UNIVERSITY OF EDUCATION, WINNEBA

COLLEGE OF TECHNOLOGY EDUCATION, KUMASI

QUALITY EVALUATION OF USED FRYING OILS FROM SELECTED HOTELS AND RESTAURANTS IN SEKONDI-TAKORADI, GHANA

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A thesis in the Department of HOSPITALITY AND TOURISM EDUCATION, Faculty of Vocational Education, submitted to the school of Graduate Studies in partial fulfilment of the requirements for the award of the degree of Master of Philosophy

(Catering and Hospitality) in the University of Education, Winneba

APRIL, 2021

DECLARATION

STUDENT'S DECLARATION

I, MORRIS BRAKO, declare that this thesis with the exception of quotations and references contained in published works which have all been identified and duly acknowledged, is entirely my own original work, and it has not been submitted, either in part or whole, for another degree elsewhere.

SIGNATURE..

DATE...

SUPERVISORS' DECLARATION

I hereby declare that the preparation and presentation of this thesis was supervised in accordance with the guidelines for supervision of thesis as laid down by the University of Education, Winneba.

NAME OF SUPERVISORS

DR. WILFRED SEFAH Signature.......................... Date………………

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Finally, to all who helped in one way or the other in ensuring the success of this work, I say think you.

DEDICATION

This work is dedicated to my parents, Rev and Mrs. Brako and to my siblings Peter, Noel, Noble and Godson.

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ABSTRACT

The study focused on the quality assessment of used frying oils in some selected hotels and restaurants in Sekondi-Takoradi. Specifically, knowledge and usage of oils among kitchen staff; determination of how often the same oil is used in cooking; ascertaining the physical properties kitchen staff look at to discard oil and assessing the physicochemical qualities of oils used by hotel/restaurant kitchen staff were sought. The study adopted a mixed method approach (quantitative and qualitative) in evaluating the quality of oils after repeated frying. Samples of used frying oils were collected from selected hotels and restaurants from the metropolis. The target population (45 respondents) were aged eighteen (18) years and above. Data was obtained by means of a self-administered questionnaire and analysis was conducted using both descriptive and inferential statistics. From the study, the FFA of the oils ranged between 0.35% and 1.4% for the oil sampled. The acid value of the oils sampled was within the range of 0.67mg KOH/g to 2.79mgKOH/ whilst The peroxide values obtained for the oil samples were within the range from 0.99 meq/kg to 12.85 meq/kg. The study revealed that respondents had a fair idea or knowledge on what to look for when selecting a good cooking oil on the markets. Most consumers of cooks believe that it is easy to dispose used oils by using them for preparing 'shito' and other sauces regardless of the health implication. The study therefore recommends that cooks should not continue reusing cooking oils over and over again since reusing over a period of time produces reactions that are harmful or injurious to the health of the human consumptions.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

Presently, fried foods are celebrated globally, and it tends to be seen by the expanding number of drive-through joints over the last few years. Deep frying of foods improves the sensorial properties which incorporate a unique fried flavor, brilliant earthy colour and crispy texture. Chemical responses like oxidation, polymerization, hydrolysis, among others occur in the food system, which eventually changes the physical and chemical properties of fat/oils. Therefore, numerous by-products, for example, free unsaturated fats, alcohols, cyclic mixes, dimers and polymers are produced. Thus, it is important to know the physical and chemical changes during deep fat frying to assess the quality of fried foods. The world in recent years is suggested to be undergoing a nutrition transition, characterized by a convergence on the so-called Western diet, high in saturated fats, sugar, and processed foods (Popkin, 2017; Lieberman, 2017). This trend has been associated with the response of food systems to the most recent phase of globalization, in which increased integration within the world economy has resulted in a global homogenization of institutional, legal, economic, social and cultural practices (Kennedy, Nantel and Shetty, 2004). Indeed, Lang (2019) argued that "the food system is one key area in which a tension between globalization and internationalism is being fought out". Food frying has long been used as a technique to prepare various foods both at home and in industrial food sectors. Since fried foods develop a much-desired texture, flavour and appearance, they are consumed in large quantities all over the world

(Saguy and Dana, 2013). Vegetable oil quality and stability are the main factors that influence its acceptability and market value. Oxidative stability is one of the most important indicators of the keeping quality of vegetable oils. According to Marquez-Ruiz and Dobarganes (2017), in frying, the frying oil serves as a heat transfer medium and an ingredient of fried food. During this process, heat transfer is from oil to food and cooking of food, meantime water vaporization from food into the oil and then to the atmosphere, penetration of oil into the capillaries formed in food, air-oil mixing at the surface and similar phenomena occurred constantly. According to Gupta *et al*. (2014), the warmth lessens dampness substance of food surface almost to 3%, and oil goes into the spaces left by the dissipating water. A progression of physical and chemical changes occurs in frying oils used at around 175°C or above. The factors that affect the oil and product quality during deep-fat frying are refreshing ratio of oil, frying time and temperature, heating type, composition of frying oil quality of startup oil, composition of fried food, fryer type, antioxidants and oxygen availability. During frying, some substance responses like oil hydrolysis, thermo-oxidation, dimer and polymer development, Maillard responses and others occur in the oil. The results of these responses aggregate by time and lead to crumbling the oil; lessens the frying oil quality and the health properties of fried foods (Choe and Min, 2017). From a nutritional point of view, it should be considered that oils with high amounts of saturated fatty acids and fats containing trans fatty acids are less desirable for good health (Tarmizi *et al*., 2013). Moreover, highly saturated fatty acid composition of some industrial frying oils may represent a problem in case it is necessary to keep the product in the liquid state (Gupta *et al*., 2014). Regardless of common suggestions to diminish the fat content in human diet, fried foods are highly valued for their unique sensory properties (Dobarganes *et al*., 2000). The fatty acid (FA) content of oils has been modified (either by blending, hydrogenation or fractionation) to improve the oil frying stability (Tarmizi *et al*., 2013). In contrast to hydrogenated oils which form trans fatty acids, blending of oils is much preferred since the process is further advantageous and reasonable (Naghshineh *et al*., 2010). In this process, various synthetic antioxidants are used including butylated hydroxyl anisole (BHA), butylated hydroxytoluene (BHT) and *ter*-butyl hydroquinone (TBHQ) to increase stability or shelf-life of the oils (Tarmizi *et al*., 2013). However, the use of TBHQ has been banned in European countries and other countries because of its serious health hazards such as toxicity and carcinogenicity. Another chemical, ascorbyl palmitate (ASCP), has been demonstrated to decrease dimerization in edible frying oils (Dobarganes *et al*., 2010). The quality of frying oil closely affects the nature of fried foods (Innawong *et al*., 2004). Different quality assessments are used to assess the quality of frying oils, including free fatty acid (FFA) content, peroxide value, color and viscosity measurements as traditional methods, and total polar component, oxidized fatty acid and conjugated dien contents as standardized methods (Perkins and Erickson, 1996). The aim of the current study was to investigate quality of oil used in frying in some selected hotels and restaurants in Takoradi.

1.2 Statement of the Problem

Several studies have been carried out on frying process involving chemical reactions (increased free fatty acid (FFA), polar components and high molecular-weight products), physical changes (colour change, increased foaming, decreased smoke-point) and sensory changes creating decomposed oils which contribute to the low quality of fried foods (Dobarganes *et al*., 2000). Understanding of mechanisms and changes that occur during the frying process is important. Deep-fat frying is a complex process carried out at 150-190°C by immersing food in hot oil, which makes a connection between food, air and the hot oil. This results in various physical and chemical changes in the oil and formation of the new compounds (Melton, 2007). As a result, these compounds play a significant role in public health problems, including gastrointestinal disorders, Immune-related disease cancer, diabetes, hypertension and preterm fetuses (Otunola *et al*., 2009). The researcher for the purposes of the study sampled oils used continuously for the frying of chicken. Sunisa *et al* (2011), asserted that the PV, FFA and p-AV of used oils and fried chickens increased significantly at $p<0.05$ with frying time. They further pointed that The quality of used-fried oil as repeated frying 3 consecutive days by 10 batches a day showed better oil quality than those continue frying for 30 batches a day. The color of fried chicken became darker with higher proportion of chicken to oil ratio similar to color of used-fried oil. It is upon this background that the researcher assesses the quality of oils used in frying in some selected hotels and restaurants in Sekondi-Takoradi.

1.3 Objectives of the Study

The objective of the study was to evaluate the quality of oil used in frying in some selected hotels and restaurants in Secondi-Takoradi.

1.3.1 Specific Objectives

The specific objectives are:

i. To determine the factors caterers, look out for in their choice of oils
ii. To determine the Frequency of usage of cooking oils.
iii. To ascertain the physical properties kitchen staff look at to discard oil.
iv. To assess the physiochemical qualities of oils used by kitchen staff.

1.4 Research Questions

i. What factors do caterers look out for in their choice of oils?
ii. How often is the same oil is used in cooking?
iii. What are the physical properties kitchen staff look at to discard oil?
iv. What are the physiochemical qualities of oils used by kitchen staff?

1.5 Significance of the Study

The research work would be beneficial to the following category of people:

i. It will bridge the knowledge gap and inform the general public on the oil usage among caterers.

ii. The findings from the research will provide information on the health risks implications posed by the continuous usage of the same oil usage in cooking.

iii. The study will also serve as a reference for other researchers who would like to replicate the study. Students and researchers can use this study as the basis for further research.

iv. It will further help in the formulation and implementation of policies and regulations.

v. The study will further contribute to the body of knowledge on oil usage among caterers in hotels and restaurants.

1.6 Delimitation of the Study

The scope of the research work was limited to evaluating quality of oil used in frying in some selected hotels and restaurants in Takoradi. It specifically targeted kitchen staff in hotels and restaurants in Takoradi.

1.7 Limitation of the Study

The researcher faced a number of challenges in carrying out the study. These brought about some limitations in the study. Some of these challenges are as follows:

A larger sample size would have given better results but due to limited time and funds, the research was limited to some selected hotels and restaurants in the Takoradi Metropolis. Large sample sizes also affect the generalizability of a study positively, thus choosing that sample is somehow problematic. Secondly, some of the handwritings of the respondents were not readable and therefore the researcher had to struggle to make meaning of what was written. There was challenge during the oil collection, as some of the respondents wouldn't allow the researcher into their kitchens to observe the oils that are mostly abused.

1.8 Organization of the Study

This study is organized into five chapters. Chapter One introduces the study and it consists of background of the study, statement of the problem, purpose of the study, research questions, objectives of the study, significance of the study, delimitation of the study, limitation of the study. Chapter Two reviews related literature, focusing on issues such as: Theoretical Framework of the Study, Overview of Frying, Chemical Changes in Oil during Frying, Effects of Re-frying of Oil, Evaluation of Chemical and Physical Changes in Different Commercial Oils during Heating and Physio-Chemical Changes during repetition of Cooking Oil in Frying. Chapter Three deals with research methodology and it includes research design, sources of data, sampling procedure, data collection and data analysis. Chapter Four presents the analysis and findings of the data collected. Chapter Five finally provides a Summary of the major findings, Conclusions and Recommendations offered based on the research findings.

CHAPTER TWO

LITERATURE REVIEW

2.1 Theoretical Framework of the Study

2.1.1 Theory of Fat Absorption

Deep-fat frying is a complicated process that includes simultaneous heat and mass transfer. The process stimulates variety of physiochemical changes in both the food and the fricasseeing medium. The principles underlying the water loss mechanisms and oil absorption are closely related. Fat absorption involves numerous mechanisms such as vacuum absorption, capillary action, and surface wetting (Perkins and Erikson, 2009). At the point when the food item is submerged in hot oil, the underlying fat absorption happens through surface wetting; absorption of oil may take place through capillary action depending on the surface structure. As the item heats up, water is changed to steam, relocates to the surface and inevitably into the oil because of a weight differential. This period of the frying cycle was said to be "surface boiling", during which the fume being delivered from the item's surface blocks fat interruption into the item (Singh, 2015). Toward the finish of frying, when the item is cooled, the weight inclination switches and oil assimilation happens by vacuuming the surface oil into the item (Gamble and Rice, 1987; Moreira and Barrufet, 2008; Perkins and Erikson, 2016). Moreira and Barrufet (2008), clarified that as the item's temperature diminishes, the interfacial strain among gas and oil expands, causing an expansion in slender weight. This sucks the surface oil into the permeable medium, hence expanding the final oil content. Sun and Moreira (2014), recommended that fat assimilation is essentially a post-frying wonder, having seen that 64% of absolute fat substance of tortilla chips was ingested during the cooling (post-frying) period.

2.1.2 Impact of Frying on Fatty Acids

Several theories have been proposed to account for the mechanism by which acrylamide is formed in fried foods (Rosén and Hellenas (2002); Gertz *et al*., 2003). Previous experiments have confirmed with radio-labeled asparagine that asparagine is the nitrogen source for acrylamide. Asparagine is found abundantly in wheat, corn, potatoes, green beans and peanuts. The heating of asparagine alone does not efficiently produce acrylamide but combined with reducing sugars like glucose and fructose where the formation of acrylamide is accelerated (Franke *et al*., 2013). Other factors influencing the reaction may include oil type, temperature, product moisture and pH. In the discussion about possible pathways of the formation of acrylamide in deep frying products, it was firstly assumed that acrylamide is formed via glycerol by oxidation of acrolein to acrylic acid which reacts with ammonium coming from amino acids. Glycerol should be formed by hydrolysis of triacylglycerides. In used deep frying fats, no significant variations were found for mono- and diglyceride concentrations throughout the successive frying. An increase around the diglyceride peak can be explained by an oxidative degradation of polyunsaturated fatty acids producing more volatile fatty acids like octanoate (C8:0) and heptanoate (C7:0). The remaining molecule of triacylglycerol contains the fragment at the position 1n and 3n resulting in a lower molecular mass which is now equal to diacylglycerol. No free glycerol is formed which could act as a precursor of acrylamide (Márquez-Ruiz, Dobarganes, 2016). Another possible mechanism describes that acrylic acid arises directly from the decomposition of two common amino acids, alanin and aspartic acid. Acrolein is also being formed in various concentrations in the pyrolysis of triglycerides (not via glycerol) and depending on the kind of cooking oil heated and the temperature applied to the oil (In and Liou, 2010). From the fat chemistry, it is well known that monoacylglycerols decompose above 150°C in a cyclic reaction to an olefine (acrolein) and a free fatty acid. The same mechanism may explain the immediate formation of acrolein by heating mono acylglycerols. It is expected that in meat or bakery products acrylamide disappear at a rather high rate, presumably through bonding to reactive constituents (Biedermann, Biedermann-Brem, Noti and Grob, 2012).

The elimination may even occur at such a high rate that no relevant acrylamide concentration builds up or destroyed immediately after it is formed. It is generally accepted that the first stage of the actual Maillard reaction is the condensation of unprotonated amino group with reducing sugar in the open chain form resulting in a Schiff's base glycosylamine (Van Boekel Majs, 2011). The rate of reaction between sugars and amino groups of amino acids is maximal at weakly acidic pH. The pKb of asparagine is 8.8 and the lowest of all amino acids. More probably, at the pH in meat the other amino acids get more and more reactive than asparagine, not forming acrylamide. It is also possible that the low pH in a fryer induced the splitting of glucose or fructose in two triose glycerine-aldehyde and dihydroxyacetone following a reverse aldol condensation as the heat causes a decrease of pH because of higher water dissociation and water activity in the crust. The reaction of asparagine with fructose via dihydroxy acetone is quicker than with glucose via glycerolaldehyde. Weisshaar and Gutsche

(2012), found that the acrylamide formation is mo.re accelerated in presence of silicagel as an acid medium than in starch as carrier.

