FAT DETERMINATION OF PRESSED CAKE: A COMPARISON OF EXTRACTION EFFICIENCIES OF DIFFERENT SOLVENTS.

BY

Amokaha Fanen O. F.

97/5941EH

DEPARTMENT OF CHEMICAL ENGINEERING

School of Engineering and Engineering Technology,

Federal University of Technology, Minna, Niger State, Nigeria.

October, 2003.

FAT DETERMINATION OF PRESSED CAKE:
A COMPARISON OF EXTRACTION EFFICIENCIES FOR DIFFERENT SOLVENTS.

BY

Amokaha Fanen O. F.

97/5941EH

DEPARTMENT OF CHEMICAL ENGINEERING
PROJECT WORK SUBMITTED TO THE
DEPARTMENT OF CHEMICAL ENGINEERING
FEDERAL UNIVERSITY OF TECHNOLOGY,
MINNA NIGER STATE IN PARTIAL
FULFILMENT OF THE REQUIREMENTS FOR
THE BACHELOR OF ENGINEERING DEGREE
(B.ENG).

OCTOBER, 2003

CERTIFICATION.

This is to certify that this project titled "FAT DETERMINATION OF PRESSED CAKE: COMPARISON OF THE EXTRACTION EFFICIENCY OF DIFFERENT SOLVENTS" was carried out by AMOKAHA FANEN O. F , and submitted to the Chemical Engineering Department of the Federal University of Technology, Minna Niger State.

21/10 2003

ENGR. U.G.AKPAN.
PROJECT SUPERVISOR.

DATE.

DR. ABERUAGBA
HEAD OF DEPARTMENT

DATE

EXTERNAL EXAMINER

DATE.

DEDICATION

This work is dedicated to several people; Stanley, J, Sesugh , Lola, Austen, Moira, Sam Popcorn, Ogechi, El Remo, Von Aike and everybody I couldn't remember.

It is also warmly dedicated to my family, brothers, teachers and my friends.

Most especially, this work is dedicated to Avese.

ACKNOWLEDGEMENT

My first acknowledgements go to God and my parents.

It is with great appreciation that I also acknowledge and wish to thank my project supervisor, Engineer U.G Akpan for his constant important corrections that I needed throughout this study.

I would also wish to thank Mallam Sidi and Mallam Dikko of the chemical Engineering laboratory for the help before and during the set-up of the apparatus.

My gratitude also goes to my friends and cohorts: all of them.

TABLE OF CONTENT.

Page No

CHAPTER 1

Introduction

CHAPTER2

Literature review

CHAPTER 3

Materials and methods.

CHAPTER 4

Results and Calculations

CHAPTER 5

Conclusion and Recommendation.

APPENDIX 1

APPENDIX 2

APPENDIX 3

TABLES

FIGURES

ABSTRACT

The fat determination of the pressed cakes of the groundnuts and soya beans was carried out using ground samples of 1.40mm particle size. A **standard procedure** (obtained from literature) was first used to extract the groundnut and the soya beans cakes. It was assumed that this standard procedure extracted all the lipids in the sample (assumed to be 100% efficient). The solvents used for the extraction included Hexane, Isopropyl alcohol, petroleum ether, diethyl ether and a mixture of hexane/isopropyl alcohol .Using the **Soxhlet extraction procedure** as well; both cakes were again extracted by all four solvents and the value of the oil masses extracted taken. The comparison was then made for the extraction efficiency of a solvent and the percentage yield of the cakes. The extraction efficiency of the Hexane/isopropyl alcohol mixture was the best extracting solvent with an efficiency of 98.34% and 98.2% for groundnut and soya beans respectively. It also produced the best oil yield from the cake samples. Yields of 23.361% for groundnut cake and 21.111% for soya bean were obtained from the experiment and conclusions drawn.

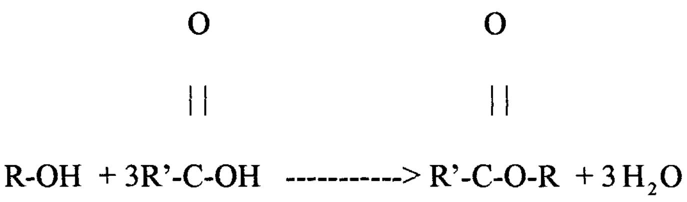
CHAPTER 1

INTRODUCTION

1.0 Description.

Lipids are generally a group of substances that are soluble in ether, chloroform (and most other organic solvents) but relatively insoluble in water. They are either of plant or animal origin. They are greasy / oily to touch and chemically, are produced by the reaction of an alcohol (glycerol) and certain members of a group called fatty acids.

