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AVAILABILITY OF DIFFERENT TYPES OF PALM OLEIN AND THEIR PERFORMANCE DURING DEEP FRYING

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Abstract

Palm olein is the liquid fraction of palm oil which is obtained after the process of fractionation. By using special fractionation techniques, several types of palm olein such as standard (POo), double fractionated (DF), and special quality (SQ) are obtained and available in the market. These oleins are mainly used for cooking and frying purposes. Frying experiments were conducted simulating fast food service operations for 5 consecutive days using these three types of olein. The objective of this study was to compare their frying performance during deep fat frying using French fries. French fries were fried in the tested oleins for 3.5 minutes at 180^{o}C. Physical and chemical quality of the oleins before and after frying such as free fatty acid content, smoke-point, colour, polar compounds, polymer content and iodine value were analyzed. The iodine value of fresh oleins ranged from 56.1 to 65.0. The colour of fresh SQ was extremely low (1.1R) compared to other oleins. After frying for 5 consecutive days, it darkened rapidly to 8.8R while DF and POo darkened to more than 9R. On day 5, the free fatty acid (FFA) of SQ was lowest (0.18%), followed by POo (0.25%) and DF (0.28%). SQ also showed the highest smoke point value of 204^{o}C compared to POo and DF after frying for 5 days. The increment in polymer content for SQ was very minimal over the 5 days period of frying ranging from 0.44-0.62%. The polar compound of the 3 oleins after frying for 5 days ranged from 16.5 to 19.92%. The frying performance of SQ was found to be superior than other oleins in most of the parameters evaluated.

Key words: *standard palm olein, double fractionated palm olein, special quality palm olein, deep frying*

1. INTRODUCTION

Palm oil produced in Malaysia is consumed in more than 150 countries (Lai 2005). Palm oil has now gained worldwide acceptance due to its unique properties and versatile applications as well as the competitive traded price over other vegetable oils (Choo et al. 2007). The acceptance of palm oil worldwide is due to its special characteristics that encourage its use in a wide range of end products. These properties are made more versatile by the various fractions and refined forms that are available in the world market.

Refined palm olein is one of the major forms of product exported from Malaysia suitable for various food-uses. Bracco et al. (1981) reported that POo performed satisfactorily and produced fried products with acceptable cooking qualities compared to other major commercial vegetable oils as frying media. Double-fractionated palm olein is also known as superolein with an iodine value between 60 and 67. It contains a high content of oleic (C18:1), palmitic (C16:0) and linoleic (C18:2) acids (Siew 2000). Super olein is unable to withstand cold temperatures and becomes cloudy and crystallizes when the temperature is lower than its melting point. Palm olein is used as cooking oil as well as frying oil for food industries such as snack food and ready-to-eat food. Palm olein is used globally for both batch and continuous frying because it offers several technical characteristics desirable in food applications, such as resistance to oxidation, which contributes towards longer shelf life of end products.

Palm olein is the liquid fraction obtained by fractionation of palm oil after crystallization at controlled temperatures. The physical characteristics of palm olein differ from those of palm oil. It is fully liquid in warm climate and has a narrow range of glycerides. In addition to finding uses as in the case of palm oil, palm olein is widely used as cooking oil. It also blends perfectly with other popular vegetable oils that are traditionally used in many parts of the world ; prompting a nickname ‘blending partner’ for palm olein. For example, in Japan, refined palm olein is blended with rice bran and in Malaysia, it is blended with groundnut oil. Like palm oil, palm olein is also widely used as a frying oil and much of its popularity is due to its good resistance to oxidation and formation of breakdown products at frying temperatures and longer shelf life of finished products. In fact, palm olein is considered as the gold standard in frying and is perhaps, on its own, the most widely used frying oil in the world.

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Palm olein is often known as a heavy duty frying oil which is normally used in fast food outlets due to its oxidative stability and presence of tocols and carotenoids composition (Nallusamy 2006). Deep-fat frying is one of the most popular and important processes in food preparation. It is commonly utilized for food preparations such as frozen pre-fried foods, snack foods and fast foods It gives products with attractive sensory attributes, such as crunchy texture, desired orange–brown color, and characteristic flavor. These properties are controlled by the Maillard reaction and by the fat absorption, respectively (Franke & Reimerdes 2007). In deep fat frying, the layer of the frying oil is about 20–200 mm or greater and frying oil is reused several times (Xu 2000; Pokorny 2002). The quality of the products cooked by deep fat frying depends not only on the frying conditions such as temperature of the heated oil, frying time, food weight and frying oil volume, but also on the types of oil and the kind of food used (Sa´nchez-Gimeno et al. 2008).

