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Physicochemical Evaluation of Used Frying Oils Through Determination of Saponification, Acid, Peroxide, And Iodine Values

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ABSTRACT: This study investigates the degradation of frying oils used in local food establishments through the analysis of key quality parameters. Oil samples, collected after frying common food items such as samosas, Manchurian, chicken, medu vada, jalebi, and momos for prolonged periods (8–9 hours), were examined. Palm and vegetable oils were analysed for acid value, saponification value, peroxide value, and iodine value using standard titrimetric techniques. Acid-base titration methods were applied for acid, peroxide, and saponification values, while iodometric titration was used for iodine value. The comparative assessment highlights the chemical changes occurring in reused oils, emphasizing the necessity of regular monitoring to ensure safety and suitability for continued use in food preparation.

KEYWORDS: Acid value, Iodine value, Peroxide value, Saponification value, Titrimetric analysis, Used frying oil.

INTRODUCTION

I. The repeated use of frying oil leads to chemical degradation through hydrolysis, oxidation, and polymerization, producing harmful compounds such as free fatty acids, peroxides, and polymerized triglycerides. These changes negatively affect oil quality and pose potential health risks, including gastrointestinal irritation and long-term toxicity. To assess oil quality, key parameters such as acid value, peroxide value, saponification value, and iodine value are analyzed. The acid value reflects the extent of hydrolysis, indicating free fatty acid formation. The peroxide value measures primary oxidation products, while the saponification value indicates the average molecular weight of fatty acids. The iodine value quantifies the level of unsaturation in the oil. This study evaluates used frying oils collected from local vendors after 8–9 hours of frying samosas, Manchurian, medu vada, jalebi, and momos. Titrimetric methods were employed to determine these parameters, aiming to assess oil quality and highlight the importance of routine monitoring for safe oil reuse in food preparation.

II. SAMPLE COLLECTION

Oil samples used for frying various food items were collected from different local food establishments in Chinchpokli, Mumbai. The Medu Vada oil was obtained from a local eatery, while the Samosa oil was sourced from Maharashtra Farsan Mart, also located in Chinchpokli. Additional oil samples, including those used for Manchurian, Fried Chicken, and Chinese preparations, were collected from various stalls in Chinchpokli. The Jalebi oil was procured from Siddhivinayak Sweet Shop, and the oil used for Momos was obtained from a vendor in Lalbaug. These samples were selected to evaluate the chemical characteristics of oils commonly used in the preparation of popular street foods in the region.

III. II. METHODS

1: DETERMINATION OF SAPONIFICATION VALUE

Procedure:

Standardization of Alcoholic KOH:

1. 10 cm^3 of 0.5N succinic acid was pipetted into a clean conical flask.
2. The succinic acid was titrated against 1N alcoholic KOH from the burette, using phenolphthalein as an indicator.
3. The endpoint was determined by a color change from colorless to pink. The exact normality of the supplied alcoholic KOH was calculated and denoted as ('A' N).

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Standardization of HCl:

1. 25cm³ of approximately 0.1N HCl was pipetted into a clean conical flask.
2. It was titrated against the standardized alcoholic KOH from the burette, using phenolphthalein as an indicator.
3. The endpoint was marked by a color change from colorless to pink. The exact normality of the supplied HCl was calculated and denoted as ('B' N).

Blank Titration:

1. 25cm³ of the standardized alcoholic KOH solution was pipetted into a 250 cm³ standard flask. The solution was diluted to the mark with distilled water.
2. 25cm³ of the diluted alcoholic KOH solution was pipetted into a clean conical flask, and a few drops of phenolphthalein were added as an indicator.
3. The solution was titrated against the standardized HCl ('B' N) from the burette.
4. The endpoint was marked by a color change from pink to colorless and the volume of HCl used in the blank titration was recorded as 'C' cm³.