Oils and fats primarily consist of glycerides, which are esters formed between three molecules of fatty acid and one molecule of glycerol.



$$R\text{-}OH + 3R'\text{-}\overset{\overset{O}{\|}}{C}\text{-}OH \text{ ----------->} R'\text{-}\overset{\overset{O}{\|}}{C}\text{-}O\text{-}R + 3H_2O$$

Where:

R, R' - attached radicals..

Oils are generally liquids at ordinary temperatures such as 25 degrees Celsius while fats are solids at the same temperature; lipids being a much broader term used to include all ether-soluble, water-insoluble substances obtained from plant and animal sources (Benton, 1982).

Oils and fats are soluble in a number of organic solvents. These solvents however, have different physical and chemical properties.

Extracting solvents are required to have an acceptable level of all the qualities of a good extracting solvent. These qualities include:

-Non-toxicity

-High volatility.

-Low boiling point.

-High vapor pressure

-Non-flammability.

- Low density.

- Low viscosity.

- High flashpoint.

1.0.1 Non-Toxicity.

An extracting solvent is regarded as being a good extracting solvent if it is non-toxic. This is because ultimately, the extracted oil is used for edible purposes. If a solvent with a high toxicity level is used, even trace amounts that remain in the oil could pose as a health hazard to the people who consume such oil.

1.0.2 High Volatility.

Volatility is the quality of having a low boiling point or subliming temperature at ordinary pressure. It can also be described as the quality of having a high vapor pressure at ordinary temperature. From the correlation, high volatility means low boiling point, hence, showing the solvent is easily removable from the oil by evaporation.

1.0.3 Low Boiling Point.

An extracting solvent is always expected to have as low a boiling point as can be. This is because all the solvents are removed from the oil by evaporation. This not only enables all the solvent to be removed to a very high degree but it also saves cost in the processing industry. A low boiling point means the more readily the solvent evaporates on little heating.

1.0.4 High Vapor Pressure.

Vapor pressure is the pressure exerted when the liquid phase of a solvent is in equilibrium with its vapour phase at a stated temperature.

1.0.5 Non-Flammability.

All good solvents are non-flammable. The extracting efficiency of a particular solvent could be good, but if the operating conditions are such that its high flammability level would make it a fire hazard (for example, in steel works), a non –flammable solvent with a lesser efficiency would be used due to safety reasons.

1.0.6 HIGH FLASH POINT

The flashpoint of a solvent is the lowest temperature at which a flammable liquid gives off sufficient vapour to form an ignitable mixture with air near its surface or

With in a vessel (see table 1). A good extracting solvent is supposed to be non flammable. Therefore, the flash point ould be either as [illegible] as possible or non existent.

1.0.7 Low Viscosity.

The viscosity of all good extracting solvents is always very low. Viscosity is the measure of the internal resistance to flow exhibited by solvents at a given temperature. If the viscosity of the solvent is low, its flow in the process vessels is relatively easy.

1.0.8 Low Density.

Simply, the density of a solvent is the mass per unit volume of the solvent at a given temperature. A good solvent always has a low density

Table 1 - Summary of some of the properties of the solvents used.

Solvents	Boiling Pt/°C	Freezing Pt /°C	Flashpoint / C	Density g/cm	Viscosity/ centipoise	Vapor press / Torr
Diethyl ether	34.55	-117.4	-45.0	0.714	0.24	
Isopropyl alcohol	82.26	- 88.0	53.00	0.785	2.4	32.415
Hexane.	68.7	-95.3	-7.01	0.659	0.31	124.0
Petroleum ether	35 – 60	----	< 0	0.640	----	442.0
Hex/isoprop. Mixture	47.3	----	----	----	-----	-----

Also summarized below is the fat content of some common oilseeds and their percentage composition by mass.

Table 1b : Fat content of some oilseeds (Zulberti C. 1988)

Oilseeds	Percent Content (per wt. basis) / %
Groundnut	**40**
Rapeseed	**40**
Sesame	**44**
Sunflower	**44**
Soya bean	**18**

CHAPTER 2

LITERATURE REVIEW.

2.1 Solvent Extraction.

Solvent extraction is the separation of materials of different chemical types and having different solubilities, by selective solvent action. That is, some materials are more soluble in one solvent than another and hence, there is preferential action. This selective action is used to refine chemicals, vegetable oils and vitamins (Parker, i984)

Cakes obtained by pressing operations still retain between 3- 15% of residual oil. When the volume of the oil is considerably greater as oil than as part of the cake, it is usually more desirable to obtain more complete extraction with solvents.

