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# Assessment of Hydrogen Peroxide Index in Cooking Oils from Fast Food Shops Around Traffic Chowk, Biratnagar, Nepal

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**Abstract**

The quality of cooking oils deteriorates under repeated heating, leading to the formation of peroxides and other oxidative compounds. The peroxide value (PV) or hydrogen peroxide index (HPI) measures the extent of primary oxidation, expressed as milliequivalents of active oxygen per kilogram of oil (meq $O_2$/kg). In this study, 22 oil samples from fast food vendors around Traffic Chowk in Biratnagar, Nepal, were analyzed using iodometric titration. Peroxide values ranged from 2.08 to 16.03 meq $O_2$/kg. Four samples (18%) exceeded the recommended maximum limit of 10 meq $O_2$/kg, indicating poor oil quality and potential health risks. These findings suggest the need for regular monitoring, regulation, and public awareness to ensure the safety of frying oils used in commercial settings.

***Keywords***: *Hydrogen peroxide index, peroxide value, frying oil, lipid oxidation, food safety*

## 1. Introduction

Cooking oils are widely used in food preparation, particularly in fast food and street foods, due to their flavor and heat transfer properties. However, when reused multiple times, especially under high temperatures, oils undergo oxidative degradation. Unsaturated fatty acids react with oxygen to form hydroperoxides, which decompose into secondary oxidation products. These compounds have been linked to chronic health issues such as inflammation, cardiovascular disease, and cancer (Falade et al., 2017; Ng et al., 2014).

Primary lipid oxidation increases the peroxide value (PV) of the oil, also known as hydrogen peroxide index (HPI). PV measures the concentration of hydroperoxides (expressed as milliequivalent of active oxygen per kilogram) and serves as a key rancidity indicator. Fresh refined edible oils typically have very low PV (often < 1 – 10 meq $O_2$/kg) (Mishra et al., 2023), whereas values above about 20 – 40 indicate advanced oxidation (Wazed et al., 2023). Thermally oxidized oils produce aldehydes, ketones, trans – fatty acids and other reactive byproducts (e.g., alcohols, acrylamide) via oxidation and related reactions (Nabilah et al., 2020). These toxic compounds promote oxidative stress – for example, repeatedly heated oils raise LDL – cholesterol and blood pressure while lowering HDL, and are genotoxic and carcinogenic (Nabilah et al., 2020). Animal studies confirm these effects; chronic feeding of oxidized vegetable oils cause hypertension, atherosclerosis, oxidative damage and liver dysfunction (Ambreen et al., 2020).

Global surveys consistently report frequent misuse of cooking oils in street and fast-food settings, often leading to unsafe levels of oxidation. For example, studies in Iran found that a significant proportion of fryer oils exceeded safe peroxide value (PV) limits, with Esfarjani et al., (2019) reporting high levels of oxidation markers in discarded oils from Tehran, and Ghanbari et al. (2018) observing that 36% of samples from northern Iran were unusable due to excessive oxidation. In India, (Mishra et al., (2023) found that nearly all reused oils from street vendors surpassed recommended PV and free fatty acid thresholds. Similarly, Szabo et al., (2022) demonstrated that even brief domestic frying significantly elevated trans-fatty acids and atherogenic indices, emphasizing that prolonged or repeated heating should be avoided. Supporting these findings, (Ambreen et al., 2020) showed in animal models that long-term consumption of repeatedly heated mixed vegetable oils led to liver enzyme elevation, fat accumulation, and oxidative stress in rabbits. Collectively, these studies highlight a growing global concern: the widespread reuse of frying oils is now closely associated with increased risks of cardiovascular, metabolic, and carcinogenic outcomes.

In Nepal, national food standards follow Codex Alimentarius guidelines, which recommend a maximum peroxide value (PV) of 10 meq $O_2$/kg for refined vegetable oils. Exceeding this limit indicates significant degradation and potential toxicity (Dhakal et al., 2024; Masson-Matthee, 2007). Despite the popularity of fried foods in Biratnagar, local studies assessing frying oil quality are scarce, prompting this investigation.

## 2. Materials and Methods

### 2.1. Materials

A total of twenty-two used samples of cooking oil were collected from various fast-food shops and street vendors located around Traffic Chowk and adjacent areas in Biratnagar, Nepal. Each sample was properly labeled with key identifying details, including the location, type of oil (e.g., sunflower, mustard, or Dalda blends), and the date of collection to ensure traceability and consistency in analysis.

