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PHYSICOCHEMICAL PROPERTIES AND CONSUMER ACCEPTABILITY OF REUSE OIL FOR FRYING FAST FOOD IN RESTAURANT IN BAUCHI, METROPOLY.

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Abstract

The present study was carried out to investigate the degree of rancidity and quality of reused cooking oil for frying fast food such as fish, beans cake, potatoes, maza (fermented puff batter) and doughnut, in Bauchi State, Nigeria. 100ml of reused cooking oils from each food sample were collected from five (5) different fast food restaurants. Physicochemical properties of each sample of reused oil were analyzed has followed: acid value (6.02-16.06 mgKOH/g), peroxide value (18.09-38.12 mEqv/kg), Iodine value (2.56-6.04mEqv/kg), saponification value (186.25-210.07mEqv/kg), Free fatty acid (2.44-8.12%), moisture content (2.40-2.80 %)and viscosity (22.14-48.22mm^2/S) respectively. The results obtained for sensory properties for reused cooking oil suggested that there was significant ($p>0.05$) in the level of rancidity. Due to hazardous secondary oxidative products which make it unsafe for human consumption. The reason given for this is that the oil has been used for frying for too many times instead of the recommended two times. The values obtained in this study far exceeded the stipulated standard acceptable ranges given by WHO, FAO and INSO. It is therefore recommended that there should be awareness and education among the fast food seller on the reuse of cooking oil for frying food products. In the same vein, public should be advised and oriented that oil that has been used for frying food items twice should be discarded and food from such oil be avoided. Also, Policy makers and relevant authorities should pass a bill and to determine when frying oils should be discarded and consider the consumption of over degraded oils as a public health hazard.

KEYWORDS: Reuse, physicochemical, fast food, restaurant, frying

1.0 Introduction

Frying is one of the most common methods used for preparation of foods throughout the world.

It over heat is a very popular method used by many to give a golden brown, tasty and delicious food (Meyer, L., *et al*., 2018). In Bauchi, like many other states in Nigeria, there has been a steady increase in the consumption of fried foods because of the high demand for such foods as a result of changing lifestyle, growth in the number of working women, and rapid expansion of fast food centers. Fast food is termed as a food obtained from restaurants and other catering establishments, where the aim is to provide a fast service and rapid customer turnover at reasonable prices. They are easily served and prepared by energy-efficient cooking methods and increase palatability due to fat absorption, crust formation, pleasant flavors, and odors. The importance of edible oils in industries such as foods, energy, cosmetics, pharmaceuticals, or lubricants has been well documented.

The assessment and monitoring of the quality of fat and oil used for preparing foods is of special importance as it affects the taste, odor, texture, and quality of the food. Physicochemical properties are an important factor that determines the overall quality and stability of a food system. It has been shown that for vegetable oils, density decreases linearly with temperature increasing (Esteban, E. *et al*., 2012). Density, saponification value, iodine value, acid value, peroxide values are some of the important characteristics of a vegetable oil.

Physicochemical properties of different types of edible oils have been presented in literature (Toscano,G. et al., 2012, John, N. *et al*., 1997, Gaikwad, R.D and Swamy, P.,2008 and Rodenbush,C.M, 1999). Physical properties of vegetable oils depend primarily on composition and hence on biological origin and temperature (John, N. *et al*., 1997).

The physical and chemical properties of edible oil influence the degree of oxidation and hydrolysis reactions, which occur during frying. It is known that the frying oils used continuously or repeatedly at high temperatures in the presence of oxygen and water are subject to thermal oxidation, polymerization, and hydrolysis, and the resultant decomposition products can adversely affect the flavor and color of the foods. Their stability depends on the composition of fatty acids and natural antioxidants, as well as the frying temperature (Crosa, M.J., *et al*., 2014).

