Original Research Article

QUALITY CHANGES OF COMMON EDIBLE FRYING OILS DURING FRYING OF TRADITIONAL FOODS

ABSTRACT

The abstract should be shortened to less than 250 words

This study was formulated to examine the impact of the frying process on the physical and chemical properties of widely consumed edible oils. In this research endeavour, soybean, palm, and mustard oils, as well as raw dulpuri and singara products, were procured from the nearby marketplace. The oils underwent five consecutive frying cycles at temperatures exceeding 160°C and were subjected to five hours of heating. The samples underwent physical and chemical analyses subsequent to each cycle. These analyses included the determination of free fatty acid (FFA), peroxide value (PV), saponification value (SV), iodine value (IV), and optical density (OD) at a wavelength of 425 nm. Following multiple rounds of frying and heating, the levels of free fatty acids (FFA), peroxide value (PV), and oxidative stability index (SV) exhibited an increase, whereas the iodine value (IV) demonstrated a decrease across all three types of oils. The optical density (OD) of soybean and palm oils exhibited an upward trend, whereas that of mustard oil initially displayed a decline, followed by a gradual ascent. In comparison to soybean and mustard oils, palm oil exhibited the most noteworthy escalation in FFA, PV, SV, and OD parameters. The levels of free fatty acids (FFA), peroxide value (PV), saponification value (SV), and oxidative stability (OD) in palm oil exhibited an increase from 0.23 to 2.6 mg KOH/g sample, 5.0 to 10.2 m.eq/kg, 195 to 206 mg KOH/g sample, and 0.37 to 0.85, respectively. Conversely, the iodine value (IV) decreased from 51 to 43 g I2/100 g. The results of the sensory evaluation revealed that the palatability of food items fried in palm oil and soybean oil was comparable, with the products fried in mustard oil being ranked lower in terms of acceptability.

Keywords:*Edible oils, frying, physicochemical changes, reuse, stability*

1. INTRODUCTION

Fat frying is a popular cooking method that yields crispy and savory results. Immersion of food in heated oil causes heat and mass transfer between the food, oil, and air [1]. Frying oil serves as a medium for heat transfer and contributes to the texture and flavor of fried dishes. However, fat frying causes chemical reactions that might have an impact on the quality of both the meal and the oil [2]. Deep-fat frying generates a variety of unpleasant flavor compounds, alters the flavor stability and quality, color, and texture of fried foods, and reduces food nutritional quality [3]. Oil hydrolysis, oxidation, and polymerization are all prevalent chemical processes in frying oil that result in volatile or nonvolatile chemicals [4]. The majority of the volatile compounds in oil evaporate with steam into the atmosphere, and the remaining volatile compounds in oil undergo further chemical processes or are absorbed in fried foods [5].[6]. Nonvolatile chemicals have an impact on the flavor stability, quality, and texture of fried meals during storage. Deep-fat frying degrades tocopherols, important amino acids, and fatty acids in meals [7]. Deep-fat frying reactions are affected by elements such as replenishment of fresh oil, frying circumstances, initial quality of frying oil, food components, fryer type, antioxidants, and oxygen [8][9]. The oxidative stability and flavor quality of oil are reduced by high frying temperatures, the number of frying's, and the concentrations of free fatty acids, polyvalent metals, and unsaturated fatty acids [10]. The amount of oil absorbed by foods is influenced by frying time, food surface area, moisture content of food, battering ingredients, and frying oil [11]. The reuse of frying oil is quite hazardous. Oil becomes increasingly prone to oxidation and the production of free radicals as it is used repeatedly [12] [13]. This can result in the development of diseases such as cancer, heart disease, and diabetes [14].

Due to the high cost of frying oil in developing countries such as Bangladesh, it is typical to use it frequently during the production of snacks. This can cause a variety of health issues for the population, such as respiratory infections, skin diseases, and digestive issues [15]. Despite these hazards, many countries lack understanding and regulation surrounding the reuse of frying oil. This underscores the need for additional study and education on the subject, as well as improved regulation and enforcement of safe food preparation and handling practices. To address these concerns, we conducted a study that examined the physicochemical properties of frying oils as well as the changes that occur during different frying cycles. We concentrated on how changes in oil quality affected the sensory and nutritional aspects of the fried treats during numerous frying cycles. This study sought to investigate the effect of frying time and different frying cycles on the quality of edible oils. This study may serve to raise awareness of the dangers of reusing frying oil and the importance of safe and sustainable food preparation practices.

