NUTRITIONAL, PHYSICOCHEMICAL, MICROBIAL AND SENSORY ANALYSIS OF COMPOSITE FOOD SPREADS PRODUCED FROM *PERSEA AMERICANA* AND *ARACHIS HYPOGEA* PLANTS

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A PROJECT SUBMITTED TO THE DEPARTMENT OF FOOD SCIENCE AND TECHNOLOGY, COLLEGE OF BASIC AND APPLIED SCIENCES,

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF DEGREE OF BACHELOR OF TECHNOLOGY IN FOOD SCIENCE AND TECHNOLOGY

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DECLARATION

I hereby declare that this project has been written by me and is a record of my own research work. It has not been presented in any previous application for a higher degree of this or any other University. All citations and sources of information are clearly acknowledged by means of reference.

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NICHOLAS, CHELSEA GINIKACHUKUWU

……

Date

CERTIFICATION

This is to certify that the content of this project entitled '**Nutritional, Physicochemical, Microbial and Sensory Analysis of Composite Foodspreads Produced from *Persea americana* and *Arachis hypogea* plants'** was prepared and submitted by **NICHOLAS CHELSEA GINIKACHUKWU** in partial fulfillment of the requirements for the degree of **BACHELOR OF SCIENCE IN FOOD SCIENCE AND TECHNOLOGY.**

The original research work was carried out by him under my supervision and is hereby accepted.

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DEDICATION

I dedicate this work to the Creator of the universe, for making all things work together for good for me, always. To my loving mother who was the sole source of inspiration to my endeavour. To my family, friends, fans and haters, who keep me going one way or the other.

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ABSTRACT

Avocado (Persea americana) fruit deteriorates rapidly after harvest and this necessitated the implementation of this project. The objective of this project was centred around two accomplishments, i) to salvage the wastage of avocado fruits by enriching peanut butter with fresh avocado pulp, and ii) to provide a healthful option of fat-based foodspread containing monounsaturated and polyunsaturated fats opposed to saturated and trans fats rampant in the widely consumed contemporary food spreads. *Arachis hypogaea* (groundnuts) have high amount of oleic and linoleic fatty acid profile that accounts for about 75 to 80% of the total oil it contains. The nutritional, physicochemical, microbiological, and sensory properties of peanut butter fortified with Avocado pear fruit were analysed in this study. Peanut butter and avocado paste were substituted at varying ratios of 100:0, 80:20, 70:30, 50:50 and 0:100. Studies on the proximate composition, mineral constituents, and sensory evaluation revealed that fortifying groundnuts with Avocado significantly increased its fat content from 25% to 52.6% and 47.9% for 20g and 30g of avocado pulp respectively. Addition of avocado pulp significantly increased the fibre content of peanut butter from 2.8% to 4.5 and 3.85% for 20g and 30g of avocado pulp respectively. Most importantly, the fortified samples showed significant increase in % ash content from 0.87% to 1.9%, 1.61% and 1.42% for 20g, 30g and 50g of avocado pulp respectively, as compared with the standard sample, indicating that the avocado enriched foodspread contains appreciable levels of mineral composition and could be used to supplement the daily energy intake of consumers. The composite spreads also possessed more Na and Cu than the standard sample and had a higher score for mouthfeel by the sensory panelists. The aforementioned results show that traditional peanut butter foodspread could be substituted with peanut avocado composite foodspread up to 20% in edible, spreadable foodspread production.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of Study

Fruits and vegetables are exceedingly perishable foods (due to their high moisture content). They are subject to a number of microbial, chemical and physical deteriorative changes, which shorten their shelf-life and leads to degradation in nutritional value (Bovi et al., 2016).

A number of processing methods are being employed to increase the shelf-life of these food products. Deterioration can result unless the inherent enzymes are controlled or destroyed by

food processing techniques, hence, the need for conversion of fruits and vegetable into other more stable forms, to elongate shelf-life and make readily available to consumers nutrients in a variety of spread options (Singh et al., 2018).

The main aim of processing food into spreads will be to facilitate the physicochemical and microstructural changes, which transform the blend to an end product with the desired characteristics and physicochemical stability, to harness the nutritional benefit of the vitamin dense fruits used, and to ensure the availability of a variety of fruits all year round (Lieberman et al., 2012).

So far, the kinds of spreads we have available include but are not limited to those of animal and plant (or fruit and vegetable) base, and a combination of edible vegetable oils and animal fat e.g. margarine, cheese and butter. The spreads obtained from fruits and vegetables include jams, preserves and marmalades. During the last few years, the popularity for the plant-based food spread has become high flying (Gorrepati et al., 2015).

Breadspreads are a delicious range of highly nutritious preparations, which are likened to butter, but varying in fat content. This series of products come in different tastes, flavors, textures, and a variety of compositions, and are typically spread onto food items such as sandwiches, to enhance their flavour or texture. These edible food products can be prepared in paste, syrup, or liquid form, and from a range of plant or animal origin, including fruits, nuts, vegetables and animal fats (such as in cheese, butter, and cream). (Oxford Reference, 2021)

The true definition of spreads may be quite ambiguous, since they contain a vast variety of types and sources, based on their method of preparation, fruit used, and place in a meal (Young et al., 2019). Food spreads are one of the confectionery food products widely consumed in Nigeria, by people of all age groups. They are highly nutritious, varied, ready to eat, and largely available through all seasons.

The word “butter” comes from a Greek word bou-tyron (cowcheese), and is obtained by churning the cream that has been separated from warm cow’s milk to a product consisting of unbroken fat globules and moisture droplets embedded in a continuous phase of butterfat. Diary butter is perhaps the traditional spread developed since the inception of ancient food technology, and contains butterfat, water and curd which is made up of casein, lactose and mineral matter (Gorrepati et al., 2015). In Nigeria, reliance on the importation of existing

foreign brands of food spreads has over the years, discouraged the consumption of indigenous food spreads, using our own home-grown food crops available to domestic use.

In recent years, food processing firms have through intensive collaboration with research institutes, encouraged the manufacture of innovative formulations of food spread, patronizing some of the nation's most under-utilized plant produce. This initiative has triggered the use of cashew nut, almonds, walnut, sesame, pumpkin-seeds, pears, mangoes, pawpaw, tomatoes, etc, amongst other under-utilized crops that are great sources of nutrients and vitamins, in the manufacture of novel fruit-based, nut-based and diary food spreads (Gorrepati et al., 2015).

The adoption of these locally produced food spreads in the food industry will increase the utilization of aboriginal crops cultivated in Nigeria and also lower the cost of importation of foreign food spreads.

Peanut (*Arachis hypogaea*) belong to the family *Fabaceae of bean/legume and is* technically considered as pea. There are thousands of peanut cultivars around the world. Certain cultivars groups are preferred for particular uses because of differences in flavor, oil content, size, shape, and disease resistance (Shibli, 2019). For many uses the different cultivars are interchangeable however, the most popular cultivars are Spanish, Runner, Virginia and Valencia. Most peanuts marked in the shell are of the Virginia type, along with some Valencias selected for large size and the attractive appearance of the shell. Spanish peanuts are used mostly for peanut candy, salted nuts, and peanut butter. Most Runner cultivars are used to make peanut butter (National Peanut Board, 2021).

Peanut consumption all over the world varies in large proportions hence the commercial products too are variant and generally localized. Peanuts have been developed into a variety of products like roasted peanuts, peanut butter, peanut oil, peanut paste, peanut sauce, peanut flour, peanut milk, peanut beverage, peanut snacks (salted and sweet bars) and peanut cheese analog. Raw peanuts are consumed all over the world (Moharana et al., 2020).

Other peanut products like peanut milk, fermented peanut products, cheese analogs, peanut beverages are still not very popular to be utilized for their production and commercialized.

Peanuts are continually applied for the preparation of new and improved food products. A large proportion of peanut production in the world is destined to domestic foods such as peanut butter, snack products, confections and roasted peanut products (Settaluri et al., 2021).

Although a legume; it is generally included amongst the oilseeds due to its high oil content and have more protein than any other nut with levels comparable to or better than serving of beans. Peanuts are rich in protein, oil and fibers (Suchoszek-Łukaniuk et al., 2011).

Apart from oil, peanuts are widely used for production of peanut butter, confections, roasted peanuts, snack products, extenders in meat product formulation, soups and desserts (Moharana et al., 2020). Commercially it is used mainly for oil production but apart from oil, the by-products of peanut contains many other functional compounds like proteins, fibers, polyphenols, antioxidants, vitamins and minerals which can be added as a functional ingredient into many processed foods. Peanut oil has the highest stability with high oleic/ leinoleic acid ratio. Nutritionally, high linoleic acid is desirable as it is an essential fatty acid and produces a hypocholesterolemic effect (Arya et al., 2016).

Recently it has also revealed that peanuts are excellent source of compounds like resveratrol, phenolic acids, flavonoids and phytosterols that block the absorption of cholesterol from diet. It is also a good source of Co-enzyme Q10 and contains all the 20 amino acids in variable proportions and is the biggest source of the protein called "arginine" (USDA, 2014 & Arya et al., 2016).

Protein, fats, and fiber are the major components that make up peanuts. All these components are present in their most beneficial forms. The protein is plant-based: the fat is unsaturated, and the fiber is complex carbohydrate which are all proved to be the best for human nutrition (Akhtar, 2014).

According to the American peanut council, peanut fat profile contains about 50 % monounsaturated fatty acids (MUFAs), 33% Paraformaldehyde (PFAs) and 14% saturated fatty acids which is a heart friendly combination of fatty acids (Campos-Mondragón et al., 2009).

According to research, foods that include high level of peanut products (raw, butter and oil) are more beneficial to heart health when compared to the low fat diets (Jones et al., 2014). Emerging data clearly shows that type of fat can impact health in various ways at different stages of life. The fat in peanuts and peanut butter provides healthy calories to malnourished infants and children at their time of need. Peanuts contain all the 20 amino acids in variable proportions and is the biggest source of the protein called "arginine" (Toomer, 2018).

These days, awareness by consumers on the need to eat high quality and healthy foods, known as functional foods that contain ingredients providing additional health benefits beyond the basic nutritional requirements, is increasing (Ndife and Abbo, 2009).

1.2 Statement of Problem

The rate of utilization of the Avocado fruit in Nigeria is quite low despite the nutritional qualities and health benefits of this fruit. Also, because of the high rate of deterioration and lack of proper preservative measures to extend its shelf-life, a huge proportion of the fruit gets wasted Avocado (*Persea americana*) fruit deteriorates rapidly after harvest due to its high moisture content and composition which facilitates microbial activities and aids deterioration (Kassim et al., 2013).

The fact that the use of Avocado is limited to just being sliced and added to meals like cooked rice, boiled yam and plantain and used in salads filling or spreadis due to its susceptibility to physical deterioration is a big problem associated with its production, storage and consumption. Hence, there is a need to process avocado to extend its shelf life and also diversify its uses. (Ofusu, 2011).

Not much has been done to process and store the fruit when it is in season and in abundance. The fruits when ripe have short life span and would discolour and rot whether refrigerated or not, and lose its flavour (Blakey, 2011). The solutions to the problems of the short shelf life of the fruits is to eliminate the above shortcomings by presenting to consumers a processed product with an added value which would retain the nutritional and aesthetic properties of the original fruit. (Ofusu, 2011).

Spreads made from peanut butter alone were found to be lower in antibiotics, anti-oxidants like vitamin E (tocophenols), and gluthathione. It has also been discovered that certain individuals with coronary heart disease (CHD) react to certain levels of cholesterol, particularly the presence of saturated fats in diary butters. Processing Avocado into different

commodities is expected to help reduce the records of CHDs in elderly and obese individuals (dos Santos, 2014).

1.3 Aim and Objectives of the study

The general objective of the study is to produce bread spread from the blends of avocado and peanut butters. The specific objectives are to:

1. develop bread spread from the blends of avocado and peanut butters.
2. evaluate the proximate composition, physico-chemical and microbial properties of bread spread produced from the blends of avocado and peanut butters.
3. assess the sensory quality rating of the bread spread produced from blends of avocado and peanut butters.

