31.82 | -1.39 | 6.99 | 33.01 |
| Day 2 | -1.45 | 11.63 | 30.79 | -1.89 | 9.80 | 35.26 |
| Day 3 | 0.25 | 12.52 | 29.98 | 1.41 | 10.69 | 30.43 |
| Day 4 | -0.25 | 13.02 | 31.06 | -1.95 | 10.18 | 35.69 |
| Day 5 | 0.77 | 14.62 | 33.86 | -1.66 | 9.54 | 30.86 |

*+a = red, -a=green, +b=yellow, -b=blue, L, 0=black, 100=white

PV of both oils were considered higher than the specifications for fresh oil which was 1 meq/kg whereas *p*-AV of RBO was slightly higher than 10 for fresh refined oils (Rosell, 1986). Iodine value (IV) for RBO was much higher due to the higher degree of unsaturation. Smoke point for both oils were higher than 200$^0$C making these oils were suitable for deep-fat frying purposes (Moreira *et al*., 1999). RBO had lower value in yellowness and whiteness but higher in redness than the PO.

Table 2 showed changes in FFA, PV, smoke point, *p*-AV and IV for RBO and PO for the 5 days of frying. Both oils showed increasing trend in FFA content and PV while decreasing trend in smoke point during five days frying. It was observed that FFA and PV of PO increased markedly on first frying day, compared to steady rise for RBO throughout five days frying. The liberation of FFA throughout frying experiment had been found consistently lower the smoke point for both oils, with PO having the lowest smoke point over the frying period. This was due to the smoke point is directly proportional to the concentration of low-molecular weight decompositions such as FFA and volatile compounds in the oil (Matthaus, 2006). The difference rate of changes in FFA, PV and smoke point between both oils were due to the presence of high unsaponifiable lipids (4%) such as tocopherols, tocotrienols, γ-oryzanol, sterols and carotenoids (Sayre, 1988) in the RBO. According to Duve and White (1991), γ-oryzanol has several biological and physiological effects such as serving as anti-oxidation. In was reported that the presence of the γ-oryzanol decreased the oxidation rate of the oil during frying periods and was possible to inhibiting the lipid peroxidation and FFA production in several oil modes (Xu *et al*., 2001; Nystrom *et al*., 2005).

Results from Table 2 also shown increase trend of the *p*-AV in both oils with increasing frying days with higher increase rate of *p*-AV in PO than RBO. The increase of the *p*-AV value on first frying day was due to the less stable hydroperoxides from primary oxidation decompose further to form secondary oxidation products aldehydic compounds which are measured by *p*-AV (Abdulkarim *et al*., 2007). The further steady rise of *p*-AV for both oils indicated the formation of volatile breakdown products such as aldehydes, ketones and anhydrides of unsaturated fatty acid which can affect the flavor of fried food (Mohammad Imtiyaj Khan *et al*., 2008). Nevertheless, higher *p*-AV for PO reflects higher secondary oxidation products (aldehydes) decomposed from the higher content of oxidation products (hydroperoxides compounds) produced from primary oxidation which was detected in PO with higher PV (Mariod *et al*., 2006).

Changes in IV over the five days frying period from the initial values for RBO was found larger than PO. The RBO showed faster reduction in IV due to its presence of high unsaturated fatty acid in the oil compared to PO and this was reflected by IV which is used to measure the degree of unsaturation of the oils. On the other hand, PO had slower reduction in IV which was resulting from its lower degree of unsaturation due to the presence of large amount of saturated fatty acid (Erickson, 1990). Decreased of IV indicated that the increased rate of oxidation during frying due to the break down of double bonds in fatty acid by oxidation and polymerization leading to decrease in the degree of unsaturation and IV (Abdel-Aal and Karara, 1986).

Table 3 shows the colour changes of both oils over five days of frying period with RBO showing higher increase rate in red colour and yellow colour compared to PO. Nevertheless, the initial colour of PO was lighter than the RBO but it was found to be darker than the RBO at the end of the frying trial. Rate of darkening is proportional to the frying to time. Accumulation of nonvolatile decomposition products such as oxidized triacylglycerols and FFA during oxidation can lead to colour changes which indicate the extent of oil deterioration (Abdulkarim *et al*., 2007). This explained that PO with higher production rate of FFA (table 2) and other possible oxidized products over frying days showed greater colour darkening compared to RBO.

## Conclusion

Both RBO and PO showed decreasing oxidative stability after frying process. PO showed higher increment in FFA, PV and greater of smoke point reduction compared to RBO. The different rate of increment between these two oils was due to the presence of natural antioxidant such as tocopherols and γ-oryzanol in RBO which was found can decrease the oxidation rate of the oil during frying periods. Higher increase rate in *p*-AV for PO was observed which reflects higher secondary oxidation products decomposed from the higher content of primary oxidation products which was with higher PV in PO. Decrease in IV for RBO was found greater than PO due to its high degree of unsaturation compared to PO leading to increased rate of oxidation and break down of double bonds in fatty acid during frying. Colour of the RBO became redder and yellowish along frying but PO was darker at the end of the frying trial. Greater accumulation of oxidized triacylglycerols and FFA from oxidation during frying was found leading to greater darkening of oil which supported by PO with higher production rate of FFA and other possible oxidized products over frying days. In conclusion, RBO shows better stability than the PO in deep frying of French fries.

## Acknowledgements

The authors would like to thank School of Food Science and Nutrition, Universiti Malaysia Sabah to make this research possible.

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