2. MATERIALS AND METHODS

A local market in Mymensing provided refined, bleached, and deodorized soybean, mustard, and palm oils. The ingredients for the frying's, such as dulpuri and singara, were also obtained from the same market.

2.1 Apparatus and equipment used

The experiment was carried out in the Department of Food Technology and Rural Industries laboratory and the Department of Agricultural Chemistry laboratory at Bangladesh Agricultural University in Mymensingh, 2202.

2.2 Chemicals, reagents used

Except for the optical density (OD) test, all chemicals and equipment were borrowed from the laboratory. The Department of Agricultural Chemistry of Agriculture faculty conducted these tests.

2.3 Methods

2.3.1 Frying process

Five Frying cycles were completed using soybean, mustard, and palm oils. The raw material (dalpri, singara) was fried at temperatures more than 160°C. The oil was allowed to cool at the end of each frying trial. Oils were collected and stored in a clean, dark container in the deep freeze until analysis.

2.3.2 Heating process

The heating was done without a sample for five consecutive hours using soybean, mustard, and palm oils. The oil was allowed to cool at the end of each heating experiment. Oils were collected and stored in a clean, dark container in the deep freeze until analysis.

2.3.3 Free Fatty Acid value determination

The free fatty acid content of the samples was measured using the usual technique [16]. The following formula was used to obtain the free fatty acid value:

$$\text{Acid Value} = \frac{\text{Titre} \times \text{Normality of KOH} \times 56.1}{\text{Weight of sample(g)}}$$

2.3.4 Saponification value determination

The saponification value of the samples was assessed using the usual method [16]. The saponification value was obtained using the following formula:

$$\text{Saponification Value} = \frac{(\text{Blank titre} - \text{Sample titre}) \times \text{Normality of KOH} \times 56.1}{\text{Weight of sample(g)}}$$

2.3.4 Iodine value

The saponification value of the samples was assessed using the usual method [16]. The saponification value was obtained using the following formula:

$$\text{Iodin Value} = \frac{(\text{Blank titre} - \text{Sample titre}) \times \text{Normality of Na2S2O3} \times 127 \times 1000}{\text{Weight of sample(g)}}$$

2.3.5 Peroxide value determination

The peroxide value of the samples was evaluated using the usual method [16]. The following formula was used to compute the peroxide value:

$$\text{Iodine Value} = \frac{(\text{Blank titre} - \text{Sample titre}) \times \text{Normality of Na2S2O3} \times 1000}{\text{Weight of sample(g)}}$$

2.3.6 Optical density (OD) value determination

The sample was placed in the spectrophotometer in a clean cuvette. The wavelength of this device was set to 425 nm. The related reading was taken down.

2.3.7 Sensory evaluation of fried product

Food samples (dulpuri, singara) fried at various frying cycles up to 5 frying cycles in soybean, palm, and mustard oil were evaluated by 15 semi-trained panellists on a 9-point hedonic rating scale [17], with panelists chosen from students, teachers, and employees of the Department of Food Technology and Rural Industries, Bangladesh Agricultural University, Mymensingh. The panelists (15) were asked to rate the color, flavor, texture, and overall acceptability on a 1–9-point scale where, 1 = dislike extremely, 2 = dislike very much, 3 = dislike moderately, 4 = dislike slightly, 5 = neither like nor dislike, 6 = like slightly, 7 = like moderately, 8 = like very much and 9 = like extremely.

2.3.8 Statistical analysis

Fischer's LSD multiple comparison test was used to see whether there was a difference between the powders. A single component analysis of variance (ANOVA) was used to determine the significant difference between the acquired data at the 5% level of significance, using the software Microsoft Office Excel'2013 and STATA v15.

3. RESULTS AND DISCUSSIONS

3.1 Physicochemical properties of soybean oil, mustard oil, palm oils

Table 1 shows the baseline values of the physicochemical parameters of soybean oil, mustard oil, and palm oil utilized in experiment fats. All values were found to be within the BSTI range.