Palm olein is widely used in industrial frying. It offers a large number of advantages, does not emit undesirable odors, is highly-resistant to oxidation, does not contain linolenic acid and has a favourable nutritional composition for being free of trans fatty acids and presenting tocopherols in its composition. It facilitates the production of fried foods of acceptable quality without the need of hydrogenated oils (Basiron 2005).

The mechanism of thermal degradation of frying oil is complicated. Variables involved in the process include frying conditions, replenishment of fresh oil, original oil quality, food materials, and fryer type (Paul & Mittal, 1997). The quality of fried products is not only determined by the frying conditions, but also by the type of oil and food used in the process (Moreira et al. 1999).

SQ is a superior quality palm olein produced under stringent quality assurance from harvesting until refining with FFA of less than 0.05%. SQ also contains high level of the antioxidants (tocopherols and tocotrienols,which have vitamin E equivalence) naturally present in palm oil (Karimah 2005). Currently, there are a lot of research done on comparing the effects of frying between standard palm olein and and double fractionated palm olein. However, few studies have been done on special quality palm olein. Therefore, the purpose of this study was to evaluate the frying performance of different types of palm olein during deep fat frying of French fries.

2. MATERIALS AND METHODS

2.1. Materials

Standard palm olein (POo) and special quality palm olein (SQ) were purchased from Lam Soon Edible Oils Sdn. Bhd and Golden Jomalina Food Industries Sdn. Bhd. Malaysia. French fries were purchased from the local supermarket (Selangor, Malaysia) from the same brand at the same time in order to avoid variations among sample lots. Products were kept frozen (–18°C) until frying.

2.2. Oils analyses

Parameters such as free fatty acids (FFA), smoke point, colour, polar component, polymer content, fatty acid composition (FAC) and iodine value (IV) were determined in the fresh oleins and after one, three, and five days of frying,

2.3. Free Fatty Acids (FFA)

The FFA content was measured by a titration method defined in AOCS Official Method Ca 5a-40 (American Oil Chemists' Society 1989). The isopropanol solution was neutralised using phenolphthalein before analysis. The oil sample (20g) was dissolved in neutralised isopropanol (50 mL) with phenolphthalein as indicator. The mixture was heated until oil colour mixture becomes clear. The mixture was then titrated with sodium hydroxide (0.02 N) until a light pink appeared. The FFA content was calculated as a percentage of palmitic acid. The titration was done in duplicate.

2.4. Smoke Point

The smoke point was determined using the Cleveland open cup method as described in AOCS Official Method Cc 9a- 48. The oil sample was poured into the Cleveland open cup up to the filling line. The light beam was positioned across the centre of the cup. The thermometer was suspended at the centre of the cup in a vertical position. The cup was heated rapidly up to 40-50^{0}C, followed by regulated heating at the rate of about 5^{o}C min^{-1}. The smoke point was designated when the oil sample gave off a thin and continuous stream of bluish smoke.

2.5. Lovibond Test (Red Colour)

Colour was measured using the Lovibond tintometer. Oil sample (70mL) was taken in a cuvette (Lovibond 5.25"cell) and placed in the provided space in tintometer PFX880 Series (Tintometer Gmbh, Germany). The Hunter colour scale parameters redness, yellowness and lightness were used to estimate colour changes during frying as a function of the main process variables (oil temperature, oil type and sample thickness). The dominant factor in this measurement is the red colour; the yellow filters are used to enhance the colour match. The colour is then expressed in Lovibond RYBN colour units. The yellow and red value of the slide colour was taken and repeated twice for each sample.

2.6. Polar Compounds

Polar compounds were determined gravimetrically using silica column chromatography following the IUPAC 2.507. The oil sample was dissolved with a mixture of petroleum ether (PE):diethyl ether (DE) of 87:13 (v/v). The solution was then transferred into a 4.5 m glass column, packed with Silica Gel 60 No. 7734 (Merck, Darmstadt, Germany) and a PE:DE mixture. Non polar fraction was separated by passing 150 mL of PE:DE mixture through the column within 60–70 min. The column outlet was rinsed with a PE:DE mixture for completion of non polar fraction separation. The non polar substance was then collected in the flask. Solvent (PE:DE mixture) was removed from a non polar fraction using a rotary evaporator. Shortly before termination of distillation, nitrogen was introduced to the system from a rubber bulb. The residue was cooled at room temperature as the flask was flushed with nitrogen. The amount of polar compounds were calculated by deducting the weight of the sample dissolved in a PE:DE mixture with the mass of non polar residue.

2.7. Polymer Compounds

Polymer compounds were analyzed based on the modified method described by Azmil & Razali (2008). The oil sample was initially reacted with 1% sulfuric acid in methanol. The solution was then refluxed using an Erlenmeyer conical flask with a ground-joint fitted with a reflux condenser. The process consumed about 2½ hour with stirring throughout. The methanolic layer was separated from the semi-solid or viscous residue after overnight of cooling. The insoluble residue was rinsed several times using chloroform before being transferred to a conical flask by dissolving it with chloroform (LAB-SCAN, Dublin, Ireland). Chloroform was then removed using a rotary evaporator and the residue was dried in an oven at a temperature of 103^0C for about overnight. The dried residue was finally weighed after being cooled at room temperature.

