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Research Article

Quality Assessment of Fried Oils from Different Street Food Vendors and Restaurants in Different Areas of Gilgit, Pakistan

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Abstract: The study was designed to estimate the quality of the frying oils used in northern areas of Pakistan. A cross-sectional analysis was performed to investigate the behavior and common practices of street food vendors (SFVs) regarding oil selection, food preparation, and awareness of rancid oil on human health. Seventy-Eight (78) commercial fried oil samples were evaluated based on the free fatty acid (FFAs), peroxide value (PV), moisture contents (MC), total polar matter (TPM), color, and iodine value (IV). The analysis showed that FFAs, PV, TPM, color, and IV significantly deviated from standard values provided by Pakistan Standard Quality Control Authority, (PSQCA) Pakistan. The SFVs used low-quality oil because of low price and ease of availability over quality, frying oil was changed infrequently and blended with new oil. Furthermore, the majority of SFVs were unaware of the hazards of rancid oil to human health, food handling practices were unsanitary, and cleaning methods were ineffective. Quality control, legislation, and SFVs safety and hygiene training are the most critical requirements to improve the overall quality of fried street foods in Gilgit, Pakistan.

Keywords: Street Food Vendors, Quality, Deep frying, Rancidity, Pakistan

1. INTRODUCTION

Street foods (SF) come under the category of food or drink sold by vendors, hawkers, and small stalls located in a street, local markets, and any other public places that can be consumed instantaneously. SF is more in demand due to its cheap prices, easy availability, and being culturally accepted either in rural or urban areas. Past studies have revealed that about 2.5 billion people are involved in the consumption of SF globally [1, 2].

People purchased SF normally from street food vendors (SFVs) including mobile SFVs, fixed stall SFVs, and semi-fixed SFVs. The working conditions of SFVs have normally been characterized as low incomes, absence of social security or state benefits, extensive working hours, and unsafe working environments [3]. The literacy rate among SFVs is found to be very low and they are observed as untrained in maintaining food safety and hygiene [4]. The ignorance of SFVs in following the food safety regulations not only compromises the quality of food but is also associated with the outbreak of major food-borne illnesses [5].

In Pakistan, people preferred to choose ready-to-eat foods available at low prices due to their low income [6]. In the past few years, major cities of Pakistan have suffered a significant increase in urbanization mainly due to the high rate of migration from rural areas. The pressure of increased population in urban areas tends to cause SF vending businesses to grow at an extensive rate. SFVs earn their livelihood by catering to the needs of a large number of migrant workers far away from their home places [7].

People preferred to fill their snack cravings with foods sold by SFVs available nearby their location. SFVs usually compromised the quality of fried foods by using cheaper substitutes for frying

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oil [4]. The replacement of cheaper oil substitutes, use of low-quality utensils, and improper cleaning methods lead to a highly contaminated poor quality end product that adversely affects consumer health [8]. SFVs associated with selling fried food items mainly target crowded areas such as bus stands, commercial areas, and educational and industrial zones to capture more people [7]. Most of the vendors preferred to reuse the leftover oil over and over without being properly stored. Moreover, SFVs are not well aware of personal hygiene and do not follow cleaning and safety practices. The poor infrastructure, improper sanitation, and poor personal hygienic practices are directly associated with the proliferation of microbial hazards, chemical contamination, and environmental pollution [9-10]. SFVs mostly use locally manufactured unhealthy fat obtained from animal sources, the frequent consumption of unhealthy fats causes cardiovascular diseases and carcinogenic impacts on human health [11].

The relatively high temperature (150-180 ^{o}C) and repeated heating of cooking oil affect the quality by increasing the viscosity, darkening of color, and nutritional changes by altering the fatty acid profile due to hydrolysis, oxidation, thermal polymerization and pyrolytic reactions [12]. Consequently, various by-products including esters, aldehydes, ketones, and peroxides can be produced and absorbed by fried foods [13]. The severity of chemical changes during frying reactions is dependent on duration, method of heat treatment, frying medium, and type of product [14]. A study reported that the fifty repeated heating of sunflower oil (160-200 ^{o}C) for 5 mins on the same day produced low-quality end products [15]. This discarding point can be easily detectable by physical indicators, the oil must be discarded or changed, when it turns dark, produces excessive smoke and a strong odor, and cause the greased texture of the product [13]. Another study also reported that change in the physicochemical properties of the frying oil samples collected from Multan, Pakistan. The results of the study showed that FFA, conjugated dienes, and heavy metals concentrations (cobalt and nickel) were normal, while, peroxide values, Cd, and Pb were more than normal [16]. A recent study conducted in Lahore, Pakistan also reported the quality of fifty frying oil samples being used by SFVs. The results of the study reported that most of the frying oil samples were unhealthy and exhibited higher moisture content (> 0.10 %), total polar content (> 25 %), peroxide value (>10 meq.O2/kg), and free fatty acid (> 0.20 mg KOH/g); and very low IV (< 80 g/100 g) [17]. Another similar study conducted in Faisalabad, Pakistan also reported that fifty oil samples were collected and most of them were found oxidized and degraded [18].

