REFINING OF PALM KERNEL OIL

BY

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DEPARTMENT OF CHEMICAL ENGINEERING

FACULTY OF ENGINEERING

CARITAS UNIVERSITY, AMORJI-NIKE, ENUGU STATE

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TITLE PAGE

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AUGUST, 2012.

CERTIFICATION

This is to certify that the project on “Refining Of Palm Kernel Oil” was carried out by Ibeawuchi Bright E.C in accordance with the regulations governing the presentation of project for the award of bachelor of engineering degree (B.Eng) in Chemical Engineering, Caritas University, Enugu State.

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DEDICATION

To my dearly beloved parents, Chief & Lolo F.INjoku who has contributed immensely towards my upbringing.

ACKNOWLEDGEMENT

My profound gratitude goes to Almighty God, who is my creator and source of my inspiration, for his unconditional love, mercy, guidance and protection throughout stay in the university and for making me attain this great height in life.

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ABSTRACT

This work studied the refining of crude palm kernel oil derived from the kernels within the nut of a palm fruit.

This research project was aimed at reducing the non-glycerides present in oil in their crude form using an alkali method of refining. The crude palm kernel oil was first washed with distilled water by heating the mixture in an electric heater for about 2 hours to reduce the impurities present in the oil in their crude form, degummed with phosphoric acid and neutralized with NaOH (caustic soda).The saponification value, iodine value and acid value was analyzed and their values are: for crude palm kernel oil, 33.1, 695.45 and 746.13 respectively, for neutralized palm kernel oil, 11.22, 725.6 and 687.24 respectively

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CHAPTER ONE

1.1 INTRODUCTION

Palm kernel oil, the second most consumed lauric acid group oil is derived from the dried kernels of the oil palm, ElaeisGuinensis.

Palm kernel oil (co-product of palm oil) and coconut oil comprises less than 5 percent of the total natural fats and oils, but they are important feed stocks of the oleochemical industry. Coconut oil is commercially a major source of lauric acid, together with palm kernel oil and to small extent babassu oil. It belongs to the so called lauric oils, which are characterized by their high lauric oil content of approximately 50 percent.

The lauric oils are highly desirable materials in the oleochemical industry world-wide because of the important of the lauric fraction especially in the manufacture of soap and detergents.

1.2 BACKGROUND OF THE STUDY

Two distinctly different types of oils are produced from the fruit of the south East Asia and African oil palm, ElaeisGuinensis Central American palm ElaeisOleifera.

Palm oil is obtained from the fleshy part of the fruit which resembles an over sized olive about the size of a small chicken egg. Palm kernel oil is derived from that kernel within the nut. Well over 98 percent of the fatty acids in palm oil belong to the C: 16 and C: 18 group where as approximately 64 percent of the fatty acids in palm kernel oil consist of C: 12 and C: 14 lauric group.

A palm tree produces 10-15 fresh fruit bunches throughout the year weighing 5-23kg (10-50lb) each. The bunches are cut from the tree with knives attached to long poles and are transported to the oil mill. There they are sterilized by steam at about 40psig for 56-75 minutes to deactivate lipase enzymes and loosen the fruits from the stalk.

The fruits are knocked loose from the stalk in thresher drums and passed through a digester to convert the fleshy pulp to mash. Then the mash is pressed by twin-screw expellers or hydraulically to yield red crude oil. The shells of the nuts cracked and the kernels are separated, dried and bagged for later solvent extraction or mechanically pressed in a fashion similar to the processing of raw crop oil seeds.

For satisfactory release of the kernels from the fruits, the requirements are that the oil bearing mesocarp shall be removed and the shells cracked without damage to the kernels.

Palm kernel oil is not usually extracted on the plantations, though occasionally mills contain press designed for this purpose.

The conditions for the release of palm kernel oil, which is liquid at tropical day temperatures, are different from those of palm oil, but similar to those of copra and hand oil bearing seeds.

Very small quantities are extracted in producing countries by primitive means but the greater bulk of the palm kernel produced are subjected to industrial process.

Although the extraction of palm kernel oil from palm kernel is not a new project, this project is capitalized on using different types of refining processes to determine the one that will yield a higher output.

Further cultural and agricultural practices differ for its fruit species depending on the type of soil, different samples from different localities were collected in consideration to its essential commercial plantings on which each sample produces high quality fruit/seed and profitable yield. Thus this research study is being conducted.

1.3 STATEMENT OF PROBLEM

Palm kernel oils consist mainly of glycerides, and like other oils in their crude form, may consist of small and variable portions of non-glyceride components as well. In order to render the oils to an edible form, some of these non glycerides need to be either removed or reduced to an acceptable level so as to meet the request of the buyers.

Therefore, this project aims at reducing the non-glycerides present in oil in their crude form using the chemical (alkali) method of refining.

1.4 AIMS/OBJECTIVE OF THE STUDY

1. Reduction of the free fatty acids from 5.0 to 0.03 percent or less.
2. Production of a fully deodourized product.
3. Operation without substantially greater utilities consumption than a standard deodourizer.
4. Recovery of the fatty acids from the sparge stream.
5. Obtaining a mixture of traicylglycerols with the desired solid content profiles over the range of product used;

6. Preparation and storage of semi-solid products with desire textures.

1.5 SCOPE OF THE STUDY

The refining of crude palm kernel oil is converting it to quality edible oil renewing objectionable impurities to the desired levels in the most efficient manner where possible, losses in the desirable components are kept minimal.

After refining of crude palm kernel oil, a good quality has low free fatty acid (FFA) content, does not contaminate with water or other impurities and has a good bleacheability.

CHAPTER TWO

2.0 LITERATURE REVIEW

This chapter presents the theoretical valuable information on palm kernel oil, the method of extraction, refining and scientific information needed to support the research / study.

A kernel is a small embryonic part of a plant enclosed in a covering called the kernel shelf, usually with some stored food. It is the product of ripened ovule of gymnosperm and angiosperm plants which occurs after fertilization and some growth within the mother plant. The formation of the level completes the process of reproduction in seed plants (started with the development of flowers and pollination), with the embryo developed from the zygote and the seed coat from the integuments of the ovule seeds have been an important development in the reproduction and spread of flowering plants, relative to more primitive plants like mosses, ferns and liverworts, which do not have seeds and use other means to propagate themselves. This can be seen by the success of the seed and plants (both gymnosperms and angiosperms) in dominating biological niches on land from forests to grass lands both in hot and cold climates.

The term seed also has a general meaning that predates the above anything that can be sown i.e. "seed" potatoes, "seeds" of corn or sunflower "seeds".

In the case of sunflower and corn "seeds," what is sown is the seed enclosed in a shell or hull, and the potato is a tuber. Vegetable seeds can be generally referred to as a seed, which contains reasonable quantity of oil embedded in cellular materials (seeds or shells) from which the oil may be separated by extraction. The method of extraction usually employed is called Leaching.

Most of the vegetable seeds are Annual crops e.g. groundnut seeds others are perennial (e.g. rubber seeds, castor seeds, e.t.c). Most vegetable seeds acts as cash crops in many countries and as such occupy reasonable hectares of land as plantations. Vegetable seeds and oils may be edible or inedible, coconut oil and palm kernel oil is used in oleo chemical industries.

