

Preparation of Trans Fat Free Bakery Margarine with Rice Bran Oil and Palm Stearin

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To cite this article:

Suduwa Devage Chamika Sewwandi, Palitha Chandrapema Arampath. Preparation of Trans Fat Free Bakery Margarine with Rice Bran Oil and Palm Stearin. *World Journal of Food Science and Technology*. Vol. 6, No. 2, 2022, pp. 31-38. doi: 10.11648/j.wjfst.20220602.12

Received: March 8, 2022; Accepted: March 29, 2022; Published: May 24, 2022

Abstract: The most common modification technique used to improve the antioxidant capacity and plasticity of oils is partial hydrogenation. However, during this method formation of trans fatty acids (TFA) is the significant drawback that causes harmful effects on human health. An alternative method for partial hydrogenation is chemical interesterification (CIE) which used in the production of commercial fat based products. Palm stearin (PS) represents the higher melting fraction of palm oil with a higher percentage of saturated fatty acids. Rice bran oil (RBO) is healthy, low melting oil composed of unsaturated fatty acids. The objective was to produce potential trans-fat free bakery margarine using CIE of RBO and PS. Oil blends of RBO and PS were chemically interesterified using sodium methoxide catalyst. The subsequent analysis were conducted to determine iodine value, peroxide value, free fatty acid content (FFA) and slip melting point (SMP) before and after the interesterification reactions. The bakery margarine was prepared using interesterification, physical blends and SMP was compared. Results were statistically analyzed with an independent sample using T-test to compare the means and Post hoc Tukey's test to compare the differences. The results shows that all interesterified blends had lower SMP value compared to the non-interesterified blends (NIE) due to wide-ranging redistribution of fatty acids among the triacylglycerol's. The SMP of the 40:60 and 50:50 interesterified blends was remained constant ($p < 0.05$). The iodine values of all interesterified blends of PS to RBO (40:60, 50:50, 60:40 and 70:30) were not significantly different ($p < 0.05$). Chemically interesterified oil blends have lower peroxide values. Peroxide values of blends (50:50), (60:40) and (70:30) were not detected after the interesterification. CIE significantly increases the FFA value of binary blends ($p < 0.05$). There was no significant difference between the 40:60 interesterified mixture for FFA. Resulted interesterified fat especially 50:50 and 60:40 binary blends have the potential to use in manufacturing fat spread and margarine. NIE oil blends were shown oil separation during the storage.

Keywords: Chemical Interesterification, Trans Fatty Acids, Rice Bran Oil, Bakery Margarine

1. Introduction

Oil is considered an important nutritional source that plays a critical role in improving the palatability of foods [1]. Bakery shortenings, margarine is the most common fat product used in the food industry. To broaden their applications, Oils and fat are modified, either chemically through hydrogenation or interesterification, or physically through fractionation [2]. One of the most significant practices for modifying the physicochemical properties of

oils and fats is interesterification [3]. The food value of fat and oil is determined by chemical properties such as iodine value, free fatty acid value (FFA), and peroxide value, as well as physical properties such as slip melting point (SMP), color, and appearance [4].

The most common modification technique used to improve the antioxidant capacity and plasticity of oils is partial hydrogenation [5]. Trans fats are produced by partial hydrogenation. Hydrogen atoms are added to cis unsaturated fats during the hydrogenation process, breaking the double bonds between carbon atoms and turning them to

saturate. In the food industry, hydrogenation is used to increase shelf stability by reducing fat rancidity. Rancidity is caused by free radicals disrupting the double bond between carbon atoms. Because it has a higher melting point, hydrogenated fat is preferred for frying [6]. However, during the hydrogenation process, some of the *cis* links in fatty acids are converted to *trans* bonds, resulting in *trans* fatty acids rather than saturated fatty acids. *Trans*-fats, regrettably, are harmful to human health. They raise the risk of cardiovascular disease by increasing LDL cholesterol while decreasing HDL [7].

An alternative method for partial hydrogenation is chemical interesterification (CIE) which does not contribute to the production of *trans* solid fats and gives desired physical and nutritional properties to the final product. If free *trans* fats could be used as a basic interesterification stock, interesterified fats would also be free from *trans* fats [8]. Fatty acids (FA) are transferred inside (intra-esterification) and between (inter-esterification) triacylglycerol (TAGs) until a thermodynamic equilibrium is achieved during inter-esterification [9]. The interesterification of hard fats and vegetable oils may result in a fat blend with ideal properties. By rearranging or randomizing acrylic residues in TGAs, new physical properties of fats or oils are established. Unsaturated fatty acids occupy the two places of the TAG molecules in the majority of oils and fats. CIE randomly redistributes FAs among TGA molecules. The extent of unsaturation or configuration of FA remains unchanged. [10].

