UTILISATION OF CASSAVA PEELS FERMENTED WITH OIL PALM SLURRY AS FEED IN THE DIET OF WEST AFRICAN DWARF SHEEP

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ABSTRACT

Shortage of pasture during dry season militates against production of grazing animals in Nigeria. Cassava Peels (CaP) and Oil Palm Slurry (OPS) are agro-industrial by-products obtainable throughout the year. Utilization of CaP as feed can be enhanced through fermentation with OPS. However, there is dearth of information on the use of fermented CaP as feedstuff for West African Dwarf (WAD) sheep. The use of CaP fermented with OPS as feed for WAD sheep was therefore investigated.

Samples of OPS randomly obtained from Ikoyi, Badeku, Mamu and Benin in South Western Nigeria and CaP were analysed for their dry matter (DM), and proximate (Crude Protein (CP), Crude Fibre (CF), Ether Extract (EE) and fibre (Neutral Detergent Fibre (NDF), Acid Detergent Fibre (ADF), Acid Detergent Lignin (ADL), cellulose and hemicelluloses) compositions. One litre of OPS was mixed with 1Kg, 2Kg, 3Kg, 4Kg, 5Kg (Diets A – E) of CaP, respectively while 6Kg (Diet F) of CaP only served as the control. The diets were fermented for five days in air-tight cellophane bags, sun-cured and analysed for proximate and fibre contents. Eighteen WAD sheep were allocated to the six treatments in triplicate using completely randomised design and each group was fed *ad libitum* for 14days. Samples of rumen liquor were collected for *in vitro* Gas Production (IVGP) to predict the Potential Degradability (PD), Insoluble Degradable Fraction (IDF), Rate of Gas Production (RGP), Organic Matter Digestibility (OMD), Metabolisable Energy (ME), Short Chain Fatty Acids (SCFA), pH and ammonia-N (NH_3-N) for 96 hours at 3 hours interval. The *pre prandia* and 3, 6 and 9 hours *post prandia* samples of rumen liquor were collected for microbial count in a 4x6 factorial arrangement. Data were analysed using ANOVA (p=0.05)

The OPS from Mamu had the highest DM (43.2%), CP (8.2%), EE (6.5%) and CF (8.0%). The CF and EE obtained for the fermented diets decreased with CaP inclusion (4.7 to 3.7% and 10.0 to 7.5%) in diets A and E respectively. Similar decreasing values for ADF (40.2-30.2), NDF (59.0-48.0), ADL (20.2-18.0), Cellulose (20.7-12.3) and hemicellulose (22.0-18.0) contents were obtained due to fermentation. The IDF value was significant for diets A (39.3) and F (47.0) at 24hours and for other treatments at 60 hours. The PD estimates varied significantly from 73.5 in diet E to 98.5 in diet B at 60 hours. The RGP increased with time at all observed hours. The pH value (6.21) was significant at 60 hours. Estimated ME, OMD and SCFA were highest for diet B with values of 11.4, 83.0 and 1.6 respectively. The LogCFU of all treatments pre-prandial was between 5.0 and 5.3. Apparent interaction between 0-9 hours for pH and NH_3-N were not significant.

The combination of three parts of cassava peels fermented with one part of oil palm slurry from Mamu for five days and sun-cured was best as supplement for grazing West African dwarf sheep.

KEY WORDS: West African dwarf sheep, Oil palm slurry, Cassava peels, *In vitro* fermentation.

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DEDICATION

This thesis is dedicated to the glory of GOD the Almighty, who made all things possible and my mother OLORI FLORENCE MAKINDE.

CERTIFICATION

I certify that this study was carried out under my supervision by Oluwanike ABIOLA-OLAGUNJU, in the Department of Animal Science, University of Ibadan, Ibadan, Nigeria.

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CHAPTER ONE

1.0 INTRODUCTION

Livestock rearing plays an important role in the livelihood of small – scale farmers in Nigeria and contributes to the regional and national economic development. In recent years, the human population has increased rapidly and the demand for food, in particular livestock products is expected to increase in all developed and developing countries. (Phengvilaysouk *et al.,* 2008).

Mako (2009) described the major constraint to livestock production in developing countries as inadequacy of feed in terms of quality and quantity all year round. Most ruminant livestock, especially cattle, sheep and goats obtain most of their nutrients from herbages growing on poor soils. Another problem is that these herbages often grow fibrous and are of, low digestibility. These animals gain weight slowly in the rainy season and loose it rapidly in the dry season (Babayemi and Bamikole, 2006) due to all-year round feed inadequacies.

The major hindrances to the abundance of all year round lush pasture are in two folds. First is the obvious fast rate of infrastructural development and constant change in government policies. Another factor is the constant rise in population in Nigeria. There is an uncontrollable rise in human head count. The net effect is the negative impact on the available space for herbage production and limited green area for grazing animals (Makkar, 1994).

Feeding alone, accounts for approximately 60- 80% of the total cost of animal production (Aregheore, 2000). The conventional feed resources are also in limited supply, very scarce and expensive. This stemmed from the perpetual competition between man and his livestock (Longe *et al.,* 1988). Such feedstuff is maize, a source of dietary energy for livestock farmers. It thus becomes cost ineffective for livestock farmers. All these factors prohibit the use of such feed ingredient for ruminants that may require a large quantity to satisfy energy requirements.

Smallholders (Stur *et al*., 2002) own 95% of all livestock and most of the households produce food mainly for subsistence (Chantalakkana, 2001). Unfortunately, in most towns and villages, free-range system of animal rearing has been the order of the day. Animals are left to roam the streets as scavengers. These animals face the hazardous

conditions of being beaten or knocked down by vehicles or at times being poisoned by angry farmers whose crops are damaged.

Researchers in the last three decades realized the need for a pressing integration with the use of less popular feed alternative such that ruminant production could be sustained all year round. Thus efforts have been geared at improved supplemental feeding with the use of grasses, crop residues and agro- industrial by products (AIBS) in the dry season (Mako, 2009).

Various authors (Ayoade, 1993; Ayoola., 1993; Adebiyi, 2004; Mako, 2009) concluded that non conventional feedstuff is better alternatives to the conventional feed resources. They are readily available in their local areas from crop cultivation and industrial processing. They are easily afforded by the farmers at least cost and are important sources of roughages for ruminants. The AIBS and crop residues have been described as low- quality roughages due to high levels of cellulose, hemicelluloses, lignin and fermentable carbohydrates. (Phengvilaysouk and Wanapat *et al.,* 2008) However, ruminant livestock have the advantage of their unique ability to synthesis high quality protein from non-protein nitrogenous compounds (NPN) through the action of micro- organisms present in their digestive tract (Adeleye, 1991).

Many authors (Adebiyi, 2006; Mako, 2009) have reported fermentation as an important tool of upgrading AIBS, especially the protein level for adequate utilisation by the microbes in the rumen. It also aids in the breakdown of the fibrous cell wall thereby making the feed more susceptible to microbial attack. Achinewhu *et al.* (1998) reported fermentation as being responsible for product stability, flavor development, fibre break down and enhanced nutrient content of feed through the biosynthesis of vitamins, microbial proteins and fibre digestibility.

Oil palm slurry (OPS) is the waste or effluent remaining after production of palm oil. It is obtained in a ratio of 2:4 liters of finished palm oil (Aderiye, 1996). It is essentially an emulsion containing 4-5% solids, 0.5-1% residual oil, 75% water, 4.5-9% crude protein and crude fibre content of 8.0% depending on the extraction method used. The OPS is usually channeled into rivers, dams or sunk into a dug pit, which could seal the passage of air and reduce the crop yield of the area of production due to its high biological oxygen demand (B.O.D) (Apori, 1984).

In most villages and localities in the South-Western parts of Nigeria, palm oil production is an all year round exercise thereby making its slurry abundantly available throughout the year. Although several works have been done on the use of oil palm slurry in the feeding of non- ruminants, yet works are scanty on its utilization as feed for ruminants. Reports of Hutagalung *et al*., (1978) suggested that for optimal results in the use of OPS as feed for ruminant animals, it should be fed along with or used as a binder with other AIBS. The residual oil in the OPS is considered an essential component of many fermentation media, since it possesses defoaming properties as well as serve as a supplemental nutrient source for growth and maintenance of the microbial cells (Yang *et al*., 2000). Oil palm slurry is also a detoxifying agent that helps in reducing toxic effects.

Cassava peel has been established over the years to be well relished by all classes of animals including non-ruminants. It is a source of energy. Though highly acidic, it possesses anti-nutritive factors, and fibrous (Babayemi, *et al.,* 2010). It is also a waste that could be found all year round; especially in the South- Western parts of Nigeria where its cultivation is highest. However, its low protein and cyanide content has been the major limitation for its use in the feeding of livestock. (Okpako *et al*., 2008).

This work is undertaken to evaluate the utilisation of cassava peels fermented with oil palm slurry as feed in the diet of West African dwarf sheep.

The objectives of this project are:

1. To evaluate the nutrient composition and availability of OPS in South-Western Nigeria.
2. To determine the nutrient contents of graded mixtures of OPS and CaP fermented over a period.
3. To evaluate the intake, digestibility and microbial load in the rumen of sheep fed fermented graded mixtures of OPS and CaP

JUSTIFICATION

Ruminants are naturally fed with grasses that are low in nutrient especially in the dry season, which suggests the need for supplementation with lesser known feed stuffs of no direct dietary value to man.

The available conventional feed ingredients such as maize and pulse legumes are excellent supplements for ruminants, but are rather exorbitant, uneconomical and this therefore necessitates the search for other cheaper source of feed supplies.

Palm oil is the second largest source of dietary oil consumed daily by man and Nigeria is rated the fifth largest producer of crude palm oil. There is dearth of scientific documentation on the use of its invariably abundant liquid effluent as alternative feed for ruminants in Nigeria. Most of the researches on Oil palm slurry were carried out in Malaysia (Arowora, 2002).

The report of Wambeck (1990) suggested that results that are more valuable would be obtained if oil palm slurry could be integrated with other ingredients in formulation of useful animal feeds. The OPS and CaP are unconventional feedstuffs that are abundantly available in the production areas. Depending on the disposal techniques they could constitute environmental menace. This calls for alternative practical uses particularly in the light of the dearth of scientific documentation on the use of the effluent.

Ruminants need the supply of vitamins A, D, E and K which are naturally in short supply in grasses during the and dry seasons of the year Cott (2009). Hence a need to supplement their diets with AIBS like oil palm slurry which contains all of these vitamins due to its residual palm oil content (Hutagalung *et al.,* 1977)

In view of these, a bond could be formed between oil palm slurry a liquid effluent and cassava peel since both are obtainable all year round.

CHAPTER TWO

2.0   LITERATURE REVIEW

2..1   AGRO INDUSTRIAL BY-PRODUCTS (AIBS)

Crop residues or agro-industrial by products are the left over at the sites of harvest of some crops on the farm which are usually left to rot in the fields. While some are used to improve soil fertility, or may be set on fire. They can also be defined as the waste or residues from agro-industrial feed processing plants or small scale units. They are usually fibrous, low in nutrient and are not directly edible but could be fed to animal. Babayemi and Bamikole (2006) described crop residues and agro-industrial by products as bulky with high fibre, low protein and poorly degradable, while Dixon and Egan. (1987) further explained that they are derived from the processing of a particular crop or animal products usually in an agricultural firm. They are, readily available in each locality of production. The nutrient composition and nature of agro-industrial by-products depends on the amount and types of crop grown in that area. Although research work has been in top gear to evaluate the use of these byproducts as feed, a large amount of these by products produced on both private and government could be wasted. In such findings (Ayoade *et al.,* 1991) established that in some eastern parts of Nigeria, more than 60% of livestock farmers are not aware of the value of crop residues and agro-industrial by products. Research to date is geared towards the determination of biological value of residues as they occur, rather than on methods of increasing this value. In an attempt to improve the nutritional quality of fibrous residues, it has been confined mainly to physical treatments, such as grinding. There is the need to explore more and where need be, fully apply other methods of treatments if their potential value as animal feed is to be realised.

2.1.1   Characteristics of Agricultural by-products

Only a part of agricultural products can be utilized by man himself. The amount of by-products for feeding farm animals can be considerable. There is a considerable variation in quantity and quality of by-products among the crops, influenced by, varieties, climate, season and stage of harvest. The most important parts of roughage are the aerial parts (stems, leaves). These can be utilised fresh, dry, cut or grazed, in the field or in the stable/barn.