1.4 Scope of Study

Considering the nutritional value of fruit products, this research attempted to highlight the issue of wide consumption of high amounts of trans-fats and artificial sweeteners which is common in many spread formulations and contributes largely to the advent of cardiovascular diseases and type 2 diabetics.

The formulation of a plant-based composite foodspread produced from blends of *Persea americana (*Avocado pears*)* and *Arachis hypogea* (peanut) aimed at presenting a healthier option of food spread for health-conscious consumers.

1.5 Significance of the Study

This study seeks to execute product development by utilizing the avocado fruit pulp to produce a shelf-stable avocado fruit composite spread, which preserves the nutritional and aesthetic properties of the original fruit. Fresh avocados when compared with butter, margarine and cheddar cheese, shows the fat content for 100g are 22.2 g, 82.0 g, 81.0 g and 33.5 g respectively (Peraza-Magallanes, 2017). This presents Avocados as being suitable for consideration as substitute for most fat-based spreads.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Origin, Distribution, and Diversity of Bread Spreads.

The definition of ***spreads*** is more ambiguous since they may contain a wide variety of fat contents. The *category* is diversifying as manufacturers add new flavours and varieties ever so often (Young et al., 2019). Food spreads generally includes fat-based spreads of edible vegetable oils or animal fat such as margarine, cheese and butter, or spreads obtained from fruits and vegetables such as jams, jellies and purees. Spreads are added to food in order to enhance the flavor, texture and nutritional properties of the food. Salads, sandwiches and many other home recipes will be bland and unattractive without food spreads. (Owusu, 2012).

Butter is perhaps the oldest breadspread to be discovered, and from it stems the development of the other more recent spreads we have available today. The history of butter traces back to Ancient Africa in 8000 B.C, in a discovery which can be termed as "*a happy accident*" (Reiter, 2017).

As a herder journeyed through his way with a sheepskin pouch of warm sheep milk strapped to one of his sheep and jostling from place to place as they strode. Later on, the herder realized that the agitation from the movement had led to the formation of tasty curds of fat-rich thickened milk at the surface of the milk (Reiter, 2017). Unbroken fat globules and moisture droplets is retained from the churning of the cream separated from warm cow's milk, which typically contains butterfat, water and curd and is made up of casein, lactose and mineral matter, Man (2002) and Yap (2017). Butter Regulation, authorised in 1966 SI No. 1074 (American Food and Drug Administration), states that butter shall contain not fewer than 80 percent milk fat, not beyond 2 percent milk solids other than fat, and not greater than 16 percent water (Orgnean 2006). However, research proves butter contains high levels of cholesterol which is precipitously consumed

vigorously several times daily in the form of the varied spreads, as butter and butter products are frequently used as a spread on various foods, such as bread, toast, or crackers (Engel, 2015).

Another variety of spread is cheesew hich is essentially gotten from curd produced from the coagulation of curdling milk. The thickening is achieved by rennin, an enzyme found in the inner lining of the fourth stomach of the calf (Man, 2002).

The development of the fruit-based spreads (Jam, jelly and marmalade) constitute yet another category. They are typically made from whole fruits cut into pieces or crushed, then heated with water or sugar (and sometimes pectin and acid), until all its individual components are bind into one in complete gelatinization (Owusu, 2012).

Jelly manufacture involves boiling the fruit with water and then the extract after filtration is boiled with the sugars. For marmalade, the peel is heated independently prior to mixing in (Wells-Moses, 2016).

Often from ground foods such as fruits and nuts, spreads can be prepared in paste, syrup or liquid forms, and are generally added to foods to improve their texture and flavor.

Another variety of spread is margarine, a water-in-oil emulsion consisting of a continuous oil phase and a finely dispersed discontinuous aqueous phase. Margarine is a butter substitute obtained from vegetable oils that have been solidified by a process known as ***hydrogenation***. Based on the type of margarine, the process can be *completely hydrogenated*, causing the oils to solidify, or *partially hydrogenated*, leading to the semisolid oils to being fluffier and more spreadable with more water, carbohydrate and protein stabilizers. Colorings, flavorings, milk solids and salt are often added (Andersen, 2016).

Margarine was invented in response for a less expensive, longer lasting substitute to butter. Any edible oil or fat source may be used in its manufacture. However, a minimum of 80% by weight of fat content must be available (Andersen et al., 2016).

Many researchers examine the nutritional appeal of margarine and other spreads largely around two constituents. These are the total amount of fat and the types of fat (saturated fat, trans-fat) as elements of the formulation. It has been concluded by some researchers that the saturated fatty acids in triglycerides contribute to elevated blood cholesterol levels (Gagliardi, 2010; Mensink et al., 2003; EFSA, 2004; EFSA, 2005; IoM, 2005), which in turn has often

been linked to cardiovascular diseases. It has been observed that firmer margarines contain more saturated fat (Partel, 2016).

Pimpin., (2018), Kummerow., (2009) and Hayakawa et al., (2000) have also indicated a strong link between earlier death and consumption of high amounts of trans-fats which had been common in many spread formulations not quite too long ago. Trans-fats which do not occur naturally in vegetable fats are a consequence of partial hydrogenation of the oils, a requirement for some spread formulation procedures.

According to some researchers (Duijn, 2005; Floter and Duijn, 2006), many industries have gradually moved away from using partially hydrogenated oils since the mid-nineties and now produce new spreads that contain less or no trans fats.

The choicest quality margarines are produced usually from vegetable oils but in current years approximately half of all the oils used are partially hydrogenated marine oils. Animal fats are still in use in some speciality margarines. The Margarine Regulations in 1967 and the Codex standard for margarine (CAC/RS 32-1969) demands all margarine to contain at least 80 percent fat of which not more than one-tenth by weight may be milk fat and not more than 16 percent water. In addition, the Margarine Regulations approved in 1967 by the American Food and Drug Administration insist that any margarine being sold by retail should contain in each ounce 760-940 i.u. vitamin A and 80-100 i.u. vitamin D (Orgnean, 2006).

Though margarine may be free from cholesterol due to their preparation methods, the ample saturated fat in margarine engenders the bad type of cholesterol (low density lipoproteins) in the course of human metabolisms (Young, 2019).

Margarines and other spreads excluding butter are however, important sources of vitamin E and they supply14 % of total vitamin E intake in adults, 17 % in boys and 16 % in girls in the United Kingdom (British Nutrition Foundation, 2004).

For example, there are diverse types of spread varying from cheese, butter, margarine to fruit spreads on the Ghanaian market (Mpere, 2008).

Owing to drawbacks accompanying consumption of such as cheeses and margarines, substitutes which may be able to supply the functionalities required in conventional spreads with fewer nutritional predicaments are being pursued (Johnson, 2004).

Several efforts are being made to expand the utilization of some local food sources in the manufacture of variety of breadspreads, which are becoming increasingly pursued because of the nutritional benefits of some of the local foods that are readily available however under-exploited.

The Persea americana fruit also known as avocado pear now proves convenient. Avocado pear is a seasonal fruit and native to the tropics and sub-tropics such as tropical America, Far Asia and Cuba (Pamplona-Roger, 2007).

Peanuts are a good source of minerals such as calcium, phosphorus, magnesium and potassium and some vitamins such as vitamin E, K and B and contains 44 to 56% oil and 22 to 30% protein on dry matter basis (Bonku et al., 2020, Guo, 2020). Tocopherol present in peanut oil in an amount of about 0.05 percent is a good sign of the highest stability of the peanut oil (Aoyagi, 2015).

Due to its low moisture content and high oil stability, the peanut plant is becoming widely utilized in the production of peanut paste to be consumed as foodspread and in soups in Nigeria and several parts of the world (Abdulrahama, 2014).

A variety of food spreads is now consumed worldwide, ranging from spreads of dairy origin, plant-based spreads, and more recently, composite food spreads.

Common spreads include dairy spreads such as cheeses, creams, and butters; plant derived spreads such as jams, jellies and hummus. Food spreads are mostly used with baked foods and other moistened baked foods like bread; biscuits that are consumed instantly.

In Nigeria, the most popular food spreads include both spreads of dairy and plant origins, with the most common including dairy butters, mayonnaise, margarine, jams, peanut-butter and chocolate spreads (de Brauw, 2021; Steyn, 2006).

2.2 Classification of Food Spreads

The general classification of spreads include, but not limited to, spreads made from edible vegetable oil (plant-based spreads) or animal fat (diary spreads) or a combination of both such as margarine, cheese and butter, and those obtained from fruits and vegetables such as jams, preserves and marmalades. Food spreads are classified based on the following factors, the source of the spread, the ratio of ingredients and the technique used in the preparation of

the spread. The two most common categories are the dairy and plant-based spreads, while a third less common category comprises meat-based spreads (Young et al., 2019).

2.2.1 Spreads of animal origin

Food spreads of animal origin can also be called dairy spreads. Thesetypically consist of edible oils of fat source (as they are mainly fat-based). *Edible* fats and oils mean foodstuffs constitute of glycerides of fatty acids. They are of vegetable or animal (including milk) or marine origin and may contain a continuous oil phase for preparation of emulsifier-free, structured without emulsions, a homogenous mixture of plant fiber-containing material, edible oil, water, and an efficient amount of an emulsifier to prevent oil separating out from the plant fiber and other mixture solids, which would otherwise take place in the absence of an emulsifier and in the condition of when the edible spread composition is discharged while held under pressure (O'Dwyerd, 2013: Macias-Rodriguez, 2020). Lastly, is the use of packaging containing the edible spread composition held inside a pressurized container and dispensed without experiencing oil separation is possible.

2.2.2 Spreads of Plant origin

Plant derived spreads are typically thick and gelatinous. This state is reached by a combination of fruit with three ingredients: pectin, acid and sugar. They are all produced by preserving the fruit with sugar, and are thickened or jellied to some degree. Most fruit jellies and jams contain about one percent pectin. It is naturally occurring and found in many fruits, some containing enough natural pectin to make finished product (Wells-Moses, 2016).

These products have the following characteristics:

Jams: high sugar foods prepared by crushing fruits (including flesh and juice) with sugar and water, and heating till pectin is activated. The pectin thickens the final product via cross-linking of the large polymer chains until form sets. Jams are usually thick and sweet but not as firm as jelly. They are rich in vitamin C, minerals, iron, phytonutrients and even fibre.

Jellies (gelatin): made from cooking fruits, and then straining to extract the juice which is combined with pectin and sugar for the final product, a clear, gelatinous, and sparkling spread of thin consistency. Typically, they contain more pectin than jams, which gives their firm texture and holds its shape. Only selected kinds of fruits are used in jellies.

Purees: this is the raw pulp obtained from the boiling of whole fruits or vegetables, flesh and juice. Due to the absence of sugar or acids to serve as preservative, purees have a relatively low shelf-life.

Marmalade: made from the juice of fruits boiled with sugar and water (just as in jelly), but usually containing sliced, ground, or diced peels (of a single or a combination) of citrus fruits evenly dispersed through the clear gel, incorporating a slightly bitter taste. Just like jelly, it contains more water compared to jam, but unlike jelly, the fruit pulp is not strained out of the liquid.

Fruit spreads: generally, fruit juices or whole fruits processed, concentrated along with sugar and pectin (and may sometimes contain no added sugar). The major difference between fruit spreads is their consistency and the type and proportions of fruits used.

Fruit conserves: also known as a whole fruit jam, conserves are made either from simmering fruits in a hot sugar mixture long enough for all the flavor to be extracted and sugar to penetrate the fruit without dissolving it or sprinkling dry sugar over raw fruit in layers and leaving to steep before boiling slightly to achieve setting point. This is the chunkiest fruit spread.

Fruit preserves: made from whole or cut up fruit in clear, slightly jelled syrup this fruit preparations have sugar as their main preserving agent (and sometimes acid). Dried fruits may be added (but not nuts). There are many varieties of fruit preserves globally, distinguished by method of preparation, type of fruit used, and place in a meal. Can be used like a jam.

Fruit compote: These are 100% fruit with no sugar added. If needed, a sweet fruit juice such as white grape juice or apple juice may be added.

Fruit curd: mostly used as a dessert topping, it's usually made with fruit juice (lemon, lime, orange or raspberry). Other basic ingredients include beaten egg yolks, sugar, and zest cooked together and the cooled to give a soft, smooth, intensely flavored spread.