Table 1: Physicochemical properties of soybean oil, mustard oil, palm oils

Parameter	Soybean oil	Mustard oil	Palm oil	Quality limit according to BSTI
FFA mg KOH/g fat	0.072	1.4	0.23	0.60(max)
Peroxide value m. eq/kg oil	2.0	0.83	5.0	10max
Iodine value g I_2 /100 g fat	135	101	51	120-141(soybean oil) 96-112(mustard oil) 45-56(palm oil)
Saponification KOH/g fat	192	160	195	189-195(soybean oil) 168-177(mustard oil)

				195-205(palm oil)
OD at 425 nm	0.69	3.75	0.37	

3.2Changes of chemical parameters during frying

3.2.1 The change of peroxide value during frying food

Peroxide value (PV) is used to determine the extent to which rancidity reactions occurred during storage and could be used to predict the quality and stability of fats and oils [19]. Table 2 shows that the PV of the heated oil grew significantly during the frying cycle. The data also show that the PV of palm oil grew substantially throughout the course of the five frying cycles. It increased to 10.2 m.eq/kg oil from the original (5.0 m.eq/kg oil). In comparison to the palm oil, the soybean and mustard oils showed a small difference after 5 frying cycles (table 2). After 5 frying cycles, the PV of soybean and mustard oil increased sequentially from (2.0 m.eq /kg oil) to (5.1 m.eq /kg oil) and from (0.83 m.eq /kg oil) to (1.72 m.eq /kg oil), respectively. The increases in PV value were greater in palm oil than in soybean and mustard oil, possibly due to the larger levels of polyunsaturated fatty acids in palm oil than in soybean and mustard oil. Park et al. (2016) reported a very identical study [20].

Table 2: Changes of physicochemical properties of soybean oil, mustard oil, and palm oils during frying

Parameter	Frying cycle	Soybean oil		Mustard oil		Palm oil	
		Heating with food	Heating without food	Heating with food	Heating without food	Heating with food	Heating without food
FFA (mg KOH/g fat)	0	0.07^a	0.07^a	1.40^a	1.40^a	0.23^a	0.23^a
	1	0.09^a	0.08^a	1.58^b	1.44^a	0.28^a	0.50^b
	2	0.49^b	0.13^a	1.60^b	1.50^b	0.48^b	1.40^c
	3	1.19^c	1.24^b	1.62^b	2.10^c	0.96^c	1.82^d
	4	1.49^d	1.27^b	1.86^c	2.30^d	2.40^d	2.40^e
	5	1.79^e	1.36^c	2.10^d	2.58^e	2.60^e	2.90^f
Peroxide value (m. eq/kg oil)	0	2.0^a	2.0^a	0.83^a	0.83^a	5.0^a	5.0^a
	1	3.50^b	3.0^b	0.92^b	2.72^b	5.60^b	8.0^b
	2	3.90^c	3.50^b	0.94^b	2.19^c	6.0^b	10.20^c
	3	4.0^c	4.60^c	1.06^b	1.83^d	8.40^c	12.0^d
	4	4.8^d	7.20^d	1.24^c	3.20^e	9.80^d	14.60^e
	5	5.1^e	9.0^e	1.72^d	3.60^f	10.20^e	22.10^f
Iodine value (g I_2 /100 g fat)	0	135^a	135^a	101^a	101^a	51^a	51^a
	1	134^a	134.2^a	99^a	101^a	50^a	50^a
	2	131^b	130^b	97^b	101^a	48^b	48.6^b
	3	130^b	129.2^b	97^b	99^a	47^b	47^b
	4	124^c	125.8^c	94.6^c	97.8^b	46^c	45^c
	5	120^c	121.2d	92^c	92^c	43^d	45^c
Saponification value (KOH/g fat)	0	192^a	192^a	160^a	160^a	195^a	195^a
	1	192^a	192.8^a	160^a	161^a	197^a	197^b
	2	194^b	195^b	162^a	161^a	200^b	200^c
	3	195^b	197.6^c	162^a	164.2^b	202^b	202.8^c
	4	195^b	203.8^d	164^b	165.2^b	202^b	204^c
	5	195.05^b	207.6^e	166^c	167^c	206^c	210.2^d
OD at 425 nm	0	0.069^a	0.069^a	1.33^a	1.33^a	0.37^a	0.37^a
	1	0.072^a	0.07^a	0.899^b	0.639^b	0.658^b	0.634^b
	2	0.089^b	0.095^b	0.908^b	0.652^c	0.761^c	0.743^c
	3	0/096^c	1.08^c	0.909^b	0.746^d	0.850^d	0.799^d
	4	0.109^d	1.24^d	0.935^c	0.765^d	0.925^e	0.843^e

	5	0.588^{e}	1.36^{e}	0.995^{d}	0.866^{e}	0.988^{f}	0.953^{f}

Different superscript letters in columns indicate statistical differences ($p<0.05$).