Biedermann, Biedermann-Brem, Noti and Grob (2012), found that higher concentration of sodium carbonate (pH>9) decreased the acrylamide concentration even in presence of fructose. Otherwise, the reduction of browning when organic acids are added could be attributed to the inhibitory effect of acidic pH on the development of non-enzymatic alkaline catalysed browning (Onigbinde and Onabun, 2013). Therefore, it may be possible that citric acid or frying oil improving agents containing citric acid like Maxfry classic induce a decrease of the acrylamide concentration if it is added to the frying oil at higher levels. Some authors studied the formation of acrylamide in various browning model systems (Yasuhara, Tanaka, Hengel and Shibamoto, 2013). When asparagine as nitrogen source was reacted at 170°C or 180°C with fructose, glucose, acrylic acid or dihydroxy acetone, very high levels of acrylamide were formed whereas asparagine did not produce detectable amounts of acrylamide with ethylenglycole. Also, when ammonium chloride or asparagine were heated with triolein, glycerol or acrolein, only low levels of acrylamide were formed.

By repeating the heating experiments of organic acids (lactic, malic, citric acid) with asparagines as nitrogen source, the formation of acrylamide was very low or zero. Heating experiments with amino acids like cysteine, aspargic acid or valine show no effect or result even in a slight reduction of acrylamide concentration. Relatively high levels of acrylamide were formed from ammonia in combination with acrolein or acrylic acid whereas ammonium chloride and acrolein did not produce detectable amounts of acrylamide. The most important reaction is the splitting of glucose or fructose forming dihydroxy acetone or glyceraldehyde and finally acrylic acid. Reaction products containing 3 carbons like glycerol (from triglycerides), propionaldehyde, methylglyoxal and acrolein can be excluded as precursors. Obviously, asparagine seems to work as a nitrogen source and to form acrylamide at the same time as presumed (Weisshaar and Gutsche, 2012).

2.1.3 Chemistry of Frying Oil

Fat or oil used for deep-fat frying comprises transcendently of fatty substances, which are three unsaturated fat particles joined by glycerol (Sanders, 2016) and are hydrophobic substances (Kalapathy and Proctor, 2010). The esterification of glycerol joined with unsaturated fats structures mono-, di-, and fatty oils. Frying oil is typically portrayed dependent on the unsaturated fats present in the fatty oils. These segments might be short or long chain unsaturated fats. Unsaturated fats with no twofold security are alluded to as soaked (e.g. palmitic corrosive), those with one twofold security are monounsaturated (e.g. oleic corrosive); and those with more than one twofold connection between carbons are polyunsaturated (e.g. linoleic corrosive). The security of the oil relies upon the atomic structure of these bonds.

Deep-fat frying is usually performed in a temperature range of 120 to 180°C (Costa and Oliveira, 2019). The rehashed and constant utilization of oil at high temperature in the presence of air and water brings about warm and oxidative disintegration. Thus, volatile and non-volatile deterioration items are developed inside the medium. Frothing likewise happens when items with high starting water content are fried. The advancement of surfactants by warm change, brings about the arrangement of cyclic monomers, dimers and polymers through polymerization. This reason expanded consistency (thickening). Hydrolysis, a substance response that happens in the presence of water and heat deteriorates the fatty oils into free unsaturated fats (FFA) (Kalapathy and Proctor, 2010). This happens when water leaves the frying food and blends with the frying oil. Off-flavours and polar compounds are developed because of the decomposition of the frying oil, some of which are poisonous or hazardous to human health (Romero et al., 2010). The distinct flavor and odor of the frying oil is an indication decomposition in frying oils. To reduce the rate of decomposition, dissolvable particulates and solvent segments ought to be mixed and separated intermittently (Subramanian et al., 2000).

2.2 Stability of deep fat frying oils

The heat stability of frying oil is governed primarily by two inherent factors: the fatty acid composition and the presence of antioxidants and precursors such as butylatedhydroxyanisole (BHA), tert-butylhydroquinone (TBHQ), butylated hydroxytoluene (BHT), propyl gallate (PG) and tocopherols (Adam, Das, Jaarin, 2009). Antioxidants have been proven to retard room temperature auto-oxidation of oils but are rendered inefficient at typical frying temperatures due to volatilization losses and thermal fissions (Valantina and Neelamegam, 2012). An ideal frying oil should thus possess little amount of polyunsaturated fatty acids (notably linolenic acids) and prominent levels of oleic acid with moderate amounts of saturated fatty acids as the former are highly susceptible to oxidative degradation during frying (Choe and Min, 2007) potentiating breakdown reactions that often yield harmful polymers (Zhang, Saleh, Chen, Shen, 2012). Thus, the accompanying changes in the physical and chemical parameters of oils used repeatedly for deep frying has raised global health concerns (Lobo *et al*., 2010). Subtly, the frying stability of oils are assessed by physicochemical investigation of changes occurring during heating of the oils at elevated temperatures. The color value of oils, usually expressed as 1 × Red + 1 × Yellow Lovibond units, registers a drastic increase in both the red and yellow units during the incipient phases of heating. According to the results of (Rahman, 2007) using rice bran oil, a threefold increase in red units and nearly fourfold increase in yellow units was found after 2 hours of frying while darkening occurred beyond 2 hours. Physicochemical properties and oxidative degradation of the frying oil during the initial 2 hours of heating registered a steep increment in POV from 0.2 to 6.3 meqO2/kg, AnV from 5.04 to 19.4 and total polar components from 1 to 4.1% (Gunstone, 2011). FFA content of frying oils has been reported to rise with number of frying (Chase-Dunn, 2005) and frying time (Erikson and Bearman, 2006). The formed FFA, glycerol, di- and mono-acylglycerols have been implicated by several authors to energize further thermohydrolysis (Jackson, 2004). Fatty acids composition, tocopherols and total phenols influences the oxidative stability of oils during frying (Martinelli, 2005) with some polar compounds such as triacylglycerol dimers and oxidation triacylglycerols (Nollert, 2005) dimers (O'Rourke and Williamson, 2002) and polymers (Nayyar, 2006) reported to accumulate during the frying process. Warner *et al*. (2009) reported that polar compounds accumulation during potato chips frying in cottonseed oil increased proportionately with increase in the oil linoleic acid content. Mono- and di-acylglycerols in cotton seed oil during frying of potato chips at 155 to 195ºC increased initially and then reached a plateau according to the results of Houhoula *et al*. (2010). Frequent replenishing of frying oil retards its hydrolysis (Sebastian *et al*., 2014) and increases its frying life; alkalis deployed in cleaning a fryer potentiates oil hydrolytic degradation while the frying time has no appreciable effect on hydrolysis rate (Valdés and Garcia, 2006). Diop *et al*. (2011) investigated the effects of deep fat frying on chemical properties of three selected brands of oils (two peanut oils A and B and sunflower oil, C) common in Senegalese preparation of fried meat, fish and potatoes. Their findings revealed that frying affects the chemical stability of cooking oils. The acid value as reported increased after 40 minutes from 0.62 to 1.08 mg/kg after frying fish, from 0.39 to 0.73 mg/kg for meat and 0.37 to 0.51 mg/kg for potatoes. Peroxide value increased slightly for A and sharply for B and C oils. Juárez *et al*. (2009) assessed some physicochemical changes occurring during discontinuous potato frying using milanesas and churros in partly hydrogenated, soybean and sunflower oils. For 80.5 hours of churros deep fat frying, the oils measured total polar compounds surpassing 25% and the corresponding percentage dimeric and polymeric triacylglycerols surpassed 10% with tocopherol losses of 70%. Xu *et al*. (2014) thought about the oxidative strength of camellia oil made out of soaked unsaturated fat (SFA), monounsaturated unsaturated fat (MSFA) and polyunsaturated unsaturated fat (PUFA) in a proportion of 1:7:1 during potato profound broiling with palm and nut oils made out of SFA, MSFA and PUFA in proportions of 4:4:1 and 2:4:4 separately. Their assessments of corrosive worth, IV, POV, AnV, complete oxidation (TOTOX) esteem, tocopherols substance and unsaturated fats synthesis of the oils enrolled little change of the unsaturated fat substance of camellia oil with alpha-tocopherol answered to be all the more thermally labile contrasted with gamma and delta tocopherols. They presumed that the strong qualities of the oils as dictated by oxidizability esteem followed the succession camellia oil > palm oil >peanut oil. The at first most elevated recorded AnV was in palm oil, which rose from 0.11 to 0.40. The recorded AnV change was at first high in nut oil preceding searing however expanded more steadily from 0.74 to 1.04 while that of camellia oil rose from 0.17 to 0.55. The IV recorded in nut oil was the biggest however it diminished from 104.74 to 80.52 gI2/100g. Immaterial changes of 53.83 to 45.36 gI2/100 g and 65.40 to 55.29 gI2/100g was enlisted in palm oil and camellia oils individually. POV in palm oil enrolled an augmentation from 4.98 to 18.86 meqO2/kg while that of nut and camellia oils changed from 4.75 to 13.24 meqO2/kg and 4.68 to 11.58 meqO2/kg. The least AnV was in camellia oil that expanded from 1.70 to 51.78 while nut and palm oils enrolled 2.25 to 84.71 and 1.36 to 60.00 separately. Abdulkarim (2014), evaluated the frying suitability of high-oleic *Moringa oleifera* seed oil soaked unsaturated fat (SFA) comprising of SFA: MUFA: PUFA in a proportion of 2:7:0 opposite soybean, palm olein and canola oils with SFA: MUFA:PUFA proportions of 1.5:2.5:6, 4:4:1 a 1:6:3 separately. Test results demonstrated that the %FFA of the four regular oils used similarly in the evaluation individually expanded by 66.6, 71.4, 60.0 and 65.0%. TOTOX and AnV estimations of the oils were enlisted in the request *Moringa oleifera* seed oil< palm olein < canola and soybean oils.

2.3 Overview of Frying

Frying is one of the most common techniques for food preparation that is characterized as a food drying and cooking process by dipping food into oil at a high temperature, usually between 165 and 190°C (Moreira, 2014). Frying is one of the most widely used practices in food preparation and production (Urbančič *et al*., 2014). Today, fried food is being increased and is related to contemporary consumers' demand for processed foods, the rise of the snack industry, as well as the increase in fast-food and takeover restaurants. Lazarick *et al*., 2014). Such changes contribute to the development of gold brown colours, attractive fried scent, delicious flavour, crispy texture and a juicy taste in fried goods. Thanks to its ease of service, economic feasibility, high variety and its ability to develop distinctive sensory characteristics in foods that are highly valued by consumers, the frying industry and domestic goods are widely used (Teruel *et al*., 2015).

The use of frying oil is standard practice for minimizing expenditures on a continuous and ongoing basis (Aladedunye and przybylski, 2013). Oil is subject, however, to long periods of high heat, oxygen (from air or food), and moisture, which result in a complex series of reactions involving oxidation, hydrolysis, isomerization and polymerisation. These reactions cause oil structure degradations (Brühl, 2014), and then a wide variety of volatile and non-volatile compounds, eventually altering the sensory, nutritional, and functional characteristics of an oil (Crosa et al., 2014). Oil degradation has an adverse impact on the properties of fried foods not only in frying oil, such as sensory characteristics, nutrition and shelf life (Dobarganes et al., 2000; Aladedunye, 2015), but also on the food safety and, as well, on human health (Wang et al., 2015). The foods absorb a substantial amount of oil during frying and transform oil into a final product component (Al-Khusaibí et al., 2012).

2.4 Methods of Frying Foods

Despite the presence of air and moisture, the oil is continuously exposed to high temperature during frying. Many complex reactions can be categorized as oxidation, polymerisation, or hydrolysis under these conditions. The desired taste, color and texture of the fried food is caused by some of these reactions. Others are undesirable from a standard diet and toxicology viewpoint (Stier, 2013). One of the factors which significantly contribute to the quality of the final frying product is the frying medium (Aladedunye and Przybylski, 2013). Its degradation depends on the structure and original state of fatty acids and on the presence of pro-oxidants or antioxidants. While most improvements are known, due to the large number of factors involved, it is hard to predict the rate of degradation. Such factors are not only correlated with the medium but also with the frying process itself (temperature, heating length, heating mode, turnover rate) or with the heating of foods (Pawar *et al*., 2013). Frying in shallow fat is called pan frying or sautéing. Shallow frying means that the oil is used only once and its role as a heat transfer medium is minor. Its action is mainly to prevent sticking to the pan or to give glaze (Brühl, 2014).

Deep frying uses enough fat to cover the food. The oil is hot enough to seal the surface of the food to form a crust. Deep-fat frying is the most widely used method domestically, industrially, and in catering outlets. Roasting in an oven where temperatures may be as high as 220°C can be also considered frying (Choe and Min, 2017). If the oil is discarded frequently and appropriate frying methods apply, the oil in the fried food maintains its nutritional value and a significant proportion of the liposoluble vitamins. The fried product conserves water solutions in a larger way than other cooking methods, including vitamins, minerals and other nutrients. Frozen food is one of the oldest food storage processes. This is believed to have been used by ancient Egyptians as early as 1600 BC. It was most likely found by roasting a piece of meat over a hot fire into a pot. The fat would be returned from the meat, the humidity would boil away, and pan-fried meat would result (Zhang *et al*., 2012).

2.5 Overview of Oils used in Frying

Oils are fats which are liquid at room temperature. Oils are part of an organic group known as lipids. Lipids are biological and water dissolving chemicals (LibreTexts, 2020). Lipid function includes acts as control messengers (hormones), forms the basis for cell membrane structural components, serves as energy storage, isolates the body organ, and transportation via blood of fat-soluble vitamins. The molecular structure of oils is composed of three fatty acids and a glycerol molecule and is shown in Figure 2.1.

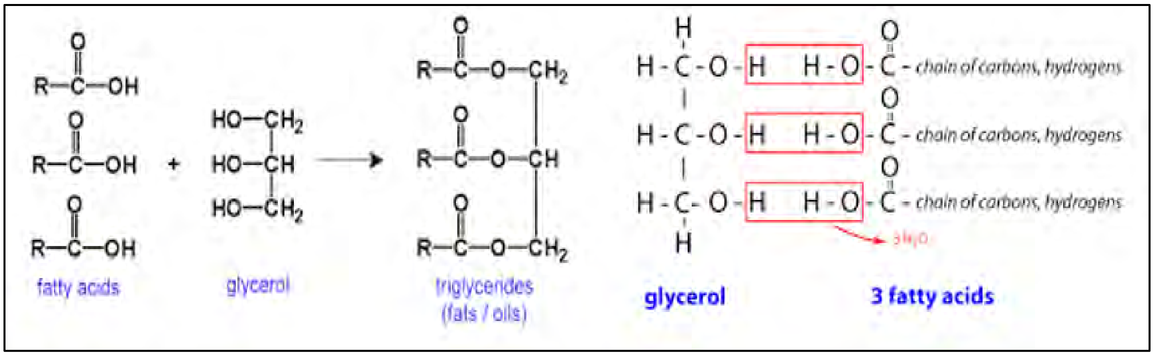

Figure 2.1: Molecular structure of oils.

Source: (Thapar, 2019).

Fats are often referred to as tri-glycerides or tri-acyl glycerols, as shown in NutriStrategy (2015). Since fatty acids have a single bond between each C-atom, the fats are considered saturated fats and the fats are considered unsaturated fats when they are bound by other double bonds in a chain bundle of fatty acids. If a double bond exists in the carbon chain, the oil is said to be monounsaturated, and if more than one double bond exists within a carbon chain, then the oil is said to be polyunsaturated.

2.6 Kinds of Oils used for Frying Food

The types of oil used for cooking and the percent of total fatty acids present are shown in Table 2.1.