Fruit butters: made by forcing the whole fruit through a sieve after cooking to softness. The pulp is cooked with sugar and stirred rapidly or blended to give a smooth consistency. Usually, spices and herbs are added and a limited amount of sweeteners and pectin. Fruit butters are thicker and have less sugar than jam. Only certain fruits is used.

Hummus: this is a smooth blend of chickpeas (or other similarly leguminous foods) usually eaten with bread or vegetables.

Nut spreads: this consists a series of products, which are likened to butter, containing less cholesterolat least 40% nut ingredients, which can be combined in various forms, e.g., as nuts, a paste and/or a slurry. They are rich in vitamins andsome phytochemicals such as tocopherols and phenolic compounds.

Chocolate spreads: made from chocolate paste and flavour and does not solidify under room temperature. It is suitable for eating bread, waffles, pancakes, muffins, and pies.

Syrups: a highly viscous blend of boiled fruit juice, sugar, lemon juice (optionally) and further thickened by powdered pectin (if desired).

2.3 Ingredients used in food spread production

Each ingredient used in the formulation of the composite foodspread is employed for the specifically characteristics it has and/or the result it has on the finished product, the nutritional benefits it contributes, and it aesthetic qualities. If these effects are understood, the ingredients may be selected with the assurance that the products produced will be good (Ishinwu, 2011).

2.3.1 Peanut

Peanuts (Arachis hypogea) are agreat source of minerals such as calcium, phosphorus, magnesium and potassium and some vitamins such as vitamin E, K and B and holds 44 to 56% oil and 22 to 30% protein on dry matter basis, freshly harvested peanut contains 5-7% moisture on average and about 3% ash (Rodrigues, 2013). Tocopherol present in peanut oil in an amount of about 0.05 percent is a good sign of the highest stability of the peanut oil (Aoyagi, 2015). Due to its low moisture content high oil stability, the peanut plant offers better processing characteristics and keeping quality. Peanuts' protein nature provides better water binding and emulsifying abilities.

Due to its' high fibre content, peanut has a digestibility index of 89%. Of the various amino acids present in peanut, sixteen are responsible for the reaction it undergoes during roasting which leads to browning, due to high amount of sucrose, extreme temperature of roasting and high fiber content (Settaluri, 2012).

Peanuts are a good source of minerals such as calcium, phosphorus, magnesium and potassium and some vitamins such as vitamin E, K and B and contains 44 to 56% oil and 22 to 30% protein on dry matter basis. It also has high amount of oleic and linoleic fatty acid profile that accounts for about 75 to 80% of the total oil it contains (Syed, 2021).

Peanut seeds are a good source of protein, lipid and fatty acids for human nutrition. Peanut-containing foods have high consumer acceptance because of their unique roasted peanut flavour. Peanut constitutes a major annual oilseed crop and a good source of protein containing high lysine content which makes it a good complement for cereal.

Roasted peanuts are processed by heating the peanuts up to 180 °C for around 12–15 min or at 160 °C for 40–60 min depending on the moisture content. The processing methods like roasting and boiling have shown increase in the concentration of these bioactive compounds. These bioactive compounds have been recognized for having disease preventive properties and are thought to promote longevity (Adeyeye, 2010).

2.3.2 Avocado pears

Persea Americana commonly known as Avocado pears or alligator pears. Avocados are very nutritious, high in unsaturated fat and at their buttery best when used in raw preparations (Brooks, 2020).

Avocado has several medicinal and health benefits (Pamplona-Roger, 2007 and Duarte, 2016).

The pulp of the avocado fruit is added to the diet it helps to reduce cholesterol levels (Pamplona-Roger, 2004). Various studies have confirmed that apart from being a source of energy and vitamins, avocado also delivers specific non-nutritive physiological benefits that may enhance health. It can thus be considered as a "functional food", based on the definition of (Velderrain-Rodríguez et al., 2021).

Among the nutraceutical ingredients found in avocado pulp are antioxidants, such as vitamin E or tocopherols (4.31 UI/100 g) and glutathione (17.7 mg/100 g), more than three times the amount in any other fruit.

As a source of antioxidants, the vitamin E and glutathione neutralize free radicals that may damage aging cells, the heart (Adaramola, 2016), and contribute to the development of some types of cancer, such as cancer of the mouth and pharynx (O'Toole, 2000; Heber, 2001; Pamplona-Roger, 2007).

Lutein, a carotenoid, helps to protect the eye from diseases such as cataracts and reducing the risk of age related macular eye disorders. Avocados contain a high amount (248 mg/100 g) of lutein (Johnson et al., 2015).

The level of β-sitosterol in avocado is similar to that in soy and olives. It has been demonstrated through animal studies that β-sitosterol is related to the inhibition of cancerous tumors (Lambri et al., 2013).

β -sitosterol has been shown to improve men's prostate function (Lu, 2005). As a good source of vitamin D, it is beneficial for those at risk from osteoporosis.

Oleic acids and folate prevents stroke, breast cancer and lowers cholesterol levels in blood. The avocado (*Persea americana*) is known for its pleasing taste and predominance of monounsaturated fatty acids (Dreher & Davenpot 2013).

It is also recognized as a functional food that contains health- promoting phytochemicals such as glutathione and beta- sitosterol (Ferreira da Vinha et al., 2013).

It has been used as a fruit, mashed as a sandwich spread, and cubed as a topping for baked potatoes and soups, but its feasibility as a fat replacer has not yet been studied.

2.3.3 Flavouring Ingredients

Salt:

This provides the salt content of the food spread (about 1.5%). It balances sweetness and contributes to flavour, as well as highlighting the natural flavours of other ingredients.

Salt contains the element sodium, which is an essential nutrient needed by the body in small amountsto balance fluids in the blood and maintain a healthy blood pressure

Adding salt to the formulation restructures the proteins, which then act as a binding and emulsifying agent.

2.3 Miscellaneous ingredients

Hydrogenated vegetable oil (0.125 %): is generally added to improve oil stability. While acting as a stabilizer to prevent the oil from collecting at the top of the jar, vegetable oil also enhances smoothness, spreadability.

Other ingredients include dextrose (2%), sweetener, xanthan gum, vinegar and corn syrup (2%), and protein sources whichare added as prescribed by the specific recipe being usedto produce particular flavors and textures.

2.4 Composite Foodspreads

These encompasses the combination of two or more distinct plant sources or animal fat, or both, in the formulation of food spreads. It utilizes different percentage compositions of each individual primary ingredient. Usually, an experimental design is laid out with treatments in replications, using Completely Randomized Design (CRD) under controlled condition. Some existing examples include: Cocoa Hazelnut cream, Soy Peanut spreads, Peanut, Crayfish Ginger butter and Honey Peanut butter. e.t.c.

2.5 Chemical composition and bioactive components

Plants yieldoil seeds, grains, fruits and vegetables (Murkovic*et a.,l* 2002; Aamir *et al.*, 2017).The bioactive components ofpeanuts and avocado fruit varies from one cultivar or species to another.According to Nagaraj (2009) different varieties have different chemical composition due to the differences in their gene sequence, geographical location and season

of cultivation. Study by Özcan and Seven, (2007) and Boli et al., (2013) shows that, moisture content of peanut paste ranged between 4.50 to 6.06 % , crude protein ranged between 21% and 35%, crude fat ranged from 24.55% to 50%, ash ranged from 1.86% to 5.5% and crude fiber ranged from 1.00% to 6.78 as shown in Table 2.1

Table 2.1: Proximate composition of Peanut paste

%Moisture	%Crude protein	% Fat	%Ash	%Fibre
4.50-6.06	21-35	24.55-50	1.8-5.5	1.00-6.78

Source:(Özcan & Seven, 2007)

Peanuts paste comprises of fat in monounsaturated and polyunsaturated forms and this can lower LDL cholesterol and triglycerides levels by promoting the increase of HDL cholesterol (Nouran et al., 2010).

Consumption of peanut snacks regularlyis very important to the health of the individual since it contains other nutrient such as calcium, fiber, protein carbohydrate and fat essential to the human systems development (Aktar, 2014). Peanut paste can therefore serve as a good product for the control of type 2 diabetes (peanut butter is low in Glycemic index and Glycemic load) when consumed often or included into our daily rations (Jiang et al., 2002). When peanut products is incorporated to meals with high glycemic load, it reduce post prenatal glycaemia (Johnston and Buller, 2005).

Avocado pears have many nutritional components including polysaccharides, proteins, essential amino acids, valuable antioxidants, carotenoids and minerals. Peanuts and Avocado pears are rich in oil and the variability in the oil content is due to broad genetic diversities. Peanut plants have a high nutritional value, provides good quality oil, and excellent source of protein.

Avocado pears are high in β-carotene and licopene, which gives it yellow or green color. Beta-carotene in plants that have a pleasant yellow-orange color is a major source of vitamin A. It is also high in carbohydrates and minerals. (Ferreira da Vinha et al., 2013)

Avocados are a great source of vitamins C, E, K, and B-6, as well as riboflavin, niacin, folate, pantothenic acid, magnesium, and potassium. They also provide lutein, beta-carotene, and omega-3 fatty acids. However, most of the calories in an avocado come fromfat.

Fresh avocados contain lycopene and beta-carotene, which are important carotenoid antioxidants. The highest concentration of these antioxidants is located in the dark green flesh closest to the peel, according to the California Avocado Commission. Antioxidants help reduce cell damage (Ramos-Aguilar, 2021)

Consumption of carotene containing foods helps in the inhibitionof dermatological ailments, eye disorders and certain cancers (Dhiman, 2009).Integrationof β -carotene rich ingredients in the formulation of plant-based composite foodspreads is therefore considered a very effective approach to stamp outvitamin-A related health problems (Dutta, *et al.* 2006, as observed by Aamir *et al.* 2017).

CHAPTER THREE

3.0 MATERIALS AND METHOD

3.1 Experimental Location

All research work was under taken in the Food Science and Technology Laboratory in Mountain Top University, Km 12 Lagos-Ibadan expressway, MFM Prayer City Ibafo, Ogun State**,** Nigeria**.**

3.2 Sources Of Raw Materials And Equipments

Groundnuts,saltand vegetable oil were purchased from Ibafomarket inObafemi Owode local government area of Ogun State, Nigeria.The other ingredients Avocado pears, were purchased from Ketu Fruit market, Ketu.

3.2.1 Equipment, instruments and utensils

The equipment instruments and utensilsused for production and analysis included food processor, oven, plastic jars, stirrer (stainless-steel spoon), weighing balance, polythene bags, spoons, conical flasks, beakers, pipette, burette, retort stand, measuring cylinders, kjeldahl apparatus,crucibles, tins, Soxhlet apparatus, distilled water and centrifuge, air oven dryer,hand mixer, refrigerator, blender, weighing balance, stainless steel trays, pot, cooking stove, gas cylinder, bucket, colander sieve, roasting pan, metal sieve, bowl, paper tape, cooking spoon, plastic bottles, plastic bowl plates, fume cupboard, digestion box, Khejal distillation machine, measuring cylinders, beakers, conical flask, burets, separating funnel, retort stand, muffle furnace, Muffle furnace (Vulcan 3-550), funnels, reagent bottles, distilled water, distilled water bottles, Analytical balance, Potato Dextrose Agar (PDA) [Microxpress, A division of Tulip Diagnostics (p) Ltd], de Man, Rogosa and Sharpe (MRS) Agar [Titan Biotech Ltd], Plastic sterile petri-dishes, Durham bottles, Bunsen burner, spirit lamp, McCartney bottles, micro pipette, Eppendorf pipette, water bath, Autoclave, Colony counter [UNISCOPE Colony Counter; SURGIFRIEND MEDICALS, ENGLAND], Microscope, Porcelain crucibles, Volumetric flasks (2000ml), 50ml polyethylene centrifuge tube, Precision balance (0.0001g accuracy) [Denver], Vortex mixer [Genius 3], Weighing paper, Centrifuge [5810R machine], Atomic Absorption Spectrophotometer [Buck 211] and

Inductively Coupled Plasma –Optical Emission Spectrophotometer (ICP/OES) [Perkin Elmer].