Estimation of Oil Sample:

1. 10-15 cm³ of the oil sample solution was taken in a clean round-bottom flask (RB flask). 25 cm³ of the standardized alcoholic KOH was added to the RB flask.
2. A few fine pieces of porcelain were added, and a reflux condenser was attached to the RB flask.
3. The content was refluxed on a boiling water bath for approximately 1 hour.
4. After refluxing, the contents of the RB flask were cooled and quantitatively transferred to a 250 cm³ standard flask.
5. The RB flask was rinsed with distilled water, and the washings were collected into the same standard flask.
6. The contents were diluted to 250 cm³ with distilled water. 25 cm³ of the diluted refluxed solution was pipetted into a clean conical flask, and a few drops of phenolphthalein were added.
7. The solution was titrated against the standardized HCl ('B' N) from the burette.
8. The endpoint was indicated by a color change from pink to colorless. The volume of HCl used in the estimation titration was recorded as 'D' cm³.

Final Calculation:

The volumes of NaOH used in the blank titration (‘C’ cm³) and the estimation titration (‘D’ cm³) were recorded. The difference between these two volumes (D – C) was used to calculate the Saponification Value of the oil sample using the following formula:

Saponification Value = [(D - C) × N × 56.1] / W

Where:

- D is the volume of NaOH used in the estimation titration (in cm³),
- C is the volume of NaOH used in the blank titration (in cm³),
- N is the normality of NaOH (0.1 N),
- 56.1 is the molecular weight of KOH in g/mol,
- W is the weight of the oil sample (10 g).

The calculated saponification values for different oil samples were tabulated and interpreted for comparison

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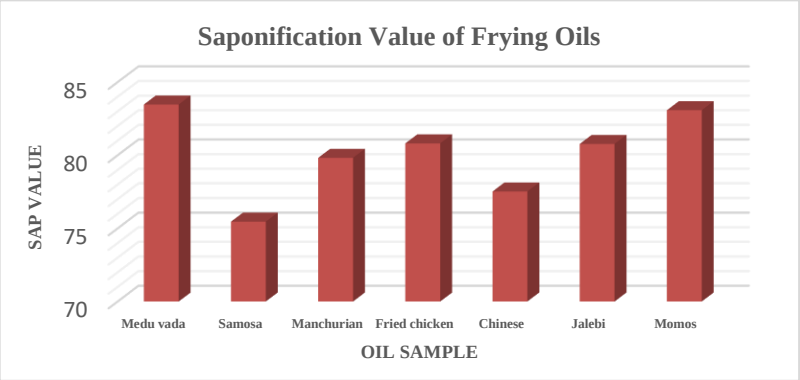
Table 1: Saponification Value

SR. NO.	OIL SAMPLES	SAPONIFICATION VALUE (mg KOH/g oil)
1	MEDU VADA	83.47
2	SAMOSA	75.46
3	MANCHURIAN	79.82
4	FRIED CHICKEN	80.81
5	CHINESE	77.52
6	JALEBI	80.77
7	MOMOS	83.08

Graph 1: Saponification Value



2: DETERMINATION OF ACID VALUE

Procedure:

Standardization of NaOH:

1. 10 cm^3 of 0.1 N succinic acid was pipetted into a 150 cm^3 conical flask.
2. It was then titrated against the supplied 0.1 N NaOH solution using phenolphthalein as an indicator, with the endpoint indicated by a light pink color.
3. The exact normality of the supplied NaOH was subsequently calculated.

Sample Preparation:

1. 10 g of oil sample was weighed and placed in a 150 cm^3 conical flask.
2. To this, 50 cm^3 of ethanol was added, followed by a few drops of phenolphthalein indicator, and the mixture was shaken.
3. The solution was titrated dropwise with 0.1 N NaOH until a light pink color was achieved.
4. This neutralized solution was then transferred into the conical flask containing the oil sample. The mixture was boiled until the oil was fully dissolved in the ethanol.

Main Titration:

1. Phenolphthalein indicator was added to the hot solution of oil and ethanol.
2. The solution was titrated against the standardized NaOH solution, with the endpoint marked by a color change from colorless to pink.

Final Calculation:

The volume of 0.1 N NaOH used in the titration ('V' cm^3) was recorded for each oil sample. The acid value was then calculated using the formula:

Acid value = (Mw × N × V) / W

Where:

- Mw = Molecular weight of sodium hydroxide (NaOH)
- N = Normality of the sodium hydroxide solution (NaOH)
- V = Volume of NaOH used (burette reading)
- W = Weight of the oil sample (in grams)

This calculation provided the acid value, indicating the amount of free fatty acids present in the oil sample.