Table 2.1: Kinds of oils and their Percentage Distribution of Saturated, Mono-unsaturated and Poly-unsaturated Fatty Acids

S. No.	Kinds of oil	Saturated (%)	Mono-unsaturated (%)	Poly-unsaturated (%)
1	Safflower oil	9	12	75
2	Sunflower oil	10	20	66
3	Corn oil	13	24	59
4	Olive oil	13	74	8
5	Soybean oil	14	23	58
6	Peanut oil	17	46	32
7	Cotton seed oil	26	18	52
8	Lard	40	45	11
9	Palm oil.	49	37	9
10	Palm-kernel oil	81	11	2
11	Coconut oil	86	6	2

Source: Thapar, 2019

2.7 Chemical Changes in Oil during Frying

When the frying takes place, the following changes occur in the composition of oil: **Hydrolysis of oil** - Hydrolysis means breakdown of oil into free fatty acids and glycerol. This process increases with increase in frying (Haresign and Cole, 2016). Oxidation of oil- When the fried oil (frying temperature) comes in contact with oxygen in air, it gives rancid flavor. The rancid flavor is because of the reaction of free fatty acid in the oil with oxygen, which is known as oxidative rancidity. This reaction produces various compounds like including aldehydes, ketones or other volatile products like sterol oxides. These products are responsible for rancid odours and flavours (Bordin, Tomihe, Kunitake, Aracava and Trindade, 2013). Oil (During frying) + Oxygen (Air) → dehydes, Ketones.

Polymerization of oil - Frying of oil, leads to decomposition of oil with generation of products like dimers and non- polar polymers, cyclic monomers, trans isomers and position isomers. Polymers are acyclic or cyclic compounds depending on the kinds of fatty acids forming an oil. The acyclic polymers are formed when fatty acids like oleic acid are present in oil. Also, oils rich in linoleic acid is more easily polymerized than oleic acid (Bordin *et al*., 2013). Linoleic acid content of various oils is presented in Table 2.2.

Table 2.2: Kinds of oils and their Percentage of Linoleic Acid in Oils

No.	Name	Linoleic acid (%)
1	Safflower oil	78
2	Grape-seed oil	73
3	Poppy seed oil	70
4	Sunflower oil	68
5	Hemp oil	60
6	Corn oil	59
7	Wheat germ oil	55
8	Cotton seed oil	54
9	Soybean oil	51
10	Walnut oil	51
11	Sesame	45
12	Rice bran oil	39
13	Peanut oil	32
14	Canola oil	21
15	Egg yolk oil	16
16	Linseed oil	15
17	Lard	10
18	Olive oil	10
19	Palm oil	10
20	Butter	2
21	Coconut oil	2

Source: Haresign and Cole, 2016

Flavour Quality of frying oil- During frying, certain compounds are formed from linoleic acid. Volatile compounds like dienals, alkenals, lactones, hydrocarbons and various cyclic compounds produces off-odours and flavours. Hence, sensory quality of the fried food decreases. Changes in nutrients in food- As mentioned above, during oxidation of oil, the aldehydes and ketones which are formed, react with amines, amino acids and proteins in fried foods. This causes nutrient loss and browning in fried foods (Diop *et al*., 2014).

2.8 Selection of Deep-frying Oils and Fats

According to Franke *et al*. (2013), the selection of deep-frying oils should be based on the optimization of the process with regards to nutritional physiological and culinary aspects. During deep-frying a substantial portion of the deep-frying medium may be absorbed by the food. In addition, there is an exchange between the fat present in the food and the deep-frying medium i.e. the fatty acid composition of the deep-fried food is determined considerably by the fatty acid composition of the deep frying medium (Food Safety Authority, 1996). Thus, deep-frying with animal fats result in a high portion of saturated fatty acids in the food while, deep-frying in olive oil rises the content of monounsaturated oleic acid.

Gupta *et al*., (2014), posit that the evolved degrees of thermal-oxidant degradation in the deep-frying medium may have major impacts on the consistency and stability of the deep-fried product. Deep fried foods are often flavored by the fats used, as a portion of the multi-unsaturated fats contribute to the deep freezing flavours, so vegetable oils are preferred instead of heat-stable firm fats (Rossell, 2001). The quality of the frying medium is of great importance only for a few applications; here fat which is solid or semisolid at ambient temperatures is clearly preferred. The choice of the deep-frying medium is always a compromise between the technological and nutritional-physiological requirements (Referenzwerte *et al*., 2010).

2.9 Nutrition-physiological Aspects

Three parameters have substantial influence for consideration: the quantity of fat absorbed by the food, the quality of the frying oil (chemical composition) and the degradation status of the frying oil. In the average population the supply of energy by fat in nutrition is too high and should be reduced, particularly to prevent cardiovascular diseases and diabetes (Franke *et al*., 2013). The appropriate processing (among other things the appropriate deep-frying temperature) and lowering of oils / foods from the deep-fried foods are of great importance to minimize the absorption of fat by eating fried foods, considering that badly fried foods can contain excessively high amounts of fat. Fatty acids are almost the same as energy content as the building blocks of all fats and oils but are chemically differentiated by the saturation level and the length of the chain (Gertz *et al*., 2003).

Vegetable oils are rich in unsaturated fatty acids, while solid fatty acids are primarily saturated. The monounsaturated oleic acid in olive oil and predator oil should be favoured from a nutritionist point of view. Polyunsaturated fatty acids, linoleic and alpha linolenic acid, which should not exceed 5:1, because the diet typically absorbs linoleic acid too much. The two fatty acids are essential materials in the metabolism for various hormone-like substances effective against cardiovascular disease. Alpha-linolenic acids also contribute in other inflammatory processes. With respect to temperature and oxidation stability against atmospheric oxygen, long chain saturated fatty acids are more stable than the corresponding fatty acids. The major essential fatty acids, linoleic and linolenic acids are less stable with continuously heating over 175/180°C for longer periods and/or days. For sensitive reasons the frying oil's linolenic acid concentration should be less than 3% otherwise the product and the deep-frying media might lead to a fishy taste.

Food frying with soya, maize or rapeseed oil at a higher temperature can result in indoor pollution due to the formation of toxic acrolein. However, if those requirements are met, nutritionally desirable oils may be used to deep-fry. This does not exceed 180°C for the deep-frying temperature. The fresh oil should be shielded against light and stored in a cool place; stabilizing additives may also be required. Polyunsaturated fatty acids should not be concentrated too high, as they are considered to be unfit for deep-frying.

2.10 Effects of Re-frying of Oil

Once the oil has been used for frying in a batch, and the remaining oil when kept for longer time without any use, to be used again, has certain disadvantages which should be noted (De Alzaa *et al*., 2018). Firstly, there is an increase in fatty acid content; hydrolysis of oil leads to development of free fatty acid content which increases with re-frying of oil. If an oil has free fatty acid content greater than the permissible limit, then the oil becomes unsuitable to be used, since free fatty acids are insoluble in water and they have tendency to get maximum oxidization. Again, increase in rancidity; free fatty acids and their oxidized compounds produce rancid (off- flavors) and makes the oil less acceptable for re-frying. Rancidity leads to loss of freshness in food, affects the shelf- life of food adds an objectionable flavours and odours (Diop *et al*., 2014). Increased rancidity due to re-frying of oil produces certain toxic compounds like acrylamide which is a probable human carcinogen.

Bordin *et al*. (2013) pointed out that there is an increase in polymerization. With re-frying, the polymerization of oil increases, which accelerates the degradation of oil, which increases oil viscosity, reduces heat transfer, produce foam during frying and develops undesirable colour in food. Polymers also cause high oil absorption in foods. Miao et al. (2013) on the other hand indicated that with re-frying, certain cyclic compounds are formed from linoleic acid like 1,4- dioxane, benzene, toluene and hexyl benzene which do not contribute to desirable flavor and are toxic in nature. Re-frying also increases the formation of trans-fatty acids (depending on oil used). These trans-fatty acids cause the risk of cardiovascular diseases.

Food Safety Information, (2012) in their research found that there is a nutrient loss in fried foods. When the oil is used for re- frying, the intensity of browning of food increases which also leads to loss of essential amino acids like lysine in fried food. There is also loss of vitamins like Vitamin C (ascorbic acid), Vitamin B (thiamine, riboflavin, niacin and B6), Vitamin A and Vitamin E which changes the flavour and colour of oil due to the destruction of these nutrients, adverse health effects could occur like mutations or gastro-intestinal irritations.

2.11 Evaluation of Chemical and Physical Changes in Different Commercial Oils during Heating

Frying oil at high temperatures (approximately 180ºC (356ºF) or over) is a very common processing method used to prepare foods of vegetable and animal origin (Santos, 2013). The numerous factors influencing the stability and performance of frying oil can be categorized into external and internal factors depending on whether they are operation-dependent (relatively independent of the inherent quality of the frying oil) such as frying temperature, accessibility to oxygen, and duration of frying; or oil-dependent (arising from the inherent composition of the frying oil) (Aladedunye, 2015). Edible oils are composed of triacylglycerols (>96%) and endogenous minor components. It is generally agreed that the inherent composition of edible oils exerts considerable influence on their frying stability (Zribi, 2013).

At elevated temperatures, oils will change significantly due to the many chemical and physical reactions which occur, such as oxidation, hydrolysis, cyclization, isomerization and polymerization (Zribi, 2016). When frying, oil also decomposes into a variety of volatile compounds and monomeric and polymeric products, which are capable of influencing not only the sensory and health quality, but also the shelf life of the fried product (Hammouda, 2017). Some of these compounds are, in fact, responsible for the pleasant flavor, taste and the typical crispness and golden color when food is fried under appropriate conditions. However, free radicals, trans-fatty acids, conjugated linoleic acids and some oxidized volatile products (acrolein and other α, β-unsaturated aldehydes) commonly formed during edible oil degradation, are known to be responsible for the off-flavor, reducing the shelf-life of edible oils and may further cause health problems (Ziribi, 2016).

Physical changes in oils that occur during heating and frying include increased viscosity, darkening in color, and increased foaming as frying time continues. At the same time, the smoke point of the oil decreases. The frying operator may not notice these effects until the oil has been used for prolonged periods of time. Specific methods exist to measure degradation processes and products quantitatively: free fatty acids, carbonyl compounds, and high molecular weight products will increase with increased frying time and can be measured chemically or by chromatography (Warner, 2014).

2.12 Physio-Chemical Changes during repetition of Cooking Oil in Frying

Edible oil is a vital food module that provides energy, fatty acid and is a carrier of fat-soluble vitamins. It provides energy. India is the largest importer of foodstuffs and the third largest consumer of foodstuffs worldwide (Choudhary and Grover, 2013). In India, consumption of edible oil per year and per person in 2007 amounted respectively to 11 million tons and 11.5 kg. Oil is commonly used in industrial and domestic food processes for trendy food processing and increases fatty consumption (Gertz *et al*., 2010). Oil is also commonly used in fatty preparations. Deep fat frying involves simultaneous transfers of heat and mass during food processing by plunging the whole food into hot oil at or above 180°C (Debnath *et al.,* 2009). Throughout the process, water vapor is transferred from food to oil and eventually to the atmosphere (Farid, 2011). Different chemistries including thermal oxidation, polymerization and hydrolysis are performed in this process. These reactions produce in solutions that increase viscosity, color, spray and smoke (Kalogeropoulos *et al*., 2007). These are the results of the insoluble and non-volatile reactions.

Deep fat frying deteriorates the quality of oil. Most streets vendors reuse the deep-fried oil for further cooking purposes without discarding it. The level of awareness, actions and practice of food outlet operators in Kuala Lumpur, Malaysia regarding the re-heated use of cooking oil has been identified by Azman *et al*., 2012). By means of a face-to-face interview, they collected data from respondents (n=100) and found that most respondents had only a low (53.0%) or a moderate level of awareness on the subject. Most interviewees (67.0%) agree that the practice is not good. Most (69.0%) accepted that regular heated cooking should be used.

In spite of that most respondents (63.0%) conceded that they had used cooking oil over and again. Generally, (62.0%) of the cooking oil tests taken from the night market food outlets were considered fit for human utilization. Saxena (2014), conducted a research together with the National Diabetes, Obesity and Cholesterol (N-DOC) Foundation, IIT-Delhi and Diabetes Foundation of India (DFI) that uncovered that reuse of oil in home-prepared food frames a substantial portion of trans-unsaturated fats (TFA). An arbitrary example review of 402 ladies between the age gathering of 25 and 60 across Delhi was led by a group of specialists to screen the example of use of oil while cooking. Other than featuring the unsafe impacts of TFA, the examination has likewise raised some genuine worry over the cooking practice in numerous family units. Almost 43.3% of the ladies reuse the fat or oil (used for frying) in any event a few times for cooking. Additionally, 54% of the ladies left the pre-owned oil subsequent to frying in a similar utensil in which the frying was done, and only 6% of ladies depleted off the pre-owned oil before putting away. This gives negative impacts on the medical issue of purchasers. The cycle of oxidation in the human body is thought to be a causal factor of specific maladies, for example, cardiovascular, malignancy, early maturing, or waterfall. Besides, disposing of the weakened oil to the climate brings about contamination.

The presence of air and water further quickens the decomposition of frying oil (Chatzilazarou *et al*., 2006). It likewise relies upon the idea of the fried material, the frying oil, time, temperature, discontinuous consistent warming, new oil supplement, fryer model and utilization of filters (Lalas *et al*., 2006; Mariana *et al*., 2014). Various factors, for example, unsaturated fat structure of oil, item quality, frying time, temperature, warming sort, organization of frying oil, creation of fried food, fryer type, cancer prevention agents and oxygen accessibility influence the hardship of oil. A few examinations have been done on corruption of oil, yet an orderly report and the impact of oil decay have not been concentrated at this point. This audit is a methodology towards the examination of the detail system of rot of oil and boundaries to be estimated to decide the quality file of oil.

2.13 Phenomenon Responsible for Quality Changes during Deep Fat Frying

Kassama (2003), found that there are expanding wonderful changes engaged with the centralization of free unsaturated fats, just as polar materials, polymeric mixes and diminishing in the unsaturated fat arrangement. It is mostly relies upon three kinds of synthetic responses, for example, hydrolysis, oxidation and polymerization. Oil turns out to be steadier on the off chance that it contains lower levels of linoleic, linolenic corrosive and more elevated levels of oleic corrosive (Aladedunye and Przybylski, 2013). Disintegration of linolic corrosive produces 2.4-decadienal which is answerable for rotisserie flavour.

Hydrolysis includes the breakage of fatty oils within the sight of water and steam. It produces monoglycerides, diglycerides, free unsaturated fats and glycerol, inevitably. The degree of hydrolysis relies upon the oil temperature, interface zone among oil and the fluid stage, measures of water and steam. Free unsaturated fats and lower sub-atomic weight acidic items emerging from fat oxidation upgrade the hydrolysis cycle in presence of steam during browning (Choe, 2007). The degree of hydrolysis can be controlled by the saponification estimation of oil.

Another remarkable change is oxidation. As per Shukla and Bhattacharya (2014) three kinds of oxidation happen in pan fried oil, for example, autoxidation, warm oxidation and photosensitized oxidation. The oxidation by direct blend with oxygen at standard temperature is called autoxidation. It brings about the rancidity of oil, which causes unpalatable smell and flavor due to the oxidative or hydrolytic debasement of oil.

Oxidative rancidity includes oxygen assault of glycerides and happens in a wide range of unsaturated fats (Sangle and Daptare, 2014). Warm oxidation happens because of warming at high temperature more than 180°C (Marinova *et al*., 2012). The pace of warm oxidation is quicker than the autoxidation (Choe and Min, 2007).