Due to favorable qualities such as high oxidative stability heat resistance and flexibility, palm oil (PO) and its fractions are essential sources of edible oil for the food sector. The high melting fraction generated by controlled crystallization is palm stearin (PS) [11]. It is widely used in these studies because of its multifunctional composition of fatty acids and triacylglycerol. The high melting point of stearin (44–56°C) poses challenges in the manufacturing of items by causing low plasticity and inconsistent melting at body temperature. As a solution for that, Palm stearin (PS) can be blended and interesterified (IE) with vegetable oils that contain more polyunsaturated fatty acids and have a favorable melting profile to improve PS's melting properties [12]. On the other hand, rice bran oil (RBO) is an underutilized co-product of the rice milling process. It's nutrition composition is better than other common vegetable oil and its abundant in phytosterols, gamma-oryzanol, tocopherols, tocotrienols and vitamin B complex [13, 14]. Rice bran oil has less quantity of saturated fatty acids and contains high amount of unsaturated fatty acids. Rice bran oil contains 38-46% oleic acid (C18:1), monounsaturated and 33-40% linoleic acid (C18:2), polyunsaturated. [15].

In this study, blends of PS: RBO in ratios (w/w) of 50:50, 70:30, 60:40, and 40:60 were chemically interesterified and some physicochemical characteristics were studied. Finally, the use of interesterified blends in the manufacture of different types of margarine and cake was investigated.

2. Materials & Methodology

2.1. Analysis of Raw Materials

RBD rice bran oil and palm stearin were subjected to different test including iodine value (IV), peroxide value (PV), saponification value (SV), free fatty acid (FFA), slip melting points (SMP) and Moisture content. All the testing procedures are discussed below.

2.1.1. Determination of SMP

The digital slip melting point and AOCS Method No. Cc 3-25 were used to assess the slip melting point of the palm stearin and interesterified oil blends. Fat samples were melted using water bath and placed in a capillary tube (with 10 mm high column). The sample was cooled in the refrigerator for 16 hours at 4±1°C. After that, the tube was immersed in cold water in a beaker. The water was agitated and slowly warmed. When the solid fat in the tube's column began to rise due to a pressure difference, the reading was measured. The temperature was measured using a thermometer. The mean values were computed after each sample was performed in triplicate [16].

2.1.2. Determination of Iodine Value

The AOAC Official Method 993.20 (AOAC Wijs Cyclohexane-Acetic Acid solvent) method was used to estimate the iodine values of the raw material and oil blends. In a dry and clean conical flask, the sample weight was taken to the nearest 0.001 g. Sample size and weight used was varied according to its expected iodine value, as specified in Table 1.

Table 1. Test sample weights according to iodine value.

Iodine value	Test sample weight (g)
10	3.17-2.54
20	1.59-1.27
40	0.79-0.63
80	0.40-0.63
120	0.20-0.16
200	0.16-0.13

The test sample was melted and passed across a filter paper to remove any solid filths and residual water. (All the glassware should be completely dry). About 0.10-0.15g of liquid oil sample was measured into a clean, dry 500 mL conical flask. About 7.5 mL of cyclohexane and 7.5 mL acetic acid was added and twirled to dissolve the oil. Then, 25 mL of Wijs into the flask. The flask was plugged and spun to mix. Then the test sample containing flask was kept in the dark at 25±5°C for hour duration. Then the flask was detached from the darkness, and 20 mL of 15% Potassium Iodide (KI) solution was added and mixed. After that, 150 mL distilled water was added, and the content was gradually titrated with 0.1M Sodium thiosulfate solution. The titration was conducted until the almost disappearance of the yellow colour of the solution. Then, 1 to 2mL of 1% starch indicator was added, and the titration was continued to blue colour missing after strong shaking. A blank determination was also

conducted providing the same conditions. For each oil sample, titration was triplicated [17]. The iodine value of the oil blends was calculated according to the equation mentioned below.

$$\text{Iodine value} = \frac{(B-S) \times 12.69}{\text{wt of the oil or fat}}$$

Where, B = Titration of blank (mL)

S = Titration of test sample (mL)

M = Molarity of $\text{Na}_2\text{S}_2\text{O}_3$ solution.

