DETERMINATION OF PHYSICO-CHEMICAL PROPERTIES AND NUTRITIONAL CONTENTS OF AVOCADO PEAR

(*Persea americana M.*)

BY

JINADU, ABDULHAMID OHIANY

MATRIC NO. 2006/25757EA

BEING A FINAL YEAR PROJECT REPORT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF ENGINEERING (B.ENG) DEGREE IN AGRICULTURAL & BIORESOURCES ENGINEERING, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGER STATE.

JANUARY, 2011

DECLARATION

I hereby declare that this project work is a record of a research work that was undertaken and written by me. It has not been presented before for any degree or diploma or certificate at any university or institution. Information derived from personal communication, published and unpublished work were duly referenced in the text.

Jinadu, Abdulhamid ohiany

25/01/2011

Date

CERTIFICATION

This is to certify that the project entitled " Determination of Physico-chemical properties and Nutritional Contents of Avocado pear (*Persea americana*)", by Jinadu, Abdulhamid Ohiany meets the regulations governing the award of the degree of Bachelor of Engineering (B. ENG.) of the Federal University of Technology, Minna, and it is approved for its contribution to scientific knowledge and literary presentation.

Mrs. Orhevba, Bosede — 24/01/11

Supervisor — Date

Engr. Dr. A. A. Balami — 24/01/2011

Head of Department — Date

External Examiner — 13/01/2011

Date

DEDICATION

This project work is dedicated to Almighty God who has given me the grace to go this far and to the family of mallam Shuaibu Jinadu for their love,moral and financial support.

ACKNOWLEDGEMENTS

My gratitude goes to almighty Allah the most Beneficent and the most merciful who has give me the strength and opportunity to go this far throughout my years and endeavor in school.

Firstly, my profound gratitude goes to my supervisor, Mrs. Orhevba Bosede for her immense contribution and effort throughout my project work. I also acknowledge my H.O.D, Engr. Dr. A.A. Balami, Prof. Itodo, Prof. D.D. Yusuf, Prof. K.M. Baba, Engr. Dr. O.Chukwu, Mr.John Jiya Musa, Dr.(Mrs) Osunde, Dr.M.Y.Otachee, Dr.Peter Idah, Engr. M.A. Sadeeq, Dr.Igbadun, Engr. Peter Adeoye and all other lectures both academic and nonacademic staff. May God reward you all abundantly, (Amin).

My sincere gratitude goes to my parents, Mallam Shuaibu Jinadu and Mrs Wozilat Jinadu, my uncle's for their love, care and financial support throughout my years in school, my brother's and sister's, Abdulazzeeze, Lqman, Fatimah, Latifat, Rashidat, Nurat, Rihanat, Kareem and not forgetting my late brother, Nafiu (may his soul rest in peace), May almighty Allah reward you all, (Amin).

I am very greatul to my friends, Abbey Godknows, Samuel Uloko, Femi Adebayo, Dandy Lawal Yunusa, Mariah Olufemi, Akande Banjo, Ayodeji Dare,Tosin Joseph, Akeem Yakubu, Adams Joshua, Joel Yakubu, Sherif Abdulrashid and all students in the department of Agricultural and Bioresources Engineering, Federal University of Technology Minna, may God reward you all, (Amin).

ABSTRACT

The physical, chemical and nutritional properties of avocado pear which are relevant to engineering and industrial application were selected for study. These were determined using standard tests and experiments. Four replicates of *Fuerte* avocado pear specie was used for the analysis.The following physical properties of Avocado pear were studied: shape, size, weight, volume, density, surface area, colour and sphericity. The physico- chemical properties of Avocado Pear oil studied include: Ph value, acid value, Flash point and density. The nutritional content determined are: Ash, moisture content, protein, Fat (lipid), crude fibre and carbohydrate. The result obtained for the physical properties of avocado pear are: oblong (shape), major diameter of 10.075mm,a minor diameter of 8.465mm and intermediate diameter of 9.025mm (size), 0.2825kg (weight), $2.687\times10^{-3}m^2$ (volume), $1051kg/m^3$ (density),$1.63065\times10^{-4}m^2$(surface area), purplish black (colour) and 0.042 (sphericity). The result for the physico-chemical properties include: 5.7 (pH), 22.44mg/KOH/g(acid value), 108^0C (flash point) and $0.9032g/cm^3$ (density).The result obtained for the nutritional properties are as follows: Ash content 1.52%, Moisture content 77.72%, Protein 0.94%, Fat (lipid) 12.18%, Crude fibre 6.9% and Carbohydrate 0.74%.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

Avocados are native to central and South America, they have been cultivated in this region since 8,000 BC. In the mid-17th century, they were introduced to Jamaica and spread through the Asian tropical regions in the mid 1800s.

The avocado pear (*Persea americana M.*) is in the flowering plant family of *Lauraceae.* Avocado is colloquially known as the Alligator Pear, reflecting its shape and the leather like appearance of its skin. Avocado is derived from the Aztec word "*ahucatl*''. According to scientific classification, the avocados belong, to the kingdom: *plantae*, division: *magnoliophyta*, class: *magnoliopsida*, order: laurels, family: *lauraceae*, genus: *persea*, species: *americana* with *bionomial* name *Persea americana M.*

Avocados are of dozens of varieties which fall into three main categories-mexico *Guatemalan* and West Indian species which differ in their size, appearance, quality and susceptibility to cold. The most popular type of avocado is the *Hass* variety of the United State, which has rugged, pebbly brown-black skin. Another common type is the *fuerte* which is larger than *Hass* and has smooth, dark green skin and a more defined pear shape.

The avocado pear vary in weight depending on the variety; the edible portion of the avocado is its yellow-green flesh, which has a luscious, creamy, buttery consistency and a subtle nutty flavor. The tree grows to 20 m (69 ft), with alternately arranged leaves 12 cm (4.7 in) – 25 cm (9.8 in) long. The flowers are inconspicuous, greenish-yellow, 5 mm (0.2 in) – 10 mm (0.4 in) wide (Whiley, 2000).

Pear-shaped fruit is 7 cm (2.8 in) – 20 cm (7.9 in) long, weighs between 100 grams (3.5 oz) – 1,000 grams (35 oz), and has a large central seed, 5 cm (2.0 in) – 6.4cm (2.5 in) long.

Avocado is a climacteric fruit, which means that it matures on the tree but ripens off the tree. Avocados used in commerce are picked hard and green and kept in coolers at 38 to 42°F (3.3 to 5.6°C) until they reach their final destination. Avocados must be mature to ripen properly. Avocados that fall off the tree ripen on the ground, depending on the amount of oil they contain, their taste and texture may vary greatly. Generally, the fruit is picked once it reaches maturity; Mexican growers pick *Hass*-variety avocados when they have more than 23% dry matter and other producing countries have similar standards. Once picked, avocados ripen in few days at room temperature (faster, if stored with other fruits such as apples or bananas, because of the influence of ethylene gas).In some cases, avocados can be left on the tree for several months, which is an advantage to commercial growers who seek the greatest return for their crop; if the fruit remains unpicked for too long, however, it will fall to the ground (FAO, 2002).

Avocados are good source of Vitamin K, dietary fiber, Vitamin B6, Vitamin C, Folate and copper. Avocados are also a good source of potassium: they are higher in potassium than a medium banana. Although they are fruits, avocados have a high fat content of between 71 to 88% of their total calories - about 20 times the average for other fruits. A typical avocado contains 30 grams of fat, but 20 of these fat grams are health-promoting monounsaturated fats, especially oleic acid.

A typical avocado contains 30 grams of fat but 20 of these fat grams are healthy promoting monounsaturated fats, especially oleic acid. High avocado intake has been shown to have a beneficial effect on blood serum cholesterol levels (USDA, 2009).

About 75% of an avocado's calories come from fat, most of which is monounsaturated fat. Avocados also have 60% more potassium than bananas. They are rich in B Vitamins, as well as Vitamin E and Vitamin K. They have high fiber content among other fruits - including 75% insoluble and 25% soluble fiber. A fatty triol (fatty alcohol) with one double bond, avocadene (16-heptadecene-1-2-4-triol), is found in avocado (Naveh *et al*, 2002).