3.2.2 Chemicals and Reagents

The chemicals and reagents were of analytical grade and was obtained from the Laboratory of Food Science and Technology, Mountain Top University, Km 12 Lagos-Ibadan expressway, behind MFM Prayer City Ibafo, Ogun State**,** Nigeria**.**

They include: Conc. H_2SO_4, 40% NaOH, 40% Boric acid (Bromocresol green, ethanol, 0.1g Methyl red), 0.1000 HCl, 0.1N NaOH, Petroleum ether, Ethanol, Diethyl ether, Nitric acid (HNO3) [Redistilled, min 69%, GFS chemical], Hydrochloric Acid (HCl 37%) [Merck no. 1.00317], Aqua Regia.

3.3. Methods

3.3.1 Peanut paste preparation

The peanuts were sorted before being emerged in boiling water for one minute. Thereafter, they were transferred to a large plastic colander and salted evenly. After leaving to stand for a few minutes to hasten the water drainage, the peanuts were laid out flat on top a sack under direct sunlight for 30 minutes, then split into two batches. The first batch were spread out thinly in a flat aluminium tray and placed in the oven for an hour at 80^{o}C, during which the peanuts were stirred intermittently to aid uniform roasting and flavour development. The second batch of peanuts were hand-roasted at low heat, using a large frying pan, fan, and heat carrier (raw garri).

After roasting, peanuts were left out to cool before blending at a steady, controlled speed, until paste was formed. This was immediately packaged in an air-tight plastic jar and labelled.

3.3.2 Production of Avocado Pulp

The avocado fruits were kept at room temperature for three days to complete the ripening process. The ripped fruits were then washed with clean water, then peeled, deseeded and cut into four smaller pieces to aid blending. These small pieces were finally pulverized using a domestic food blenderat speed 4.

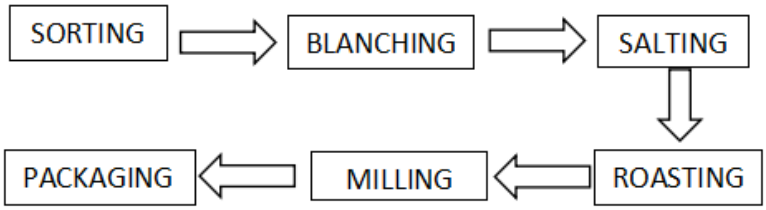


Figure 3.1: Flowchart of Peanut butter sample preparation.

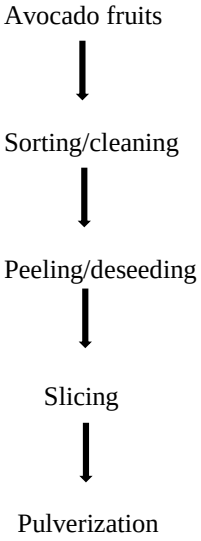


Figure 3.2: Flowchart for Avocado pulp

3.3.3 Sample formulation

Table 3.1 shows how the Peanut and Avocado pastes were mixed in the following ratios, i.epeanut : avocado

80:20, 70:30, 50:50, 100:0 and 0:100 respectively (ratios 0:100 and 100:0 as control).

3.3.4 Production of food spread from blends of peanut and avocado paste

Appropriate volumes per portion of peanut paste were weighed into bowls containing corresponding volumes of smoothly blended Avocado pulp with hydrogenated vegetable oil. The mixture was homogenized using a hand mixer until the appearance of an even consistency and smooth texture. Each of the samples were then transferred to air-tight plastic containers and stored in refrigerated condition for further analysis.

3.3.5 80% Peanut paste and 20% Avocado pulp

80grams of peanut paste was weighed into a jar containing 20grams of smoothly blended Avocado pulp with hydrogenated vegetable oil. The mixture was homogenized using a hand mixer until the appearance of an even consistency and smooth texture. This blendwas then transferred to air-tight plastic containers and stored in refrigerated condition for further analysis.

3.3.6 70% Peanut paste and 30% Avocado pulp

70grams of peanut paste was weighed into a jar containing 30grams of smoothly blended Avocado pulp with hydrogenated vegetable oil. The mixture was homogenized using a hand mixer until the appearance of an even consistency and smooth texture. This blend was then transferred to air-tight plastic containers and stored in refrigerated condition for further analysis.

3.3.7 50% Peanut paste and 50% Avocado pulp

50grams of peanut paste was weighed into a jar containing 50grams of smoothly blended Avocado pulp with hydrogenated vegetable oil. The mixture was homogenized using a hand mixer until the appearance of an even consistency and smooth texture. This blend was then transferred to air-tight plastic containers and stored in refrigerated condition for further analysis.

Table 3.1: Formulation of foodspread mixture.

Sample	**Peanut paste (g)**	**Avocado paste (g)**
OP	100	0
OA	0	100
ET	80	20
ST	70	30
FF	50	50

OP= 100% Peanut paste, OA= 100% Avocado pulp, ET= 80:20 Peanut Avocado paste, ST= 70:30%Peanut Avocado paste, FF= 50:50% Peanut Avocado paste.

3.4 Proximate Analysis

The moisture, crude protein, crude fat, crude fiber, Carbohydrate and ash contents of the Peanut Avocado foodspread samples were determined according to the official standard methods of analysis by the Association of Official Analytical Chemist (AOAC 2012).

3.4.1 Determination of moisture content

5.0g of each sample wasweighed into previously weighed crucibles using analytical balance (Denver instrument company, TR-2102). The weighed samples were put into the pre-set oven (memmert air oven model UN 55, (SCHWBACH, GERMANY) at 105℃ for 3hoursafter which they were retrieved, cooled in a dessicator for 30 minutes and weighed.then returned to the oven and re-weighed every one hour until constant weight was obtained (W2). The percent moisture was then calculated. The differences in weight between sample before drying and sample after drying is the moisture loss (AOAC, 2012).

$$\%\ moisture\ content = \frac{wt\ of\ sample\ before\ drying\ - wt\ of\ sample\ after\ drying}{original\ weight\ of\ sample} \times 100$$

Comment [LC1]: Realign this equation

3.4.2 Determination of ash content

Ash content was determined using the AOAC (2012) method. 5g of thesample was weighed into a pre weighed empty crucible. This was transferred into the muffle furnace set at 600°C and left for about 2 hours, after which sample has completely combust into white ash. The crucible and its content was cooled to room temperature in a desiccator. The crucible with the sample was weighed and the percentage of ash was calculated as;

$$\%\ Ash\ content = \frac{weight\ of\ ash}{original\ weight\ of\ sample} \times 100$$

3.4.3 Determination of fat content

Approximately 35g of the sample was weighed and wrapped in a filter paper and placed in a fat free thimble and then placed into the extraction tube. Clean and dried round bottom flask was weighed and filled with 350ml of hexane and then fitted into the Soxhlet apparatus. The water hoses were connected to aid the flow of water, and the heating mantle was turned on.After 2hours, siphoning allowed hexane to evaporate and condense back into the receiving flask and the process was repeated until extraction was complete. The set-up was disconnected before the last siphoning. Oil extract was placed in a water bath for residual hexane to evaporate; the flask was then placed in an oven at 105oC for 2 hours and cooled in a desiccator then weighed. The percent crude fat was determined.

3.4.4 Determination of protein content

The macro Kjeldahl technique was used to determine the crude proteins. 1g of the material was placed in a Kjeldahl digestion flask along with one KJELTAB® tablet. In the fume cupboard, 12 mL of concentrated sulphuric acid was added and the flask swirled. Digestion was carried out in the digestion block for about 3 hoursuntil the entire solution was clear.

Next, the distillation procedure was carried out in an auto distillation unit (dilute with 70mL of distilled water and alkalize with 50mL of 40% w/v NaOH) along with 30ml of 4% Boric acid (with methyl red and bromocresol green indicators) (mix indicator 0.198g bromocresol green plus 0.132g Methyl red in 200 mL alcohol) measured into a 250ml conical flask as the receiving vessel. The mixture was automatically distilled into the conical flask containing the 30mL of 4% w/v boric acid solution and the distillation was continued until the boric acid solution turned from pink togreen and a total volume of about 150 mL was reached. The solution in the conical flask was titrated against 0.1N hydrochloric acid after distillation until an endpoint violet colour was obtained. The identical process was used to test a blank, using just distilled water.

The % Nitrogen (%N) and % crude protein (%CP) is determined using the equation below:

$$\%N=(Vs-Vb)C1,4007W$$

$$\%CP=\%NCF$$

Where:

Vs: volume (mL) of standard acid used to titrate the sample to the endpoint.

Vb: volume (mL) of standard acid used to titrate the blank to the endpoint.

C: molar concentration (mol dm-3) of HCl used in four decimal places.

W: weight (g) of sample used.

CF: sample conversion factor (6.25).

The conversion factors are determined by the material being analyzed.

3.4.5 Determination of crude fibre

Two grams each of the samples were accurately weighed into dry round bottom flasks and digested by boiling in 200mL of 1.25% aqueous $H_2SO_4$for 30 minutes,under reflux and filter (This hydrolysis the carbohydrate and protein). The residue left was then washed with distilled water several times and further digested with 200mL of 1.25% aqueous NaOH by boiling for 30 minutes under reflux to saponify fats present. The final residue was then filtered and washed severally with distilled water to ensure no NaOH was left.

The residue is dried for 2 hours at 100-105^oC in a crucible of known weight (W1). The dried residue was burned up in the muffle furnace at 600^oC for an hour, cooled and weighed (W_2).

The results are given in % of crude fibre per gram of dry matter.

$$\% \text{ Crude fibre} = \frac{(W_1 - W_2) \times 100}{\text{Initial weight of sample.}}$$

3.4.6 Determination of carbohydrate content.

The determination of carbohydrate in the samples was determined by a difference method. That is the values or percentages of moisture, ash, protein, fat and fibre was summed up and then the results was subtracted from hundred which gives the carbohydrate content (AOAC, 2012).

CHO=100 - % (ash + protein + fat + crude fibre + moisture)

3.5 Mineral Analysis

3.5.1 Preparation of aqua regia

In a 2 liters volumetric flask, about 1.2 liters distilled water was added. 400ml concentrated Hydrochloric acid and 133ml of 69% nitric acid and diluted to 2 liters was cautiouslyadd.

3.5.2 Procedure for mineral analysis:

Into a clean porcelain crucible, 0.50-0.52g of sample was weighed and recorded to the nearest (+0.001g), as the actual weight was recorded as well.

(Each batch of the samples contained five internal control samples, one external reference sample and two blanks).

The samples were placed in a casual muffle furnace and temperature raised to 500 degree Celsius over a period of 4 hours.

Remove sample from oven in an air-tight space. Pour the ashed sample first initially labeled 50ml centrifuge tubes. Rinse crucible with 5ml of distilled water into a centrifuge tube, rinse again the crucible with 5ml of aqua regia and repeat to make up 20ml in total. Vortex sample for proper mixing.

Next, samples were centrifuged for 10 minutes at 3000 rpm, and their supernatants decanted into clean vials for macro and micronutrient determination. (This procedure can be used for the analysis of P, Ca, Mg, K, Na, Zn, Cu, Mn, Fe and B. it cannot be used for N and S) using the atomic absorption spectrophotometer or inductively coupled plasma. (Hunter R.C., et al, 1984; J. Benton Jones, Jr. and Vernon W. Case 1990).

3.6 Physico-chemical analysis

The Physico-chemical analysis were determined according to the standard method of analysis described by the Association of Official Analytical Chemist (AOAC 1995, AOAC 2010, AOAC 2012).

3.6.1 Determination of pH

The pH was done using a pH meter as described by AOAC (2010). The electrode was dipped in already weighed 5 ml of the yoghurt and the pH was recorded.

3.6.2 Determination of salt

Salt (as NaCl) Salt content of the peanut butter samples was determined using general chemical procedure by Pearson-Mohr method as recommended by AOAC (2005).Ash fraction was obtained by the incineration of dried sample (2 g)into the dried crucible (pre-dried in the furnace) in a muffle furnace (Carbolite) at 550°C for 4h until grey ash obtained. Cooled in desiccator and wetted with 10 ml of distilled water then transferred to a conical flask whereby few drops of 5% potassium dichromate indicator were added and titrated with the 0.1M of Silver Nitrate (AgNO3) solution to the appearance of permanent orange colour endpoint. Percent salt of the sample was calculated as follows;

$$\%\ Salt\ (NaCl) = \frac{(V \times 0.005844)}{Sample\ weight \times 100}$$

V= Volume in ml of the AgNO3 used (titre value).