Modern commercial methods of solvent extraction use volatile purified hydrocarbons, especially the various grades of petroleum-ether, commercial hexane and heptane (Benton, 1982).

Industrially, a typical extraction system follows the general procedural steps:

(1) Cleaning the seeds to remove dirt, stones and tramp iron.

(2) Removing seed hulls by cracking and screening operations.

(3) Rough grinding the pre-pressed cake.

(4) Cooking/steaming the pre-pressed cake.

(5) Flaking the small pieces between small flaking rolls.

(6) Extracting the oil with solvent.

(7) Separating the 'meal' from the oil-bearing mixture called the ' miscella'.

(8) Removing the solvent from both the 'miscella' and the 'meal'.

The meal may be toasted or pelletized for use in animal feeds. Most extracted meals contain less than 1% of residual oil (Benton, 1982). The amount varies depending on any of the following:

- The amount of pre-pressing the seeds were subjected to.
- The initial oil-content of the seed/ cake.
- The efficiency of the extracting mechanical presses.

In the laboratory however, the best method for extracting residual oil from either the crushed seed or the pressed cake is the soxhlet extracting procedure. The soxhlet extractor is shown on page 13b.

2.2 Physical and Chemical Properties of Fats and Oils.

Oils and fats may be divided into animal fat and vegetable fat (according to their sources).Table 2 shows different kinds of oils and their principal uses.

Table2: Types of vegetable oils and their principal uses (Benton, 1982)

Vegetable Oils	Principal Uses
Linseed oil	Paint. Varnish. Printing ink.
Soya – bean oil	Food. Paint. Resins. Chemicals.
Groundnut oil.	Food. Soap.
Castor oil	Medicine. Lubricant. Chemicals.
Sunflower oil.	Food and Resins.
Olive oil.	Soap. Food. Lubricating oil.
Poppy seed oil.	Salad oil. Artist paint.

Table 3 shows animal oils and their principal uses (Benton, 1982)

Animal Oils	Principal Uses
Cod liver oil.	Vitamins. Leather currying.
Sardine oil.	Resins. Paint. Food.
Whale oil.	Food, Soaps, Greases.
Lard.	Pharmacy, Food, Chemicals, Soap.
Sperm-whale oil.	Lubricating oil for delicate machinery.

The physical and chemical properties of fats and oils generally include the following:

2.2.1 Degree of Unsaturation (Benton, 1982)

The liquid fats (from both plant and animal sources) have a high degree of unsaturation. Solid vegetable fats melting between 20-35 degrees Celsius are found in the kernels and seeds of tropical fruits. Most animal fats are solid at room temperature but also have a high degree of unsaturation.

2.2.2 Specific Gravity (Benton, 1982)

This is more a physical property than a chemical one. The specific gravities of oils and fats range from 0.913 (for rape-seed oil) to 0.975 (for Japan, myrtle wax).For most fats and oils, the specific gravities range from values of 0.915 – 0.945.

2.2.3 Solubility (Benton, 1982).

Fats are practically insoluble in water (with the exception castor oil) and insoluble in cold alcohol. They are however, sparingly soluble in hot alcohol. Fats (and oils) are soluble in diethyl ether, carbon disulphide, chloroform, hexane and benzene.

2.2.4 Freezing/ Melting Temperature (Benton, 1982).

Fats and oils have no distinct melting /freezing points because they are such complex mixtures of glycerides, each of which has a different melting point. These glycerides further have several polymorphic forms with different melting / transition points. The freezing point of the oils range from a few degrees above zero to about minus thirty (-30) degrees Celsius.

2.2.5 Hydrolysis (Benton, 1982)

Fats are hydrolyzed readily and easily. This property is used extensively in soap manufacture and in the preparation of fatty acids for industrial purposes. They are hydrolyzed at 220 degrees Celsius with water only under high pressures or at lower pressures in the presence of caustic alkalis or basic metallic oxides that act as catalysts. Free fatty acids and glycerol are formed. If sufficient alkali is present to combine with these formed fatty acids, SOAPS are then formed.

2.2.6 Bodying (Benton, 1982).

Bodying is done commercially in the protective-coating industry. This is a process where fats heated above 250 degrees Celsius gradually polymerize and considerably more viscous. For example, if castor oil is heated to very high temperatures the presence of catalyst, it loses a molecule of water from each ricinoleic acid- radical to form `dehydrated castor oil'. This modified oil is used in the protectve-coating industry to manufacture light-coloured finishes.