All the above said oxidation measures follow a component known as free extreme instrument. It chiefly includes three stages: chain inception, engendering and end. In chain commencement, the responses proceeding by warmth, light and metal impetus with the development of alkyl free extremist (R) (Scott-Thomas, (2011). In spread, the extremist shaped in the first step responds with oxygen to frame the peroxy revolutionary (ROO) (Scott-Thomas, (2011). The degrees of peroxy extremists are higher than lipid free revolutionaries. Peroxy revolutionary modified works hydrogen from another lipid atom and structures lipid extremist (R + ROOH). The hydroperoxides are entirely shaky and offers ascend to short chain mixes by the cleavage of O-O, C-C and C-O bonds around the peroxide gathering to break down into short chain mixes. The revolutionaries catalyze the responses while the development and decay of peroxide revolutionary happens in a reversible manner.

End includes the arrangement of final items like nonpolar dimer, oxidized monomer, oligomer, alcohols, aldehydes, ketones, acids, lactones, and so on Silvagni *et al*. (2010) have clarified arrangement of aldehyde legitimately from peroxyl revolutionary through an autonomous pathway during the warm treatment of nut oil at 180C and it very well may be subjectively examined by gas chromatography (Marmesat *et al*., 2008).

Browning temperature, the quantity of fricasseeing measure, the substance of free unsaturated fats, polyvalent metals and unsaturated fats of oil diminishes the oxidative solidness and flavor nature of oil. While cancer prevention agents assume a significant part in diminishing the searing oil oxidation, the adequacy of cell reinforcement diminishes with raised broiling temperature. Oxidation is one of the most significant deteriorative changes that happen in broiled oil and it contains five principle stages, in particular acceptance period, peroxide development, peroxide decay, polymerization and debasement. Photograph oxidation happens when typical trio oxygen is changed over to a singlet oxygen by the presentation of bright (UV) radiation. The singlet oxygen associates with polyunsaturated unsaturated fats to shape hydroxyl peroxide which start the autoxidation response.

2.14 Change in Physical Parameters during Deep Fat Frying

Physical changes in oil because of profound fat fricasseeing remember increment for shading, frothing and thickness. There are different strategies to gauge these changes. The subjective changes can be assessed by visual investigation. Shading is a biased marker used by the food business for fast checking of browning oil quality. Obscuring of oil tone happens because of the advancement of shades (nonvolatile disintegration items [NVDPs] and α-,β-unsaturated carbonyl mixes) during oxidation and warm deterioration of unsaturated fats which diffuses into the oil during fricasseeing, albeit because of hints of carotenoids accessible in oil, Maskan, 2013 has likewise clarified that oil obscuring might be brought about via caramelized singed item, which quickens the decrease of delicacy esteem (L-esteem) in oil when surveyed by the Hunter colorimeter (Ketaona et al. 2013). In the investigations directed by Tarmizi *et al*. (2013), the obscured searing oil tests demonstrated higher daintiness (L*), redness (a*) and yellowness (b*) values during broiling, when surveyed by the Hunter colorimeter. It demonstrated that the oil was more obscure, more rosy and yellowish, when contrasted with the shade of new oil. Besides, complete shading distinction which consolidates L*, a* and b*values was discovered to be expanded with fricasseeing time. Aladedunye and Przybylski (2009), have seen that shading advancement in oil going through browning was 67% higher than broiling performed under carbon dioxide covering measure, yet the oil handled by vacuum frying has minimal measure of shading colors when contrasting with the different cycle.

Nor *et al*. (2008), additionally announced that the obscuring of oil tests was because of the oxidation of phenolic cell reinforcements present in the oil while warming. Debnath et al. (2012), have recommended that shade of rice wheat oil rely on the quantity of frying cycle. They saw that after six patterns of warming and searing, red tone was expanded from two units to three and 4.5 units during warming and browning, separately. The expansion in yellow tone was seen from 15 units to 20 and 25 units during warming and broiling, separately. The expansion in shade of oil was ascribed because of the Maillard response. In starter relative examinations directed by Sulieman *et al.* (2006), on the antiradical execution and physicochemical qualities of vegetable oil after frying of French fries, the steady increment in murkiness was seen during the frying time frame. The shading estimation of the vegetable oil increments with expanding the frying time. It was because of the development of earthy colored shades from the singed items into the frying oil. The mix of oxidation and polymerization of unsaturated fats in the fricasseeing medium was additionally to be accused for the expansion in the shading esteems (Irwandi *et al*., 2000).

When contrasting the final consequences of three unique examples of vegetable oil, the creators have reasoned that the obscuring of oil tone was because of increment in linolenic substance of the oil. It was seen that the shading changes in palm olein during broiling were moderately quicker than the other oil. Nonetheless, examines have demonstrated that even though palm olein gets hazier with having higher shading an incentive during broiling, it won't influence the shade of the seared items (Razali *et al*., 1999). The findings subsequently demonstrated that obscuring is considered as a helpful wonder as it forestalls the constant utilization of eatable oil which has gone through extreme decay.

Thickness is a significant property influencing the warmth move by common convection and light development of gas rises in a fluid. The thickness of various sorts of oil is divergent because of contrasts in its creation. Kalogianni *et al*. (2011) have examined that the adjustment in thickness of palm oil and olive oil by differing the quantity of patterns of frying from four to forty. During frying and heating of oil, responses like oxidation, polymerization, isomerization (in both frying and heating) and hydrolysis (in browning) happen; accordingly, a few polymers were created.

The adjustment in palm oil thickness is more than olive oil, recommending that the age of higher polymer content in palm oil than olive oil and change in the thickness was more articulated after the twentieth pattern of frying. Zahir *et al*. (2014), have seen that the thickness of corn and mustard oil were diminished with the ascent in temperature as compared to similar oil for frying of potato for multiple times. The densities of oil were identified with the standard incentive in the scope of 0.898–0.907 g/mL (Standard Organization of Nigeria, 2000). They likewise watched the thickness estimations of 0.9694 and 0.9223 g/mL for mustard and corn oil, individually, at room temperature (35°C). It might be because of the pi bonds which make the more inflexible bonds and the more exhausting turn between C-C bonds.

Consistency is one of the pointers used to assess the physical changes in palatable oil. It relies on thickness, sub-atomic weight, liquefying point, level of unsaturation and temperature (Sharova and Ramadan, 2012). Consistency increments during hydrogenation as the expansion in the chain length of tri-glyceride unsaturated fat and diminishes during unsaturation of unsaturated fats (Santos et al., 2014). Further polymerization of oil and arrangement of dimmer, polymer items with sub-atomic load somewhere in the range of 690 and 1,600 Da builds the consistency of oil (Choe and Min, 2007). Oil rich in linoleic corrosive are more handily polymerized during profound fat browning than the oil rich in oleic corrosive (Formo *et al*., 1979; Takeoka *et al*., 1997; Valdes and Garcia, 2006). Santos et al. (2005) have seen that heating of oil (190C) for a few hours will not change the Newtonian conduct of a few kinds of oil including olive.

The distinctive plan of unsaturated fats on glycerol spine of tri-glyceride atoms changes the thickness of oil. Zahir *et al*. (2014) have contemplated that at 35°C consistency of mustard oil is higher than corn oil because of the level of unsaturation of oil. Sharova and Ramadan (2012) have researched the impact of unsaturation upon the consistency of sunflower oil (SO), cottonseed oil (CO) and palm oil (PO) and found that the significant unsaturated fats C18:1 and C18:2 seemed to make an extraordinary commitment towards the flowing conduct. The thickness of oil increments with the expansion in the degree of C18:2 and diminishes the degree of C18:1 unsaturated fat. The presence of twofold bond does not permit unsaturated fat particles to remain intently together; in this way, they will meddle with pressing in the glasslike state (Abramovic and Klofutar, 1998; Aravindan *et al*., 2007). Along these lines, unsaturated fats with higher number of twofold securities will not be unbending and carry on like fluids when they are stuffed freely (Kim *et al*., 2010).

Thickness is firmly influenced when presented to higher temperatures, air and increment in the quantity of searing cycles, and it upgrades the development of oxidative and polymeric mixes and expands the propensity to froth during broiling (Samah and Fyka, 2002). Tarmizi *et al*. (2013), have contemplated that the thickness of oil expanded significantly on account of vacuum and climatic seepage following 2 days of browning from 45.48 to 54.12 and 55.97 mPa·s, individually. After 80 groups of frying, polar mixes expanded from 7.81 to 15.03% and 17.19 % on account of vacuum waste and environmental seepage, individually. This is because of the development of higher sub-atomic weight polymeric mixes upon increment in browning time. The comparable impact was seen by Debnath *et al*. (2012). They watched the kinematic thickness of rice wheat oil as 3.39 × 10-6m2/s. This worth was expanded by expanding the quantity of successive browning cycles (Lalas *et al*. 2006). Consistency of oil likewise relies on the estimating temperature. Lioumbas *et al*. (2012), have decided the consistency of olive oil and palm oil by fluctuating the estimating temperature from 30 to 180°C. At the point when temperature builds, the thickness of oil diminishes because of increment in motor energy, which improves the development of particles and decreases the intermolecular powers.

2.15 Level of Knowledge, Attitude and Practice of Food Outlet Operators Regarding the Usage of Repeatedly Heated Cooking Oil

It is a common practice in the family unit or in the business area to utilize a similar frying oil over and again to spare expense. The oil is disposed of just when it gets frothy, produces awful smell or when the shading turns dim (Phiri *et al*., 2016). deep frying is a frying process where the food is totally drenched in the frying oil at temperatures of between 160-190°C within the presence of air and water. Chemical responses, for example, oxidation, hydrolysis and thermal polymerization are initiated when cooking oil is heated during the deep-frying process. The nature of oil crumbles with expanded length of frying time because of the quickened development of oxidized and polymerized lipid species in the frying oil (Lapointe *et al*., 2016). Repeatedly heated oil can cause changes in physical appearance of the oil such as increased viscosity, darkening in color, increased foaming and decrease in smoke point of the oil. If the physico-substance properties of cooking oil crumble, the oil must be disposed of on the grounds that it can end up being unsafe for human utilization. The pace of arrangement of cooking oil decay items relies upon the sort of food being singed, the kind of oil used and the plan of the fryer. (Soriguer *et al*., 2013).

The utilization of consistently heated cooking oil is unfortunate. During the time spent frying food, cooking oil is frequently presented to high temperatures for extensive stretches of time. This training creates lipid peroxidation items that might be unsafe for human wellbeing. The presence of overabundance polar compounds in more than once used frying oil has been related with increased danger of creating hypertension. Utilization of consistently warmed cooking oil may expand the danger of creating atherosclerosis. Lipid peroxidation items actuate oxidative worry in endothelial cells, bringing about endothelial brokenness that could in the end prompt the arrangement of atherosclerosis. Utilization of consistently warmed cooking oil is likewise connected with increased complete serum lipid and low thickness lipoprotein (LDL) levels (Garrido-Polonio *et al*., 2014)

Additionally, thermally oxidized lipids upgrade peroxidation of layer macromolecules, adding to their mutagenicity and genotoxicity which might prompt carcinogenesis (Hageman *et al*. 2018). An ongoing report directed in our specialty indicated that utilization of soy oil that has been more than once warmed may cause an expansion in lipid peroxidation and LDL in ovariectomized female rodents (which reenacts a postmenopausal state with estrogen lack in people). The consequences of that specific research proposed that continued warming step by step lessened the safety defensive impacts managed by soy cooking oil and may add to the pathogenesis of atherosclerosis in post-menopausal ladies.

Another ongoing investigation led indicated that utilization of consistently heated cooking oil brought about expanded circulatory strain and rot of cardiovascular tissues in trial rodents. The expansion in pulse because of utilization of consistently heated cooking oil may be because of quantitative changes in endothelium needy and autonomous variables incorporating proteins legitimately engaged with the guideline of circulatory strain (Yang *et al*., 2019). The nature of oil used for frying food is influenced by frying temperature, the neatness of cooking utensils, turnover of cooking oil used for frying, the separating cycle just as the utilization of sifting operators, among others. Irregular heating and cooling causes more noteworthy crumbling of cooking oil than persistent warming alone, because of expanded oxygen solvency in the oil when it chills off from the high frying temperature (Siti *et al*., 2008). Moreover, the oil corruption items content in cooking oil increments with repeated number of frying. Studies conducted to check food outlet administrators' mindfulness on the risks of devouring over and again heated cooking oil are deficient. An investigation led in New Zealand demonstrated that solitary 8% of autonomous food outlet administrators had formal preparing in deep frying rehearses contrasted and 93% of chain (establishment) food administrators (Chung *et al*., 2014). That review likewise uncovered that 65% of food outlet administrators studied replaced the oil used for frying in any event once per week, in any case, a large number of them depended on late indications of oil decrease (change in oil tone and smoke radiating from heated oil) in their choice to supplant an old clump of oil with another one (Morley-John *et al*., 2012).

As per Tyagi and Vasishtha (2016), Malaysians burn-through a lot of fried food purchased from side of the road outlets, night market food outlets and eateries. Therefore, the food frying acts of the administrators of these foundations could have large effect on the overall soundness of the Malaysian populace. As far as anyone is concerned, no endeavor has been made to assess the information, disposition and practice of food outlet administrators in Malaysia with respect to the use of consistently warmed cooking oil (Leong *et al*., 2010). Hence, this investigation expects to decide the degree of information, demeanor and practice of night market food outlet administrators in a few zones inside Kuala Lumpur with respect to the use of over and again warmed cooking oil. The nature of cooking oil that was used continuously market administrators to fried food was likewise controlled by estimating the Peroxide Value (PV) of the inspected oils.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Study Area

The study was conducted within Sekondi-Takoradi of Ghana. The study area (Sekondi-Takoradi Metropolis) is the regional capital for the Western Region with Sekondi as its administrative capital. The metropolis occupies the south-eastern part of Western Region and shares boundaries with the Ahanta West Municipal and the Shama district. It is located on the West Coast of Ghana and it is about 200 km west of Accra and 130 km east of La Cote D'Ivoire. It is the most highly developed of the 13 districts of the Western Region and it is also the fourth largest metropolis in Ghana and an industrial and commercial centre. It covers an area of 23,921 kilometres square with a population of 559,548 (Ghana Statistical Service, 2012). Fishing and farming is the main occupation for folks in the rural areas. With the recent oil find, the metropolis has become highly cosmopolitan. This is due to the fact that the oil find has created a lot of jobs which in turn has caused influx of people from various places into the metropolis.

3.2 Research Design

The study adopted a mixture of a quantitative and qualitative research design approaches. The designs were used because the study sought to explore and describe or evaluate quality of oil used in frying in some selected hotels and restaurants in Sekondi-Takoradi. This design agrees with Almeida (2018), which states that mixed methods research is an approach that combines both quantitative and qualitative methods Mixed methodologies are employed when both comparative analysis and the development of into a single study in order to provide a broader and more complete vision of a problem. aspects of the study need to be undertaken comprehensively and in depth. The process of research involves emerging questions and procedures, data typically collected in the participant's setting Questionnaires were used as the data collection methods whilst qualitative and descriptive methods of data analysis were used. The research work was in two phases. The first phase involved sampling oils that are mostly abused for lab work to determine their quality. The chemicals used in this investigation were of high analytical purity. The assortment of volumetric glassware employed were pre-sterilized in an autoclave and oven dried prior to analysis. The oils samples were warmed in a water bath at 50 ℃ for 10 minutes to increase the flow and reduce viscosity of the oils. The oils were shaken on an orbital shaker for 30 seconds for complete mixing to ensure homogeneity. A weight of 5 g of each oil sample was measured into 250 mL Erlenmeyer flask and 50mL of hot, neutralized ethyl alcohol added.

