



Thermal Stability of Blending Soybean Oil with Coconut Oil During Continuous Deep Frying of Banana Chips [†]

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Abstract: Soybean oil is susceptible to thermal deterioration, especially during the deep-frying process due to its high polyunsaturated fatty acids. Soybean oil has been employed to enhance the nutritional profile and thermal stability by simply blending it with other oils, including palm olein, camelia, sesame, and cashew nut oil. In particular, coconut oil is more resistant to oxidation than those oils, so adding it to soybean oil that is prone to oxidation can make the mixture more stable. Therefore, this study aims to investigate the thermal stability of soybean oil by blending it with coconut oil and evaluating the blend's physicochemical changes during the continuous deep frying of banana chips. Refined soybean oil was blended with refined coconut oil at different ratios (% v/v), including 100:0 (A), 80:20 (B), 70:30 (C), and 60:40 (D). All the mixtures were used for continuous deep frying at a constant temperature of 180 °C. The banana chips were fried for 1 min at 5 min intervals over a total of nine batches. The findings show that changes in the physicochemical properties of the frying oils were significantly affected by the soybean oil to coconut oil ratios and the frying duration, which were analyzed using a two-way analysis of variance ($p < 0.05$). The alteration in free fatty acids and peroxide values were found to be the lowest in treatment C, followed by $D < B < A$, by using a two-way analysis of variance ($p < 0.05$). Conversely, the highest total oxidation value was found in treatment A, followed by $B > C > D$. The lightness of the oil reached the highest value in the last frying cycle in treatments B and C, followed by D and A, while the color of the fried banana chips achieved the maximum value in treatment D, followed by $C < B < A$. In addition, the lipid content in the fried banana chips was observed to be the lowest in treatments D and C compared to B and A. This study indicated that blending highly unsaturated soybean oil with coconut oil could enhance its thermal stability. Consequentially, a 70:30 (% v/v) ratio of soybean oil with coconut oil exhibited good thermal stability during continuous deep frying. This study provides insights into an alternative blending technique for soybean and coconut oils to improve the thermal stability of frying oil during continuous deep frying.



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Keywords: lipid oxidation; thermal deterioration; frying oil; physicochemical properties; alteration

1. Introduction

Soybean oil is frequently used in domestic and commercial deep-fat frying. However, its suitability for frying applications is restricted due to its low stability and oxidation [1]. Unsaturated fatty acids of soybean oil have high reactivity, which is linked to oxidation, given the loss of nutritional quality [2]. The majority of the oxidation leads to an increase in saturated fatty acids or monounsaturated fatty acids and a decrease in polyunsaturated fatty acids in soybean oil during a thermal-oxidative reaction [3]. As a result, soybean oil

needs to be improved to make it resistant to the deep-fat frying. The thermal stability of soybean oil can be enhanced using a simple method—blending it with other oils, including camellia oil, palm olein, sesame oil, and cashew nut oil [4–7]. Blended oil production is currently in high demand worldwide for culinary purposes due to rising consumer awareness, nutritional benefits, improvement in thermal stability, lower cost compared to pure vegetable oils, and the ability to tailor the desired properties [4]. Wang et al. found that there were no significant changes in the fatty acid composition of soybean oil when it was blended with camellia oil in ratios of 60:50 and 50:50 (% *v/v*) during the deep fat frying of French fries at 180 ± 2 °C for 37.5 h. In addition, their physicochemical properties had the least degradation when a higher amount of camellia oil was added to the soybean oil [4]. In addition, Le et al. [5] revealed that blending soybean oil-based diacylglycerol with palm olein exhibited improved frying stability compared to pure soybean oil-based diacylglycerol. According to Garg et al. [6], the thermal stability of soybean oil was also improved by blending it with sesame oil, as sesame oil contains high levels of antioxidants. Although the previous studies have explored blending soybean oil with other oils, there is a noticeable lack of research on the thermal stability of the blends of soybean oil with coconut oil.