3.2.2 The change of peroxide value during heating oil without food

Table 1 shows that after 5 hours of heating, PV increased significantly in soybean, mustard, and palm oil with increasing time during heating. The results also show that the PV of palm oil grew fast during the continuous 5 h heating, reaching (22.1 m.eq/kg oil) compared to the start time (5.0 meq /kg oil). In comparison to the palm oil, the mustard oil showed a small difference after 5 frying cycles. In the case of soybean and mustard oil, the PV increased sequentially from 2.0 m.eq /kg oil to 9.0 m.eq kg oil after 5 frying cycles and from 0.83 m.eq /kg oil to 3.6 m.eq /kg oil at the end of 5 frying cycles, the change in PV value was high in palm oil compared to soybean and mustard oil, which could be due to higher levels of polyunsaturated fatty acids in palm oil.

Several research [21] [22] have closely monitored the process of oil deterioration during frying and stated that a good quality vegetable oil should have a PV of less than 2 meq/kg. Several research [23][24] have noticed a decrease in PV during frying. Jaswir et al., (2000) [24] discovered an increase in oil PV while frying. The peroxide value alone is insufficient to determine the level of frying oil degradation. An increase in PV during the frying time suggests an increase in peroxide production owing to oxidation. Peroxides, on the other hand, have been observed to be unstable under deep-frying conditions, and when the oil deteriorates, the hydroperoxides breakdown, generating carbonyl and aldehyde molecules, leading the peroxide value to fall [25]. According to Li et al. (2008), hydroperoxides, which are the results of primary oxidation, react to create secondary products, of which aldehydic compounds are detected using the anisidine test.

3.2.3 The change of free fatty acid value during frying food

The loss of oil quality during heating owing to oxidation and hydrolysis is represented by free fatty acids (FFA). Many food processors use free fatty acid (FFA) as a measure of oil degradation. This is due to the method's relative speed and dependability in measuring the acidity of oil during frying [13]. The proportion of fatty acids liberated as a result of hydrolysis and oxidation [13]. The change in acid value of different oils as a result of continuous use in conventional food frying suggests that the FFA of the heated oil increased significantly with the frying cycle for all three types of oil presented in Table 2. The data also show that the FFA of palm oil grew fast during the five frying cycles, reaching (2.6 mg KOH/g of oil) compared to (0.23 mg KOH/g of oil) at the start. When compared to palm oil, the FFA value of soybean and mustard oil increased slowly after 5 frying cycles. In case of soybean and mustard oil, the FFA was increased successively from (0.072 mg KOH/g of oil) to (1.79 mg KOH/g of oil) after 5 frying cycles and from (1.4 mg KOH/g of oil) to (2.1 mg KOH/g oil) at the end of 5 frying cycle, the change of FFA value was high in palm oil compared to soybean and mustard oil, although the initial value of FFA of mustard oil is high (1.4 mg KOH/g of oil), the change of FFA value is lowest among three types of oil. The findings were consistent with the findings of Debnath et al. (2012).

3.2.4 The change of free fatty acid value during heating without food

The change in free fatty acid value (FFA) of different oils as a result of continuous heating up to 5 h indicates that the FFA of the heated oil increased dramatically with heating duration, as indicated in Table 2. The data also show that the FFA of palm oil grew fast over five frying cycles, reaching (2.9 mg KOH/g of oil) after 5 h heating from 0.23 mg KOH/g of oil. In contrast to palm oil, soybean and mustard oils showed a gradual increase in FFA value after 5 hours of heating. After 5 hours of heating, the FFA in soybean and mustard oil was increased from 0.072 mg KOH/g of oil) to (1.36 mg KOH/g of oil) and from (14 mg KOH/g of oil) to (2.58 mg KOH/g oil). Although the baseline value of FFA in mustard oil was high (1.4 mg KOH/g of oil), the change in FFA value was the lowest among the three types of oil after 5 hours of heating.