The second part of the research work involved using a set of questionnaires to elicit information from the respondents which were analysed using qualitative and descriptive methods. The questionnaire was made up open and close ended type of questions. This helped in achieving the objectives of the study

3.3 Population and Sampling

The study targeted some selected hotels and restaurants caterers in the Sekondi-Takoradi Metropolis who were aged eighteen (18) years and above. The rationale behind this population and age group was because, those below 18 years of age may not be educated, knowledgeable or informed enough on the subject understudy to make meaningful contribution. However, the sample frame, the actual group of people from which the sample was taken comprised all those, above 18 years, who are caterers in some selected hotels and restaurants in Sekondi-Takoradi. Oil samples that were used in frying chicken were drawn from all the catering outlets, because they were repeatedly used. According to Aladedunye & Przybylski (2013), continuous and repeated use of frying oil is a common practice to cut expenses. Oil degradation has adverse effects not only on properties of fried foods, such as sensory attributes, nutrition and shelf-life (Dobarganes et al., 2000; Pawar et al., 2013; Aladedunye, 2015), but also on food safety, thereby affecting human health (Stier, 2013; Urbančič et al., 2014; Wang et al., 2015). the researcher therefore sampled the most abused oil for quality assessment to determine their quality. Only oils used for frying chicken were sampled to determine their quality.

3.4 Sampling Technique

The study used the combination of both probability and non-probability sampling techniques. The purposive sampling technique was to select the hotels. The list of registered hotels and restaurant were obtained from the Ghana Tourism Authority (GTA). The researcher sampled hotels from 4-2 star hotels. 1-star hotels were not included because they hardly provide meals. The convenience sampling technique was to select respondents that were in the star-ratings of the hotels and restaurants selected. Respondents who were easily accessible and were willing to participate in the study were used for the study. After responding to the questionnaires, the researcher requested and took oil samples of most abused oil in a sterilized plastic container for physicochemical analysis to ascertain their quality. The hotels sampled were assigned with codes.

3.5 Sample Size

Sample size refers to basic questions such as: how large or small must the sample be for it to be representative (Sarantakos, 2005). Choosing the right sample size is a major issue that often confronts social investigators. In all forty-five (45) hotels and restaurants were sampled from the Sekondi-Takoadi metropolis, this was made up of thirty (30) hotels (three 4-star hotels, five 3-star hotels and thirty-seven 2-star hotels; and fifteen (15) restaurants). The hotels and restaurants sampled were assigned with the following codes.

Table 3.1: Serialized Codes of hotels and restaurants in the Sekondi-Takoradi used for the study and their ratings. Number of hotels = 30, Number of restaurants =15.

Serial number	Hotels	Star rating	Serial number	Hotels	Star Rating	Serial number	Restaurants
001	PH-1	4	**016**	TLS-16	2	**031**	VNR-1
002	AIH-2	4	**017**	PES-17	2	**032**	VRR-2
003	AHI-3	4	**018**	NAS-18	2	**033**	KVR-3
004	SCH-4	3	**019**	AHS-19	2	**034**	SPR-4
005	SJH-5	3	**020**	BHS-20	2	**035**	MRR-5
006	DBH-6	3	**021**	GHS-21	2	**036**	AJR-6
007	ADH-7	3	**022**	RHS-22	2	**037**	ADJ-7
008	BMH-8	3	**023**	ATS-23	2	**038**	JSR-8
009	SKH-9	2	**024**	PTS-24	2	**039**	GR-9
010	GSH-10	2	**025**	AMS-25	2	**040**	STR-10
011	TSH-11	2	**026**	WSH-26	2	**041**	GLR-11
012	APH-12	2	**027**	NHS-27	2	**042**	HTR-12
013	FSH-13	2	**028**	APH-28	2	**043**	GIR-13
014	HCI-14	2	**029**	PLH-29	2	**044**	TUR 14
015	YMH-15	2	**030**	TDH-30	2	**045**	SRC 15

N=45

Source: fieldwork, 2020

3.6 Data Collection Instrument

Data was obtained by means of a self-administered questionnaire. A questionnaire is a data collection tool by which people respond to a set of standard questions in a pre-determined way (Creswell, 2003). Questionnaire surveys help to characterize the features of the target population in relation to the identified variables and also ensure reliability. Just as any other data collection technique, the use of the questionnaire is not without problems. Questionnaire surveys have been associated with low response rates and other errors such as biases in responses. For this reason, the researcher personally administered the questionnaire to obtain high response.

To ensure that the responses represented the views of the respondents, the questionnaire was made up of both open-ended and close-ended questions. Open-ended questions are questions which give respondents the total freedom to express themselves whilst the close-ended questions were that which restrict respondents in their response by providing a set of predetermined or coded answers for them to choose from. A bit freedom is, however, provided by occasionally asking respondents to specify or add their own response where applicable. The questionnaire for the study was grouped as sections A, B, C, D and E

Section A was made up of five (5) items soliciting data on some of the demographic details of the respondents. Section C consisted of eight (8) questions. It focused on number of times frying oil was used. Section D looked at knowledge on the quality parameters of used oils. Three (3) questions were asked under the section. The final section looked at knowledge of the physicochemical properties of used oils.

Empty bottles, that were sterilized and clearly labelled were also used in collecting used oil samples to determine their physicochemical properties. The samples were transported to the Biochemistry laboratory of Kwame Nkrumah University of Science and Technology to determine their acid value, peroxide value and free fatty acid (FFA) levels.

3.7 Data Collection Technique

In collecting the data for the study, a self-administered questionnaire was developed and distributed to the respondents. However, to improve the response rate, the researcher administered all the questionnaires personally. In all, a total of fifty (50) questionnaires were sent out to gather the data. However, forty-five (45) questionnaires representing about ninety percent (95%) were returned completed. Furthermore, a pilot study was conducted in July, 2020 using ten (10) catering outlets from the Sekondi- Takoradi clusters, administering ten questionnaires to test the appropriateness of the questionnaire items and respondents understanding of the questions. This assertion is similar to that of Creswell (2007), who indicated that a pilot study is normally carried out for a questionnaire with the aim of ensuring that respondents have no problems responding to the items and also to ensure the reliability and validity of the items in the questionnaire.

3.8 Ethical consideration

To abide by the ethics of research, the study took ethical issues into consideration. To ensure anonymity, respondents were told not to write their names on the questionnaires. This was to hide the respondents' identity, assured confidentiality and privacy. Attached to the questionnaire was a respondents' consent form which sought to enable them to stop or withdraw at any time they wanted. The consent of a respondent was even sought before given a questionnaire to complete.

3.9 Determination of Free Fatty Acids (FFA)

3.9.1 Principle

The free fatty acids in the oils were measured by extracting the sample with hot ethyl alcohol and titrating the supernatant alcohol layer with standard alkali. For the oils used in this study, the free fatty acids were calculated as oleic acid.

3.9.2 Reagents

1. Ethyl alcohol, 95%
2. Phenolphthalein indicator, 1%
3. Sodium hydroxide solution, 0.1 N: Standard

3.9.3 Preparation of Neutralized Alcohol

The neutralized alcohol was prepared by adding 2 mL of 1% phenolphthalein to 1L ethyl alcohol (95%). Aliquots of 0.1 N sodium hydroxide solution was added dropwise until a faint pink color persisted.

3.9.4 Sample Preparation and Titration

The oils samples were warmed in a water bath at 50°C for 10 minutes to increase the flow and reduce viscosity of the oils. The oils were shaken on an orbital shaker for 30 seconds for complete mixing to ensure homogeneity. A weight of 5 g of each oil sample was measured into 250 mL Erlenmeyer flask and 50mL of hot, neutralized ethyl alcohol added. The solution was titrated against 0.1 N Sodium hydroxide solution till an endpoint indicated by a permanent pink color formation which persisted after allowing the mixture to settle for some seconds. The volume of Sodium hydroxide used was recorded and the FFA% calculated.

Calculation

$$\text{Free Fatty Acid\%} = \frac{\text{Vol. of 0.1N NaOH} \times \text{N NaOH} \times \text{M}}{\text{Weight of sample (g)}}$$

Where;

Vol. of 0.1N NaOH =The volume of alkali used in the titration

M = 28.2 for Oleic acid

N = 0.1N NaOH

3.10 Determination of Acid Value

The acid value also known as acid number of the oil samples were elucidated from the FFA% determined from the titration using the formula

Calculation

Acid value = 1.99 × FFA

Based on assuming the samples to be seed oil thus using the Oleic acid number.

3.11 Determination of Peroxide Value

Peroxide value (PV) is a measure of peroxides contained in the oil. PV is determined by measuring iodine released from potassium iodide. A mass of 2.5 g of each sample was weighted into 250 mL Erlenmeyer flask and 15 ml mixture of acetic acid and chloroform

(3:2) solution was added. The solution was shaken to mix followed by the addition of 0.5 ml of saturated KI solution subsequent to the addition of 15ml of distilled water. The indicator (0.5 mL of starch indicator) was added to the solution and mixed. The measure of iodine liberated from KI by the oxidative action of peroxides present in the oil was determined by titration with standard 0.1 N sodium thiosulphate until the solution turn from oily yellow to colorless. Titration was also performed for blank with all components except the sample and the titer values recorded (Zahir *et al*., 2014).

3.10.1 Calculation

$$\text{Peroxide Value} = \frac{(S-B) \times N \times 1000}{\text{Wt. of sample}}$$

Where,

S = ml of sodium thiosulphate for sample titration

B = ml of sodium thiosulphate for blank titration

N = Normality of sodium thiosulphate

Wt = Weight of oil sample

3.11 Data Analysis Procedure

The primary data resulting from the survey were analyzed using both descriptive and inferential statistics. The data were screened for incomplete entries. Numbers were assigned to the responses under the closed ended questions and were retained as codes for data entries. On the other hand, the responses from the open-ended questions were grouped based on their meanings and were also coded to facilitate data entry. The statistical tools that were specifically applied in analyzing the data were frequencies, percentages and averages using the version 26 of the SPSS Statistics computer software.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Demographics Characteristics of Respondents

Table 4.1: Percentages of Respondents Details in relation to Gender, Age range, Level of education, Position in the institution and Establishment type. N=45

VARIABLE		FREQUENCY N=45	PERCENTAGE (%)
Gender			
	Male	9	20
	Female	36	80
Age			
	18-25	12	27
	26-35	22	49
	36-45	4	9
	Above 45	6	13
	Non-responses	1	2
Level of education			
	Secondary education	5	11
	Tertiary	37	82
	Non-responses	3	7
Position			
	Head chef	5	11
	Chef	9	20
	Cook	28	62
	Catering Assistant	3	7
Type of establishment			
	Hotel	30	67
	Restaurant	15	33

Fieldwork, 2020

Data on Table 4.1 were the personal information on the participants. Characteristics such as gender, age, level of education, position and type of establishments were all presented. According to the results, over two thirds of the respondents (80%) were females and just 20% were males. In terms of the age distribution, majority of the respondents were youth between ages 18 and 35 years. Specifically, most of the respondents (49%) were aged between 26 years and 35 years. This was closely followed by those in the age bracket of between 18 years and 25 years (27%). Also, in the results, about 13% were above the age 45 years and just 9% were aged between 36 to 45 years.

The implication therefore is that a significant number of the respondents were youth. This may be good for the spirit of the study because if a greater number of the population are youth, then the right education will ensure they also relay the education to their colleagues for the greater good of the country and policy. Moreover, over 80% of the respondents (82%) had attained a tertiary education and 11% also with secondary education. Just 7% did not respond to the question. Furthermore, on Table 4.1, more than half of the entire respondents (62%) were cooks, and 20% were Chefs. Also, 11% were head Chefs and just 7% of the respondents catering assistants. Finally, the results on Table 4.1 indicated that the majority were in the Hotels and 33% also in the restaurants. The presentation of demographic data in research studies normally helps to provide context to the analysis and discussion. Considering this, it not out of place to have presented the demographic characteristics of respondents.

4.2 Factors Caterers look out for in their Choice of Oils

This section concerns examining the knowledge level and usage of oil when frying. In a bid to achieve this objective, the study assessed the type of oils used, the common brands of oils used, why certain brands are used and how often they are used.

Table 4.2: Frequency distribution and Percentages of Types of Oil Normally Purchased by respondents for cooking. N=45

VARIABLE	FREQUENCY N=45	PERCENTAGE (%)
Vegetable oil	26	58
Sunflower	9	20
Olive oil	4	9
Palm kernel	3	7
Soyabean	3	7

Fieldwork, 2020

From Table 4.2, it was clear that most of caterers or cooks use vegetable oil. Specifically, 58% of the respondents use or purchase vegetable oil in frying. Also, less than a quarter of the respondents (20%) purchase sunflower to fry in their various establishments. Moreover, about 9% of the respondents indicated that they purchase olive oil for usage in their hotels or restaurants. Results also showed that 3 respondents representing 7% respectively purchase palm kernel oil and soyabean oil.

Oils have good nutritional values that helps the growth of the human body. Studies have suggested that oil, regardless of the type of help in the lubrication of the muscles. They also contain fat that could be condensed or turned into glucose that the body would use when needed. For instance, in the study of LibreTexts (2020) oils or lipid function as control messengers (hormones), forms the basis for cell membrane structural components, serves as energy storage, isolates the body organ, and transportation via blood of fat-soluble vitamins.

Generally, there is an undercurrent and crave for sunflower oil and vegetable oils in the Ghanaian households. This is stemmed from the fact that it is claimed to have higher nutritional components compared to the other cooking oils available. Hence it is not unfortunate to have majority of the respondents to be using these products. Aside, its acclaimed health benefits, some authors believe that vegetable oil and sunflower oils have the right packaging (Saguy and Dana, 2013). The results were also consistent with the preposition of Otunola *et al*. (2009). In Africa and Ghana these brands are the kinds of cooking oils that are mostly found in the country. They are either imported or produced here and so they come as no option are readily available on the markets. Moreover, according to Biedermann *et al*. (2012) cooking oils are bought or used depending on what the consumers wants to use them for. That is there oils for cooking and oils for frying and so consumers purchase a type of oil based on what the consumers want to do.

Table 4.3: Frequency Distribution and Percentages of types of Oil Brand Normally Purchased for Cooking by Hotels and Restaurants in Sekondi-Takoradi. N=45

VARIABLE	FREQUENCY (N=45)	PERCENTAGE (%)
Frytol	26	58
Lele sunflower oil	9	20
Palm oil	3	7
Sabroso olive oil	4	9
Unoli soyabean oil	3	7

Fieldwork, 2020

Table 4.3 also present the brands of oils normally purchased in the country. From the results, more than half of the entire respondents (58%) prefer Frytol oil and 20% prefer Lele Sunflower oil. Also, in Table 4.3, about 9% stated that they normally buy Sabroso olive oil and about 6% of the respondents respectively buy Palm oil and Unoli Soyabean oil. Like Otunola *et al.* (2009) rightly indicated that there are different brands of cooking oils, however, just few ones are available in our local markets and so consumers buy them. Weisshaar and Gutsche (2012) added that in developing countries demand for commodities are motivated by the level of advertisement on the local media. Advertiser are able convince consumers or blind consumers to other products also available on the market. The brands of cooking oil mention have a history especially the Frytol oil thus consumers choose to purchase them.

Table 4.4: Frequency Distribution and Percentages of Why hotels and restaurants use the brand of oil they use. N=45

VARIABLE	FREQUENCY N=45	PERCENTAGE (%)
The nutritional properties of the oil	17	37.7
The flavour of oil	8	17.7
Quality properties of oil	8	17.7
Less expensive and available	6	13.3
Non-responses	6	13.3

Fieldwork, 2020

Table 4.4 presents assessment of the reasons for the purchase of certain brands oil in the household and business establishments. According to the results, most people (38%) buy cooking oils because of their nutritional properties and about 18 percent of the respondents buy certain types or brands of cooking oils for their flavour and quality properties. There were about 13% of the respondents who also indicated that they buy cooking oils for their houses and restaurants based on the market prices and availability on the markets. The results on Table 4.4 partly support the study of Grigg (2009). According to Grigg (2009), the crave for certain types of cooking are determined by price and readily availability on the market. That is most consumers are gradually drifting away from animal oil to plant oil based on the market prices. Though the study acknowledged that health properties or benefits of plant based cooking oils are also some of the reasons for the drift, in developing countries such as Ghana, the price is what people look out for especially the low and middle-class consumers.