1 ml 0.1M $AgNO_3 \equiv 0.005844$g NaCl

3.6.2 Determination of Peroxide Value

Peroxide Value Indicators of lipid oxidation in peanut butter samples were measured by peroxide values (PV).

PVs were quantified following the AOAC (2005) official method no. 965.33.

PV was determined by first extracting the Peanut Avocado pastes oils.

Approximately 35g of peanut butter was extracted with petroleum ether through a thimble for 8 h in a Soxhlet extractor apparatus.

The solvent was then removed using a rotary evaporator to recover peanut oil.

Peroxide value was then determined on 5 g of oil by adding 30 ml of acetic acid chloroform (3: 2 ratio) swirled to dissolve then 0.5 ml of 20 saturated potassium iodide solution, with occasional shaking for one min. This was followed by addition of 30 ml of distilled water and 0.5ml of 1% starch indicator then slowly titrated with 0.01 N of sodium thiosulfate

(Na2S2O3). Blank determination was also conducted which was then subtracted from sample titration. Peroxide Value was expressed as mill equivalents of peroxide per kilogramme of sample (meq peroxide/kg sample) and calculated using the formula:

$$\text{Pv (meq 02/kg} = \frac{\text{Volume in ml of Na2S2O3(blank corrected)} \times (0.01\ Normality\ of\ Na2S2O3 \times 100)}{g\ oil\ sample}$$

3.6.3 Acid Value

The acid value of an oil/fat is the quantity of potassium hydroxide needed to neutralize the free acids resulting from the complete hydrolysis of 1g of the sample. About 10 g of the spread was taken in a thimble and its oil extracted using n-hexane for 3h in a soxhlet apparatus. Afterwards, the extract was turned into a beaker and placed in an air oven for complete evaporation of the solvent. The oil obtained was then liquefied with warm neutral alcohol solution and titrated with standard 0.1M of sodium hydroxide solution to a faint pink colour which persists for 10s. The acid value was therefore, determined using equation below:

$$\%\text{Acid value (as Oleic acid)} = \frac{56.1 \times VM}{m} \times 100$$

V = volume in ml of standard sodium hydroxide solution used (Titre value).

M = molarity of standard sodium hydroxide solution, and

m = mass in g of the sample taken for the test.

3.6.4 Free Fatty Acids

The sample is mixed with hot neutralized alcohol and indicator and titrated with aqueous alkaline. 7g of the oil extract is weighed into an Erlenmeyer flask and shook vigorously for one minute. 75ml of hot neutralized alcohol and 2ml of indicator was added. The alkaline

was used to titrate until an end-point pink colour was obtained. The free fatty acid value was determined using the equation below:

$$\text{The \%FFA is calculated as oleic acid} = \frac{\text{Ml of alkaline } \times 0.25 \times 28.2}{\text{Weight of sample (g)}}$$

3.7 Microbial Analysis

Analytical studies were carried out in the Microbiology laboratory of Mountain Top University, Km 12 Lagos-Ibadan expressway, behind MFM Prayer City Ibafo, Ogun State**,** Nigeriafor Total bacteria count and Fungi count and identification.

3.7.1 Preparation of media

The media employed for isolation were; Potato Dextrose Agar (PDA) for fungi count and Nutrient Agar (NA), MacConkey Agar (MA) and Eosin Methylene Blue Agar (EMB) forBacteria count and identification.

After autoclave sterilization of all apparatus to be used (Durham bottles, McCartney bottles and micro pipettes) at 160^{o}C for 1hr. Each medium was accurately weighed and liquified in appropriate quantity of distilled water inside the Durham bottles. 28.08g of PDA was dissolved in 720ml of distilled water (for cultivation of yeasts and molds from samples). 20.16g of Nutrient Agar was dissolved in 720ml of distilled water (for cultivation and enumeration of bacteria species). After swirling, the bottles were kept in the water bath for about 10 minutes to homogenize before being transferred to the autoclave and heated up at 120mmHg, after which they were returned to the water bath to preserve their temperatures and prevent congealing.

3.7.2 Serial dilution

After autoclave sterilization of the Eppendorf micro pipettes, One millimeter (1ml) of each sample was pipetted into previously measured 9.0 ml of sterile distilled water in the McCartney bottles. This was carried out for each sample to obtain the stock solution. Then dilutions were performed from the stock by adding one millimetre from the preceding

concentration unto the nextusing a six-fold dilution method from 10^{-1} to 10^{-6}inside McCartney bottles.

3.7.3 Isolation of Microorganisms

Using the micro pipettes, a one milliliter (1.0ml) aliquot of each diluent known as the inoculum, was planted unto previously labelled sterile petri-dishesfor Potato Dextrose Agar (PDA), Nutrient agar (NA), MacConkey agar (MA) and Eosin Methylene Blue Agar (EMB). The dissolved Agar was then aseptically poured intothe plates labeled from 10^{-1} to $10^{-6}$and the 1 plate reserved as control for each medium. The plates were rocked gently to allow uniform distribution of agar throughout the plate.

After all plate were properly set, they were incubated at 37^{o}C for 24 - 48 hours for bacteria and 28^{o}C for 3-5 days for fungi. Microbial growth was observed in all media at the end of the incubation periods as described by Afolabi L.O *et al.*, (2017).

3.7.4 Counting and Identification of Organisms

Total colonies on the surface of the dishes were counted using the colony counter [UNISCOPE Colony Counter; SURGIFRIEND MEDICALS, ENGLAND]and expressed as log10 colony forming unit per milliliter (log10 cfu/ml) of the Peanut Avocado paste sample.The fungal isolates weretotalled as well and characterized based on their microscopic appearance. The bacteriacolonies were then isolated and sub-culturedonto appropriate media for identification purpose.

3.7.5 Identification and characterization of bacterial isolates

Bacterial isolates were characterized based on their colonial morphology and biochemical characteristics and then identified using Bergey's Manual of Systematic Bacteriology (Holt et al., 1994). The biochemical tests for microbial identification included: Gram staining, motility test, Catalase test, Citrate test, Starch hydrolysis and Oxidase test (colour / pigmentation on culture plates).

3.7.6 Gram staining:

The inoculating loop was flamed until red hot using dry heat for sterilization. A small portion of isolate was picked and smeared upon a clean, dry glass slide and heat fixed swiftly over open flame. The slide was first flooded with Crystal violet and held up for one minute before rinsing out with spurting distilled water and being flooded with Gram's iodine, held up for 1 minute and rinsed again. The slide was decolorized with 75% alcohol for about 10sec, rinsed off and flooded with safranin, held up for 30sec, rinsed and air-dried. The slides were viewed under the light microscope with100× objective lens (oil immersion lens) The bacteria cells that appeared purple were the Gram-positive either cocci or rod, while those that appeared pink were the Gram-negative either rod or cocci. All observations were documented.

3.7.7 Motility test (hanging drop method)

This was carried out under the light microscope, where the standard concave slide after being dabbed with a small drop of the isolate was smeared with Vaseline around its edges, screened with a cover slip and observed usingx40 objective lensfor movement using their flagella.

3.7.8 Biochemical Tests

3.7.8.1 Catalase Test:

A sterile inoculating loop was used to pick a minute amount of isolate and transferred unto a clean grease free glass slide then 1 drop of 3% hydrogen peroxide (H_2O_2) was pipetted unto the colony using Pasteur pipette. Observation was made for immediate effervescence which suggests the organism being tested is catalase positive, while if there is no bubble formation, the organism cannot generate catalase enzyme.

3.7.8.2 Oxidase test

This laboratory test is used to detect the production of the cytochrome oxidase enzyme by Gram- negative bacteria.The oxidase reagent was used to flood filter then A large mass of the isolate was introduced upon it. A colour change from purple to dark-blue in 30sec to 1min was observed for a positive reaction. If no colour change, then organism is oxidase negative.

3.7.8.3 Citrate Test

10ml of Simmon's citrate agar poured into McCartney bottles. It was autoclaved for sterilization at 121°C for 15 min then cooled in a slanting position. The isolates were inoculated by streaking with a sterile needle and stabbing into the solidified agar, reserving one un-inoculated medium to serve as control. The culture was incubated at 37°C for 48h.

Citrateis the only carbon source available to the bacteria in the media. Therefore with ill-utilization of citrate growth will be suppressed. Effective utilization of citrate will lead to growth of bacteria that will be evident in the decolouration of the media from light green to deep blue as a result of increase in pH.

3.7.8.4 Starch Hydrolysis

Starch agar was prepared and autoclaved for sterilization at 121^0C for 15 minutes. The media was poured into Petri dishes and left to congealand the isolates were inoculated onto the plates with a disinfectedinoculating loop. The plates were then incubated at 35°C for 48hrs, after which the plates were flooded with Gram's iodine and observed for clear zone around the test organism to indicate a positive result.

3.8 Sensory Evaluation

Half teaspoon of samples of the product were evaluated using hedonic method and overall acceptability by panelists sourced from student of in Mountain Top University, Km 12 Lagos-Ibadan expressway, behind MFM Prayer City Ibafo, Ogun State**,** Nigeria**.**

The serving order of the 6 samples was planned using codes p1 to p6to characterize for the chosen parameters; appearance, taste, texture, aroma, spreadability, mouthfeel and overall acceptability (as described in Table 3.4), using a 9-point hedonic scale (9 – like extremely to 1- dislike extremely) described by Omola E.M., *et al.,* (2014). The panellists were provided with water to rinse out their mouths between samples.

Table 3.3: Sensory parameters

Sensory Parameter	Definition and range of Sensory Parameter
Appearance	Pasty appearance, from brown to dark brown
Taste	Dominant peanut taste with to having a tinge of characteristic avocado pear taste
Texture/Handfeel	Smooth and greasy to buttery and rough-to-touch.
Aroma	Dominant peanut aroma to having undertone of characteristic avocado fresh leafy scent
Spreadability	Smooth, buttery spread to aggregate, coarse spread
Mouthfeel	Creamy to thick, pasty mouthfeel

3.10 Statistical Analysis

Statistical Package for Social Science (SPSS version 26 statistical software) was used for Statistical analysis.In each case, a mean value and standard error will be calculated. Statisticalparameters wereassessed usinganalysisofvariance(one way ANOVA) to verify whether the values recorded from the 3 trials show any significance differenceand distinctions between means were evaluatedbytheDuncan multiplerangetestandsignificance were acknowledged ($p = 0.05$)**.**

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Proximate Composition

4.1.1 Moisture content

Results shown in Table 4.1 reveal that the moisture content of the samples ranged from 1.7±0.50 to 22.5±2.50 with the standard sample obtained from the supermarket having the lowest moisture content at 1.70±0.50($p>0.05$) and the 100% Avocado pulp, having the highest value at 22.50±2.50. Next in line is the sample containing 50% Avocado pulp having moisture content of 11.60±1.00, followed by the 70:30 ratio at 11.30±0.50, then the 80:20 at 10.10±0.5. Preceding the 100% Peanut paste at 2.20±0.20, is the standard sample purchased from the supermarket at 1.70±0.50. This complies with values reported by Chang et al. (2013) of 1% moisture content.

However, there was a contrast with previous studies performed by Özcan and Seven (2007) who reported values of 4.5 to 6.06 ±0.18. The contrasts may own up to the varieties in peanut cultivars used for the peanut paste production, since different peanut varieties have different compositions of moisture (Payman et al., 2011).

This result generally infers that peanut butter on its own contains a minute amount of moisture content which is attributed to the roasting effect on moisture content of the peanut. Depending upon the seed size and moisture contents of the peanuts, roasting is usually done at 160 °C for 30 min for peanut butter preparation (Pattee et al. 1982). Ogunsanwo et al. (2005) testified that the peanut butter formulated by roasting were as good as the commercial samples.

Statistically, peanut paste samples (both standard and control), avocado paste, and the blends from peanut and avocado all showed a significant difference of ($p>0.05$), while there were similar values obtained from all 3 formulations (ET, ST and FF).