CHAPTER 3

MATERIALS AND METHODS

3.0 Extraction of Oil from Cake Samples.

The extraction was carried out in the laboratory using two methods; the standard procedure and the soxhlet extraction procedure. Cake samples of soya-beans and groundnuts, sieved to an average particle size of 1.40mm were used.

3.1 Experimental Work.

Reagents and Materials

The materials used in the experiment include: cake samples, the soxhlet extractor, dessicator , analytical balance, evaporating apparatus and a mortar and pestle.

Reagents/solvents used.

- Diethyl ether.
- Petroleum ether.
- Hexane.
- Isopropyl alcohol.
- Mixture of hexane/isopropyl alcohol.

Test specimen.

The test specimen consists of approximately 9.0g of crushed and sieved samples of 1.40mm average particle size.

3.2 Standard Extraction Procedure (AOAC, 1990)

(1) 9.0g of sample was weighed and put in an extraction flask.10.0ml of ethanol was added to moisten the particles. After the particles had been moistened, 45.0ml of

hydrochloric acid was also added and the flask, placed in a water bath at 80 degrees Celsius for 40 minutes.

(2.) After this time has elapsed, 110ml of diethyl ether was also added to the flask, stoppered and shaken vigorously for some time. Any adhering solvent was washed off the stopper (after it had been opened) with 25ml of petroleum ether. The flask was then allowed to stand until the upper layer was clear. This took 40 minutes. The ether-fat solution is then decanted (through a cotton-plugged glass funnel) into a 150ml beaker.

(3) The residue was then re-extracted using 15ml each of petroleum ether and diethyl ether and the second ether-fat mixture poured into the same 150ml beaker. The beaker contents were then evaporated slowly in a water bath, under a gentle stream of air. After all the visible solvent had evaporated, the residual oil was dried for 30 minutes in a vacuum oven kept at 120 degrees Celsius , allowed to cool in a dessicator and weighed.

3.3 Soxhlet Extraction Experimental Procedure (B. Swaile, 2003).

(1) Using the soxhlet extractor, 9.0g of the sample was again placed in the cellulose thimble of the extractor and a plug of cotton wool placed on top of the contents to prevent spillage. 100ml of the required solvent was poured into the 250ml round-bottom flask (C) of the apparatus. An additional 25ml was added into the thimble compartment (B) to speed up the extraction (see page 14b).

(2) After the apparatus and solvents had been set up (see Figure 1) and added respectively, the round-bottom flask was placed on a heating mantle to heat the solvent. The solvent was brought to the vaporization stage gently and not in a rolling

boil. The solvent percolation rate was the adjusted so that the solvent flushed through the sample every 10 minutes and was kept thus for an hour.

(3) After the hour has elapsed, the heating mantle was switched off and the soxhlet apparatus allowed to cool. The round-bottom flask's contents are then emptied into a pre-weighed beaker, placed in a water bath and evaporated. Once all the solvent had been evaporated, the beaker was placed in a vacuum oven pre-heated at 120 degrees Celsius for 30 minutes, and then weighed so that the mass of extracted oil could be calculated.

3.4 Precautions.

(1) It is the experimenter's responsibility to specifically follow the standard operating procedures. Hence, the use of appropriate personal protective equipment such as goggles and hand-gloves must be ensured.

(2) Since the solvents used in this experiment are not only highly inflammable but also hazardous, they must be properly disposed off.

(3) Extractions and post-extraction evaporations MUST be carried out in a vented hood. This is due to the flammability levels of all the solvents used.

(4) In the solvent extractor during heating, the solvent in the round-bottom flask should not be brought to a rolling boil because when this happens, under- vaporization occurs and hence, the flushing process is affected.