Human do not consume crop by-products. These by-products contain high amount of fibrous material which are not easily disposable due to treat on environmental pollution.

Statistics on production and utilization of fibrous residues in Nigeria is inadequate. However, the production of roughage could be fairly estimated accurately from crop production, if reliable data are available.

Low quality roughage is found in poor grazing range lands. It also includes enormous amount of cereal crop residues such as rice straw, wheat straw, bean straw, maize stover, corn cobs and rice hulls. Analysis of roughages by detergent procedures (Goering and Van Soest, 1970) showed that they are high in lignin, cellulose and hemicelluloses.

Also most cereal wastes are characterised as low crude protein, low available energy and deficient in certain minerals. These low quality roughages are inefficiently utilized by ruminants. This is due to low digestibility and poor nutritive value associated particularly with cereal straw. Their utilization is also limited because of low voluntary intake of the animals due to their huge bulk, which makes transportation more costly.

The chemical composition of roughages varies with the variety of plant (Kharat, 1974; Salem and Jackson, 1975), location (Van Soest, 1969) and agricultural practices employed in the growing of the crop and handling of the residue from which they are obtained. Chahal. (1985) referred those differences between crop residues and wood residues to be due to their chemical composition. He found that crop residues contain 30-40% cellulose, 16-27% hemicelluloses, 3-13% lignin, and 3.6-7.2% crude protein, while the wood residues contain 45-56% cellulose, 10-25% hemicelluloses and 18-30% lignin.

2.2   UPGRADING AGRICULTURAL WASTES

Approximately 2 billion tonnes of cereal grains and 140 million tonnes of legume and oil are produced throughout the world annually. Choct. (1998) estimated 230 million tonnes of fibrous material as part of a variety of global by-products. In legumes, non starch polysaccharides (NSP) also play a role as energy storage material. Longe (1988) and Derick. (1989) advocated the increased utilization of non-conventional feed resources in non-ruminant feed. They suggested processing techniques, which are simple and inexpensive, and do not significantly increase costs but still make it

worthwhile in terms of nutrient availability. Processing techniques widely documented in literature could be grouped into physical, chemical and biological treatments.

2.2.1   Physical treatment.

In smallholder livestock systems, most physical treatments of crop residues are either too expensive or the equipment is not available and labour intensive. However, there are benefits in reducing particle size (not necessarily grinding), for ensiling and stall-feeding. Reduction of particle size can be achieved by using a power driven chopper. There are other advantages, in that the surface area of non-lignin material exposed to microbial attack increased the rate of digestion, thereby reducing a possible limitation to intake (Van Soest, 1982).

2.2.2   Chemical treatment.

The potential for increasing digestibility and intake of fibrous residues through treatment with alkali has been reviewed (Sundstol and Owen, 1984). Urea treatment is of most practical significance in the tropics, acting as both an alkali and a source of supplementary nitrogen (N) to materials inherently low in crude protein.

The procedure will vary according to circumstances. Smith *et al*. (1989) noted that the greatest improvement was observed when 5% urea solution was added at 20% weight for weight to dry stover followed by an incubation period of five weeks. The stover had been rotor slashed before treatment. Urea treatment is relatively easy to apply and is effective However; its adoption at smallholder farm level has been slow and the cost of urea prohibits adequate usage

2.2.3   Biological treatment

Biological treatments include the use of microbial proteins, antibiotics, probiotics, enzymes and ensiling. These constitute the most recent methods of enrichment of non-digestible feedstuffs or those imbued with the well known anti-nutrients. Dierick (1989) emphasized that polyphenols such as tannins are not removed by physical or chemical treatments but by fermentation or germination. Even the nutritive value of maize in form of lysine and tryptophan contents leading to improvement in biological value and utilizable protein was achieved through germination (Ram *et al.,* 1979). Besides ensiling, the most recent additive for improving silage quality is the biological aid. This involves microbial inoculants and cellulolytic enzymes with easy, safer

handling and application to its credit. It is neither volatile nor corrosive and is usually aimed at breaking down cell walls to provide a wealth of readily available substrates (Dutton, 1987). Addition of enzymes to feed ingredients results in an improved energy availability that reduces the difference between gross and metabolisable energy of raw materials (Cowan *et al.,* 1996). The level of improvement seen is related to energy type and dosage and correlated well with the substrate specificity of the various enzymes present. The microbial enzyme source, accounts for 90% of commercial enzymes and are more advantageous than the commercially prepared enzymes. According to Underkoffler. (1972) the following advantages are found in the microbial enzymes;

(a) Microbial enzymes do not compete for glandular tissues of animals with other more expensive products made from a limited supply of the same glandular tissues.

(b) There scanty microbial sources

(c) There is irregularity and non predictability of supplies from non microbial sources which may be subjected to seasonal, climatic and other agriculturally related uncontrollable variables.

(d) Production from non-microbial sources cannot be expended at will in response to increased demand. Microorganisms both aerobic and anaerobic are able to produce extracellular enzymes to degrade macromolecules like starch, cellulose, hemicelluloses, lignin, and pectin of the plant cell (Priest, 1984) as well as protein and other membrane constituents.

It has been reported that the solid state fermentation (SSF) is an alternative process to produce fungal microbial enzymes using lignocellulose materials from agricultural wastes due to its low capital investment and lower operating cost (Haltrich *et al*., 1996; Jecu, 2000).

2.3   FERMENTATION

Fermentation can be described as the change in state of the physical and chemical condition and make up of a substance or substrate (feed) to a more stable form. This process changes the total make up of the substrate, by breaking down the complex formation of the feed through natural or artificial introduction of microorganism (fungal or bacteria) which breaks down the complex cell wall into a more simple form. Fermentation could be anaerobic or aerobic. This process of

substrate breakdown is advantageous in many ways. It increases the surface area of the feed particle for the hosts' microorganisms for adequate utilization.

1. Fermentation brings about a more stable product thereby increasing the shelf-life of the product.
2. It helps to increase the nutritive value of the substrate through protein enhancement.
3. It improves acceptability of the feed.
4. The aroma of the end substrate is enhanced.

2.3.1 Solid state fermentation

Aerobic microbial transformation of solid materials or Solid Substrate Fermentation (SSF) can be defined as the application of living organisms and their components to industrial products. The process is not an industrial, but an improvement in technology that will have a large impact on many different sectors (Hamlyn, 1998). Aderolu (2000) considered SSF as a process in which solid-substrate are decomposed by known mono or mixed cultures of micro organisms under controlled environmental conditions, with the aim of producing high quality products. The substrate is characterized by relatively low water content (Zadrazil *et al.,* 1990). Solid state fermentation (SSF) is an attractive alternative process to produce fungal microbial enzymes, using lignocellulosic materials from agricultural wastes due to its lower capital investment and lower operating cost (Chahal *et al., 1996;* Haltrich *et al.,* 1996; Jecu. 2000). For the reasons stated, the SSF process will be ideal for developing countries. Solid–state fermentation is characterised by the complete or almost complete absence of free liquid. Water which is essential for microbial activities is present in an absorbed or in complex-form within the solid matrix and the substrate (Cannel and Moo-Young, 1980). These conditions are especially suitable for the growth of fungi, known to grow at relatively low water activities. As the microorganisms in SSF grow under conditions closer to their natural habitats, they are more capable of producing enzymes and metabolites, which will not be produced or will be produced only in low yield in submerged conditions (Jecu. 2000).The SSF's are practical for complex substrates including agricultural, forestry, food-processing residues and wastes which are used as carbon sources for the production of lignocellulolytic enzymes (Haltrich *et el.,* 1996). Compared with the two-stage hydrolysis-fermentation process during

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ethanol production from lignocelluloses, SSF has the following advantages: Sun and Cheng (2002).

1. Increase in hydrolysis rate by conversion of sugars that inhibits the enzymes (cellulase) activity;
2. Lower enzyme requirement;
3. Higher product yield
4. Lower requirement for sterile conditions since glucose is removed immediately and ethanol is produced;
5. Shorter process time ;
6. Less reactor volume.

Malherbe and Cloete. (2003) reiterated that the primary objective of lignocellulose treatment by the various industries is to access the potential of the cellulose encrusted by lignin within the lignocelluloses matrix. They expressed the opinion that a combination of SSF technology with the ability of an appropriate fungus to selectively degrade lignin will make possible industrial-scale implementation of lignocelluloses based technologies.

New application of SSF has been suggested for the production of antibiotics (Barrios *et al., (*1994), secondary metabolites (Trejo-Hernandez *et al.,* 1992, 1993) or enriched foodstuffs (Senez *et al.*, 1980). The SSF is a batch process using natural heterogeneous materials (Raimbault, 1998), containing complex polymers like lignin (Agosin *et al.,* 1989), pectin (Oriol *et al.*, 1988a) and lignocelluloses (Roussos, 1985). Bacteria, yeasts and fungi can grow on solid substrates, and find application in SSF processes mainly on the production of feed, hydrolytic enzymes, organic acids, gibberellins, flavours and biopesticides. Bacteria are mainly involved in composting, ensiling and some other food processes (Doelle *et al.*, 1992). Yeasts can be used for ethanol and food or feed production (Saucedo-Castaneda *et al.*, 1992a,).

Filamentous fungi are the most important group of microorganisms used in SSF processes owing to their physiological, enzymological and biochemical properties. The hyphae of fungal growth are tolerant to low water activity and high osmotic pressure conditions make fungi efficient and competitive in natural micro flora for bioconversion of solid substrates (Raimbault, 1998).

Microorganisms are currently the primary sources of industrial enzymes; 50% originates from fungi and yeast, 35% from bacteria, while the remaining 15% is either from plant and animal origin (Boophathy, 1994). Microbial enzymes are either produced through submerged fermentation (SMF), or solid substrate fermentation (SSF) techniques. According to the Central food technological Research Institute (CFTRI) in India, enzyme production by SSF accomplishes high production per unit volume of fermentor space than SMF technique. Processing wastes such as cassava peels (Ofuya and Nwajuba, 1990) has been upgraded through production of enzymes by SSF techniques. Such information (Iyayi and Losel 2001; Belewu and Banjo. 1999; Iyayi and Aderolu 2004; Onilude 1994; Balagopalan. 1996) clearly showed the use of microorganisms for upgrading lignocelluloses into animal feeds.

Like all other technologies, SSF has its advantages. These have received some attention (Mudgett, 1986). Problems commonly associated with SSF are heat buildup, bacteria contamination, scale-up, biomass growth estimation and control of substrate content.

2.4   THE PALM TREE AND ITS ORIGIN

The palm tree (*Elaeis guineesis spp*) is a multipurpose tree crop which grows and fruits all year round. Its cultivation started at the beginning of this century (Davendra. 1977).The tree crop is confirmed a native of West Africa and it flourishes in the humid tropics in groves of varying density. The palm tree moved out of Africa through European travelers who used the nuts as ship ballast and latter found it useful as a source of food for human consumption and also animal feed. The primary areas of production now are Southeast Asia, Latin America, and currently Malaysia produces half the world's production followed by Indonesia and Nigeria.

2.5   CHARACTERISTICS OF THE PALM TREE

The tree crop is characterised by its vertical trunk and the feathery nature of its leaves. Every year, 20 to 25 new leaves "fronds" develop in continuous whorls at the apex of the trunk. The fruit bunches develop between the trunk and the base of the trunk and

the base of the new fronds. Although new plantations start to bear at three years, generally the first commercial crop requires between five and six years and continues to produce for 25-30 years or until the palms grow too high to be harvested. Once a plantation reaches full production, a new inflorescence is produced every 15 days. It weighs between 15 and 20kg and can contain up to 1500 individual palm fruits of between 8 and 10 grammes each. The individual fruit consists of the following four parts;

A pericarp,a thin outer covering or skin which upon ripening changes from brown to orange.

A mesocarp, a layer of fibrous material, which surrounds the nut.

An endocarp or a hard inner shell (nut) to protect the seed or kernel.

The seed (kernel).

2.6   PRODUCTION OF THE PALM TREE

The African oil palm, yields 20tonnes /ha/yr of fresh fruit bunches (Bolarios, 1986; Garza, 1986). It can produce between 3 and 5 t/ha of crude oil from the fruit (mesocarp) and an additional 0.6 to 1.0t/ha from the palm kernels (Ocampo *et al.*, 1990a). The factors that affect productivity are; climate, soil type, genetic factors, maturity, rainfall, fertilization and the period of harvest. The African palm oil requires a minimum of 1600mm of well-distributed precipitation (Mijares, 1985) a relative humidity no less than 75%, a minimum and maximum temperature of between 17 and 28c, and a total of 200hours of light and soil depth of 100 centimetres.