Iodine value of the raw material was determined before use. Iodine value of the fat blend was determined before and after the interesterification process.

2.1.3. Determination of Moisture and Volatile Matters

AOAC Official method 926.12 (2000) was used to determine the moisture and volatile material content of raw material and fat blends. Test sample softened by gentle heating and mixed. The prepared test sample (5 ± 0.2 g) was weighed into an Aluminum moisture dish approximately 5 cm diameter and 2 cm height with a tight slip-over cover. The samples were dried at $105 \pm 1^\circ\text{C}$ in a vacuum oven to get constant weight. Then the dried samples were kept in a desiccator to cool for 30 min. A successive 1 hour drying period was maintained until the sample gets constant weight. Moisture and volatile matter content was calculated as a percentage by using the loss of weight. Each sample was executed in triplicate, and the average values were computed.

$$\text{Moisture and volatile matter content } \left(\frac{m}{m} \% \right) = \frac{W_1 - W_2}{W_1 - W_0} \times 100$$

W0= Weight of Aluminum Moisture dish

W1= Weight of Sample + Aluminum Moisture dish before drying

W2= Weight of Sample + Aluminum Moisture dish after drying

2.1.4. Determination of Free Fatty Acid (FFA) Content

The AOAC Official Method 940.28 was used to determine the FFA content. Each raw material and oil blend was melted if they are not in the liquid form and filtered through a clean cloth piece. About 50 ml of 95% ethanol was measured into a clean and dry conical flask. Then about a few drops of the oil sample and 2 ml of 0.1% phenolphthalein were added. After warming the conical flask in a water bath at $60-65^\circ\text{C}$, enough standard 0.1M NaOH was applied to give a faint permanent pink color. The oil was then measured into the neutralized ethanol and titrated with standard 0.1M NaOH, periodically warming and violently shaking the combination until the same faint permanent pink color appeared in the supernatant ethanol. Each sample was executed in triplicate, and the mean values were computed.

$$\text{Percent of FFA} = \text{required } 0.1\text{M NaOH volume (ml)} \times 0.05$$

2.1.5. Determination of the Saponification Value

The AOAC Official Method (2000) 920.160 was used to determine the saponification value (SV). Each raw material

and oil blend was melted if they are not in the liquid form and filtered through a clean cloth piece. Then about 5.00 ± 0.05 g of oil was measured into a clean, dry round bottom flask. About 50 ml of the alcoholic KOH solution was added into the flask using a pipette. Next, the round bottom flask was joined to the air condenser and boiled in 30 minutes. Then the content of the flask was cooled and titrated with standard 0.5M HCl using 0.1% phenolphthalein. A blank experiment was carried out using the same conditions as mentioned above.

$$\text{Saponification value (SV)} = \frac{(28.05(B-S))}{W}$$

B – Required volume of standard 0.5M HCl for the blank determination in ml

S – Required volume of standard 0.5 M HCl for the sample determines in ml

W- Weight of the oil sample in grams

2.1.6. Determination of the Peroxide Value

This was done according to the AOAC Official method 965.33 (2000) was used to determine the peroxide value of the raw material and fat blends. The oil sample (5.00 ± 0.05 g) was measured precisely into a conical flask and dissolved in 30 ml of a mix of organic solvent containing chloroform (CHCl_3) and glacial acetic acid (CH_3COOH) in 2:3 ratio. Then about 0.5 ml of the saturated aqueous KI solution was added to the conical flask. The conical flask was plugged and left for 1 minute to stand. After adding about 30 ml of distilled water, the solution was titrated with the 0.1M $\text{Na}_2\text{S}_2\text{O}_3$ solution until the yellow color virtually vanished. About 0.5 ml of 1% starch solution was added, and the titration was continued with the addition of 0.1M $\text{Na}_2\text{S}_2\text{O}_3$ until the black-blue color vanished. To move the released iodine from the chloroform layer to the aqueous layer, the conical flask was violently and continuously shaken. A blank titration was also employed, and the PV was calculated using the formula. For each oil sample, titration was triplicated was, and the average peroxide value was calculated (For the oil samples which had titration reading below 0.5ml, titration was repeated using standard 0.01M $\text{Na}_2\text{S}_2\text{O}_3$ instead of 0.1 M $\text{Na}_2\text{S}_2\text{O}_3$ and following the same conditions as mentioned above).