The nutritional value of avocado pear makes it a good raw material for cosmetics industries; the avocado oil serve as ahigh source of nutrients in the production of cosmetics to enhance the skin good looking condition (Le poole,1995).

In a developed country like U.S.A, this has been made possible with the application of modern technology which involves subjection of agricultural products to physical and chemical additives in storage processes to increase the lifespan and maintain the nutritional value of the product. Therefore, in processing, handling and machine operations to be designed with maximum efficiency and high quality of the end product of the plant materials, their physical and chemical properties are required for maximum accuracy in processing.

The increasing economic importance of food materials together with the complexity of modern technology for their production, handling, storing, processing, preservation, quality evaluation, distribution, marketing and utilization demands a better knowledge of the significant physical and chemical properties of the plant materials.

1.2 Statement of Problem

Avocado pear is a fruit that is not common but possesses meaningful physico-chemical properties and nutritional contents. It has a wide range of application and great potentials. This study therefore will provide useful and meaningful data in the

development of new methods of processing, handling and storage of the crop since available information on basic physical and nutritional properties of the crop is limited.

1.3 Objectives of the Study

- To determine the physical properties of avocado pear
- To determine the physicochemical properties of avocado pear oil
- To determine the nutritional contents of avocado pear

1.4 Justification of the Study

The study of the physicochemical properties and nutritional contents of avocado pear is an attempt to provide meaningful data for engineering analysis and the design of oil extraction machines. The data generated will give designers accurate and appropriate view towards the fabrication of machines. Also the nutritional benefits of the fruit to human life would be investigated.

1.5 Scope of the Study

The study of physicochemical properties and nutritional properties of Avocado pear which are relevant to engineering perspectives were selected for study in this project work.

The physical properties of Avocado pear to be determined will be limited to the following: shape, size, weight, volume, Density, surface Area, colour and sphericity. The physicochemical properties of Avocado pear oil to be determined will be limited to the following: pH, Acid value, Flash point and Density of the oil.

The Nutritional properties of Avocado Pear to be studied are limited to the following: Ash content, Moisture content, Protein content, Fat (lipid) content, Crude fibre content and Carbohydrate content.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 History of Avocado Pear

Avocado pear is a fruit since far back 8000B.C. the fruit was first planted by Rudolph Hass in 1926. *Persea americana M.*, or the avocado, originated in the state of Puebla, Mexico. The native, undomesticated variety known as a *criollo*, is small, with dark black skin and contains a large seed. The oldest evidence of avocado use was found in a cave located in Coxcatlán, Puebla, Mexico that dates to around 10,000 years BC. The avocado tree also has a long history of cultivation in Central and South America; a water jar shaped like an avocado, dating to AD 900, was discovered in the pre-Incan city of Chan ChanThe earliest known written account of the avocado in Europe is that of Martín Fernández de Enciso in 1519 in his book, *Suma De Geographia Que Trata De Todas Las Partidas Y Provincias Del Mundo.*

The first written record in English of the use of the word 'avocado' was by Hass Sloane in a 1696 index of Jamaican plants. The plant was introduced to Indonesia in 1750, Brazil in 1809, the Levant in 1908 and South Africa and Australia in the late 19th century. Since the 15th century the largest producer has been Mexico, particularly in Uruapan in the state of Michoacán. Table 2.1 shows the word producers of avocado pear:

Table 2.1 World producers of Avocado Pear:

Country	Quantity	World Rank
Mexico	1,040,390	1
Indonesia	263,575	2
Unites States of America	214,000	3
Colombia	185,811	4
Brazil	185,811	5
Chile	163,000	6
Domipican Republic	140,000	7
Peru	102,000	8
China	85,000	9
Ethiopia	81,500	10

Source: FAO, (2002)

The fruit contains 65% of the edible flesh, 20% of the seed and 15% of the skin which gives the total weight of the fruit it contains a toxic substance called persin which is a fungicidal toxin present in the seed; it leaches into the body of the fruit through the fatty acid oil. Persin is generally harmless to human being but when the skin is consumed by domestic animals in large quantities it is dangerous. The molecular formula of Persin is $C_{23}H_4O_4$ and has a molar mass of 380.56g/mol.

2.2 Maturity, Harvesting and Handing of Avocado Pear

The state of maturity of avocado pear varies depending on the variety duration of growth and maturity size, for example the *Hass* variety in the USA matures in November and December, weighs about 80ounces and has a pebble dark green or black skin containing high flesh and oil content than the *fuerte* avocado with 5ounces which has smoother and brighter green skin with less fat and oil content.The colour changes depended on the variety, fruit is hand harvested from tree when mature using an array of picking aids, Orchard trees are harvested with the aid of hydraulic ladders (cherry pickers) while on the smaller properties picking poles are used to reach the fruits. Fruit maturity may also be estimated using specific gravity or growth time of fruit (Whiley, 2000).

2.3 Growth of Avocado Pear

According to Barlow and Connie (2000), Avocado tree is about 20m tall with alternately arranged evergreen leaves about 12-25cm long, the flowers are inconspicuous greenish yellow of 5-10mm wide. The fruit is botanically a berry; it is pear shape, 7-20cm long with a large central seed or pit, 4cm in diameter. The growth of avocado pear varies depending on the variety and mode of rootstocks.

2.3.1 Propagation and Rootstocks

Avocado propagated by seeds can bear fruit within 4-6 years and the offspring in unlikely to resemble the parent cultivar in fruit quality in commercial orchards, They are planted using grafted trees and rootstocks, rootstocks are propagated by seeds (seedling rootstocks) and also layering (clonal rootstocks).

After about a year of growing the young plants in a green house are ready to be grafted. Clonal rootstocks have been selected for specific soil and disease condition such as poor soil aeration or resistance to the soil borne disease. Seedlings of the rootstocks are the most commonly employed methods (Parnezny and Marlatt, 2007).

Avocado characteristics affected by climate include: disease resistance, yield, bearing habit, fruit size, quality and season of maturity. Avocado propagated by seedling tends to be larger and more vigorous, begin bearing later than grafted trees. Perfect growth of avocado pear is mostly favoured in the tropical and subtropical countries; weather has a strong impact upon production, prolonged cool weather, subfreezing weather, low humidity, strong winds at flowering time result in low set of fruit and production. The most critical effect of temperature occurs during flowering (Landon and Thomas, 2005).

2.3.2 Flowering of Avocado Fruit

Avocado have a special flowering behavior that under most conditions ensures cross pollination between trees of two avocado flowering types known as type A and type B.

Every avocado tree is one type or the other; the avocado flower is called a "perfect" flower because it has both the female part (the pistil, containing the ovary) and a male part (the stamens, bearing the pollen). Although self pollination occasionally occurs, an avocado flower is not likely to self pollinate because the different parts (male & female) function at different time.

When the female part of a flower is ready to receive pollen, the male part of the flower is not ready to shed pollen. There are different pollinating agents that visit the avocado flowers for nectar and pollen; these include the honey bee, wasps, flies and hummingbirds.

Due to species, some avocado plant flowers between 7:25am and 11am and some at 2:50pm to 6:20pm during the various stage of pollination (Martin *et al*, 1987).

2.4 Nutritional Value of Avocado Pear

Avocado pear is one of the most nutritional fruit; the percentage edible flesh is 65%, seed of 20% and skin of 15%. The avocado fruit is a good source of Vitamin K, dietary fiber, Vitamin B6, Vitamin C, folate and copper; avocados are also good source of potassium: they are higher in potassium than a medium banana. Although they are fruits, they have high fat content of between 71 to 88% of their total calories which is about 20 times the average for other fruits. A typical avocado contains 30 grams of fat, but 20grams of this fat are health promoting monounsaturated fats especially oleic acid (Wood, 2000).