2.6.1   Types of oil palm

There are two basic types of oil palm. These are the "Dura" and the "Pisifera" The basic difference between the two is in their nuts. The "dura" type has a thick and hard shell while the 'pisifera' has a small kernel, with no shell but rather surrounded by a matrix of fibre. A cross between pisifera male and dura female, results in a "Tenera' type of fruit. It has an immediate type of thickness. Tenera is now the most widely grown type in most plantations.

2.7   TECHNOLOGICAL PROCESS OF THE PALM OIL

There are two major commercial products extracted from the African oil palm. They are; raw or crude oil which is approximately 22% of the weight of fresh fruit bunch while the palm nuts represents 4-6%.When the nuts are processed, it yields palm kernel oil and palm kernel meal. The two main industrial residues, the oil- rich fibrous residue and the palm nutshell are usually incinerated and the ash is returned to the plantation as fertilizer.

2.7.1   The extraction and technical processes of oil palm

The technological process by which the oil is extracted from the palm fruit consists of the following steps: Fig 1 flow chart. The fresh fruit bunch includes the stem and the adhering individual palm fruits.

Reception: where sand dirt and gravel are separated from the fresh fruit bunch.

Sterilization: Necessary to rapidly inactivate certain enzymes which tend to reduce the quality of the oil by increasing the amount of free fatty acids. In addition, this process contributes to the mechanical separation of the fruit from the stem and to the rupture of the oil cells within the mesocarp.

Oil extraction: An oil press, into which hot water is injected, is used to separate the crude oil from the solid or fibrous-like material containing the nuts. The crude oil is then pumped to the purification section.

Fig 1 shows the quantities of the principal components of the oil palm based on 100 tons of the fresh fruit bunch. The nuts are treated and cracked to extract the kernel, which contains approximately 50% oil. The oil-rich fibrous residue, is traditionally used as a source of energy to run the plants, has a caloric value superior to 18.8MJ/Kg. This is largely due to the residual oil, calculated as between 8 and 18 %.(Solano,1986; Wambeck, 1990).

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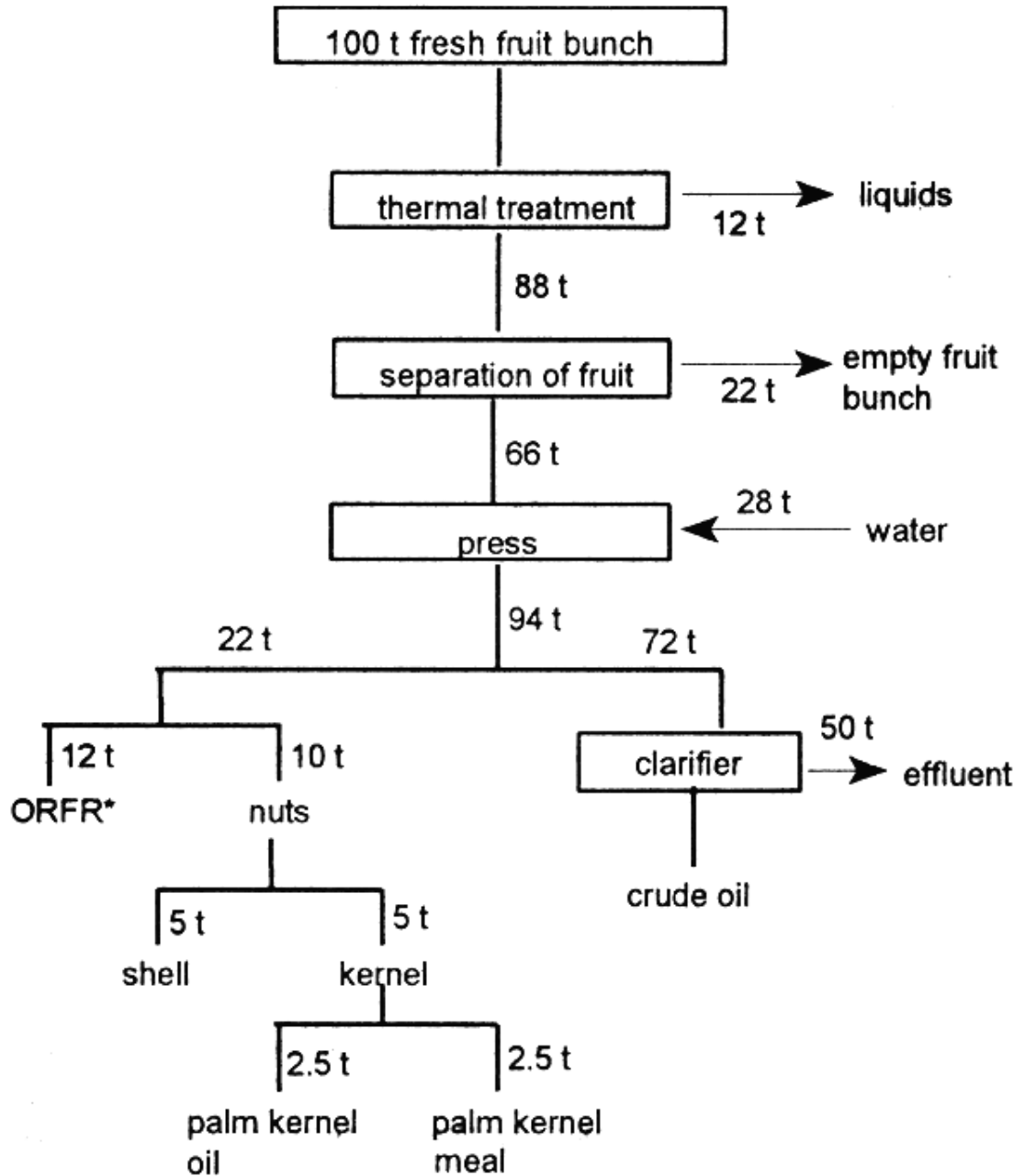
Fig 1; Showing the flow chart production technology for 100tons of fresh fruit bunch of African oil palm Solano 1986

2.8   PECULIARITIES OF PALM OIL IN MAN AND ANIMAL NUTRITION.

Palm oil has been used traditionally for more than 5000 years in African countries, where small-scale family farms flourish. It is the most heavily consumed dietary oil in the world after soybean oil. In its natural state, palm oil is red in colour in most of the tropical countries while in the temperate region, it is usually an orange colour like carrot due to the naturally cool environment. This red colour is due to a high concentration of the natural nutrients carotenes, a (precursor of vitamin A) which our bodies need to convert to vitamin A which is essential for good eye sight. Vitamin A can be toxic at excessive levels, whereas carotenes are not. Therefore, vitamin A toxic levels are not possible from consuming virgin palm oil.

Palm oil is one of the best sources of Vitamin E an important phytonutrient in edible oils which takes care of the skin pigmentation. Vitamin E consists of four tocopherols and four tocotrienols naturally present in most plants, however they are found most abundantly in palm oil extracted from palm fruits. The antioxidative ability of palm oil is due to its high biochemical content of tocotrienols, naturally present in most plants. However, they are found most abundantly in palm oil extracted from palm fruits and are believed to be much more potent antioxidant than tocopherols.

Oils and fats generally are susceptible to attack by atmospheric oxygen, resulting in rancidity. The content of tocols in (Vitamin E) makes palm oil very powerful natural antioxidants. Therefore, it has exceptional resistance to rancidity. It is also known for its excellent stability at high temperatures. This gives it an advantage in cooking over any other oil because it will not denature so easily upon long exposure to heat.

The essential vitamins A, D, E AND K (responsible for strong bones) which are mostly needed by pregnant women, young children and the aged and in animals, (pregnant, lactating and young animals) are all present in the red palm oil. Another advantage of the crude palm oil is found in its use in a manner similar to molasses. Up to 5% improves palatability, reduce dustiness, to supply vitamins and to improve the texture of rations prior to pelleting (Devendra, 1977; Hutagalung and Mahyudin, 1981).The oil contains approximately 80% of saturated fatty acids, and 10% of linoleic acid, an essential fatty acid required at a dietary level of 0.1% for pigs. (NRC, 1988) Palm oil is also known to be a detoxifying agent.

2.8   OIL PALM SLURRY (OPS).

After the extraction of palm oil from the palm fruit bunch, the final discharge effluent which is in a semi solid form is called the slurry. The process of extraction of palm oil from the fresh fruit bunch (FFB) according to Jamal *et al*. (2010) requires large amount of water mainly for sterilizing the fruits and oil clarification, resulting in the discharge of organic, non-toxic waste water known as palm oil mill effluent (POME).The quantity of (POME) produced is about 60% for every tone of (FFB) processed. Thus, about 18 to19.5 tones effluent (POME) is generated from the milling process of an average of 30 tonnes FFB (Rashid *et al*., 2009).Oil palm slurry was described as the liquid effluent produced during the extraction of oil at the rate of 2 to 3 tons per ton of finished oil (Olie and Tjeng. 1972). It contains soil particles, residual oils and suspended solids. Results from Rashid *et al.* (2009) estimated that OPS contains water 95-96%, oil 0.6-0.7%, total solids 4-5%, pH 4.7, biological oxygen demand (BOD) - 25000mg and total nitrogen of 750mg. After palm oil extraction in Nigeria and due to poor disposal systems, the liquid effluent is channeled into streams and rivers around and the high biological oxygen demand of the slurry causes a tousle with aquatic animal. This could lead to aquatic loss of lives and also render soils around areas of production useless for cultivation since it seals off oxygen penetration to the roots of crops. Davis and Briggs. (1998) described the effluent as a potent environmental pollutant. This effluent represents 0.5 ton per ton of fresh fruit and can cause serious problems to the entire ecosystem (Wambeck. 1990). Oil palm slurry could be put to use either by filter-pressing before drying and grounding to produce dehydrated palm oil mill effluent or centrifuged in the wet state, after undergoing anaerobic, thermophilic and acidophilic fermentation. In the latter case, the product is known as fresh centrifuged slurry solids of between 15 and 20% dry matter. It may be dehydrated to form dry centrifuged slurry solids of between 94 and 97% dry matter. Oil palm slurry has a crude protein value of 4.6% which could be increased by the addition of poultry litter. The enriched slurry could be used to substitute other sources of protein such as soybean and groundnut cake in the diet of broilers (Abu *et al*., 1984).

2.8.1 OIL PALM SLURRY UTILISATION AS FEED STUFF FOR ANIMALS

There have been numerous attempts to convert OPS into a viable animal feed resource. In poultry, Yeoung (1980, 1981) evaluated the nutritive value of oil palm by-products with poultry. He reported that the metabolisable energy (ME) value of oil palm slurry in broiler chickens was 1814kcalME/kg at 20% inclusion in diets. He recommended an optimum level to be 15%, beyond which adverse effects on feed intake; body weight gain and feed efficiency, were observed.

Swatson (1979) replaced the maize component of a reference diet with raw oil palm slurry at 0, 5, 10, 15% on weight basis. The effect of inclusion was significant ($p<0.05$) on feed intake compared to birds on control diet (0% oil palm slurry).The oil palm slurry containing diets also recorded a comparatively better feed conversion efficiency.

In pigs, Vroom (1978) replaced the maize component of an 18% crude protein diet for weaner pigs with 0, 10, 15, 20% oil palm slurry. He observed that the crude protein level of 18% in oil palm slurry supplemental diets with fish meal had significantly better carcass characteristics for pigs on oil palm slurry based diets. He also reported that increasing the level of oil palm slurry led to a corresponding increase in the rate of gain. However, there was a decrease in feed conversion efficiency compared to pigs on control diet.

In ruminants, limited work has been done on the utilization of palm oil slurry. Dvendra (1977) studied the digestibility of diets containing 10-60% oil palm slurry and reported high dry matter digestibility with an average of 87.0%. However, with increasing levels of OPS from (10-60%) significantly lower decreased differences ($p<0.05$) were observed. The 10% inclusion gave the best results with respect to digestibility values. Devendra (1977) in feeding adult sheep with or without fat supplemented diets at 8% level, recorded digestibility of 85.4% which was equivalent to digestible energy value of 33.6MJ/kg of palm oil.