According to mark set al (1996), tropical and sub-tropical regions of the world are the greatest producers of vegetable seeds. Brazil for instance is known to be involved in the production of vegetable seeds like babassu, cotton, castor seeds e.t.c. United states is also known for producing almond, Apricot, cottonseeds e.t.c Nigeria is a major producer of palm kernel and groundnut oil.

2.1 VEGETABLE OILS

Introduction: Vegetable oils are neither animal nor marine oils. Vegetable oil is an oil extracted from the seeds, fruits or nuts of plants and generally considered to be mixtures of mix glycosides (e.g. cotton seed, linseed, corn, coconut, babassu, olive, tung, peanut e.t.c) many types are edible.

Being plant derived product, vegetable oils are a form of biomass. Some are reported to be convertible to liquid fuels by passing them over zeolite catalysts. Vegetable oil consumption has been in creasing and currently surpasses animal fat consumption. This trend represents a change in the fatty acid composition of the diet. With the change in consumption that has occurred over the past 50 years, dietary linoleic acid utilization has increased the most and saturated fatly acid consumption has decreased.

2.1.1 Classification of Fats and Oils

Traditionally, fats and oils have been classified as to their animal or vegetable origin. Vegetable oils are further classified by iodine value or number into drying, semi-drying and non-drying oils. The main vegetable oil categories are given below.

Principal fatty acid	Oil source
1. Lauric	Coconut, palm kernel oil, babassu oil
2. Palmitic	Palm
3. Oleic	Olive, canola, peanut, safflower
4. Linoleic (Medium)	Corn, cottonseed, sesame, soyabean
5. Linoleic (high)	Sunflower, safflower
6. Eruic	Rapeseed.

They may also be grouped according to the following

1. **Botanical classification:** Although this method may be systematic, it does not readily reveal the compositional relationship of the oils.

2. **Classification based on the dominant fatty acids present:**

   This helps in revealing of industrial purpose but its weakness is that it does not suit the purpose of edibility.

3. **Grouping based on the dominant fatty groups**:

   Also, this helps in revealing the inter-changeability of the oils in a group.

2.1.2 Characteristics of oil Classes lauric acid group

The lauric acid group mainly in made up of oils from the seeds of palms, specifically, coconut, babassu and palm kernel oils. The lauric acid content ranges from about 40-50 percent.

Oils from the lauric acid group are higher in short chain fatty acids having 8, 10 and 14 carbon chain lengths fatty acid.

Palm kernel oil (P.K.O) and coconut oil (co)

Typical fat % by weight

Fatty acid saturated	P.K.O	C.O
Caproic	0.2	0.5
Caprylic	4.0.	8.0
Capric	3.9	7.0
Lauric	50. 4	48.0
Myristic	17.3	17.0
Palmitic	7.9.	9.0
Stearic	2.3	2.0
Unsaturated		
Palmitoleic	0.2	
Oleic	6.6	11.8
Linoleic	2.3	2.1

Unsaturated fatty acid present are mainly oleic and linoleic acid.

The long chain saturated fatty acids are palmitic and stearic acids.

These are present in relatively minor quantities. The high content of short chain fatty acids combined with the high degree of saturation implants both high solids and a low melting point. The lauric acid oils are very stable due to the high content of saturated fatly acids. Combined with the desirable melting points, they are very adaptable to soap manufacture, giving preferred solubility's and leathering characteristics.

The lauric acid oils are the primary source of short chain for production of fatly acid derivatives. These include c-6,c-8, c-10 and c-12 acids produced by fractional distillation of hydrogenated coconut oil. Non-food uses, particularly cleaning products and chemically derived emulsifiers, account for the major uses of this oil.

The food uses of lauric oil captures

i. The resistance to oxidation and

ii. Desirable melting characteristics.

Palm kernel oil is similar to coconut oil but is somewhat less saturated and lower in medium chain length fatty acids (capric and caprylic acids).

Palmitic group – palm oil.

Oleic / linoleic – corn, cottonseed, peanut, olive, sunflower, sesame, safflower e.t.c.

2.1.3. Uses of Vegetable Oil

The classification of vegetable oil as non- drying, semi-drying and drying is convenient, because oils in a given grouping may be used in the same application. Large quantities of non drying oils are consumed in cooking and salad oils, salad dressing and similar edible products because they have low instauration. The lower the instauration the higher the melting point and hence the possibility use in shortening, margarine, and bakery and confection products.

The drying oils are consumed in large quantities in paints, varnishes, preparations, linoleum, plasticizers, lubricants, foundry-core sand binders, carbon electrodes and brake linings.

2.2 METHOD OF EXTRACTION OF VEGETABLE OIL

All vegetable oils can be extracted through the following process.

1. Hydraulic or mechanical press extraction
2. solvent extraction or leaching

2.2.1 Hydraulic or Mechanical Press Extraction

This is an old extraction process known to man. It is dated to at about 6, 000 years old before the discovery of palm kernel seed and it is regarded in the extraction process for most of our vegetable oils. It uses much labour and is now regarded as an expensive operation.

A press is a machine for subjecting substances at steady pressure. Most vegetable oils (Palm kernel oil) are separated by the use of press, particularly when other methods have failed. But the yield is always some what low.

Operation prior to pressing may involve

i. Cleaning
ii. Grinding or crushing
iii. Heating, moistening or steaming

In hydraulic pressing of oils, the following method of applying pressure has been devised.

i. The use of wedge
ii. Lever
iii. Screw
iv. Hydraulic press
v. Extraction presses.

Whichever method is applied / employed, pressure up to 500 kg /cm2 are applied to press the cake area.

The material to be pressed is plastically deformed and the oil is displaced leaving behind a strongly consolidated residue, the cake.

Hydraulic presses have variation in size / design. In one of the designs, the press is made of four corner posts connected at one end by rigid plate and closes at the other end by a ram.

In between are a series of steel plates which can be lifted up to form a space bounded top and bottom by a plate but open at the sides. Soft cakes of cooked meal are first pressed together and then wrapped in cloth before being placed between the steed plates in the press. When all the spaces are filled, hydraulic pressure is applied, forcing the ramp upward and squeezing the oil out of the meal. The oil trickles out through the loath and runs down into a receiver at the base of the press. When the press is opened, the cakes are removed by hand and the wet edge trimmed off to be returned for re-pressing in an extractive design, the meal is filled direct on to a number of horizontal plates resting within a closed vertical casing perforated with minute holed through which the liquid oil excludes when pressure is applied on the meal.

2.2.2 Solvent Extraction / Leaching:

Extraction by a solvent involves the dissolution of the soluble constituents from a solid material by means of a suitable solvent. This process could be used for the separation of oil from cellular materials, which forms the rest of the seed. Oil is a kind of lipid and it is insoluble in water. Therefore, extraction of oil from its cell is possible with solvents of low polarity characteristically. Vegetable oils are soluble in organic solvents like acetone, ether, chloroform, petroleum, spirit, carbon tetrachloride and hexane to mention but a few.

