BIOLOGY, MEDICINE, & NATURAL PRODUCT CHEMISTRY
Volume 14, Number 2, October 2025 | Pages: 1599-1605 | DOI: 10.14421/biomedich.2025.142.1599-1605
ISSN 2089-6514 (paper)
ISSN 2540-9328 (online)

Effect of Repeated Frying of Potato Chips on Physiochemical Properties of Different Frying Oils and Its Sensory Evaluation

Rabin Poudel, Bishal Thagunna, Bishal Bhattrai, Sushan Subedi, Nishal Baral
Department of Food Technology, Tribhuvan University, Pokhara, Kaski, Nepal.

Corresponding author*
bisu.thaguna123@gmail.com

Manuscript received: 15 September, 2025. Revision accepted: 26 January, 2026. Published: 02 February, 2026.

Abstract

Deep frying involves submerging food in heated oil at about 180°C. Throughout the deep-frying process, various chemical reactions occur, leading to alterations in the physicochemical characteristics of the oil, which can ultimately have detrimental health impacts on consumers. Nevertheless, for reasons of economic efficiency, both home and industrial users frequently reuse cooking oils for deep frying. Consequently, this research aimed to evaluate the physicochemical and nutritional properties of commercially available mustard oil, sunflower oil, soybean oil, and palm oil, in addition to investigating how the repeated deep frying of potato tubers affects the physicochemical and nutritional qualities of the analyzed oil samples. Consequently, the ideal amount of frying cycles for every type of oil was explored. To accomplish this, potato was fried individually using coconut, palm, and sunflower oils over four successive frying cycles. Results revealed that increasing the frying counts resulted in increased peroxide value, acid value, viscosity and refractive index, whereas decrease in moisture, iodine value and DPPH value of four oil samples. The peroxide value (PV) and acid value of mustard oil, sunflower oil, soybean oil, and palm oil showed increases ranging from 1.82 to 7.98 meq/Kg, 5.19 to 11.69 meq/kg, 4.81 to 9.89 meq/kg, and 2.49 to 11.08 meq/kg respectively, with acid values shifting from 1.24 to 6.74 mg KOH/g, 0.17 to 0.49 mg KOH/g, 0.25 to 0.42 mg KOH/g, and 0.80 to 2.86 mg KOH/g. The viscosity increased from 183.33 to 615.09 mPA s, 51.66 to 405.49 mPA s, 165.57 to 590.17 mPA s, and 376.42 to 711.43 mPA s of mustard oil, sunflower oil, soybean and palm oil respectively, while the refractive index increased from 1.4654 to 1.4672, 1.4668 to 1.4710, 1.467 to 1.4722, and 1.4552 to 1.4610 of mustard, sunflower, soybean and palm oil respectively. In contrast, there was a reduction in moisture content, iodine value, and DPPH value for mustard, sunflower, soybean, and palm oil, ranging from 0.16-0.06%, 0.09-0.03%, 0.11-0.04%, and 0.21-0.09%, respectively. The findings indicate that the iodine values decreased from 106.2-88.6 g, 126.2-106.5 g, 129.4-108.4 g, and 54.3-31.82 g, respectively. The DPPH values of oil samples were 63.25%, 72.08%, 82.55%, and 78.18%, respectively. Following the fourth frying cycle, these values dropped to 47.85%, 53.79%, 79.62%, and 69.58%. Higher sensory scores regarding overall acceptability were obtained by chips fried in palm oil and lower by mustard oil.

Keywords: Cooking oil; frying; iodine value; refractive index; DPPH.

INTRODUCTION

Vegetable oil plays a crucial role in various food preparation methods, particularly frying (Diop et al., 2014). Alterations occur in the oil's physical, chemical, nutritional, and sensory attributes, influencing its effectiveness during frying (Boskou et al., 2006). The most widely consumed fried foods are French fries and potato chips. The quality characteristics relevant to fried potatoes can be categorized into physical and chemical properties, as well as fat content, water content, and several other attributes (Pedreschi et al., 2004). Deep frying foods enhances their sensory qualities, resulting in a crispy texture, flavorful juiciness, and a golden-brown appearance (Kim et al., 2010). Nevertheless, there have also been reports of adverse effects of frying on food. The repeated use of frying oil speeds up its degradation, which can directly impact the quality of the fried items, leading to the formation of substances that are both organoleptically undesirable and potentially harmful (Choe et al., 2006). The key quality parameters for fried potatoes are categorized into physical and chemical properties, fat content, water content, and several other attributes (Pedreschi et al., 2004). Oils can experience chemical transformations due to their chemical composition, influenced by numerous factors, which may render them detrimental to health. These factors include temperature, light, airflow, metallic ions, and enzymatic activity. They can operate individually or synergistically, leading to phenomena known as autoxidation, thermal polymerization, and oxidation in oils. Owing to a cascade of reactions in these processes, a variety of byproducts can form, or fats may become rancid (Allam et al., 2002). Reusing fried oil can have a direct impact on the quality of fried foods due to the creation of harmful compounds that excessively degrade both sensory quality and speed up the deterioration of fats (Choe et al., 2007).