The mineral contents of avocado pear vary depending on the varieties: temperature, Relative humidity, soil nitrogen content, rainfall and environmental factors. Therefore a typical avocado pear contains: Strontium,Chromium ,Nickel, Silver, Aluminum, potassium, Phosphorus, Calcium, Magnesium, Sulphur, Sodium, Chlorine, Manganese ,Iron, copper, zinc and Boron (Batista *et al*, 1993).

Avocado also contains essential nutrients such as carbohydrates, sugar, soluble and insoluble fiber, avocado is also good source of oil containing monounsaturated fat its oil contents varies depending on its varieties and the period of extraction of oil by cold-press process.

The oil content ranges from 16-17% in September and 25-30% in April. High avocado intake has been shown to have a beneficial effect on blood serum cholesterol levels. Specifically, after a

seven-day diet rich in avocados, hypercholesterolemia patients showed a 17% decrease in total serum cholesterol levels. These subjects also showed a 22% decrease in both LDL (harmful cholesterol) and triglyceride levels and 11% increase in HDL (helpful cholesterol) levels. Additionally, a Japanese team synthesised the four chiral components and identified (2R, 4R)-16-heptadecene-1, 2, 4-triol as the natural antibacterial component (Bora *et al,* 2001).

Avocado is a rich source of minerals; this is shown in Tables 2.2 and 2.3.

Table 2.2 Mineral content of two varieties of Avocado pear per 100g of edible portion

Minerals (mg)	Fuertes	Hass
Potassium	555	723
Manganese	41	64
Phosphorus	30	42
Silicon	21	31
Calcium	9.5	12
Sodium	9.0	15
Iron	1.40	1.95
Boron	1.2	3.70
Strontium	0.45	0.75
Magnesium	0.34	0.36
Aluminum	0.32	0.28
Copper	0.23	0.26
Chromium	0.062	0.016
Titanium	0.046	0.014
Lithium	0.029	0.075
Nickel	0.020	0.110
Silver	0.003	0.000

Source: (Batista *et al*, 1993)

Table 2.3 Composition of Avocado Pear per 100g (3.50Z)

Contents	Value
Energy	16kcal
Carbohydrate	8.53g
Sugars	0.66g
Dietary fiber	6.7g
Fat	14.66g
Saturated	2.13g
Monounsaturated	9.80g
Polyunsaturated	1.82g
Protein	2g
Thiamine (Vit B1)	0.067mg
Riboflavin (Vit B2)	0.130mg
Niacin (Vit B3)	1.738mg
Panthenic acid (B50	1.389mg
Vitamin B6	0.257mg
Folate (Vit B9)	81ug
Vitamin C	10mg

Source: (USDA, 2009)

2.4.1 Nutritional facts of Avocado Pear

- The avocado is one of the world most nutritious fruits.
- It is nature's original health foods and it is important not only in maintaining one's vigour but also instrumental in reducing one's chance of falling prey to common life threatening disease.
- Avocado pear also helps pregnant woman and those trying to conceive with high level of folic acid (vitamin B) in avocados, which is essential in developing foetus.
- Avocados do not contain cholesterol but are very rich in mono-unsaturated oil and essential element for lowering low density lipoprotein (LDL) cholesterol by 22% and also increasing high density lipoprotein (HDL) by 11%.
- Mono and poly-unsaturated oils make up more than 70% of the oil content in avocados. This good oil has been shown to protect the arterial walls and therefore protect against arterial heart disease.
- Avocado also contains vitamin A in the safe beta-corotene form.
- Aside from folic acid and vitamin A and C, Avocado is very rich in vitamin B6 which helps to keep the nervous system in good working order and is especially beneficial to some woman suffering from Premenstration syndrome.
- Avocado is brimming with potassium a mineral necessary for maintaining the right balance of water in the body, half of an avocado provides you with an eight of your claim needs.
- Avocado pear also contains Phosphorus an important mineral for strong bones.

- Avocados are particularly rich in important antioxidant which protects the body from free radicals that cause gradual deterioration and ageing.
- Eating an avocado a day gives large vitamin E, necessary for boosting energy levels and strengthening the immune system.
- The benefits of vitamin C are numerous, ranging from common old prevention to protect the body from stressful situations.
- Avocado Pear is high in vitamin B – complex and potassium, which is beneficial for heart and blood pressure.
- Avocado Pear is an excellent source of pectin (an important aid in digestion and cleansing the body of toxins and other waste) so they help prevent and treat constipation.
- Avocado phytonutrients combat oral cancer due to the presence of Zeaxanth alpha carotene, beta- carotene and lutein (Ensminger and Esminger, 1986).

2.5 Storage, Handling and Selection of Avocado Pear

A ripe, ready to eat avocado is slightly soft but should be free from bruise, dark sunken apats or cracks. Avocado fruit can ripen in a paper bag or in a fruit basket within few days especially with banana due to presence of ethylene gas.

Avocado can be refrigerated in a whole form rather than slice to prevent browning reaction due to oxidation from that occure when it comes in contact with air; or sprinkling the surface with lemonjuice or vinegar will prevent oxidation.Depending on the varieties,temperature recommended for cold storage is 10^0c to 13^0c for west Indian race, 7^0c to 8^0c for *Guatemalan* race and 40^0c to 45^0c for *Hass* of the united states with relative humidity of 50 to 90% which

can be stored for one month, the recommended temperature for the stored fruit is 15-21^{0}c (Overholser, 2004).

2.6 Production features of avocado pear

Avocado pear is a fruit grown in tropical and subtropical countries across the world. With the presence of nitrogen in the form of ammonium nitrate which have a very high effect on the plant during growth and fruits production.

2.7 Diseases of avocado pear

The diseases of avocado pear are of different types, it can be attacked by bacterial, fungal and virus diseases as shown in Tables 2.4 to 2.7.

Table 2.4: Bacterial Diseases of Avocado Pear

Disease	**Bacterial**
1.Bacterial canker	*Pseudomonas syringae*
	Xanthomonas cospestris
2.Blast and Bacterial fruit spot	*Pseudomonas syringae*
3.Crown Gall	*Agrobacterium Tumefaciens*

Source: Coffer and Mcmillan (2009)

Table 2.5: Fungal diseases of Avocado Pear

Disease	Fungi
1. Armillaria root rot	*Amillaria Mellea*
2. Shoestring root rot	*Rhizomorph subcorticalis*
	(Anamorph)
3. Anthracnose	*Colletrichum Gloesporioides*
	Glomeralla cingulated
4. Black mildew	*Asteridiella Perseae*
5. Cercospora spot (blotch)	*pseudocercospora purpurea*
6. Collar rot	*Sclerotinia Sclerotiorum*
7. Phomopsis spot	*Phomopsis spp*
8. Physalospora canker	*physalospora perseae*
9. Powdery mildew	*Oidium spp*
10. Root and bark rot	*Fusarium spp*
11. Root rots	*Pythium spp*
12. Roseline root rot	*Rosellinia bunodes*
13. Seedling blight	*Phytophthora palmivora*
	Scelerotium roltsu
14. Tar spot	*phyllachora gratissima*
15. Scab (Fruit and leaf)	*Sphacelema Perseae*

Source: Coffer and Millan (2009)

Table 2.6: Virus Diseases of Avocado Pear

Diseases	Virus
1.Sunblotch	Avocado sunblotch viroid
2.Trunk Pitting	Graft transmissible agent

Source: Coffer and Mcmillan, (2009)

Table 2.7: Other miscellaneous disease of Avocado Pear

Diseases	Causes
1.Algal spot	*Cephaleuros viresens kunze*
2.Black streak	Unknown cause
3.Dieback	Copper deficiency
4.Edema	Physiological
5.Little leaf Rosette	zinc deficiency
6.Tip burn	Excess mineral salt

Source : Coffer and Mcmillan, (2009)

Phylopthora root rot caused by *phylophtora cinnamoni* is the major disease of avocado and is present in all countries producing this fruit Phylopthora root rot can be controlled by trunk injection of potassium orthophosphonate solution which is injected at the rate of 15ml per meter of tree Diameter. General form of treatment for avocado tree is spraying with copper-oxychloride and post harvest treatment depending on the species and environmental effects.