Coconut oil is one of the most popular cooking oils, primarily used for frying in India and Sri Lanka [8,9]. Coconut oil contains approximately 93% saturated fatty acids, making it resistant to thermal oxidation [8]. Although it is stable against thermal oxidation, using pure coconut oil, which contains high levels of saturated fatty acids, could be costly and harmful to health. This is due to the formation of unhealthy trans fats during frying, especially with repeated uses [10]. Therefore, coconut oil should be incorporated in proper amounts with other oxidation-susceptible oils. Blending coconut oil with other vegetable oils can enhance its oxidative stability while enriching it with polyunsaturated and monounsaturated fatty acids, natural antioxidants, and greater radical scavenging activity [8]. Sharanke and Sivakanthan [9] found that coconut oil had higher thermal stability than palm oil, followed by sunflower oil, during the continuous deep frying of potato chips. In agreement, Patil et al. [11] also demonstrated the higher oxidative stability of palm olein oil than sunflower oil. Additionally, blending coconut olein with palm olein was found to have less deterioration during the deep-fat frying of potato chips at 180 °C for 100 min, as reported by Khan et al. [12]. Bhatnagar et al. [8] performed an oxidative stability test on different oil blends in a beaker, storing them in an incubator at 37 °C for 42 days. The results revealed that adding coconut oil to vegetable oils, especially soybean oil, can enhance the blend's oxidative stability and increase the medium-chain fatty acids [8]. Nonetheless, this study did not assess the oxidative stability of these oil blends during the deep-frying process.

The previous studies have primarily focused on the thermal stability of blends involving soybean oil with camellia oil, sesame oil, and palm olein [4–7]. However, no research has explored the thermal stability of blending coconut oil with soybean oil during the deep-frying process. Therefore, this research investigated the thermal stability of different blending ratios of soybean oil with coconut oil during the continuous deep-frying process and their effects on physicochemical properties, including the peroxide value (PV), p-anisidine value (p-AV), free fatty acid (FFA) content, total oxidation (TOTOX) value, and color. In addition, the colors and lipid content of fried banana chips from the continuous deep frying were also evaluated.

2. Methodology

2.1. Materials

Refined soybean and coconut oils were purchased from a supermarket, and banana fruits as a sample for deep-frying process were procured from a local market in Phnom Penh, Cambodia. All chemicals were of analytical grade, including ethanol (Labscan, Bangkok, Thailand), phenolphthalein (Sigma-Aldrich, Beijing, China), acetic acid and n-hexane (Daejung, Seoul, Republic of Korea), sodium thiosulfate (QRêC®, Wellington, New Zealand), chloroform and potassium iodide (Fisher Scientific, Brussels, Belgium), starch

and sodium hydroxide (Sigma-Aldrich, Darmstadt, Germany), and isooctane (Thermo Scientific, Waltham, MA, USA).

2.2. Oil Blending Preparation

The refined soybean and coconut oils were blended using different blending ratios (% *v/v*). The blending ratios (% *v/v*) of soybean oil to coconut oil were 100:00, 80:20, 70:30, and 60:40 in a total volume of 7.5 L for each ratio, and they were identified with the uppercase letters A, B, C, and D, respectively. Based on the protocol by Tiwari et al. [13], each ratio was prepared in duplicate by mixing it in a stainless-steel container at a constant temperature of 60 °C for 5 min before use in the deep-frying process.

2.3. Banana Preparation

The banana fruits were cleaned twice to remove dust and other impurities. The cleaned banana fruits were manually peeled off and soaked immediately in a 2% citric acid solution for 10 min. After that, the banana fruits were sliced to a thickness of 1 mm, according to the protocol by Venkatachalam [14].

2.4. Deep Frying Procedure

The deep-frying process was conducted in an electric deep fryer (YSG-EF-132, Beijing, China). Briefly, each blended oil sample was poured into the twin frying tank of the electric deep fryer. Based on modified protocols from Khattab and Serjouie et al. [15,16], when the initial heating oil reached 180 °C, the first batch was initiated by transferring 40 g of freshly sliced bananas into the twin frying tank of the electric deep fryer for 1 min. The deep-frying experiment was conducted continuously for 9 batches, with each batch spaced apart in 5 min intervals, at a constant temperature of 180 ± 2 °C. This temperature, commonly used in deep-frying, was adopted from various studies in the literature [5,15–17]. The entire frying process lasted 50 min until the final batch. After each batch, 100 mL of frying oil was collected, transferred to a glass container covered with aluminum foil, and stored in a deep freezer at –19 °C for further physicochemical analysis. The fried banana chips from each batch were cooled for 5 min, then packed in polyethylene bags, sealed, and stored in a refrigerator at 4 °C.

2.5. Physicochemical Analysis

The physicochemical quality of the blended oils from each treatment, including acid value, free fatty acid (FFA) content, peroxide value (PV), and p-anisidine value (p-AV), was analyzed using the official AOCS method [18].