Considering the importance of the literature cited above, the present study was first time conducted in Gilgit (a crowded city in the northern area) of Pakistan to evaluate the knowledge, selection, and oil preferences for frying by the SFVs. The quality of oils used for frying was also analyzed using a set of physicochemical attributes including moisture content (MC), total polar matter (TPM), color determination, free fatty acid (FFAs), and peroxide value (PV), and compared the results with the standard values reported by the PSQCA, Pakistan. Moreover, this study also determined the ratio of rancidity among the oil samples used by SFVs in northern areas particularly Gilgit, Pakistan.

2. MATERIALS AND METHODS

2.1 Sample and Data Collection

In this cross-sectional study, a total of 78 frying oil samples were collected from different SFVs and restaurants present in eight different areas of Gilgit, Pakistan including Ghizer, Sonikot, NLI market, Danyor, Kashrot, bus stand Gilgit, Jutial, and Konodas. The homogeneous samples (approx. 700 mL) were collected in pre-cleaned transparent containers. Collected samples were coded and transported for analysis in dark boxes with ice sheets. Later, the oil samples were filtered and stored at 4 °C for further analysis. To assess the status of frying oil and its handling, a survey questionnaire was compiled to record feedback from SFVs and restaurant workers. The parameters discussed in the questionnaire included the frequency of oil change, hygiene habits of SFVs, awareness regarding rancidity and its impact on human health, and preferences regarding the selection of oil.

2.2 Qualitative Assessment of Fried Oils

For qualitative assessment of fried oils following physicochemical parameters were performed. The tests were performed based on the quality control parameters set by the PSQCA, Pakistan.

2.2.1 Total polar matter

The TPM was analyzed by following the procedure reported by Ghobadi *et al*. [19] using the TPM digital counter (VITO®, Tuttlingen, Germany). The sensor of the TPM counter was placed in heated oil samples (120 °C) and the reading was noted after 30 sec. The sensor indicated the quality of the oil by showing the color; the presence of green color indicated that the quality of the oil is not degraded yet; while the red color indicated the oil has been degraded. Further, the concentration of TPM was determined by the value that appear on the probe.

2.2.2 Moisture content

The MC of the samples was measured by following the method by AOAC: 2005 [20]. The MC in oil samples was determined through drying in a hot air oven at 105 °C. About 50 g of each oil sample was taken into a pre-cleaned and pre-weighed petri dish. The drying was performed for 6 h at 105 °C until the constant weight gain. The difference in weight was calculated by using the formula (1)

$$\text{Moisture content (\%)} = \frac{W_1 - W_2}{W_1} \times 100 \quad (1)$$

Where;

W_1= weight(g) of the sample before drying
W_2= Weight(g) of the sample after drying

2.2.3 Color determination

The 20 g sample of each fried oil at a temperature of 50 ℃ was placed in a transparent petri dish. The digital colorimeter (Chroma Meter, Konica Minolta, Japan) was used to determine the color of the frying oil samples. The sensor of the colorimeter was positioned directly on the light path to measure the R-value and Y-value and compared them with the standard value of 5.0 and 50, respectively, set by the Codex Alimentarius maximum level [21].

2.2.4 Free fatty acids

The production of FFAs was determined by following the method reported by Folayan *et al*.[22] with slight modifications. Pure ethanol (20 mL of 95 %) was added to 10 g of each fried oil sample. A few drops of phenolphthalein as an indicator were added and the mixture was titrated with 0.1 N NaOH. The amount of FFAs in terms of oleic acid oil can be expressed by the formula (2).

$$\text{FFA (\%)} = \frac{V \times N \times 28.20}{\text{Sample weight (g)}} \quad (2)$$

Where;

V= volume of NaOH used (mL)
N= normality of NaOH used

2.2.5 Iodine value

The IV of oil samples was determined following the method of ISO 3961:2009 [23] with slight modification. 0.2 g of oil was dissolved with 20 mL of chloroform the resultant mixture was further mixed with 20 mL of iodine solution and placed in the dark for 30 mins. After that 15 % of potassium iodide (KI) was added to 100 mL of distilled water and mixed with the aforementioned mixture and titrated with 0.1 N of sodium thiosulfate ($Na_2S_2O_3$). Starch was added as an indicator and titrated until transparent. The IV was determined by the amount of iodine absorbed by 100 g of the oil.