Furthermore, McMichael (2011) recounted that though the rich usually opt for cooking oils based on their health or medical positive, majority of the consumers nonetheless, choose a certain brand of cooking oil referenced to it price, availability, and flavour. Experience and observation also have it that there are some consumers who select certain types or brands of cooking oils based on history or what their parents had been using some time ago. So, it is not that there are no other brands of cooking oil like olive oil and oily fish (a source of omega-3) on the market but its prices and taste or flavour normally make them shy away.

Table 4.5: Percentage Distribution on How respondents got to know the oil they use. Respondents got to know their brands from advertisement and recommendations. N=45

VARIABLE	FREQUENCY (N=45)	PERCENTAGE (%)
Advertisement	25	56
Recommendations	18	40
Offers	1	2
Non-response	1	2

Fieldwork, 2020

Results from Table 4.5 revealed how respondents or consumers got to know the oils they purchase for cooking. Over 50% of the respondents said they got to know of the type of cooking oil they purchased through advertisements. Also close to half of the entire respondents (40%) mentioned that they got to know the type or brand of cooking oil based on recommendations from friends or people and some 2% also indicated that they got to know the type of oils from the offers or market promotions they are often done. The results from Table 4.5 partly supported the study by Franke *et al*. (2013). According to Franke *et al.* (2013), hoteliers or cooks select cooking oils for frying, especially deep-frying based on the nutritional physiological and culinary aspects. However, information regarding the nutritional properties on oils are either advertised or recommended by a user. That is to say that for a consumer or clients to know the nutritional properties of an oil, it is normally through advertisements or through recommendations from someone who has already used the products before.

Generally, advertisements and promotions are some marketing strategies that usually convinces clients to fall for certain products. Normally, the advertisements are blended with testimonies from users usually celebrities or experts. This often convince clients or users to choose a certain brand over other brands. Thus, it is not out of place to have majority of the respondents to select their type of cooking oil based on the advertisements and recommendations from other users or experts.

Table 4.6: Percentage Distribution of How Often Respondents Change Oil Brand They Use at the Hotel and Restaurants in Sekondi-Takoradi. N=45

VARIABLE	FREQUENCY (N=45)	PERCENTAGE (%)
Half a year	9	20
Once a Year	2	4
Two-three years	6	13
Never	23	21
Non-response	5	11

Fieldwork, 2020

On Table 4.6, respondents were asked how often they change the brand or type of cooking oils. Most of the respondents (20%) mentioned that they change their cooking oil every half a year. About 13% indicated that they change their cooking oils every 2 to 3 years, just 4% stated that their cooking oils are changed once every year. However, 23 respondents representing approximately 21% of the respondents said they never change their cooking oils. Usually, habits once formed is difficult to alter especially relating to behaviour. In Ghana and other developing countries, people prefer to use or choose a variety or a type of food or commodity because it is the favorite of the parents, loved one or a respected person. Thus, it is normally rare to have a change in taste or behaviour overnight. This may not support the study of Gupta *et al*. (2014) who stated that with recent developments some manufacturers are able to add some flavours and other nutrients or vitamins to their products which may require that clients taste or try them.

Table 4.7: Mean, Standard Deviation and Ranking of Factors Respondents Consider in Deciding Which Oil Products to Purchase for Use in the Hotels and Restaurants.

MS= Mean SD =Standard Deviation

Factor	MS	SD	RANK
Price of the oil	4.09	0.883	5
Quality (flavour, texture, etc) of the product	4.25	0.751	1
Ability to cook various types of foods	4.15	0.793	3
Label of the product	3.97	0.885	8
Ease of pouring when using it for cooking.	4.10	0.797	4
Reuse of the container after using the oil	3.89	0.920	10
Attractiveness of package	4.06	0.897	6
Healthy eating attributes	4.20	0.790	2
Availability	3.99	0.916	7
Number of times it can be used	3.93	0.883	9

Fieldwork, 2020

Table 4.7 examined the factors influenced the type of oil used or selected on the markets. Overall, quality in terms of flavor, texture received the highest mean score 4.25. this means that the major indicator caterers looks at when selecting oil is the quality parameters. This was followed by the eating healthy attributes with a mean ranking of 2 (4.20). The ability to cook different meals with it came third with a mean score of 4.15. the fourth major factor caterers look at when selecting oil is the ease of pouring. This received a mean score of 4.10. The price of the oil is the fifth major factor that caterers consider when selecting oils. This clearly shows that respondents pay more attention to other parameters when selecting oils than price. The least parameter caterers pay attention to when selecting oil is the ability to reuse the bottle or container. Surprisingly caterers do not pay much attention to the number of times the same oil could be used. The number of times the same oil could be used received a mean ranking of 9 and a score of 3.93.

According to Franke *et al.* (2013) nutritional value or components of cooking oil influence most clients in the selection of cooking oils for food. Moreover, Gupta *et al.* (2014) added that the taste and flavour of some cooking oil affect the decision to either choose a type of oil or not. The results were also consistent with the study of Choe and Min (2017) and that most clients or consumers on the markets are influenced by the prices of commodities, quality of that item, taste or flavour, and readily availability of the commodity when needed. It is very true, some commodities may be good, however, because it often dear and difficult to get make consumers to shy away. The belief is that when their taste changes in flavour of it and along the line, they are not able to get would make they uncomfortable, thus they are very good factors to look for when choosing the type of cooking oils. However, the results contradicted the study of Valantina and Neelamegam (2012) who stated that packaging and labelling of food items influence consumers on the choice of food items.

4.3 The Frequency of usage of cooking oils

This section examines the number of times frying oils are used. Here the number of times the oil is used or reused in a day was assessed, the frying method, and the duration or period each cooking or frying session lasts.

Table 4.8: Percentage Distribution of Frying Methods Normally used by Hotels and Restaurants in Sekondi-Takoradi. N=45

VARIABLE	FREQUENCY (N = 45)	PERCENTAGE (%)
Shallow frying	7	16
Deep frying	38	84

Fieldwork, 2020

Table 4.8 shows the methods of frying or cooking with the oils. According to the results there are broadly two methods of frying which are the deep frying and the shallow frying. Over two thirds of the respondents (84%) maintained that the oil they purchase were used for deep frying and only 16% said they do shallow frying. Usually most of the cooks at the hotels and restaurants often do deep frying because the type of food they prepare involves the use of the deep-frying methods. This method, however, requires that clients or cooks pay attention to the cooking oil used. Especially some cooking oils settle upon standing for a while, others also lose their flavour and taste when reused hence cooks and kitchen staff ought to stay with the oil that are good. According to Lobo et al. (2010) cooking oils physical and chemical change when they are used repeatedly for deep frying.

The study advised that cooks be careful with the type of oils used. For example, it is claimed that sunflower oils are good when one wants to use them repeatedly.

Table 4.9: The Percentage of How Frequent Hotels and Restaurants Change the Frying Oil After Usage. N=45

VARIABLE	FREQUENCY (N = 45)	PERCENTAGE (%)
Once daily	5	11
Once every two days	7	16
After two usage	17	38
Once every 4 days	8	18
After one usage	2	4
When oil is dirty for frying	2	4
After 7 days of usage	1	2
Non-responses	3	7

Fieldwork, 2020

Table 4.9 presents how often cooking oils are changed after usage. Most of the respondents (38%) indicated that they change the cooking oils after two usages while about 16% of the participants also stated that they change their cooking oil. Moreover, about 18% of the respondents indicated that they change their cooking oils once in every four days, and 11% also were clear that they change their oil every day. Similarly, 4% of the respondents said they change their cooking oil only after one usage. This may be very expensive to do but, may also be the healthy thing to do since repeated use of cooking oils have its own health implication given the chemical and physical parameter variation (Lobo et al., 2010).

Furthermore, 4% of the respondents were of the view that changing cooking oil as and when they are dirty was the ideal thing to do. Same as others (2%) change their cooking oil after every 7 days of usage. One cannot say that it is bad to use cooking oil severally because some change theirs over short time. The notion is that some restaurants or hotels have high demand and as such even in a day can use the oil many times. Some hotels or food joints may not be overwhelmed by demand hence even within some days, the oil would not be busy, the oil could be used for some time. That is to say that the usage of cooking oil depending on the demand vary from hotels thus if one hotel is used as a yardstick may be problematic. Generally, it is believed that the FFA content of frying oils rise with the number of frying and frying time. Again, the formed FFA, glycerol, di-and mono-acylglycerols have been implicated by several authors to energize further thermohydrolysis (Chase-Dunn, 2005; Erikson and Bearman, 2006). This rather possess certain health hazards when humans consume them.

Table 4.10: Percentage Distribution of length of each Frying Session During Deep Frying in Hotels and Restaurants. N=45

VARIABLE	FREQUENCY (N=45)	PERCENTAGE (%)
Approx. 15 minutes	27	60
Approx. 20 minutes	7	16
Approx. 30 minutes	4	9
Approx. 45 minutes	4	9
Non-responses	3	7

Fieldwork, 2020

From the results in Table 4.10, 60% of the respondents said most of the time, their frying sessions last approximately 15 minutes. Also, about 16% of the respondents said their last frying or cooking sessions lasted approximately 20 minutes. Moreover, about 9% of the respondents responded that their last frying moment lasted 30 minutes and 45 minutes each. Additionally, 7% never responded to the question. Usually, frying or cooking depends on the type of food and the cook but the deep-frying time for chicken is approximately 15 minutes. Some food or food item takes long time to fry or cook. Others relatively take few or little time to cook so the time would differ. The person cooking or the chef too is a factor, while some prefer food to cook over long period of time, others think otherwise. In this regard, different type of cooking oils is preferred or chosen depending on the type of food that is being prepared.

The results partly contradict the study of Popkin (2017). In the view of Popkin (2017) when cooking especially deep frying, certain ingredients or nutrients in the cooking get absorbed into the food. Hence, cooks are advised to take time cook for the food to absorb the small nutrients in the cooking oil. This assertion to some extent motivates cooks to choose certain brands of cooking oils over others. Especially, cooks who are academically inclined prefer cooking oils fortified with vitamins and other nutrients and thus prefer plant-based cooking oil such as vegetable oil, sunflower oil, palm kennel oil, and soyabean oil. The results also support the views of Lang (2019) who opined that food frying is a way of adding flavour, texture, and have appearance to food worldwide hence frying must take an appreciable time for the oil to absorb into the food.

Table 4.11: Frequency and Percentage Distribution of Health Issues Respondents Think Old Usage of Oils Can Pose. N=45

VARIABLE	FREQUENCY (N=45)	PERCENTAGE (%)
Heart related issues	9	20
Chest pains	6	13
Cholesterol issues	7	16
General sickness	2	4
High blood pressure	6	13
Non-responses	15	33

Fieldwork, 2020

According to results in Table 4.11, most (20%) diseases that are related to cooking oils are heart related. About 16% of the respondent mentioned cholesterol issues as some of oil eating disadvantages that affect consumers. Also, in the Table, 13% said eating food that are fried with cooking oils often lead to health problems relating to chest pains and high blood pressure. It is worth noting that though eating cooking oil is good for the movement of the muscles, it can give rise to certain health problems if they are eaten too much. Commonly, it is said that eating foods with oil more often lead to increasing the cholesterol content in the human body.

According to Biedermann *et al*. (2012) cooking oils contain fats that usually concentrate or build up in the cells and veins of the human body, thus if they are not taken out can block the veins and may lead to heart failures. Basically, research has it that there are two type of cholesterols-good cholesterol and bad cholesterol. The good cholesterol usually come from plant extract while the other comes from animal extracts. One way is to either detoxify or do more exercises to burn them. In the view of Yasuhara *et al*. (2013) whether good or bad cholesterol, if they are eaten in excess, they can inflict harm to the health of humans. Examples of health-related issues that can results are high blood pressure, heart failure, and stroke. The study also supports the views of Marquez-Ruiz and Dobarganes (2017). Cooking oil can have negative health implications for the body.

Generally, oils when eating condenses and stores in the adipose cells of the human body and may translate or condense to form glucose when the body is in limited supply of carbohydrates. However, when these fats in the oil are more than it demands, they can build up and block the veins and arteries in the human body. This in effect could lead to high blood pressure as the heart tries to pump, but because of the blockage would make the heart to overwork. The blockage, however, prevent oxygenated blood to other part of the body such as the brain, the limbs and so on, this moreover led to seizure and stroke. Thus, the responses from the participants are not a departure from the truth. Moreover, Hageman *et al*. (2018) said that thermally oxidized lipids enhance peroxidation of membrane macromolecules, contributing to their mutagenicity and genotoxicity which could potentially lead to carcinogenesis.

Table 4.12: Frequency and Percentage Distribution of How Hotels and Restaurants Store Oil at The End of Frying Session. N=45

VARIABLE	FREQUENCY (N=45)	PERCENTAGE (%)
Poured into a container	36	80
Left in frying pan	5	11
Disposed off	2	4
Non-response	2	4

Fieldwork, 2020

Table 4.12 explains how cooks store cooking oils after frying. Most of them (80%) stated that the oil is poured into a container after usage. About 11% responded they leave the oil in the frying pan after frying and just few (4%) said they dispose them off. Generally, cooking oil are stored in a clean container for reuse if the oil is not dirty or may not been used severally. They should not be left in the frying pans for anything because dirt or dust may fall into it and may bring infection or sicknesses when it is used again. Again, cooking oils that have been heated or used before should not be mixed with fresh oils and so must be kept in clean bowl or containers. This because the chemicals reactions could contaminate the other fresh oil (Melton, 2007).

4.4 Knowledge on the quality parameters of used oils

This section on the study also examines the knowledge levels of respondents on the quality parameters of used oils. The study considers the factors people consider for discontinuing used oils, and whether the usage lose or reduces the value of the oil.

Table 4.13: Percentage Distribution of Respondents Perception on Whether Frying Oils Lose Their Value After Being Used for Some Time. N=45

VARIABLE	FREQUENCY (N=45)	PERCENTAGE (%)
Yes	39	87
No	2	4
Not sure	4	9

Fieldwork, 2020

In Table 4.13, majority of the respondents (87%) said that using oil after being used before loses its value. However, 4% thought otherwise, that is they believe oils would lose their value after being used before. The view of the majority was in line with the study of De Alzaa *et al*. (2018) that when oil is used for some time, it loses its value. Especially where it gets in contact with heat increases the fatty acids or oxidation in the oil. The views were also consistent with most studies that, cooking oil after some time decreases the value or nutritional contents in the product (Choudhary and Grover, 2013; Farid, 2011).

Table 4.14 presented the factors clients consider discontinuing the usage of frying oils. Over 60% said that they usually discontinue the usage of frying oils when the colour changes. About 11% of the respondents said that the black smoke that normally fumes from oil discourage some from continuing usage. Some respondents also believed that the change in the smell discourage them from continuous usage of cooking oil after some time. Moreover, 7% said the change in taste or variation in the taste of the oil after usage for some time prevents them from continue usage.