In cattle, Pillai and Tan (1976) fed oil palm slurry to cattle and reported improved live weight gains. Dazel (1978) used OPS with 75% moisture to formulate diets containing palm kernel cake, palm press fibre and mineral supplements for buffaloes, local Indian cattle (L.I.C) and kedan kelantin Cattle in 3year feedlot trial. He observed that fresh or untreated slurry can be effectively utilized and when the dry matter content of the diet

was 85% OPS, LIC heifers produced average daily gain (ADG) OF 0.47Kg/day. Feed cost per unit body weight gain was lowered in cattle and buffaloes by OPS inclusion.

2.9   ORIGIN OF CASSAVA (Manihot *esculenta*)

Cassava (manihot esculenta) is an annual staple crop with great economic importance worldwide. Although, the evolutionary and geographical origins has remained unresolved and controversial (Kenneth *et al.*, 1999). It has been established as an important root crop in West Africa, Asia and South America (Okpako *et al.*, 2008).World production of cassava roots was estimated to be 184 million tons in 2002. The majority of production is in Africa where 99.1 million tons were grown, 51.5 million tons were grown in Asia and 32.2 million tons in Latin America and the Caribbean. Nigeria is the world's largest producer of cassava. However, based on the FAO statistics, Thailand is the largest exporting country of dried cassava with a total of 77% of worlds export in 2005. Cassava provides energy for about 500 million people and also it is known as one of the leading crops with respect to the energy produced per hectare per year. It has also been discovered to be the third largest source of carbohydrate for humans in the world (Okpako *et al*., 2008).

2.9.1   Characteristics of Cassava (*Manihot esculenta*)

Cassava plays a particularly important role in the developing sub-Saharan Africa countries, because it performs well on poor soils and requires low rainfall. It is a perennial root crop that can be harvested as needed. Cassava (Manihot *esculenta*) is characterized by its short-lived perennial, 1 to 5metres tall. From stem cuttings, the plant produces 5 to 10 tubers of very fleshy adventitious roots up to 150centimetres in diameter. Young roots may have 30- 35% stands by weight but very little protein or fat. As many as 300 million people in the tropics consume cassava daily. After planting a stem cutting, the crop does not have to be tended, and the roots are harvested 6-8 months latter before they become woody. Cassava has the greatest yield of starch per acre of any crop in the world often exceeding 20tonnes of roots per acre (Okpako et al., 2008).

Cassava roots are bitter and poisonous if eaten raw (bitter cassava, *kii*). The bitter principal is a glycoside of hydro cyanic acid (HCN), which occurs in the white, yellow and red flesh. Very poisonous forms have greater than 100 ppm of cyanide. If ingested,

inhibits a respiratory enzyme and in a series of actions ultimately causes asphyxiation. The lethal concentration of HCN is 150milligrams for a 50killogram adult. Various methods have been used to remove the toxic agent (HCN). In native America, the deadly bitter principal could be removed by boiling or squeezing. Another method of its removal is by adequate fermentation (Adebowale, 1983). Although some cultivars lack HCN (sweet cassava, makasera; less than 50ppm of cyanide), this is highly variable and unreliable. Certain cassava cultivators have very strong preference for the most bitter, i.e. lethal, forms and even intentionally used the most toxic tissues. However, the most poisonous forms often detoxify more completely than the milder forms, because they contain more hydrolytic enzymes linamarase which causes the release of hydrogen cyanide gas.

2.9.2   The use of Cassava peel

Cassava has been found to be the third largest source of carbohydrate for human food in the world (Okpako *et al*., 2008). In Nigeria today; it is an important staple food in almost every household, thereby making its peel, which is non edible by human useful for feeding almost all classes of animals. Handful of researches (Osakwe and Nwose. 2008; Okpako *et al*., 2008; Pham and Preston, 2009) has been conducted with meaningful results on the incorporation of cassava wastes in animal feeding.

2.9.3   Monogastrics

Osakwe and Nwose, (2008) fed twenty eight week old crosses of New Zealand White x Chinchila weaner rabbits in an experiment in which maize was replaced with graded cassava peels at 0, 25, 50 and 100%. It was concluded that maize supplementation in the diets of weaner rabbits could be replaced with cassava peel up to 100% without any adverse effects. However, 75% cassava peels replacement was observed to be the optimum.

Using a ration in which cassava peels contained up to 27.3% of the ration, Tewe *et al.* (1981) observed no significant difference (p>0.05) in the performance of pigs on the control and the test diets. Longe and Adetola. (1983) incorporated cassava peels up to 20% levels in the ration of layers and observed no significant (p>0.05) variations in the feed intake between the birds on the control and test diets.

2.9.4 Sheep and Goat

Twelve female and twelve castrated male sheep were allocated to rations containing dried fermented cassava peels at 0, 20, 40 and 60% and fed over a period of 6months to determine the optimum level that maize could be replaced without any effect on the performance. Increased fermented cassava peels in the test rations produced greater economic benefits. Fermented cassava peels had a fattening effect on sheep (Adebowale, 1981).

2.9.5 Cattle

In the works of Pham and Preston. (2009), four Lai Sind bull aged 26-28months, weighing 290 kg live weight with permanent rumen cannula were fed diets of natural grass and graded dried cassava root peels (RP) at 0, 0.25, 0.50, and 0.75kg DM per 100kg live weight. An apparent negative effect in the balance of rumen bacteria and products was observed. The overall impact of the RP supplementation appeared to be a better balance of nutrients for the animal as reflected in the linear increase in total DM intake.

2.10   LIMITATIONS TO THE USE OF CASSAVA AS FEEDSTUF

Anti nutritional factors are substances generated in natural feedstuff as secondary metabolites by the normal metabolism of the plant species. They are usually referred to as "Toxic Factors" due to their deleterious effects when consumed by animals (Radostits *et al*., 1997; Bruneton, 1999). Many plant components have the potential to elicit adverse effect on the productivity of ruminants. Anti nutritional factors could be classified on the basis of the type of nutrients affected and the biological response elicited in the animals like;

(1) Substances depressing digestion or metabolic utilization of proteins. This group is known as protease inhibitors, haemaglutimins (basically, lectin and ricins), saponins, tannins and cyanogenic substances.

(2) Substances inactivating certain vitamins and hormones. These consists of lipoxygenase (antivitamin A), racitogens (antvitamin D), dicoumarol (antivitamin k), mimosine (antihormone) and cyanogenic glucoside (anti-thyroid).

These factors are widely distributed naturally throughout the plant kingdom and in all the parts of plant (Bruneton, 1999). They occur essentially as defense mechanisms against predators and microbial infections. (Feeny, 1970; Deshpande *et al*., 1986). It was also described as a means of defense and storage of their nutrients, structure and reproductive elements (Harborn,. 1989). The effects of both secondary metabolites and mycotoxins vary with animal species. Non- ruminants such as pigs and poultry are usually more susceptible to toxicity than animals, which have the capacity to denature potential toxins in the rumen (Norton, 2004).

2.11 CYANOGENIC GLUCOSIDES

The cyanogenic glucosides have been implicated in the incidence of goiter and cretinism in humans. The effects of cyanide on livestock performance have been investigated (Okpako *et al*., 2008). Cassava has a definite anti- thyroid action in man and animals, resulting in the development of endemic goiter and cretinism (Ermanus *et al.*, 1980; Delange *et al.*, 1973). This action is attributed to the endogenous release of thiocyanide from linamarin which is a cyanogenic glucoside contained in cassava.

The high moisture content and ratio of carbohydrate to nitrogen, makes cassava tubers an excellent substrate for microbial growth and production of high levels of toxic metabolities. It has been demonstrated (Nartey, 1966) that on cassava meal substrate where *Aspergillus flavus* thrives, high levels of aflatoxins was produced. This heat-stable carcinogenic metabolite inhibits protein synthesis and causes liver damage in animals (Butler and Barnes, 1963). Like other root crops; cassava roots are richer in protein, ether extract and edible ash than the edible protein (Arowora, 2002). This valuable waste product has been used extensively to feed cattle, sheep, goat, pig and poultry in areas of high cassava production.

Diverse ways have been applied to reduce anti nutritional effect of cassava roots to the barest minimum; by soaking, sun drying (Tweyong and Katunga. 2002), par boiling and through fermentation (breaking down of the complex feed constituent to simpler forms and restructuring of the chemistry of the substrate to a more stable form).

2.12 VOLUNTARY INTAKE

The digestibility of a feed is most accurately defined as the proportion which is not excreted in the feaces and perhaps assumed to be absorbed by an animal (Mc Donald *et*

al., 1988).Digestibility is affected by the chemical composition and stage of maturity of the forage or feed substance (Mako, 2009) and also by processing and chemical treatments. Voluntary feed intake and digestibility of energy decrease as crude protein content of forages decrease (Van Soest, 1995).

In a digestibility trial, the feed under investigation is given to the animal in known amount and the output of faeces measured. The feed would be thoroughly mixed to obtain uniform composition. It is then offered to the animal for at least a week prior to collection of faeces. This would be done to get the animals adjusted to the diet and to clear the tract of the residues from previous feeding. This preliminary period is followed by a period when feed intake and faecal output are recorded. It is highly desirable that diet should be given at the same time daily and the amount of feed offered should not vary from day to day (Mc Donald *et al*., 1988).

2.12.1 Feed intake on fat based diets and organic matter digestibility

(Clapperton (1974). obtained significant variations in apparent dry matter and organic matter digestibility when isocaloric diets supplemented with linseed oil were fed to four groups of sheep. Similar reports (Putnam *et al*., 1969; 1978; Kane *et al.,* 1979; Palmquist and Conrad. 1980) had been published.

Kowalczyk *et al.* (1977) obtained lowered digestibility of dry grass, after infusing 0, 40, 80 and 120g tallow per day into rumen of lambs. Similar observations for dry matter digestibility were reported (Dyer *et al*., 1957; Wayne *et al.,* 1971).

Phengvilaysouk and Wanapat. (2008) focused on the effect of cassava hay (CH) and coconut oil (CO) supplementation on feed intake and digestibility in a 4 by 4 latin square design. Supplementation improved diet digestibility and feed intake with swamp buffaloes when supplemented with CH or CH and CO compared to supplementation with only CO, which decreased roughage intake.

Bohman *et al.* (1957) incorporated animal fat into fattening steer ration at 5 and 10% levels and found no significant effect on feed intake.

2.12.2 Dietary fat on crude protein digestibility

Dietary fat decrease protein digestibility significantly (Grainger *et al., 19*57; Perry and Stewart, 1979). Conversely, for heifer, protein digestibility tended to increase with dietary fat inclusion (Kromfeld and Donoghue, 1980) which accords with similar documented observations (Putman *et al.,* 1969; Wayne, 1971; Palmquist, 1977).

Protected tallow at 0, 25 and 37.5% in the diets of beef cattle did not influence protein digestibility (Haaland *et al.,* 1981). Similar findings were observed with linseed oil (Clapperton. 1974; Sharma *et al.*, 1978) and the feeding of 0-15% level of protected tallow (Palmquist and Conrad, 1980).

2.13   THE RUMEN ENVIRONMENT

The rumen is a function of the quantity and type of feed eaten by the animal at a particular time. The periodic mixing through contraction of the rumen, salivation rumination, diffusion secretion into the rumen, absorption of nutrients from the rumen and passage of materials down the digestive tract (Preston and Leng, 1987) are imment factors. The rumen environment can be disorganized under abnormal circumstances; A sudden introduction of feed substance into the diet such as grains could result in lacticacidaemia. This is due to a drop in ruminal pH, growth of streptococcus bovis and the accumulation of lactic acid. The saliva helps in maintaining the pH of rumen as a buffer. The quality of saliva secreted by ruminants depends on the diet. The presence of protozoa population affects the salivary flow and may be reduced by its prescence.The protozoa rapidly assimilate starch and sugar and removes the need for copious salivation to maintain rumen pH (Preston and Leng. 1987).Saliva, a buffered bicarbonate solution of about pH 8, contains high concentration of sodium and phosphate ions. Both the saliva and bicarbonate movement across the rumen epithelium maintains the pH within narrow limits. The buffered rumen liquor favours the growth of the anaerobic bacteria, fungi and protozoa with accumulation of VFAs in the fluid (up to 0.2 molar).Perhaps, for continuous fermentation however, the ruminal pH must be constantly maintained at neutral level and to ensure VFAs absorption. The biomass of microbes in the digestive tract and by the death and lyses of the micro-organisms in the rumen, methane and carbon dioxide are produced as products of

fermentation. At low rumen pH, carbon dioxide comes out of solution and accumulates in a pocket of the dorsal sac. Methane and carbon dioxide are largely eliminated by eructation, (Dougherty *et al*., 1964). At high pH most of the carbon dioxide produced by fermentation or entering the saliva, is absorbed and excreted via the lungs.