2.2.6 Peroxide value

PV of the oil samples was performed by the following method of ISO 3960: 2007 [24] with slight modification. The 5 g of each oil sample was poured into a 250 mL Erlenmeyer flask then the 25 mL mixture of acetic acid and chloroform was added in the ratio of (3:2). After proper mixing, about 0.5 mL KI was added and mixed for 1 min. Afterward, 35 mL of distilled water was added to the same Erlenmeyer flask. The standard starch solution (0.5 mL) was added as an indicator and kept for a half hour in the dark. Then, the mixture was titrated with 0.01 N ($Na_2S_2O_3$) solution until the blue color turned transparent. PV can be calculated by using the formula (3).

$$PV = \frac{(S - B) \times N \times 1000}{\text{Sample weight (g)}} \quad (3)$$

Where,

S = burette reading of 0.01 N $Na_2S_2O_3$ with sample
B = burette reading of 0.01 N $Na_2S_2O_3$ without sample
N = normality of $Na_2S_2O_3$ solution used

2.3 Statistical Analysis

The data analysis was performed on SPSS version 21. The obtained results were analyzed using the z-test method along with their mean value and standard deviation. All the experiments were performed in triplicates. Moreover, the reliability of the survey was analyzed using Cronbach's alpha as the standard value.

3. RESULTS AND DISCUSSION

3.1 Survey-based Analysis by SFVs

A survey questionnaire was designed to evaluate the knowledge, selection, and preferences of SFVs for the oil used during frying. The Cronbach's alpha value with a coefficient of 0.895 indicated that the survey was reliable and can predict the impact of evaluated questions. The parameters studied in the questionnaire include oil quality, mixing of the oil with solid fats, less frequent oil changes, unsanitary methods, and ineffective cleaning methods. According to the results of the survey, the quality of frying oil samples was found poor and SFVs have no information regarding safety practices. This could be due to a lack of knowledge about frying methods and safety practices associated with the oil used for the frying. A full overview of the variables that were discussed in the questionnaire along with the absolute and relative frequency is presented in Table 1.

Table 1 presents that 93.59 % of SFVs preferred to use cooking oil for deep frying of foods and among them, 65.38 % preferred to use sunflower oil as a frying medium, while 6.41 % of SFVs preferred animal fat for frying. Their preference for choosing cooking oil was based on ease of availability and access. About 42.31 % of SFVs tend to add the new oil to used oil to increase the quantity, while 33.33 % of SFVs completely discarded the used oil, the highest trend was observed in Ghizer (11.54 %) followed by Jutial (5.12 %). About 24.36 % of SFVs continued to use the same oil until it cannot be further used. A study is in strong agreement with the current study reported that over the globe, 75 % of plant-based oil (corn oil, sunflower oil, and olive oil) consumption is for the preparation of snack food, frying oils, shortening, and salad dressings [25].

It was also observed that the frequency of frying oil change was mainly dependent on the sale of fried products. If demand increased, the frequency of oil changes increased, otherwise, they used to change it every single day or two days. Table 1 showed that 66.67 % of SFVs changed the oil on daily basis, and 29.49 % SFVs used the same oil for more than 2 days. This practice was performed due to a lack of knowledge regarding the health issues associated with the use of repeatedly fried oil. While 3.85 % of SFVs changed the oil more than twice a day and the highest trend was observed in the NLI market (2.56 %). A supported study conducted in India also presented that almost 25 % of SFVs tend to change their oil regularly while 75 % of SFVs did not change their oil daily or used oil without changing it [26]. Another study is in strong agreement with the current study reporting that SFVs in Ethiopia tend to use recycled frying oil on regular basis. This study also extended that recycled or repeated frying oil (at least five times) significantly increased the body weight of rats during the cell line studies [27].

Colour plays important role in determining the physical quality of oil used for frying. About 72 % of SFVs fully utilized the oil daily without considering the change in color of oil; where the highest trend was observed in Ghizer (30.76 %), followed by Danyor (10.25 %), NLI market (8.97 %), Sonikot (7.69 %), Konodas and Kashrot (6.41 % each) and Jutial (1.28 %). While the remaining 28 % of SFVs used the oil until its appearance turned fully blackish.