The free fatty acid concentration, which results from the hydrolysis of triacylglycerol as well as the subsequent degradation of hydro-peroxides, is one of the most important indicators of oil deterioration during heating. During frying, the oil is continually and repeatedly used at elevated temperatures (160-180°C) in the presence of air and moisture [25]. Under frying temperatures, the released fatty acids are more vulnerable to thermal oxidation. The oxidized products of fatty acids provide off-flavors and odors (hydrolytic rancidity) to the frying medium and fried foods [26].

3.2.5 The change of Iodine value during frying food

The iodine value (IV) of a fat or vegetable oil indicates its degree of unsaturation. It assesses the oxidation stability of oils and allows for qualitative determination of the fat's total unsaturation [23]. The change in free Iodine value (IV) of different oils as a result of continuous usage in conventional food frying results demonstrate that the IV of the heated oil reduced dramatically with the frying cycle for all types of oil, as indicated in Table 2. The results also show that the IV of soybean oil fell significantly over the five-trying cycle, reaching (120 g I2/100 g fat) compared to the start period (135g I2/100 g fat). In contrast to soybean oil, palm and mustard oils showed a modest decline in iodine value during a 5-hour frying cycle. After 5 frying cycles, the IV of palm and mustard oil was reduced from (51 g I2/100 g fat) to (43 g I2/100 g fat) and from (101 g I2/100 g fat) to (92 g I2/100 g fat). The rate of change of Iodine value (3.028) at the end of the 5 h frying cycle was higher in soybean oil than in palm and mustard oil.

3.2.6 The change of Iodine value during heating without food

As shown in Table 2, the change in free Iodine value (IV) of different oils as a result of frequent use in 5 h heating indicated that IV of the heated oil was dramatically decreased with heating time for all types of oil. The results also show that the IV of soybean oil declined significantly during the five-hour heating period, with a final value of (121.2 g I2/100 g fat) compared to the initial value of (135 g I2/100 g fat). In contrast to soybean oil, palm and mustard oils showed a modest reduction in iodine value after 5 hours of heating. When compared to palm and mustard oil, the rate of change of Iodine value (2.714) was high in soybean oil.

3.2.7 The change of saponification value during frying food

The change in free saponification value (SV) of different oils as a result of continuous use in conventional food frying revealed that the SV of the heated oil grew dramatically with the frying cycle, as shown in Table 2. The results also showed that the SV of palm oil grew fast over the five frying cycles, reaching (206 mg KOH/g of oil) compared to the start time (195 mg KOH/g of oil). In contrast to palm oil, soybean and mustard oils showed a gradual increase in saponification value after 5 frying cycles. Although the initial value of SV of soybean oil is high (192 mg KOH/g of oil), the rate of change of SV value of soybean oil is lowest (0. The ranges were comparable to those found in earlier research [27].

3.2.8 The change of saponification value during heating without food

Table 1 shows the change in saponification value (SV) of different oils as a result of numerous 5 h heating results, which revealed that the SV of the heated oil increased dramatically with heating duration. The results also showed that the SV of palm oil grew fast over the course of five hours of heating, reaching (210 mg KOH/g of oil) compared to the start time (195 mg KOH/g of oil). In comparison to the palm oil, the mustard oil showed a gradual increase in saponification value after 5 hours of heating. The pace of increase of SV followed the rate of increase of palm oil. In the case of soybean and mustard oil, the SV was increased sequentially from (192 mg KOH/g of oil) to (207 mg KOH/g of oil) after 5 h heating and from (160 mg KOH/g of oil) to (167 mg KOH/g oil) at the end of 5 h heating, but the rate of change of saponification value (3.16) was higher in palm oil than mustard oil. The saponification value (SV) is a measure of the average molecular mass of the fatty acid in an oil sample. For the oil samples, the SV value was 192 mg KOH/g for soybean oil and 160 mg KOH/g for mustard oil. The readings are within the range of what is expected for oil [27]. The lower the saponification value, the smaller the mean molecular weight of fatty acids or the number of ester linkages. This could mean that the fat molecules did not interact.