2.14   RUMEN MICROBIAL ECOSYSTEM

The rumen microbial ecosystem is complex and highly dependent on the diet (Mako, 2009). The vast majority of ruminants consume a mixture of carbohydrates of which cellulose and hemicelluloses are the highest components. The diet can contain large amounts of soluble carbohydrates or starch (e.g. molasses or grains). Plants have developed molecular structure in their cell wall specially to stop invasion by micro-organisms. In the rumen, the main agents that break down carbohydrates are anaerobic bacteria, protozoa and fungi. The anaerobic bacteria are the principal agents for fermenting plant cell-wall carbohydrates but the anaerobic phycomycetous fungi, may at times be extremely important (Bauchop, 1981). There is a close relationship between fungi and other microbes in the rumen since the fungi appear to be the first organisms to invade plant cell wall, which allows bacterial fermentation to start and to continue. Some bacteria in the rumen assumed a symphonic association, where one organism uses the products of fermentation of another and the removal of the end- product allows further fermentation of the primary feeds source by the first organism (Preston and Leng, 1987).

2.15   MICROBIAL INTERACTIONS IN THE RUMEN

A myriad of micro-organisms are found throughout the digestive tract of the ruminant, but it is only the microbiota in the rumen that have a true symbiotic relationship with the host (Idahor, 2006). The rumen contains varied and dense microbial population predominantly anaerobic bacteria protozoa and fungi. They depend on the ruminant to provide the physiological conditions necessary for their existence. They in turn are essential for digestion and fermentation of the large amounts of fibrous feeds which the host cannot efficiently utilise (Czekawsk,. 1986; Yokoyama and Johnson, 1993). Since the rumen naturally utilises the end products of microbial fermentation and

biosynthetic activities to meet its own nutritional requirements. Interestingly, there is no indication of host specificity of these micro-organisms in ruminants. While many species are unique in the rumen, others closely resemble those found in the digestive tracts of other ruminants. The microbial population varies within animals, with time after feeding, between days in the same animal and apparently, in animal in different countries on similar feed (Hungate, 1975). However, the end- products of fermentation are virtually the same. Bacteria associate with related organisms and function as a couple, one organism growing on the end-products of metabolisms of another. The sequential fermentation process involving different species of organism converting cellulose to VFAs is well recognized. The interrelationships between levels are high above a certain optimum, in which ammonia is incorporated into ammonia acids without using ATP.

It has been suggested (Satter and Slyter, 1974) that maximum microbial synthesis rate occurs at ammonia concentrations between 5 and 8 mg N/100 ml. Different options have been found, suggesting that diet influences the optimum ammonia level. A study (Schaefer *et al*., 1980) suggests that value may be as high as 14 mg N/100 ml depending on the diet. The high ammonia concentration needed for maximum microbial cell growth suggested that the rumen micro-organisms probably have similar mechanisms for incorporation of ammonia via glutamate dehydrogenase.

2.15.1 METHODS OF CLASSIFICATION OF RUMEN MICROORGANISMS

The types of micro-organisms that develop and are sustained in the rumen are those that have adapted best to the specific conditions of the ecosystem (Idahor. 2006). Hence, saccharolytic microbes predominate due to the readily available carbohydrates (cellulose) and other polysaccharides that constitute the major substrates for fermentation. More so, the low oxygen tension in the rumen encourages the growth of more obligate anaerobes. However, a few facultative anaerobes are present under aerobic conditions (Yokoyama and Johnson. 1993).

In a more detailed investigation (Bryant. 1993), twenty-one genera and sixty-three species of rumen bacteria have been classified (Orpin. 1975; 1977; Ogimoto and Imai, 1981) describe a system of differentiating these rumen microorganisms according to morphological divisions. These are according to shapes (cocci, rods and spirilla), sizes

(ranging from 0.3 to 50 um and according to their different structures (including the presence of a cell envelope, cytoplasmic and surface adherents or appendages).

Generally, preliminary classification of the rumen microorganisms has largely followed a system based on the type of substrate they will attack and on the different end products of fermentation. However, there is a considerable ambiguity because most species are capable of fermenting more than a few substrates (Yokoyama and Johnson. 1993).

2.16   VOLATILE FATTY ACIDS

The end product of fermentation of organic matter by micro-organisms in the rumen are the volatile fatty acids (VFAs).The major (VFAs) acetic, propionic and butyric while the isobutyric, isovaleric, valeric and some other acids are produced in small amount. The rate and volume of the end products produced is directly proportional to the microbial activity in the rumen (Mako, 2009). Also, (Bergman, 1990) stated that concentrations and relative proportions of VFAs are related to the nature of the feed. In a similar report (Firkins *et al*., 1986; Robinson *et al*., 1986) the VFAs produced depend on the extent (effective degradability) of the feed ingested by the animals which subsequently determines the amount of substrate available for fermentation.

2.17   PRODUCTION OF METHANE THROUGH FEEDS

Ruminants depend on micro- organisms to ferment plant cell wall and polysaccharides into volatile fatty acids and (VFAs) and other amino acids. They also produce wastes such as carbon dioxide (CO_2) and methane (CH_4).Methane production in the rumen is a loss of energy, since the proportion of animal feed which is converted to CH_4 is eructed as gas. Approximately, 6% of dietary gross energy intake is lost to the atmosphere as CH_4 (Holter and Young. 1992; De Ramus *et al*., 2003). Recently, emission of CH_4 and other volatile organic compounds has attracted the attention of air regulatory agencies in many parts of the world. Methane contributes to climatic change and global warming (Johnson and Johnson. 1995) by trapping outgoing terrestrial infrared radiation 20 times more effectively than CO_2. This leads to increased surface temperature and directly affects an atmospheric oxidation reaction that produces CO_2 in animal agriculture.

There may be potential to reduce the extent of CH_4 production by manipulating diet and management practices that influence ruminal microbial fermentation (Johnson and Johnson. 1995).Environmental pollution and menace could be caused by over feeding and / or poor synchronization of release of nutrients in the rumen. Attempts have been made to manipulate rumen fermentation using ration manipulation strategies, including the addition of ionophores, fats and yeast cultures. For example, addition of monensin to dairy cattle rations decreased CH_4 production, decreased feed intake and increased milk yield (Sauer *et al*., 1998). This suggests that reduction in CH_4 production per unit of ingested feed is associated with improvement of feed utilization efficiency. A suppressing influence of ration fat content on CH_4 production has been reported (Sauer *et al*., 1998; Dohme *et al*., 2001; Lee *et al.,* 2003).It is not only the total amount of fat, but also its composition that excerts biological important influences on rumen fermentation (Gatechew *et al* ., 2001 ; Fievez *et al., * 2003). Gatechew *et al*., (2005) observed differences in methane produced from incubation of commercial total mixed rations (TMR) for lactating dairy cows. The proportion of CH_4 in total gas did not differ among TMR at 6 and 24 hrs of incubation, but differences did occur at 48 and 72 hrs giving an average of 33.8 ml CH4/g DM produced at 24 hrs of incubation. Approximately 0.80 of total CH_4 was produced during the first 24 hrs of incubation

2.18   ROLE OF AMMONIA IN RUMEN FERMENTATION

The 40-60% of the dry matter of the microbial cells in protein and therefore the synthesis of amino acid and proteins are the reactions that require ATP. The pathways of synthesis of amino acids in rumen microbes are not clearly defined. It is however; abundantly clear that ammonia is highly important for the efficient synthesis of amino acids and therefore microbial protein (Satter and Slyter, 1974). At low ammonia level in rumen fluid, reactions that fix ammonia into acids require ATP whereas, when ammonia level is high above a certain optimum, the ammonia is incorporated into amino acids without using ATP.

It has been suggested (Satter and Slyter, 1974) that maximum microbial synthesis rate occur at ammonia concentrations between 5 and 8 mg N/100 ml. Different options have been reported, suggesting that diet influences optimum level of ammonia. Another study (Schaefar *et al.,* 1980) suggests the value may be as high as 14 mg N/100 ml depending on diet. The high ammonia concentration needed for maximum

cell growth suggests that the rumen micro-organisms probably have similar mechanism for incorporation of ammonia via glutamate dehydrogenase.

2.19   FATE OF FAT IN THE RUMEN

Fat supplementation of animal ration could be done using animal fat (e.g. lard, tallow, cod liver oil, salmon oil and whale oil) or vegetable oil (e.g. soya bean oil, palm oil, linseed oil and cotton seed oil). The incorporation of plant oil into rations is done through the addition of the pure oil or crop residues/plant oil by-products. Examples of oil crop residues which have been used in ruminant nutrition are groundnut cake, cotton seed cake, palm kernel cake, coconut cake and babassu cake (Apori, 1984).

Reports of supplementation (Kirchgessne *et al*., 1967) showed that 100-350g per animal per day as the minimum, depending on the basic foodstuff and nature of dietary fat Sundstol. (1974) recommended 25-30g digestible ether extract per kilogram 4% fat corrected milk as the minimum level and an upper limit of 700g ether extract per day per animal.Fat added to the diet of ruminants varies from negligible amounts to levels in excess of 10% of the dry matter in leafy forages or where animals are able to select leafy-tip materials (Hawke, 1973).

Fats added to the diet are mainly in the form of triglycerides with smaller amounts of phospholipids and sterol esters. Dawson and Kemp. (1970) reported that triglycerides are rapidly hydrolysed by the rumen microbes into free fatty acids and glycerol. The unsaturated fatty acids then undergo extensive hydrogenation and isomerisation before being used by the animal. The long chain fatty acids (largely stearic, palmitic and oleic acids) are absorbed only from the intestines.Rumen bacteria incorporated some of the long chain fatty acids into their cellular components.

Nutritional limitation to fat use is attributed to its effect on fermentation of the fibrous cell wall components in the rumen and to a lesser extent, on protein degradation. (Apori, 1984). Storry. (1972) stated that the effect of fat on fibre digestion depended on quality, quantity and physical form of fat being used. Andrews and Lewis. (1970) reported that fatty acid mixtures found in most common fats are associated with relatively high digestibility. Macleod and Buachanan. (1972) however reported that highly saturated fatty acids (as found in hydrogenated tallow) are poorly digested,

probably due to poor dispersion and hydrolysis in the rumen and solubilisation in the small intestine.

Devendra and Lewis. (1974) summarized various effects of fat on fibre digestion as absorption of fat on fibrous particles, by preventing attack of rumen microorganisms. Others are adverse effect on integrity of microbial cell walls, modification of rumen microbial population, especially reduction in cellulytic bacterial population it also reduced availability of calcium and magnesium iron as are result of formation of soaps. Macleod *et al.* (1972) reported that saturated fatty acids and blended tallow tend to depress fibre digestion to a greater extent than flaked tallow. There was no benefit from extending the preliminary period beyond 10days, provided that fat supplemented diets are acceptable from the start of the experiment. They attributed the reduction in the digestibility of fibre to the coating of feed particles with fat. The degree of saturation of dietary lipid was identified as a factor which could critically affect digestibility in ruminants (Devendra. 1977).

2.19.1 Effects of added fat on feed degradation

Fallow and Yellow grease (YG), both by-products, are typical fats used in the diets of lactating dairy cows. The gas technique was used to examine the effect of source and levels of added fat on gas production and rumen fermentation of a total mixed ration (Getachew *et al.,* 2000). Fatty acids in the form of triglyceride has no effect (when comprising up to 25% of the diet) on gas production, but fatty acids in the form of potassium salts (YG soap) significantly depressed gas production. In the animal, however, there is a limit to the amount of fatty acids that can be successfully fed, and this is lower than *in vitro*. The fatty acids in potassium salts are quickly available to microbes as free fatty acids in ruminal fluid. They have detrimental effects on microbial growth. In contrast, the fatty acids in the triglyceride form must be released through hydrolysis of the ester bond and therefore are available at a slower rate. Hydrolysis refers to breaking the chemical bond between the individual fatty acid and the glycerol backbone of the triglyceride. The effects of fatty acids on rumen fermentation are important because feeds with high levels of residual fat, for example rice bran produced in the production of white rice are commonly fed to ruminants.