The increased moisture content observed in the blends may be linked to the addition of the avocado pulp which is naturally high in moisture. The moisture content of the raw avocado fruit was corresponding to that obtained by Pamplona-Roger (2007) and other fruits such as raw garden egg 73.46 % (Akaninwor and Arachie, 2002), banana (71.00 g), medlars (74.50 g) and passion fruit (73.30 g) (Food Standards Agency (FSA), 2007). According to Hawthorn

Table 4.1: Proximate Composition of the Samples

Sample	% Moisture	% Ash	% Fat	% Crude protein	% Crude fibre	% Carbohydrate
OP	2.20±0.20^{c}	1.18±0.02^{d}	39.00±0.10^{c}	28.11±1.25^{a}	2.58±0.04^{e}	26.93±1.57^{cd}
OA	22.50±2.50^{a}	0.91±0.00^{e}	30.20±0.20^{e}	3.62±0.67^{e}	1.36±0.00^{f}	41.41±1.63^{b}
ET	10.10±0.50^{b}	1.87±0.05^{a}	52.55±0.35^{a}	18.75±1.51^{b}	4.49±0.03^{a}	28.09±2.13^{c}
ST	11.30±0.50^{b}	1.61±0.01^{b}	47.90±0.10^{b}	18.64±2.10^{b}	3.85±0.15^{b}	12.35±1.39^{e}
FF	11.60±1.00^{b}	1.42±0.07^{c}	36.70±0.20^{d}	10.04±0.24^{c}	3.55±0.15^{c}	25.19±1.07^{d}
STD	1.70±0.50^{c}	0.87±0.04^{e}	25.00±1.00^{f}	7.83±0.66^{d}	2.78±0.04^{d}	61.82±0.76^{a}

Mean values with different superscript in the same column are significantly different at $p<0.05$.

OP= 100% Peanut paste, OA= 100% Avocado pulp, ET= 80:20 Peanut Avocado paste, ST= 70:30%Peanut Avocado paste, FF= 50:50% Peanut Avocado paste.

Where ratio represents = peanut:avocado

(1981) and Pamplona-Roger (2007), most fruits contain about 70% moisture or more, higher than that in their seeds.

The variation, in addition to diversity in raw material variety may also have resulted from the accumulation of iced water during freezing and thawing over the duration samples were refrigerated before analysis. Peanut paste samples obtained from the supermarket and that formulated using 100% peanut as control with moisture contents 1.70±0.50 and 2.20±0.20may have a longer shelf-life, due to its comparatively lower moisture content, which implies less water for microbial activities and hence delay in food spoilage (Copetti et al., 2011).

Moisture content is a crucial parameter in the development of spreads, as it affects the physical and chemical properties (the structure, appearance, and taste) of the food product as

well plays a major role in determining the food's susceptibility to deterioration, keeping ability, processing and packaging conditions Akua et al(2012). Adegoke et al (1992) also acquiesced to high moisture content supporting the growth and proliferation of microorganisms.

Low moisture environments should be of concern as well, as suitable conditions favour microorganisms present leading to severe food safety concerns. Many outbreaks of food-borne illness have been linked to low moisture foods, especially nuts and nut products (Cavallaro et al., 2011;CDCP, 2014CDCP, 2016Chang et al., 2013;Keady, 2004;Wittenberger and Dohlman, 2010).

4.1.2 Ash content

The ash contents of the samples ranged from 0.87±0.04to 1.87±0.05. The 4:1 ratio spread (ET) has the highest ash content at 1.87±0.05, while the standard sample STD had the lowest ash content value 0.87±0.04. All formulated spreads had a higher value than that obtained from the supermarket.

The high ash content of ET (80% peanut) may be based on the salt added to the peanuts during processing.

It was observed that there was a slight increase in the percentage of ash in samples as peanut portions increased. Sample FF (1:1) had 1.42±0.07% ash content, which increased to 1.61±0.01 as the proportion of peanut was increased by 40% in sample ST (70% peanut) and attained the highest value at 80% peanut (ET) 1.87±0.05.

The 6 variations in ash values may have resulted from the uneven particle size distribution of peanuts milled and the combined high fibre contents of Avocado pears and groundnuts. High ash content in food is an indication of high minerals content, although it may also be an indication of impurities in the samples such as skin stuck to peanuts (Ayoola et al., 2012).

There were significant differences observed in samples ET, ST and FF of ($p>0.05$). However, there was a wider gap between ET and STD at 1.87±0.05and 0.87±0.04respectively of ($p>0.05$). The presence of 20% Avocado pear in the spread clearly accounts for this.

The values recorded for OA (100% Avocado) 0.91±0.00generally agrees with those reported by Morton (1987) that ash in raw avocado ranges from 0.46 to 1.68g.

The results obtained proved contrary to that gotten by (Scheuer et al., 2006; Nwosu et al., 2014; Olaoye & Onilude, 2008; Das et al., 2012) who reported increased ash content with an increase in ratio of avocado paste, indicating that the avocado fruit spread contains appreciable levels of mineral composition and could be used to supplement the daily energy intake of consumers (Nkafamiya et al., 2007).

All the values obtained mostly agreed with those reported by Özcan & Seven, (2007), who recorded values of 1.86 to 5.5%.

4.1.3 Fat content

The total values obtained for fat content ranged from 25.00±1.00 to 52.55±0.35, which conforms to values recounted in earlier studies by (Dwivedi et al., 1996; Özcan and Seven, 2003; Yav et al., 2008; Önemli, 2012; Hassan and Ahmed, 2012; Chaiyadee et al., 2013; Mzimbiri et al., 2014; Chowdhury et al., 2015; Escobedo et al., 2015) of fat content values ranging from 37.9-56.3%.

It was observed that, peanut butter bought from the supermarket (25.00±1.00) and the control (39.00±0.10) were within the ranges of 24.55 to 50% as reported by Özcan & Seven (2007).

The formulation with the highest fat content was the 80:20 ratio of peanut and Avocado (ST) at 52.55±0.35, next was the 70:30 spread at 47.90±0.10, followed by the 100% peanut paste at 39.00±0.10, up close was sample ET (80% peanut) with 36.70±0.20 fat content, 100% Avocado pulp comes next with 30.20±0.20 and finally the standard sample with the least amount of fat at 25.00±1.00.

Statistical analysis showed all samples displayed a profound a significant difference of ($p>0.05$).

The fat content of the avocado spread (OA) was similar to that reported by the United States Department of Agriculture (USDA) (2005) nutritional database for guacamole but lower than that of salad cream, peanut butter, margarine (including planta margarine) and cheddar cheese (FSA, 2007) as described by FSA (2007), who recounted avocado has a comparably lower fat content than peanut butter as well as salad cream, margarine (including planta margarine) and cheddar cheese.

According to table 4.1, the result of 30.20±0.20 fat content obtained for 100% avocado paste exceeds that reported by Morton (1987) of avocados lipid content ranging from 5 to 25% subject to the cultivar. This high fat content complies with Indriyani et al. (2015), who stated

avocado paste containsmonounsaturated fatty acid which could be beneficial to the health of consumers who ate bread fortified with avocado paste. The only other plants that match up to this are olive and rapeseed oil are other well-known sources of monounsaturated fats.

Although the highest values of fat content was found in ST at (52.55±0.35) which may be attributed to the oil added during processing, it can be suggested to patients of higher energy needs due to the appreciable amount of fat content. Vanessa (2011)detected peanut fat contains 9 kCal of energy per gram of fat.

Peanuts generally contain monounsaturated and polyunsaturated fatty acids, which are a beneficial type of fat. According to the American Heart Association (AHA), consuming monounsaturated fats and polyunsaturated fats instead of saturated and trans fats can enhance a person's blood cholesterol levels.

The raw avocado pulp contained 30.20±0.20% fat, pure peanut paste contained 39.00±0.10%, while their blends had increased fat content of 47.90±0.10, 52.55±0.35and 36.70±0.20 for samples FF, ST and ET respectively. The standard sample presented the least value for fat content at 25.00±1.00.

Fat is one of the major constituents of both groundnuts and Avocado fruit and should be critically assayed as these factor may affect physical and chemical properties of foodspreads if not properly handled.

4.1.4 Protein

The protein contents of the samples ranged from 3.62±0.67 to 28.11±1.25. Protein content was highest in OP (100% peanut) with a value 28.11±1.25%, while the least was the 100% Avocado paste at 3.62±0.67. This may imply that groundnuts generally have more protein content than Avocado and may be suitable for addressing protein deficiencies in certain individuals.

All the other samples significantly varied from each other, and the control, except ET and ST. There was no significant difference between the samples containing 80% peanut and 70% peanut with $p<0.05$.

The value of the 100% peanut paste falls within the range 23.67±0.05 to 31.56 ±0.78studies conducted by Boli et al., (2013) showed.

However, the crude protein content for the avocado pulp gave a generally low value– 3.62±0.67 and a slight increase was observed as portions of groundnut were raised.

Fruits have been reported to provide moderately little protein in comparison to nuts (Hawthorn, 1981).

The values for samples 1:1 and the standard were 10.04±0.24 and 25.00±1.00 respectively, whereas Ahmed and Young (2011) observed that the varieties of peanuts which are commonly grown around the world have an average protein content of about 25% which the control 100% peanut paste sample falls into.

In contrast, McWatters et al. (2006) reported protein contents of (8.2 to 12.1%).

The difference observed between the standard sample and the control sample may be because of difference in peanut cultivars used in the production of spreads.

It can thus be concluded that the avocado fruit is a poor source of protein and should be complimented with other foods rich in protein.

4.1.5 Crude Fibre

Crude fibre values for the samples ranged from 1.36±0.00 to 4.49±0.03. The highest value was 4:1 formulation of peanut avocado spread at 4.49±0.03. Next in line was 1:1 ratio at 3.85±0.15, which may be attributed to the addition of 80% of peanut. The crude fibre content of peanut alone was found to be 2.58±0.04, while that of Avocado alone was 1.36±0.00 which was the least percentage.

Peanut avocado spread formulated with 80% peanut and 20% contributed the highest fibre content, making this product ideal for patients with fiber requirment according to (Boli et al., 2013). In contrast, the work of Boshra & Tajul (2013) attributed increased fibre content in bread samples to the high fibre content in avocado paste indicating that the avocado fruit spread is a good source of fiber which could aid the digestion of food in the intestinal tract and valuable in the bakery.

Generally, the percentage crude fiber content complied hugely with the values obtained from previous studies by Özcan & Seven., (2007), who reported values of 1.00 to 6.75%.

4.1.6 Carbohydrate

Carbohydrate mean values of the formulated peanut avocado spreads ranged from 12.35±1.39 to 61.82±0.76. There was significant difference between the standard sample obtained from the supermarket and the control sample prepared from 100% peanut.

Values obtained were found to be higher than previous studies by Boli et al (2013) that reported values of 15 to 26%.

This result proves the formulations are a suitable source of nutrient. Low carbohydrate content may be due to the variety of raw peanut used for the paste preparation (Asibuo et al., 2008).

The enrichment of peanut with 50% of avocado paste resulted in a significant increase from the overall lowest value of 12.35±1.39(in 30% avocado paste) to 25.19±1.07. This shows carbohydrate content increased with a decreased proportion of peanut. There was an increase in carbohydrate content from 12.35±1.39 to 28.09±2.13 with an increase in peanut proportion.

The decrease in carbohydrate content from 25.19±1.07 to 12.35±1.39 could be attributed to the low carbohydrate content of peanut butter and the reduction in the proportion of avocado paste.

Between ET (20% avocado) and ST (30% avocado), carbohydrate content decreased with an increase in proportion of avocado paste. The standard sample purchased from the supermarket was significantly higher compared to all the other samples, which values were are lower than the values (54.03-61.46% and 52.25-60.58%) reported by Scheuer et al. (2006) and Olaoye & Onilude (2008) respectively.

Low carbohydrate content may be due to the variety of raw peanut used for the paste formulation (Asibuo et al., 2008).

4.2 Mineral Composition

Assessing table 4.2, it is seen that The Phosphorous content of the Peanut avocado butter ranged from 0.17 to 0.37%.