A moderate rainfall area with proper drainage and drained soils are best land for growing avocados since the main root rot phytophora cinnamoni in the soil and fungus diseases are

eveloped in water logged long must soils and excessive rainfall areas, therefore avocados grow ell in moderate soil without excessive in waterlogged and rainfall (Whiley, 2000).

.8 Effects of temperature on Avocado plant

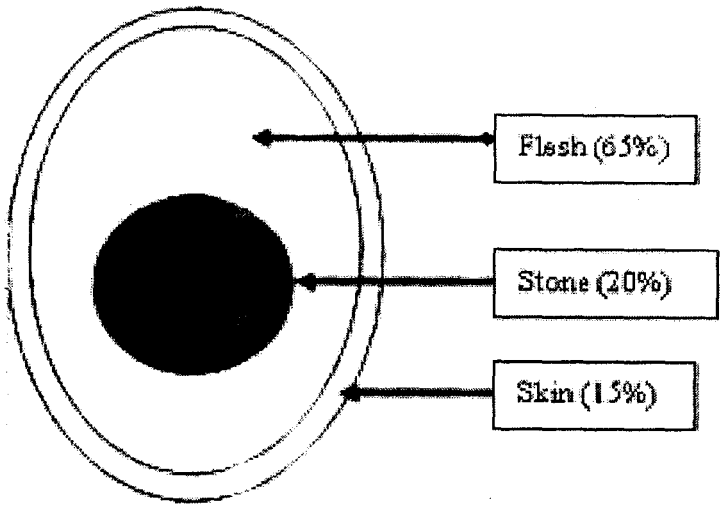
One of the main problems in avocado growing countries is the low yield exhibited by arts during high prevailing temperature. Effect of temperature on the stages of avocado plants ıch as: pollination, fertilization and fruit set vary with each species of the fruits.

According to Whiley (2000), A temperature of 32-35^{0}C during the day and 21 – 23^{0}C ight temperature lasting for a whole week causes damage to ovules and especially to the pollen f "*fuerte*" tubes growing from such pollen, hardly ever penetrated the ovary or reached the mbryo sac and fro "ettinger" species the pollen on the other hand is unaffected by high mperatures. A low temperature region of 17^{0}C-24^{0}C day and 9^{0}C -12^{0}C night, did not cause ıy detectable damage to the ovules and pollen of any species but "*Hass*" of Califonia still have ıe hightest resistance to cold as low as -1^{0}C.

.9 Physical features of Avocado pear

FAO (2004) identified the avocado as a fruit adapted for ecological relationship with rge mammals. Avocado is colloquially known as the Alligator pear reflecting its shape and the ather like appearance of its skin.It is a Medium-sized pear-shaped fruit with a green easy to el leathery skin; it has Creamy flesh of mild and rich flavour.

hen ripe the colour of the skin is purplish black, the edible flesh of the fruit constitutes 65%, ed is 20% and the skin is 15% which makes up the total weight of the fruits.



g 2.1 Physical Features Of Avocado Pear

10 Persin content of Avocado Pear

Persin is a fungicidal toxic substance present in the leaves, bark skin and the seed of 'ocado pear; when consumed by animals in large quantities it can cause a severe harm and even ll. The persin substance is similar to a fatty acid carried in oil and it leaches into the body of e fruit from the pits,its negative effect on human being seem to be primarily in allergic dividuals.

Feeding animals with avocado back should be avoided completely since it has severe fects such as gastrointestinal irritation, vomiting, diarrhea, respiratory distress, congestion, uid accumulation around the tissues of the heart and even death of which birds are particularly nsitive to the toxic compound.

The effects on animals are given bellow:-

- In birds, the symptoms are: increased hearth rate, myocasdical tissues damage, labored breathing, disordered plumage, unrest, weakness and apathy.

- ❖ High doses cause acute respiratory syndrome (asphyxia) with death approximately in 12 to 24 hours after consumption.

Lactating rabbits and mice: non-infectious mastitis and agalactia after consumption of leaves or bark.

- ❖ Rabbits: cardial arrhythmia,Submandibular edema and death after consumption of leaves.
- ❖ Cows and goats: Mastitis after consumption of leaves or bark.
- ❖ Horses: Mastitis after consumption of leaves or barks of avocado pear.
- ❖ Hares, pigs, rats, sheep, ostriches, chickens, turkeys and fish: Symptoms of intoxication similar to those described above. The lethal dose is not known; the effects are different depending upon the animal.

The medical use of persin in avocado pear in humans is that, it kills breast cancer cells, which also enhances the effect of the breast cancer fighting drug tamoxfen.The persin substance is insoluble in aqueous solution and need to be in soluble form for efficient use (Oclrichs *et al*, 1995).

2.11 Methods of extraction of Avocado Pear oil

Avocado pear contains oil which is about 16-17% in September to 25-30% in April, not only is there more oil in fruit from late season but also the oil is also easier to extract from the fat containing "Idioblast" cell. The extraction process of avocado fruits is cold press oil extraction procedure due to its high oil content. Modern cold press extraction process involves maceration of the fruit flesh by a high speed grinder, followed by mixing of the pulp in malaxers. After this processes, oil, water and solids are separated by a three phase decanter and then polished using multi-cone centrifuges (Ibanez *et al*, 2002).

2.13.1 Avocado Pear oil in skin care products

Avocado oil is one of the natural oils that is most easily absorbed by the skin and transported deep into the tissue. It's wonderful emollient and hydrating properties makes it ideal for dry, dehydrated or mature skins, it also helps to relieve the dryness and itching of psoriasis and eczema. The oil is high in sterolins which help to reduce age spot and helps heal sun damage and scars, it also help to soften the skin, which imparts superior moisturizing regeneration and rejuvenation effects. Avocado oil is classified as a vegetable oil containing Vitamins A, B1, B2 and D, lecithin, Potassium as well as Vitamin E.

In its crude, unprocessed form, it has a green colour as it contains natural chlorophyll, it is classified as mono-unsaturated oil and is very useful when treating sun or climate damaged skin that is dehydrated and undernourished. Typical avocado oil contains the following fatty acids:

- palmitic
- Palmitoleic
- stearic
- Oleic
- linoleic
- linolenic

The contents of avocado oil significantly increase the amount of collagen in the skin, which normally is under attack as we grow old (Hartel, 1998).

According to Martin *et al* (1987), avocado oil has a density of 0.9006g/cm^3, ash content of 0.31% and flash point of 103.8^{0}C. Also, Ikhuoria and Maliki (2007) reported that avocado pear oil has a melting point of 10.50^{0}C and refractive index of 1.462.

According to USDA (2009), avocado pear has carbohydrate content of 8.5g, Fat content of 14.66g, protein content of 2g and ash content of 0.91%.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Materials

Samples of *Fuerte* avocado pear used for this analysis were obtained from lokoja, kogi state, Nigeria; the fruits were thoroughly screened to remove the bad ones.

Plate 3.1: Ripe avocado Pear.