Table 4.14: Percentage Distribution of Factors Hotels and Restaurants Consider Discontinuing Frying Oil Usage. N=45

VARIABLE	FREQUENCY (N=45)	PERCENTAGE (%)
Colour	30	67
Taste	3	7
Smell	4	9
Black smoke	5	11
Non-responses	3	7

Fieldwork, 2020

In the study of Choudhary and Grover, (2013) some physicochemical changes that occur in cooking oil after some time is the taste, colour, and smell. Fresh cooking oils have certain smell and flavour that distinguished them from the used oils. Thus, it is no coincidence that most people mention that the change in colour, taste and smell make them shy away from oil after some time. Kalogeropoulos *et al.* (2007) indicated that oil usage after some time produces solutions that increases viscosity, color, spray and smoke. They also change the smell and produces some odour after some time. Additionally, the study of Saxena (2014) supported the view of the study that cooking oil after some time may be unfit for human consumption.

Table 4.15: Percentage distribution of the various Means Hotels and Restaurants use to Dispose Old Oils. N=45

VARIABLE	FREQUENCY (N=45)	PERCENTAGE (%)
Shito preparation stew and sauce preparation	40	89
Refill	3	7
Poured away when dirty	1	2
Non-responses	1	2

Fieldwork, 2020

Means of disposal of old cooking oils were also examined in Table 4.15. The results showed that majority of the people or cooks (89%) use the old cooking oil for preparing shito, stew, and sauce. Also, 7% said they refill with other oils. Oil disposal is often preferred over being used for other food preparation especially where the oil is dirty. In some studies, when oil is heated and reheated, exposes certain injurious chemicals in the oil when eating can harm the growth of the body (De Alzaa *et al*., 2018). The study of De Alzaa *et al*. (2018) also noted that when cooking oils are reheated or reused, they lead to fatty acid content in the oil and these fatty acids if they go beyond the permissible levels can lead to health problem. This because they become insoluble in water. Again when old oils are reused for food preparation it leads to loss of flavour, give rise to odour and also reduce the shelf life of the food item, hence ideally, old oils especially the ones that have been used severally should be disposed off entirely.

However, in Ghana or developing countries where poverty levels are rife, just disposing cooking oils after first or second usage is problematic. Most people see that as addition to cost especially where there are other foods to be prepared that need lots of oil. Many shito sellers or manufacturers use the old oils that have been left at the restaurants, hotels and other food joints. Others even add it to the little fresh oil they have and use it for the shito preparations. Observation also show the catering staff at hotels and some restaurants store the cooking oils and reused them for stew and other sauces. The view is that it helps to reduce the cost in food preparation. Though oils may be used after certain times care should be taken and storage should be done properly because if old cooking oils are used, they have the tendencies to increase rancidity. Here rancidity of oil produces certain toxic compounds like acrylamide which is a probable human carcinogen (Diop *et al*., 2014).

4.5 Knowledge of the Physicochemical Properties of Used Oils

In this section of the chapter, the study assessed the knowledge levels of respondents on the physicochemical properties of used oils.

Table 4.16: Respondents Responses in Frequency and Percentages On Whether They Have Knowledge of How to Test the Quality of Frying Oils and by What Means. N=45

VARIABLE	FREQUENCY N=45	PERCENTAGE (%)
Yes	9	20
No	36	80
If yes explain		
By measuring the iodine content of oils	8	18
By colour and thickness	1	2
Non responses	36	80

Fieldwork, 2020

Respondents were asked whether they know how to test the quality of frying oils. From Table 4.16, only less than a quarter (20%) replied that they know how to test it. Over two third majority of the respondents indicated that they have no idea how to test the quality of the cooking oils. The study further asked respondents to explain how to measure it. Out of the 20% who maintained that they knew how to test, 18% representing the majority said the quality is tested by measuring the iodine content of the oil. About 2% said the colour and thickness are used to determine the quality of a cooking oil.

The results of those view contradict the study of Sangle and Daptare (2014); Aladedunye and Przybylski (2013). According Aladedunye and Przybylski (2013), there are three main components (hydrolysis, oxidation and polymerization) that determines the quality of cooking oils. And that the higher levels of these proves that the oil is unfit for human consumption. For instance, higher levels of hydrolysis produces monoglycerides, diglycerides, free fatty acids and glycerol that causes harm for the liver and other sensitive parts of the human body. Oxidation however, makes the fatty acid unsaturated and insoluble. This also has the tendencies of blocking the veins of the human body. In effect, the test for the quality of cooking oil goes beyond just the colour and taste but involves other laboratory tests.

Table 4.17: Respondents Responses in Frequency and Percentage on How They Test for The Free Fatty Acid Percentage of Frying Oils. N=45

VARIABLE	FREQUENCY (N=45)	PERCENTAGE (%)
By titrating against KOH	8	17.7
Non responses	37	82.2

Fieldwork, 2020

Results in Table 4.17 present the views of respondents on how free fatty acids are tested. According to the results, majority of the respondents (82%) never replied meaning they have no idea on how free acids are tested. Only 18% mentioned that the free acids are tested by titrating against KOH at the lab. The results were contrary to scientific principles and that the test for free fatty acids (FFA) are titration against ethanol in standard alkali solution. Scientifically the name for KOH is potassium hydroxide which is a strong base used for other things at the lab. The implication therefore is that the test for FFA may not just free knowledge for everyone to know unless one is scientifically inclined.

Table 4.18: Responses in Frequency and Percentages on any other Test Hotels and Restaurants Run to Test the Quality of Frying Oils. N=45

VARIABLE	FREQUENCY N=45	PERCENTAGE (%)
Digital total polar molecule device	3	7
Free fatty acid test strips	3	7
Oil colour guide test kits	3	7
Closely monitoring oil colour and viscosity	6	13
Non responses	30	67

Fieldwork, 2020

In Table 4.18, respondents were asked to specify any test one could run to test for the quality of frying oils. Though most of the respondent (67%) never replied, others (13%) indicated they monitor closely the colour and viscosity of the oil. Even though monitoring the viscosity of oil may not be a test to run it is important to notice the thickness of cooking oils. According to Warner (2014) monitoring is physical properties one could use to decipher between a good oil and other oil with fatty acids. About 7% of the respondents each said; the free fatty test strip, oil colour guide tests, and digital total polar molecular device are some of the test that can be done to test quality thereof or otherwise of a cooking oil. Again, Sharova and Ramadan (2012) mentioned that viscosity is one of the indicators used to evaluate the physical changes in edible oil. Viscosity also increases during hydrogenation as the increase in the chain length of tri-glyceride fatty acid and decreases during unsaturation of fatty acids.

Table 4.19: Percentage Distribution of How Frequent Hotels and Restaurants Measure The %FFA and Peroxide Value of Fresh Oils after Purchase N=45

VARIABLE	FREQUENCY OF TESTING	FREQUENCY N=45	PERCENTAGE (%)
%FFA	Daily	2	4
	Fortnightly	2	4
	Monthly	3	8
	Non responses	38	84
Peroxide value	Fortnightly	2	4
	Non responses	43	96

Fieldwork, 2020

In Table 4.19 respondents were asked how frequent the test for quality of oil be done. On the FFA percentage, 4% said this test should be done daily, with 7% stated that the test for peroxide value should be done monthly. Furthermore, about 4% of the respondents also indicated that the percentage of FFA should be tested fortnightly and about the same proportion of the respondents the Peroxide value must also be done fortnightly. From Table 4.19, most of the respondents never responded to questions with the view that the questions were quite technical for their lay mind. The test for the quality of oils were in line with most studies reviewed however the duration or period for the test is not determined. For instance, Lioumbas *et al*. (2012) indicated that the tests for the quality of oil may not be easy and general like that so it should be done before packaging and eating but it may not be possible for the oil to be tested monthly or weekly. Again, if an oil is tested and not used, the test for its quality parameter may not be necessary. In simple terms it is not possible to be testing cooking frequently before eating because aside it cost involved, it requires specialized kit to do the testing and that may not be generally possible or practical all the time. The study moreover study agreed with the study Phiri *et al*. (2016) that it is a common practice in the household or in the commercial sector to use the same frying oil repeatedly to save cost and that the oil is discarded only when it becomes foamy, emits odour or when the colour turns dark.

4.5.1 Physiochemical Analysis of most abused oils

Detection of peroxide gives the initial evidence of rancidity in unsaturated fats and oils. Other methods are available, but peroxide value is the most widely used. It gives a measure of the extent to which an oil sample has undergone primary oxidation, extent of secondary oxidation may be determined from p-anisidine test (Chakrabarty 2018). In general, fresh oils have a peroxide value of >10 mEq/Kg while peroxide values in the 30-40 mEq/Kg range are generally associated with a rancid taste (CODEX Stan 210, 2019). Edible vegetable oils are foodstuffs which are composed primarily of glycerides of fatty acids being obtained only from vegetable sources. They may contain small amounts of other lipids such as phosphatides, of unsaponifiable constituents and of free fatty acids naturally present in the fat or oil. Acidity is defined as the content of FFA in an oil or fat determined according to the method specified in ISO 660:1996 or equivalent methods and is expressed as a percentage by mass of FFA. The acceptable level of Free fatty acid percentage is 0.5% expressed as oleic acid (CODEX Stan 210, 2019).

4.5.1.1 Free Fatty Acid

The FFA of the oils ranged between 0.35% and 1.4% for the oil samples analyzed in the study. The details are provided in Table 4.20. Table 4.20 shows free fatty acid of values of oil samples used for the study. From table 4.20 it can be seen that four-star hotels sampled for the study (PH-1, AIH-2 and AIH-3) had low values in percentages of 0.41%, 0.31% and 0.43%. This showed that the oils used in the hotels have less free fatty acids hence the oil is not mostly abused. With regards to the three-star hotels sampled, it can be deduced from Table 4.20 that they also recorded low percentage values ranging from 0.30% - 0.46%. This result implied that the oils used in Three-star hotel for cooking fresh, it has not been reused for several times. Regarding two-star hotels used for the study, about 10 of them recorded low percentages values of free fatty acids ranging from 0.24% - 0.47% just like the values recorded in 4-star and 3-star hotels. This result indicates that some two-star hotels used fresh oils in cooking were fresh. However, the majority of the Two-star hotel recorded high percentage values of free fatty acids ranging from 0.54% - 1.40%. This showed that oil used in these hotels have been used in and reused several times for cooking.

From Table 4.20, it can be seen that some restaurants sampled also recorded low percentage value of free fatty acids between the ranges of 0.34% and 0.47%. This result indicated that only fresh oil was used for cooking. However, some restaurant also recorded somewhat high percentage values above 0.47% to 0.53%. This showed that some restaurant reuse oils that have already used for cooking.

Table 4.20: Free Fatty Acid percentage and standard deviation of most abused oil sampled from hotels and restaurants in Sekondi-Takoradi of Oil. N=45

SN.	Sample (Hotel)	FFA (%)	St. Dev	SN.	Sample (Hotel)	FFA (%)	St. Dev	SN.	Sample (Restaurant)	FFA (%)	St. Dev
001	PH-1	0.42	0.036	**016**	TLS-16	0.34	0.001	**031**	VNR-1	0.50	0.000
002	AIH-2	0.32	0.028	**017**	PES-17	1.40	0.009	**032**	VRR-2	0.42	0.121
003	AHI-3	0.44	0.038	**018**	NAS-18	0.42	0.037	**033**	KVR-3	0.50	0.000
004	SCH-4	0.30	0.021	**019**	AHS-19	0.95	0.074	**034**	SPR-4	0.36	0.036
005	SJH-5	0.32	0.030	**020**	BHS-20	0.48	0.036	**035**	MRR-5	0.36	0.039
006	DBH-6	0.46	0.034	**021**	GHS-21	0.35	0.020	**036**	AJR-6	0.47	0.038
007	ADH-7	0.47	0.033	**022**	RHS-22	0.78	0.071	**037**	ADJ-7	0.36	0.037
008	BMH-8	0.41	0.036	**023**	ATS-23	0.87	0.060	**038**	JSR-8	0.50	0.003
009	SKH-9	0.32	0.030	**024**	PTS-24	1.30	0.009	**039**	GR-9	0.34	0.035
010	GSH-10	0.39	0.034	**025**	AMS-25	0.34	0.020	**040**	STR-10	0.34	0.036
011	TSH-11	0.39	0.033	**026**	WSH-26	0.24	0.001	**041**	GLR-11	0.53	0.000
012	APH-12	0.40	0.032	**027**	NHS-27	0.55	0.046	**042**	HTR-12	0.37	0.036
013	FSH-13	0.31	0.030	**028**	APH-28	0.94	0.072	**043**	GIR-13	0.50	0.003
014	HCI-14	0.36	0.032	**029**	PLH-29	0.64	0.053	**044**	TUR-14	0.43	0.035
015	YMH-15	0.35	0.031	**030**	TDH-30	0.46	0.033	**045**	SRC-15	0.50	0.035

Fieldwork, 2020

4.5.1.2 Acid Value

The acid value of the oils was within the range of 0.67mg KOH/g to 2.79mgKOH/g

Table 4.21: Acid value and standard deviation of most abused oil sampled from hotels and restaurants in Sekondi-Takoradi of Oil. N=45

SN.	Sample (Hotel)	FFA (%)	St. Dev	SN.	Sample (Hotel)	FFA (%)	St. Dev	SN.	Sample (Restaurant)	FFA (%)	St. Dev
001	PH-1	0.78	0.071	**016**	TLS-16	0.68	0.001	**031**	VNR-1	1.00	0.001
002	AIH-2	0.64	0.060	**017**	PES-17	2.78	0.019	**032**	VRR-2	0.77	0.241
003	AHI-3	0.78	0.071	**018**	NAS-18	0.89	0.076	**033**	KVR-3	1.00	0.001
004	SCH-4	0.77	0.070	**019**	AHS-19	1.79	0.146	**034**	SPR-4	0.77	0.715
005	SJH-5	0.54	0.054	**020**	BHS-20	0.89	0.073	**035**	MRR-5	0.66	0.777
006	DBH-6	0.62	0.061	**021**	GHS-21	0.67	0.039	**036**	AJR-6	0.89	0.752
007	ADH-7	0.62	0.060	**022**	RHS-22	1.45	0.140	**037**	ADJ-7	0.67	0.075
008	BMH-8	0.60	0.060	**023**	ATS-23	0.79	0.014	**038**	JSR-8	1.00	0.003
009	SKH-9	0.80	0.072	**024**	PTS-24	0.96	0.084	**039**	GR-9	0.78	0.069
010	GSH-10	0.77	0.070	**025**	AMS-25	0.65	0.059	**040**	STR-10	0.86	0.061
011	TSH-11	0.74	0.072	**026**	WSH-26	0.68	0.041	**041**	GLR-11	0.98	0.001
012	APH-12	0.74	0.071	**027**	NHS-27	0.46	0.034	**042**	HTR-12	0.88	0.075
013	FSH-13	0.53	0.053	**028**	APH-28	1.67	0.143	**043**	GIR-13	1.00	0.001
014	HCI-14	0.52	0.051	**029**	PLH-29	0.67	0.054	**044**	TUR-14	0.76	0.073
015	YMH-15	0.51	0.050	**030**	TDH-30	0.74	0.043	**045**	SRC-15	1.00	0.001

Fieldwork, 2020

4.5.1.3 Peroxide Value

The peroxide values obtained for the oil samples were within the range from 0.99 meq/kg to 12.85 meq/kg. Table 4.3 shows the peroxide values of oil samples used for the study. It can be deduced from the table that four star hotels sampled for the study (PH-1, AIH-2 and AIH-3), had low peroxide values ranging between 0.97 meq/kg - 0.99 meq/kg which indicated that the oils used for cooking is fresh and has no indication of rancidity. This implied that vegetable oils used for cooking in for hotels in Takoradi are of good quality. However, it has been indicated in the table with regards to the three star hotels selected (SCH-4, SJH-5, DBH-6 and ADBH-7) that had somewhat low levels of peroxide values ranging from 0.97 meq/kg - 0.99 meq/kg with only one hotel showing a peroxide value of 1.24 meq/kg. This result also indicated that oils used in three star hotels for cooking showed no indications of rancidity thus were fresh and good for cooking.

