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Qualitative Assessment of Cooking Oils Used by Street Food Vendors of Lahore, Pakistan

H. Ayub [1], M. Awan [1], W. Nazir [1], A. Sami [2], N. Khalid [1*]

1. Department of Food Science and Technology, School of Food and Agricultural Sciences, University of Management and Technology, Lahore 54,000, Pakistan
2. Food Safety Department, Punjab Food Authority, Lahore, Pakistan

HIGHLIGHTS

- All cooking oils used by Street Food Vendors (SFVs) of Lahore, Pakistan were unfitted for consumption.
- SFVs had poor knowledge regarding safe disposal of used cooking oils.
- Cooking oil samples contained exceeded amount of free fatty acids and peroxide values.

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Acronyms and abbreviations
FFA=Free Fatty Acid
IV=Iodine Value
MC=Moisture Content
PFA=Punjab Food Authority
PV=Peroxide Value
SFV=Street Food Vendor
TPC=Total Polar Compounds

ABSTRACT

Background: Street foods have gained popularity around the world in the past few decades. The current study was carried out in order to quantitative analysis of used cooking oils by Street Food Vendors (SFVs) of Lahore, Pakistan.

Methods: Fifty samples of cooking oil used by SFVs were collected. Also, a questionnaire was designed for qualitative assessment that revealed maximum vendors used vegetable ghee because of its low cost and practiced addition of new oil into the used one instead of disposing it. The samples were also quantified for their Moisture Content (MC), Free Fatty Acid (FFA), Peroxide Value (PV), Iodine Value (IV), and Total Polar Compounds (TPC). Statistical analysis was performed with SPSS 21.

Results: The survey data indicated poor knowledge regarding the safety and health aspects of cooking oils among SFVs. Moreover, mean values indicated that most of the samples were unhealthy as they exhibited higher MC (>0.10%), TPC (>25%), PV (>10 meq. O_2/kg), and FFA (>0.20 mg KOH/g); and very low IV (<80 g/100g) in samples.

Conclusion: The analysis revealed that the SFVs of Lahore, Pakistan used low-quality cooking oil. The quantitative assessment of cooking oils showed high values of moisture, FFAs, polar contents, and PVs.

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Introduction

A portion of food or drink available as ready to eat in a street, market or any other public place sold by any hawker, or vendor is known as “street food” (Trafialek et al., 2017). It is sold from any food cart, food truck, and portable food booth meant for intermediate consumption. Generally, street food is inexpensive, convenient, culturally accepted, and available both for rural and urban people worldwide (Choudhury et al., 2011). In many developing countries millions of people are consuming food sold by food vendors that have played a vital role in competing with the increased food demand (Recchi, 2021).

* Corresponding author (N. Khalid)
✉ E-mail: nauman.khalid@umt.edu.pk
ORCID ID: https://orcid.org/0000-0002-8045-199X

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The good taste, textures, and labels easily attract people to street foods. They provide the food at economical and reasonable prices as compared to any hotel or restaurant. Any person that has no source of income can easily make money by making fried foods with very low investment, near any college, school, industrial area, or any other place. Moreover, street food has also become a family business for some of the food vendors (Mohammed and Shehasen, 2020). Every day, street food is consumed by approximately 2.5 billion people globally (FAO, 2011).

In developing countries, no regulations are followed by the Street Food Vendors (SFVs) which are a major cause of food-borne outbreaks (Muyanja et al., 2011). In Pakistan, low-cost food is preferred by people due to poverty. The food demand for labour entirely relies on these food vendors in urban areas. Mostly, the lunch of labourers, office workers, and students are fulfilled by these food vendors. They commonly make fried products on the roadside near the education sector, industrial areas, markets, offices, etc. The use of low-quality raw material, utensils, and improper cleaning lead to contamination that ultimately pose risk to consumer health. Moreover, some vendors use the previous day's leftover raw materials, not having any knowledge of defined storage conditions for leftovers hence, increasing the microbial load of raw materials. Thus, inadequate cooking with heavily contaminated raw materials results in the survival of many food-borne pathogens (Khuluse and Deen, 2020).