2.2.Methods

To assess the oxidative quality of these oils, the peroxide value (PV), an established indicator of primary lipid oxidation, was determined using the iodometric titration method, which is widely accepted in food chemistry for quantifying lipid peroxides (Zhang et al., 2021). Approximately 5.00 grams of each oil sample was accurately weighed into a 250 mL Erlenmeyer flask. To dissolve the oil, 30 mL of a freshly prepared acetic acid–chloroform solution (3:2 volume ratio) was added. The contents were swirled thoroughly to ensure complete dissolution of the oil in the solvent mixture.

Subsequently, 0.5 mL saturated potassium iodide (KI) solution was added to the flask, which was immediately swirled for one minute to allow the peroxide compounds in the oil to oxidize the iodide ions into free iodine ($I_2$). This reaction is crucial, as the amount of iodine liberated is stoichiometrically related to the peroxide concentration in the oil sample (Zhang et al., 2021). Following this, 30 mL of distilled water was added to dilute the mixture and enhance the visibility of the endpoint during titration. The liberated iodine was then titrated using 0.1 N sodium thiosulfate ($\mathrm{Na_2S_2O_3}$) solution, with starch solution added as an indicator. The endpoint was marked by the disappearance of the blue color, indicating that all free iodine had reacted with the thiosulfate.

To ensure analytical accuracy, a blank titration was conducted simultaneously using all reagents except the oil sample. This helped correct any background reactivity or contamination that might influence the final peroxide value calculation. Each oil sample was analyzed in duplicate, and the results were considered acceptable if the replicate readings differed by less than ±0.05 mL, thereby maintaining reproducibility and reliability in the experimental data.

The peroxide value (PV) was calculated using the standard formula:

$$\mathrm{PV(meq\ O_2/kg)} = \frac{(\mathrm{V_s} - \mathrm{V_b}) \times \mathrm{N} \times 1000}{\mathrm{W}}$$

where $\mathrm{V_s}$ represents the titrant volume used for the sample (in mL), $\mathrm{V_b}$ is the volume used in the blank titration, N is the normality of the sodium thiosulfate solution, and W is the weight of the oil sample in grams. This equation quantitatively expresses the amount of active oxygen present in the oil as a result of lipid peroxidation (Dhakal et al., 2024; Zhang et al., 2021).

This methodology conforms with international standards for assessing oil quality and is particularly suited for routine monitoring in food safety and public health contexts(Masson-Matthee, 2007).

## 3. Results and Discussion

The PV of the oil samples were determined by the standard iodometric titration method. In this procedure, each 5 g of oil sample was dissolved in a 3:2 acetic acid – chloroform mixture and treated with potassium iodide (KI), converting hydroperoxides in the oil to iodine. The liberated iodine was then titrated with standard sodium thiosulphate using starch indicator, and the PV was calculated from the titrant volume. This titrimetric approach follows official methods. The resulting PV data for all samples are summarized in Table 1.

**Table 1**. Peroxide Values of different samples.

| Sample | Location | Oil Type | Peroxide Value ($meq\ O_2/kg$) |
|---|---|---|---|
| 1 | Bhumi Prasashan | Sunflower | 3.93 |
| 2 | Bhumi Prasashan | Sunflower | 10.18 |
| 3 | Bhumi Prasashan | Sunflower | 2.75 |
| 4 | Bhumi Prasashan | Mustard | 2.32 |
| 5 | Traffic Chowk | Sunflower | 3.75 |
| 6 | Gudri | Dalda+Sunflower | 16.03 |
| 7 | Bahargachi | Sunflower | 3.25 |
| 8 | College Road | Sunflower | 3.37 |
| 9 | College Road | Sunflower | 2.33 |
| 10 | College Road | Sunflower | 2.08 |
| 11 | College Road | Sunflower | 2.96 |
| 12 | Pichara | Sunflower | 6.09 |
| 13 | Pichara | Mustard | 8.76 |
| 14 | Pichara | Mustard | 7.52 |
| 15 | Hospital Chowk | Sunflower | 14.48 |