Potato chips rank as the most favored snack among different types of fried foods. While raw potatoes contain approximately 0.1% oil, the oil content in potato chips exceeds 20%, primarily derived from the oil used for frying (USDA, 2016). Research has documented the physicochemical properties of frying oils and the resulting characteristics of potato chips after they undergo deep-fat frying. Earlier studies examining the impact of repeatedly used frying oils on potato chips have generally concentrated on the oil levels and the physicochemical attributes of the chips (Granda et al., 2004; Karakaya et al., 2011). The objective of this study was to evaluate chemical characteristics of potato chips fried in repeatedly used oils and oils extracted from the fried potato chips. Refined sunflower oil, refined soybean oil, and mustard oil which have been generally used as frying oils, were used for the test.

MATERIALS AND METHODS

Raw materials

Sunflower, mustard, soybean and palm oil and fresh potatoes were purchased from the local markets of Pokhara, Nepal.

Sample preparation

In this study Fresh potato tubers (all from the same producer, geographical region and harvesting period) were used to prepare chips. Potatoes were washed, peeled and cut into pieces (approx. 5cm) and were fried immediately in the frying oil at temperature(180°C±5). Ten batches of potatoes were fried, one batch at a time in the same oil, successively in sunflower oil, palm oil, soybean oil, mustard oils by deep-frying. The cooking oil was allowed to cool for 30 minutes before sampling. A stainless-steel Sause pan, was used for the deep-frying process. The deep fryer was filled with 1-liter oil, and 200g potatoes were deep fried for 10 min each time without topping up the oil. Same ratio of 1:5 was used for frying in each frying. The fried potato tubers were further packed and sealed in polyethylene bag and kept -20° C for further analysis.

Physiochemical analysis

Determination of moisture, acid value, iodine value, viscosity, refractive index and peroxide value were determined as per the (AOAC, 2005)

Analysis of DPPH radical scavenging activity

The total antioxidant activity (TAA) of the oils was assessed through their capacity to scavenge free radicals, utilizing the 2,2-diphenyl-1-picrylhydrazyl radical (DPPH) as outlined by Brand-Williams et al. In summary, 50 µ of oil was combined with 950 µ of a methanol solution of DPPH at a concentration of 0.030 mg/ml. The resulting mixture was shaken vigorously and allowed to sit in the dark for 5 minutes. Finally, the absorbance of the mixture was recorded against methanol (serving as a blank) at a wavelength of 515 nm using a Cary 50 Scan UV–visible Spectrophotometer. The DPPH scavenging activity was represented as the percentage of inhibition of the DPPH free radicals.

$$\text{hibition}(\%) = \left(1 - \left(\frac{\text{A sample}}{\text{A blank}}\right)\right) * 10$$

Where, A sample is absorbance of the sample, A blank is absorbance of the DPPH (Fadzlina *et al.*, 2018).

Analysis of color

Oil samples were placed in a standard disposable cuvette and scanned from a wavelength of 490 nm using a UV–visible spectrophotometer. The absorbance of the spectrophotometer was adjusted to zero against air. Initially, the oils were scanned across a wavelength range from 350 to 650 nm, after which the individual absorbance values for each frying oil were recorded at 490 nm. The absorbance data at 490 nm were selected for determining TPCs because, as noted by Yin et al. (2011), a strong correlation exists between absorbance values at 490 nm and TPCs.

Sensory analysis

9-point hedonic test was chosen for sensory evaluation. For this purpose, 10 people were selected in the taste test. In order to determine the sensory properties of chips samples, 10 semi-educated panelists were asked to specify numerical values. Color, flavor, taste, texture, and overall accept- ability were examined and panelists were asked to evaluate the samples separately for each.

Statistical analysis

All the experiments were performed in triplicate. The result was evulated by using analysis of variance(One-way ANOVA) by using statistical software SPSS version 20 at 5% level of significance.