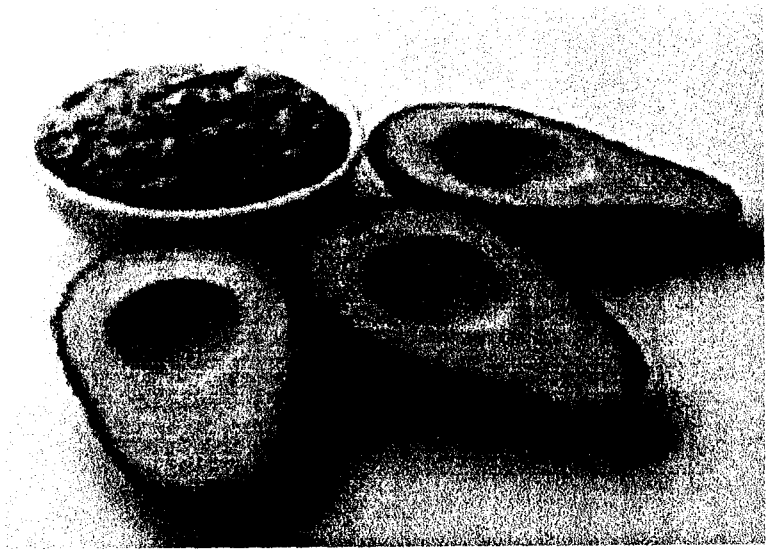


Plate 3.2: Avocado Pulp

3.1.1 Apparatus:

The apparatus used for the analysis include:

Venier caliper

Graph paper

Electrical weighing balance (Mettler PM 2000, 01, 50-6oHz, 200-240volts, 45m Amps)

Measuring Cylinders (Pyrex; 10ml, 25ml, 50ml)

soxhlet extractor

Micro kjeldahl digestion unit

pH meter

Conical flask

Electric Oven (Fisher scientific 2555 keeper, Bouldvard Dubugue, lowa 52001, USA. Model number 3511-IFS serial number 1480060997735.220, 240v, 3.3Amps, 800Watts, 50/60Hz, phase1)

Beaker

Thermometer

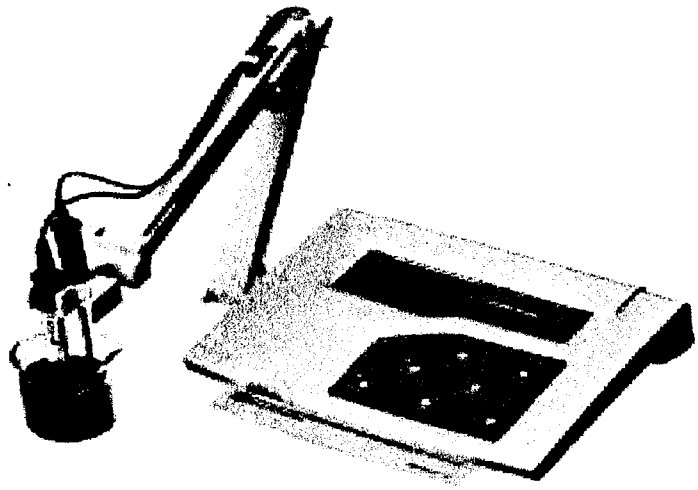


Plate 3.3: Ph Meter

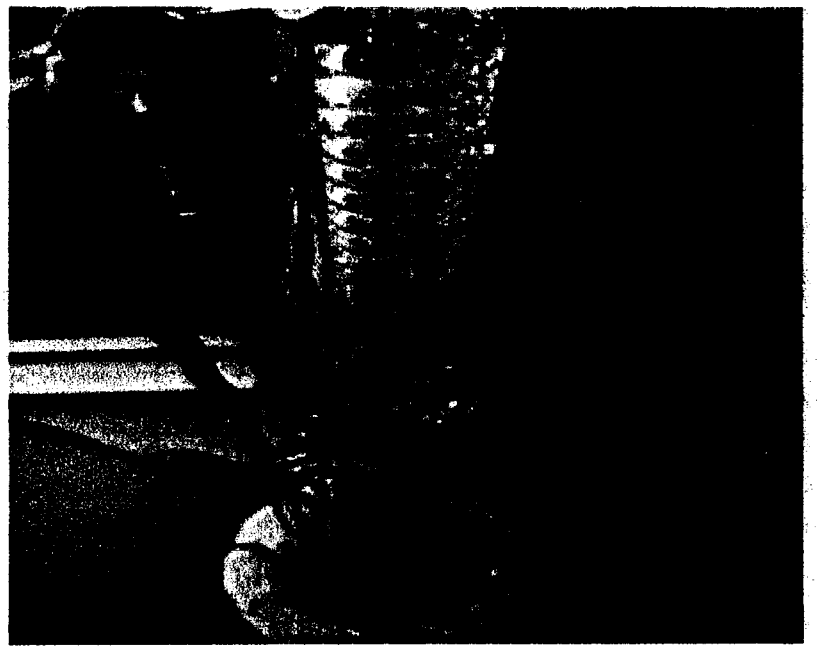


Plate 3.4: Soxhlet apparatus

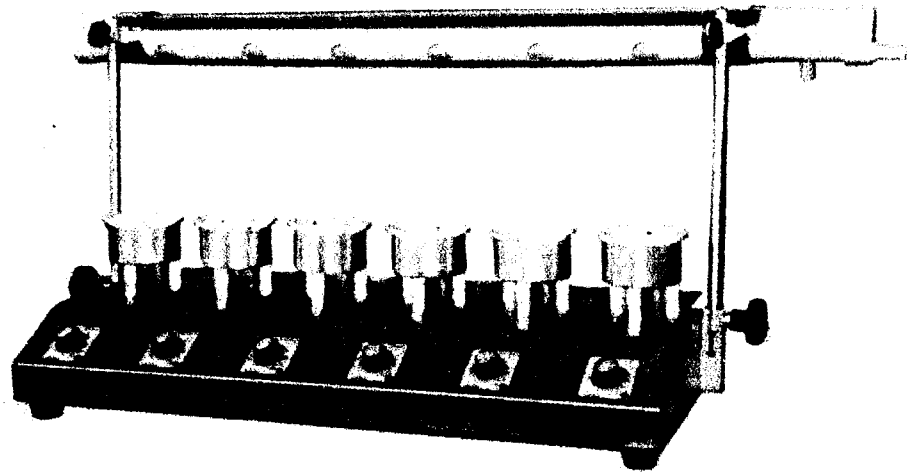


Plate 3.5: Micro Kjeldahl Digestion Unit

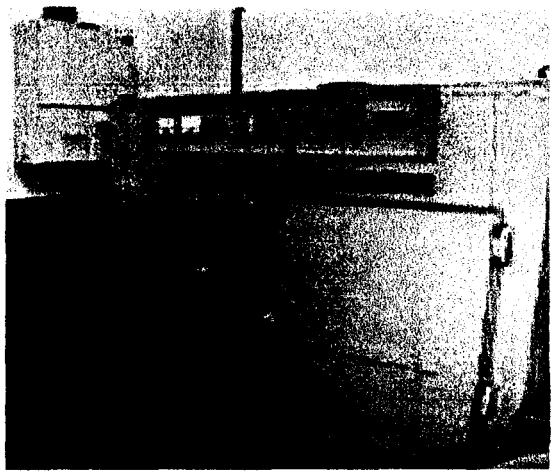


Plate 3.6: Electric Oven

Plate 3.7: Venier Caliper

3.2. METHODS

3.2.1 Selected Physical Properties of Avocado Pear

3.2.1.1 Shape

To determine the shape of avocado pear, tracing of the longitudinal and lateral cross section of the material was done, this was compared with shapes on the charted standard as described by Mohsenin (1986); using the charted standard , descriptive terms were used to define the shape of the product over four replicates.

3.2.1.2 Size

Determination of the size of Avocado Pear was done based on the method described by Mohsenin (1984); the mutually perpendicular axis a & b were referred to as major and minor diameters, while c was referred to as intermediate diameter. A venier caliper was used to measure the vertical axis which is the major diameter; the horizontal axis which is the minor axis and the intermediate axis.

3.2.1.3 Weight

This is the measurement of quantity of Avacado Pear in kg unit and counted numbers of avocado pear (N). The weight of avocado pear was determined using electronic weighing machine.

The weight of avocado pear was then calculated using the formular

Weight of avocado pear $W = \frac{M(kg)}{N}$

Where M = Mass or weight of avocado pear from the scale

N = Number of avocado pear counted.

3.2.1.4 Volume & Density

Water displacement method was used to determine the volume of the product due to its irregular shape (Mohsenin, 1986). The material was first weighed on a platform scale in air and then forced into water inside a beaker by means of a sinker sod. The second reading of the scale with the product submerged minus the weight of the container and water gave the weight of the displaced water. Using the expression given by Mohsenin (1986), the volume and density were determined.

$$volume = \frac{weight\ of\ displaced\ water\ (kg)}{weight\ density\ of\ water\ (^{kg}/_{m^3})}$$

3.2.1.5 Surface Area

The surface area of avocado pear was determined using the graph paper method. The peel of the pear was removed and traced on a graph paper with a pencil.