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|---|---|---|---|
| 16 | Hospital Chowk | Sunflower | 12.66 |
| 17 | Hospital Chowk | Sunflower | 8.80 |
| 18 | Hospital Chowk | Mustard | 7.20 |
| 19 | Hospital Chowk | Sunflower | 3.65 |
| 20 | Hospital Chowk | Sunflower | 3.80 |
| 21 | Hospital Chowk | Sunflower | 5.08 |
| 22 | Hospital Chowk | Sunflower | 6.95 |

According to FAO/WHO (Codex Alimentarius) standards, refine edible oils should not exceed a PV of 10 $\text{meq } O_2/\text{kg}$. Fresh oils generally have PV well below this value, so the 10 $\text{meq } O_2/\text{kg}$ limit effectively marks the upper bound of acceptable fresh quality. Values above 10 $meq\ O_2/kg$ indicate significant oxidation and the onset of rancidity. In our study, several used cooking oil samples exhibited PVs above this 10 $\text{meq } O_2/\text{kg}$ threshold, suggesting that those oils were substantially oxidized.

The peroxide values (PVs) obtained from the 22 oil samples analyzed in this study ranged from 2.08 to 16.03 $\text{meq } O_2/\text{kg}$ as shown in Table 1 and compared in Figure 1. Notably, four samples (18%) exceeded the maximum permissible limit of 10 $\text{meq } O_2/\text{kg}$ as set by Codex Alimentarius standards for refined vegetable oils (Masson-Matthee, 2007). The highest PV (16.03 meq/kg) was observed in a Dalda–sunflower oil blend from Gudri, suggesting significant oxidative degradation likely due to repeated heating. In contrast, the lowest PV (2.08 $\text{meq/kg}$) was recorded in a sunflower oil sample from College Road, indicating either minimal reuse or better handling practices. The majority of sunflower oil samples exhibited PVs within the 2–8 $meq/kg$ range, which corresponds to moderate usage.

High peroxide values reflect primary lipid oxidation, which occurs when unsaturated fatty acids react with oxygen during repeated or prolonged heating. Such oxidation leads to the formation of lipid hydroperoxides and secondary byproducts like aldehydes and ketones Zhang et al., (2021). The repeated consumption of oxidized oils has been linked to various health risks. According to Ng et al., (2014), thermally oxidized fats elevate LDL cholesterol, reduce HDL levels, and increase the risk of cardiovascular diseases through oxidative stress and inflammation. Falade et al., (2017) further reported that these oxidation products are cytotoxic and disrupt metabolic pathways, potentially contributing to liver toxicity and carcinogenesis.

Recent studies reinforce these concerns. For instance, Zhang et al., (2021) highlighted that the PV alone, while a useful early indicator, should be paired with secondary oxidation markers for a more comprehensive risk assessment. A 2022 study by (Mehmood et al., (2022) also found that prolonged heating of vegetable oils significantly altered their physicochemical properties, promoting the formation of peroxides and trans-fatty acids, both of which are associated with metabolic syndrome and increased cancer risk. Furthermore, a 2023 study by Mishra et al., (2023) analyzed street vendor oils in Southeast Asia and revealed that over 25% of samples exceeded WHO/FAO peroxide limits, supporting global concerns about frying oil reuse in low-regulation environments.