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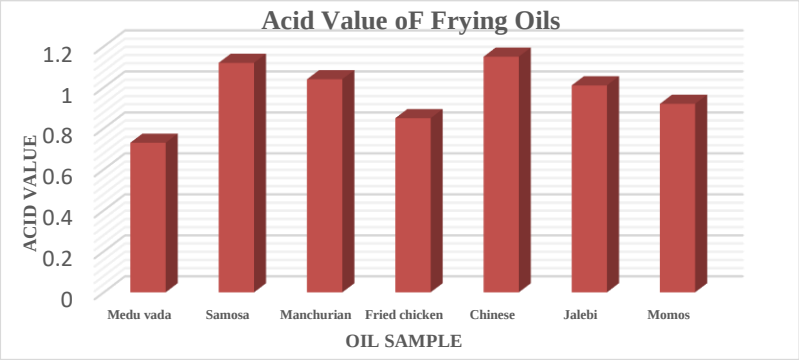
Table 2: Acid Value

SR. NO.	OIL SAMPLES	ACID VALUE (mg KOH/g oil)
1	MEDU VADA	0.73
2	SAMOSA	1.12
3	MANCHURIAN	1.04
4	FRIED CHICKEN	0.85
5	CHINESE	1.15
6	JALEBI	1.01
7	MOMOS	0.92

Graph 2: Acid Value



3: DETERMINATION OF PEROXIDE VALUE

Procedure:

Standardization of Sodium Thiosulphate:

1. A volume of 10 cm^3 of standard 0.1N potassium dichromate solution was pipetted into a clean conical flask.
2. To this, 5 cm^3 of concentrated hydrochloric acid and 10 cm^3 of 10% potassium iodide solution were added.
3. The resulting mixture was titrated against the supplied sodium thiosulphate solution using freshly prepared starch solution as an indicator.
4. The endpoint was observed through a color change from pale yellow to blue and finally to colorless.
5. The exact normality of the supplied sodium thiosulphate ($Na_2S_2O_3$) was then calculated.

Estimation:

1. Approximately 10–12 g of the oil sample was accurately weighed and transferred to an Erlenmeyer flask.
2. A volume of 30 cm^3 of an acetic acid–chloroform mixture was added to the oil sample, and the contents were shaken thoroughly.
3. Subsequently, 1 cm^3 of saturated potassium iodide (KI) solution was added and shaken for 1 minute to ensure homogeneity.
4. Then, 30 cm^3 of distilled water was added, and the mixture was shaken again for 1 minute.
5. Following this, 0.5 cm^3 of 1% starch indicator was introduced, and the solution was titrated against 0.01 N standardized sodium thiosulphate.
6. The titration was continued until the dark color completely disappeared, indicating the endpoint by a color change from black to white.

Final Calculation:

The peroxide value of the oil sample was calculated using the formula:

Peroxide Value (meq. O_2/kg) = (V × N × 1000) / W

Where:

- V = Volume (in cm^3) of sodium thiosulphate used during titration
- N = Normality of sodium thiosulphate
- W = Weight (in grams) of the oil sample taken for analysis

This formula was used to determine the peroxide value, indicating the extent of lipid peroxidation in the tested oil sample.

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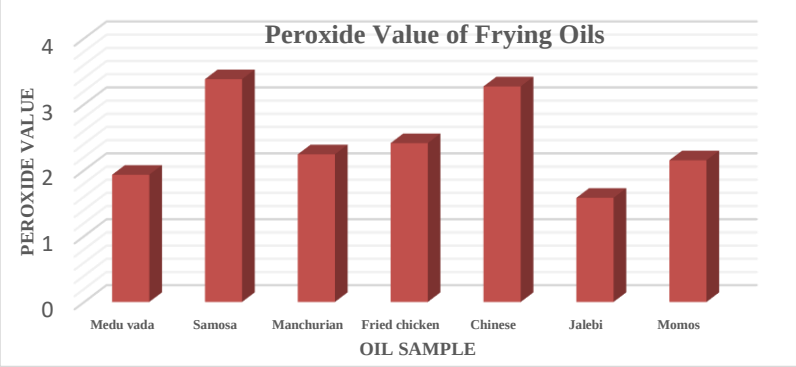
Table 3: Peroxide Value