RESULTS AND DISCUSSION

Table 1. Changes in phyisochemical properties of oils after repeated frying.

Oils used	Parameters	Before frying	1st frying	2nd frying	3rd frying	4th frying
Mustard	Peroxide value (meq/kg)	1.82±0.02	2.08±0.05	4.23±0.06	06.48±0.07	7.98±0.05
	Acid value mg KOH/g	1.24±0.02	2.31±0.03	3.82±0.05	5.08±0.08	6.74±0.04
	Color	0.322±0.03	0.33±0.02	0.357±0.03	0.408±0.03	0.471±0.04
	Moisture content %	0.16±0.01	0.13±0.01	0.09±0.01	0.07±0.01	0.06±0.01
	Iodine value (g/100g)	106.2±2.20	102.4±3.36	97.10±2.25	92.20±2.20	88.60±1.22
	Refrective index	1.4654±0.01	1.4659±0.01	1.4662±0.01	1.4666±0.01	1.4672±0.01
	Viscosity (mPA s)	183.33±3.35	280.59±2.58	394.48±4.45	495.64±3.88	615.09±4.25
	DPPH %	63.25±1.15	58.46±1.55	55.05±1.25	51.69±1.11	47.85±1.10
Sunflower	Peroxide value (meq/kg)	5.19±0.02	6.86±0.06	7.75±0.08	9.91±0.02	11.69±1.10
	Acid value mg KOH/g	0.17±0.01	0.24±0.02	0.33±0.02	0.40±0.02	0.49±0.02
	Color	0.007±0.01	0.025±0.01	0.037±0.02	0.053±0.01	0.073±0.01
	Moisture content %	0.09±0.01	0.07±0.01	0.05±0.01	0.05±0.01	0.03±0.01
	Iodine value (g/100g)	126.20±2.22	122.60±3.58	117.80±2.22	112.10±3.15	106.50±2.55
	Refrective index	1.4668±0.01	1.4671±0.01	1.4682±0.01	1.4695±0.01	1.4710±0.01
	Viscosity (mPA s)	51.667±2.25	126.76±3.58	208.92±4.10	302.57±4.10	405.49±5.45
	DPPH %	72.08±2.55	67.28±3.12	62.34±2.12	58.06±3.15	53.79±2.25
Soyabean	Peroxide value (meq/kg)	4.81±0.02	5.47±0.04	6.98±0.03	8.12±0.08	9.89±0.08
	Acid value mg KOH/g	0.25±0.02	0.31±0.02	0.37±0.02	0.39±0.02	0.42±0.02
	Color	0.041±0.01	0.098±0.01	0.130±0.04	0.170±0.02	0.190±0.02
	Moisture content %	0.11±0.02	0.08±0.01	0.06±0.01	0.05±0.01	0.04±0.01
	Iodine value (g/100g)	129.40±2.25	125.20±3.15	119.50±1.15	115.10±3.33	108.40±2.25
	Refrective index	1.4670±0.01	1.4678±0.01	1.4685±0.01	1.4692±0.01	1.4722±0.01
	Viscosity (mPA s)	165.57±3.15	256.81±3.12	377.32±3.30	482.54±2.30	590.17±3.30
	DPPH %	82.55±2.25	82.36±2.0	81.08±2.20	80.51±2.22	79.62±2.22
Palm	Peroxide value (meq/kg)	2.49±0.02	4.68±0.07	6.13±0.08	9.34±0.09	11.08±0.09
	Acid value mg KOH/g	0.80±0.03	1.13±0.06	1.98±0.01	2.08±0.03	2.86±0.04
	Color	0.015±0.01	0.038±0.03	0.077±0.01	0.170±0.02	0.263±0.02
	Moisture content %	0.21±0.01	0.16±0.02	0.13±0.02	0.10±0.01	0.09±0.02
	Iodine value (g/100g)	54.30±2.22	50.10±1.10	45.40±1.12	38.50±1.10	31.82±1.10
	Refrective index	1.4552±0.01	1.4568±0.01	1.4579±0.01	1.4588±0.01	1.4610±0.01
	Viscosity (mPA s)	376.42±2.20	436.81±2.230	512.14±3.33	608.21±2.30	711.43±3.95
	DPPH %	78.18±1.15	76.31±2.24	73.96±2.20	71.07±2.22	69.58±2.10

Values are means ± standard deviation of triplicate analysis.