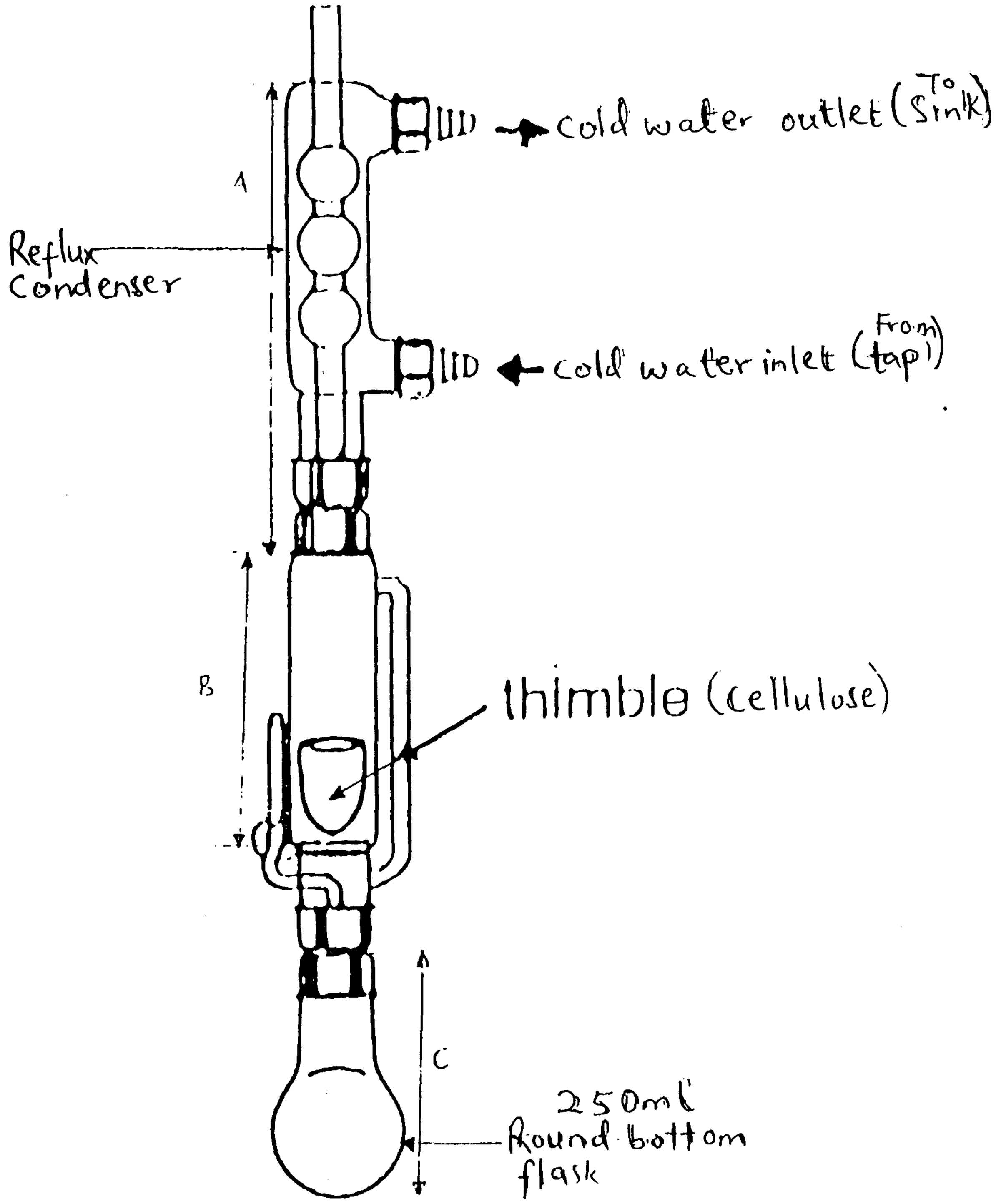


Figure 1: Soxhlet Extractor

CHAPTER 4

RESULTS AND CALCULATION

4.1 Experimental Results.

*** For groundnut cake**

Sample mass used for extraction procedure = 9.00g

Table 4.1- Groundnut cake's experimental results.

	A	B	C	D
Solvent	Tare weight / g	Average final weight /g	Mass extracted /g	**Extraction efficiency. / %**
Diethyl ether	99.1	101.101	2.001	**93.59**
Isopropyl alcohol	99.1	99.535	0.4345	**20.32**
Hexane	99.1	101.153	2.0530	**96.02**
Petroleum ether.	99.1	101.104	2.004	**93.73**
Hexane/ Isopropyl alcohol	99.1	101.2025	2.1025	**98.34**

4.2 Experimental Results

For soya bean cake.

Sample mass used for the extraction procedure = 9.00g

Table 4.2 Experimental results for soya- bean cake.