The surface area was calculated from the area covered by the face on the graph paper as: surface area = sum of the areas of the squares covered by the stripes on the graph paper (Mohsenin, 1986).

3.2.1.5 Colour

The colour of avocado pear was determined by reflectivity and absorptive character using electromagnetic radiation.

3.2.1.6 Sphericity

The measurement of sphericity of avocado pear was determined by obtaining the values of the major, minor and intermediate diameter of the avocado pear.

The sphericity was then calculated using:

$$sphericity\ S = \frac{(bc)^{\frac{1}{3}}}{a^2}$$

a = Major diameter

b = Intermediate diameter

c = Minor diameter

Mohsenin (1986)

3.2.2 Selected Physicochemical Properties of Avocado Pear oil

3.2.2.1 Ph of Pear Oil

The Ph of oil shows the level of acidity or alkalinity of a substance with values from the readings. A 10% w/v suspension of the sample was put in distilled water and mixed thoroughly in a warming micro blender; the pH was then measured with a pH meter (Gregory, 2005).

3.2.2.2 Acid Value

2g of the sample was weighed accurately and dissolved in about 20ml of fat solvent, (diethyl either), the solution was titrated with KOH using phenolphthalein (ml) as an indicator. The titration continued until a faint pink colour persisted for 20-30 seconds. The acid value measures the extent to which the glycerides in the oil have been decomposed by lipase action (Gregory, 2005).

3.2.2.3 Flash Point

Flash point is a measure of the thermal stability of a fatty material. The flash point refers to the temperature at which volatiles evolving from the heated oil will flash but not support combustion.

According to Gregory (2005), 10ml volume of the oil was poured into an evaporating dish, a thermometer was suspended at the centre of the dish ensuring that the bulb just diped

inside the oil without touching the bottom of the dish. The temperature of the oil was gradually raised using an electric stove, the temperature at which the oil sample started flashing (when flame was applied) without supporting combustion was noted as the flash point.

3.2.2.4 Density

According to Gregory (2005) the density of pear oil is given as = $\frac{X_W}{X_V}$

Where x_w = weight of oil (g) and x_v = volume of oil (m^3)

3.2.3 Nutritional value of Avocado Pear

3.2.3.1 Ash Content

Ash in food constitutes the residue remaining after all the moisture has been removed as well as the organic materials (fats, proteins, carbohydrates, vitamins, organic acids e.t.c) have been burnt away by igniting at a temperature of about 550^0c.

AOAC (2005) method was use, the Porcelain crucible was dried in an oven at 100^0c for 10 minutes cooled in desiccators and weighed (W_1). Two grams of the finely ground samples was placed into the previously weighed porcelain crucible and reweighed (W_2). It was first ignited and then transferred into a furnace, which was then set at 550^0c. The sample was left in the furnace for eight hours to ensure proper ashing. The crucible containing the ash was then removed, cooled in the desiccators and reweighed (W_3), the percentage ash content was calculated as:

% Ash content = $\frac{W3-W1}{W2-W1} x\ 100$

3.2.3.2 Moisture content

Moisture content of food is of great important to every food processor as a number of biochemical reactions and physiological changes in food depend very much on the moisture content of even greater significance is the effect of moisture on the stability and quality of foods. Water present as free water in at least three forms, a certain amount is present as free water in the intercellular spaces and within the pores of the materials, Such water retains its usual physical properties to serve as a dispensing agent for colloidal substances and as solvent for crystalline compounds; Parts of the water absorbed on the surface of macromolecular colloids (Starches, pectins, cellulose and proteins) the water is closely associated with the absorbing macromolecules by forces of absorption which are attributed to Van dar Waal forces or to hydrogen bond formation. Finally, some of the water is in bond form in combination with various substances that is, as water of hydration.

According to AOAC (2005) method, a clean crucible was dried to a constant weight in an air oven at 110^0c, cooled in a desiccators and weighed (W_1), two grams of the finely ground sample was accurately weighed into the previously labeled crucible and reweighed (W_2). The crucible containing the sample was dried in an oven to a constant weight (W_3) the percentage moisture content was calculated thus:

$$\% \text{ moisture content} = \frac{W2-W3}{W2-W1} \, x \, 100$$

3.2.3.3 Protein Content

Amino acids are the building blocks of proteins and therefore polymers of amino acids most of which are α amino acids having the general formular NH_2CHR_2COOH. It is the only macronutrients in foods that contain nitrogen. The nitrogen in proteins thus becomes the basis of the estimation of protein in foods.

Protein Digestion:

AOAC (2005) method was adopted, 1.5g of the ground defatted sample in an ash less filter paper was dropped into 300ml kjeldahl flask. 25mL of concentrated H_2SO_4 and 3g of digesting mixed catalyst $CUSO_4 + Na_2SO_4$ (1:10) were weighed separately into an ash less filter and also dropped into the kjeldahl flask. The flask was then transferred to the kjeldahl digestion apparatus. The sample was digested until a clear green colour was obtained.

Distillation of the Digest:

The digest was transferred into 500ml kjeldahl flask containing anti-bumping chips, Two hundred and fifty mililiters distilled water was added (rising the 300ml/flask into the 500ml flask with part of the 250m/water) about 70 -120ml of 40% NaOH was slowly added by the side of the flask and then followed by 3 drops of 1% phenolphthalein indicator.

A 500ml conical flask containing a mixture of 125ml 4% boric acid and 4 drops of mixed indicator was used to trap the ammonia being liberated.

The conical flask and the kjeldahl flask were then placed on kjeldahl distillation apparatus with the tubes inserted into the conical flask and the kieldahl flask. The distillation was carried out until 125ml of the distillate was trapped in the boric acid solution to make a total volume of 250ml) the distillate was then titrated with 0.1MHCL.

Calculation:

$$\% N_2 = \frac{0.014 \times M \times V}{wt\ of\ sample} \times 100$$

% crude protein = % Nitrogen (N_2) x 6.25 where M = actual molarity of acid

V = volume of HCL used.

3.2.3.4 Fat (Lipid) Content

The fat is the combination of fat fatty acid esters, compound fat, neutral fat, sterolspseudo fat (vitamin A, D_2, D_3, E, K) and carotene. In general lipids are characterized by their sparing solubility in water and their considerable solubility in organic solvents and those food constituents soluble in non-polar organic solvents such as benzene and petroleum ether.

The lipid fraction includes fats also known as triglycerides or triacylglycerols, phospholipids sphingo lipids, waxes, steroids terpens and fat soluble vitamins, in real terms fat make up to about 99% of the lipid fraction of a food usually in analysis, total lipid content is what is determined rather than the true fat content and this has resulted in the term fat and lipid becoming virtually indistinguishable.

According to AOAC (2005) method, A clean dried 500ml round bottom flask containing few anti bumping granules was weighed (W_1) and 300ml of petroleum ether (40^0C-60^0C) for the extraction was poured into the flask fitted with soxhlet extraction unit.

The extractor thimble containing twenty grain was fixed into the soxhlet extraction unit, the round bottom flask and a condenser were connected to the soxhlet extractor, cold water circulation was put on. The heating mantle was switched on and the heating rate adjusted until the solvent was refluxing at a steady rate. Extraction was carried out for six hours, the solvent was recovered and the oil was dried in the oven at 70^OC for one hour.

The round bottom flask and oil was cooled and then weighted (W_2)

The lipid content was calculated thus: % crude lipid content = $\frac{W2-W1}{\text{Wt of sample}} \times 100$

3.2.3.5 Crude Fibre Content

Crude fibre is made up of cellulose and a little lignin, crude fibre includes theoretically material that are indigestible in human and animal organism. Also, crude fibre represent the

organic residue left behind after the material has been treated under standardized conditions with light petroleum, boiling dilute sulphuric acid; boiling dilute sodium hydroxide solution dilute hydrochloric acid, alcohol and ether.