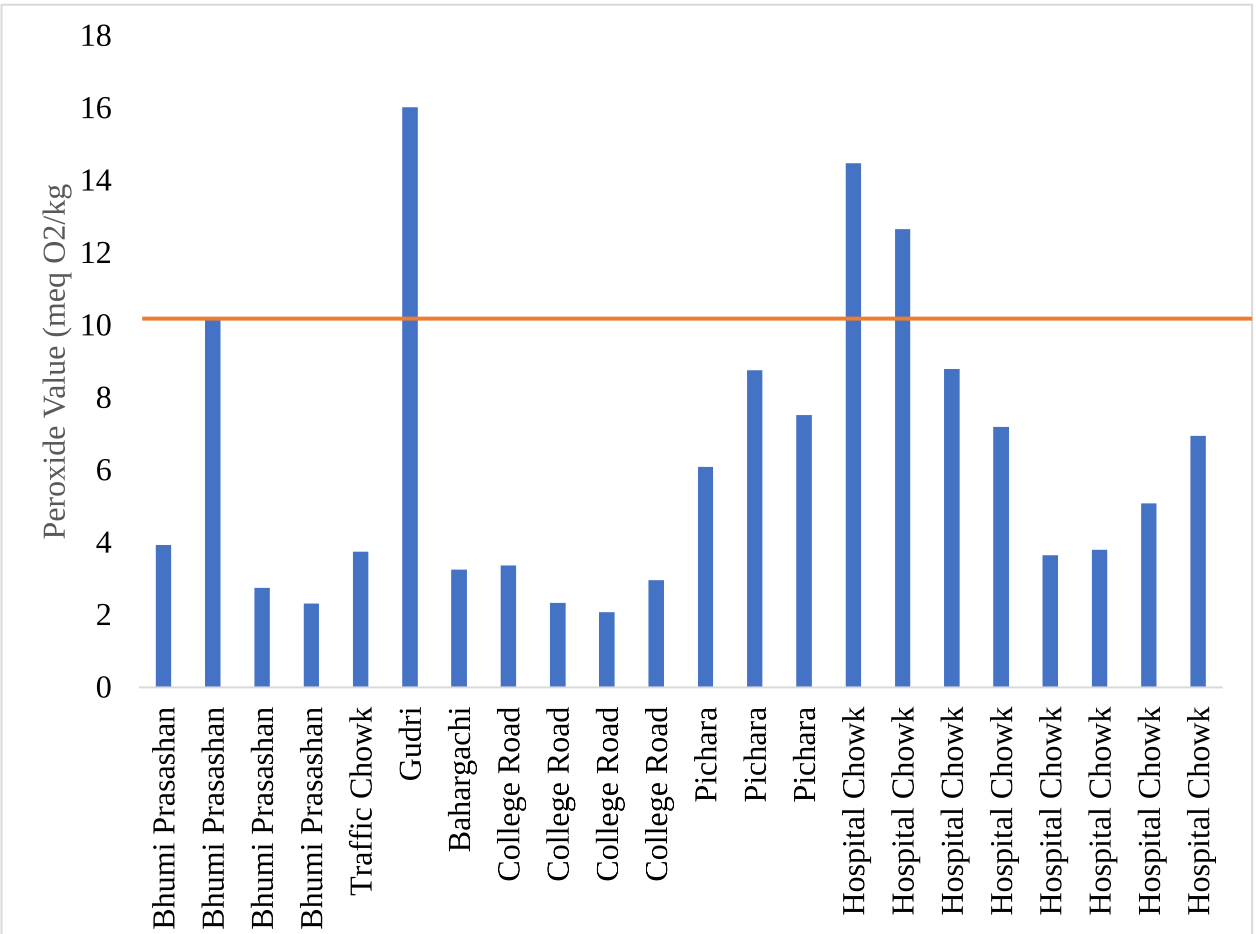


Figure 1. Comparison of PV values of several samples.

The Dalda-based samples showed the highest oxidation levels. Dalda, being partially hydrogenated fat, is often chosen for its cost-effectiveness but is more prone to oxidation when reused extensively. These findings are consistent with the results from Adelagun et al., (2023), who observed PVs exceeding 40 meq $O_2$/kg in oils used for frying snacks in Nigeria. Similarly, (Sajjadi et al., 2019) reported that all cooking oil samples collected from fast food restaurants in Mashhad, Iran, surpassed safe PV thresholds.

The misuse of cooking oil not only deteriorates the sensory quality of fried foods but also increases the toxicological burden on consumers. The presence of high PVs, particularly in four of the analyzed samples, underscores the urgent need for local regulatory enforcement and routine surveillance of edible oil quality in street food environments. Public education initiatives must also be introduced to inform both vendors and consumers about the dangers of reusing cooking oils beyond safe limits.

The findings of this study are consistent with reports from other lower – resource settings that street vendors often use highly oxidized oil. For example, Okalany et al. (2024) found that over 94% of frying oils sampled from Kampala street vendors exceeded the Codex peroxide limit of 10 meq per Kg – with mean PV of about four time higher that recommended. Likewise, Aboagye et al., (2024) measured reused from Ghanian food vendors and found medial PV values of ~16.8 – 21.9 meq $O_2$/kg after typical frying durations. In Bangladesh, Lisa et al. (2022) observed that all test oils become essentially inedible after three frying cycles, as peroxide surpassed 10 meq $O_2$/kg. These global observations mirror our results: extensive reheating and reuse rapidly divers PV well above safe limits. In each case, the repeated frying caused primary oxidation (hydroperoxides) to accumulate, and secondary oxidation products to rise as well. Taken together, these data suggest that excessive oil reuse in street – food operations in a widespread problem, not unique to our Nepalese setting, and poses a clear food – quality concern (Okalany et al., 2024; Aboagye et al., 2024; Lisa et al., 2022).