The solvents contact the solute absorbed in the solid and dissolved it and therefore provides the product mixture as liquid rich in solute. Though the process was accomplished in a variety of ways, but its efficiency depends to a very large extent, on attaining intimate contact between the liquid – solvent and the solid containing the solute.

Three steps are involved in leaching and they determine the rate of leaching.

Step1: Change in the phase of the solute by dissolving in the solvent.

The solute in the solid changes into liquid as it dissolves in the solvent.

Step II: Diffusion through the pores of the solid with the solvent by the solute to the surface of the solid.

Step III: The movement from the surface of the solid to the bulk of the solution. Leaching is either used to concentrate a solid valuable product or remove impurity from the solid such as pigments. In designing a system for leaching to produce a given amount of extract from a given quantity of solid materials.

This is generally accomplished using a material balance en the various compliments involved in the process. The solvent, the solute and the insoluble solid are the three components considered in the leaching process. Equilibrium is attained when the solute diffuses into the solvent until the solvent concentration equals that of the insoluble solid.

2.2.3 Factors Affecting the Rate of Leaching

1. **Particle size:** Small particle sizes increase the surface area per unit volume of solid to be leached.

   It also decreases the radial distances to be transverse within the solid and hence a higher transfer rate. Very fine particles are not desired because they pose problems during drainage (Solid separation), they cause slow percolation rate and possible poor quality of solid product.

2. **Temperature:** Solubility of the component in the mixture increases with increase in temperature. The diffusion coefficient is also affected thereby increasing the leaching rate. The optimum temperature is usually determined by such consideration as the enzymes action during the extraction of sugar.
3. **Agitation:** This increases the eddy diffusion, which improves the rate of transportation and prevents particles sedimentation during leaching.
4. **Solvents:** This liquid should be a good selected solvent. In as much the solvents must be of purity but the desirable solvent must also posses these properties. Selectivity: This is the ability of the extract to select from a mixture of A, B and C.
5. **Recoverability:** The solvent must be recovered from both extract and raffinate. Distillation is normally used.

Capacity: This is the ability of the solvent to dissolve the solute.

6. **Solvent solubility:** The Solid should not be soluble in the solvent.

7. Density: The solvent and solute densities must be varying largely.

8. Low corrosiveness: To materials of equipment construction.

9. **Non- inflammability**

10. **Low cost**

11. **Low viscosity:** Many viscous solvents give problems of diffusion and occur in high power requirement.

12. **Low toxicity**

2.4 METHODS OF REFINING OF CRUDE PALM KERNEL OIL

There are two routes which can be taken to process crude oil into refined oil;

1. Chemical / Alkali refining
2. Physical refining

2.4.1 Chemical / Alkali Refining:

As the name implies, this method of refining uses chemicals in the form of alkalis and normally caustic soda is used. The process involves the addition of an alkali solution to the crude oil which results in chemical reactions and physical changes. Chemical refining can be carried out either by batch or by continuous process and undergoes various processes. Before the start of the off –take from the crude oil tank, the oil undergoes heating at a steady rate, up to the required temperature (about 45^0c) for ease of pumping and kept homogenized to provide a final product consistency. The crude oil then undergoes gum conditioning. The crude oil is pumped through a heat exchanger where its temperature is raised to about 800c. The oil is then treated with 0.05% - 0.10% food grade orthophosphoric acid in a mixer.

A reaction time of 15 minutes is allowed during which the gums (phosphatides) are precipitated making them easily removable at the next stage.

The acid treated oil is then continuously dosed with caustic soda. The concentration and amount of the alkali to be used will vary with the free fatty acid (FFA) content of the oil. The neutralized oil then undergoes washing here the oil is washed with water to remove the soap impurities present. The oil water mixture is passed through a centrifuge separator where the heavy phase discharge contains soapy water and the light phase discharge is water washed oil with a soap content of less than 80 ppm which is subsequently removed at the next bleaching stage.

The water –washed is then dried in a vaccum dryer and the resulting oil is a semi –refined oil termed neutralized oil.

2.4.2 Physical Refining

Physical refining of crude oil is the most common process for the simple reasons of its higher efficiency, lesser losses, less operating costs, less capital input and less effluent to handle. The pre-treatment stage of physical refining is exactly the same as that of the alkali route. Once again, phosphoric acid is used. At the bleaching stage, however, relatively higher dosages of earth are used. The "excess" earth is used to adsorb impurities which are removed with the soap stock and by washing in the chemical route. Earth dosage used for PKO is usually less than 1% the filtered bleached oil is termed Degummed Bleached (DB) oil.

The re-treated oil enters the deodorizer at an FFA content which is much higher than neutralized bleached oil. As such, deodorization has to be of a much heavier duty using higher temperatures of 250^0c-270^0c for palm kernel oil, more stripping steam and a bigger vacuum. The fatty acids distilled –off are condensed and collected. They are termed fatty acid distillate. The oil leaves the deodorizer as a refined, bleached and deodorized or RBD oil.

2.4.3 Aim of Refining

Palm and palm kernel oils consist mainly of glycerides and, like other oils in their crude form may consist of small and variable portions of non-glycoside components as well.

In order to render the oils to an edible form, some of these non glycerides need to be either removed or reduced to an acceptable level.

The non-glycosides are of two broad types. Oil insoluble- fruit fibres nut shells and free moisture oil soluble- free fatty acids, phospholipids, carotenoids, trace metals, oxidation products.

2.5 ORIGIN OF OIL PALM (PALMKERNEL OIL)

It is generally agreed that the oil palm (ElaeisGuinensis) originated in the tropical rain forest region of West African.

The main belt runs through the southern latitudes of Cameron, Ghana, Liberia, Nigeria, Togo and into the equatorial region of Angola and the Congo.

Processing oil palm fruits for edible oil has been practiced in Africa for thousands of years, and the oil produced, highly coloured and flavoured, is an essential in gradient in much of the traditional West African cuisine.

The traditional process is simple but tedious and inefficient.

Palm oil is rich in carotenoids. (Pigments found in plants and animals) from which it derives its deep red colour, and the major component of its glycerides is the saturated fatty acid palmitic, hence it is a viscous semi-solid, even at tropical ambient and a solid fat in temperate climates.

Because of its economic importance as a high-yielding source of edible and technical oils, the oil palm is now grown as a plantation crop in most countries with high rainfall and in tropical climates within 100 of the equator. The palm bears the fruits in bunches varying in weight from 10-40kg. The individual fruit ranging from 6-20gm, are made up of the outer skin (the exocarp), a pulp (mesocarp) containing the palm oil in a fibrous matrix, a central nut consisting of a shell (endocarp) and the kernel, which it self contains an oil, quite different to palm oil, resembling coconut oil.