$$\text{Peroxide value (PV)} = \frac{(S-B) \times 0.5 \times M \times 1000}{W}$$

S – Required volume of standard sodium thiosulfate for the sample titration in ml

B – Required volume of standard sodium thiosulfate for the blank titration in ml

M- Molarity of the standard sodium thiosulfate solution

W- Weight of the oil sample in grams

2.2. Preparation of Binary Oil Blend

The RBD palm stearin was melted at 85°C , and RBD rice bran oil was heated at 60°C using a water bath. Both were filtered using a clean piece of cloth [18]. Fat blends were

formulated with RBO and palm stearin by mixing at different ratios, as specified in Table 2.

Table 2. Palm stearin: Rice bran oil weight ratios of four blends.

Ratio (% w/w)	
RBD palm stearin	RBD rice bran oil
40	60
50	50
60	40
70	30

2.3. Chemical Interesterification

Formulated fat blends (400 g from each blend) were heated at 100°C for 15 minutes to get rid of traces of water before the chemical interesterification [2]. Dehydrated fat blends were transferred into a vacuum flask, and the temperature was reduced to 90°C. In the next stage, 0.5% (w/w) dry sodium methoxide was added to the dried fat blends. The dried fat blends were then treated with 0.5 percent (w/w) dry sodium methoxide. The chemical interesterification process was then carried out at 90°C for 1 hour at 0.8 bar abs pressure and 300 rpm. The fat blend's SMP was determined to keep track of the reaction equilibrium during interesterification. Since the SMP of the fat blend changes and finally become a constant value through the process. To cease the catalyst activity, 2% (w/w) citric acid solution (20%, w/v) was added after the reaction equilibrium point was reached. After that, the mixture was brought to 70°C (300 rpm), and the stirring was continued for 15 min. Next, 1.5% bleaching earth (bentonite) was added into the blend (at 110°C, 300 rpm, and under 0.8 bar abs for 15 min) to eliminate sodium methoxide, citric acid, and excess alkalinity. In the final step, the mixture of fat was vacuum filtered twice through the Whatman filter paper, grade 4, to separate the bleaching earth [9]. Non-interesterified oil is abbreviated as NIE and chemically interesterified oil is abbreviated as CIE.

Physiochemical parameters in non-interesterified blends and chemically interesterified blends were analyzed according to the above methods. [19].

2.4. Preparation of Bakery Margarine

Ingredients: Oil blend, Water, Salt, Emulsifiers (DMG, PGPR, PGE), Preservatives (Potassium sorbet), Citric acid, Antioxidant (Butylated hydroxyanisole), Butter flavor, Colourant (Sunset yellow, tartrazine).

Oil phase was prepared from interesterified and non interesterified oil blends. Oil phase was heated at 40-50°C and emulsifiers were added to the oil blend. Water phase was pasteurized at 75-80°C. Oil phase was mixed with aqueous phase and homogenized at 500 rpm for 40 min. Then the chilling was done on an cool water bath. Prepared margarine samples were packaged in polyethylene bags and stored at 20-22°C in 24 hours. The SMP of all the margarine samples were measured and recorded after 24 hours [20].

2.5. Statistical Analysis

All determinations were triplicated and the results were stated as mean values \pm standard error of the mean. The differences of the non-interesterified oil blends and interesterified oil blends in terms of iodine value, peroxide value, free fatty acid value, and slip melting point were statistically determined using an independent T-test. Variances were considered significant at $p < 0.05$. SPSS software was used to perform the statistical analysis. Statistical analysis was done to identified most suitable margarine product.

2.6. Preparation of Cake by Using the Prepared New Margarine

Ingredients: Wheat flour, Prepared margarine from physical blend and interesterified blend, White sugar, Whole egg, Baking powder.

Initially 500g formulated margarine and 500g white sugar was mixed until mixture become fine batter. Then ten eggs were added to the mixture with keeping two minutes intervals. After that 500g wheat flour and 5g baking powder was added to the batter. A commercial mixer is generally used for mixing the batter, which keeps beating the mixture for about 20 minutes even after all the ingredients have combined thoroughly. Then the mixture was filled to the mold and baked at 180°C for 45 minutes. Cake samples were kept to reach room temperature and packed in polyethylene bag with labeling sample name, sample number and manufacture date. Then the cake samples from existing market margarine product and formulated margarine were compared.