The behavior of SFVs towards the disposal of used cooking oil showed that 62.82 % of SFVs disposed of used oil in open drains. This practice was mostly observed in Ghizer, Sonikot, NLI market, Danyor, Kashrot, bus stand Gilgit Jutial, and Konodas. About 26.92 % of SFVs discarded the used oil in open fields and 14.10 % of SFVs disposed of the used oil in a separate container. A similar study in Harare, Zimbabwe reported that 93 % SFVs used to discard the waste food in waste bins, while 7 % discarded all the leftovers and waste food in unspecified places on regular basis [28].

The results related to the knowledge of SFVs regarding the rancidity of oil showed that 51.28 % of SFVs found with no knowledge of the rancidity of frying oil, which highest trend was observed in the NLI market (11.53 %) followed by Ghizer

(8.97 %), Danyor (7.69 %), Kashrot and Jutial (6.41 % each), bus stand Gilgit and Sonikot (3.84 %) and Konodas (2.56 %). About 37 % of total SFVs had little knowledge about the impact of rancid oil on human health and it was found that only 1.28 % SFVs were fully aware of the impact of consuming rancid oil on human health.

The trend of using PPE while working was also observed among SFVs. The results showed that 83.33 % SFVs were not using any kind of PPE during frying practices. Only 12.82 % SFVs responded that they have easy access to PPE and were using it as per the requirement. Among them, 3.85% of SFV responded that they have easy access to PPE but never use them because they found the use of PPE uncomfortable while frying. Table 1 showed that 61.54 % have little knowledge about hygiene practices, and only 25.64 % of people were fully aware of personal hygiene and safe handling, while 12.82 % SFVs were found completely unaware. The current study was in agreement with a study conducted in Lucknow, India, where 94 % of the SFVs practiced selling their foods without wearing gloves, and 96 % of the SFVs don't wear headcovers [26]. Another study is in support of the current study, which reported that due to improper safety knowledge, SFVs used to prepare their foods in explicitly unhygienic conditions [29].

The results for the usage of new oil for different food products are also present in Table 1. About 85.90 % SFVs do not prefer to use new oil for frying of variety of food products instead of it they mixed each frying product in the same oil and 8.97 % of SFVs change oil for different food products regularly. Table 1 also showed that 61.54 % of SFVs preferred to use LPG as their source of ignition. While 38.46% SFVs preferred to use wood for ignition and the highest trend was observed in Ghizer (29.44 %) followed by Kashrot (3.84 %), Sonikot, and Jutial (2.56 %). The trend of using vegetable oil instead of animal fat was also observed and 93.59 % were found associated with it. While 6.41 % of SFVs preferred to use animal fat for frying because they considered it a good source for taste enhancement. A study also supported the current results, which presented that restaurant workers and roadside SFVs of Okota, Lagos State Nigeria, preferred to use plant oils. This study further presents that total phenolic content, vitamin E, and vitamin A contents were found significantly lower in oil samples collected from roadside SFVs and fast food restaurants as compared to the unused oil [30].

3.2 Qualitative and Physicochemical Analysis of Frying Oil Samples

3.2.1 TPM of fried oil samples

The mean TPM values of different fried oil samples are presented in Figure 1. The development of TPM is a predominant indicator to estimate the deterioration in frying oil. The repeated heating frequency induces chemical changes in oils including hydrolysis, oxidation, polymerization, and isomerization [14]. After determining the TPM of all oil samples, the values obtained were in ranged from 17.17 ± 4.28 to 23.36 ± 2.45. The TPM results presented in (Figure 1) show that the values were significantly higher ($p = 0.00$) than the standard values set by PSQCA (< 18 %). Out of 78 samples, only 4 samples (5.12 %) from Sonikot 17.17 ± 4.28 were under the PSQCA limits and considered fine quality and 74 samples (94.87 %) were not fulfilling the PSQCA standard criteria.

It was concluded that with the increased frying time and high-temperature exposure, the TPM of oil samples get increased. A similar study also presented the significant correlation between the TPM and frying, with the overheating of oil at high temperatures more polar matter is produced due to the heat decomposition of chemical substances [31].

