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# Physicochemical properties and oxidative stability of oils from samrong (*Sterculia foetida*) seed

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**Abstract** Samrong seed kernel consisted of 5.91 ± 0.12% moisture, 2.80 ± 0.17% ash, 46.09 ± 0.44% oil, 11.68 ± 0.16% protein and 33.52 ± 0.07% carbohydrate. The crude oil was extracted from samrong seed kernel using cold hexane as solvent. The oil from samrong seed kernel contained 27.32% saturated fatty acid (SFA), 5.30% mono-unsaturated fatty acid (MUFA) and 55.95% poly-unsaturated fatty acid (PUFA). Gamma-linolenic acid (47.80%) was the dominant fatty acid, followed by palmitic acid (16.49%) and steric acid (10.45%). The physicochemical properties including color, viscosity, tocopherol content, total phenolic content, acid value, free fatty acid, peroxide value (PV), thiobarbituric acid reactive substances (TBARS) and ρ-anisidine value of kernel oil were determined. When kernel oil was stored at 30℃ for 48 days, the oxidative stability of kernel oil was also examined. The kernel oil had the increase in PV and TBARS within the first 36 days of storage ($P < 0.05$). Subsequently, a decrease in PV and TBARS were noticeable up to day 48 ($P < 0.05$). Oil from samrong seed kernel showed high quality and oxidative stability during storage. Thus, samrong seed kernel could be used as a potential source of edible oil for use in the food industrial.

**Keywords:** Samrong seed kernel, Oil quality, Fatty acid, Oxidative stability

## Introduction

Plant seeds are considered as sources of healthy food for humans and animals because of their high nutritional value such as polyunsaturated fatty acids (PUFAs). Oil seeds are often extracted to produce rich oils, including soybean sunflower, palm, sesame, flaxseed, etc. (Mathew *et al*., 2014).

*Sterculia foetida* L. (Sterculiaceae) commonly called “homrong, marong, chammahong or samrong)” in Thai, “Java olives” in English and “Jangli badam or Pinari” in Hindi is a large, straight, deciduous plant. Samrong is a wild plant and well adapted in tropical and subtropical zones. Samrong has been found usually in many parts of the world such as Australia, Bangladesh, Djibouti, Eritrea, Ethiopia, India, Indonesia, Kenya, Malaysia, Myanmar, Oman, Pakistan, Philippines, Somalia, Sri Lanka, Tanzania, Thailand, Uganda and Republic of Zanzibar. The different parts of samrong can be used as food or medicine (Orwa *et al*., 2009). The

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seeds of samrong are roasted and eaten like chestnuts. The edible oil can be produce from the kernels as well as the testa of samrong seeds (Prakash *et al*., 2012). It has been reported that the kernel of samrong seeds have high amount of oils (Vipunngeun and Palanuvej, 2009). Samrong seed could be an alternative source for edible oil in food industry. However, the oil from samrong seed kernel is rarely used in food industry of Thailand. A little information about oil from samrong kernel seed has been reported. Thus, the objectives of this investigation were to study the physicochemical properties and the oxidative stability of oil from samrong seed kernel, which is responsible for edible oil choices. The different parts of samrong seeds are shown in Figure 1.

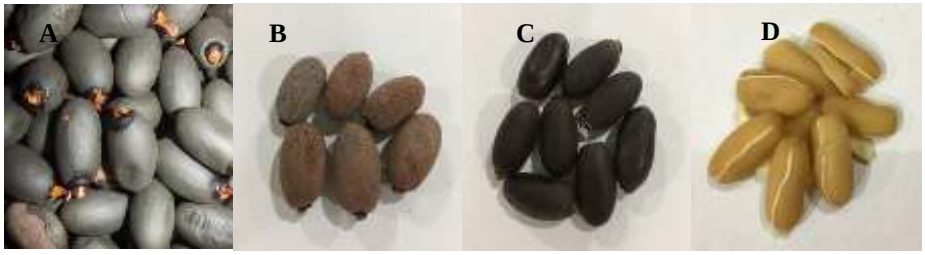


**Figure 1.** The different parts of samrong seeds. A is the samrong seeds; B is the outer shell of samrong seeds; C is the inner shell of samrong seeds; D is the samrong seed kernels

## Materials and methods

### *Chemicals*

Folin-Ciocalteu's phenol reagent, ρ-anisidine and gallic acid were purchased from Sigma-Aldrich, Inc. (St. Louis. MO, USA). 2-Thiobarbituric acid and 1,1,3,3-tetramethoxypropane were procured from Fluka (Buchs, Switzerland). Hexane and hydrochloric acid were purchased from Lab-Scan (Bangkok, Thailand).