In the last few decades, fast-food restaurants grew in numbers all over the world because of their popularity among new generations. High frying temperatures of fats and oils provide a diverse fried taste, dark brown color, and a light texture. Moreover, different chemical reactions such as polymerization, hydrolysis, and oxidation also occur during processing, which eventually changes the chemical properties of oils resulting in the formation of many by-products such as dimers, polymers, Free Fatty Acids (FFAs), cyclic compounds, alcohols, and reactive oxygen species (Freire et al., 2013; Ku et al., 2014; Totani et al., 2012).

The used oil is taken by vendors for frying to reduce costs. The used oils are commonly applied in frying by vendors to reduce costs. The continuous reuse of oil changes its appearance causing an increased viscosity and dark color, which ultimately changes the fatty acid composition and nutritional value (Nayak et al., 2016). Furthermore, frying at a high temperature and reuse of edible oils causes chemical changes such as the production of trans fatty acids (Bhardwaj et al., 2016). The formation of different toxic compounds and other by-products in the used oils are associated with various diseases such as diabetes, obesity, cardiovascular diseases, and cancer (Li et al., 2019).

In Lahore (Pakistan), 73% of the SFVs premises were found dirty, 55% had long nails and 14% had sores on their hands, 77% smoked during work and most of the vendors did not wash their hands during the serving of food (Hasan et al., 2016). The hygienic conditions in developing countries such as Nigeria are poor where 42.86% do not use aprons, 52.38% do not wear masks, 19% wear jewelry while serving, and 23.81% of retailers prepare food in unhealthy conditions (Chukuezi, 2010). In another research, (Mehmood et al., 2012) also observed deviation in the quality parameters of cooking oil in the Pakistani market that failed to meet Pakistan Standard Quality Control Authority (PSQCA) standards. Moreover, oil samples collected from the fast-food restaurants in Tehran, Iran contained harmful oxidative products and the reuse of frying oil was the potential reason (Esfarjani et al., 2019).

The quality of oil used to prepare food is very critical in a densely populated city such as Lahore, Pakistan where a mass population consume food prepared by SFVs daily. The current study was carried out to assess the knowledge of SFVs about food safety and quality of the used oils as well as the quantitative analysis of used cooking oils by SFVs.

Materials and methods

Sample collection

A 50 ml sample of oil was collected during March 2021 from each vendor at the time of deep-frying during the peak time between 1:00 pm to 4:00 pm from different street vendors of Lahore city to assess the quality. A total of 50 samples were collected from 5 selected vending points (rural area, urban area, market area, educational area, and fast-food fryers), with 10 samples from each point. Oil samples were filled in the tubes using a stainless-steel scoop and shifted to the laboratory for analysis.

Materials

All the chemicals and reagents used for analysis were of analytical grade. Sodium hydroxide, potassium iodide, iodine, sodium thiosulphate, starch, phenolphthalein, and chloroform were purchased from Sigma-Aldrich (Germany). Ethyl alcohol was purchased from Merck (Germany) while acetic acid was purchased from BDH (England). Moreover, double distilled water was used to prepare the standard solutions.

Questionnaire

A questionnaire was prepared, and a survey was conducted to analyze the quality of oil used by SFVs

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(Table 1). Two hundred fifty respondents were surveyed using face to face interview method and responses were later evaluated for knowledge assessment. A total of 10 questions such as the type of oil used, duration of frying, the purpose of using oil or ghee, frequency of oil change, physical parameters to change oil, filtration process applied on oil/ghee, and knowledge about the effects of bad oil or ghee usage were part of the survey.