2.8. Fatty Acid Composition (FAC)

The FAC was analyzed according to ISO 5508:1990. The fatty acids composition was determined with a gas chromatograph (6890N, Agilent Technologies, Palo Alto, Calif., U.S.A.) equipped with an Agilent HP-88 column (100 m length, 0.2 μm film thickness) and a flame ionization detector. Initially, 0.1 g of filtered oil was methylated, and then the methylated oil, 200 μL of KOH and 2 mL of hexane were placed in a vial. This blend was stirred for 2 min and centrifuged for 5 min. After that, 30 μL of supernatant was diluted with 10 mL of hexane. This blend was placed in a vial and introduced to the gas chromatograph with automatic injection (injector temperature = 50°C) and fatty acids were separated in a temperature oven of 240°C. Helium and nitrogen were used as the carrier gases at a flow rate of 1.3 mL/min (Enr´ıquez-Fern´andez et al. 2011).

2.9. Iodine value (IV)

The iodine value was determined according to ISO 3961:1996 animal and vegetable fats and oils. A mixture of cyclohexane (Merch Darmstadt, Germany) and glacial acetic acid (Systerm, Shah Alam, Malaysia) was reacted with Wijs reagent (Merck, Darmstadt, Germany) followed by the addition of potassium iodide (Systerm, Shah Alam, Malaysia) and distilled water after a specified time. The liberated iodine was further titrated with sodium thiosulphate (Univar, Seven Hills, Australia) until the yellowish iodine colour almost faded.

2.10. Statistical Analysis

The analyses were conducted in duplicate. The mean, standard deviation and range were analyzed using Minitab software 14 (Minitab Inc., State College, Pa.,U.S.A).

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3. RESULTS AND DISCUSION

3.1. Free fatty acid (FFA)

Hydrolysis is the main cause for FFA formation. Water present in fried products and elevated temperature stimulate the formation of free fatty acid. Usually, with frying time the amount of FFA increase and similar data were observed in this trial. Different oils have different rates of hydrolysis and the starting values also affect the results. The initial FFA of DF and SQ were similar (0.04%) while that of POo was 0.08%. At the beginning of the frying experiment, all oils started with a low amount of free fatty acids (<0.1%), typical of refined oils (Matthaus 2006). When exposed to frying for one day, the rate of FFA formation was higher for DF compared to SQ and POo. After frying for 16 hours, the increment of 0.14% FFA was observed for DF (Figure 1). DF showed the highest FFA content after frying for 5 consecutive days. POo and SQ showed a gradual increase in FFA throughout the frying period. The increment of FFA for DF, POo and SQ from day 1 to day 5 was 0.24%, 0.17% and 0.14% consecutively. DF clearly showed the highest increment in FFA during frying for 5 consecutive days compared to SQ and POo. SQ exhibited the lowest FFA (0.18%) compared to POo (0.25%) and DF (0.28%) after frying for 5 days. According to Choe and Min (2007), water attacks the ester bond of triglycerides producing di- and monoglycerides, glycerol, and free fatty acids. The oleins used for frying French fries did not exceed the FFA values for discarding oils, as according to regulations in different countries, the maximum FFA value should not exceed 1.3% to 2.5% (Paul & Mittal 1996).