During the frying process, different by-products including alcohols, cyclic compounds, polymers, dimers, and free fatty acids are produced as a result of oxidation and hydrolysis reactions, which have adverse impacts on human health (Chen,W.A., *et al*, 2013). Also, they play important roles in the flavor, texture, and aroma acceptability of the fried products (Li,Y., Ngadi,M., and Oluka,S., 2008). Due to the relatively high temperature of frying (150–180°C) and repeated heating, various undesired chemical reactions such as fission, hydrolysis, oxidation, polymerization, and pyrolysis occur very rapidly in triacylglycerol (Aladedunye,F.A., 2015; Zhang, Q., *et al* 2012). These reactions result in other transformations in the physicochemical properties of the frying oil including its appearance (color, smell, foaming, viscosity, and density) and nutritional characteristics (increase in trans fatty acid [TFA] content, polar materials, and polymeric compounds and decrease in unsaturated fatty acid [USFA] compounds; Al-Harbi,M., and Al-Kahtani,H.A., 1993). Consequently, various by-products, such as esters, aldehydes, ketones, and peroxides that can be absorbed by the foods, are produced (Saguy, I.S., and Dana,D., 2003). Peroxide is the first compound that is produced after oxidation of fats and oils. It can have negative impacts on human health and may contribute to different diseases such as cardiovascular diseases (CVDs), cancers, allergies, and obesity (Pizzino, G., *et al*., 2017). During deep frying, different reactions occur depending on the factors such as replenishment of fresh oil, frying condition, and the original quality of the frying oil. Oil storage and cooking conditions can also produce a variety of materials due to oil oxidation and polymerization and thus contribute in the incidence of non communicable diseases (NCDs; Mozaffarian, C, *et al* 2006; Oyagbemi, A.A., Azeez,O., and Saba,A., 2009). Also, some investigations about the negative effect of TFAs and SFAs on health, especially on coronary heart diseases (CHDs), have been conducted (Oomen, C.M., *et al*., 2001).

Two irreversible processes including hydrolytic and oxidative rancidity determine the chemical stability of the frying oil, which affect the oil turnover during the frying process. Therefore, the quality of utilized frying oils and the factors that can influence their heat resistance are also important in order to monitor the quality of fried foods in fast food restaurants (Sebastian, A., *et al*., 2014).

Various criteria are being used to judge when the frying oils need to be discarded. In restaurants and food services, changes in the physical properties of frying oils are considered as an indicator of oil quality. For instance, the frying oil may be discarded when it becomes dark, causes too much smoke, produces strong odor and greased texture, or when a persistent foam layer of the specified thickness is observed (Moreira,R., Castell-Perez,M., and Barrufet,M., 1999). There is no agreement among different authors on the limits of color changes in frying oils because changes in their color depend on the oil variety, duration of exposure to light and heat, and the food itself. However, the information or protocol about discarded oils is limited.

The presence of metals in vegetable oils depends on several factors. They might come from the soil, environment, and genotype of the plant, fertilizers, and metal-containing pesticides, introduced during the production process or by contamination from the metal processing equipment (Jamali, *et al*., 2008).

Deep frying is especially of concern because the oil from shallow frying are reused at very high temperatures for longer period which is why high stability oil is preferred for snack foods requiring a long shelf-life (Fateneh, E. *et a*l.,2019). The degradation of the frying oil produces harmful compounds, which are absorbed by the snacks and for this reason the discard point of the frying oil is very important (Chaudan, P. and Suri, S. 2021, Karini, S, Wawire, M. and Mathooko, F.M. 2017). Claims of nutritional implications of the consumption of oxidized fats and oils are varied. The symptoms of rancid fat toxicity are diarrhea, poor growth rate, myopathy (replacement of healthy muscle with scar tissue), hepatomegaly (enlarged liver), steatites or yellow fat disease, hemolytic anemia and secondary deficiencies of vitamins A and E. Evidence exists that dietary oxidation products are involved in arterial injury, artherosclerotic plaque formation and thrombosis/spasm which are potentially dangerous (Tony, A.2015). With the growing concerns for diets and public health, this study was undertaken to investigate the quality of some fried foods (fishes, beans cake and potatoes) sold and consumed in road side restaurant in Bauchi, Bauchi State, Nigeria.

2.0 Materials and Methods

2.1 Materials

All reagents used are of analytical grade.

2.2 Sample preparation

In this study, samples of reused frying oils were collected randomly from five (5) fast food restaurants in five different locations (Gwalameji,Yelwa, D/pack junction, Wunti market and

Muda Lawan market) who are selling different fast food products (fishes, beans cake, potatoes, maza(fermented-puff batter),dough nut). The level of rancidity and quality of reused oil in fast food restaurants was assessed by conducting an interview with the fast food restaurants' chefs about the used oil type, frequency of changing the oil in the fryer, frying methods, filtering methods. 100ml of reused samples of oil were collected from each location and labeled. Then, they were passed through the paper filter to a dark-colored PET container (to prevent chemical changes). Subsequently, the encoded samples were transported in a cooler box with ice sheets to the food laboratory where the oil samples were filtered and stored at 4°C. The samples were analyzed after 4hr. All measurements were replicated three times.