2.5.1. Free Fatty Acid Content

A total of 5 g of the oil sample was placed into a 250 mL conical flask, and 80 mL of freshly neutralized, heated ethyl alcohol was added, following titration with 0.1 N KOH solution and using 0.5 mL of phenolphthalein solution as an indicator. The acid value (AV) can be determined using the following equation:

$$AV \text{ (mg KOH/g oil)} = (56.1 \times V \times N)/W \quad (1)$$

where V is the volume in mL of standard potassium hydroxide used, mL; N is the normality of the standard potassium hydroxide solution, N; and W is the mass of the sample, g. The acidity is frequently expressed as the free fatty acid (FFA) content and can be calculated using the following equation:

$$\% \text{ FFA (as oleic acid)} = (28.2 \times V \times N)/W \quad (2)$$

2.5.2. Peroxide Value

A total of 5 g of oil sample was dissolved in 30 mL of acetic acid–chloroform (3:2, *v/v*), then 0.5 mL of saturated KI solution was added and properly shaken for 1 min before

the addition of 30 mL of distilled water. The solution was titrated with 0.1 M of sodium thiosulphate (Na_2SO_3), with 0.5 mL of 1% starch solution as an indicator. The peroxide value (PV) can be calculated using the following equation:

$$\text{PV (meq/kg oil)} = (\text{S} \times \text{M} \times 1000)/\text{W} \quad (3)$$

where S is the volume of Na_2SO_3 titrated with the sample (mL) with the volume of blank corrected, mL; M is the molarity of Na_2SO_3 used, and W is the mass of the sample used, g.

2.5.3. P-Anisidine Value

A total of 4 g of the oil sample was dissolved in 25 mL of 2,2,4-trimethylpentane (isooctane) in a volumetric flask to obtain a fat solution. After that, the absorbance of the solution was measured at a wavelength of 350 nm using a UV-Vis spectrophotometer (Cary 60 UV-Vis, Agilent, Santa Clara, CA, USA), with isooctane as a blank. Initially, 5 mL of the fat solution was placed into a tube with 1 mL of p-anisidine reagent, shaken well, and then kept in a dark place for 10 min. After that, the absorbances of the samples were analyzed, using isooctane with anisidine as a blank in the reference cuvette. The calculation of p-anisidine value (p-AV) can be expressed by the following equation:

$$\text{p-AV} = 25 \times [1.2 \times (\text{A}_s - \text{A}_b)]/m \quad (4)$$

where A_s is the absorbance of the oil solution after reacting with p-anisidine reagent; A_b is the absorbance of the fat solution, and m is the mass of the oil sample, g.

2.5.4. TOTOX Value

The total oxidation (TOTOX) value combines evidence regarding the original oxidation state of the oil, known as p-AV, with its current oxidation state, known as PV. The industry frequently uses p-AV in conjunction with PV to calculate the so-called TOTOX value, otherwise referred to as the “total oxidation” (TOTOX) [19].

$$\text{TOTOX value} = 2\text{PV} + \text{p-AV} \quad (5)$$

2.5.5. Analysis of Oil and Fried Banana Color

The color of the oils and the fried bananas were measured by a portable colorimeter (Chroma CR400, Konika Minolta Ltd., Osaka, Japan) with the corresponding coordinates of lightness (L^*), greenness–redness (a^*), and blueness–yellowness (b^*) identified.

2.6. Determination of Lipid Content in Fried Banana

The lipid content in the fried bananas was measured using a solvent extractor (SER 148/3, VELP Scientifica, Usmate Velate, Italy) according to the official AOAC method 920.39 used for oil determination [20]. The yield of the oil extracts was expressed as a percentage of the weight of the extracts obtained from the extraction, as follows:

$$\text{Total fat content} = [(W_1 - W_2)/m] \times 100 \quad (6)$$

where W_1 is the mass of the extract after the initial drying, g; W_2 is the mass of the extract that contained oil after the extraction, g; and m was the mass of the fried banana sample used, g.

2.7. Statistical Analysis

All data, conducted in duplicate, were calculated as mean $\pm$ standard deviation and analyzed using IBM SPSS Statistics for Windows (Version 26.0. Armonk, NY, USA: IBM Corp.). The effects of the soybean oil to coconut oil ratios and the frying batches on the physicochemical parameters of oils, as well as the color and lipid content of the fried

banana chips, were analyzed using a two-way analysis of variance (ANOVA) at a 95% confidence level.

3. Results and Discussion

3.1. Changes in Free Fatty Acid (FFA) Content

During nine consecutive cycles of frying each blend, the soybean oil to coconut oil ratios and frying batches significantly affected the FFA values, as shown in Figure 1 ($p < 0.05$). The results show that the FFA contents before and after frying significantly increased in treatments A (0.15 and 0.35%) and B (0.14 and 0.26%) ($p < 0.05$), while the contents had no significant changes ($p > 0.05$) in treatments C (0.15 and 0.16%) and D (0.13 and 0.16%). This means treatments C and D have the most stability compared to treatments A and B. This study highlights that a reduction in the FFA content occurred when coconut oil was incorporated into the blends. Similarly, Ali et al. [3] reported that the rate of FFA formation gradually increased in pure soybean oil compared to its blend with rice bran oil. Partially replacing soybean oil with rice bran oil enhanced the stability of FFA during heating. Consequently, short-chain saturated fatty acid oils tend to hydrolyze more frequently than long-chain saturated fatty acid oils [12].