Quantitative analysis of cooking oils

The Moisture Content (MC) of oils was determined through a hot air oven at 105 °C for 6 h as per the standard method (AOAC, 2005). About 50 g of fat samples were weighed before and after drying and the % moisture was determined based on the weight loss by the samples. Peroxide Value (PV), FFA, and Iodine Value (IV) were analyzed through titration and according to the standard protocol (AOCS, 2017). FFA was determined by titrating hot mixture of oil and ethanol with 0.1 N KOH whereas, PV was calculated by titrating a mixture of oil, potassium iodide, and starch with sodium thiosulphate solution. IV was determined by titrating the oil containing acetic acid, Wijs reagent, mercuric acetate solution, and potassium iodide with sodium thiosulphate solution. The deep-frying oil tester (Testo 270, Germany) was used to determine the Total Polar Compounds (TPC) as described by Song et al. (2017). The oil tester was dipped in hot oil (120 ^{o}C) for 30 s and TPC% was determined.

Statistical analysis

The oil samples collected from different SFVs were qualitatively and quantitatively analyzed to assess the knowledge of SFVs regarding food safety, and food quality, and to determine the composition of used cooking oils. The standard values for cooking oils as per Punjab Food Authority (PFA; Pakistan) were taken as a reference to evaluate the overall quality of cooking oils collected from SFVs. The analysis of samples was performed in triplicates and their mean and standard deviation were calculated. The differences among samples were checked using analysis of variance (ANOVA) using a 95% probability level. Moreover, the reliability of the survey was conducted using the Cronbach alpha value and the analysis was performed with SPSS 21 (IBM, New York, USA) using the standard methodology of Steel et al. (1997).

Results

Qualitative assessment of cooking oil

The results of the survey indicated usage of poor-quality oils, mixing, and adulterations in oil, less practice of oil change, poor hygienic practices, and inappropriate cleaning of the utensils. The complete survey results were presented in Figure 1. The lack of knowledge was the major reason behind such practices that ultimately affect the health of consumers. Moreover, Cronbach's alpha value of 0.603 showed reliability of survey questionnaire and effectively predict the impact of evaluated questions.

The survey results showed that 36% of the SFVs preferred vegetable ghee while the highest trend was observed in SFVs of urban and market areas. Moreover, 60% of the SFVs preferred the vegetable ghee over other oils due to its low price however, 16% preferred a specific oil based on its better sensory attributes and low price. Most of the SFVs used oil continuously for 4 h while 34% fried products in oil for 6 h. As per the survey results, 20% of the SFVs did not change their oil at all and continued the addition of fresh oil into the used one. However, 34% of the SFVs continue using the oil and do not add fresh oil.

Changes in the oil color was used as major indicator for oil change by 36% of the vendors while 34% change oil using its odor as an indicator whereas, the highest trend was observed in rural, market, and educational areas. Furthermore, 34% of the SFVs discard oil in the drains while the highest trend was observed in urban areas and fast-food fryers. Most of the SFVs do not treat oil to enhance its life however, 28% filter the used oil to remove the physical impurities. Moreover, 70% SFVs had medium to high knowledge about the effect of low oil quality on human health however, the vendors of rural and educational areas possessed less knowledge on the oil effects. Clean in Place (CIP) of the utensils is another vital food safety and hygiene concern and 36% of SFVs performed it every day while 34% performed it at the time of oil disposal.

Quantitative assessment of cooking oil

The quality of cooking oil used by SFVs was analyzed using different quantitative parameters, that include MC, FFA, PV, IV, and TPC. As per the findings, the mean MC of the cooking oils collected from rural area, urban area, market area, and educational area areas did not meet the standard values and have average MC of 0.13% (Figure 2). However, the lowest MC of 0.08% was observed in the samples collected from fast-food fryers. Moreover, the results of FFA in frying oils collected from rural area, educational area, market area, and urban area did not comply with the PFA standards and showed FFA as high as 0.22 mg KOH/g of oil however, the mean FFA content of fast-food fryers (Figure 3) was within the permissible standard i.e., <0.20 mg KOH/g.