2.3 Determination of Acid Value

Acid value is defined as the mg of KOH necessary to neutralize the free acids present in 1gm of fat or oil. Acid value was determined by mixing 50 ml diethyl ether and 50 ml ethanol and 2 ml of 1% phenolphthalein. To the mixture was added 0.1 M KOH for neutralization. Five (5 g) of the sample extracted oil was dissolved in the neutralized solvent mixture. Titration was carried out using 0.1 M KOH as the titrant. The end - point was indicated by a change in colour of the solution to pink colour. Finally, the acid value was calculated based on the sample weight (Equation 1). If the acid value is less than one (1), the oil is safe, and if the value is more than one (1), the oil is unsafe and has become rancid (Sanchez M., and Muniz F.J. (2006)).

$$Acid\ Value = \frac{Titre\ value\ x\ 5.61}{Weight\ of\ oil\ used\ mg\ KOH/g}$$

2.4 Determination of Peroxide Value

It is defined as the amount of peroxide oxygen generated per 1 kilogram of fat or oil expressed in milliequivalents or millimoles per kilograms. Peroxides are the intermediate compounds synthesized during autoxidation reaction; the peroxide value is therefore a measure of the degree of oxidation reactions (rancidity) in food samples. Autoxidation is a free radical reaction involving oxygen that leads to deterioration of fats and oils, which is responsible for off-flavour and off-odours.

5 g of the sample extracted oil was added to 30 ml of acetic acid: isooctane (3:2) solution followed by swirling and then addition of 0.5 ml potassium iodide. The solution was swirled again for 1 min. The peroxides oxidized the iodide to iodine, and the iodine was titrated against 0.1 N sodium thiosulfate solution with 1 ml starch (10%) as an indicator. The amount of produced iodine was directly proportional to peroxide value (INSO,2018). The peroxide value

was calculated with regard to the amount of used thiosulfate (Equation 2). If the value is less than 5mEq/kg, the oil is safe, if the value is between 5-10, the oil is usable and not preserveable, and if the value is more than 10, the oil is unuseable and rancid.

$Peroxide\ Value = 2\ (a-b)/W$ mEq/kg

2.5 Determination of Free fatty acid profiles

Fatty acid methyl esters (FAMEs) were prepared from 0.5 g of oils according to ISO 12966 (2011). Then, they were analyzed using gas chromatography (GC) (Agilent 6890 GC, carrier gas Helium, flame gas H2, column HP-88: 100 m) with a flame ionization detector (FID). The initial oven temperature started at 180°C, hold for 5 min, increased at the rate of 1°C/min to 190°C, hold for 20 min, then increased at the rate of 1°C/min to 200°C, and then hold for 17 min. The FID temperature was 220°C, the injection temperature was 210°C, and the retention time was 62 min. The quantification was done by comparing the peak area/height of lipid standards in the sample normalization system ("International Organization for Standardization (ISO), Animal, and vegetable fats and oils—Gas chromatography of fatty acid methyl esters," 2011; Saghafi, Z., *et al*., 2018).

2.6 Determination of Iodine value

The iodine value (IV) indicates the degree of unsaturation of the oil. It is defined as the number of grams of iodine absorbed by 100 grams of oil.

The iodine value was determined using Hanus method. The oil sample taken into a glass stopper iodine flask is dissolved in chloroform. The measured volume of Hanus reagent is accurately added and after thorough mixing, it is placed in the dark for exactly one hour. A corresponding blank reagent is simultaneously prepared. At the end of the specified time, the reaction is stopped by adding potassium iodide and diluted with water to prevent loss of the free iodine. The amount of free iodine is determined by titration with sodium thiosulfate using starch as indicator.