Changes in the peroxide value of oils after repeated frying

The peroxide value effectively indicates rancidity processes that take place in oils over time during storage, serving as an indicator of the quality and stability of fats and oils. This is linked to monitoring the generation of peroxides that occur in the initial phases of oxidation (Habarakada et al., 2021). Moreover, the peroxide value was found to be increased with the storage time, temperature, and level of contact with air. Thus, the variation of peroxide value of sunflower, mustard, soybean and palm oil used for deep frying of potato and fish for four consecutive frying cycles were examined, and the obtained results are shown in **Table 1**. The results reveal that the PV of mustard oil, sunflower oil, soybean oil and palm oil were increased from 1.82 to 7.98 meq/Kg, 5.19 to 11.69 meq/kg, 4.81 to 9.89 meq/kg and 2.49 to 11.08 meq/kg respectively after potato was fried for four times (Table 1). The suggested peroxide value limits for quality edible oils are below 3 meq/kg when the oil exits the processing facility, under 5 meq/kg once the bottles are opened, and less than 10 meq/kg during use. Therefore, peroxide values exceeding 10 meq/kg suggest that the oil is inappropriate for cooking (Sebastian et al., 2014). According to the results gathered, the peroxide value for each of the four types of oil was observed to be marginally above the standard threshold of 5 meq/kg. This increase may be attributed to inadequate storage and packaging, which can result in the breakdown of fatty acids through photo-oxidation. Based on the findings, the peroxide value of all four types of oils examined in this study rose with an increase in the number of frying cycles, with a notably higher increase when potato was used as the frying material. The recorded rise in peroxide value aligns with the findings reported by Omara et al. (2019), Acquah et al. (2016), Xu et al. (2015), as well as Habarakada et al. (2021). In contrast, mustard oil proven to be use for three cycles with potatoes when compared to other oils. This could be attributed to the instability of polyunsaturated fatty acids when exposed to elevated temperatures, which leads to their increased reactivity with oxygen to produce peroxides (Serjouie et al., 2010).

Variation in acid value of oils during repeated frying

The acid value indicates how many milligrams of KOH are needed to neutralize the free fatty acids present in one gram of oil, providing insight into the oil's acidity during frying (Habarakada et al., 2021). In this context, during the current study acid value of all four-oil using potato as the frying material and the obtained results were summarized in **Table 1**. As per the guidelines established by the Codex Alimentarius Commission, the acid value of purified oil that is fit for human consumption is 0.6 mg KOH/kg (Wolke, 2007). The results show that the acid value of mustard oil, sunflower oil, soybean oil and palm oil were increased from 1.24 to 6.74 mg KOH/g, 0.17- 0.49 mg KOH/g, 0.25 to 0.42 mg KOH/g, and 0.80 to 2.86 mg KOH/g respectively in potato fried oil. In addition, as indicated in Table 2, the acid values for all four types of oils were observed to rise with an increasing number of frying cycles. This increase can primarily be attributed to the generation of carbonyl compounds and low molecular weight free fatty acids, which are produced as a result of oxidation and the breaking of double bonds during deep frying. Additionally, the moisture released from the fried food tends to speed up the hydrolysis of triglycerides, leading to the formation of mono and diglycerides, free fatty acids, and glycerol. These findings align with those reported by Acquah et al. (2016) and Debnath et al. (2009).

Variation of color of oil during repeated frying

Color is considered to be a good visual indicator to determine the quality of frying oil. There was significant increase in spectrophotometric absorbance readings for each frying oil (mustard oil, soybean oil, sunflower oil, palm oil) as the frying cycle proceeds as shown in **Table 1**. Less absorbance 0.007 was shown by sunflower initially (0 frying) and less absorbance 0.073 was shown by sunflower after 4th frying cycle whereas high absorbance 0.322 was shown by mustard oil at initial (0 frying) and 4th frying 0.471 absorbance. Similar study was conducted by Karakaya and Simsek (2011) where initial absorbance was 0.971 and further goes on increasing above 1.51 with increase in frying times. As per (Serjouie et al., 2010), study, frying was done in palm olein, sesame oil, canola oil and their blends, result shows that changes in color for all frying oils were observed in five consecutive days of the frying process. When deep frying, the oil's color darkens because of the creation of pigments like non-volatile decomposition products and α- and β-carbonyl compounds generated through the oxidation and breakdown of fatty acids (Nayak et al., 2015).