### *Preparation of samrong seed kernel powder*

Samrong seeds were obtained from a local market in Bangkok, Thailand. 5 kg of samrong seed kernels were finely ground using blender (Phillips, Guangzhou, China) for 1 min. Samrong seed kernel powders were stored at -18℃ until use. The proximate composition of samrong seed kernel powder were determined by AOAC (2000).

### *Extraction of oil from samrong seed kernel*

Samrong seed kernel powders were extracted using cold hexane as solvent according to the method of Takeungwongtrakul and Yarnpakdee

(2018). The obtained oil was calculated for yield and was subjected to analyses.

### *Fatty acid profile*

Fatty acid profile was determined as fatty acid methyl esters (FAMEs), which were prepared according to the method of AOAC (2000). FAMEs were injected to the gas chromatography (Shimadzu, Kyoto, Japan) equipped with the flame ionisation detector (FID). Fatty acid content was calculated, based on the peak area ratio and expressed as g fatty acid/100 g oil.

### *Physicochemical properties of samrong seed kernel oil*

The color of samrong seed kernal oil was measured using a colorimeter (ColorFlex, Hunter Lab Reston, VA, USA) and reported in the CIE system, including *L**, *a**, and *b**. Viscosity of samrong seed kernel oil was determined using a brookfield. Spindle of S03 was used at 100 rpm in room temperature. Tocopherol (α-tocopherol) of samrong seed kernel oil was analyzed using method following AOAC (2018). The phenolic content of samrong seed kernel oil was extracted and measured according to the method of Yu *et al*. (2002). Total phenolic content was calculated from a calibration curve of gallic acid and expressed as gallic acid equivalents (mg GAE/100 g oil). Acid, free fatty acid, peroxide and ρ-anisidine values of the samrong seed kernel oils were determined according to the AOCS official methods (AOCS, 1990). Thiobarbituric acid reactive substances (TBARS) were determined as described by Buege and Aust (1978).

### *Oxidative stability of samrong seed oil*

The extracted oil was transferred into amber bottles and capped tightly. The samples were stored at 30±1 ℃ in an incubator (Memmert, D-91126, Schwabach, Germany) and analysed for PV and TBARS at day 0, 6, 12, 18, 24, 30, 36, 42 and 48.

### *Statistical analysis*

Experiments were run in triplicate using three different lots of samples. Data were subjected to analysis of variance (ANOVA). Comparison of means was carried out by Duncan's multiple range test. Statistical analysis was performed using the Statistical Package for Social Science (SPSS for windows, SPSS Inc., Chicago, IL, USA).

## Results

### *Proximate analysis of samrong seed kernel powder*

The proximate composition of the samrong seed kernel powders are shown in Table 1. Samrong seed kernels contained 5.91 ± 0.12% moisture, 11.68 ± 0.16% protein, 46.09 ± 0.44% oil, 2.80 ± 0.17% ash and 33.52 ± 0.07% carbohydrate. It was noted that oil was the major composition of samrong seed kernels, followed by carbohydrate, protein, moisture and ash, respectively.

### *Fatty acid profiles*

Fatty acid profiles of oils extracted from samrong seed kernels are shown in Table 2. The samrong seed kernel oils consisted of 27.32% SFA, 5.30% MUFA and 55.95% PUFA. PUFAs in kernel oils were found as the major fatty acids. Gamma-linolenic acid (C18:3, n-6) (47.80%) was the dominant fatty acid, followed by palmitic acid (C16:0) (16.49%), steric acid (C18:0) (10.45%), linoleic acid (C18:2) (6.48%) and oleic acid (C18:1) (4.96%), respectively. Among the fatty acids, the highest contents of SFA, MUFA and PUFA were palmitic acid, oleic acid and gamma-linolenic acid, respectively. Additionally, eicosapentaenoic acid (EPA) was found in samrong seed kernel oil at a level of 0.55%.