According to AOAC (2005) method, Two gram of the finely ground sample was weighted out into a round sample bottom flask, 100ml of 0.25m sulphuric acid solution was added and the mixture boiled under reflux per 30 minutes. The hot solution was quickly filtered under suction; the insoluble matter was washed several times with hot water until it was acid free.

It was quantitatively transferred into the flask and 100ml of hot 0.3lm sodium hydroxide solution was added and the mixture boiled again under reflux for 30 minutes and quickly filtered under suction. The insoluble residue was washed with boiling water until it was base free, it was dried to constant weight in the oven at 100^0c cooled in desiccators and weighed (C_1).

The weighted sample (C_1) was then incinerated in a mottle furnace at 550^0c for 2 hours, cooled in the desiccators and reweighed (C_2)

Calculation:

The loss in weight on incineration = C_1-C_2, the calculation was carried out thus:

$$\% \; crude \; fibre = \frac{C_1 - C_2}{weight \; of \; original \; sample} x100$$

3.2.3.6 Determination of Carbohydrate Content (By Difference)

Carbohydrates are generally the most abundant singular food component in nature and are widely distributed, carbohydrates are classified into three:-

i. Monosaccharides which are xylose, arabirose, glucose and fructose.

i. Oligosaccharides which occur when the hydroxyl group of one monosaccharide is condensed with the reducing end of another monosaccharide (two sugars when joined in this way produces a disaccharide).

iii. Polysaccharides which are grouped into two – the structural polysaccharides (which includes: cellulose hemicellose, liqnin) they constitute the rigid mechanical structures in plants and nutrient polysaccharide Include (starch and glycogen) which can be easily digested.

The total carbohydrate content was determined by difference, i.e the sum of percentage of moisture, ash, crude lipid, crude protein and crude fibre was subtracted from 100, (Inuller and Tobin, 1980).

CHAPTER FOUR

4.0 RESULTS AND DISCUSSIONS

4.1 Results

The result obtained for the physicochemical and nutritional contents of avocado pear are given in Tables 4.1- 4.3.

4.1.1 The physical properties of avocado pear

Table 4.1 below shows the result of the physical properties of Avocado Pear

Table 4.1: Result of Physical Properties of Avocado Pear

Properties	Values
Shape of avocado pear	Oblong shape
Size of avocado pear:-	
a. Major diameter	10.075mm
c. Intermediate diameter	9.025mm
b. Minor diameter	8.465mm
Weight of avocado pear	0.2825kg
Volume of avocado pear	$2.687\times 10^{-4}m^3$
Density of avocado pear	$1051kg/m^3$
Surface area of avocado pear	$1.634\times 10^{-3}m^2$
Colour of avocado pear	Purplish-black
Sphericity	0.042

4.1.2 Result of the physicochemical properties of Avocado Pear oil

Table 4.2 below shows the result of the physicochemical properties of Avocado Pear oil

Table 4.2: Result of Physicochemical properties of avocado pear oil

Properties	values
PH	5.7
Acidity	22.44mg/KOH/g
Flash point	108^0C
Density	0.9032g/cm^3

4.1.3 Nutritional properties of Avocado Pear

Table 4.3 below shows the result of the Nutritional Contents of Avocado Pear

Table 4.3: Result of Nutritional Contents of Avocado pear

Composition	Values (%)
Ash content	1.52
Moisture content	77.72
Protein content	0.94
Fat (lipid) content	12.18
Crude fibre content	6.90
Carbohydrate content	0.74

4.2 Discussion of Results

4.2.1 Physical properties of Avocado Pear

Table 4.1 shows the shape of avocado pear as oblong; a shape in which the diameter of the vertical axis is greater than the diameter of the horizontal axis. The size of avocado pear was determined with respect to its major, intermediate and minor diameter of 10.075mm, 9.025mm and 8.465mm. Manuwa and Muhammad (2010) reported that the size of fruits decreases with an increase in moisture content.

The average weight of avocado pear was determined to be 0.2825kg using four replicates; this is close to the value of 0.374kg of *Hass* variety of avocado as reported by FAO, (1997).

The value of volume obtained is $2.687 \times 10^{-4}m^3$, on comparing this with the volume of shea kernel obtained by Olajide and Otunola (2000), $1.910^{-3}m^3$, it can be observed that avocado pear has smaller volume than shea kernel.

The value of density obtained is $1051kg/m^3$, on comparing this with the value of $987kg/m^3$ reported by FAO (1997), it can be observed that the value is greater due to different species and environmental factors; also on comparing the value ($1051kg/m^3$) with density of cashew nut ($933kg/m^3$) as reported by Iliyasu Yusuf (2005), it can be observed that the density of avocado pear is greater than density of cashew nut.

The surface area obtained for avocado pear is $1.63065\times 10^{-4}m^2$. The colour of ripe avocado pear was determined to be purplish-black. This the same as the colour of *fuerte* avocado reported by Mohsenin, (1986).

Sphericity of avocado pear was determined to be 0.042, on comparing with the sphericity of cashew nut (0.75), it was discovered that cashew nut has a roundness ratio greater than *fuerte* avocado pear.

Sphericity of avocado pear was determined to be 0.042, on comparing with the sphericity of cashew nut (0.75), it was discovered that cashew nut has a roundness ratio greater than *fuerte* avocado pear.

4.2.2 Physicochemical properties of Avocado Pear oil

From Table 4.2, the pH value of avocado oil was determined to be 5.7 this shows the slightly acidic nature of the oil, it compares favourably with the value of 5.5 reported by Bzimana *et al,* (1993).

Whiley (2000) reported that Avocado oil is used as edible oil, lubricant in engines and in cosmetics due to its regenerative and moisturizing properties.

The acid value of avocado pear oil was determined to be 22.44mg/KOH/g, the acid value is the mass of potassium hydroxide (KOH) in milligram that is required to neutralize 1g of the substance, comparing this value with the acid value of cashew nut oil of 20mg/KOH/g as reported by Iliyasu Yusuf, (2005) and 0live oil of 8.8mg/KOH/g as reported by FAO (1997); these shows that avocado oil has higher acid value than cashew nut oil and olive oil. Acid value is used to measure the quality of oil which must not be too high; Avocado oil can be oxidized if exposed to light and comparing it with cocoa butter, coconut oil, palm oil and olive oil, it can be used as lubricant and plasticizer.

The flash point of avocado pear was determined to be 108^0C, this compares favorably with the value of 103.8^0C reported by Martin *et al,*(1987); it is lower than the value obtained for canola oil (327^0c) , higher than ethanol (16.6^0C) and kerosene ($38\text{-}72^0$c) as reported by Martin *et al,* (1987).

4.2.3 Result of Nutritional content of Avocado Pear

From Table 4.3, the ash content of avocado pear was determined to be 1.52% this is the residue remaining after all the moisture and organic materials have been removed. Comparing with the value of 0.91% as reported by USDA, (2009), the slightly higher value obtained for avocado pear may be due to difference in variety but it falls within the range (0.4-1.68%) reported by FAO (1989) for *fuerte* variety.

Moisture content of avocado pear was determined to be 77.72% per 100g of the pulp which is the total percentage present inform of water, it is slightly greater than 70.34% reported by USDA (2009); Oladele and Oshodi, (2007) reported 2.53% moisture content for Jatropha plant and FAO, (1989) reported a moisture content of 8% for Wheat; thus, it is observed on comparing avocado pear with these crops that it has a high moisture content.

Protein content of avocado pear was determined to be 0.94g; this value is close to the values of 2g and 1.72g obtained by USDA, (2009) and FAO, (1989). USDA reported the protein content of some crops as follows: Grape 1.2g, Kiwi 0.4g Lemon 1.1g, Melon 0.6g and strawberries 0.8g.

Fat (lipid) content of avocado pear was determined to be 12.18g per100g, this is close to the value of 14.66g reported by USDA (2009), the slight difference may be due to difference in specie since *Hass* avocado is higher in lipid content than *fuerte* avocado pear, the lipid content of other crops as reported by USDA (2009) are: 0.1g (Apple), 0.3g (Banana), 0.1g (Grape), 0.1g (Melon) and 0.1g (orange); Oladele and Oshodi (2007) also reported lipid content of some other crops as follows, Jatropha (47.13g), Locus bean (11.7g) and cowpea (3.6g).