Change in the moisture content during repeated frying

The change of moisture content of mustard oil, sunflower oil, soybean and palm oil with repeated fried potato were shown in **Table 1**. According to the findings, the moisture content diminished with each cycle of frying across all four types of oil. A notable difference ($p<0.05$) was observed between the moisture levels of the fresh oil samples and those of the fried oil samples at each frying frequency. The decrease in moisture content in the oil with increased frying frequency could be attributed to the evaporation of moisture from both the food and the oil into the surrounding atmosphere during the heat transfer process. There was rapid decrease in moisture content of sunflower and soybeans oil in comparison to mustard and palm oil with increase in frying cycle. Moisture loss is directly proportional to the amount of oil uptake by potato chips. This may be due to mass transfer including water loss, oil absorption and heat transfer (Vitrac et al., 2002). In a study by (Yadav et al., 2023), result showed that fried in groundnut oil, had the maximum moisture content, while lowest on canola oil. The water content in food and oil accelerates the hydrolysis of the oil and also provides a protection against oxidation of the oil during frying (Dana et al., 2003).

Changes in the iodine value of oils during repeated frying

Iodine value (IV) quantifies the level of unsaturation in a fat or vegetable oil. It assesses the oils' stability against oxidation and provides a qualitative measure of the fat's overall unsaturation (AOCS, 1993; Asuquo et al., 2012). In this context, during the current study iodine value of all four-oil using potato as the frying material and the obtained results were summarized in **Table 1**. The results reveal that the iodine value of mustard oil, sunflower oil, soybean oil and palm oil were decreased from 106.2-88.6 g, 126.2-106.5 g, 129.4-108.4 g, and 54.3- 31.82 g respectively. Frying causes a reduction in the unsaturation levels of all kinds of oil; this reduction in iodine value (IV) arises from intricate physio-chemical transformations and signifies a diminished oxidation rate (Lalam et al., 2013). The iodide values (IVs) of all oil samples that were exposed to air and to air–light showed no significant changes, while deep frying significantly lowered the IVs (Naz et al., 2005).

Changes in the refractive index of oils during repeated frying

Table 1 shows the changes in refractive index of different types of oils (mustard, sunflower, soybean and palm oil) after four cycle frying. The refractive index of all four oils (mustard, sunflower, soybean and palm oil) samples increased from 1.4654 to 1.4672, 1.4668-1.4710, 1.467-1.4722, and 1.4552-1.4610 respectively after four cycles of frying. the refractive index of sunflower and soybean increases rapidly in comparisons to mustard and palm oil. It was due to the increase in the levels of conjugated fatty acids as a result of thermal degradation during the frying process. The increase in the number of conjugated acids also conveys an increase in the level of autoxidation. The refractive index during heating of oil increases as more conjugated acids are formed (Chakrabarty, 2003).

Changes in oils viscosity after repeated frying

Viscosity serves as one of the parameters for assessing the physical transformations in edible oils. It is influenced by factors such as density, molecular weight, melting point, level of unsaturation, and temperature (Sharova and Ramadan 2012). The viscosity rises during hydrogenation due to the elongation of the tri-glyceride fatty acid chain, while it decreases when fatty acids become more unsaturated (Santos et al. 2004). The **Table 1** also shows that the repeated frying of oil samples (mustard, sunflower, soybean and palm oil) increases in viscosity from 183.33-615.09 mPA s, 51.66-405.49 mPA s, 165.57-590.17 mPA s, and 376.42-711.43 mPA s respectively. Samah and Fyka (2002), also supported that viscosity is significantly influenced by elevated temperatures, air exposure, and an increase in the number of frying cycles, which promotes the development of oxidative and polymeric compounds and heightens the likelihood of foaming during frying. During the frying process (Samah and Fyka, 2002; Tarmizi et al. 2013) found that the viscosity of oil showed a notable increase in both vacuum and atmospheric drainage after two days of frying, changing from 45.48 to 54.12 and 55.97 mPa·s, respectively.