### *Physicochemical properties of samrong seed kernel oil*

The yield and the physicochemical properties of oil from samrong seed kernels are presented in Table 3. Oil extracted from samrong seed kernel using cold hexane as solvent showed yield of 53.65% (Table 3). The yield of samrong seed kernel oil extracted with Soxhlet (hot hexane as solvent) was 46.09% (Table 1). The result demonstrated that the extraction yields of oils from cold hexane extraction were higher than those from soxhlet extraction ($p < 0.05$). The obtained oil was generally liquid at room temperature. Oil from samrong seed kernel was golden yellow in color. The color expressed as $L^*$- (lightness), $a^*$- (redness) and $b^*$- (yellowness) values of the samrong seed kernel oil. $L^*$, $a^*$ and $b^*$ values of samrong seed kernel oil were 85.64 ± 0.01, 1.02 ± 0.01 and 76.26 ± 0.03, respectively. The apparent viscosity of samrong seed kernel oil was 25 ± 0.01 cP. Total phenolic content of samrong seed kernel oil was 7.2 ± 0.15 mg GAE/g oil. α-Tocopherol was found in seed kernel oil (0.594 ± 0.1 mg/kg of oil). The acid value, free fatty acid value, PV and ρ-anisidine value of seed kernel oils were found to be 1.66 mg KOH/g oil, 0.83% oleic acid, 0.97 meq $O_2$/kg oil and 39.10, respectively. For TBARS value, no detectable value was observed. Those values of oil indicated the valuable measure of oil quality.

**Table 1.** Proximate analysis of samrong seed kernel powder

| Proximate composition | Percent (%) |
|---|---|
| Moisture | 5.91 ± 0.12 |
| Protein | 11.68 ± 0.16 |
| Oil | 46.09 ± 0.44 |
| Ash | 2.80 ± 0.17 |
| Carbohydrate | 33.52 ± 0.7 |

Data are expressed as mean ± SD (n = 3).

**Table 2.** Fatty Acid Profile of samrong seed kernel oil before and after storage for 48 days at 30 ℃

| Fatty acids (g/100 g oil) | Samrong seed kernel oil |
|---|---|
| Myristic acid (C14:0) | 0.12 ± 0.00 |
| Pentadecanoic acid (C15:0) | 0.03 ± 0.00 |
| Palmitic acid (C16:0) | 16.49 ± 0.10 |
| Palmitoleic acid (C16:1, n-7) | 0.17 ± 0.00 |
| Heptadecanoic acid (C17:0) | 0.06 ± 0.00 |
| Steric acid (C18:0) | 10.45 ± 0.19 |
| Oleic acid (C18:1, n-9) | 4.96 ± 0.03 |
| Linoleic acid (C18:2, n-6) | 6.48 ± 0.03 |
| α -Linolenic acid (ALA) (C18:3 n-3) | 0.17 ± 0.00 |
| γ -Linolenic acid (C18:3 n-6) | 47.80 ± 1.34 |
| Arachidic acid (C20:0) | 0.10 ± 0.00 |
| Gadoleic acid (C20:1, n-9) | 0.13 ± 0.00 |
| Eicosadienoic acid (C20:2, n-6) | 0.78 ± 0.05 |
| Dihomo-gamma-linolenic acid (C20:3, n-6) | 0.03 ± 0.01 |
| Arachidonic acid (C20:4 n-6, ARA) | 0.14 ± 0.01 |
| Eicosapentaenoic acid (C20:5 n-3, EPA) | 0.55 ± 0.07 |
| Behenic acid (C22:0) | 0.02 ± 0.00 |
| Lignoceric acid (C24:0) | 0.04 ± 0.00 |
| Nervonic acid (C24:1) | 0.04 ± 0.00 |
| Saturated fatty acid (SFA) | 27.32 |
| Mono-unsaturated fatty acid (MUFA) | 5.30 |
| Poly-unsaturated fatty acid (PUFA) | 55.95 |

Data are expressed as mean ± SD

**Table 3.** Physicochemical properties of samrong seed kernel oil extracted using cold hexane

| Parrameters | Samrong seed kernel oil |
|---|---|
| Yield (%) | 53.65 ± 0.00 |
| Color | |
| - *L** | 85.64 ± 0.01 |
| - *a** | 1.02 ± 0.01 |
| - *b** | 76.26 ± 0.03 |
| Apparent viscosity (cP) | 25 ± 0.01 |
| Total phenolic content (mg gallic acid/100g oil) | 7.20 ± 0.15 |
| α-Tocopherol (mg/kg oil) | 0.594 ± 0.1 |
| Acid value (mg KOH/g oil) | 1.66 ± 0.03 |
| Free fatty acids (as oleic acid %) | 0.83 ± 0.01 |
| Peroxide value (meq $O_2$/kg oil) | 0.97 ± 0.07 |
| ρ-anisidine value | 39.10 ± 1.41 |
| TBARS (mg MDA/kg oil) | NA |