3. Results and Discussion

According to the independent sample T-test, chemical interesterification significantly modified physicochemical properties, including iodine value, peroxide value, FFA value and SMPs of binary mixtures ($p < 0.05$). All four oil blends were improved by chemical interesterification. When comparing the iodine value and peroxide value, interesterified oil blends show lower values than non-interesterified oil blends. FFA content of interesterified mixtures were greater than the non-interesterified blends. Chemically interesterified oil blends have lower SMP than non interesterified oil blends. According to the findings, prepared bakery margarine shows desirable melting points. Although margarine from interesterified blends and non-interesterified blends does not display a considerable difference, margarine from non-interesterified combinations was express an oil separation during the storage.

3.1. Physico-Chemical Characteristics of the Raw Materials

The raw materials quality in the chemical interesterification is crucial. Important parameters measured are iodine number, saponification value, peroxide value, FFA content, and moisture content. Table 3. indicates the

physicochemical characteristics of the RBO and PS.

Table 3. Physicochemical Properties of Rice bran oil and Palm stearin.

	Palm Stearin	Rice bran oil
Saponification value (mg KOH/1g fat)	135.2±0.035	151.62±0.068
Iodine value (g iodine/100 g oil)	37.33±0.125	101.81±0.156
Free Fatty Acid content (mg KOH/1g fat)	0.63±0.0637	0.11±0.0543
Slip melting point (°C)	52.5±0.1	20.67±0.1
Peroxide value (milliequivalent peroxide/kg oil or fat)	ND	7.9845±0.0169
Moisture (%)	1.17±0.089	1.22±0.074

Table 4. Iodine values, Peroxide values and FFA values of NIE and CIE blends.

Oil blend (PS: RBO)		Iodine value (g iodine/100 g oil) Mean ± SD	Peroxide value (milliequivalent peroxide/kg oil or fat) Mean ± SD	FFA value content (mg KOH/1g fat) Mean ± SD
40:60	NIE	71.23±0.247	5.76±0.090	0.4233±0.035
	CIE	56.21±0.235	2.14±0.180	0.4040±0.021
50:50	NIE	65.30±1.113	5.85±0.124	0.3367±0.097
	CIE	46.86±1.167	ND	0.8700±0.066
60:40	NIE	68.29±0.306	9.43±0.557	0.3300±0.036
	CIE	45.10±0.767	ND	0.6167±0.049
70:30	NIE	56.09±0.344	5.42±0.095	0.2467±0.060
	CIE	48.60±0.175	ND	0.5600±0.118

Statistical analysis Independent T Test IBM SPSS 26.0

*NIE – Non interesterified

*CIE - Chemical interesterified

*SD- Standard Deviation

*ND- Not Detected

3.2. Effect of CIE on Iodine Value of Oil Blends

The iodine value of the fat and oil determines the degree of unsaturation, one of the most significant analytical features of the oil blend. The iodine value of the oil blends before chemical interesterification and after interesterification was indicated in the figure 1. The chemical interesterification process was decreased the iodine value of all four blends. Therefore, CIE significantly changes the iodine value ($p<0.05$).

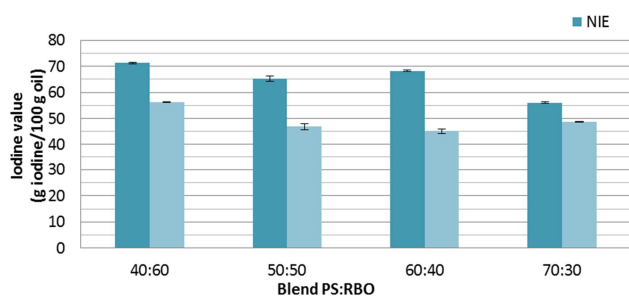


Figure 1. Iodine values of CIE blends vs NIE blends.

3.3. Effect of CIE on Peroxide Value

The peroxide value of the fat and oil decides the degree of oxidative rancidity and the extent of degradation of the oil blends. The conversion of the peroxide values of the binary blends before CIE and after CIE can be seen in the figure 2. Peroxide values of all binary blends were significantly different from non-interesterified blends ($p<0.05$). Chemically interesterified oil blends have lower peroxide values. Peroxide values of blends (50:50), (60:40) and (70:30)

were not detected after the interesterification. Reduction of PV after interesterification may be due to the absorption of peroxides onto soaps during CIE [9].