	A	B	C	D
Solvents.	Tare wt. /g	Average final wt. /g	Mass extracted /g	**Extraction efficiency. /g**
Diethyl ether.	99.1	100.892	1.792	**92.68**
Isopropyl alcohol.	99.1	99.40	0.300	**15.52**
Hexane	99.1	100.972	1.8715	**96.82**
Petroleum ether.	99.1	100.875	1.775	**91.83**
Hexane/ Isopropyl alcohol mixture.	99.1	101.00	1.900	**98.29**

4.3 Discussion of Result.

The experiments show that oil is extracted by all the used solvents, albeit some being more efficient than others. The average extraction efficiency (AEE) for diethyl ether, hexane, petroleum ether and hexane / isopropyl alcohol mixture was 95.42% for groundnut cake and 94.905% for the soya-bean cake. The efficiencies of isopropyl alcohol for both groundnut and soya-bean cake; 20.32% and 15.52% respectively, were not used in the AEE calculation because of the discrepancy in the obtained values.

The average percentage yield (APY) was 22.7668% and 20.382% for groundnut and soya-beans respectively. It can thus be deduced from the experiments that:

- The smaller the particle size, the better the extraction efficiency of the solvent.
- The larger the surface area/volume ratio of the solvent and the residual oil in the particles, the greater the volume of oil extracted from the sample and the lesser the time taken for the solvent to percolate through the sample. In other words, the smaller the particle size the better the extraction.

From table 4.3, the mixture of hexane / isopropyl alcohol was the most efficient extracting solvent, being more efficient than the more commonly used hexane,

This can be explained thus: as lipids are relatively non polar molecules, they can be pulled out of the sample using relatively non polar solvents as has been done. However, some lipids are bound in the cell membrane s of the cake. Plant cell membranes are made up of molecules that have both polar and non - polar regions such as triglycerides (which have both polar glyceride 'heads' and non polar fatty acid 'tails') or phospholipids (also with polar glyceride 'heads' and non-polar 'tail' of a phosphate group). These molecules end up grouping together with polar heads sticking outward and non – polar tails inward. This makes it difficult for non polar solvents like hexane to interact with the non polar 'tails' and extract them. Thus, since these molecules are part non polar and part-polar, isopropyl alcohol presents both characteristics. This is the reason why the mixture is used. The isopropyl alcohol is polar enough to interact with the polar regions and help "pull apart" the cell membrane so the non polar hexane can reach deeper and extract the oil, and is also non polar enough to help in the extraction.

The ratio of 3:2 is used because, too much of isopropyl alcohol in the mixture and the solution will be too polar to extract fat properly.

The total mass of the oil from the soya- bean sample was less than that obtained from the groundnut cake sample due to the following reasons

- The extraction process used to remove oil from the groundnut seeds was a less efficient method than that used for the soya-bean seeds. Therefore, the amount of residual oil in the former sample was more than that of the soya-beans.
- From the oilseed content (see Table 1B), it is seen that while the fat content of groundnuts is up to 40% by mass, that of soya- bean is only 20%.

This also shows why more oil was obtained from the seeds of groundnuts than from soya -beans.

Table 4.3 below shows the summary of the experimental results obtained from the soxhlet extraction. The mass of fat/oil extracted, percentage yield from the cake samples and the extraction efficiency of the solvents have all been summarized in the table.

Table 4.3: Summary of the experimental Results from **Soxhlet extractor**

Solvents	Mass of oil extracted /g		Percentage yield / %		Extraction Efficiency / %	
	Groundnut.	Soya beans.	Ground nut.	Soya beans.	Ground Nut.	Soya beans.
Diethyl ether	2.001	1.7915	22.233	19.906	93.59	92.68
Isopropyl alcohol.	0.4345	0.300	4.830	3.333	20.32	15.52
Hexane.	2.0530	1.8715	22.811	20.790	96.02	96.82
Petroleum ether.	2.004	1.775	22.267	19.720	93.73	91.83
Hexane/isopropyl alcohol.	2.1025	1.900	23.361	21.111	98.34	98.29

4.4 Extraction Efficiency Results

In the experiment, different solvents were used.

They include diethyl ether, isopropyl alcohol, hexane, petroleum ether and 3:2 mixture of Hexane and isopropyl alcohol, with each of the 20 runs lasting approximately half an hour.

From the two previous Table summaries of 4.1 and 4.2 (see pages 14 and 15), it is noticed that hexane/isopropyl alcohol mixture was the most efficient extracting solvent with efficiencies of 98.34% and 98.29% for groundnut and soya-bean cakes respectively.

This is due to the "pulling apart" effect of the isopropyl as it dissolves some polar molecules existing in the sample, leaving hexane with a polar- free sample to work on.

The maximum percent yield for the groundnut cake of well over 23% was obtained from the hexane / isopropyl alcohol mixture and 21% for soya bean from the same solvent.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.0 Conclusion.