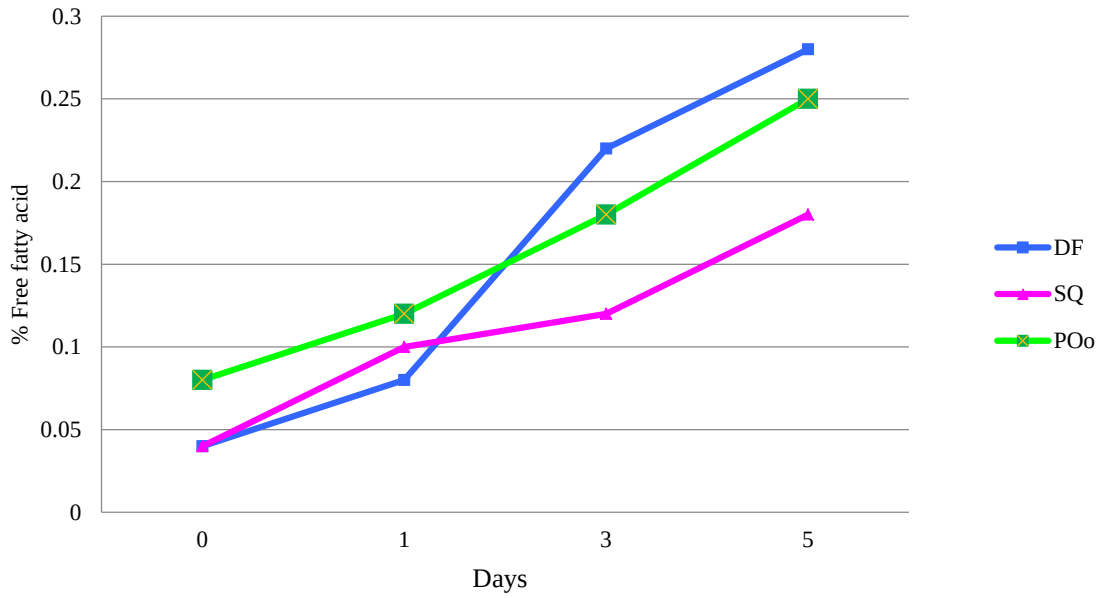


Figure 1 : Changes in %FFA of palm oleins during frying of French fries (5 days)

3.2. Smoke point

During frying, decomposition of low-molecular-weight compounds such as FFA and volatile compounds in the oils contributes to the formation of smokes (Azmil & Razali 2008). Smoke point is defined as the lowest temperature of a heated oil or fat at which smoke continuously and visibly develops on the surface. It is an important characteristic in deciding when to change the frying oil. The initial smoke point value for DF and SQ was 231^{o}C and 238^{o}C respectively. POo showed the lowest initial smoke point of 208^{o}C compared to DF and SQ (Figure 2). The drop in smoke point for DF was rather drastic compared to SQ and POo. This observation could be due to the presence of high amount of polyunsaturated fatty acid in DF. The greater the degree of unsaturation, the more rapid the oil tend to be oxidized particularly during deep fat frying (Azmil & Lin 2008). Throughout the frying period of 5 days, the smoke point values obtained were still above typical frying temperature of 180°C and were higher than the dicard point of 170°C. DF exhibited a drop of 43°C during frying from day 1 to day 5. POo showed the lowest smoke point profile and the drop in smoke point was very gradual. SQ showed the best resistance to drop in smoke point value compared to DF and POo after frying for 5 consecutive days. According to Berger (2005), the maximum difference of smoke point between fresh and used oil should be within 50°C. The final smoke point obtained was found to be in range with this statement.