2.20   MONITORING RUMEN MICROBIAL CHANGE

In addition to rate and extent of digestion, the gas production method can be used to study substrate related factors that influence microbial population in the rumen. This enables manipulation of microflora to increase the utilization of feeds through degradation of fiber and lignin, increasing the efficiency of nitrogen utilization or allowing the degradation of antinutritional and toxic components of feeds. Such controlled fermentation system could potentially be used with genetic engineering of plants to solve animal productivity problems. The technique is suitable for application of molecular based assays, such as polymerise chain reaction (PCR) and ribonucleic acid (RNA) – targeted oligonucleotide probes. It facilitates study and measure of rumen microbial growth, with the goal of increasing the efficient utilization of feeds and reducing environmental impacts. Gas technique, (Muetzel and Becker, 2003) was used in combination with ribosomel RNA targeted probes to measure the efficiency of microbial growth, when barley straw was supplemented with legume leaves.

Nutrient synchronization carbohydrate and nitrogen sources must be available simultaneously in order to maximize microbial growth. Ruminal ammonia concentrations can be influenced by the degradation rates of carbohydrates and nitrogen-containing compounds. For a given level of dietary protein, an increased rate of protein degradation enhances the runimal ammonia concentration while an increased rate of carbohydrate degradation decreases. Increased carbohydrate availability for fermentation promotes microbial growth and as a result less nitrogen is lost from the rumen in the form of ammonia-nitrogen (Getachew *et al.,* 2000a). The gas method offers an opportunity to study microbial requirement for nitrogen and carbohydrate to enable efficient fermentation activity and accumulation in the rumen. Using this technique, studies have been conducted to assess rumen microbial requirements for nitrogen when different types of carbohydrate sources are incubated.

2.21   ANIMAL FACTORS AFFECTING MICROBIAL FIBER DIGESTION

Animal and feeding systems can have a significant effect on the digestion of fibre. Notably, intake, dietary interactions, feeding strategies and feed additives will, to some degree, influence microbial growth and subsequent fiber digestion.

2.21.1 Intake

The extent of fibre digestion is the result of competition between the rates of digestion and passage and, as such, is not a static value. Rumen liquid and particulate turnover rates are positively correlated with intake. Thus, as intake increases, the digest flowing from the rumen will contain feed particles at earlier stages of digestion, and this will result in a lower dry matter digestibility (Russell *et al.,* 1992). Because the rate of degradation of structural carbohydrate is of the same order as passage rate, at high levels of intake the depression in digestibility of structural carbohydrate can be two to three times greater than that of the faster degrading, nonstructural carbohydrate. Although a high level of intake may depress ruminal fibre digestion, compensation occurs through increases in gross energy intake and hindgut digestion (Bourquin *et al.,* 1990).

2.21.2 Composition of dietary fiber

Rumen available energy normally limits growth of bacteria, and any additional organic matter fermented in the rumen. Hence changing the forage: concentrate ratio will probably increase microbial protein synthesis by providing more energy. Sniffen and Robinson (1987) suggested that the yield of bacteria was maximized with a forage content of 70% in the diet dry matter. Because structural carbohydrate-fermenting microbes are usually limited by a ruminal pH less than 6 (Hoover, 1986), the depression in fiber digestibility at higher inclusion rates of concentrate can most likely be explained by the rapid degradation of nonstructural carbohydrate. It is likely that fiber digestion will not be maximized at single forage: concentrate ratio; rather, it will depend on the various rates of digestion of structural and nonstructural carbohydrate supplied by the forage and the concentrate. This may be shown indirectly by the studies of Tamminga. (1981), who reported no relationship between forage: concentrate ratio and bacterial yield.

2.22 ASSESSMENT AND TECHNIQUES OF NUTRITIONAL QUALITY OF FEEDS THROUGH *IN VITRO* TECHNIQUES

The quality of forage is a limiting factor in the growth and yield of ruminants (Minson, 1990).The *in vitro* determination in quantifying intake and digestibility of feedstuff has

been found to be time consuming (Coelho *et al*; 1988; Carro *et al*; 1994) laborious, expensive and also require a large quantity of feed. This makes it better suitable for large scale evaluation. In recent times, major attempts were made in predicting intake and digestibility using laboratory procedures. However three major biological techniques to determine the nutritive value of feeds are available. These are;

1. Digestion with rumen microorganisms (Tilley and Terry. 1963)

2. Cell from fungal cellulose

3. *In situ* incubation of samples in nylon bags in the rumen. (Mehrez and Orskov. 1977).

Biological methods are more effective in this study since microorganisms and enzymes are more sensitive to factors influencing the rate and extent of digestion than are chemical methods. (Van Soest. 1994) The ability to correlate well with actually measured in vivo parameters and also a replicable efficient laboratory method determines a viable invitro technique.

Method (Tilley and Terry. 1963) was found convenient and widely used when large scale testing of feedstuffs is required. This method is usually adopted in most forage evaluation laboratories and involves two stages. Forages are subjected to 48hours fermentation in a buffer solution containing rumen fluid. Thus followed by 48hours of digestion with pepsin in an acid solution and the residue are treated with neutral detergent solution after 48 hours to deduce the true dry matter digestibility. Although this method has been extensively justified with *in vivo* values (Van Soest. 1994), it has several shortcomings. The method gives only one observation and unless lengthy and labour intensive, time course studies are made. The technique does not provide information on the kinetics of forage digestion. The residue determined destroys the sample and therefore a large number of replicates are needed. The method is therefore cumbersome to apply materials such as tissue culture samples or cell-wall fractions.

Both the rate and extent of disappearance of feed constituents have appraised the use of in-situ and in-sacco technique for many years (Mehrez and Orskov. 1977).The method provides a meaningful means of measuring rate of disappearance and potential degradability of feedstuff and feed constituents. In this technique however, only a small amount of forage samples can be assessed at any time and also requires at least

three fistulated animals to account for variations due to animals. Hence it is of limited value in laboratories undertaking routine screening of a large number of data samples, very laborious, time consuming and provides a limited number of data points (Cone, 1991). Therefore it requires a large number of samples; large error could result in values obtained at early stages of digestion due to a reduced weight loss and adherence of microbes to poor quality roughages at early stages. This can lead to higher weights and distortion of results

Orskor and Ryle. (1990) showed the possibility of underestimation of dry matter loss from the nylon bag technique at an early stage of incubation, which could be due to adherence of microbes. Tilley and Terry. (1963) established that the nylon bag technique overestimated fermentation. This extent was due to the carbohydrate composition of feeds, especially at short incubation times and this infers that it could be caused by a rapidly fermentable fraction which was lost from bags before it was fermented.

The relationship between rumen fermentation and gas production has long been established (Gatechew *et al*., 1998) The genesis however of rumen gas fermentation, technique began in the early 1940s (Quin, 1943).The idea of this method became a routine method of feed evaluation after the works of Menke *et al*., (1979) where a high correlation between gas production and in vitro apparent digestibility was reported.

2.23   ORIGIN OF INVITRO GAS

The incubation of feedstuff with buffered rumen fluid during *in vitro* results in carbohydrate fermentation to short chain volatile fatty acids (SCFA), gasses (mainly Co_2 and CH4) and microbial cells. The fermentation of carbohydrate to acetate, butyrate and propionate, results in gas production (Wolin, 1960;, 1992; Blummel and Orskor, 1993). Fermentation of protein produced relatively small gas (Wolin, 1960) as compared to carbohydrates, (Wolin, 1960 cited by Gatechew *et al.*, (1998). Gas production from fat fermentation is negligible (Menke and Steingas, 1988;; Gatechew *et al*., 1997). Incubation of 200mg of coconut oil, palm kernel oil and /or soybean oil, 2.0 and 2.8ml of gas were produced, while 200mg of ceasin and cellulose produced about 23.4ml and 80ml gas respectively (Menke and Steingass. 1988; Gatechew *et al.,* 1997). In the gas technique, gas produced is the indirect gas produced as a result of fermentation (CO_2 and CH_4) while the indirect gas produced is from the buffering of

the of SCFA (CO_2 released from the bicarbonate buffer) Such works (Blumel and Orskor; 1993) it was established that incubation of roughages with bicarbonate buffers produced about 50% of the total gas from buffering of the SCFA and the rest was generated from fermentation.

When a substrate is fermented to acetate and butyrate, gas is produced. A conclusion was drawn from Van Soest. (1994) that substrate fermentation to propionate yields gas only from buffering of the acid. This suggested that relatively lower production is associated with propionate production. It is also important to note that the type of substrate fermented influences the major proportions of different SCFA (acetate, propionate and butyrate) Blumel and Orskor. 1993s. Hence, the molar ratio of acetate to propionate was used to substantiate substrate related differences. Rapidly degradeable carbohydrates yield higher propionate as compared to acetae while slowly fermentable carbohydrates yield higher acetate when incubated (Gatechew *et al*., 1998).

The intrinsic characteristics of the carbohydrate fraction such as the proportion of starch or cellulose and the extent of lignifications of the cell wall also the intrinsic factor which is the supply of fermentable nitrogen required by micro-organisms to help them synthesis cellular constituents such as protein and nucleic acids required for growth, are one of the factor affecting the rate of fermentation of feed by rumen microbes, hence the production of gas.

Information (Hume *et al.,* 1970) had concluded that microbial protein was maximal with an ammonia concentration of 88mgN/1 but microbial protein flow was highest with an ammonia concentration of 133mg N/1.Allen and Miller. (1976) also informed that greatest flow of non-ammonia nitrogen through the abomasum was achieved when the ammonia concentration in the rumen was between 160 and 200mgN/1. Menke *et al*. (1979) using an in sacco method, observed that an ammonia concentration of 200mg N/1 were necessary to acquire the maximum rate of disappearance of barley DM in sheep. Similarly, Wallace. (1979) perceived an increase in *in situ* DM and CP degradation rates of barley grain accompanied by increased bacterial growth when rumen NH_3 concentration was increased from 97 to 214mg.

CHAPTER THREE

3.0   CHEMICAL COMPOSITION AND NUTRITIVE POTENTIAL OF OIL PALM
SLURRY FERMENTED WITH CASSAVA PEEL

3.1   INTRODUCTION

Meeting the nutritional needs of ruminants throughout the year is a major challenge facing livestock farmers in the tropics due to the seasonality of forages. Grazing animals have adequate amount of lush pasture to feed on in the wet season, which is usually low in nutritive value. The latter (dry) six months of the year are characterised by scarcity and lignifications of available forage with low protein content (Babayemi *et al*., 2010).

The rapid increase in population, the attendant infrastructural development and land acquisition by the government for other uses other than agricultural purposes that has gradually decreased the green area available for animal grazing during the rainy and dry seasons is another plaguing problem. Farmers are faced with the problem of escalating prices of conventional feedstuff, which consequentially increase the feeding cost of the animals. This various preponderances in livestock production, have made researchers sort out other alternative ways that could solve the problem of feed all year round like the browse plants, crop residues and agro industrial wastes and by products.

Agro industrial by products are derived from the processing of a particular crop or animal product usually by an agricultural firm (Dixon and Egan, 1987). They have been found to be cheaper and available in each locality of their production. The use of agro industrial by products allows us to convert materials that have limited application for use as human food. Jakanda (1975) stated that the utilisation of non-conventional feed stuffs by farmers and feed manufactures reduce cost of animal feed. Although they contain high levels of cellulose (Phengvilaysouk and Wanapat, 2008) hemicellulose, lignin as well as low levels of fermentable carbohydrates and poor quality protein (Adeleye, 1991), ruminant animals are unique in their ability to

synthesis high quality protein from non-protein nitrogenous (NPN) compounds through the action of micro-organisms present in their digestive tract.

Agro-industrial by products and crop-residues account for 70% of the total feed intake during the dry season (Adeoye, 1994). Diverse techniques like physical, biological and chemical means have been employed in upgrading or improving on their inadequacies, such as increasing the protein content, reduction of the cellulose, hemicelluloses and most of all the lignin content of feed for the animals to gain better access to available nutrients.

Oil palm slurry is an agro-industrial by product of oil palm industry obtained after the processing of the palm fruits (*Elaeis guineensis*). This by-product is a potential environmental pollutant (Davis and Briggs, 1998) and its utilisation as animal feed will minimise the environmental problem as well as provide energy for the animals (Webb *et al.*, 1977). Oil palm slurry contains 4.6% crude protein (Abu *et al*., 1984). This value could be higher or lower depending on the extraction method used (mechanical or manual). However, due to its high moisture content, Webb *et al*., (1978) suggested that oil palm slurry should be processed before its incorporation into feed.