3.2.2 MC of fried oil samples

The mean MC values of different fried oil samples are presented in (Figure 2). MC values obtained from different fried oils samples ranged from 0.08 ±0.05 to 0.24 ± 0.08. The values indicated that most of the oil samples for MC were under the limit as set by the PSQCA (0.15 %) except for the three samples that were deviating from the standard limits. Overall, there was a non-significant relation ($p = 0.51$) observed among the MC of frying oil samples. The highest value was reported in the NLI market at 0.24 ± 0.08 followed by Gilgit bus stand 0.2 ± 0.10, Kashrot 0.16 ± 0.08, Konodas 0.118 ± 0.116, Jutial 0.11 ± 0.13, Danyor 0.10 ± 0.11, Sonikot 0.101 ± 0.07 and Ghakuch 0.08 ± 0.05. Possible reasons for higher moisture content

Table 1. Results of survey-based analysis of fried oil samples collected from restaurants and SFVs in Gilgit, Pakistan (N =78)

Variables	Absolute frequency (N)	Relative frequency (%)
Preference for frying		
Cooking oil	73	93.59
Animal fat	5	6.41
Any Other	0	0.00
Reason of preference		
Quality	51	65.38
Availability	16	20.51
Price	11	14.10
Utility of oil per day		
Dispose of it	26	33.33
Mix it in new oil	33	42.31
Continuously use it	19	24.36
Frequency of oil change		
2 or more times a day	3	3.85
Daily	52	66.67
More than 2 days	23	29.49
Physical parameters use to change the oil		
Blackish appearance	22	28
Fully utilization	56	72
Other	0	0
Where used oil was disposed		
Drain	49	62.82
Separate container	11	14.10
In open field	21	26.92
Knowledge of rancid oil's impact on human health		
Yes	1	1.28
Little knowledge	37	47.44
No	40	51.28
Trend of using personal protective equipment (PPE)		
Available and use	10	12.82
Not available	65	83.33
Available but don’t use	3	3.85
Knowledge about personal hygiene and handling		
Fully aware	20	25.64
Somehow	48	61.54
Not at all	10	12.82
Usage of oil for different items		
Yes	4	5.13
Sometime	7	8.97
No	67	85.90
Medium of heating		

Variables	Absolute frequency (N)	Relative frequency (%)
Wood	30	38.46
LPG	48	61.54
Kerosene oil stove	0	0.00
Usage of animal fat for frying		
Yes	5	6.41
Somehow	0	0.00
No	73	93.59

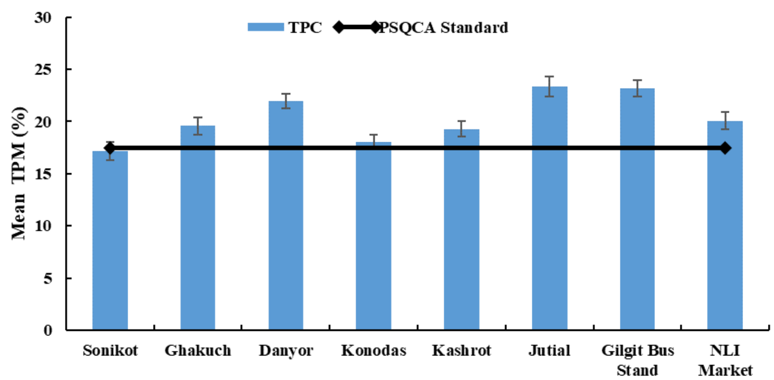

Fig. 1. Mean TPM obtained from oil samples from different SFVs.

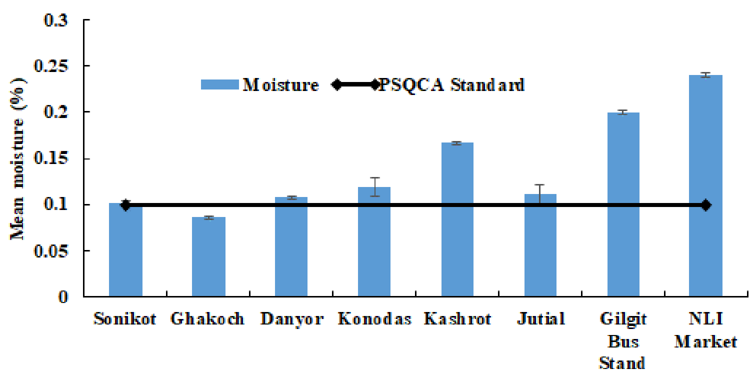

Fig. 2. Mean MC mean values obtained from oil samples from different SFVs.

might be poor packaging, storage conditions, and extensive exposure to light and high temperatures which commonly exist in the Pakistani climate. The present study is in agreement with the findings of Sanli *et al*. [23] that the initial high MC induces more enzymatic hydrolysis in oils due to more activity of the lipase.