The iodine value was calculated with the

Equation: $IV = \frac{V1-V2 X 0.01269 X 100}{m}\ \{\frac{I2\ g}{Sample\ 100g}\}$

where IV represents iodine value, (g I2/100 g sample); 0.01269 - number of grams of iod corresponding to 1 mL of sodium thiosulfate solution, (g); V1 - volume of sodium thiosulfate solution used for the blank reagent, (mL); V2 - volume of sodium thiosulfate solution used for the sample, (mL); m - weight of the oil sample (g) (Fatemeh, E., *et al*., 2019).

2.7 Determination of saponification value

The saponification value (SV) is defined as the weight of potassium hydroxide, in milligrams, needed to saponify one gram of oil. The method for saponification value determination is based on the oil sample saponification by refluxing with a known excess of alcoholic potassium hydroxide solution.

The alkali required for saponification is determined by titration of the excess potassium hydroxide with standard hydrochloric acid, in the presence of phenolphthalein as indicator. A corresponding blank reagent is simultaneously prepared. The saponification value was calculated with the equation: SV= $\frac{28.055(VI-V2)}{m}\{\frac{KOHmg}{Sampleg}\}$

Where SV represents saponification value, (mg KOH/ g sample); V1 - volume of standard hydrochloric acid required for the blank reagent,

2.8 Moisture content

Moisture Content determination by AOAC, (1995). Dry oven at 105ºC for 4 hr. At the end, the samples was removed from the oven and placed in desiccators and after getting cool, the samples weighed again to calculate the moisture content in the samples. The process of drying, cooling and weighing was repeated until a constant weight (W2) is obtained. The weight loss due to moisture was obtained using equation 3:

$Moisture$ (%)=100 ($w1 - w2$)

2.9 Viscosity measurement

The viscosity reveals the rate of flow of the oil. It is an indicator of polymerization after frying. The viscosity of the extracted oil sample was measured using a DV-I Prime viscometer, Spindle number 2 (Brookfield), and constant shear rate = 100 1/s. The viscosity of the oil was carried out at room temperature. AOAC, (1990)

2.10 Sensory evaluation

Sensory evaluation was conducted using a trained panel consisting of twenty members who are familiar with different fast food products. The Panelists were instructed to evaluate the coded samples for appearance, aroma, taste, color, and overall acceptability. Each sensory attribute was rated on a 9- point hedonic scale (9 = like extremely and 1 = dislike extremely) (Ekanem and Ojimehkwe, 2017).The fast food samples were served in 3-digit coded white plastics. The order

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of presentation of samples to the panelists was randomized. Sensory evaluation was carried out under controlled conditions of lighting and ventilation.

2.11Statistical analyses

The data obtained were subjected to Analysis of Variance (ANOVA), while Duncan Multiple range test was used to separate means where significant differences existed, data analyses was achieved using the Statistical Package for Social Statistics (SPSS) software version 20.0. All analyses were performed in triplicate determination.

3.0 Result and Discussion

Table 1: Physicochemical properties of reuse oil used for frying fast food in restaurant

Parameters	AAI	BCI	PTI	MZI	DNI
Acid value (mgKOH/g)	16.06	14.10	8.04	6.02	14.11
Peroxide (mEqv/kg)	38.12	24.13	28.06	18.09	32.16
Iodine value (mEqv/kg)	6.04	4.39	4.04	2.56	5.22
Saponification (mEqv/kg)	210.07	192.14	186.25	188.02	200.05
Free fatty acid (%)	8.12	4.84	3.60	2.44	6.02
Moisture content (%)	2.00	1.60	1.80	1.84	1.40
Viscosity (mm^2/S)	48.22	34.14	32.06	30.14	36.42

Data were summarized using frequency (%) for categorical variables, mean (±*SE*). *p*-Values <0.05 were considered as statistically significant.

KEY:

AAI: The reused vegetable oil for frying fish

BCI: The reused vegetable oil for frying beans cake

PTI: The reused vegetable oil for frying potatoes

MZI: The reused vegetable oil for frying maza (fermented puff batter)

DNI: The reused vegetable oil for frying doughnut.

The acid value is a measure of the free fatty acids content of the oil. The acid value of the different oil samples from different fried food showed that the degree of deterioration of the oil was very high. The least acid value obtained was 6.02 mgKOH/g and the highest is 16.06 mgKOH/g which when compared to the standard as given by the WHO (≤ 0.6 mgKOH/g) is very high. The United States Department of Agriculture and some European Countries have regulatory guidelines on maximum free fatty acid levels in frying oil, ranging from 1.0% to 2.5% (Bailey,A.E., and Shahidi,E. 2005; Sebastian, A. *et al*., 2014).