SR. NO.	OIL SAMPLES	PEROXIDE VALUE (meq. O_2/kg)
1	MEDU VADA	1.93
2	SAMOSA	3.38
3	MANCHURIAN	2.24
4	FRIED CHICKEN	2.41
5	CHINESE	3.27
6	JALEBI	1.58
7	MOMOS	2.15

Graph 3: Peroxide Value



4: DETERMINATION OF IODINE VALUE

Procedure:

Standardization of Sodium Thiosulphate ($Na_2S_2O_3$):

1. A 10 cm^3 aliquot of standard 0.1N potassium dichromate solution was pipetted into a conical flask.
2. To the flask, 5 cm^3 of concentrated hydrochloric acid (HCl) and 10 cm^3 of 10% potassium iodide (KI) solution were added.
3. The resulting mixture was titrated with freshly prepared sodium thiosulphate ($Na_2S_2O_3$) solution using starch solution as an indicator.
4. The endpoint of the titration was noted by a color change from pale yellow to blue and then to bright green.

Estimation of Oil Sample:

1. Sample of oil weighing between 0.3 to 0.5 g was accurately weighed and placed in a stopper bottle.
2. To the sample, 10 cm^3 of chloroform was added to dissolve it.
3. 25 cm^3 of Wij's solution was pipetted into the stopper bottle containing the dissolved oil sample.
4. The bottle was swirled gently to ensure thorough mixing.
5. The bottle was tightly stoppered and placed in a dark location for 30 minutes.
6. After the incubation period, 10 cm^3 of 10% KI and 100 cm^3 of distilled water were added to the bottle.
7. The solution was titrated with the standardized sodium thiosulphate ($Na_2S_2O_3$) solution, with vigorous shaking, and freshly prepared starch solution as the indicator.
8. The endpoint was observed as a color change from pale yellow to blue and finally to bright green.

Blank Titration:

A blank titration was carried out under identical conditions, using distilled water in place of the oil sample, to account for any background interference in the titration.

Final Calculation:

Iodine Value = ((S - B) × N × 12.69) / W

Where:

- S = Volume of sodium thiosulphate ($Na_2S_2O_3$) solution required for the sample (in mL)
- B = Volume of sodium thiosulphate ($Na_2S_2O_3$) solution used in the blank titration (in mL)
- N = Normality of the sodium thiosulphate ($Na_2S_2O_3$) solution (in N)
- W = Weight of the oil sample (in grams)
- 12.69 = A constant that converts the volume of iodine reacted into iodine value units (g of iodine per 100 g of oil)

The formula was used to determine iodine value of oil samples i.e. the degree of unsaturation (i.e., the number of double bonds) in an oil or fat sample.

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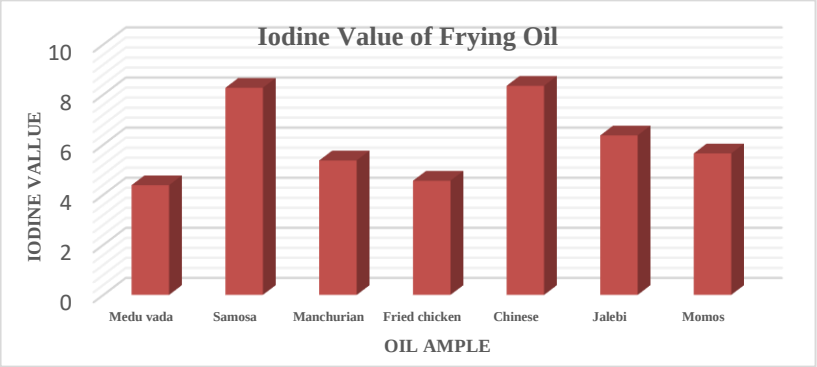
Table 4: Iodine Value

SR. NO.	OIL SAMPLES	IODINE VALUE
1	MEDU VADA	4.38
2	SAMOSA	8.27
3	MANCHURIAN	5.37
4	FRIED CHICKEN	4.56
5	CHINESE	8.35
6	JALEBI	6.37
7	MOMOS	5.65