Cassava peel is a waste generated after the tuber (root crop) has been peeled. Various varieties of cassava exist but the one peculiar to Africa is *Manihot esculenta.* The limitation to the use of cassava for feeding livestock is in its low protein content. The flour for example contains about 3.0% protein and the peels about 1.66% protein (Okpako *et al*., 2008).

Farmers usually feed cassava peels as a whole diet to their animals especially in South-Western Nigeria. This diet alone could lead to low performance and productivity due to its low content of protein and vitamins. Cassava peels and oil palm slurry are both obtainable all year round in most villages in South-West of Nigeria. Though oil palm slurry contains high moisture content, like palm oil, it also has the ability to increase acceptability, and reduce dustiness, supply vitamins and improve the texture of rations (Devendra, 1977). In addition, it is a strong detoxifier, which gives it the ability to reduce toxicity in a feed thereby making the feed more acceptable.

This study is aimed at determining the chemical composition of oil palm slurry (OPS) collected from four different locations. In addition, to access the suitability of

combining mixtures of oil palm slurry and cassava peels (CaP) fermented as feed resource for farmers in the South-Western Nigeria.

3.2   MATERIALS AND METHOD

3.2.1   Collection and processing of samples

Oil palm slurry was collected from four different oil palm processing locations in South-Western Nigeria.

Oyo state ------- Badeku jako

Osun state ------ Ikoyi

Ogun state ------ Mamu

Edo state ------- Nifor

Cassava peels (Cap) was collected from a cassava processing unit at Eleyele Ibadan, Oyo state and it served as control for this experiment. Samples of oil palm slurry and cassava peels collected were then oven dried at $105^{O}C$ until constant weight was recorded for dry matter determination. Each of the samples was thoroughly mixed and sub sampled. The dried samples were milled in a Thomas Willey laboratory mill fitted with 0.5mm mesh. The milled samples were kept in airtight bottles until required for chemical analysis.

3.2.3   Chemical Analysis

Crude protein, crude fibre, ether extract and ash content of the samples were determined using standard procedure of A.O.A.C (1995). Cell wall components consisting of Acid detergent fibre (ADF), Neutral detergent fiber (NDF) and Neutral detergent lignin (NDL) were determined using Van Soest (1994) method. Hemicellulose contents were estimated as the difference between NDF and ADF while cellulose was estimated as the difference between ADL and Hemicellulose.

3.2.3 Fermentation of the mixtures of Oil palm slurry (OPS) and Cassava peels (CaP)

Different ratios of fresh samples of Cassava peel (CaP) were fermented with a constant amount of oil palm slurry (OPS) as follows:

Diet A -1 kg of cassava peel + 1 liter of OPS

Diet B -2 kg of cassava peel + 1 liter of OPS

Diet C - 3 kg of cassava peel + 1 liter of OPS

Diet D - 4 kg of cassava peel +1 liter of OPS

Diet E -5 kg of cassava peel + 1 litre of OPS

Diet F -6 Kg of Cassava peel only (control)

Fermentation was carried out at these ratios in airtight cellophane bags for microbial action. Samples were fermented for five days and after which each diets were separately sun–cured. The proximate composition and the fibre fractions of the fermented mixtures were determined.

3.2.4 Statistical Analysis

Data were analysed using analysis of variance (SAS, 1999). Significant means were separated using the Duncan's Multiple range test. Experimental model of the design was: $Y_{ij} = u + a_i + E_{ij}$ Where

Y_{ij} = Individual observation

U = General mean of population

a_i = treatment effect

E_{ij} = Composite error effect

Plate 1:   **Clarified Oil palm slurry from a palm oil processing site at Mamu (Arrow is indicating slurry)**

Plate 2:   **Relatively drained palm oil slurry in basket.**

3.4   RESULTS

3.4.1   Proximate composition of oil palm slurry collected from four different locations   in South –Western zones of Nigeria.

The results of the dry matter and proximate composition of Oil palm slurry and Cassava peel are presented on Table 1. Results revealed significant differences in proximate composition of oil palm slurry collected from different locations in South-Western Nigeria. A significant $p < 0.05$ value of 43.20 Dry matter (DM) was obtained from Mamu while collection from Nifor had the least significant value of 6.03. The Crude protein (CP) values ranged from the highest value of 8.15 for Mamu to 6.19 for Nifor. Significant ($p < 0.05$) observation was obtained within locations for Crude fibre (CF) with values of 10.21, 9.15 and 8.50 recorded for Badeku, Nifor and Ikoyi respectively. Significantly low value ($p < 0.05$) of 8.00 was obtained for Mamu. The least values obtained for ash ($p < 0.05$) 7.00 was recorded for Badeku and highest (10.00) for Mamu. All the locations were significantly different ($p < 0.05$) for Ether extract (EE) recording values of 35.00, 39.20, 32.27 and 32.01.

TABLE 1: Proximate composition (g/100gDM) of Oil palm slurry from different locations in the South-West Zone of Nigeria.

	Mamu	Ikoyi	Badeku	Edo	SEM
Dry matter	43.20a	16.61b	8.20c	6.03bc	0.06
Crude protein	8.15a	7.00b	7.31b	5.15c	0.08
Crude fibre	8.00c	8.50cc	10.21a	9.15b	0.06
Ash	10.00a	8.11b	7.00c	7.10c	0.01
Ether extract	35.00b	39.20a	32.27c	32.01c	0.01

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a, b and c means on the same row with different superscripts are significant ($p < 0.05$)

3.42 CELL WALL FRACTIONS OF OIL PALM SLURRY COLLECTED FROM FOUR DIFFERENT LOCATIONS IN SOUTH-WESTERN NIGERIA

The cell wall fraction results of oil palm slurry collected from four different locations in South- Western Nigeria are represented on Table 2. There were significant variations among all the parameters observed for cell wall fractions. Value for Mamu was least 25.80 for Acid detergent fibre (ADF) followed by Ikoyi 28.21 and the highest value of 31.00 was recorded for Badeku. Samples collected from Edo state recorded highest values of 50.41 for Acid Detergent Lignin (ADL) while Mamu recorded least value of 43.25. Significantly varied values of 45.28, 49.22, 53.54 and 47.08 respectively, were obtained for Mamu, Ikoyi, Badeku and Edo states for Neutral Detergent Fibre (NDF). OPS collection from Mamu revealed significantly $p<0.05$ varied values of 23.77 and 19.48 for cellulose and hemicellulose contents while Badeku recorded significant $p<0.05$ values of 22.54 and 27.87 for both cellulose and hemicellulose contents.

TABLE 2:   The Fibre Fractions of Oil Palm Slurry collected from four locations in South-Western Nigeria

Parameters	Mamu	Ikoyi	Badeku	Edo	SEM
Acid detergent fibre	25.80^d	28.21^b	31.00^a	26.45^c	0.02
Acid detergent lignin	43.25^d	46.26^b	50.41^a	45.00^c	0.01
Neutraldetergent fibre	45.28^c	49.22^b	53.54^a	47.08^b	0.01
Cellulose	23.77^d	25.22^b	27.87^a	24.37^c	0.02
Hemicellulose .	19.48^d	21.01^b	22.54^a	20.63^c	0.03

a, b, c and d means on the same row with different superscripts are significant (p<0.05)

3.4.3 PROXIMATE COMPOSITION AND CELL WALL CONSTITUENTS OF CASSAVA PEEL FERMENTED AND UNFERMENTED

The proximate composition and cell wall constituents of cassava peel unfermented and fermented is shown on Table 3. The analysis was done in triplicates and values obtained were not significantly different hence average values were recorded. Cassava peel unfermented values were; 73.63 Dry matter (DM), Crude protein (CP) 5.50, Crude fibre (CF) 21.02, Ash 8.50, Ether extract (EE) 23.20, Acid detergent fibre (ADF) of 43.21, Neutral detergent fibre (NDF) of 59.00, Acid detergent lignin (ADL) of 33.46 hemicellulose of 15.79 and cellulose content of 17.67. Fermented Cassava peel results revealed Dry matter (DM) of 68.42, Crude protein (CP) of 6.50, Crude fibre (CF) of 20.36, Ash content of 6.90, Ether extract (EE) of 28.00, Acid detergent fibre (ADF) of 58.52, Acid detergent lignin (ADL) of 31.00, and Neutral detergent fibre (NDF) of 40.45, Cellulose 12.95 and Hemicellulose content 18.05.

TABLE 3:   Proximate composition of unfermented and fermented Cassava peel

Parameter	Unfermented Cassava peel	Fermented Cassava peel
Dry matter	73.63	68.42
Crude protein	5.50	6.50
Crude fibre	21.02	20.36
Ash	8.50	6.90
Ether extract	23.20	28.00
Acid detergent fibre	43.21	40.45
Neutral detergent fibre	59.00	58.52
Acid detergent lignin	35.46	31.00
Cellulose	17.67	12.95
Hemicellulose	15.79	18.05

Plate 3:   **Heap of cassava peel at a garri processing site at Eleyele.**

3.4.4 DRY MATTER AND PROXIMATE COMPOSITION OF FERMENTED GRADED MIXTURES OF OPS AND CaP

The dry matter, proximate composition and cell wall fractions of graded fermented mixtures of Oil palm slurry and Cassava peel are represented in Fig 2. The results of this study showed that Diet C had the least significant $p>0.05$ value (52.27) for DM while Diet A recorded the highest value of (71.04). Diet B, also observed significant values of 68.47 while diets D and E were not significantly varied. All the graded mixtures significantly varied $p<0.05$ for (CP). Diet A obtained the least value of 9.10 and Diet C recorded the highest value of 14.15, A drastic reduction in (CF) was recorded from 19.20 for Diet A, 18.96 for Diet B, 14.25 for Diet C. Diets D and E values were 17.00 and 18.04 respectively, while (Diet F) recorded the highest value of 20.36. The results also showed that there was a significant $p<0.05$ reduction in the Ether Extract (EE) values from 20.21 for Diet A and 20.47 Diet E. Significant $p<0.05$ increases 30.21, 36.00, 33.40 and 31.75 were recorded for Diets B, C, D and F respectively. Ash values of 3.20 was least for Diet C.