3.2.3 FFA of fried oil samples

FFA values obtained from fried oil samples ranged from 00.26 ± 0.16 to 0.52 ± 0.21 % and are shown in (Figure 3). FFA analysis showed that all values significantly deviate ($p = 0.00$) from the standard values of PSQCA (≤ 0.02 %). The highest trend was observed in Ghakuch at 0.52 ± 0.21 % followed by NLI Market at 0.46 ± 0.20 %, Kashrot at 0.35 ± 0.23 %, Gilgit Bus Stand at 0.33 ± 0.15%, Danyor at 0.31 ± 0.15 %, Jutial 0.28 ± 0.16 %, Konodas 0.28 ± 0.13 % and Sonikot 0.26 ± 0.16 %. The presence of increased FFA tends to cause toxicological effects on human health such as obesity and type 2 diabetes mellitus. This study is in close relation to the study presented by Sebastian *et al.* [33] reported that about 30–35 % of in-use frying oils and 45–55 % of discarded oil samples were not acceptable, that were collected from restaurants in downtown Toronto, Canada. The possible causes are excessive hydrolysis and oxidative reactions in oil samples due to extensive frying, exposure to light, lipase activity, and high temperature. The poor neutralization process and hydrolysis of triglycerides and deterioration of oil also increase the amount of short-chain free fatty acids [34].

3.2.4 Color of fried oil samples

The color of the cooking oil is due to carotenoids, zeaxanthins, and other coloring pigments. The standard value of colors set by PSQCA is Y:50-R: 5.0 while the mean observed values in fried oil samples were Y: 54.2, R: 6.05. Color values for oil samples deviated significantly ($p = 0.00$) from standard values (Figures 4a and 4b). The redness of cooking oils is mainly due to the formation of polymers and the yellow color is due to combined peroxide and aldehydes in cooking oils. Another factor is the lipase enzyme, which promotes hydrolytic rancidity with the production of FFA and free radicals which significantly affects taste, color, and aroma by breaking the ester bond [34].

3.2.5 IV of fried oil samples

IV is the relative degree of unsaturation of fatty acids that are part of triacylglycerol in oil components and are used for the classification of oils [35]. The recommended IV is (not less than 80 g/100 g of iodine) for vegetable oil blends according to PSQCA and the value decreased with overheating. The average comparison of IV between different areas of Gilgit, Pakistan (Figure 5) concluded that the NLI market with a maximum value of 87.3 ± 3.7 followed by Danyor 76.2 ± 3.8, Sonikot 75.7 ± 3.3, Jutial 68.6 ± 3.4, Gilgit bus stand 59.7 ± 5.1 and Kashrot 59.2 ± 4.9. Results showed that IV of all areas did not fall under the limits of PSQCA and only NLI is near the limits. This was because of the multiple deep-frying practices performed that led to a higher unsaturation, and the presence of a higher amount of trans fatty acids in the oil. A study also reported the IV for olive oil, palm oil, corn oil, soya bean oil, sunflower oil, and peanut oil in the range of 75-90, 50-55, 103-135, 120-143, 110-143 and 84-105, respectively [36]. The study also concluded that the decrease in the IV indicates oxidative stress and physicochemical changes during frying which is considered an important quality indicator.

3.2.6 Peroxide value of fried oil samples

PV is considered the measure of active oxygen species bounded by cooking oils [34]. PV helps to estimate the amount of oxidation as it reacts with other molecules resulting in aldehydes and ketones responsible for the development of off-flavor. According to PSQCA, the recommended level of POV is 10 meq/kg (PSQCA, PS:2858-2003). The mean PV of collected oil samples from different areas of Gilgit is presented in (Figure 6). The results showed a significant difference ($p = 0.00$) in the PV of all oil samples. The high trend of PV was observed at Sonikot at 16 ± 5.3 followed by NLI Market at 15.2 ± 2.3, Jutial at 12.6 ± 7.4, Danyor at 11.7 ± 5.2, Kashrot at 10.5 ± 7.6 and Gilgit bus stand 7.5 ± 6.5. Potential reasons for higher PV could be poor packaging, improper storage conditions, and cooking oils rich in unsaturated fatty acids especially linoleic and linolenic acid. Phenolic compounds and antioxidants tend to suppress the oxidation of cooking oils but their activity is lost due to extensive heating. A study also reported that the PV of corn oil increased to 11.9 meq/kg after 3rd frying, where the PV of 27 out of 35 samples was above the acceptable level [19]. The results of the current study also supported the findings of Mudawi *et al.* [37] in which an increase in PV was reported due to the continuous deep-frying of oil [37-38]. Another similar study conducted in Kasmir, India reported the higher degradation of the 16 fried oil samples with a high PV than the standard value (>10 meq/kg) [39].