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The highest PV of 11.60 meq O_2/kg was observed in educational area that also not comply with the PFA standards that allows a maximum of 10 meq O_2/kg. Moreover, the samples from urban area and rural area also exhibited high PV while the lowest value of 7.50 meq O_2/kg was noticed in the oil samples from fast-food fryers (Figure 4). Furthermore, higher IV was observed in fast-food fryer (83.5 g) followed by 80.8 g in market area while the samples collected from educational area, urban area, and rural area showed IV less than 80 g/100 g of oil as presented in Figure 5. The highest TPC (26.8%) was present in samples of educational area while the lowest (18.23%) was observed in fast-food fryers samples (Figure 6).

Table 1: The questionnaire used for qualitative assessment of cooking oils used by Street Food Vendors (SFVs) of Lahore, Pakistan

Q1. What do you prefer for frying?	a. Vegetable ghee b. Cooking oil c. Mustard d. Any
Q2. Why do you prefer that oil/ghee?	a. Price b. Quality c. Sensory attributes d. Any other
Q3. How many hours a day do you perform frying?	a. 4 b. 8 c. 12 d. 16
Q4. At the end of the day, how do you utilize the remaining oil?	a. Discard it b. Mix in fresh oil c. Continue using it d. Sale oil
Q5. What is the frequency of oil change?	a. Everyday b. Every week c. Fortnightly d. Do not change, add new oil into it
Q6. What physical parameter do you consider for an oil change?	a. Change in color b. Smell c. Other d. Do not change
Q7. What is done with wasted oil?	a. Discarded in drain b. Donate c. Sale d. Other
Q8. Do you perform any treatment to enhance the life of your oil?	a. No treatment b. Filtration c. Antioxidant addition d. Other
Q9. Do you know the effects of bad oil/ghee on human health?	a. High b. Medium c. Low d. Nil
Q10. What is the frequency of Clean in Place (CIP) of equipment/utensils?	a. Everyday b. At the time of disposal c. When they feel its dirty d. Don’t know