Wood (2000) also reported that, depending on the variety, avocado pear has 71-88% of fat content and 20g of it is health promoting monounsaturated fat especially oleic acid.

Bora *et al* (2001) also reported that, avocado has 0% cholesterol level and it decreases the LDL (Harmful cholesterol) level in the body by 22%, it also increases the HDL (helpful cholesterol) level by 11%.

The crude fibre of avocado pear was determined to be 6.90g, this agrees with the value of 6.7g as reported by USDA (2009).

USDA (2009) also reported the crude fibre contents for other crops as follows 2.2g (pear), 1.7g (orange), 0.7g (melon), 1.9g (kiwi), 0.7g (Grape), 1.1g (Banana), 2.8g (Lemon).

The crude fibre content is a significant component of a diet, it increases stool bulk and decreases the time that waste materials spend in the gastro intestinal tract, it is also used as index of value in poultry and stocks feeds (Oladele and Oshodi, 2007).

Carbohydrate content of avocado pear was determined to be 0.74g per 100g,this is less than the value of 1.9g obtained by Wood (2000), on comparing this value with other fruits such as lemon 9.32g, Apple 11.8g, Banana 23.2g, melon 5.5g, orange 8.5g, strawberries 5.7g, (USDA, 2009); It shows that the value of carbohydrate in avocado pear is lower. Carbohydrate is a major food substance for animal and human being needed for growth and strong health.

CHAPTER FIVE

5.0 CONCLUSIONS

This study was carried out to determine the Physicochemical and Nutritional properties of avocado pear. The results obtained are as follows:

Physical properties: Shape (Oblong), Size {major diameter (10.075mm), minor diameter (8.465mm), intermediate diameter (9.025mm)}, weight (0.2825kg), volume ($2.687 \times 10^{-4} m^3$), Density ($1051 kg/m^3$), Surface area ($1.634 \times 10^{-3} m^2$), Sphericity (0.042) and Colour (purplish-black).

Physicochemical properties of avocado pear oil are: pH (5.7), Acid Value (22.44mg/KOH/g), Flash point (108^0c) and Density ($0.9032 kg/cm^3$).

The nutritional contents of avocado pear are: Ash (1.52%), Moisture content (77.72%), Protein (0.94%), Fat (12.18%), Crude fibre (6.90%) and Carbohydrate (0.74%).

The results obtained for the physical properties of avocado pear shows that it has common properties like other biomaterials needed for processing, handling and storage after harvesting and the nutritional contents shows that it has a high moisture content thus, it is a highly perishable fruit which must be stored with care, it also has high lipid content with 0% cholesterol; which is a good source of nutrition.

5.2 RECOMMENDATIONS

- More research work should be conducted on other properties of avocado pear.
- It is recommended that avocado pear being a fruit with high nutritional value, with its high fat content of zero percent cholesterol can be consumed by adults and children.
- Large commercial production of avocado pear should be encouraged in Nigeria.
- The effect of storage period on the nutritional quality of avocado pear oil should be investigated.

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APPENDIX A

CALCULATIONS

1. Shape of avocado pear is oblong

2. Size of avocado pear:

A=Major diameter=10.075mm

B=Intermediate diameter=9.025mm

C=Minor diameter=8.465mm

3. Weight of avocado pear:

Sample A=299.5g

Sample B=289.2g

Sample C=271.2g

Sample D=270.2g

$$\text{Average weight} = \frac{299.5+289.2+271.2+270.2}{4}$$

$$= \frac{1130.1}{4}$$

$$= 282.50\text{g}$$

4. Volume & Density of avocado pear

Volume displaced by samples:

A=286.3cm^3

B=295.50cm^3

C=257.1cm^3

D=263.4cm3

$$\text{Average volume} = \frac{286.3+295.0+257.1+263.4}{4}$$

$$= \frac{1074.8}{4}$$

$= 268.7cm^3$

$= \frac{268.7}{10^6}$

$= 2.687 \times 10^{-4} m^3$

Density of avocado pear $= \frac{\text{Average mass(kg)}}{\text{Average volume}(m^3)}$

$= \frac{0.2825}{2.687 \times 10^{-4}}$

$= 1051 kg/m^3$

5. Surface area of avocado pear

Sample "A"

Number of full size square = 1605squnit

Number of half size square $= \frac{53}{2} = 26.5$squnit

Number of quarter $= \frac{69}{4} = 17.25$squnit

Total number of square unit =1605+26.5+17.25

1649.75squnit

Sample "B"

Total number of square units =1586+24.5+17.25

= 1627.75squnits

Sample "C"

Total number of square units = 1702+32.5+20.25

= 1754.75squnits

Sample "D"

Total number of square units = 1484+23+14.5

= 1521.5squnits

Sample "E"

Total number of square units =1564+21+14.5

=1599.5squnits

Average total unit square = 1599.5+1521.5+1754.75+1627.75+1649.75/5

=1630.65squnits

$=1630.65/10^6$

$= 1.63065\times 10^{-4}m^2$

6. sphericity of avocado pear = $(\frac{bc}{a^2})^{1/3}$

$= \frac{(9.025\times 8.465)}{10.075^2}\frac{1}{3}$

=0.042

7. Acid value of avocado pear = $\frac{titre\ value\times 5.61}{wt\ of\ sample\ used}$

$= \frac{0.8\times 0.1\times 5.61}{0.2}$

= 22.44mg/koH/g

8. Density of avocado pear oil

Wt of oil, $X_w = 2.8g$

Volume of oil, $X_v = 3.1m^3$

Density = $\frac{X_w}{X_v}$

$= \frac{2.8}{3.1}$

$= 0.9032g/m^3$

9. Moisture content of avocado pear

Wt of empty crucible = W_1

Wt of crucible + sample before drying = W_2

Wt of crucible + sample after drying = W_3

$$\%\text{Moiture content} = \frac{W3-W1}{W2-W1} \times 100$$

$$= \frac{32.250-27.385}{32.250-25.99} \times 100$$

$$= 77.72\%$$

10. Ash content of avocado pear

Wt of empty crucible = W_1

Wt of crucible + sample = W2

Wt of crucible + ash =W3

$$\%\text{Ash content} = \frac{W3-W1}{W2-W1} \times 100$$

$$= \frac{26.085-25.990}{32.250-25.990} \times 100$$

$$= 1.5176\%$$

11. Protein content of avocado pear

Wt of sample = 4.347

Titre value = 4.ooml

Molarity of HCL = 0.117M

$$\%N_2 = \frac{0.014 \times M \times V \times 100}{Wt\ of\ sample} \times 100$$

$$= \frac{0.014 \times 0.117 \times 4.00}{4.347} \times 100$$

$\%N_2 = 0.1507\%$

% Crude protein = $\%N_2 \times 6.25$

$= 0.942\%$

12. Fat (Lipid) Content of avocado pear

Wt of sample = 56.64g

Wt of flask + Wt of chips (W1) = 176.31g

Wt of flask +Wt of chips (W2) = 183.21g

$$= \frac{W2-W1}{wt\ of\ sample} \times 100$$

$$= \frac{183.21-176.31}{56.64} \times 100$$

= 12.1822%

13. Crude fibre content of avocado pear

Wt of samples = 8.694g

Wt of residue after digestion C_1 = 0.78g

Wt of ash C_2 = 0.18g

$$\text{Wt of crude fibre} = \frac{C1-C2}{wt\ of\ original\ sample} \times 100$$

$$= \frac{0.78-0.18}{8.694} \times 100$$

= 6.9%

14. Carbohydrate content of avocado pear

= 100- %(Moiture+Ash+Crude lipid+Crude fibre+crude protein)

= 100 - % (77.72+1.52+12.18+0.94+6.90)

= 100 - 99.26

= 0.74%