Structure of the palm fruit

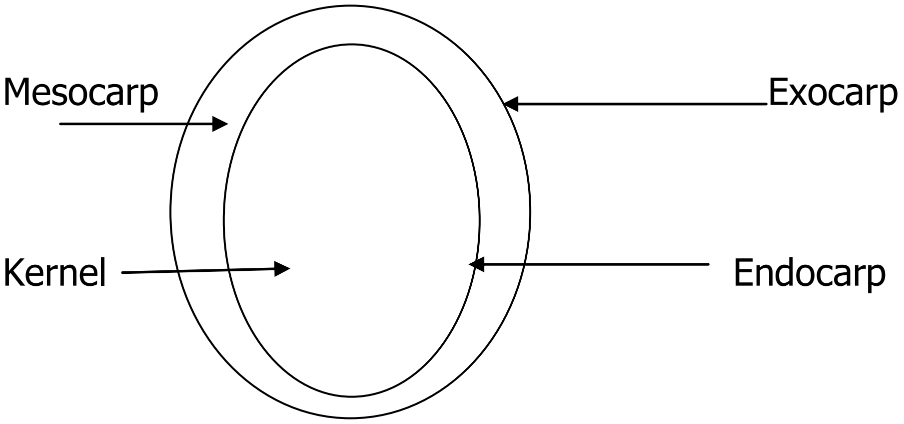


Fig 1: Fresh fruit bunch

The extensive development of oil palm industries in many countries in the tropics has been motivated by its extremely high potential productivity. The oil palm gives the highest yield of oil per unit area compared to any other crop and produces two distinct oils – palm oil and palm kernel oil – both of which are important kernel oil- both of which are important in world trade.

Ideal composition of palm fruit bunch

Bunch weight - 23- 27kg

Fruit / bunch - 60- 65%

Oil / bunch - 21-23%

Kernel / bunch - 5-7%

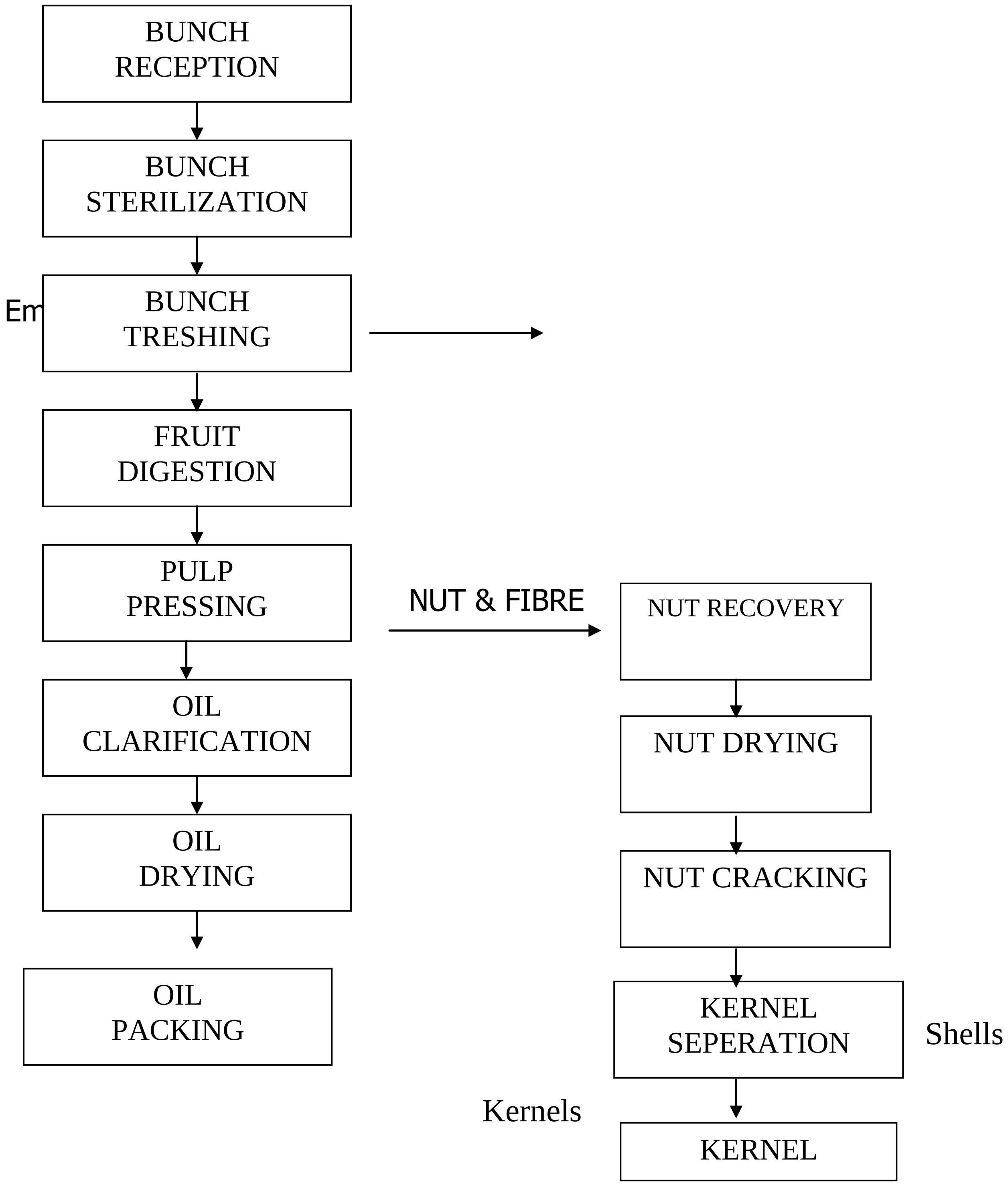
Mesocarp / bunch - 44-46%

Mesocarp / fruit – 71-76%

Kernel / fruit – 21 -22

Shell / fruit – 10-11

2.5.1 Palm Oil Processing Unit Operations



2.5.2 Kernel Recovery

The residue from the press consists of a mixture of fibre and palm nuts. The nuts are separated from the fibre by hand in the small scale operations. The sorted fibre is covered and allowed to heat, using its own internal exothermic reactions, for about two or three days. The fibre is then pressed in spindle presses to recover a second grade (technical) oil that is used normally in soap making. The nuts are usually dried and sold to other operators who process them into palm kernel oil. The sorting operation is usually reserved for the youth and elders in the village in a deliberate effort to help them earn some income. Large – scale mills use the recovered fibre and nut shells to fire the steam boilers. The upper – heated steam is then used to drive turbines to generate electricity for the mill. For this reason, it makes economic sense to recover the fibre and to shell the palm nuts. In the large –scale kernel recovery process, the nuts contained in the press cake are separated from the fibre in a depricarper. They are then dried and cracked in centrifugal crackers to release the kernels. The kernels are normally separated from the shells using a combination of winnowing and hydro cyclones. The kernels are then dried in silos to a moisture content of about 7 percent before packing.

During the nut cracking process, some of the kernels are broken. The rate of FFA increase is much faster in broken kernels than in whole kernels. Breakage of kernels should therefore be kept as low as possible, given other processing considerations.

2.5.3 Principles of Preservation

The general principles of preservation include.

- Destruction of enzymes (a complex organic substances which in solution produces fermentation and chemical changes in other substances apparently without undergoing any change it self) in the raw material and contaminating micro organisms by heat (sterilization) during processing.
- Elimination of as much water as possible from the oil to prevent microbial growth (bacterial activity, or diseases- causing germs) during storage. The oil therefore has a long shelf life due to its low moisture content.
- Proper packaging and storage of the extracted oil to slow down chemical deterioration (rancidity).