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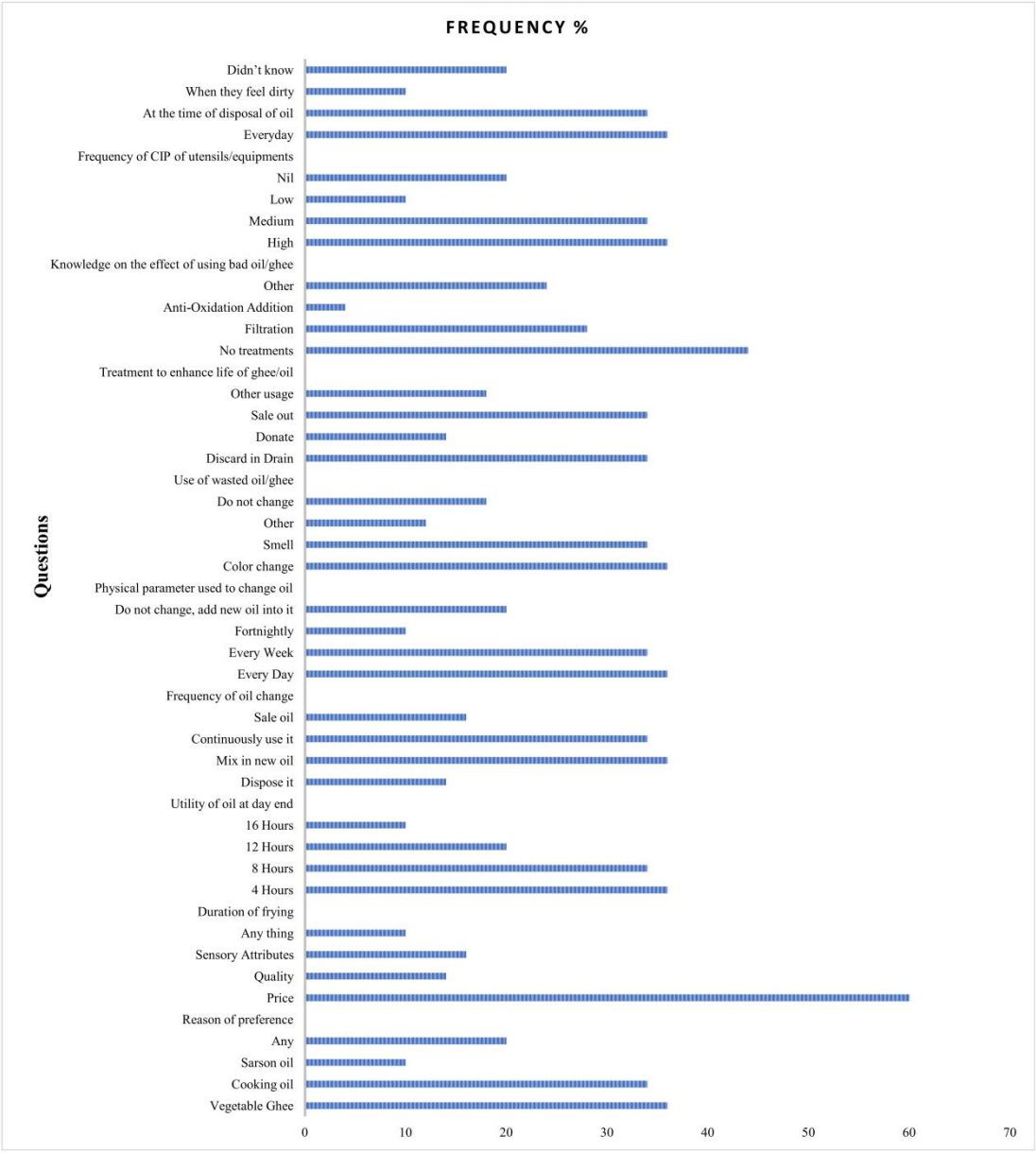

Figure 1: Relative frequency assessment of cooking oils used by Street Food Vendors (SFVs) based on the questionnaire survey (CIP=Clean in Place)

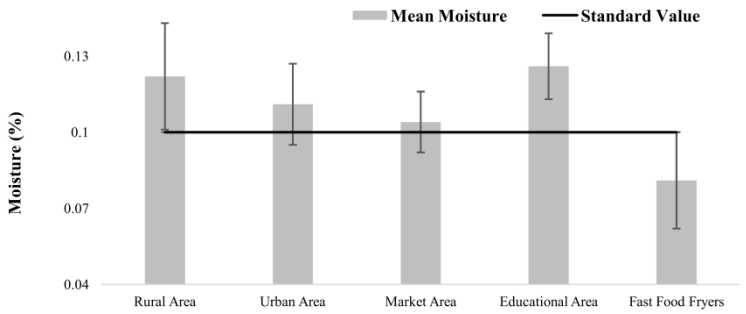

Figure 2: Mean Moisture Content (MC) of cooking oil collected from different locations. The straight line shows the standard value for MC of oil

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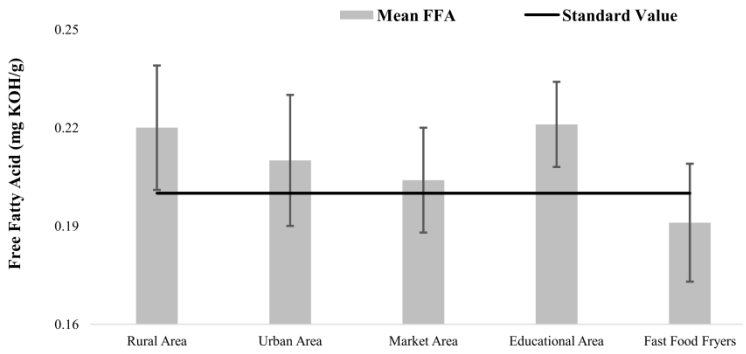