3.3 Comparative Analysis of Frying Oils Quality

In this study, a z-test was carried out along with descriptive statistics and correlation analysis while studying all the parameters. z-test was considered an appropriate statistical technique. In this study, 78 samples were statistically analyzed in triplicates and the mean value, standard deviation, z-value, and p-value were at a significant level. The comparison of results from the physicochemical analysis is presented in (Table 2). The results of the survey- analysis predict the negative impact of consuming food products fried in degraded oils and SFVs are not aware of the health effects. The results of the TPM showed an extremely significant difference between mean values ($p = 0.00$) and 94 % of oil samples were found beyond the PSQCA limits. In agreement with this study, another study

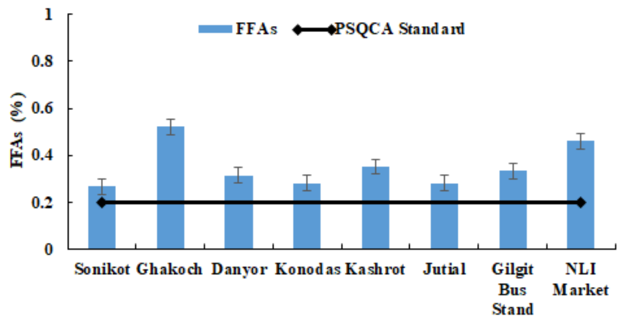

Fig. 3. Mean FFA obtained from oil samples of different SFVs.

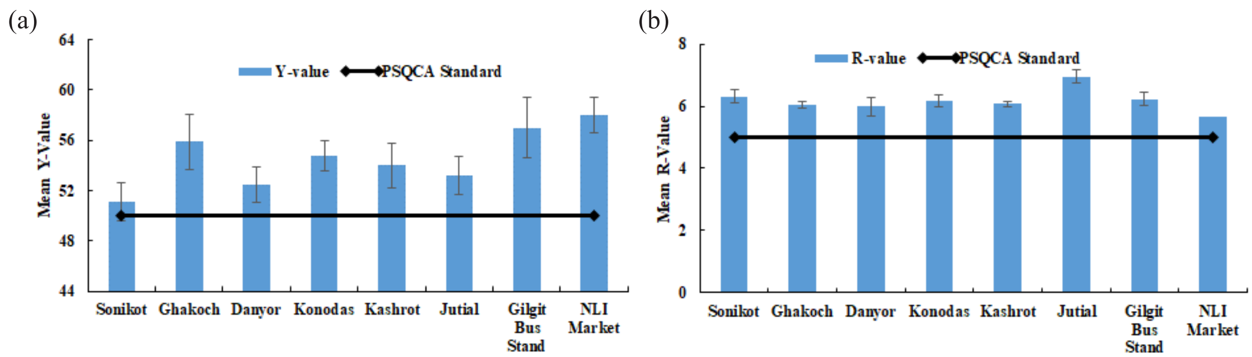

Fig. 4. Colour values of different oil samples (a) R values and (b) Y values.

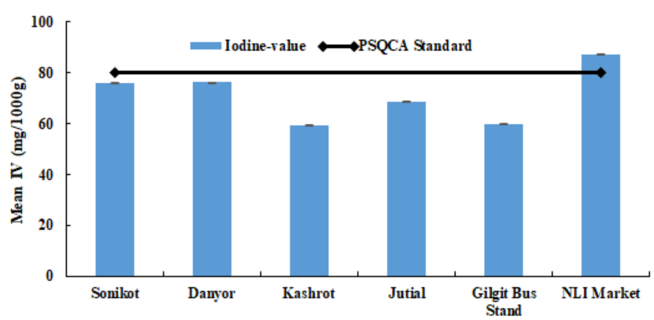

Fig. 5. Mean IV obtained from oil samples of different SFVs.