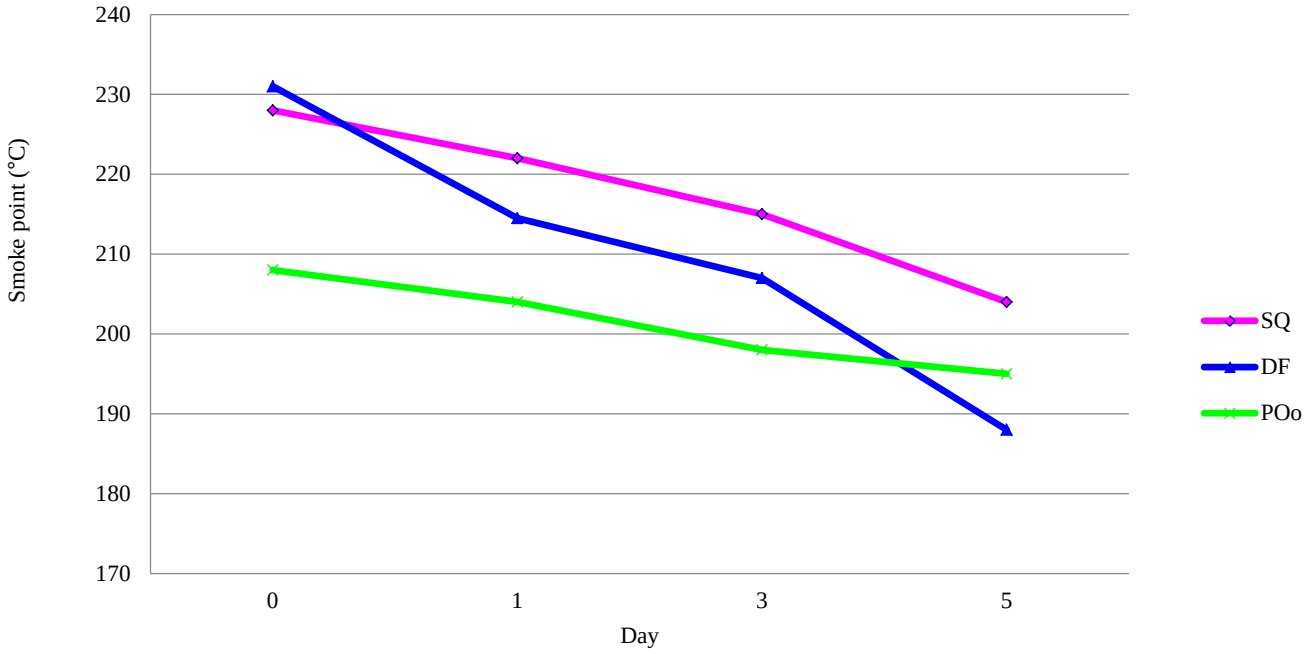


Figure 2 : Changes in smoke point of palm oleins upon frying

3.3. Colour

Colour change is not a good indicator for assessing the quality of frying oil. However, very dark colours do indicate some kind of abuse of the oil. During frying, oil color changes quickly from light yellow to orange/brown, mainly due to oxidation reactions which generate colored compounds (Maskan 2003). The colour of fresh DF and POo are 1.7R and 2.75R respectively. SQ showed the lowest colour reading before frying (1.0R). This result is supported by previous studies done by Karimah (2005) which showed that the initial SQ POo has an extremely low red value compared to other types of oleins. The increment in colour from day 1 to day 5 for DF was 7.9R, SQ 7.8R and POo 7.1R (Figure 3). Again DF showed the highest increment in colour compared to SQ and POo. POo exhibited the lowest and very gradual increase in colour throughout the frying duration. However, the final colour value of POo was highest due to its high colour value before frying (2.75R). The darkening of oil during frying is due to an accumulation of nonvolatile decomposition compounds such as free fatty acids, polymers or oxidized triglycerides (Serjouie et al. 2010). Throughout the frying duration of 40hrs/5days SQ showed the best resistance to breakdown in colour compared to DF and POo. The final colour reading of SQ was 8.8R compared to DF (9.6R) and POo (9.8R). According to Tsaknis (2002), the darkening of palm oil is mainly due to the presence of unsaturated carbonyl compounds which are intermediates that resulted in the formation of non-volatile decomposition products containing carbonyl group that have the ability to absorb energy of the visible light magnitude during frying.