Figure 3: Mean Free Fatty Acids (FFAs) of cooking oil collected from different areas. The straight line shows the standard value for FFAs in oil

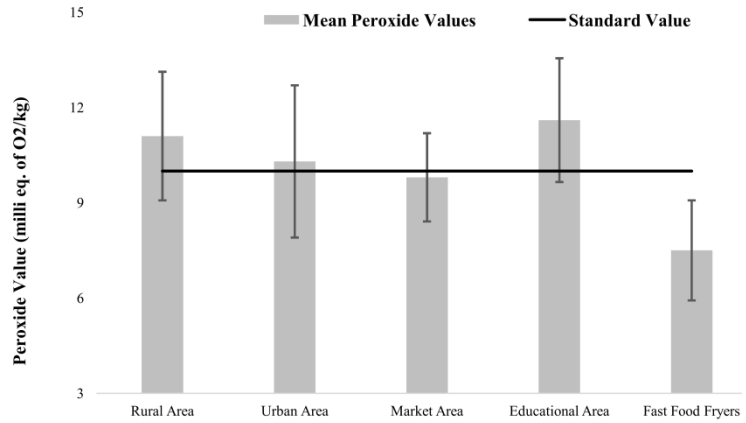

Figure 4: Mean Peroxide Value (PV) of cooking oil collected from different locations. The straight line shows the standard value for PV of oil

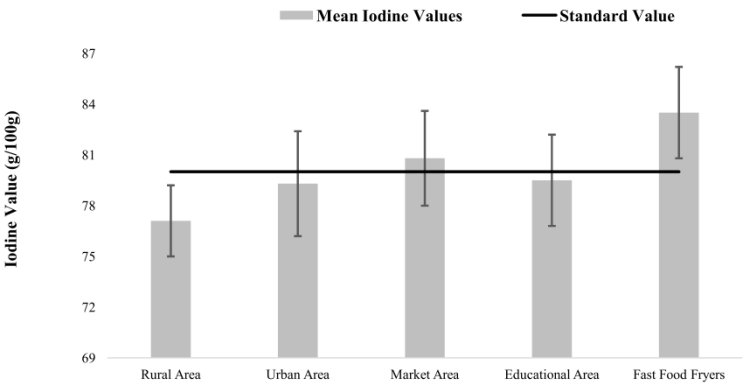

Figure 5: Mean Iodine Value (IV) of cooking oil collected from different locations. The straight line shows the standard value for IV of oil

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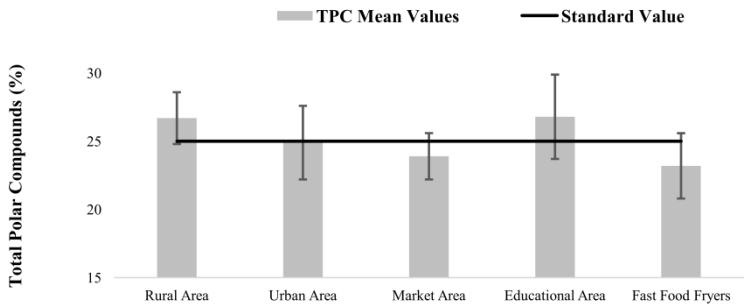

Figure 6: Mean Total Polar Compounds (TPC) of cooking oil collected from different locations. The straight line shows the standard value for TPC of oil.