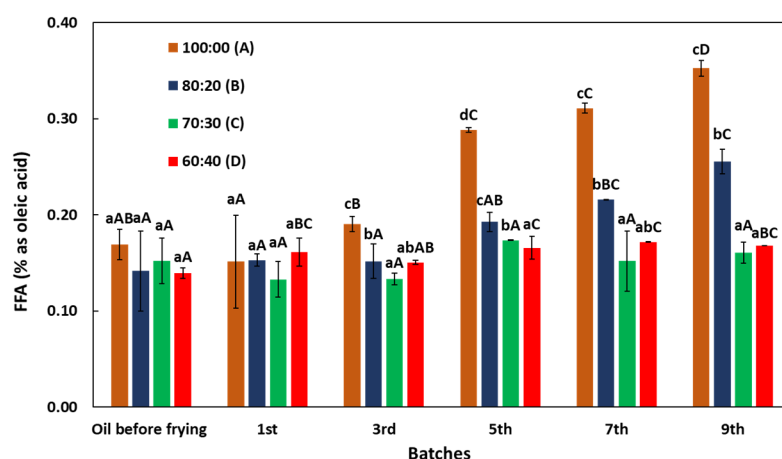


Figure 1. Effect of ratio and frying batch on FFA of oil during continuous deep-frying process. Different small letters indicate the significant differences between different ratios within the same batches, while different capital letters indicate the significant differences between different batches within the same blending ratios of the oils, as determined by Duncan's test ($p < 0.05$).

3.2. Changes in Peroxide Value (PV)

The changes in the PV value of the different frying treatments and batches during the continuous deep-frying process are presented in Figure 2. The formation of PV in all the treatments significantly differed with the repeated frying and the ratios of each blend ($p < 0.05$). The oxidative deterioration patterns of A jumped from 1.99 to 3.78 meq/kg oil, while D rose from 0.83 meq/kg oil to 1.79 meq/kg oil. The PV values of treatments C and D ranged from 1.2 to 1.79 and from 0.83 to 1.79 meq/kg oil, respectively. These PV values of C and D indicate that they had a higher thermal stability than A and B. Matthäus [21] revealed that pure soybean oil was very vulnerable to oxidation due to its high level of unsaturated fatty acids and the lack or low concentration of naturally occurring minor chemicals with antioxidant action. As seen in Figure 2, the pure soybean oil used in treatment A had the highest PV of all the batches. This study denoted that adding more coconut oil to the blends could slow down the PV formation. Subsequently, Bhatnagar et al. [8] presented that coconut oil played a role in extending the peroxide formation during frying, because coconut oil is rich in saturated fatty acids that could reduce the proportion of high polyunsaturated fatty acids in soybean oil. Hence, coconut oil is responsible for extending the peroxide formation in this context. Another investigation by Sivakanthan et al. [22] revealed that the PV of refined bleached and deodorized coconut

oil slightly increased between 0.69 to 1.48 meq/kg oil during storage at 60 ± 5 °C for 28 days. Undoubtedly, the primary oxidation products have risen due to longer frying times and constant exposure to air and light [23]. Martin and Preedy [24] reported that adding coconut oil to either safflower, sunflower, or rice bran oil could elevate the blend's oxidative stability.

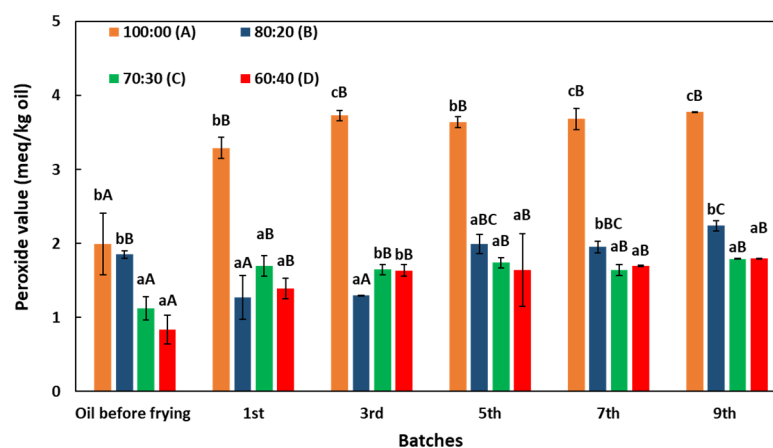


Figure 2. Effect of ratio and frying batch on PV of oil during continuous deep-frying process. Different small letters indicate the significant differences between different ratios within the same batches, while different capital letters indicate the significant differences between different batches within the same blending ratios of the oils, as determined by Duncan's test ($p < 0.05$).