Data are expressed as mean ± SD (n=3).
NA = not available

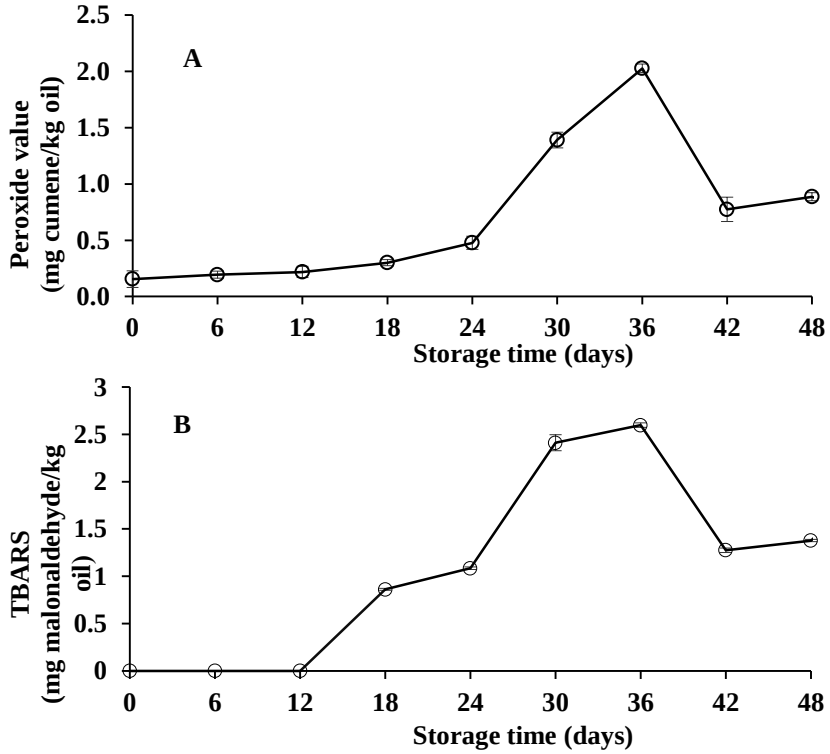


**Figure 2.** Peroxide values (A) and TBARS values (B) of samrong seed kernel oil during 48 days at 30 ℃. Bars represent standard deviations (n=3)

### *Oxidative stability of samrong seed kernel oil*

Changes in PV and TBARS value of oils extracted from samrong seed kernels during 48 days of storage are presented in Figure 2A and 2B, respectively. The initial PV of samrong seed kernel oil was 0.9 meq $O_2$/kg oil. PV of oil from seed kernel slightly increased within the first 24 days of storage and then sharply increase was found at day 36 ($p < 0.05$). Subsequently, a decrease in PV was noticeable up to day 48 ($p < 0.05$). Thus, PV clearly explained that as the storage time increased, the oxidative stability of samrong seed kernel oil decreased. For TBARS value, the result showed that no changes in TBARS was noticeable during 0 – 12 days of storage ($p > 0.05$). After day 12, the marked increases in TBARS were observed up to 36 days ($p < 0.05$). Subsequently, a decrease in TBARS was noticeable up to day 48 ($p < 0.05$). The similar trend was observed in comparison with PV. However, the low values of PV and TBARS in samrong seed kernel oil were found thoughtout the storage of 48 days.

## Discussion

Samrong seed kernel is the excellent source of edible oil with high PUFA and carbohydrate (Table 1 and Table 2). However, Silitonga *et al*. (2013) showed that the main compositions of samrong seed kernels were oil (51.78%) and protein (21.61%), respectively. Additionally, Prakash *et al*. (2012) reported that the samrong seed kernels contained about 34% oil and 31% protein. From this study, the protein content of samrong seed kernels was lower than that found in the literature. These differences might be due to the variations in cultivation and climate differences within the region. PUFAs in samrong seed kernel oils were found as the major fatty acids (Table 2). This result was in agreement with Orsavova *et al*. (2015) who found that PUFAs were the major fatty acids in vegetable oils. Gamma-linolenic acid was the dominant fatty acid, followed by palmitic acid, steric acid, linoleic acid and oleic acid, respectively. This study was different from previous report of Vipunngeun and Palanuvej (2009) who have shown that palmitic acid was found as dominant fatty acid (52%) of samrong seed oil. Among the fatty acids, the highest contents of SFA, MUFA and PUFA were palmitic acid, oleic acid and gamma-linolenic acid, respectively. Additionally, EPA was found in samrong seed kernel oil at a level of 0.55%. Kale *et al*. (2011) reported that the major SFA and unsaturated fatty acids (UFA) of samrong seed oil were palmitic acid (11.87%) and oleic acid (20.50%), respectively. When comparing the contents of fatty acid in other seed oils, it can be verified the content of UFA in the range between 70 and 90% (Ceriani *et al.*, 2008). The UFA contents of canola oil, sunflower oil, corn oil, olive oil and soybean oil accounted for 83.6%, 83.1%, 78.4%, 78.3% and 76.0%, respectively (Porto *et al*., 2016). This variability may be