Changes in DPPH of oils after repeated frying

The levels of antioxidants found in an oil are important determinants of its oxidative stability, in addition to its fatty acid composition (Aladedunye et al., 2009). Changes in DPPH in the frying oils used repeatedly are shown in **Table 1**. At the start (0 frying), the DPPH values for mustard, sunflower, soybean, and palm oil were 63.25, 72.08, 82.55, and 78.18%, respectively. After the fourth cycle of frying, these values decreased to 47.85, 53.79, 79.62, and 69.58%. Lowest DPPH value was found to be of mustard and highest DPPH value was found to be of soybean. In our study, there was significantly difference ($p \leq 0.05$) in DPPH values among the samples. There is decrease in DPPH value with increase in frying times. The interaction between the samples and the frying times was found to be significantly difference ($p \leq 0.05$). The antioxidant activity was found to be high in palm oil, while mustard oil showed a significant reduction in DPPH value, leading us to conclude that soybean oil is preferable for deep frying in terms of DPPH. Compared to mustard oil, sunflower oil, and palm oil, soybean oil retains antioxidant activity more effectively. The antioxidant capacity of palm oil decreased when subjected to deep-frying, likely due to the degradation of bioactive compounds from the high temperatures involved in the frying process. These findings are consistent with those of a previous study by Hamid et al. (2014).

Sensory evaluation

The average sensory ratings for color were recorded as (6.0, 6.5, 7.0, and 7.5) for four distinct samples (A, B, C, and D). A noted darkening of color occurred in sunflower, soybean, and palm oils, which is attributed to pigments formed during the oxidation and thermal breakdown of fatty acids that leach into the oil during frying. Furthermore, carotenoid remnants may also contribute to the change in color (Nayak et al., 2016). In contrast, mustard oil displayed the most vibrant yellow coloration among all the frying oil variants. A similar observation was made by Ravi et al. (2005), where sensory assessment reflected a reduction in the yellow color rating of mustard oil and its combination with soybean after several frying sessions. The average sensory ratings for flavor were recorded as (6.0, 5.5, 6.5, and 8.0) for the four samples (A, B, C, and D). In a study by Bakhtiary et al. in 2014, potatoes fried in palm olein received the top ratings for flavor. Additionally, they discovered that potatoes cooked in blended oils significantly outperformed those prepared in sesame oil. The average sensory ratings for taste were recorded as (5.0, 6.0, 6.5, and 8.0) for four samples (A, B, C, and D). According to the research by Kim et al., 2009, frying treatments lasting 2 minutes and 30 seconds yielded the highest crispness values for the french fries. The average sensory ratings for texture were recorded as (5.5, 6.0, 7.0, and 7.5) for four samples (A, B, C, and D). A study conducted by Bakhtiary et al. in 2014 indicated that fried potatoes in sesame oil received the lowest sensory scores for texture, whereas blended oils achieved the highest texture scores. In research by Mishra and Bhattacharjee, 2014, sample B3, which was a blend of mustard, sunflower, and sesame oil, resulted in crispier fried potato wedges compared to those made with other oil combinations. The average sensory ratings for overall acceptability were recorded as (6.0, 6.0, 7.5, and 8.0) for the four samples (A, B, C, and D).

CONCLUSION

Fried foods enjoy widespread popularity across the globe, with their annual consumption on the rise. Nonetheless, the continual use of frying oils results in alterations to their quality, highlighting the importance of managing deep-frying fats and oils. This research evaluated the physicochemical and sensory characteristics of potato chips fried in various oils before and after the first, second, third, and fourth frying sessions. The primary observations indicated that peroxide value, acid value, color, refractive index, and viscosity rose after every frying session, whereas the moisture content, viscosity, and DPPH value diminished. Sensory assessment, which included aspects like color, flavor, taste, texture, and general acceptability, suggested that potato chips cooked in palm oil achieved marginally better acceptance ratings. In summary, effectively managing frying practices, which includes choosing appropriate oils and tracking frying cycles, is crucial for producing safe and high-quality potato chips. Keeping records of safe and healthy oils, monitoring changes in frying oil, and restricting the number of frying cycles according to universal standards are essential. This study emphasizes the significance of complying with food safety regulations and upholding quality control to guarantee consumer health and satisfaction.

Competing Interests: The authors declare that there are no competing interests.

REFERENCES

Acquah, N.I., Obeng, G.Y. and Mensah, E. (2016). Repetitive use of vegetable oil and effects on physico-chemical properties – Case of frying with redfish (Lutjanus fulgens). Science and Technology, 6(1), 8-14. https://doi.org/10.5923/j.scit.20160601.02

Aladedunye FA, Przybylski R. Degradation and nutritional quality changes of oil during frying. J. Am. Oil Chem. Soc. 86: 149–156 (2009).

Allam, S.S.M.; Mohamed, H.M.A. Thermal stability of some commercial natural and synthetic antioxidants and their mixtures. J. Food Lipids 9, 277-293（2002）

A.O.A.C., 2005. Official Methods of Association of Agricultural Chemicals, 18 edn. Washington: AOAC.