3.3. Changes in *p*-Anisidine Value (*p*-AV)

The changes in *p*-AV in the deep frying of the banana chips using different oil ratios and frying batches are presented in Figure 3. The *p*-AV was significantly affected by the soybean oil to coconut oil ratios and frying batches during continuous deep frying ($p < 0.05$). For each treatment, there were gradual increments of the *p*-AV values between the frying batches ($p < 0.05$). Importantly, 22.27 of the *p*-AV content in treatment A performed a uniform increment in the last batch, which was slightly lower than treatment B (22.87) and D (23.11). On the contrary, treatment C indicated the least prominent *p*-AV of only 17.91. Hence, when compared to pure soybean oil, blended oils have much lower concentrations of secondary reaction products, as revealed by the *p*-AV. Similarly, Khan et al. [12] indicated that increasing frying time could increase the *p*-AV of all frying oils. This result may be explained by the fact that less stable primary oxidative molecules, such as hydroperoxides, further break down to create aldehydic chemicals. Aldehyde compounds are byproducts of secondary oxidation produced when lipids become rancid due to oxidation [12]. Furthermore, over half of the volatile chemicals produced during the lipid oxidation of vegetable oils like soybean oil were aldehyde compounds. However, coconut oil contained natural antioxidants that could extend the degradation of lipid oxidation, as well as extending the formation of PV [8].

Aldehydes, ketones, and anhydrides of unsaturated fatty acid are examples of volatile breakdown products that form according to *p*-AV and add to the flavor of food that is being fried [25]. The carbonyl breakdown products are measured by the *p*-AV. Unsaturation level and oxygen concentration are two important variables that influence the *p*-AV. Proteins, amino acids, and amines can interact with carbonyl compounds created during deep fat frying to yield tasty, nutty pyrazines. Thus, in deep-fat frying, some of the carbonyl breakdown products give forth a stench [26].

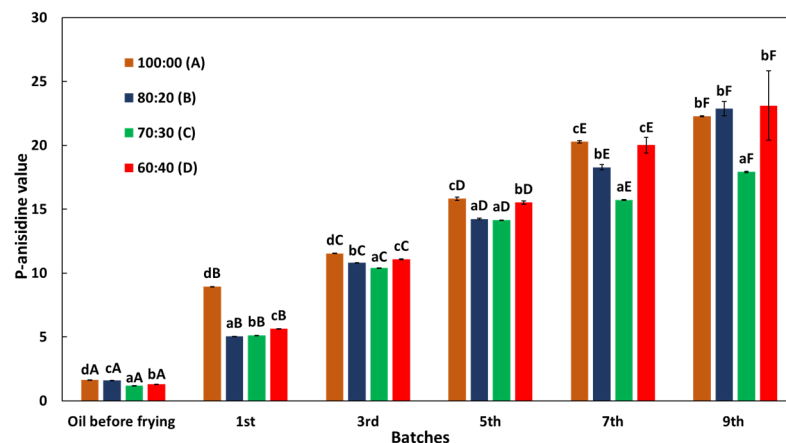


Figure 3. Effect of ratio and frying batch on p-AV of oil during continuous deep-frying process. Different small letters indicate the significant differences between different ratios within the same batches, while different capital letters indicate the significant differences between different batches within the same blending ratios of the oils, as determined by Duncan's test ($p < 0.05$).

3.4. Changes in TOTOX Value

The TOTOX formation throughout the frying batches and oil ratios differed significantly ($p < 0.05$), as illustrated in Figure 4. Regarding this result, treatment D < C < B after blending with different portions of coconut oil received low TOTOX values compared to the pure soybean oil in treatment A. The last frying cycle expressed the expansion of TOTOX compounds in A (29.83), while the lowest existence was found in treatment C (21.50) followed by D (26.70), and B (27.35). In comparison to Paul et al. [27], who contrasted sunflower oil and palm oil, the increases in the PV, p-AV, and TOTOX values were lower in coconut oil. It is abundantly obvious that coconut oil underwent less oxidation during frying than the palm and sunflower oils did. It has been reported that the rate of oxidation increases together with the degree of fatty acid unsaturation [27].