Discussion

In the present study, most of the SFVs opted ghee for frying which is in accordance with the survey conducted by Kalia (2019) where 80% of the vendors mainly used vanaspati for frying samosa, papdi, and kachori in Delhi, India. Moreover, shortening is quite popular for frying in developing countries such as Brazil and Kenya because of its low cost, easy handling, and storage (Karimi et al., 2017). Most of the SFVs used oil for long time that might be due to the increased demand for street food and less knowledge regarding the adverse health of frying at high temperatures for extended periods. Moreover, 70% of the SFVs either used oil continuously or mixed with fresh oil. Continuous frying of oil results in polar compounds which are carcinogenic while oxidation causes rancidity in oil (Ng et al., 2014). Similar trends were observed in a study conducted by Muyanja et al. (2011) on SFVs in Uganda. Likewise, Eliku (2016) also observed that 80% of the SFVs in Uganda change oil either weekly or monthly rather than daily. The study carried out by Emelike et al. (2020) showed that 66.6% of the SFVs of Port Harcourt and Rivers state, Nigeria used oil for more than three days or unless its color is changed. Karimi et al. (2017) also observed in his survey that more than 100 food items are fried in the same oil before it is discarded or changed which is a clear indication of frying oil for a longer period hence, deteriorating its quality.

In the current study, about 36% of SFVs changed oil based on its color. Generally, frying oil samples exhibit more pronounced color changes as compared to fresh oil. Moreover, these color changes are associated with the oxidation of color pigments and photo degradation (Karimi et al., 2017). Most of the vendors did not treat oil to enhance the shelf life whereas some of them filter oil to remove solid impurities. Emelike et al. (2020) observed similar trends in the oil samples collected from SFVs of Port Harcourt and Rivers state, Nigeria where 66.67% never treat oil while 33.33% filter oil after a specific time. Moreover, the trend of discarding used oil in drains was observed in urban areas. The possible reason could be the greater availability of drains in urban areas as compared to rural areas. Furthermore, a better understanding regarding the impact of oil quality on human health and cleaning of utensils was exhibited in the survey results whereas, 30% of the SFVs had power knowledge regarding the effect of oil on health and the frequency of utensil cleaning. Better utensil and equipment cleaning practices and knowledge of SFVs regarding human health in countries with higher literacy rate such as the Philippines and Brazil have been observed in different surveys (Azanza et al., 2000; Da Silva et al., 2014). However, lack of knowledge, awareness, poverty, and careless behavior are some of the major reasons behind using low-quality oil and unsafe practices.

In the current study, the mean MC of oils from rural area, urban area, and educational area exceeded the PFA standard that prohibit MC excess than 0.1% (FSU, 2018). The greater MC of frying oil indicates that the SFVs did not discard their oil after a certain period and continue using it for an extended period increases the MC while frying (Chen et al., 2013). The composition of oil, frying time, and temperature are some of the major features that affect the MC of oil. High MC not only affects the storage, but also the taste, flavor, and texture of the fried product. A small quantity of moisture is typically present in cooking oil but, after repeated use, the MC from food migrates to oil, thus increasing the level of hydrolysis hence, making the oil more prone to break down (Chen et al., 2013).

Higher FFA contents were detected in educational area, urban area, and rural area that exceed the PFA standard

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that allows <0.20 mg KOH/g (FSU, 2018). The FFA content is vital for the determination of fat hydrolysis and the extent of oil deterioration (Chen et al., 2013). Similar trends were also observed in 27 out of 42 oil samples collected from the fast-food restaurants of Shiraz, Iran and most of the samples exhibited >1 mg KOH/g of acid value (Ghobadi et al., 2018). The results are also in line with the findings of Ngozi et al. (2019) who studied the frying oil samples used by 10 street vendors in Nigeria and observed a high level of FFA. Hydrolysis of triglycerides and decompositions of hydroperoxides at high temperatures in the presence of moisture results in the formation of FFA. The higher FFA indicates that the SFVs do not discard their oil and use low-quality oil which is a huge concern as it can be a cause of high cholesterol, coronary heart diseases, and liver disease. Along with the desirable characteristics, frying also involves many reactions such as oxidation, polymerization, and hydrolysis that decrease the unsaturated fatty acids and generate FFAs (Karimi et al., 2017).