It can be thus concluded that for a higher yield of oil to be extracted from the chosen sample, it will be necessary to have the smallest possible particle sizes.

The extraction efficiency of the different samples is summarized in table 4.3 (see column f). From the table, the most efficient solvent in this work was the mixture of hexane / isopropyl alcohol with an extraction efficiency of 98.34% while the worst was the isopropyl alcohol when used alone with an extraction efficiency of 20.32%.

5.1 Recommendation.

(1) More data on the determination of the extraction efficiency of solvents not mentioned, can be obtained by repeating the methods used in this work. Solvents such as heptane, chloroform, 1, 2-dioxane, tetra-chloromethane and many others can be used with the described procedures.

(2) More data is required for the properties of the 3:2 hexane / isopropyl alcohol mixture. These properties include: flashpoint, freezing point, density, viscosity and vapour pressure.

(3) All the solvents used were very inflammable with diethyl ether being the most flammable. Diethyl ether must thus be always used in a ventilated hood.

REFERENCES

1. L.C. Craig, D. Craig (volume 3). **Techniques of organic chemistry**. 2nd edition, Pp 149-332
2. T. Sekin(1977). **Solvent extraction chemistry**. Pp 48-61
3. R.A Meyers (1992). **Encyclopedia of science and technology** (volume 25). Pp 512-517. Academic press.
4. Coulson and Richardson (volume 2). **Chemical engineering** 4th edition. Pp 361.
5. R.Macrae, R.K Robinson, M.J Sadler (1993) **Encyclopedia of food science for technology and nutrition** (volume 7), Pp 4671, 4682. Academic press.
6. W. Benton, H.Benton (1982). **Encyclopedia Britannica** (volume 13), Pp 522-534
7. S.P Parker (1984), **McGraw-Hill Dictionary of scientific and technical terms.** Pp 1510. McGraw-Hill
8. Chapman and Hall (1982). **Dictionary of organic compounds.** Volume 2 - Pp 2926, Volume 3 - Pp1805, Volume 5 -Pp 4782.
9. S.Nielsen, (1994). **Introduction to chemical analysis of food.** Pp 183-191. Jones and Bartlett.
10. B.Swaile. (2003). **Soxhlet extraction of fat from French fries.** University of Cincinnati-Ohio.
11. AOAC, **Association of Official Analytical Chemists**(1990), Official methods of analysis (method 945.16)

12. F.Bergeron, M. Benning (2002). **Comparison of two fat extraction methods.**

13. Zulberti C. (1994). **The economics of oil seed production and processing for edible oil and protein cake.** Ergerton University, Njoro, Kenya.

APPENDIX 1

A- RESULTS AND CALCULATION.

* It is assumed that there was 100% extraction of the cake samples when the **Standard Procedure** (AOAC, 1990) was used.

1. **For Groundnut cake:**

weight of pre-dried beaker = 99.1g

weight of beaker + oil = 101.238g

Mass of extracted oil/fat = (101.238 – 99.1)

= **2.138g.**

2. **For Soya bean cake:**

weight of pre-dried beaker = 99.1

weight of beaker + oil/fat = 101.033

Mass of extracted fat/oil = (101.033 – 99.1)

= **1.933g.**

B- CALCULATION OF THE PERCENTAGE YIELD OF OIL EXTRACTED FROM SAMPLE CAKES.

*** For groundnut cake.**

SOLVENTS	Mass of sample used. /g	Mass of oil extracted. /g	**Percent Yield. / %**
Diethyl ether	9.00	2.001	**22.233**
Isopropyl alcohol	9.00	0.4345	**4.83**
Hexane	9.00	2.053	**22.81**
Petroleum ether.	9.00	2.004	**22.267**
Hexane/isopropyl alcohol mixture.	9.00	2.1025	**23.36**

* **Percent Yield** = (mass of oil extracted / mass of sample used) * 100%

(a) DIETHYL ETHER - (2.001/ 9.00) * 100% = **22.233%**

(b) ISOPROPYL ALCOHOL - (0.4345/ 9.00)* 100% = **4.83%**

(c) HEXANE - (2.053/ 9.00)* 100% = **22.81%**

(d) PETROLEUM ETHER- (2.004/ 9.00)*100% = **22.267%**

(e) HEXANE / ISOPROPYL ALCOHOL- (2.1025/ 9.00)* 100% = **23.36%**

For Soya bean cake.