2.6 METHODS OF TREATMENT - CRUDE PALM KERNEL OIL

Degumming treatment

Bleaching treatment

Deodorization treatment

2.6.1 Degumming Treatment

Before the start of the off-take from the crude oil tank, the oil undergoes heating at a steady rate, up to the required temperature (about 45^0c) for ease of pumping and kept homogenized to provide a final product consistency. The crude oil then undergoes gum conditioning. The crude oil is pumped through a heat exchanger where its temperature is raised to about 80^0c. The oil is then treated with 0.05% - 0.010% food grade orthophosphoric acid in a mixer. A reaction time of 15 minutes is allowed during which the gums (phosphatides) are precipitated making them easily removable at the next stage. The acid treated oil is then continuously used with caustic soda. The concentration and amount of the alkali to be used will vary with the free fatty acid (FFA) content of the oil.

Intimate contact between the alkali and the oil is ensured by the choice of a well designed mixer. The alkali reacts with the FFA forming precipitated soaps which are removed either through centrifuge or setting and washing. The light phase discharge is mainly refined oil containing traces of soap and moisture while the heavy discharge is primarily soap, insoluble materials, gums, free alkali and minute quantity of neutralized oil. The neutralized oil then undergoes washing the soap impurities present. The oil-water mixture is passed through a centrifuge operator where the heavy phase discharges contains soapy water and the slight phase discharge is water- washed oil with a soap content of less than 80ppm which is subsequently removed at the next beaching stage. The water washed oil is then dried in a vacuum dryer and the resulting oil is semi-refined oil termed neutralized oil.

2.6.2 Bleaching Treatment

After the above steps of phosphoric acid treatment for gum removal and neutralization for FFA reduction, the oil still contains undesirable impurities, odours and colour pigments that need to be removed before the finished product will be acceptable to the buyer. Some of these remaining impurities are removed in quality by the process of bleaching or using a more appropriate term of Adsorptive cleansing.

The practice of bleaching involves the addition of activated clay (bleaching earth) to remove any undesirable impurities and this improves the initial taste, final flavour and oxidative stability of product. It also helps to overcome problems in subsequent processing by adsorption of soap traces, pro-oxidant metal ions, decomposes peroxides and adsorbs other minor impurities.

Bleaching is carried out under vacuum at a temperature of about 100^0c and given a reaction time of half an hour. The dosage of earth varies with the type and quality of starting oil and is usually in the range of 0.5%-1.0%.

As mentioned earlier the primary function of the bleaching earth is to reduce undesirable impurities through adsorption.

However, a certain amount of bleaching (colour reduction) by pigment adsorption occurs as a bonus effect. Colour effect is actually affected in the next stage through high temperature destruction of the pigment.

The slurry containing the oil and earth is then passed through the main filter to give a clear, free-from-earth particles oil. Usually a second check filter is used in series with the main filter to doubly ensure that no earth slips occurs. The presence of earth fouls deodorizes, reduces he oxidative stability of the product oil and acts as a catalyst for dimerization and polymerization activities.

Some oil is lost through entrapment in the waste earth and it is usually in the order of 20%-45% of the weight of dry earth.

The neutralized bleached oil is termed NB oil.

PORAM STANDARD SPECIFICATIONS FOR NB PALM OIL

FFA (as palmitic)	0.25%max
M&I	0.1% max
IV (Wijs)	50-55
AOS (Cc3-25)	33-39
Colour (51/4 Cell)	20 red max

NB oil then proceeds to the next stage where the free fatty acid content and colour are further reduced and more important, it is deodorized to produce a product which is stable and bland in flavour.

2.6.3. Deodorizing Treatment

Deodorization is basically a high temperature, high vacuum, steam distillation process. A deodorization operates in the following manner: deaerates the oil, heats up the oil, steam strips the oil and cools the oil before it leaves the system. All materials of contact are stainless steel.

Deodorization can be carried out in batch continuous or semi-continuous style.

In a continuous alkali refining route, the oil is generally heated 220^0c-240^0c under vacuum. A vacuum of 2-5 Mbar is usually maintained by the use of ejectors and boosters. Heat bleaching of the oil occurs at this temperature through the thermal destruction of the carotenoids pigments.

The use of direct stripping steam ensures readily removal of residual free fatty responsible for unacceptable odours and flavours.

The oil leaves the deodorizer still under vacuum and cooled down to less than 80^0c. It passes through a polishing filter before it is sent to the storage tank. The oil is now termed as neutralized, bleached and deodorized or NBD oil.

PORAM STANDARD SPECIFICATIONS FOR RBD/NBD OIL

FFA (as palmitic)	0.1% max
M & I	0.1% max
AOS (Cc3-25)	33-39
Colour (51/4 Lovibond cell)	3or 6 red max

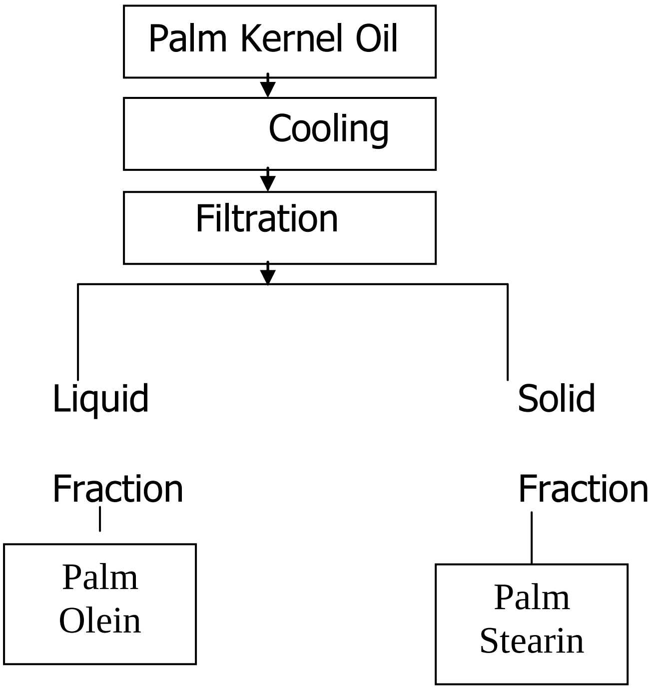
NBD/RBD PALM KERNEL OIL SPECIFICATION FOR EXPORT

FFA (as palmitic)	0.1% max
M & I	0.1% max
IV (Wijs)	19max. At time of shipment
Colour (51/4 Lovibond cell)	Red 1.5.max

At the request of buyers, antioxidants such as BHA, BHT, TBHQ, Citric acid and Vitamin A are usually added at the ex-deodorized stage fro maximum efficiency and as preferable.

2.7 FRACTIONATION OF PALM KERNEL OIL

Just like palm oil, palm kernel oil can also be fractionated via the detergent, solvent and dry processes.



Fractionation Of Palm Kernel Oil

In palm kernel oil fractionation, the stearin is the premium product and therefore higher stearin yields are sought.

stearin yields vary between 20%-40%.