The PV of fast-food fryers and market area comply with the PFA standard that allows 10 meq O_2/kg however, the PV of educational area, rural area, and urban area exceeded the standard limit (FSU, 2018). The increased PV in most of the samples is an indicator of continuous deep-frying and the use of low-quality oil (Karimi et al., 2017). Moreover, higher PV in 20% of the branded oil samples available in the Pakistani market was also observed by Mehmood et al. (2012) that indicate the low quality of the oil. Similar trends were observed by Manzoor et al. (2022) in Kashmir, India where almost 80% of the oil used by SFVs had a higher PV whereas only 20% of the samples were fit for frying. Higher oxidative degradation and the extensive reuse of oil are the major factors behind higher PV values (Manzoor et al., 2022). Ngozi et al. (2019) also studied the frying oil samples used by 10 street vendors of Nigeria and observed a high level of peroxides.

As per the standard of PFA, IV in cooking oil should not be less than 80 g/100 g of oil (FSU, 2018). However, most of the samples collected from SFVs of rural area, urban area, and educational area exhibited lower IV that do not comply with the national and international standards. IV is the measure of the degree of unsaturation in oil that changes as soon as the oil is used in frying hence; it is an important indicator of oil quality (Alireza et al., 2010). A higher IV is associated with greater unsaturation that makes such oil highly susceptible to oxidation as the unsaturated fatty acids are less stable as compared to saturated fatty acids (Odoom and Edusei, 2015). Low IV in most of the Malaysian palm, canola and sesame oil samples after frying potatoes at 180 ºC for 5 days was observed that indicate a reduction in double bonds due to the oxidation caused during the extended use of oil for frying, however, the high IV in some samples indicate a rather fresh sample (Alireza et al., 2010). Kalia (2019) observed similar trends in mustard, sunflower, soybean, and other hydrogenated oil samples used by the SFVs. All 15 samples exhibited lower IV that indicate oxidation of the oil. Likewise, heating canola, soybean, cotton seed, and tallow for a longer period lowered the IV which can be attributed to destruction of unsaturated fatty acids due to oxidation and polymerization (Takeoka et al., 1997).

TPC values of rural area and educational area did not comply with the PFA standard, that allows less than 25% TPC (FSU, 2018). Polar compounds have greater polarity than triglycerides and are vital in the analysis of oil deterioration during frying as heating induces hydrolysis, oxidation, polymerization, and isomerization in oils (Karimi et al., 2017). The continuous frying results in the formation of by-products like aldehydes, ketones, alcohols, and non-volatile forms that affect the physicochemical, nutritional, and sensory properties of the oil. The toxicity of these compounds also results in diseases such as hypertension, atherosclerosis, inflammation, oxidative stress, and endothelial dysfunction (Ng et al., 2014). Similar trends were observed by Flores et al. (2018) in the deep-fried food items sold by the SFVs of Chili whereas, 50% of the samples had high TPC values and were unfit for human consumption. Kumar et al. (2021) also observed an increasing trend in the TPC percentage of 143 oil samples with the increase in frying time that is used by SFVs in India. Higher TPC indicates the continuous use of oil by SFVs of educational area without discarding it, longer frying times and higher temperature that leads to the formation of greater TPC and pose a greater health risk to the consumers (Chen et al., 2013; Ghobadi et al., 2018; Houhoula et al., 2003; Nayak et al., 2016).

Conclusion

The data revealed that the SFVs of Lahore, Pakistan used low-quality cooking oil. The quantitative assessment of cooking oils showed high values of moisture, FFAs, polar contents, and PVs. Therefore, awareness and education regarding the discard of used oil and maintaining the overall quality of cooking oil through proper channels and the enforcement of the rules and regulations are needed for consumer's health safety.

Author contributions

N.K. and A.S. conceived and design the project; H.A., M.A., and W.N. collected the samples, analyze the data; W.N. and M.A. performed statistical analysis; N.K. and A.S finalized the data; H.A., M.A., and W.N. drafted the article; N.K. finalized the final submission.

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Conflicts of interest

The authors declare no conflict of interest.

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