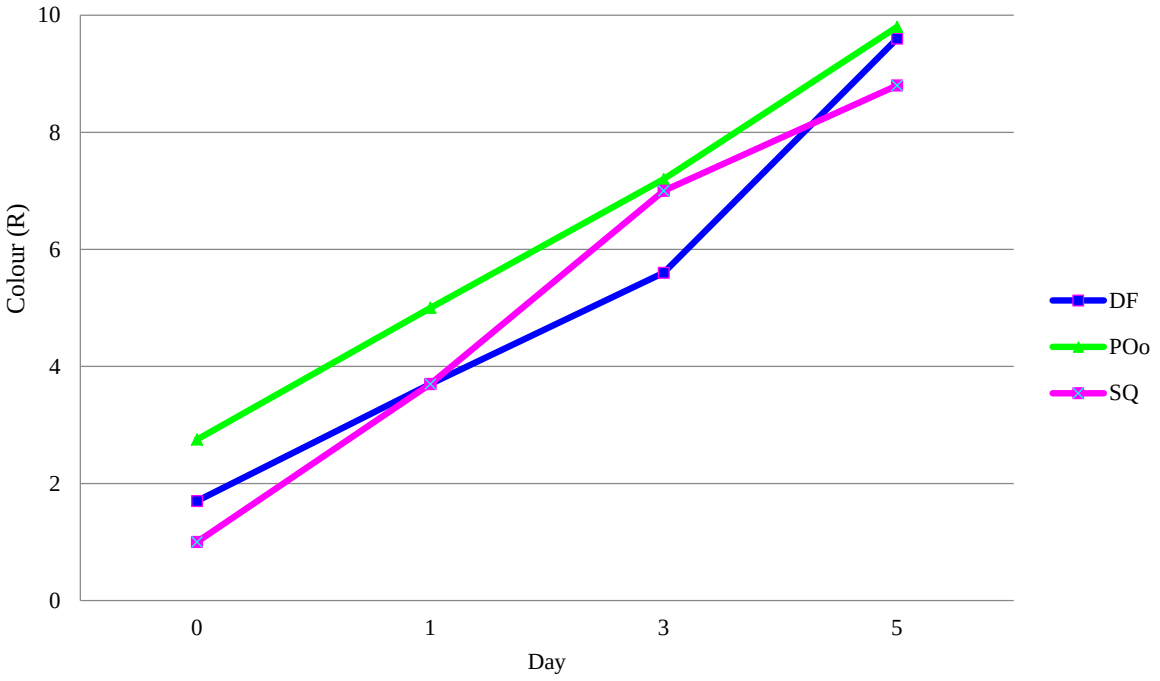


Figure 3 : Changes in colour (red) of palm oleins during frying

3.4. Polar Compound

The total polar compound and acid value are commonly used to measure cumulative degradation of the oil. It is an indicator of food quality for many operations and is widely used in many International Regulations. Formation of polar compounds is strongly related with the primary and secondary oxidation that takes place during frying and has negative effects on the quality of frying oil, flavor and nutritional value of the fried food (Doborganes et al. 2000; Gertz 2000). Therefore, the oil needs to be rejected and replaced with a fresh oil if it exceeds the discard point for polar compound which is 24%. Figure 4 shows the TPC profile of fresh oleins and their changes after repeated frying using French fries. The polar compound of fresh SQ, POo and DF are 5.81%, 6.33% and 9.04% respectively. SQ showed the lowest initial polar compound followed by POo and DF. The values obtained were in range with previous studies that reported the TPC values for fresh palm oil should be between 6.1-10.75% (De Greyt et al. 1999; Machado et al. 2007). The frying performance of the three oils clearly showed that DF exhibited the most gradual increase in polar compound even though its initial polar compound was the highest compared to SQ and POo **(**Figure 4**)**. The final polar compound of DF was the lowest (16.5%) compared to SQ (18.58%) and POo (19.92%). From day 1 to day 5, the rate of total polar compounds generation in SQ and POo are 12.77% and 13.57% consecutively. These levels are well below the discard point of 24% polar compound for batch frying.

3.5. Polymer content

Polymer content includes dimmers, trimers and tetramers and may be formed through oxidative and thermal reactions. Excess formation of polymer compounds resulted in an increased viscosity of the oil, may impart bitter taste of the fried foods and is partly responsible for the foaming during frying (Tsaknis et al. 2002; Karimah & Razali 2007). It is also used as a marker of oil degradation. The initial polymer content of SQ was the lowest (0.44%) compared to POo (1.52%) and DF (1.5%). After 8 hours of frying, POo and DF showed a rapid increase in polymer content with an increment of 0.45% and 0.33% respectively and only 0.01% for SQ (Figure 5). After frying for 5 days SQ exhibited the lowest polymer content of 0.62% followed by DF (2.43%) and POo (3.10%). The elevated polymer content of DF and POo might be due to the composition of these oils which are high in diacylglycerol compared to SQ (Berger 2005). The polymer content of the 3 oils evaluated showed that they are well below the discard point of 12%.