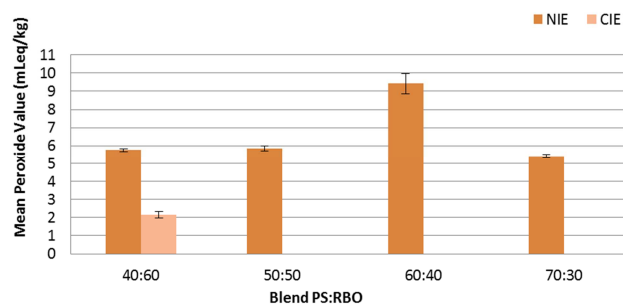


Figure 2. Effect of CIE on Peroxide value.

3.4. Effect of Free Fatty Acid (FFA) on Chemical Interesterification

FFA value of the fat and oil is used to predict the storage quality. It produces undesirable off-flavor during storage [9]. Increased FFA content weakens the catalyst activity; it is important to maintain a low level of FFA in initial oil blends, preferably lower than 0.1%. Chemical interesterification significantly increases the FFA value of binary blends ($p<0.05$). The lower the FFA content, the greater the resistance to oxidation of fat blends. According to [21], good catalyst activity affects the incensement of FFA content. Until now, no apparent reason has been given. The catalyst (sodium methoxide) mechanism may be the reason for this. In CIE, the ester linkages of fatty acid and glycerol backbones cleave, and FFA are released. They ended up randomly in the pool of fatty acids and reorganized into new

positions on glycerol. This mechanism goes on until the reaction ceases [22]. Indeed, the reason for the slight increase of FFA after interesterification may be the separation and arrangement of fatty acids.

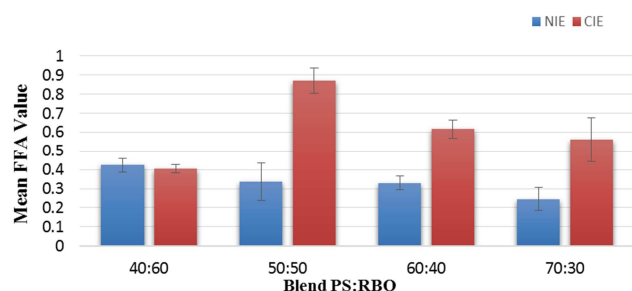


Figure 3. Effect of FFA on chemical interesterification.

3.5. Effect of Interesterification on Slip Melting Point

Melting point was established via detecting the conversion of solid fat into liquid form. Initially raw rice bran oil and palm stearin have melting point respectively, 20.67°C and 52.5°C. SMP of all the non-interesterified blends range within 42°C - 48°C. Chemical interesterification has significantly reduced the SMP of all the four blends.

Reason for the reduction of SMPs may a result of the reduction of the ratio of high melting point trisaturated triglycerols and increment of the proportion of disaturated-monounsaturated and mono unsaturated-diunsaturated TGAs [18]. SMP value of non-interesterified oil blends and interesterified oil blends were indicated in the Table 5. The graphical explanation of SMP is indicated in figure 4.

Table 5. Slip melting point of NIE and CIE blends.

Oil blend (PS: RBO)		Slip melting point °C Mean ± SD
40:60	NIE	42.5±0.50
	CIE	39.83±1.04
50:50	NIE	42.0±1.00
	CIE	39.33±1.04
60:40	NIE	45.33±1.04
	CIE	42.00±1.32
70:30	NIE	48.00±1.50
	CIE	43.83±1.25

Statistical analysis Independent T Test IBM SPSS 26.0

*NIE – Non interesterified

*CIE - Chemical interesterified

*SD- Standard Deviation

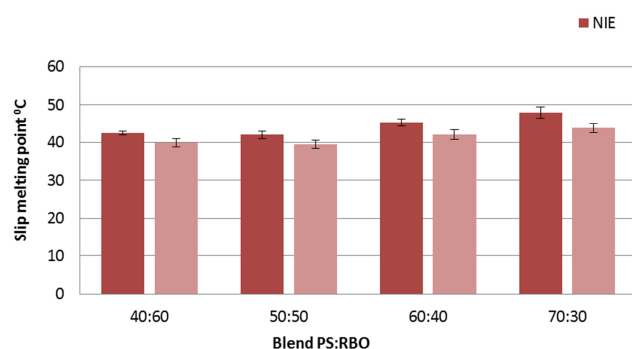


Figure 4. Slip melting points of NIE and CIE blends.