SOLVENT	Mass of sample used. /g	Mass of oil/ fat extracted /g	**Percent Yield / %.**
Diethyl ether.	9.00	1.7915	**19.906**
Isopropyl alcohol.	9.00	0.300	**3.333**
Hexane.	9.00	1.8715	**20.79**
Petroleum ether.	9.00	1.775	**19.72**
Hexane/ isopropyl alcohol mixture	9.00	1.900	**21.111**

Percent Yield = (mass of oil extracted / mass of sample used) * 100%

(a) DIETHYL ETHER.- (1.7915/ 9.00) * 100% = **19.906%**

(b) ISOPROPYL ALCOHOL.- (0.300/ 9.00)* 100% = **3.333%**

(c) HEXANE – (1.8715/ 9.00)* 100% = **20.79%**

(d) PETROLEUM ETHER- (1.775/ 9.00)* 100% = **19.72%**

(e) HEXANE/ ISOPROPYL ALCOHOL - (1.900/ 9.00)* 100% = **21.111%**

C- CALCULATION OF THE EXTRACTION EFFICIENCY OF THE USED SOLVENTS.

SOLVENTS.	**Extraction Efficiency / %**	Total mass of oil in sample. /g	**Average mass of oil extracted. /g**
Diethyl ether	**93.59**	2.138	2.001
Isopropyl Alcohol	**20.32**	2.138	0.4345
Hexane	**96.02**	2.138	2.0530
Petroleum Ether	**93.73**	2.138	2.004
3:2 Hex / Isopropyl Alcohol	**98.34**	2.138	2.1025

For:

a) Diethyl ether $\frac{2.001}{2.138} \times 100\% = 93.59\%$

b Isopropyl Alcohol -- $\frac{0.4345}{2.138} \times 100\% = 20.32\%$

c) Hexane -- $\frac{2.0530}{2.138} \times 100\% = 96.02\%$

d) Petroleum ether -- $\frac{2.004}{2.138} \times 100\% = 93.73\%$

e) 3:2 Hex / Isopropyl Alcohol -- $\frac{2.1025}{2.138} \times 100\% = 98.34\%$

For soya bean sample

SOLVENTS.	**Extraction Efficiency / %**	Total mass of oil in sample. /g	**Average mass of oil extracted. /g**
Diethyl ether	**92.68**	1.933	1.7951
Isopropyl Alcohol	**15.52**	1.933	0.300
Hexane	**96.82**	1.933	1.8715
Petroleum Ether	**91.83**	1.933	1.775
3:2 Hex \ Isopropyl Alcohol	**98.29**	1.933	1.900

For:

a) Diethyl ether – $\frac{1.7915}{1.933} \times 100\% = 92.68\%$

b) Isopropyl Alcohol -- $\frac{0.300}{1.933} \times 100\% = 15.52\%$

c) Hexane -- $\frac{1.8715}{1.933} \times 100\% = 96.82\%$

d) Petroleum ether -- $\frac{2.004}{1.933} \times 100\ \% = 9.73\ \%$

e) 3:2 Hex / Isopropyl Alcohol -- $\frac{1.900}{1.933} \times 100\% = 98.29\%$

APPENDIX 2

The **Average Percent Yield (APY)** of the samples is calculated thus:

- For groundnut cake

$$\textbf{APY} = \left(\frac{22.223 + 22.810 + 22.67 + 23.36}{4}\right)\% = 22.766\ \%$$

- For Soya-bean cake

$$\textbf{APY} = \left(\frac{19.906 + 20.79 + 19.72 + 21.111}{4}\right)\% = 20.381\ \%$$

To solve for the **Average Extraction Efficiency (AEE)** of the solvents used:

- For groundnut cake

$$\textbf{AEE} = \left(\frac{93.59 + 96.02 + 93.73 + 98.34}{4}\right)\% = 95.42\ \%$$

_ For Soya bean cake

$$\textbf{AEE} = \left(\frac{92.68 + 96.82 + 91.83 + 98.29}{4}\right)\% = 94.905\ \%$$

APPENDIX 3

* To calculate the **mass of oil extracted** (see pages 14 and 15)

$$C = B - A$$

- To solve for **the Extraction Efficiency** of the used solvents:

$$D = (C / \mathbf{2.138}) * 100\%$$

Where:

2.138g is the mass of oil extracted from groundnut cake from **Standard Procedure.**

9.00g is the mass of sample used in Procedure.

- To calculate **the fat/oil yield** from sample,

$$(B - A) / \mathbf{9.00} *100\%$$