2.7.1 DRY FRACTIONATION

The more common of the three processes, dry fractionation, operates in the following fashion. The oil is kept homogenized at about 70^0c before the start of crystallization. Crystal formation and growth occurs as the oil is agitated and cooled using chilled water circulation in the jackets or cooling coils of crystallization either the oil or water temperature.

When the oil reaches the required temperatures, usually around 22^0c, cooling is stopped. The oil, which appears as a thick semi solid mass, termed slurry, now contains stearin crystals in liquid olein and is ready for filtration.

Generally, bigger crystals are required for ease of filtration using the vaccum suction type filters. However, this tends to make the crystals group together in clumps which will include parts of the liquid and as a result, some olein is lost in the stearin.

2.7.2 Detergent Fractionation

The process involves cooling palm oil (crystallization) and separation of its fractions (fractionation) added by a detergent (sodium lauryl sulphate solution) and an electrolyte (magnesium sulphate).

As in the dry fractionation, the oil in the crystallizers is cooled using chilled water and is allowed to crystallize. When the oil reaches a set temperature of about 22^0c, the semisolid mass is pumped to the fractionation stage where it is mixed with an aqueous solution containing the electrolytes and the detergent at the same temperature as the fat mass.

The lighter phase leaving the centrifuge consists of olein and traces of detergent. This is washed, dried and stearin is sent for storage. The heavier phase containing most of the detergent is heated to melt the stearin and then sent to a second centrifuge where the stearin is then washed, dried and stored while the detergent is recycled.

2.7.3 Solvent Fractionation

It is merely uneconomical at present to fractionate palm kernel oil for normal olein-stearin products via the solvent route. High investment cost is involved due to stringent safety features and the solvent recovery requirement that needs to be incorporated. Operating costs are also high as skilled manpower and additional processing for the solvent recovery and purification are required.

The process involves crystallizing the oil in a solvent. The two common solvents used are hexane and acetone. Solvent is mixed with oil in a 1.3 ratio and then pumped into the crystallizers. Cooling is done either by chilled water or brine.

Brine is used if very low temperature crystallization is required.

The miscella containing partially crystallized oil and solvent is then \sent to a filter where vaccum suction is used to separate the olein from the stearin.

2.7.4 Palm Kernel Oil Fractionated Products

1. Crude palm kernel	FFA (as lauric)	5.0% max
Olein	M & I	0.5% max
	IV (Wijs)	21mins
2. Crude palm kernel	FFA (as lauric)	5.0% max
Stearin	M & I	0.5% max
	IV (Wijs)	8 max

3. RBD palm kernel	FFA (as lauric)	0.1% max
Stearin	M & I	0.1% max
	IV (Wijs)	21mins
	Colour (51/4 Lovibond cell)	Red 1.5 max

4. RBD palm kernel	FFA (as lauric)	0.1% max
Stearin	M & I	0.1% max
	IV (Wijs)	8 max
	Colour (51/4 Lovibond cell)	Red 1.5 max

CHAPTER THREE

3.0 METHODOLOGY

This chapter discuses the design of research used, setting, instrument for data collection, method of data collection, method of data analysis (which includes the materials used, equipments and reagents, preparation of the reagents, refining process and the characterization of the oil).

3.1 RESEARCH DESIGN

Crude palm kernel oil was collected and subjected to refining aimed at converting the crude oil to quality edible oil by removing objectionable impurities in the desired levels in the most efficient manner.

3.2 RESEARCH SETTING

The setting of the research was in the eastern part of Nigeria, wherein the materials were collected in Enugu and Imo States. The chemicals used were bought in a market in Enugu State.

Finally all laboratory works were carried out at the school laboratory.

3.3 INSTRUMENT FOR DATA COLLECTION

3.3.1. Material

The material used in this project is mainly crude palm kernel oil which was bought at Amauzo Palm Kernel Crushing & Extraction Mill, Proda Road Emene Enugu State.

3.3.2 Equipments

The equipments used in the refining of crude palm kerned oil include.

- Reflux condenser
- Water condenser
- Centrifuge
- Electric heater
- Specific gravity bottle
- Round bottom flask
- Measuring cylinder
- Weighing balance
- Conical flasks
- Beakers
- Burette
- Pipette
- Viscometer

- Retort stands.

3.3.3. Reagents

The reagents used in refining include.

Wij's solution, Ethanol, Neutral alcohol, standard KOH, phenolphthalein, and starch as indicator standard sodium carbonate solution (0.5m).

3.3.3.1 Preparation of reagents

i. 0.5ml of alcoholic solution of potassium hydroxide (kOH) was prepared by weighing 28.5g potassium hydroxide and was diluted to 1 litre with 95% alcohol in a volumetric flask.

ii. 0.5ml of HCL was prepared by measuring 10.8 ml of conc. HCL acid into 250ml volumetric flask and was diluted to 250mls with distilled water.

iii. 0.1 sodium thiosulphate, $Na_2S_232H_20$ solution was prepared by dissolving 28.4g of sodium thiosulphate in freshly boiled distilled water and diluted up to 1 litre of the volumetric flask.

3.4REFINING PROCEDURE

3.4.1Crude palm kernel oil and Distilled water

At the start of the experiment, 50mls of C.P.K.O was measured and poured into a beaker, the same quantity of water was added into the beaker. The mixture is heated for about 25mins in electric heater after which it is allowed to cool and settle and later decanted.

The upper phase discharge is the washed oil with lesser impurities while the lower phase discharge is the water containing impurities.

3.4.2 C.P.K.O AND PHOSPHORIC ACID

The washed oil is treated with phosphoric acid of the same quantity. A reaction time of 15 minutes is allowed during which the gums (phosphatides) are precipitated.

3.4.3 C.P.K.O AND NaOH (CAUSTIC SODA)

The acid treated oil is then continuously dosed with caustic soda. The concentration and amount of the alkali used varied with the free fatty acid (FFA) content of the oil.

Intimate contact between the alkali and the oil is ensured by the choice of a well designed mixer.

The alkali results with the FFA forming precipitated soaps which are removed through centrifuge.

3.4.4 Neutralized palm kernel oil and Distilled Water

The neutralized oil then undergoes washing. Here the oil is washed with water to remove the soap impurities present. The oil-water mixture passes through a centrifuge separator where the heavy phase discharge contains soapy water and the light phase discharge is water-washed oil with a soap content of less than 80ppm which is subsequently reduced at the next bleaching stage.

3.5 CHARACTERIZATION OF Palm kernel oil

3.5.1 Physical characterization

- **Determination of viscosity.**

The viscosity of the degummed P.K.O produced was determined using a viscometer apparatus which consists of a support in form of a retort stand upon which the meter rest. Directly below the meter is a connecting rod which rotates the rotor when the machine is functioning. Also included in the apparatus are pressing knobs for starting and stopping the machine and a cup where the material whose viscosity is to be obtained. The degummed P.K.O was poured into the cup and the rotor was pored into the cup and the rotor was carefully mounted the left knob was pressed for the machine to start.

When the rotor got to a maximum constant speed, the reading of the viscosity was noted and recorded.

3.5.2 Chemical Characterization

- Saponification value

Aim: To determine the Saponification value of a sample of oil.