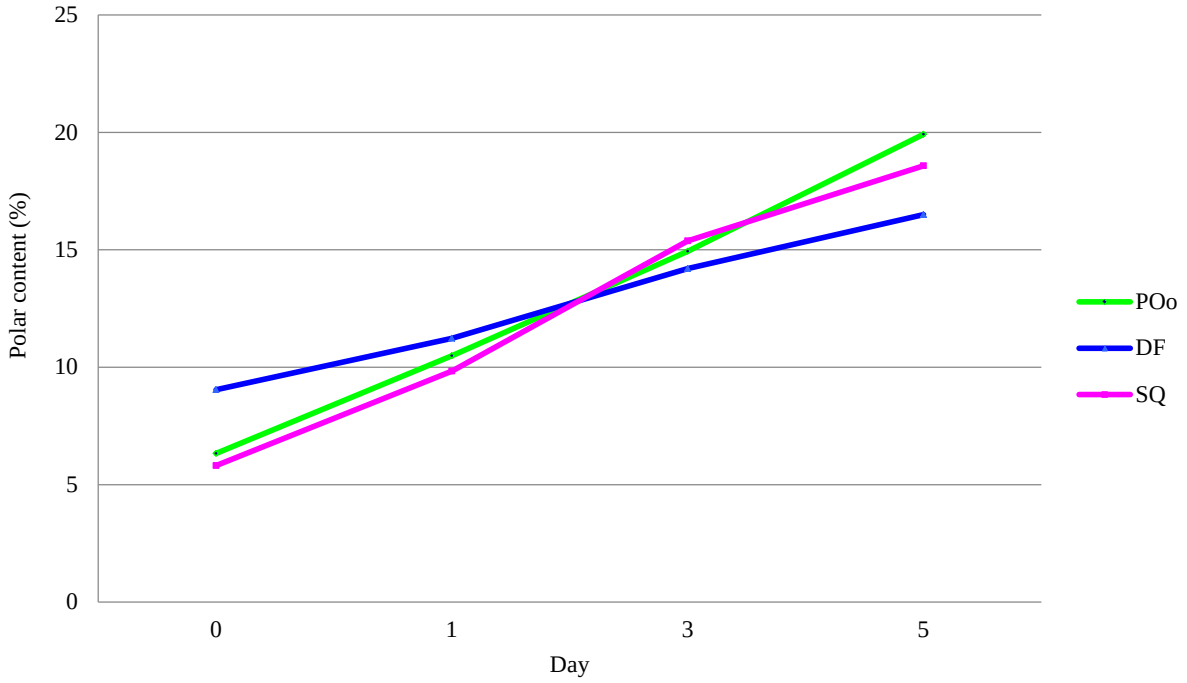


Figure 4 : Polar content of palm oleins upon frying

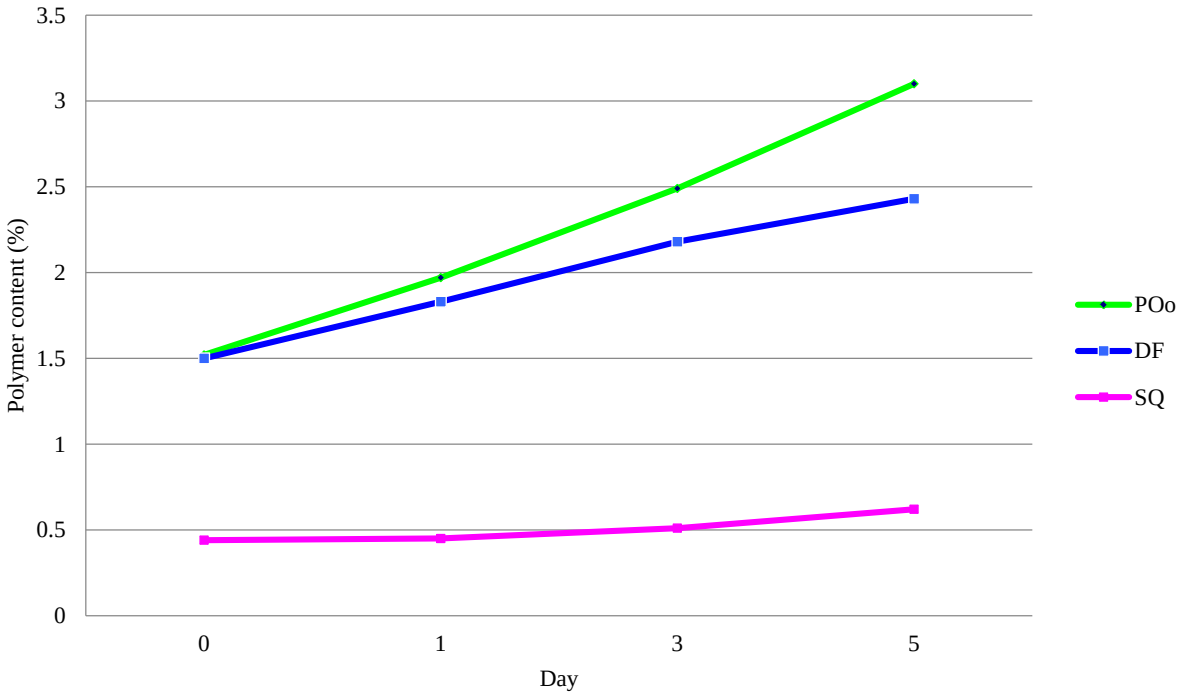


Figure 5 : Polymer content of palm oleins upon frying

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3.6. Iodine value (IV)

The IV is a test done to measure the degree of unsaturation of fats and oils and is expressed in terms of a percentage of the absorbed iodine. The degree of unsaturation of fatty acids in the oils used for frying has an effect on its frying performance. SQ and POo have similar iodine values of 56.4 and 56.1 respectively. However, the iodine value of DF was higher (65.0) due to its higher content of polyunsaturated fatty acids. For an improved oxidative stability during the deep-fat frying process, the use of fats and oils with low unsaturation is advisable because the oxidation rate of such oils is much lower than for oils with polyunsaturated fatty acids. This fact is important because polyunsaturated fatty acids are, in general, responsible for the oxidation and off-flavor development that lower the palatability of fried food (Mounts at al. 1994; Warner et al. 1997).

3.7. Fatty acid composition (FAC)

The stability of the oils is influenced by their fatty acid compositions, where the higher level of unsaturated fatty acids contributes to the susceptibility to oxidation. The three most prominent fatty acid in the three types of olein are palmitic (C16:0), oleic (C18:1) and linoleic (C18:2) acids. The palmitic acid content of DF was 33.2%, oleic acid content 47.6% and linoleic acid content 13.3%. The palmitic acid content for POo and SQ are 40.4% and 40.0% respectively. The oleic acid content of POo and SQ are 41.6% and 43.3% respectively. The linoleic acid content of POo and SQ are 11.1% and 10.7% respectively. High oleic oils provide good frying stability and high waxy/plastic flavor intensity because of oleic acid decomposition, but they are low in linoleic acid, so they result in low deep-fried flavor intensity (Romano et al. 2012). All three oils also showed that the content of linolenic acid is lower compared to linoleic acid with the value of 0.4%, 0.3% and 0.4% for POo, DF and SQ respectively. For sensory reasons, Gertz (2012) recommended that the linolenic acid concentration of the frying oil should be less than 3% and lower than linoleic acid, otherwise it could contribute to a fishy flavor within the product and the deep-frying medium. This is also proven by the studies done by Carre et al. (2003) which showed that a content of more than 1.1% linolenic acid resulted in significantly higher intensities of fishy and paints odors. The FAC results showed that DF is lower in saturated fatty acids but highest in polyunsaturated fatty acids. DF showed the highest amount of polyunsaturated fatty acid (13.6%) compared to POo (11.5%) and SQ (11.1%). POo showed the highest stearic acid content of 4.2% compared to DF and SQ (Figure 6).