Graph 4: Iodine Value

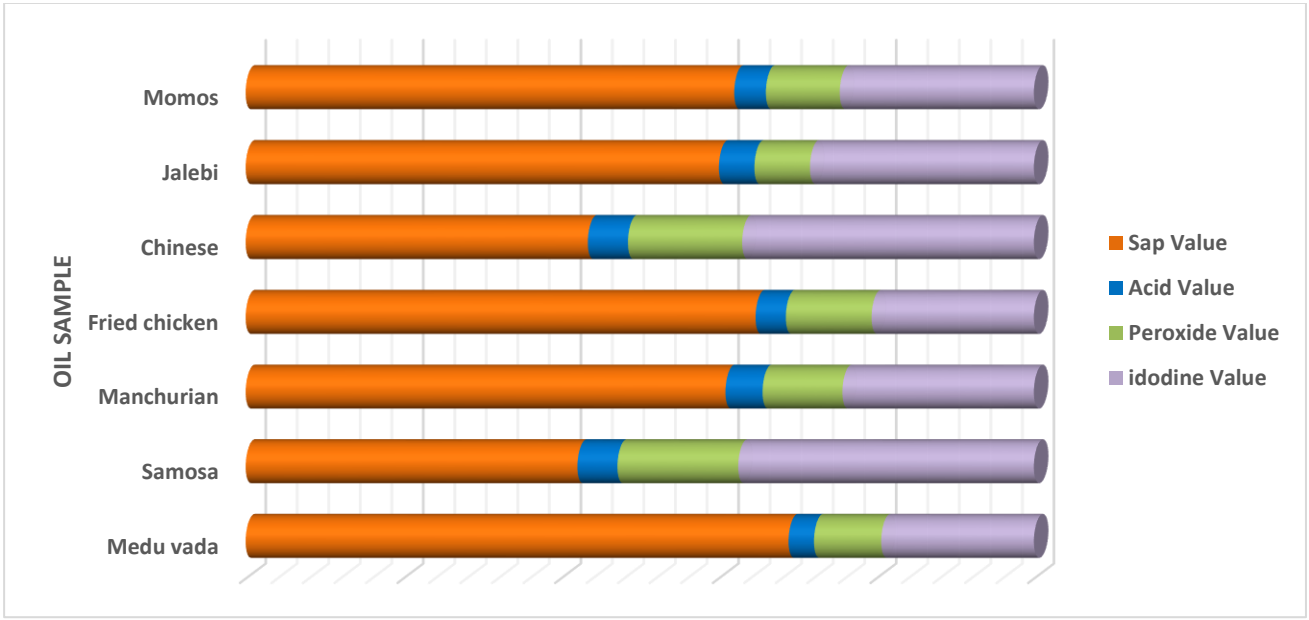


III. RESULTS AND DISCUSSION

Table 5: Overall Table showing Saponification, Acid, Peroxide and Iodine Values.

OIL SAMPLE	SAPONIFICATION VALUE	ACID VALUE	PEROXIDE VALUE	IDODINE VALUE
MEDU VADA	83.47	0.73	1.93	4.38
SAMOSA	75.46	1.12	3.38	8.27
MANCHURIAN	79.82	1.04	2.24	5.37
FRIED CHICKEN	80.81	0.85	2.41	4.56
CHINESE	77.52	1.15	3.27	8.35
JALEBI	80.77	1.01	1.58	6.37
MOMOS	83.08	0.92	2.15	5.65

Graph 5: Overall Graph showing Saponification, Acid, Peroxide and Iodine Values.



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The present study evaluated the quality of frying oils used in various food preparations by determining their Saponification Value, Acid Value, Peroxide Value, and Iodine Value. The findings indicate significant variations in oil quality parameters across different food samples. Notably, oils used for Chinese food and Samosas exhibited higher Acid Values (1.15 and 1.12) and Peroxide Values (3.27 and 3.38), reflecting considerable hydrolytic and oxidative degradation. Elevated Iodine Values in these samples suggest a higher degree of unsaturation, making them more prone to oxidative rancidity during repeated heating. In contrast, oils used for Medu Vada demonstrated the highest Saponification Value (83.47) and comparatively lower Acid (0.73) and Peroxide (1.93) values, indicating relatively fresh and stable oil with minimal degradation. The study underscores the importance of regular monitoring of frying oil quality to prevent the formation of harmful degradation products and to ensure food safety. Overall, this investigation highlights the need for strict guidelines on the reuse of frying oils, proper frying practices, and routine quality assessments in commercial and street food settings. Implementing these measures would contribute to improved food safety standards and better public health outcomes.

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