Acid value is used as a general indication of the condition and edibility of oil; it also quantifies the acidity of a substance. When oil has low acid value it shows that the nutritional value of the oil is still potent and when used in soap making will give a product that will have high cleansing ability. The results obtained for the acid value in this study showed, that the oil has deteriorated in nutritional value and become rancid. Acid value is a relative measure of rancidity as free fatty acids are normally formed during decomposition of triglycerides. Free fatty acids are produced by the hydrolysis of fats and oil. Therefore, the higher acid value in this study was has a result of continuous usage of frying oil for a couple of weeks. Even, if the color changes to black the refuse to discard the oil.

Peroxide value is the most common indicator of lipid oxidation. The reused vegetable oil for frying fishes (AAI) is characterized by greater PV values of 38.12 (mEq/kg) compared to maza (MZI) with least value of 18.09 (mEq/kg), which is higher than the stipulated standard recommended by WHO and FAO (10 mEq/kg). This can be caused by many factors such as oil type, amount of antioxidants, storage life and conditions, and also temperature in the frying process. Peroxide value gives the initial evidence of rancidity in unsaturated fats. It is also a measure of the extent to which an oil sample has undergone primary oxidation, especially during storage. Freshly refined oils usually have a PV lower than 1 mEq/kg oil, while at a PV of above 10 mEq/kg oil, the oil is considered to be oxidized (Gunstone,F.D., 2008; Sebastian, A., *et al*., 2014). Similar studies showed that most oil used for fried snacks food have higher peroxide value than the standard limit (Farrokhzadeh, H., *et al*., 2018, Arbabi, M., and Deris, F., 2011, Mohammadi, N., *et al*., 2013 and Pounahmoudi, A., 2008). It has been shown that an increase in temperature can cause a reduction in PV due to the decomposition of hydroperoxides. The amount of production and failure of hydroperoxides in oil depends on the temperature, time, and composition of the fatty acids. Because peroxide test is a function of the unstable nature of hydroperoxides, it cannot be used solely as an accurate indicator of the amount of oxidation of oils and fats (Navab Daneshmand,F., and Ghavami,M., 2012). In fact, the primary oxidation products rapidly break down into secondary oxidation products, and thus, their total accumulation in the oil could be greatly underestimated (Kubow,S., 1992). Therefore, PV may not indicate the actual extent of oil deterioration and is not recommended for measuring oil deterioration during the frying process (Farhoosh, R. and Moosavi, S.2010). However, quantitative findings showed that most fried snacks food sellers use either the same oil over and over again which leads to the loss of its nutritional value and formation of secondary oxidative products. These secondary oxidative products have health implications and effects which include cancer, heart attack, ageing, oxidative stress and even death. Frying processes in many cases release water / moisture which greatly affect the peroxide value. The presence of moisture water reduces the shelf life of both the oil and the product.

The iodine value is an indicator of the degree of unsaturation, a great value of IV indicating oil prone to oxidation. The unsaturated character affects the stability of oils, and, as a result, leads to the appearance of degradation effects during storage. From the studied, the oil used for frying fish is characterized by the greatest IV due to the high fat contents of the fish added to the oil during frying. However, the natural oil has low unsaturated fat iodine value; the higher the degree of unsaturated fat, the more will be iodine value the greater is the chance for oil to get rancid due to oxidation, FSSIA, (2017).

Saponification value is a measure of oxidation during storage, and also indicates deterioration of the oils. From the table above, the saponification values ranges from 210.07-186.25 respectively. There was no significant ($P > 0.05$) difference in saponification value of the oil samples. This is in with recommendation from FSSIA, (2017).

In this study, the reused oil for frying fish (AAI) has high level of free fatty acid of 8.12%. The United States Department of Agriculture and some European countries have regulatory guidelines on maximum FFA levels in frying oil, ranging from 1.0% to 2.5%, depending on the regulations of a given country (Bailey,A.E., and Shahidi,E. 2005; Sebastian, A. *et al*., 2014).