The standard sample contained the highest amount of Phosphorous (0.37%), next to this is the pure avocado pulp (0.30%), then both ET and FF at (0.21%), with the least phosphorous content found in the 100% peanut paste.

OA, ET and FF sample had Ca content of 0.03% , OP and STD had 0.06 and 0.07% respectively. There was no difference in the Ca content of the composite peanut paste.

100g of Avocado contains between 10-12mg of calcium. The avocado fruit also has 60 % more potassium than bananas and is rich in B vitamins, as well as vitamins E and K (Bergh, 1992).

Magnesium content of the samples ranged from 0.02 to 0.18%, with 100% Avocado paste containing the least Magnesium content.

Samples OP and STD did not have much significant difference between them with 0.17 and 0.18% Mg respectively.

Table 4.2: Mineral Profile of Samples

Minerals/Samples	OP	OA	ET	FF	STD
P (%)	0.17	0.30	0.21	0.21	0.37
Ca (%)	0.06	0.03	0.03	0.03	0.07
Mg (%)	0.17	0.02	0.13	0.09	0.18
K (%)	0.60	0.16	0.52	0.41	0.56
Na (ppm)	292.20	36.46	239.65	187.66	158.66
Mn (ppm)	13.24	2.60	10.31	7.73	12.03
Fe (ppm)	16.24	7.54	18.74	10.01	26.27
Cu (ppm)	7.61	1.76	6.78	7.61	5.94
Zn (ppm)	21.47	2.90	16.87	11.64	25.63

OP= 100% Peanut paste, OA= 100% Avocado pulp, ET= 80:20 Peanut Avocado paste, ST= 70:30%Peanut Avocado paste, FF= 50:50% Peanut Avocado paste.

Where ratio represents = peanut:avocado

OP had the highest. potassium content (0.60%) and OA had the lowest (0.16%). ET which had 20% avocado had a higher Mg content than FF with 50% avocado.

The 100% peanut sample contained the highest percentage of sodium (292.20), followed by ET (80% peanut) 239.65, then FF (50% peanut) 187.66. The standard sample contained 158.66% sodium, while OA contained the least amount of sodium (36.46). FF had a lower Na content than ET which might be due to an increase in the avocado proportion.
There was a relatable increase in the Sodium content as portions of peanut increased. This signifies a correlation between the volume of peanut and the values of sodium. This increase could possibly be attributed to the high salt content added to peanut during processing.

The Mn content of OP, OA, ET, FF and STD was recorded as 13.24, 2.60, 10.31, 7.73, and 12.03ppm respectively. ET (with 20% avocado) and FF (with 50% avocado) had lower Mn content than OP (100% peanut) and STD (standard sample).

The Fe content of the samples was obtained to be 16.24, 7.54, 18.74, 10.01 and 26.27ppm. ET (with 20% avocado) had 18.74ppm and FF (with 50% avocado) had 10.01. ET composite peanut spread had a better Fe content than FF.

According to a table on nutrition facts of Avocado fruit obtained from https://loveonetoday.com/nutrition/avocado-nutrition-facts-label/ 50g of Avocado is seen to contain 10mg of calcium, 0.3mg of Iron 250mg of K, 30mg of P, 15mg of Mg, 0.3mg of Zinc, 0.1mg of Cu and 0.1mg of Mn.
The Cu content of the samples ranged from 1.76 to 7.61ppm. OP and FF had the same Cu content (7.61ppm).

OP, OA, ET, FF and STD had Zn content of 21.47, 2.90, 16.87, 11.64 and 25.63ppm respectively.

As the avocado content of the composite peanut flour increased to 50%, the Mg, K, Na, Mn, Fe and Zn content was reduced. This might be due to increase in proportion of avocado with OA having lower mineral composition than OP,STD, ET and FF. The sample enriched with 50% (FF) avocado had a higher Cu content than the sample enriched with 20% avocado (ET).

Maitera*et al* (2014), analyzed avocado fruit in Taraba state and recorded 0.23mg/kg Na content, 2.04mg/kg (0.000204%) K content, 0.069 mg/kg Fe content, 0.103 mg/kg (0.0000103%) Mg content and 0.064 mg/kg (0.0000064%) Ca content (1ppm=1mg/kg). these

results shows that the mineral content of OA sample is higher than the mineral content of the avocado fruit in Taraba state. Edokwe*et al* (2011), analyzed mineral compositions of *Persea americana* (avocado) extract and obtained 600ppm (o.6mg/g) Fe content, 520ppm (0.52mg/g) Zn content, 0.007% (0.07mg/g) P content, 0.124% (1.24mg/g) Ca content and 0.06% (0.6mg/g) Mg content. This result shows that the Fe, Zn, Ca and Mg content of the avocado extract was higher than the OA sample. The P % of the OA sample is higher than the avocado extract.

4.3 Physicochemical Composition

Salt

Table 4.3 records salt content found in samples to range from 5.40±0.40 to 18.00±0.50. The highest salt content was found in the 100% peanut sample (18.00±0.50), while the lowest was found in the standard sample (5.40±0.40). This suggests sample FF (1:1) meets up with the salt content of commercial peanut butters.

There was no significant difference in the salt contents of FF and STD, The high salt content in OP could be attributed to salt added to peanut before roasting.

pH

The pH values obtained ranged from 4.08±0.01 to 6.03±0.01, with sample ST having the highest pH, indicating it is the least acidic, while the pure avocado paste (OA) emerged with the lowest pH value, representing the most acidic sample. The ranges obtained conforms with that reported by Engineering ToolBox, (2003) of peanut butter and Avocado pears having pH values of 6.3 and 6.3 - 6.6 respectively.

Table 4.3: Physicochemical Composition of the Samples

Samples	Peroxide Value	Free-fatty acid value	Acid Value	Salt	pH
OA	5.50 ± 0.50^{a}	0.35 ± 0.05^{e}	0.70 ± 0.10^{e}	18.00 ± 0.50^{a}	5.48 ± 0.00^{b}
OP	4.40 ± 0.20^{b}	1.78 ± 0.03^{a}	3.55 ± 0.05^{a}	1.65 ± 0.45^{e}	4.08 ± 0.01^{f}

ET	3.00 ± 0.50^{c}	0.60 ± 0.10^{d}	1.20 ± 0.20^{d}	14.75±0.65^{b}	5.18±0.02^{e}
ST	2.20 ± 0.20^{d}	0.95 ± 0.05^{c}	1.90 ± 0.10^{c}	9.60±0.80^{c}	6.03±0.01^{a}
FF	3.15 ± 0.15^{c}	1.45 ± 0.05^{b}	2.90 ± 0.10^{b}	5.50±0.30^{d}	6.03±0.01^{a}
STD	4.75 ± 0.25^{d}	1.35 ± 0.05^{b}	2.70 ± 0.10^{b}	5.40±0.40^{d}	5.26±0.01^{d}

Mean values with different superscript in the same column are significantly different at $p<0.05$.

OP= 100% Peanut paste, OA= 100% Avocado pulp, ET= 80:20 Peanut Avocado paste, ST= 70:30%Peanut Avocado paste, FF= 50:50% Peanut Avocado paste.

Peroxide value

The peroxide values ranged from 2.20 ± 0.20 to 5.50 ± 0.50, with the highest being found in the 100% Avocado oil, and the lowest in the 70% : 30% peanut and avocado oil extract.

This result present peroxide values which fall within the recommended range the oil from the avocado flesh according to Alenta, (2018), and proves its of decent quality.

Though most values are higher then the 2.60±0.05meq/kg from Fortuna avocado flesh oil obtained by Galvão et al., (2014), and 4.0 meq/kg proposed recommended standard for extra virgin avocado oil, they were all still below the 8 meq/kg for virgin avocado oil (Wong et al., 2010), and all significantly below 10meq/kg. According to Olaniyi *et al.*, (2014), oil possessing peroxide value of 10meq/kg ticks off perceptible indications of rancidity. High peroxide values is also repulsed in oil as it could pose a potential threat to human health (Dermis et al., 2012).

The lower the peroxide and acid values, the better the quality of the alimentary fats and their state of preservation (Koczon et al., 2008).

Acid value

Table 4.3 records acid values of 0.70 ± 0.10mgKOH/g, 3.55 ± 0.05mgKOH/g, 1.20 ± 0.20mgKOH/g, 1.90 ± 0.10mgKOH/g, 2.90 ± 0.10mgKOH/g and 2.70 ± 0.10mgKOH/g for OA, OP, ET, ST, FF and STD respectively, which compare favorably with the values of 1.19 ± 0.01 mgKOH/g, 1.06 ± 0.23 mgKOH/g and 0.49 ± 0.03 mgKOH/g oils from Fortuna avocado seed, peel (skin) and pulp (flesh) respectively as recorded by Galvão et al. (2014).

Whilst the values are above the maximum level recommended by FOA (2001) for edible fats and oils (which is 0.6 mgKOH/g refined), they fall significantly below the 4.0 mgKOH/g (for virgin and cold pressed oils) maximum level recommended by FOA (2001). This proves that the oils extracted from sample contains fewer free acids which makes them less prone to rancidity rancidity (Adaramola et al., 2016),
and therefore, a better preferred consumers choice.

Free-fatty acids

The FFA values ranged from 0.35 ± 0.05 to 1.78 ± 0.03 which are significantly low and desirable to oil quality as this means oil is less susceptible to rancidity (Adaramola *et al.,* 2016) thus the oil is with longer shelf-life. Rancidity of oils can produce potentially toxic compounds associated with long-term health effects such as neurological and cardiovascular diseases and cancer. The low values show these oils are less susceptible to rancidity, and therefore good for the heart and general health (Kaleem et al., 2015).

4.4 Microbial Analysis

Peanut butter and other nut butter products are generally considered as microbiologically stable and safe for consumption, due to the inherent low water activity between 0.22–0.30 as it cannot favour the growth and proliferation of bacterial pathogens (Rozalli 45 et al., 2016).
Using pour plate method, Nutrient Agar (NA), MacConkey Agar (MA) and Eosin Methylene Blue Agar (EMB) where inoculated and then incubated at 37^{o}C for 24hours.
Total colonies on the surface of the plates were counted and expressed as log10 colony forming unit per milliliter (log10 cfu/ml) of the peanut avocado sample. Serial dilution of 10^{-2}, 10^{-3} and 10^{-4} was used to calculate the CFU/ml of MA, NA and EMB respectively and was recorded as seen in table 4.4.

Results revealed samples OP.NA, ET.NA, ST.NA and FF.NA had the highest bacteria count of (2.00×10^{4}cfu/ml, 1.65×10^{4}cfu/ml, 1.132×10^{4}cfu/mland 1.29×10^{4}cfu/ml) respectively. The sample with the overall highest bacteria count was ST.

Sample OP, according to table 4.4, shows that the NA, MA and EMB values were 1.90×10^{2}cfu/ml, 7.20×10^{2}cfu/mland 2.48×10^{3}cfu/ml, respectively.

Table 4.4: Microbial Analysis of Samples

Samples	NA Bacteria CFU/ml (10^{-3})	MA Bacteria CFU/ml (10^{-2})	EMB Bacteria CFU/ml (10^{-4})	Mold CFU/ml (10)	Yeast CFU/ml (10)	Coliform CFU/ml (10)
OP	1.90×10^{2}	7.20×10^{2}	2.48×10^{3}	ND	ND	ND
OA	4.00×10^{2}	1.50×10^{3}	2.00×10^{2}	ND	ND	ND
ET	9.00×10^{2}	1.80×10^{3}	1.20×10^{3}	ND	ND	ND
ST	6.00×10^{2}	8.80×10^{2}	5.00×10^{2}	ND	ND	ND
FF	7.00×10	1.57×10^{3}	5.80×10^{2}	ND	ND	ND
STD	1.00×10^{2}	5.00×10^{2}	3.00×10^{3}	ND	ND	ND

OA, as seen on table 4.4 shows that the NA, MA and EMB values were 4.00×10^{2}, 1.50×10^{3} and 2.00×10^{2} respectively. it was observed that there was no significant growth on plates of the remaining dilutions while growth were observed on NA, MA and EMB plates for dilutions respectively.

ET on table 4.4 shows that the NA, MA and EMB values were 9.00×10^{2}, 1.80×10^{3} and 1.20×10^{3} respectively. it was observed that there was no significant growth on plates of the remaining dilutions while growth were observed on NA, MA and EMB plates for dilutions respectively.