Procedure: Approximately 5g of a given sample of oil is weighed and transferred into a clean dry bottom flask. 50 ml of 0.5m potassium hydroxide is measured out and added to the oil. To this is fixed a reflux condenser and the contents are refluxed for about one hour. Porous bite is added to the flask to ensure uniform heating.

Mean while, a 0.5 m of sodium carbonate is prepared and titrated against hydrochloric acid and its strength determined. The contents of the flask are cooled and titrated against determined. The contents of the flask are cooled and titrated against standard hydrochloric acid. In a similar manner, 50mls of the same potassium hydroxide is refluxed in a round bottom flask and the contents are cooled after refluxing for one hour. This is then titrated against standard hydrochloric acid. The difference in the above two values gives the number of millilitres of hydrochloric acid required to neutralize the excess alkali after Saponification.

- **Iodine value**

Aim: To determine the iodine value of a given sample of oil.

Procedure: About 0.1 to 0.5g of oil is weighed and poured into an iodine flask. Carbon tetrachloride and Wij's solution each 25ml is measured accurately and mixed well. This is then added to the oil in the iodine flask. The contents of the flask are shaken well to ensure complete mixing Standardized sodium thiosulphate solution is taken in a burette and titrated against the contents of the iodine flask.

The indicator used is starch.

- **Acid value**

Aim: To determine the acid value of the given sample of oil.

Procedure: About 1.00g of the given sample of oil is weighed accurately and transferred into a 250 ml conical flask. 95% alcohol is taken and neutralized with very dilute NaOH solution using phenolphthalein as indicator. About 50 ml of this neutral alcohol and 50 ml benzene are added to the oil flask. The contents of the flask are shaken well to dissolve the free fatty acid. This is immediately titrated using standard KOH solution the end point is the appearance of a pale permanent pink colour.

– Specific gravity

A specific gravity bottle was dried in an electronic oven and weighed in a weighing balance Distilled water was measured and poured in the spec. gravity and the wt was taken in the same manner crude palm kernel oil and neutralized palm kernel oil were also measured into the spec. gravity bottle and weighed.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

This section describes the analysis of the result obtained in the refining of palm kernel oil.

4.1 RESULTS

The results below were gotten from the research.

Table 4.1: Analysis of crude palm kernel oil.

Volume of oil (mls)	Volume of acid (mls)	Temperature (°C)	Timeof boiling(mins)	Percentage yield of oil (%)
50	5	100	15	35
50	10	100	15	31
50	15	100	15	27
50	20	100	15	25

Table 4.1 shows the percentage yield of oil after degumming the same volume of oil with different volumes of phosphoric acid under constant temperature of 100°C at a boiling time of 15 minutes (mins).

Table 4.2: Analysis of Washed palm kernel oil

Volume of oil (mls)	Volume of acid (mls)	Temperature (^oC)	Time of boiling (mins)	Percentage yield of oil (%)
50	5	100	10	45
50	10	100	10	40
50	15	100	10	35
50	20	100	10	30

Table 4.2shows the percentage yield of oil using different volumes of phosphoric acid to degum washed palm kernel oil (oil treated with water under heat)

Table 4.3: Alkaline refining

Volume of oil (mls)	Volume of NaOH(mls)	Percentage yield of oil (%)
50	2	46
50	4	42
50	6	36
50	8	33
50	10	30

This table shows the percentage yield of oil using caustic soda (NaOH)to neutralize the oil(alkaline refining).

Table 4.4: Physiochemical Characterization of Neutralized and Crude Palm Kernel Oil.

Classification	Neutralized oil	Crude oil
Saponification value	11.22	33.1
Iodine value	725.6	695.45
Acid value	687.24	746.13
Specific gravity	0.915	0.937
Viscosity	0.038	0.035

TITRATION RESULTS

The tables below show the chemical analysis of neutralized and crude palm kernel oil.

Table 4.4 (a)Saponification Value (Neutralized palm kernel oil)

Volume of oil	0.5 HCL		
5g(N.P.K.O)	1st titre	2nd titre	3rd titre
	26.7	26.5	26.4

Average titre= 26.5

Table 4.4(b) Saponification value(Crude palm kernel oil)

Volume of oil	0.5 HCL		
5g(C.P.K.O)	1st titre	2nd titre	3rd titre
	22.8	22.6	22.4

Average titre = 22.6

Table 4.4 (c): Iodine value (Neutralized palm kernel oil)

Volume of oil	0.1 $Na_2S_20_5.5H_20$		
0.5g (N.P.K.O)	1st titre	2nd titre	3rd titre
	38.7	38.5	38.4

Average titre =38.5

Table 4.4. (d) Iodine value (Crude palm kernel oil)

Volume of oil	0.1 $Na_2S_20_5.5H_20$		
0.5g (N.P.K.O)	1st titre	2nd titre	3rd titre
	39.8	39.6	39.4

Average titre = 39.6

Table 4.4 (e): Acid Value (Neutralized palm kernel oil)

Volume of oil	0.5 KOH		
1.0g (N.P.K.O)	1st titre	2nd titre	3rd titre
	24.7	24.5	24.4

Average titre = 24.5

Table 4.4 (f):Acid Value (Crude palm kernel oil)

Volume of oil	0.5 KOH		
1.0g (C.P.K.O)	1st titre	2nd titre	3rd titre
	26.8	26.6	26.4

Average titre = 26.6

Table 4.4 (g): Weight of bottle used and the weights of the oil.

Weight of empty bottle(g)	Weight of water (H_2O) (g)	Weight of Crude palm kernel oil (C.P.K.O) (g)	Weight of neutralized palm kernel oil (N.P.K .O) (g)
21.45	50.17	46.01	45.05

Table 4.5: Physiochemical characterization of Neutralized and crude palm kernel oil.

Classification	Neutralized oil	Crude oil
Saponification value	11.22	33.1
Iodine value	725.6	695.45
Acid value	687.24	746.13
Viscosity	0.038	0.035
Specific gravity	0.915	0.937

4.2 DISCUSSION OF RESULTS

At the beginning of the experiment, a certain quantity of crude palm kernel oil say like 50mls was measured and poured into a beaker, the same quantity of distilled water was also measured and mixed with the C.P.K.O. the mixture is heated for about 2 hours in an electric heater after which it is allowed to cool and settle and then decanted. The upper part is the washed oil while the lower part is distilled water.

The aim is to remove some impurities present in the crude oil to make degumming easy. The washed oil is mixed with the same quantity of phosphoric acid and heated for about 15mins after which the mixture is mixed with NaOH (2 moles). The mixture is shacked and allowed to settle for some hours.

The oil and NaOH mixture is separated using a centrifuge at a time of 20mins. The upper layer is the Neutralized and degummed oil while the lower part (residue) is crude soap which is also of paramount importance to man.

This experiment is repeated with different proportions of NaOH (sodium hydroxide) say 4moles, 6moles etc. the higher the quantity of NaOH, the brighter and lighter the oil and more deodorized the oil. Mixture with higher proportions of NaOHyielded less quantity of oil while mixtures with lesser quantities of NaOH yielded more oil and less crude soap. The neutralised oil then undergoes washing. Here the oil is washed with water to remove the soap impurities present. During the experiment, the temperature at which the mixture starts boiling, the percentage yield of oil and crude soap for each reaction was noted and recorded. The physical and chemical characterization were also noted and recorded.