associated with the genetic, seed quality and its corresponding environmental variation (Ramadan and Mörsel, 2002). Nevertheless, Ghazani *et al*. (2014) indicated that the extraction methods and solvent used also had the impact on fatty acid composition in oil. The oils present in samrong seed kernel are a rich source of UFA, offering benefits to human health. However, UFAs in samrong seed kernel oil were restricted due to their susceptibility to oxidation. Thus, the oxidation stability of samrong seed kernel oil need to be studied.

In this study, the extraction yields of oils from cold hexane extraction (Table 3) were higher than those from soxhlet extraction (Table 1) ($p < 0.05$). The kernels of the samrong seeds contained 50–60% of oil (Silitonga *et al*., 2013). Compared with other hexane extracted oils, the oil contents of Brazil nut, hazelnut, pecan, pistachio and walnut were 67.4%, 60.4%, 71.5%, 52.3% and 70.6%, respectively (Miraliakbari and Shahidi, 2008). The samrong seed kernels cantained golden yellow oil. Habib *et al*. (2013) reported that carotenoid is soluble in oils, and constituted as the coloring pigment in vegetable oils. *L**, *a** and *b** values of palm, soybean, sunflower, olive and corn oils ranged from 63.4 to 69.5, 3.8 to 4.4 and 9.2 to 10.4, respectively (Hsu and Yu, 2002). From the results in Table 3, *b** value of seed kernel oil was higher than that of other vegetable oils. The viscosity of oil from samrong seed kernel was lower than that of other oils (Neelamegam and Krishnaraj, 2011). α-Tocopherol and total phenolic contents were found in oil from samrong seed kernels. Tocopherols was natural lipophilic antioxidants in vegetable oils, which had effect on the stability of the oils. Phenolic compounds vary in structure and the number of hydroxyl groups, leading to the variation in their antioxidant activities. Thus, the presence of α-tocopherol and phenolic compounds might be effect on the oxidative stability of samrong seed oil during storage. Lipid oxidation is the main reaction leading to the deterioration of edible oils during processing and storage. Acid value is a measure of total acidity of the oil, involving free fatty acids during decomposition of triglycerides. PV is a widely used method for the measurement of the concentration of hydroperoxides formed in the initial stages of lipid oxidation (Onyeike and Acheru, 2002). ρ-Anisidine exhibits the amount of non-volatile aldehyde (principally 2-alkenals and 2,4-alkadienals) in oils (Choe and Min, 2006). TBARS value is an index of lipid oxidation and in related with malonaldehyde content (Chaijan *et al*., 2006). From the results, the values of acid, free fatty acid, PV and ρ-anisidine were low. For TBARS value, no detectable value was observed. Those values of oil were the valuable measure of oil quality. The results indicated that the obtained oil might be store for a long time without rancidity. In addition, the samrong seed kernel oil exhibited the good edible oils.

The oxidative stability of samrong seed kernel oil was measured by PV and TBARS values thoughtout 48 days of storage at 30 ℃ (Figure 2).

The great changes in PV and TBARS of samrong seed kernel oil were also observed in 36 days of storage. Thereafter, the decrease in PV and TBARS were noticeable up to day 48 ($P < 0.05$). The increase in PV of oil sample was more likely due to the formation of hydroperoxide. When storage time increased, the hydroperoxide was decomposed to the secondary oxidation products. It was related to decrease in PV. For TBARS value, the increase in TBARS value of oils indicated the formation of the secondary lipid oxidation products, especially aldehydes (Chaijan *et al*., 2006). The samrong seed kernel oil was a rich source of PUFAs (Table 2). Those PUFAs were prone to oxidation as indicated by the presence of TBARS in oil samples. After 36 days of storage, the increase in TBARS was retarded because of loss in low molecule weight volatile secondary oxidation products in the oils. Additionally, PV and TBARS values clearly explained that as the storage time increased, the oxidative stability of seed kernel oil decreased. However, the indigenous α-tocopherol played a crucial role as antioxidant in oils extracted from samrong seed kernel (Table 3). The low values of PV and TBARS in samrong seed kernel oil were found thoughtout the storage of 48 days. Oil from samrong seed kernel showed high quality and oxidative stability during storage. Thus, samrong seed kernel could be used as a potential source of edible oil for use in the food industrial.

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