ST judging from table 4.4 shows that the NA, MA and EMB values were 6.00×10^{2}, 8.80×10^{2} and 5.00×10^{2} respectively. There was no significant growth on all cultured plates and for all the dilutions, but for MA plate, growth of pinkish colony on 10^{-1} and 10^{-5}.

FF according to table 4.4 shows that the NA, MA and EMB values were 7.00×10 1.57×10^{3} and 5.80×10^{2} respectively. There was no significant growth on all cultured plates and for all the dilutions, but for NA plate, growth of whitish colony on 10^{-3}, and on 10^{-4} dilution, a creamy colony was observed.

STD as represented on table 4.4 shows that the NA, MA and EMB values were 1.00×10^{2}, 5.00×10^{2} and 3.00×10^{3} respectively. it was observed that there was no significant growth on plates of the remaining dilutions while growth were observed on NA, MA and EMB plates for dilutions respectively.

4.5 Sensory Evaluation

The sensory scores for appearance of the samples ranged from 3.75±0.50 to 8.50±0.58,

and significantly varied from each other ($p>0.05$) except between STD and OA which had close values (6.25±0 and 6.50±1.00) respectively. The colour of the spread sample decreased with an increase in the peanut paste ratio. The appearance of OP was most preferred by the sensory panellists, while that of ET (4:1 peanut avocado) was the least preferred.

The taste ranged from 5.25±0.96 to 7.75±0.50, with the highest value being OP (7.75±0.50) and the least value ST (5.25±0.96). The values of all the other samples showed no significant difference ($p<0.05$). According to statistics, OP is the best tasting sample.

The study shows that OP and STD had the highest values for texture/hand feel, while ST (4:1 peanut avocado) had the least value (2.75±0.96) with no significant difference with ET (3.50±0.58). This may be attributed to the coarse, grainy feel avocado paste contributed to the formulations. Although the panelists still preferred the texture of the standard peanut butter, there was no difference in the scores compared with OP at (8.00±0.82and 8.00±0.82) respectively. Heinis (1989) noted that the supplement of peanut butter with honey or corn syrup varied flavors and viscosity.

Crippen et al. (1989) arrived at increased grind size (fine, medium and coarse), decreasing the sensory smoothness, spreadability, adhesiveness and preference evaluations.

According to results, the standard sample had highest spreadability value (7.50±0.58), followed by OP (100% peanut). ET was the least spreadable, probably due to its high peanut content. It was observed that the spreadability value increased with a decrease in proportion of peanut paste. Although the panelists mostly preferred the spreadability of the standard sample, there was no significant difference with the spread produced from 100% peanut butter (7.25±0.50).

The scores for aroma ranged from 5.25±0.96to 7.25±0.96. The aroma scores of the spreads varied significantly from each other ($p>0.05$). The aroma (7.25±0.96) of sample FF was most preferred by the panelists, seconded by that of OP at 7.00±0.82, while the least value was for OA at (5.25±0.96).

The sensory scores for mouthfeel ranged from 4.50±1.00to6.25±0.96. The highest values were obtained from OP, ET and FF at 6.25±0.50, 6.25±0.50, and 6.25±0.96 respectively, while the lowest value was OA at 4.50±1.00. However, within the middle range where ST and STD with similar values of 5.75±1.26 ($p<0.05$). This presents the possibility of peanut avocado spread (70:30) replacing contemporary peanut butter in the innovation of food spreads. According to Dzurik et al. (1971) the excessive pressure homogenization following primary grinding yields smooth, glossy pastes, melts more rapidly in the mouth than regular peanut butter. Along the course of processing, ingredients like salt, emulsifiers are added. Addition of salt (< 1.2 %) enhanced gulping ingesting, as well as consumer preference of texture.

Table 4.5 Sensory Analysis of Samples

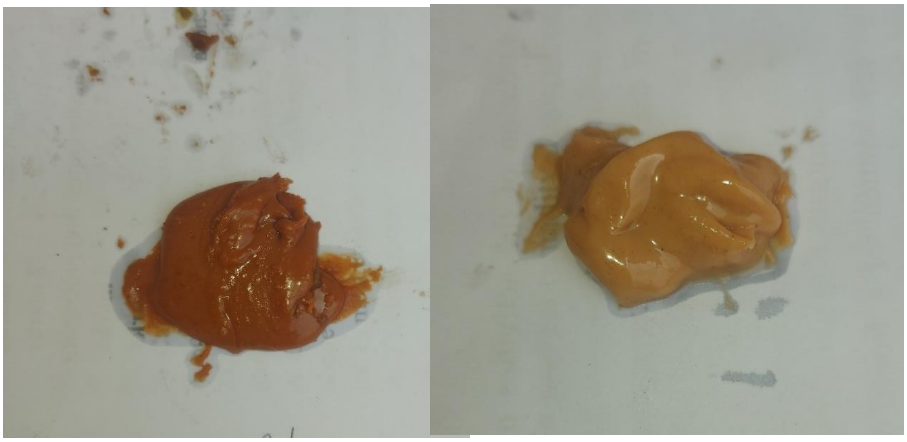
Samples	Appearance	Taste	Texture	Aroma	Spreadability	Mouthfeel	Overall/General acceptability
OP	8.50 ± 0.58^{a}	7.75 ± 0.50^{a}	8.00 ± 0.82^{a}	7.00 ± 0.82^{a}	7.25 ± 0.50^{a}	6.25 ± 0.50^{a}	7.25 ± 0.50^{a}
OA	6.50 ± 1.00^{bc}	6.25 ± 0.50^{ab}	5.25 ± 0.96^{b}	5.25 ± 0.96^{c}	5.25 ± 0.50^{b}	4.50 ± 1.00^{b}	5.00 ± 0.82^{c}
ET	3.75 ± 0.50^{d}	6.25 ± 0.50^{ab}	3.50 ± 0.58^{c}	6.50 ± 0.58^{bc}	3.50 ± 0.58^{c}	6.25 ± 0.50^{a}	5.00 ± 0.82^{c}
ST	5.25 ± 1.89^{c}	5.25 ± 0.96^{b}	2.75 ± 0.96^{c}	5.50 ± 0.58^{ab}	3.75 ± 0.50^{c}	5.75 ± 1.26^{ab}	5.25 ± 1.26^{bc}
FF	7.00 ± 0.82^{b}	6.50 ± 1.73^{ab}	5.75 ± 0.96^{b}	7.25 ± 0.96^{a}	5.00 ± 0.82^{b}	6.25 ± 0.96^{a}	6.25 ± 0.96^{abc}
STD	6.25 ± 0.50^{bc}	6.50 ± 1.29^{ab}	8.00 ± 0.82^{a}	6.25 ± 0.50^{bc}	7.50 ± 0.58^{a}	5.75 ± 0.96^{ab}	6.50 ± 0.58^{ab}

Mean values with different superscript in the same column are significantly different at $p<0.05$.

OP= 100% Peanut paste, OA= 100% Avocado pulp, ET= 80:20 Peanut Avocado paste, ST= 70:30%Peanut Avocado paste, FF= 50:50% Peanut Avocado paste.

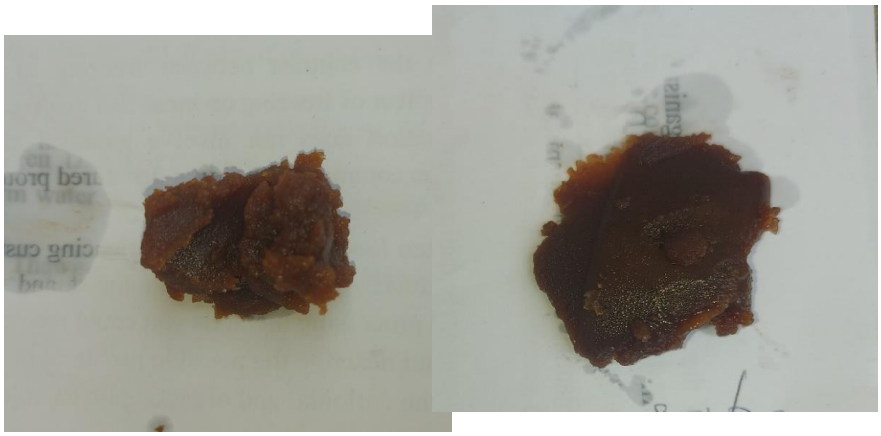
Where ratio represents = peanut:avocado

The value obtained in this research work showed that sample OP (100% peanut paste) had the highest overall acceptability based on panelists' preference. Next in line was the standard peanut butter sample STD at 6.50±0.58 ($p>0.05$). Following closely is FF (6.25±0.96), while OA, ET and ST where the least acceptable with values 5.00±0.82, 5.00±0.82 and 5.25±1.26 of no significant difference ($p<0.05$).



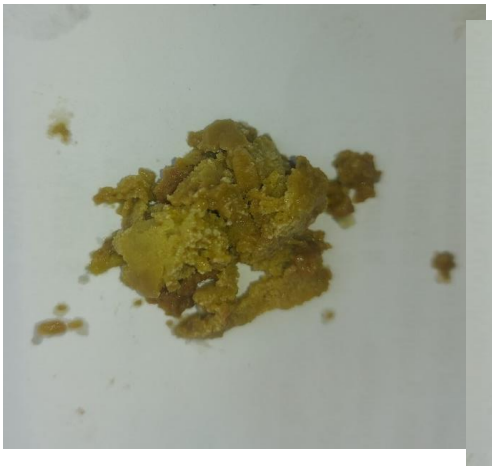
100% Peanut paste (OP)

Standard Peanut butter sample (STD)



70:30 Peanut:Avocado (ST)

80:20 Peanut:Avocado (ET)



100% Avocado Paste (OA)

50:50 Peanut:Avocado spread (FF)

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The formulation of peanut enriched with avocado pear fruits in a bid to abate the prevalence of cardiovascular diseases and type 2 diabetes due to increased sugar consumption in food spreads nowadays was successfully carried out, presenting a novel composite spread rich in monounsaturated fats and polyunsaturated fats opposed tosaturated and trans fats that clog arteries of unsuspecting individuals.

Healthful fat like those found in peanuts and avocado can enhance a person's blood cholesterol levels.

The blends had comparable nutritional profile with contemporary peanut butter but were higher in certain minerals such as potassium, manganese and copper. The fibre and ash contents of the blends were also improved with inclusion of avocado. The protein contents of the formulations were higher than that of the standard sample. This makes the formulation a potential food source to combat protein deficiency symptoms.

Based on sensory evaluation, there was no significant difference in the taste of the formulations that included avocado. However, the aroma and mouthfeel of the avocado based formulations were improved.

Lately, much consumer attention has centred on reduced carbohydrate and fat nut spreads, and most studies implemented revolved around peanut butter and peanut spreads. Since all formulations of composite peanut avocado foodspread comprised appreciable low amounts of carbohydrate, especially the 70% avocado, 30% peanut formulation (which had the lowest percentage of carbohydrate) in comparison with the standard sample, they could be considered as a healthier alternative for consumption by health-conscious individuals.

Based on this study, Avocado pastes could be an excellent alternative for consumption for the elderly, those with digestive disorders (due to its high fibre content) and patients on a low blood cholesterol diet. Owing to its high fat content, the peanut and avocado composite foodspread samples produced from blends of Groundnut and Avocado fruit was an overall healthier option for consumption and is therefore also recommended to patients of higher energy requirements.

From this study, it can be concluded that avocado puree is fit to be used as a fat replacer in fat-based foodspread formulation and that avocado enriched foodspread contains appreciable levels of mineral composition and could be used to supplement the daily energy intake of consumers, and can be substituted in the production of edible, spreadable food products.

5.2 Recommendations

I recommend that more processing techniques should be employed to transform avocado pear fruits into a more shelf stable commodity, since the high moisture content contained in the avocado makes it susceptible to hydrolytic rancidity and microbial activity.

I also recommended that further research be undertaken to develop more types of organic, plant-based foodspreads with a higher nutritional profile and sensorial aesthetics, viz a viz a more effective utilization of the avocado fruit rather than letting it go to waste.

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