AOCS., 1993. Official Methods and Recommended Practice of the American oil Chemist Society, 5th edition. Champaign.

Asuquo, J. E., Anusiem, A. C. I., Etim, E. E., 2012. Extraction and Characterization of Rubber Seed Oil International J of modern Chem. 1(3), 109-115.

Bakhtiary, D., Asadollahi, S., & Ardakani, S. A. Y. (2014). Sensory qualities of sesame oil, palm olein and the blend of them during frying of potato chips. *International Juornal of Farming and Allied Sciences*, *3*(7), 786-790.

Boskou, G.; Salta, F.N.; Chiou, A.; Troullidou, E.; Andrikopoulos, N.K. Content of trans, trans-2, 4-decadi- enal in deep-fried and pan-fried potatoes. Eur. J. Lip- id Sci. Technol. 108, 109-115（2006).

Choe, E.; Min, D.B. Chemistry of deep-fat frying oils. J. Food Sci. 72（5）,77-86（2007）

C. Granda, R.G. Moreira, S.E. Tichy, J. Food Sci. 69, 405–411 (2004)

Chakrabarty, M. M. (2003). *Chemistry and technology of oils & fats* (Vol. 1). Allied Publishers.

Dana, D. & Saguy, I.S. (2006). Review: Mechanism of oil uptake during deep-fat frying and the surfactant effect-theory and myth. *Adv. Colloid Interface Sci.*, **128–130**, 267–272, DOI: 10.1016/j.cis.2006.11.013.

Debnath, S., Rastogi, N., Krishna, A.G. and Lokesh, B.R. (2009). Oil partitioning between surface and structure of deep-fat fried potato slices: A kinetic study. LWT - Food Science and Technology, 42(6), 1054–1058.https://doi.org/10.1016/j.lwt.2009.01.006

Diop, A.; Sarr, S.O.; Ndao, S.; Cissé, M.; Baldé, M.; Ndi- aye, B.; Diop, Y.M. Effect of deep-fat frying on chemi- cal properties of edible vegetable oils used by Senega- lese households. Afr. J. Food Agric. Nutr. Dev. 14, 2218-2238（2014).

Fadzlina, A., Rosnah, I., Razmah, G. & Zainab, I. (2018). Total phenolic contents and antioxidant activity of palm oils and palm kernel oils at various refining processes. *J. Oil Palm Res.*, 1–11

Ghafoor, K., Yüksel, B., Juhaimi, F. A., Özcan, M. M., Uslu, N., Babiker, E. E., ... & Azmi, I. U. (2020). Effect of frying on physicochemical and sensory properties of potato chips fried in palm oil supplemented with thyme and rosemary extracts. *Journal of Oleo Science*, *69*(10), 1219-1230.

Hamid, A.A., Dek, M.S.P., Tan, C.P., Zainudin, M.A.M. & Fang, E.K.W. (2014). Changes of major antioxidant compounds and radical scavenging activity of palm oil and rice bran oil during deep-frying. *Antioxidants*, **3**(3), 502–515, DOI: 10.3390/antiox3030502

Habarakada, A., Perumpuli, P. A. B. N., Thathsaranee, W. T. V., & Wanninaika, I. P. (2021). Physical, chemical, and nutritional quality parameters of three different types of oil: Determination of their reusability in deep frying.

J. Kim, D.N. Kim, S.H. Lee, S.H. Yoo, S. Lee, Food Chem. 118, 398–402 (2010)

Karakaya, S. & Şimşek, Ş. (2011). Changes in total polar compounds, peroxide value, total phenols and antioxidant activity of various oils used in deep fat frying. *JAOCS, J. Am. Oil Chem. Soc.*, **88**(9), 1361–1366, DOI: 10.1007/s11746-011-1788-x.

Kim, J. M., Choi, J. H., Choi, Y. S., Han, D. J., Kim, H. Y., Lee, M. A., ... & Kim, C. J. (2009). Effects of frying time and temperature on formation of acrylamide and sensory evaluation in french fries. *Korean Journal of Food Science and Technology*, *41*(4), 471-475.

Lalam, S., Sandhu, J.S., Takhar, P.S., Thompson, L.D. & Alvarado, C. (2013). Experimental study on transport mechanisms during deep fat frying of chicken nuggets. *LWT - Food Sci. Technol.*, **50**(1), 110–119, DOI: 10.1016/j.lwt.2012.06.014.