According to the findings of Negah, Y,A *et al*., (2019), if moisture content ranges from 0.05 to 0.3 in edible oils, it shows that rancidity is likely to occur. All the samples investigated from the table above indicated that high level of moisture content, and high moisture content in a product favours microbial growth and proliferation. Negah, Y,A *et al*., ., (2019), reported that fungus species such as *Aspergillus niger* and mucor species survive and reproduce when the moisture content value was higher than 0.2%.

In the present study, the mean of reused oil viscosity was increased from 48.22-30.14mm^2/S respectively, which is an undesirable characteristic. Increasing the viscosity is an indicator of the level of polymerization in high oxidation stage of oils (Kang,Y.J., and Yang,S., 2013).The viscosity of oil is dependent upon its total polar compounds value (TPC) and electrical properties. Oil that is highly viscous affects the health and body system of a person adversely; for instance, causes heart burn and arthritis. Vegetable oil is safer to consume than the saturated fats because of its low cholesterol content compared to the saturated fat (Meyer,L., et al., 2018). During frying process, some polymerization of the fat may occur, in some case may leads to the formation of foam. Polymerization (thermal or oxidative) can affect the greasiness of fried foods (Orthoefer, F.T., and List, G.R., 2007).

Table 2: Organoleptic properties of discard and fresh cooking oil used for frying fast foods in restaurant

Parameters	Appearance	Color	Taste	Flavor	overall acceptability
Discard oil	5.23^a	4.89^a	5.01^b	5.98^a	4.22^b
Fresh oil	8.07^a	8.69^b	8.86^a	8.99^a	8.65^a

Means with the same superscript in the same column are not significantly different (P≤0.5).

The results are presented as mean ± standard deviation of triplicate observation.

The sensory evaluation of discard and fresh cooking oil used for frying fast food such as fish, beans cake, potatoes, maza (fermented puff batter) and doughnut are presented in table 2.The fast food products have a sensory value range from 5.23-8.07 for appearance, 4.89-8.69 for color, while the value ranged from 5.01-8.86 were assigned to taste, flavor was ranked between 5.98-8.99 and overall acceptability were ranked from 4.22-8.65 respectively. All the parameters for discard oil were ranked lower due to frying process at relatively high temperature of frying (150–180°C) and repeated heating, which could lead to accumulation of different by-products including alcohols, cyclic compounds, polymers, dimers, and free fatty acids are produced as a result of oxidation and hydrolysis reactions, which have adverse impacts on human health (Chen,W.A., *et al.*, 2013). Also, they play important roles in the flavor, texture, and aroma acceptability of the fried products.

4.0 Conclusion

The present study revealed that the majority of fast food restaurants in Bauchi, use over degraded frying oils, which are not discarded at the proper time. This leads to increase in the formation of free radicals in the body, which can cause inflammation in the body. This is the root cause of most diseases including obesity, heart disease and diabetes. High inflammation in the body can reduce the body immunity and make an individual susceptible to infections. The results obtained in this study implied that engage in the practice of overheating and or repeated use of the oil continuously, while some just add fresh oil to the old one instead of discarding it. Rancidity parameters values obtained from the study all far exceeded stipulated limit given.

4.1 Recommendation

The food agencies and public health should prohibit the reuse of cooking oil more than three consecutive times. This study indicated that the majority of reused oil from fast food restaurants in Bauchi were over degraded containing hazardous secondary oxidative products. Due to the potential toxicity of oxidation products, this could pose a public health hazard. Frying oil should be considered as a food item because fried foods will absorb a significant amount of oil, and there are many hazardous degradation products present in them. The high values of degradation products found in frying oils raise concerns about the safety of the foods served in some fast food restaurants in Bauchi and its environ.. In this context, it would seem appropriate to suggest to local public health authorities include frying oil safety monitoring as part of the food premises' health inspection. Unfortunately, there are no such guidelines or regulatory standards for frying oils in most of countries. There are several methods available for analyzing the heat abuse of oils. Usually, cooks decide on the quality of frying oils by visual observations such as color, excessive foaming, and smoking. Another assessment is based on odor and taste of the fried foods, as well as the cost of buying fresh oil. Therefore, it is essential to monitor the quality of oils to avoid the health consequences of consuming foods fried in degraded oils. Hence, it is highly recommended to inspect the performance of oil quality in fast food restaurants and food industry establishments and create regulatory standards for the quality of frying oils.

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