3.6. Comparison Between the Physicochemical Properties of Different Interesterified Blends

Peroxide values of all binary blends were significantly different from non-interesterified blends ($p < 0.05$). Chemically interesterified oil blends have lower peroxide values. Peroxide values of blends (50:50), (60:40) and (70:30) were not detected after the interesterification. Chemical interesterification significantly increases the FFA value of binary blends ($p < 0.05$). There was no difference between the 40:60 interesterified mixture for FFA. SMP of all the non-interesterified blends range within 42°C - 48°C. Chemical interesterification has significantly reduced the SMP of all the four blends. The SMP of the 40:60 and 50:50 interesterified blends were not significantly different ($p < 0.05$).

3.7. SMPs of Margarine Samples

Margarine prepared from non-interesterified blends were ranged from 44°C to 48°C and margarine prepared from interesterified oil blends were fluctuated between 44°C to 48°C. Prepared bakery margarine from interesterified blends has desirable melting properties, especially 50:50 and 60:40 binary blends. Table 6. demonstrates the SMP of different margarine samples. All the margarine samples produced from non-interesterified oil blends were showed oil separation during the storage.

Table 6. Slip melting points of Margarine samples.

Margarine sample		SMP °C
40:60	NIE	48
	CIE	47
50:50	NIE	45
	CIE	44
60:40	NIE	45
	CIE	43
70:30	NIE	44
	CIE	48

3.8. Comparing Existing Market Product with CIE Product

The SMP of the market margarine product and interesterified margarine product were not significantly different ($p < 0.05$). The specific gravity cake dough and cake height of the market margarine cake product and interesterified margarine cake product were not significantly different ($p < 0.05$).

Table 7. Comparing existing market product with CIE product.

Parameters	Existing market product	CIE product
Slip melting point margarine	44°C	45°C
Specific gravity cake dough	0.7483	0.7588
Cake height	4.3 cm	4.3cm

4. Conclusion

Chemical interesterification reduces the iodine value and peroxide value of all four binary blends. However, the CIE process increases the FFA value of all four blends.

Interesterified oil blends show a lower melting point than non-interesterified oil blends. According to the results, chemical interesterification improves the physicochemical properties of rice bran oil and palm stearin blends. The iodine value of all interesterified blends of palm stearin to rice bran oil (40:60, 50:50, 60:40 and 70:30) were not significantly different ($p < 0.05$). Peroxide values of all binary blends were significantly different from non-interesterified blends ($p < 0.05$). Chemically interesterified oil blends have lower peroxide values. Peroxide values of blends (50:50), (60:40) and (70:30) were not detected after the interesterification. Chemical interesterification significantly increases the FFA value of binary blends ($p < 0.05$). There was no difference between the 40:60 interesterified mixture for FFA. SMP of all the non-interesterified blends range within 42°C - 48°C . Chemical interesterification has significantly reduced the SMP of all the four blends. The SMP of the 40:60 and 50:50 interesterified blends were not significantly different ($p < 0.05$). Chemically interesterified fat blends used to produce bakery margarine. Prepared bakery margarine from interesterified blends has desirable melting properties, especially 50:50 and 60:40 binary blends. All the margarine samples produced from non-interesterified oil blends were showed oil separation during the storage.

5. Recommendations

Formation of FFA was resulted by the CIE of oil under the controlled conditions. Selection of quality oil without impurities, manipulation of raw materials and the catalyst [23]. FFA and Fatty acid methyl ester can be removed by deodorization process of oil [16]. Enzymatic interesterification is another option for CIE process. The physical properties of the enzyme interesterification product are quite similar to those of the chemical randomization product. The enzyme used in the industry is 1, 3-specific significantly [24, 25].

Data Availability

All the raw data are available with the corresponding author.

Disclosure

This research was done in Postgraduate Institute of Agriculture, University of Peradeniya, Sri Lanka. This research did not receive specific funding but was performed as part of the employment of the authors.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

Acknowledgements

The authors express their gratitude to the staff members of

the Postgraduate Institute of Agriculture, University of Peradeniya, Sri Lanka for providing comfortable working environment to conduct this research and the great support given throughout this research.

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