Again out of the 23 two star hotels selected, 13 of the hotels had acceptable low peroxide values ranging between 1.47 meq/kg - 4.54 meq/kg showing the oils used by the hotels were fresh and goof for cooking but not as fresh with no level of rancidity as that of the four and three star hotels selected. However, about 10 of the two star hotels selected showed a high peroxide values ranging between 6.89 meq/kg - 9.87 meq/kg. This showed that the oils used for cooking in these hotels have high indications of rancidity thus not good for cooking and consumption. Therefore, results from the peroxide value table showed that closed to half of the hotels used oils that have gone rancid in cooking for customers.

Table 4.22: Peroxide values and standard deviation of most abused oil sampled from hotels and restaurants in Sekondi-Takoradi of Oil. N=45

SN.	Sample (Hotel)	Peroxide value (meq/kg)	St. Dev	SN.	Sample (Hotel)	Peroxide value (meq/kg)	St. Dev	SN.	Sample (Hotel)	Peroxide value (meq/kg)	St. Dev
001	PH-1	0.98	0.007	**016**	TLS-16	9.79	1.324	**031**	VNR-1	3.87	0.097
002	AIH-2	0.97	0.009	**017**	PES-17	2.98	0.001	**032**	VRR-2	2.95	0.037
003	AHI-3	0.99	0.009	**018**	NAS-18	3.98	1.395	**033**	KVR-3	0.98	0.002
004	SCH-4	0.99	0.008	**019**	AHS-19	3.23	0.343	**034**	SPR-4	3.94	1.343
005	SJH-5	0.98	0.009	**020**	BHS-20	3.49	0.704	**035**	MRR-5	12.84	0.084
006	DBH-6	1.24	0.014	**021**	GHS-21	1.47	0.991	**036**	AJR-6	3.91	1.294
007	ADH-7	0.97	0.009	**022**	RHS-22	2.97	0.003	**037**	ADJ-7	9.90	1.518
008	BMH-8	1.64	0.012	**023**	ATS-23	3.44	0.890	**038**	JSR-8	4.94	0.070
009	SKH-9	3.43	0.067	**024**	PTS-24	7.98	1.899	**039**	GR-9	6.98	1.243
010	GSH-10	3.23	0.098	**025**	AMS-25	6.89	1.343	**040**	STR-10	8.87	1.063
011	TSH-11	4.54	0.867	**026**	WSH-26	8.90	1.435	**041**	GLR-11	9.09	1.436
012	APH-12	3.98	0.896	**027**	NHS-27	3.98	0.595	**042**	HTR-12	8.78	1.043
013	FSH-13	8.87	1.478	**028**	APH-28	9.09	1.567	**043**	GIR-13	8.76	1.073
014	HCI-14	7.82	1.798	**029**	PLH-29	7.89	1.034	**044**	TUR-14	9.09	1.098
015	YMH-15	9.87	1.679	**030**	TDH-30	8.98	1.017	**045**	SRC-15	0.89	0.008

Fieldwork, 2020

Comparing the peroxide value showed in Table 4.22, it can be concluded that oils used in 4-star hotels showed absolutely low level of peroxide values showing that they had no signs of rancidity (PH-1, PV=0.98, AIH-2, PV=0.97 and AHI-3 PV=0.99) also, oils used in three star hotels did not show sign of rancidity though but had somewhat high levels of peroxide values (PV Values of between 4.54 meq/kg to 7.82 meq/kg) than the 4-star hotels. Meanwhile two star hotels sampled for this study showed high levels of peroxide values (9.09meq/kg to 9.72 meq/kg) and high indications of rancidity in the oils used for cooking. This could be attributed to the fact that 2-star hotels may want to cut cost of operation, hence the repeated usage of oil.

Regarding restaurants sampled for the study, it can be seen from Table 4.22 that extremely high peroxide values were recorded ranging from 0.89 meq/kg – 12.84 meq/kg. This showed that most of the oils used in cooking the selected restaurants have gone rancid and not good for consumption. This could be due to the highly attributed to the reason given by Aladedunye & Przybylski (2013), that Continuous and repeated use of frying oil is a common practice to cut expenses.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary

The study aimed to evaluate the quality of oils used in frying in some selected hotels and restaurants in Takoradi. It has been become a common practice nowadays to see chefs and cooks at the major hotels and restaurants keep repeating the cooking oils oblivious of the health hazards it comes with. The intent of the study was to inform policy and reinforce education. The questionnaires were the main data collection instruments for the study. Apart from the questionnaires samples of used oils were taken to the Lab to determine their physicochemical properties (acid value, peroxide value and free fatty acid (FFA) levels). Out of the questionnaires administered, 45 were answered and returned and that represent a 100% responses rate. For the findings:

- The study found that most respondents use plants based cooking oils (vegetable oils - 57.7% and sunflower oils 20%). The brands that are normally purchased are Frytol and Lele Sunflower Oil.
- Furthermore, the study found that most of the clients or cooks prefer to choose or select cooking oils based on the nutritional properties, quality, flavour or taste and price of the oil. Also the study revealed that they got to select or choose from the different brands of cooking oils in the various advertisements, promotions and even recommendations from friends, experts and family.
- The study also showed that while some cooks or respondents never change their brands, other vary them once every or once every half a year. However, on the frequency of oil usage, most people (37.7%) said they change their cooking oil

after every two-time usage. Other 17.7 percent and 15 percent of the respondents claimed they change their oil every four days and two days of usage respectively.

- Moreover, the study found that though most respondent did not know how to store or dispose off used cooking oils, they were well aware of the health implications of eating too much oily food. Mention was made of heart related issues, high blood pressure, cholesterol issues etc.
- The study also revealed that few respondents had knowledge on the physio-chemical properties of a good or quality cooking oils. Respondent also showed ignorance on the ways or means of testing for the quality of cooking oils.
- However, most of the respondents showed ample knowledge on the physical characteristic than can help to determine a good oil to use from the bad ones. Using the colour, smell, taste, texture and viscosity.

5.2 Conclusions

From the findings the following conclusions were inferred, first, respondents considered quality parameters when selecting a good cooking oil on the markets. The study also realized that most consumers of cooks believe that it is easy to disposed off used oils by using them for preparing Shito and other sauces regardless of the health implication.

The study also realized most consumers or users of the cooking oils get their information from the various advertisements done in the media on cooking oils. Without verification some of these information may not be right. Also it was revealed that while some consumers do not change their brands of oil, other do the variation every half a year or once a year.

It could also be concluded that most people are oblivious of the chemical properties to look for before looking good cooking oils. However, most cooks new the physical properties to look for or to consider before discontinuing on the usage of cooking oils. The smell, colour, and taste are very important factors to determine either to use oil over some period of time.

5.3 Recommendations

Based on the findings the following recommendations were made:

1. Further research could be conducted to ascertain why caterers prefer to go for quality the quality parameters when selecting oil. Researchers could also consider looking at reasons why the number of times the oil could be used is not much of importance to the caterers.
2. Further research could be carried out on reasons why 2-star hotels and restaurants continue to the use the same oil over and over again. Caterers should be trained and sensitized on the need not to continue reusing cooking oils over and over again since reusing over a period of time produces reactions that are harmful or injurious to the health of the human consumptions.
3. Further research could be carried out on the effect of the reused oils that are used in the preparation of shito, stew and sauces.

4. Furthermore, research could be carried out on caterers' knowledge on quality parameter and on the need to test for physiochemical attributes of oil.

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APPENDIX I

Appendix 1: Free Fatty Acid of oil samples

Sample	wt. of sample	Vol. of NaOH	FFA (%)	Mean	St. Dev
TCHS-5	5.027	0.6	0.336582	0.337086	0.000712
	5.012	0.6	0.33759		
PEHS4-7	5.056	2.5	1.394383	1.401346	0.009848
	5.006	2.5	1.40831		
SPYTEE R-4	5.078	0.7	0.388736	0.363298	0.035975
	5.008	0.6	0.337859		
NAHS2-8	5.036	0.8	0.447975	0.420679	0.038601
	5.018	0.7	0.393384		
VR-2	5.056	0.6	0.334652	0.420367	0.121219
	5.015	0.9	0.506082		
AHS-2	5.024	1.6	0.898089	0.950032	0.073458
	5.066	1.8	1.001974		
MR-5	5.038	0.6	0.335848	0.363485	0.039086
	5.047	0.7	0.391123		
AJR-6	5.038	0.8	0.447797	0.47454	0.037821
	5.063	0.9	0.501284		
KV-3	5.021	0.9	0.505477	0.505729	0.000356
	5.016	0.9	0.505981		
				0.45003	
BHS1-6	5.013	0.8	0.45003	0.476153	0.036943
	5.053	0.9	0.502276		
PI-1	5.005	0.7	0.394406	0.419952	0.036128
	5.064	0.8	0.445498		
JSR-8	5.038	0.9	0.503771	0.502478	0.001829
	5.064	0.9	0.501185		
GHS2-3	5.018	0.6	0.337186	0.351381	0.020075
	5.014	0.65	0.365576	0.365576	

RHS-3	5.027	1.3	0.729262	0.779337	0.070817
	5.1	1.5	0.829412		
ADJ-7	5.008	0.6	0.337859	0.364105	0.037116
	5.057	0.7	0.39035		

Appendix 2: Acid Value of Oil samples

Sample	wt. of sample	Vol. of NaOH	FFA (%)	Oleic acid factor	Acid value	Mean	St. Dev
TCHS-5	5.027	0.6	0.336582	1.99	0.669799	0.670801	0.001417
	5.012	0.6	0.33759		0.671804		
PEHS4-7	5.056	2.5	1.394383	1.99	2.774822	2.788679	0.019597
	5.006	2.5	1.40831	1.99	2.802537		
SPYTEE R-4	5.078	0.7	0.388736	1.99	0.773584	0.722962	0.07159
	5.008	0.6	0.337859	1.99	0.67234		
NAHS2-8	5.036	0.8	0.447975	1.99	0.891469	0.837152	0.076817
	5.018	0.7	0.393384	1.99	0.782834		
VR-2	5.056	0.6	0.334652	1.99	0.665957	0.83653	0.241226
	5.015	0.9	0.506082	1.99	1.007103		
AHS-2	5.024	1.6	0.898089	1.99	1.787197	1.890563	0.146181
	5.066	1.8	1.001974	1.99	1.993928		
MR-5	5.038	0.6	0.335848	1.99	0.668337	0.723336	0.077781
	5.047	0.7	0.391123	1.99	0.778336		
AJR-6	5.038	0.8	0.447797	1.99	0.891116	0.944335	0.075264
	5.063	0.9	0.501284	1.99	0.997555		
KV-3	5.021	0.9	0.505477	1.99	1.005899	1.006401	0.000709
	5.016	0.9	0.505981	1.99	1.006902		
BHS1-6	5.013	0.8	0.45003	1.99	0.89556	0.947544	0.073518
	5.053	0.9	0.502276	1.99	0.999529		
PI-1	5.005	0.7	0.394406	1.99	0.784867	0.835704	0.071894
	5.064	0.8	0.445498	1.99	0.88654		
JSR-8	5.038	0.9	0.503771	1.99	1.002505	0.999931	0.00364
	5.064	0.9	0.501185	1.99	0.997358		
GHS2-3	5.018	0.6	0.337186	1.99	0.671	0.699249	0.039949
	5.014	0.65	0.365576	1.99	0.727497		
RHS-3	5.027	1.3	0.729262	1.99	1.451231	1.55088	0.140925

	5.1	1.5	0.829412	1.99	1.650529		
ADJ-7	5.008	0.6	0.337859	1.99	0.67234	0.724568	0.073862
	5.057	0.7	0.39035	1.99	0.776797		

Appendix 3: Peroxide value of oils

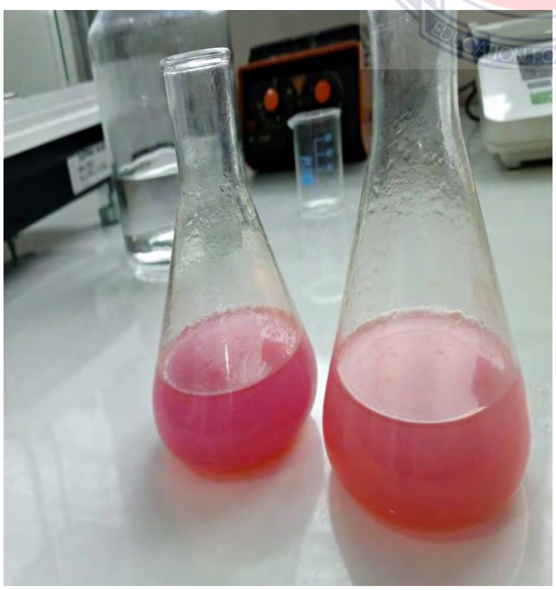
Sample	Blank	wt. of sample	Vol. of $Na_2S_2O_3$	FV	PV	Mean	St. Dev
TCHS-5	0.05	5.126	0.6	0.55	10.72961	9.793069	1.324474
	0.05	5.081	0.5	0.45	8.856524		
PEHS4-7	0.05	5.023	0.2	0.15	2.986263	2.987453	0.001683
	0.05	5.019	0.2	0.15	2.988643		
SPYTEE R-4	0.05	5.016	0.2	0.15	2.990431	3.940442	1.343519
	0.05	5.112	0.3	0.25	4.890454		
NAHS2-8	0.05	5.008	0.2	0.15	2.995208	3.981706	1.395119
	0.05	5.032	0.3	0.25	4.968203		
VR-2	0.05	5.022	0.2	0.15	2.986858	2.959991	0.037995
	0.05	5.114	0.2	0.15	2.933125		
AHS-2	0.05	5.086	0.1	0.05	0.983091	0.990149	0.009982
	0.05	5.014	0.1	0.05	0.997208		
MR-5	0.05	5.037	0.7	0.65	12.90451	12.84486	0.084357
	0.05	5.084	0.7	0.65	12.78521		
AJR-6	0.05	5.001	0.2	0.15	2.9994	3.914692	1.294419
	0.05	5.176	0.3	0.25	4.829985		
KV-3	0.05	5.061	0.1	0.05	0.987947	0.986003	0.00275
	0.05	5.081	0.1	0.05	0.984058		
BHS1-6	0.05	5.009	0.2	0.15	2.99461	3.492915	0.704709
	0.05	5.011	0.25	0.2	3.991219		
PI-1	0.05	5.096	0.1	0.05	0.981162	0.986318	0.007291
	0.05	5.043	0.1	0.05	0.991473		
JSR-8	0.05	5.002	0.3	0.25	4.998001	4.94806	0.070627
	0.05	5.104	0.3	0.25	4.898119		
GHS2-3	0.05	5.085	0.15	0.1	1.966568	1.477258	0.69199
	0.05	5.061	0.1	0.05	0.987947		
RHS-3	0.05	5.048	0.2	0.15	2.971474	2.973537	0.002918
	0.05	5.041	0.2	0.15	2.9756		

ADJ-7	0.05	5.01	0.6	0.55	10.97804	9.90425	1.518574
	0.05	5.096	0.5	0.45	8.830455		

Appendix 4: Picture Showing Samples Before, And After Titration for Free Fatty Acid Value

SAMPLE BEFORE TITRATION

SAMPLE BEFORE TITRATION



SAMPLE AFTER TITRATION

SAMPLE AFTER

Appendix 5 Picture Showing Samples Before, And After Titration for Peroxide Value

BLANK **SAMPLE BEFORE TITRATION**