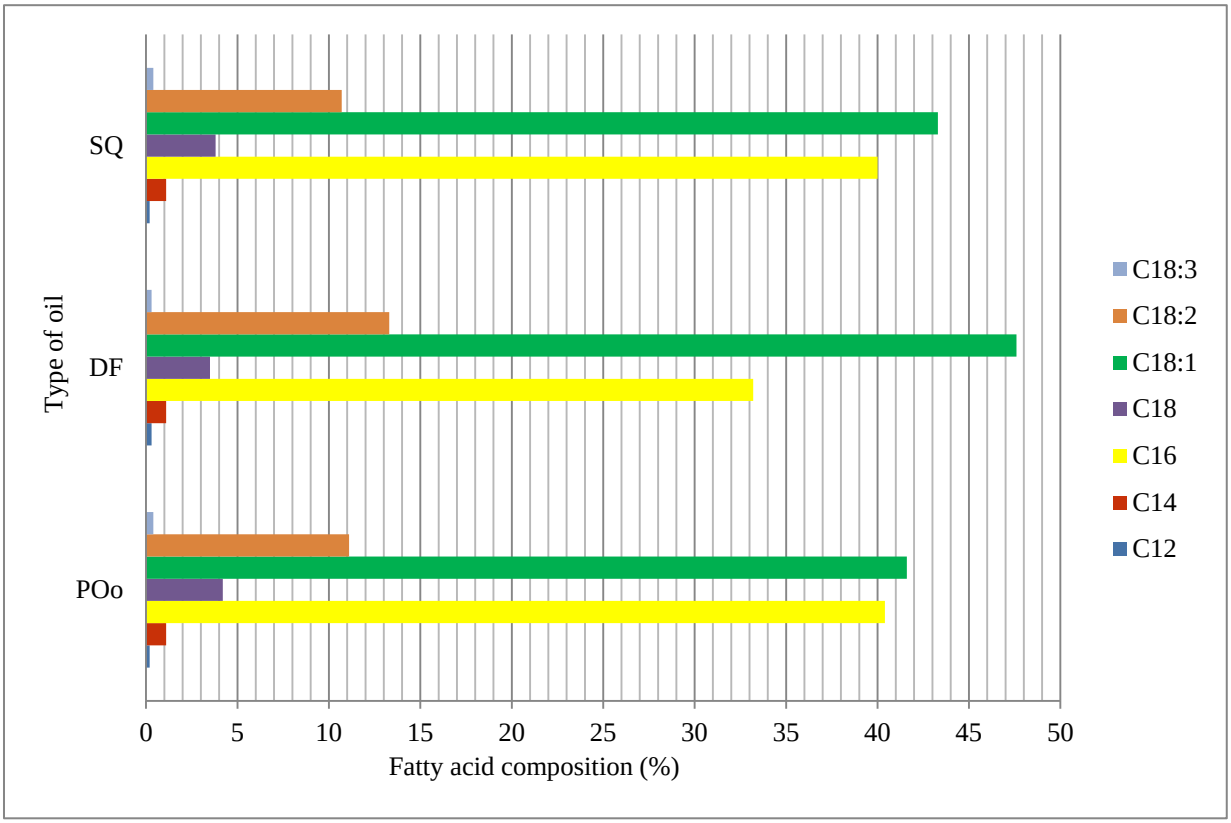


Figure 6 : Fatty acid composition of palm oleins

4. CONCLUSION

Different types of olein with different price and frying performance are available to cater the needs of users all over the world. The availability of three different types of palm olein in the commercial market is providing manufacturers and household users a wide choice of stable oil suitable for deep fat frying. Palm olein also has the advantage of being one of the cheapest oil compared to other vegetable oil. The results of this study indicate that SQ was the most stable frying oil among the oleins used. In terms of price, SQ is more expensive compared to DF and POo. After frying the oleins for 5 consecutive days their frying oil quality such as FFA, smoke point, polymer and polar content were still way below the suggested discard point.

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