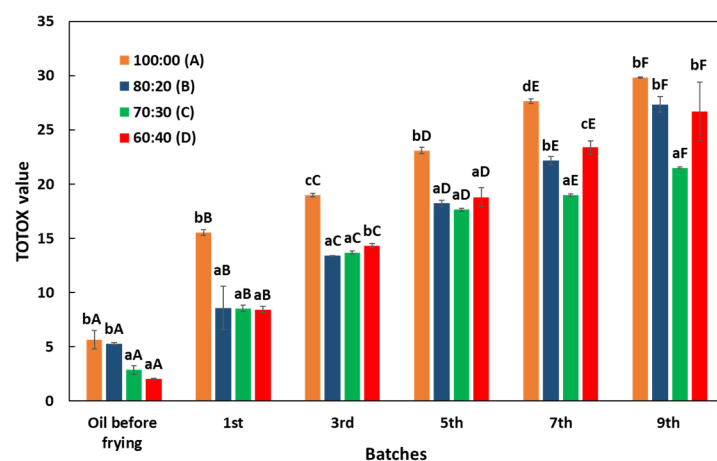


Figure 4. Effect of ratios and frying batch on TOTOX value of oil during continuous deep-frying process. Different small letters indicate the significant differences between different ratios within the same batches, while different capital letters indicate the significant differences between different batches within the same blending ratios of the oils, as determined by Duncan's test ($p < 0.05$).

3.5. Changes in Color Value of Oils

The L^* , a^* , and b^* color coordinates of the oils from the different frying mediums and batches are presented in Figure 5A–C. This study proved that the color of L^* , a^* , and b^* were significantly affected by the ratios of blended oil and frying batch ($p < 0.05$). The L^* (lightness) colors in all treatments decreased significantly ($p < 0.05$). After reaching the

ninth batch of frying, the L^* value in different ratios indicated that treatment B received the lightest color, followed by C, D, and A. The decrease in lightness may be correlated with the increase in b^* and a^* , resulting in the oil darkening as the frying time is increased. Concomitantly, a^* values before frying had no significant difference in the treatments A (0.78), C (0.71), B (0.83), and D (0.84) were not different ($p > 0.05$). In the ninth batch, it increased to 0.21, 0.23, 0.59, and 0.65 of the treatment A, B, C, and D respectively. Otherwise, b^* color in treatments A, B, C, and D had the variations from -1.64 , -2.26 , -1.56 , -2.21 to -1.10 , -0.87 , -1.66 , to -2.07 , respectively.

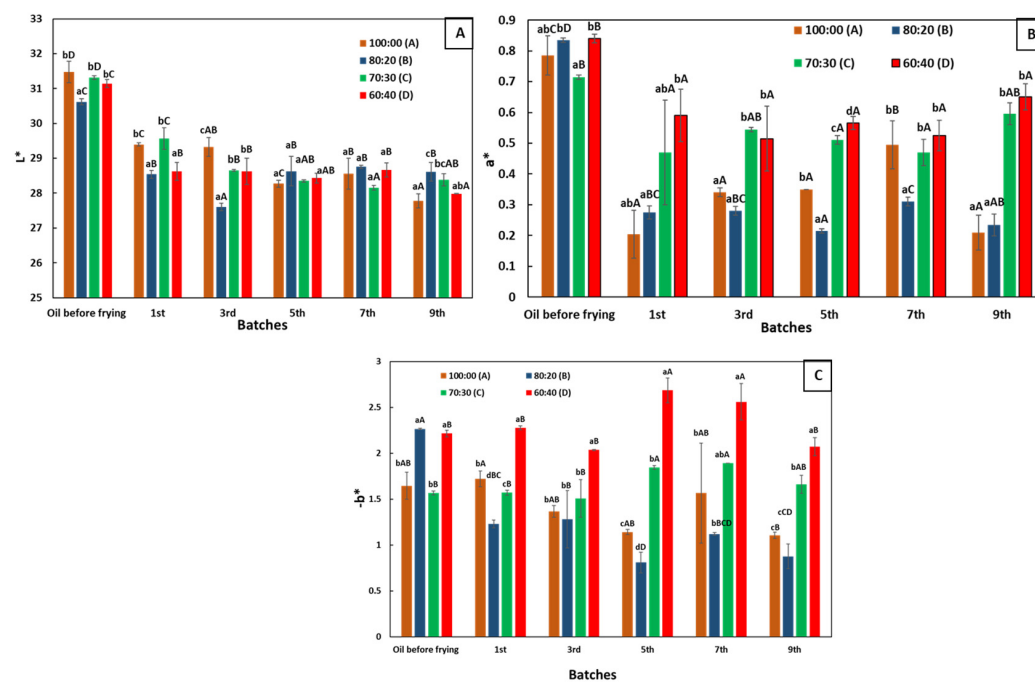


Figure 5. Effect of ratios and frying batch on the color of oil during continuous deep-frying process: (A) the degree of lightness, (B) the redness–greenness (+ or $-a^*$), (C) the yellowness–blueness (+ or $-b^*$). Different small letters indicate the significant differences between different ratios within the same batches, while different capital letters indicate the significant differences between different batches within the same blending ratios of the oils, as determined by Duncan’s test ($p < 0.05$).