CHAPTER FIVE

5.1 CONCLUSION

From the experience I have gathered in this research work, I have cometo the conclusion that oil in the crude form i.e. C.P.K.O. should be heated with distilled water for two hours to reduce the quantity of impurities present in it and to make degumming easy and also for maximum yield of oil.

Degumming is best carried out with phosphoric acid and the higher the quantity of this acid, the brighter and lighter the oil and more deodorized the oil. Due to the presence of impurities in the crude oil, the time of boiling with phosphoric acid was slow unlike the washed oil of lesser impurities which has a faster rate of boiling.

Therefore, impurities should be reduced to make degumming and filtration easy. Also, vegetable oils should be properly refined before consumption as poorly refined oils are not good to the human health.

5.2 RECOMMENDATION

I have obtained the quantity of NaOH that will neutralise 50mls of C.P.K.O. Further work should be done on full refining using that quantity to produce enough oil for bleaching and deodorising. Refining of vegetable oils is a very lucrative job to embark on as there are many job opportunities both for skilled and unskilled labours.

Therefore, I urge the government to look into our forgotten industries and try every possible means to dust and ensure effective functioning of these industries as this could reduce the rate of idleness and crimes among our youths.

Government should also allocate funds especially to rural areas where there are abundant lands to start up such business and also encourage private ownership of such business.

I will recommend the use of physical refining for commercial business because of its low cost of maintenance and also it is easy to run, not only that, it is a batch process and ensures large scale production.

Chemical refining is better used in small scale production, the use of phosphoric acid is highly recommended as this leaves no traces of gums or waxes in the oil after degumming.

Also, the use of NaOH (caustic soda) in alkaline refining is also recommended. Refineries should make sure their oil is properly refined to avoid solidifying of oil as a result of presence of fatty acids or poor refining so that the demands of the people can be met.

People should avoid using vegetable oils that has odour or solidifies easily as this is not good to the human health.

Also NAFDAC number on the stickers cannot be over emphasized.

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APPENDIX

APPENDIX (A)

Saponification value (Neutralized palm kernel oil)

Calculation: Weight of oil and bottle = 5+138.5 (A grams)

=143.5g

Weight of bottle alone = 138. 5g. (B grams)

Weight of oil taken = (A-B) = 143.5-138.5 = 5g

Strength of HCL 0.5 M

Titre value of HCL against KOH with oil after reflux

(Xmls)= 26.5.mls

Titre value of HCL against KOH alone after reflux

(Ymls)= 28.5mls

Volume of HCL required to neutralize excess alkali

after

Saponification = (Y-X) = 28.5-26.5=2mls (Zmls)

Saponification value = $\frac{Z\times M\times 56.1}{(A-B)}=\frac{2\times 0.5\times 56.1}{5}$

=11.22

Iodine value

Calculation: Weight of oil and bottle = 139grams (A grams)

Weight of bottle alone = 138.5grams (B grams)

Weight of oil taken = 0.5 grams (A-B)

Standardized thiosulphate = 0.1 M

Amount of thiosulphate required to neutralize 25mls ofWij'sSolution = 65mls

Amount of thiosulphate required to neutralize the solution

With oil= 38.5 mls

Amount of iodine consumed by the oil = 65-38.5= 26.5mls

∴ Iodine value = $\frac{136.9x0.1x\ 26.5}{0.5}$ =725.6

Acid value

Calculation: Weight of oil and bottle = 138.5+1.00g=139.5 (A grams)

Weight of bottle alone = 138.5 (B grams)

Weight of oil taken (A-B)= 139.5 – 138.5=1.00g

Standardized KOH = 0.5M

Volume of KOH required to neutralize the oil solution

$= 24.5\text{mls} = \frac{24.5x56.1x0.5}{1.00} = 687.24$

APPENDIX (B)

Saponification value (Crude palm kernel oil)

Calculations: Weight of oil and bottle = 5+ 138.5

(A grams)=143.5g

Weight of bottle alone = 138.5g (B grams)

Weight of oil taken = (A - B) = 143.5 – 138.5 =5g

Strength of HCL =0.5Molar(M)

Titre value of HCL against KOH with oil after reflux

= 22.6g (Xmls)

Titre value of HCL against KOH alone after reflux

= 28.5 mls (Ymls)

Volume of HCL required to neutralize excess alkali after saponification = (Y- X)

= 28.5 -22.6 =5.9mls (Z mls)

$$\text{Saponification value} = \frac{Z \times M \times 56.1}{(A-B)}$$

$$= \underline{5.9 \times 0.5 \times 56.1}$$

5 = 33.1

Iodine value (Crude palm kernel oil)

Calculations : Weight of oil and bottle = 0.5 + 138.5

(A grams)=139g.

Weight of bottle alone = 138.5g (B grams)

Weight of oil taken = (A - B) = (139- 138.5)

= 0.5g

Standardized thiosulphate = 0.1 molar (M)

Amount of thiosulphate required to neutralize

25mls of Wijs solution = 65mls

Amount of thiosulphate required to neutralise the solution with oil = 39.6mls.

Amount of iodine consumed by the oil

= (65- 39.6) =25.4mls.

$$\therefore \text{ Iodine value} = \frac{136.9 \times 0.1 \times 25.4}{0.5} = 695.45$$

Acid value (Crude palm kernel oil)

Calculations : Weight of oil and bottle = 1.00+ 138.5

(A grams)=139.5g.

Weight of bottle alone = 138.5g (B grams)

Weight of oil taken = (A - B) = (139.5- 138.5)

= 1.00g

Standardized KOH = 0.5 molar (M)

Volume of KOH required to neutralize the oil solution = 26.6mls

$$\therefore \text{ Acid value} = \frac{26.6 \times 56.1 \times 0.5}{1.00} = 746.13$$

NB: Saponification value constant = 56.1

Iodine value constant = 136.9

Acid value constant = 56.1

APPENDIX C

Calculation of specific gravity

For Neutralized Palm Kernel Oil

Weight of specific gravity bottle = 21.45grams

Weight of specific gravity bottle + water =71.62 grams

Weight of specific gravity bottle + oil = 67.40

∴ Weight of water =71.62 – 21.45 = 50.17

Weight of oil =67.40 – 21.45 = 45.95

$$\text{Specific gravity of oil} = \frac{\text{Weight of oil}}{\text{Weight of water}}$$

$$= \frac{45.95}{50.17} = 0.915$$

For Crude Palm Kernel Oil

Weight of specific gravity bottle = 21.45grams

Weight of specific gravity bottle + water =71.62 grams

Weight of specific gravity bottle + oil = 68.46

∴ Weight of water =71.62 – 21.45 = 50.17

Weight of oil =68.46 – 21.45 = 47.01

$$\text{Specific gravity of oil} = \frac{\text{Weight of oil}}{\text{Weight of water}} = \frac{47.01}{50.17} = 0.937$$