3.2.9 The change of optical density during frying food

Table 2 shows the change in optical density (OD) at 425 nm of different oils as a result of repeated five-cycle frying. The changes in optical density (OD) of soybean, mustard, and palm oil as a result of frequent heating (soybean oil from 0.069 in the control sample to 0.588 after the fifth frying cycle). Mustard oil, which decreased from 1.33 in the control sample to 0.955 following the fifth frying cycle. The palm oil concentration increased from 0.370 in the control sample to 0.988 following the fifth frying cycle.

3.2.10 The change of optical density during frying without food

Table 2 depicts the changes in optical density (OD) of soybean, mustard, and palm oil caused by frequent heating. The OD value of soybean oil increased from 0.069 to 1.36 after 5 hours of heating. It ranged from 1.33 to 0.866 for mustard oil and 0.370 to 0.953 for palm oil after 5 hours of heating.

3.2.11 Influence of frying time on the color of the oils during continuous heating

The results of the influence of frying time on the color of the oils evaluated as OD at 425 nm, on the other hand, reveal increased absorbance with increasing frying time in the case of soybean and palm oil. In the case of mustard oil, however, the OD value decreased from the beginning and gradually climbed. The OD value grew from 0.370 to 0.988 during the frying cycle and from 0.370 to 0.953 after continuous heating of palm oil, showing that palm oil undergoes more color change than soybean oil (the OD value increased from 0.069 to 0.588 during the frying cycle). The investigator reported a rise in color during oil frying and indicated that measuring oil color could not be utilized to monitor oil quality due to the likelihood of food components interacting with oil during frying. All of the samples' absorbance spectra were obtained, and the absorbance at 425 nm was reported. The absorbance increased from new oil to discarded oil, which matched well with Thakkar et al.[28] prior discovery of oil darkening/reddening as a function of frying duration.

3.3 Sensory evaluation

A panel of ten judges evaluated the product (dal puri, singara) after it had been cooked up to five times in three different types of oil (soybean, palm, and mustard). Table 3 shows the mean scores for color, flavor, texture, taste, and overall acceptability.

Table 3Mean score for color, flavor,texture,taste,and overall acceptability of five times frying food.

Sample	Overall acceptability	flavor	texture	color	Taste
SS-1	8.6^{a}	8.6^{a}	8.5^{a}	8.4^{a}	8.6^{a}
SS-2	8.4^{a}	8.2^{ab}	8.2^{a}	8.3^{a}	8.5^{a}
SS-3	8.0^{b}	7.9^{b}	7.7^{b}	7.9^{b}	7.8^{b}

SS-1= product fried in soybean oil, SS-2=product fried in palm oil, SS-3=product fried in mustard oil. Different superscript letters in columns indicate statistical differences ($p<0.05$).

There was no significant difference across the samples in terms of colour choice. As a result, these colour samples are equally accepted. There was a significant (p0.05) difference between the samples in terms of flavour preference. The SS-1 sample fried in soybean oil received the highest score (8.6). Sample SS-2, with a score of 8.2, was similarly acceptable as sample SS-1, and it was followed by SS-1 (Score 8.6). Sample SS-3 had the lowest rating (7.9).

In terms of texture preference, there was no significant (p0.05) difference between samples SS-1 and SS-2. The SS-3 sample received the highest score (7.7). In terms of taste preference, there was no significant (p0.05) difference between samples SS-1 and SS-2. The sample SS-3 received the lowest score (7.8), while the sample SS-1 received the highest (8.6). There was no significant (p0.05) difference in overall acceptability between the samples SS-1 and SS-2. The samples SS-1 and SS-2 were found to be the best products, with mean scores of 8.6 and 8.4 respectively, and SS-1 and SS-2 were most equally acceptable and could be ranked as liked very much. As a result, it is established that frying foods in various oils has no effect on their sensory attributes, and the difference between them is quite modest.

4. CONCLUSION

Cooking and heating edible oils repeatedly can cause major physicochemical changes that impact their quality and stability. Soybean and mustard oils were more stable than palm oil, but all three oils had lower IV and higher FFA, PV, and SV values. These findings emphasise the significance of selecting and monitoring frying oils carefully to maintain food safety and quality. We can design more effective measures to ensure the safety and quality of the food we eat if we understand the impact of frying oil reuse on both the oil and the item being fried.

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