In this study, the darkening of the oil color after frying occurred because there may be the development of the brown pigment of the banana chips and the duration of the frying process. This was also reported by Nayak et al. [19], who stated that the brown pigments that leach out of fried meals and cause product degradation during hydrolysis, oxidation, and polymerization can alter the color of an oil during frying [19]. Remarkably, the yellow color of oil in the treatment C and D increased after frying. Comparably, Debnath et al. [28] also found the increase in yellow color of oil after frying due to the non-polar compounds of fried product leached in frying oil. Additionally, Kittipongpittaya et al. [29] stated that oil oxidation and Maillard’s reaction develop because of oil darkening. Therefore, the more carotenoids were in the oil, the higher its b^* value was [30].

3.6. Color of Fried Banana Chips After Deep-Frying Process

The colors (L^* , a^* , and b^*) of all the treatments were significantly influenced by the ratios and frying batches ($p < 0.05$), as shown in Figure 6A–C. Certainly, the fried banana chips of treatment D ($L = 57.63$) demonstrated the lightest color throughout the period of frying and followed by treatments C ($L = 54.44$), A ($L = 54.27$), and then B ($L = 52.33$). These L^* colors were higher than a study by Aida et al. [31], who indicated that all the samples of banana chips had L^* values of less than 50, indicating that all samples were dark. Importantly, the smallest rate of a^* value existed in treatment C in every frying

batch. Similarly, b^* values revealed the same minor alteration in all treatments. According to Krokida et al. [32], the same amount of frying time, as the temperature rises, the a^* parameter rises as well, which is detrimental to the color of fried goods (making them redder). Additionally, higher b^* parameter values typically result in more yellow goods, which is preferable for fried foods [32].

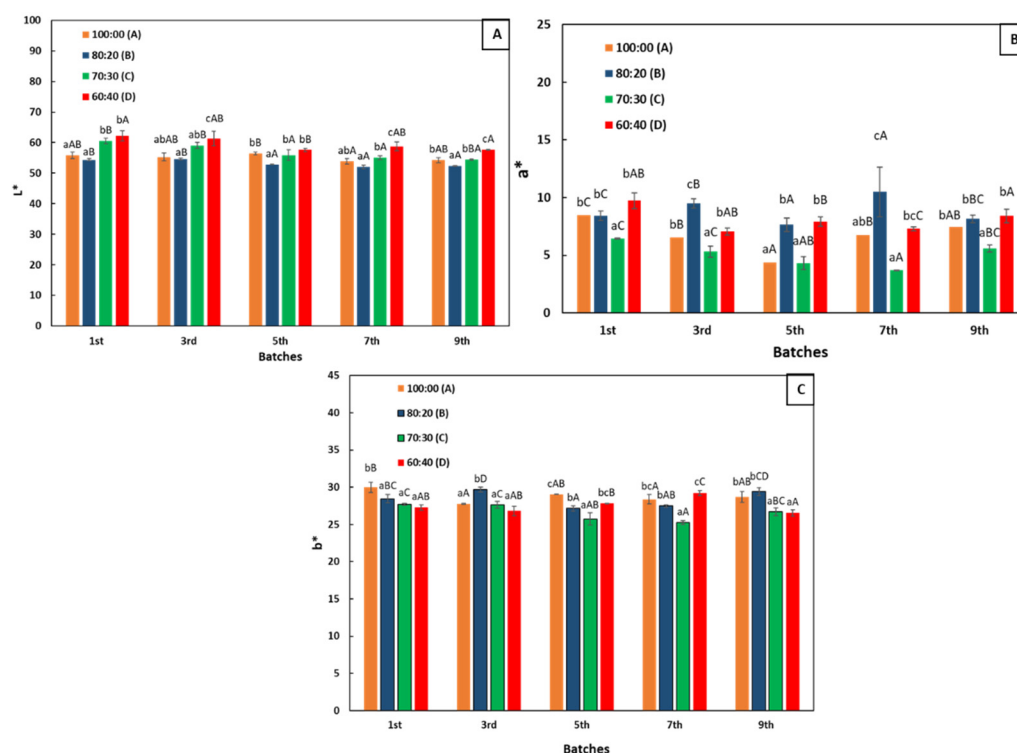


Figure 6. Effect of ratios and frying batch on the color of fried banana chips during continuous deep-frying process: (A) the degree of lightness, (B) the redness–greenness (+ or – a^*), (C) the yellowness–blueness (+ or – b^*). Different small letters indicate the significant differences between different ratios within the same batches, while different capital letters indicate the significant differences between different batches within the same blending ratios of the oils, as determined by Duncan’s test ($p < 0.05$).