From a public health perspective, consuming foods fried in such oxidized oils may have serious consequences. Thermal oxidation of oils generates cytotoxic and pro – inflammatory compounds (hydroperoxides, aldehydes, ketone, polycyclic aromatic hydrocarbons, etc.) that can adversely affect human metabolism. Experimental studies have linked chronic intake of repeatedly – heated oils to dyslipidemia, liver damage, and other metabolic disturbances. For instance, (Ambreen et al., (2020) reported that animals fed reheated oils developed higher triglycerides and cholesterol, fatty liver accumulation, and oxidative stress markers compared to controls. Other in – vivo work similarly shows elevated LDL ("bad") cholesterol, decreased HDL, and altered blood cell counts with oxidized – oil diets (Falade et al., 2017). Moreover, reheating oil dramatically increases known carcinogens: polycyclic aromatic hydrocarbons rise sharply. Nkole et al., (2025), and Rajendran et al., (2022) highlight the tumorigenic and genotoxic potential of oil – degradation products. Although human data are limited, these findings raise concern that regular consumption of street – fried foods could contribute to a range of chromic diseases via oxidative stress and inflammation. In this context, the very high PV and secondary – oxidation values we observed suggest that consumers are being exposed to harmful levels of oxidation products, warranting public – health attention (Ambreen et al., 2020; Rajendran et al. 2022).

The results also underscore the urgent need for better regulation and education around street – food practices in low – resource settings. In many informal food markets, vendors have little guidance on safe oil use. For example, Okalany et al. (2023) found that Ugandan vendors commonly left used oil uncovered overnight and were unaware that this accelerates rancidity and endangers health. Similar knowledge gas likely exists in Nepal. Regulatory limits (Codex PV $\leq$ 10 meq $O_2$/kg) are often unenforced at small scales. Our data suggest that enforcing such standards – or at least limiting the number of oil – reuse cycles – could markedly improve food quality. Possible interventions include vendor training on how to recognized oil spoilage, subsidies or technology for oil – filtration and disposal, and routine inspection of street – food outlets. Ultimately, ensuring safer frying practices and oil replacement in the street – food sector should become a priority for public – health agencies in Nepal and elsewhere, in order to reduce the risk posed by chronically oxidized oils (Okalany et. al, 2024; Aboagye et al. 2024).

## 4. Conclusion

This study highlights a significant public health concern regarding the quality of frying oils used by fast food vendors in Biratnagar, Nepal. Among the 22 oil samples analyzed, peroxide values ranged from 2.08 to 16.03 meq $O_2$/kg, with four samples (18%) exceeding the Codex Alimentarius recommended limit of 10 meq $O_2$/kg for refined oils. These elevated values indicate substantial lipid oxidation due to repeated heating and improper handling practices, particularly in cost-driven environments where oils like Dalda are frequently reused. The presence of high peroxide levels in nearly one-fifth of the samples suggests that consumers are at risk of ingesting oxidized lipids associated with various health hazards, including cardiovascular disease, metabolic disorders, and oxidative stress. While the majority of samples showed moderate PVs, the consistent reuse of oils without proper quality control or replacement raises concern. The findings underscore the urgent need for routine monitoring of frying oils in street food settings, implementation of regulatory standards, and public education on safe cooking practices. Vendors should be encouraged to limit oil reuse, adopt safer oil types for frying, and dispose of degraded oils appropriately. Health authorities and local governments must establish clear guidelines, inspection protocols, and affordable testing methods to ensure compliance and protect consumer safety. Future research should expand on this baseline study by incorporating secondary oxidation parameters (e.g., anisidine value, total polar compounds) and evaluating the health effects of chronic exposure to oxidized cooking oils in local populations.

## 5. CRediT authorship contribution statement

Sujit Kumar Shah: Writing – original draft, writing – reviewing & editing, Methodology, conceptualization. Thakur Pokharel: Methodology, Data curation, writing – original draft. Ajaya Bhattarai: Writing – reviewing & editing, validation, supervision.

## 6. Conflict of interest

Authors have no conflict of interest.

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