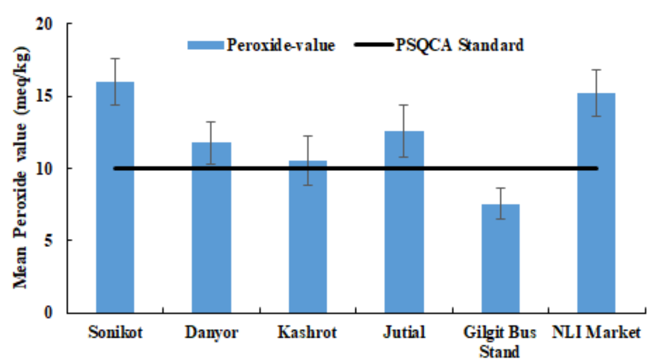

Fig. 6. Mean PV obtained from oil samples of different SFVs.

Table 2. Statistical analysis and comparison of all physicochemical parameters used for qualitative testing of fried oil samples.

Parameters	Test value	Mean	SD	*z* value	*p* value	Results
TPM	17.5	19.5	4.28	4.21	0.00	Significant
Moisture	0.15	0.11	0.09	0.65	0.51	Insignificant
FFA	0.20	0.35	0.19	6.72	0.00	Significant
R-value	5.00	6.05	1.48	6.25	0.00	Significant
Y-value	50.0	54.2	5.37	7.04	0.00	Significant
IV	80.0	87.3	2.54	14.4	0.00	Significant
PV	10.0	14.5	2.71	8.30	0.00	Significant

by Kaimal *et al.* [40] reported that there was a significant increase in TPM values found in frying soil samples collected from restaurants in India. It is predominantly highlighted here that TPM exhibit a strong correlation with the number of frying cycles and frying time, this is also in line with studies discussed in previous literature [31-41]. Further, the rate of TPM can be lowered in palm oils due to less unsaturation as compared to soya bean and sunflower oil [31-41]. The results of MC present insignificant relation with frying ($p = 0.051$) and concluded that MC is least affected by frying [31]. On the contrary, results for FFA showed a significant relationship between the high temperature during frying and extended time for all oil samples ($p = 0.00$).

These results are in strongest agreement with the previous study that reported, an increase in frying temperature tends to increase thermal oxidation and oligomerization reactions for fatty acids in oils [42]. Another study also showed that during the thermo-oxidation of oil at frying temperature (> 180 ^{o}C), the amount of polyunsaturated fatty acids (PUFA) decreased (reached 6.21 %) with the increase in short chain fatty acids (SCFA) and trans fatty acids with the increase in frying time [43]. Furthermore, the change in R-value and Y-value also validates the significant relation of change in the color of oils at high frying temperatures ($p = 0.00$). Moreover, PV and IV also showed a significant relation with frying oil samples ($p = 0.00$). A similar study in past also reported that the increase in frying time of lipids particularly oils significantly affects the PV in fried clams with concurrent reduction of docosahexaenoic acids and eicosapentaenoic acids that indicate extensive oxidative degradation [44].

4. CONCLUSION

The quality of oils used for frying and fried food items is intimately bounded. The extensive thermo-oxidation and high-temperature cooking degraded the quality of oils. The present study was conducted to develop the combined effect of practices of SFVs while frying and the chemistry of frying oil. For this purpose, the quality of fried oil was evaluated through 78 random samples collected from various SFVs and restaurants in different areas of Gilgit. The results showed that SFVs preferred to use low-quality oils because of low prices and easy availability by compromising the quality. The frying oil was changed infrequently and the used oil was combined with new oil rather than discarded, which can jeopardize the customer's health. The z-test scores of all parameters present that the quality of 78 % of fried oil samples varies from the standard values set by PSQCA, Pakistan. The majority of the frying oil samples exhibited exceedingly high levels of degradation based on TPM, FFA, color, IVs, and PV values. Based on the results, we found that the oil used for frying purposes among SFVs in Gilgit, Pakistan is mainly rancid and this is due to their lack of knowledge about hygienic and sanitary practices. It is recommended that a high-level awareness is required among SFVs and customers on hygienic practices and associated health concerns. To implement suitable frying processes in fast food restaurants, food operators must be trained. It would also be preferable if policymakers designed education initiatives in combination with increased awareness from regulatory bodies that could aid in the improvement in Gilgit, Pakistan. Regulatory bodies must ensure quality control on SFV practices and should often monitor for the sake of public health interests. It is also suggested that prior to receiving a restaurant license, sufficient training and awareness sessions must be conducted. The current research can be extended further by evaluating the quality of and nutritional evaluation of the oil absorbed by fried food items because the present situation is found quite alarming.

5. CONFLICT OF INTEREST

The authors declared no conflict of interest in writing this article.

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