3.7. Lipid Content of Fried Banana Chips After Deep-Frying Process

The oil uptake in the banana chips during the continuous deep-frying process differed significantly, as seen in Figure 7 ($p < 0.05$). The maximum oil adsorption of the first batch was discovered in treatment B (35.58%), followed by A (33.46%), C (32.61%), and D (31.08%). Similarly, the last frying batch indicated the prominent lipid content in treatment B (37.19%), while the least occurrence was found in treatment C (32.45%) and D (32.85%) followed by A (33.93%). In this study, the lipid contents after the last frying were higher than those demonstrated by Aida et al. [31], who found it to be between 26.89 and 31.88%. This may be due to the different types of oils used, the duration of banana frying, and the amount and thickness of a banana in a frying cycle. This current study and the study of Aida et al. applied the same frying temperature of 180 °C. However, this current study used 40 g of banana sample and 1 min of frying time, whereas Aida et al. used only 4 g for 4 min in the frying with palm oil. Otherwise, the soybean oil used in this study may contain higher unsaturated fatty acids than palm oil, resulting in a greater absorption of the oil into the banana chips. This was also explained by Kita and Lisińska [33] that the high unsaturated fatty acids can improve fat absorption compared to the low unsaturated fatty acids.

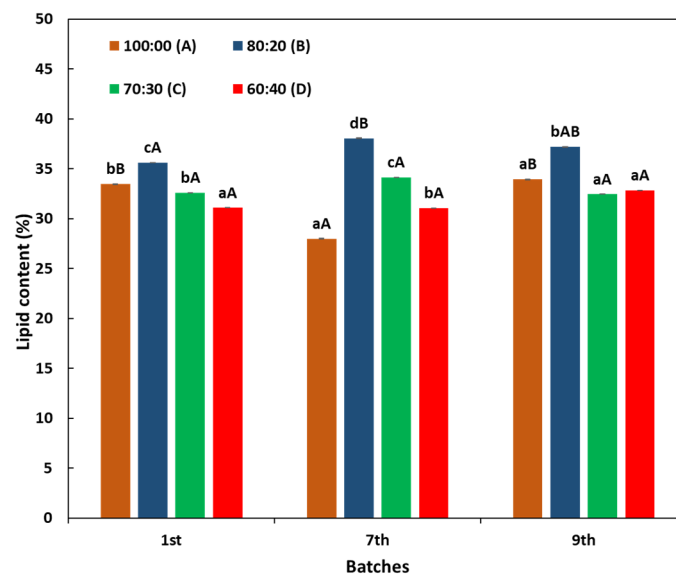


Figure 7. Effect of ratios and frying batch on the lipid content of fried banana chips during continuous deep-frying process. Different small letters indicate the significant differences between different ratios within the same batches, while different capital letters indicate the significant differences between different batches within the same blending ratios of the oils ($p < 0.05$).

4. Conclusions

This study concluded that adding coconut oil to soybean oil enhanced thermal stability during continuous deep frying. The ratio of coconut oil added to soybean oil and the frying batch significantly improved the thermal stability by delaying the degradation of the frying oil quality during the continuous deep-frying process ($p < 0.05$). All physicochemical parameters, including the AV, FFA, PV, p-AV, TOTOX, and color values were significantly different ($p < 0.05$) in all the treatments (A, B, C, and D). In terms of the physicochemical characteristics, and the color and lipid content of the banana chips, the treatment C was selected as the most stable and resistant blended oil, followed by $D < B < A$. Consequently, the blend of soybean and coconut oil offers improved thermal stability at a lower cost compared to pure coconut oil, presenting a viable alternative for cost-conscious consumers of coconut oil. However, some chemical properties of the blends such as the total polar compound, fatty acid composition, oil viscosity, and the sensory evaluation of the fried products should be further addressed.

Author Contributions: S.Y.: conceptualization, formal analysis, methodology, and writing—original draft; S.K.: validation, writing—review and editing, investigation, and supervision; M.S.: resources and writing—review and editing; R.T.: writing—review and editing. All authors have read and agreed to the published version of the manuscript.

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