Mishra, S., & Bhattacharjee, P. 2014 Assessment of Shelf Stability and Heat Transfer Coefficient of Mustard and Sesame Oil Blends during Frying. *Journal of Lipid Science and Technology*.

Naz, S., Siddiqi, R., Sheikh, H. & Sayeed, S.A. (2005). Deterioration of olive, corn and soybean oils due to air, light, heat and deep-frying. *Food Res. Int.*, **38**(2), 127–134, DOI: 10.1016/j.foodres.2004.08.002.

Nayak, P.K., Dash, U., Rayaguru, K. and Krishnan, K.R. (2015). Physio-Chemical Changes During Repeated Frying of Cooked Oil: A Review. Journal of Food Biochemistry, 40(3), 371–390. https:// doi.org/10.1111/jfbc.12215

Omara, T., Kigenyi, E., Laker, F., Adokorach, M., Otim G., Kalukusu, R., Musau, B., Kagoya, S. and Nakabuye, B.V. (2019). Effects of Continuous Deep Fat Frying on the Physical 3 and Chemical Properties of Assorted Brands of Edible four Cooking Oils Sold in Metropolitan Kampala. Asian Journal of Applied Chemistry Research, 3(2), 1-13. https://doi.org/10.9734/ajacr/2019/v3i230086

Pedreschi, F.; Kaack, K.; Granby, K. Reduction of acrylamide formation in potato slices during frying. LWT-Food Sci. Technol. 37, 679-685（2004）.

Ravi, R., Prakash, M., & Bhat, K. K. (2005). Sensory odour profiling and physical characteristics of edible oil blends during frying. *Food research international*, *38*(1), 59-68.

SHAROVA, A.M. and RAMADAN, M.F. 2012. Impact of frying on fatty acid profile and rheological behaviour of some vegetable oil. J. Food Process. Technol. 3, 161. doi: 10.4172/2157-7110.1000161

SANTOS, J.C.O. et al. 2004. Thermo analytical, kinetic, and rheological parameters of commercial edible oils. J. Therm. Anal. Calorim. 75, 419–428

SAMAH, S.M.A. and FYKA, E.S. 2002. Improving the frying characteristics of cottonseed oil by blending with apricot kernel oil. In 4th Food quality conference, Alexandria: COMIBASSAL

S. Karakaya, Ş Şimşek, J. Am. Oil Chem. Soc. 88, 1361–1366 (2011)

Sebastian, A., Ghazani, S.M. and Marangoni, A.G. (2014). Quality and safety of frying oils used in restaurants. Food Research International, 64, 420- 423. https://doi.org/10.1016/j.foodres.2014.07.033

Serjouie, A., Tan, C.P., Mirhosseini, H. and Che Man, Y.B. (2010). Effect of Vegetable-Based Oil Blends on Physicochemical Properties of Oils During Deep- Fat Frying. American Journal of Food Technology, 5 (5),310-323. https://doi.org/10.3923/ ajft.2010.310.323

TARMIZI, A.H., NIRANJAN, K. and GORDON, M. 2013. Physicochemical changes occurring in oil when atmospheric frying is combined with post frying vacuum application. Food Chem. 136, 902–908.

USDA, Food composition databases, (United States Department of Agriculture Agricultural Research Service, 2016), https ://ndb. nal.usda.gov/ndb/searc h/list. Accessed 18 May 2017

Vitrac, O., Trystram, G. & Raoult-Wack, A.L. (2000). Deep-fat frying of food: heat and mass transfer, transformations and reactions inside the frying material. European Journal of Lipid Science and Technology, 102, 529–538.

Wolke, R.L. (2007). Where There's Smoke, There's a Fryer. The Washington Post

Xu, T., Li, J., Fan, Y., Zheng, T. and Deng, Z. (2015). Comparison of oxidative stability among edible oils under continuous frying conditions. International Journal of Food Properties, 18(7), 1478–1490. https://doi.org/10.1080/10942912.2014.913181

Yin, H., Xu, L. & Porter, N.A. (2011). Free radical lipid peroxidation: Mechanisms and analysis. *Chem. Rev.*

Yadav, A. K., Chandra, S., Kumar, T., Chandra, D., Mudgal, D., Kumar, V., & Kumar, P. (2023). Effects of Different Pretreatments on Physico-chemical Properties of Potato Chips Fried in Different Oils. *Current Journal of Applied Science and Technology*, *42*(27), 1-11.