3.4.3 CELL WALL COMPONENTS OF FERMENTED GRADED MIXTURE OF OPS AND CaP.

The Acid Detergent Fibre (ADF) showed that the mixture of Diet A recorded a high significant $p< 0.05$ value of 22.00, least value of 16.50 was observed for diet C, while Diets D and E were not significantly $p>0.05$ varied. Similar decreasing trend in variation $p<0.05$ was observed for Neutral Detergent Fibre (NDF) from diets A to E, the highest value of 35.00 was recorded for Diet A, while Diet C revealed a value of 27.00. Diet A observed highest value of 37.35 Acid Detergent Lignin (ADL) while the least value of 31.25 was revealed for Diet C and Diets B, D and E also recorded significant $p<0.05$ variations of 34.21, 37.05 and 36.42 respectively. Significant $p<0.05$ observations were obtained for diets A and B with values of 24.35 and 21.66 respectively. Diets C obtained the least value of 20.75 for Cellulose contents. The least observation of 10.50 was recorded for Diet C while the highest value of 13.75 was obtained for Diet E in their Hemicellulose contents.
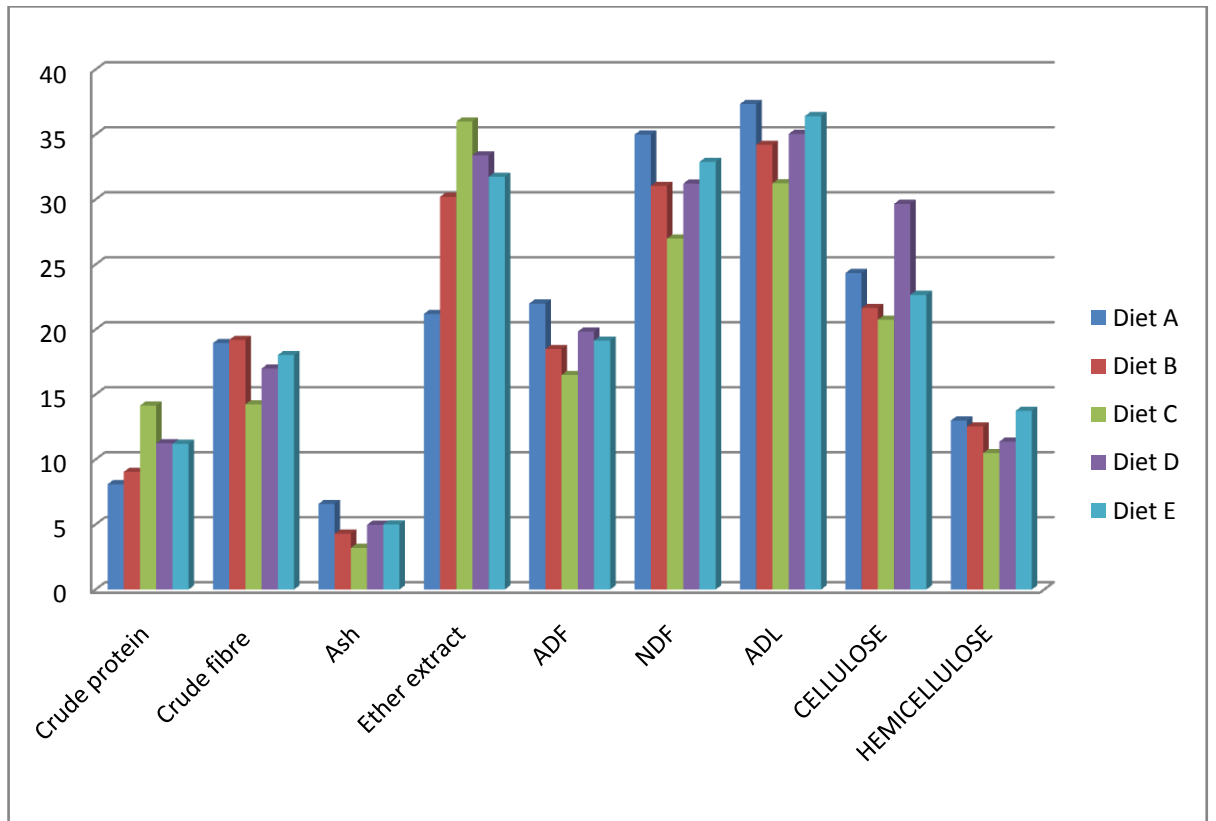
Fig 2: Chemical composition and fibre fraction of graded fermented mixture of OPS and CaP

3.5   **DISCUSSION**

Analyses of samples of Oil palm slurry from four different locations in the South-Western Nigeria revealed that samples from Mamu had the highest Crude protein, low crude fibre. Protein is required for normal body growth, repairs and maintenance (Okpako *et al.,* 2008). The CaP and OPS fermented mixtures had CP values higher than OPS collected from Mamu. This increase could be due to the oil content which acted as a substrate for the possible secretion of some extracellular enzymes such as amylase and cellulase into the CaP by the OPS in an attempt to make use of the cassava starch as carbon source.

Another reason could be the increased growth and proliferation of microorganisms in form of single cell protein, which accounted for the increase in the protein content of the CaP with OPS. This result is in accordance with the established results by other authors (Adebiyi 2006; Okpako *et al.,* 2008; Babayemi 2010) that fermentation reduces the CF and increases the CP of a feed. Although there were variations (P<0.05), that could be attributed to the different levels of CaP inclusion ratios in each diet at a constant OPS. Jones and Porter. (1998) observed that the inclusion rate of oil to a diet could affect microbial activity and the release of protein. This could be responsible for the least CP value of (9.10) in diets compared to Diet C, which recorded the highest CP of (14.15). Diet A had the highest concentration of oil, which might have suppressed microbial activity. Diet C might have had adequate proportion of oil to CaP, which probably favoured microbial activity.

These changes may also be attributed to fermentation that occurred in the mixtures of OPS and CaP. Fermentation encourages the growth of anaerobic microorganisms and aid the conversion of nitrogen and carbon to true protein (Ward *et al*., 1975). Campbell and Laherrere (1998) also stated that fermentation gives desirable biochemical changes and significant modification of food quality.

Benefits of fermentation according to Steinkraus (1995) include fortification of diet and the removal of toxins. The residual oil contained in the slurry is also an added advantage to the rate of fermentation, since oils and lipids have been found essential components of many fermentation media (Adebiyi, 2006). This can best explain why protein production was highest (at 3%) after fermentation as the level of cassava peels

increased. This result was close to the findings of Wanapat *et al.*, (2005) that CP was significantly improved by supplementation at 4% oil inclusion only. There was also a reduced crude fibre content across the treatments due to multiplication of microorganisms resulting in the breakdown of the polysaccharides to monosaccarides. Although the extent of break down varied significantly. The result conformed with the findings of Mccaskey and Anthony. (1979) that fermentation brings about improvement in nutrient composition, acceptability and convenience in the use of silage feeding equipment.

The ash content of a feed sample is an indication of mineral composition. In this study, reduced ash contents were recorded for diets (B-E) as shown in Fig 2. This suggests that oil in the mixtures aided microbial fermentation thereby reducing the ash contents. A reduced ash content recorded for diet A was statistically similar to that obtained for diet F which might have been an indication of a reduced microbial activity in both diets. This result disagreed with the conclusions of Oboh and Akindahunsi 2003; Okpako *et al.,* 2008 and Babayemi 2010 that fermentation increased the ash content of cassava products.

High NDF could result in low intake while high ADF may engender low digestibility (Babayemi *et al*., 2010). Judging by the results in Tables 1, 2, 3 and that obtained, in Fig 2, it could be concluded that the features of fermentation and break down of the fibrous cell wall components of the Diets, reduced the ADF and NDF values. However, this effect of fermentation was least observed for Diet A which had recorded the highest values due to the highest concentration of oil (Jones and Porter, 1998). Diet C had the least values of NDF and ADF suggesting its high potential digestibility among other diets.

CHAPTER FOUR

4.0 CHEMICAL COMPOSITION AND IN VITRO FERMENTATION PARAMETERS AND CHARACTERISTICS OF FERMENTED GRADED MIXTURES OF OIL PALM SLURRY AND CASSAVA PEEL BY WAD SHEEP

4.1 INTRODUCTION

The rain forest zones of Nigeria are characterised by the first six months of lush, green and fresh grass for grazing ruminants, while low quality dry grass is usually a complementary problem of the last six months of the year. Makkar *et al.* (1994) described the shortage of forage in Nigeria as a major constraint to ruminant production. Earlier remarks of Babayemi *et al.*, (2003) considered the other six months of the year as a time when forage is scarce. More so, the dry period, is characterised by standing hay and low quality feed that eventually culminates in growth retardation of the animals.

There is therefore, the need to source for more avenues to make feed available to the animals during the dry season. Although tree crops and many browse plants such as *Leuceanea leucocephala* and *Moringa olifera,* provide a better alternative yet it is highly important to source for more, to make choices readily available to both the animals and the farmer.

Agro-industrial by-products are other possible alternatives. These industrial wastes are cheap, readily available in their locality of production. At times, they constitute social menace and environmental hazards if not utilized. Agro-industrial by-products include palm kernel meal, cassava seivate, bean seed hull and oil palm slurry.

Oil palm slurry is the effluent of palm oil extraction. Its production rate is at a ratio of 2:3 litres of finished oil (Olie and Teng, 1972). Essentially, oil palm slurry is an emulsion containing 4-5% solids, 0.5-1% residual oil and 95% water (Apori, 1986). Webb *et al. (*1977) suggested that Oil palm slurry should be combined with other feedstuffs for meaningful results to be obtained.

Cassava peel is also an agro-industrial by product obtained from cassava processing plant. It constitutes a major source of livestock feed ingredient especially in the South

Western geopolitical zone of Nigeria where it is intensively cultivated. Okpako *et al*., (2008) asserted that the major limitation to the use of cassava peel for feeding livestock is in its low protein content.

Feed consumption by animal particularly, the ruminant is largely dependent on the acceptability, rate of feed degradation in the rumen and the amount of energy that could be supplied by the feed (Van Soest, 1995).

In vitro method of feed evaluation has been validated over time and adjudged as one of the means of evaluating feed degradation by animals. Reports (Menke and Steingass., 1988, Coelho *et al*., 1988; Carro *et al.,* 1994) have rated the process as one of the most accurate methods of estimating the quality of feedstuffs. The process is less expensive, simple and replicable. The incubation of feedstuff with buffered rumen fluid during *in vitro* studies in fermentation results in short chain volatile fatty acids (SCFA), gasses (mainly CO_2 and CH_4) and microbial cells.

The objective of this study was to determine the chemical composition and *in vitro* fermentation characteristics of graded mixtures of Oil palm slurry (OPS) and Cassava peel (CaP) by WAD sheep.

4.2   MATERIAL AND METHOD

4.2.1   Experimental diets :

Diet A -1 kg of cassava peel + 1 litre of OPS

Diet B -2 kg of cassava peel + 1 litre of OPS

Diet C - 3 kg of cassava peel +1 litre of OPS

Diet D - 4 kg of cassava peel +1 litre of OPS

Diet E -5 kg of cassava peel + 1 litre of OPS

Diet F -6 Kg of Cassava peel only (control)

4.2.2   Analytical procedure

4.2.3   Chemical Composition

Proximate composition of the graded mixtures of OPS and CaP was analysed in triplicates by the standard procedure of (A.O.A.C 1995). The fibre fractions were determined by Van Soest method (1995).

4.3   *In vitro* gas production of fermented mixtures of Oil palm slurry and Cassava peel.

The graded levels of each mixture (from Diet A, Diet B, Diet C, Diet D, Diet E and Diet F control) were oven dried at $105^{o}C$ until constant temperature was attained. Two hundred milligram (200mg) of each milled sample was weighed into 120ml calibrated syringes with pistons lubricated with Vaseline. A buffered mineral solution was prepared consisting of ($NaHCO3 + NaHPO_4 + KCl + NaCl + MgSO_4 . 7H_2O + CaCl_2 + 2H_2O$ (1:2, v/v) and stirred at $39^{0}C$ under continuous gassing with carbon dioxide (CO_2). Rumen fluid was collected from three female WAD sheep that were previously fed concentrate consisting 20% corn bran, 25% wheat offal, 20% palm kernel cake, 10% groundnut cake, 4% oyster shell, 0.5% common salt, 0.25% fish meal and 0.25% grower" premix.

The liquor was collected into a pre-warmed thermos flask and was later filtered through a four layer cheese cloth, gassing with CO_2. Thirty (30ml) of buffered rumen liquor fluid (inoculum) was pumped into a syringe containing sample. The syringes were placed in an incubator at $39^{0}C$. Gas production rate was recorded at 3, 6, 9, 12, 15, 18, 21 up to 96 hours and each syringe was gently swirled after reading. At the end of the 96 hour incubation the average volume of gas produced from the blanks was deducted from the volume of gas produced per sample.

The volume of the gas produced was plotted against the time, and the gas production characteristics were estimated using the equation $Y= a + b^{(1- e-ct)}$ as described by Orskor and Mc Donald (1979) where:

Y= volume of gas produced at "t"

a= intercept (gas produced from insoluble fraction)

c = gas production rate constant for the insoluble fraction (b)

t = incubation time

Metabolisable energy ME, (MJ/Kg DM) and Organic Matter Digestibility (OMD %) were estimated.(Menke and Steingass, 1988) and short chain fatty acids (SCFA) were calculated (Getachew *et al*, 1999)

ME= 2.20 + 0.136*GV + 0.057*CP + 0.0029*CF

OMD = 14.88 + 0.889*GV + 0.057*CP + 0.0029*CF

SCFA = 0.0239*GV − 0.0601

Where GV, CP, CF and XA are net gas production (ml/200 mg DM), crude protein, crude fibre and ash of the incubated samples respectively.

4.3.1   Statistical analysis

Parameters obtained were subjected to analysis of variance procedure (ANOVA) using SAS package of (1999). Significant means were separated using Duncan multiple range test of same package.

Experimental model: $Yij = u + i + Eij$

Yij = individual observation

U = general mean of the population

i = treatment effect

Eij = composite error effect

4.4   RESULTS

4.4.1   *In vitro* gas parameters of fermented graded mixtures of OPS and CaP at 24, 60 and 96 hrs incubation period

In vitro gas production over a period of 96 hrs is represented in Fig: 3. Gas production was consistently high in Diet C, followed by Diet F compared with other diets. Gas production in diet A was higher than diet D until equilibrium was attained at 60 hr, after which diet C attained the highest at 96 hr.Gas production as reported by other authors is an indication of diet fermentation by the microbial population (Van Soest, 1982).
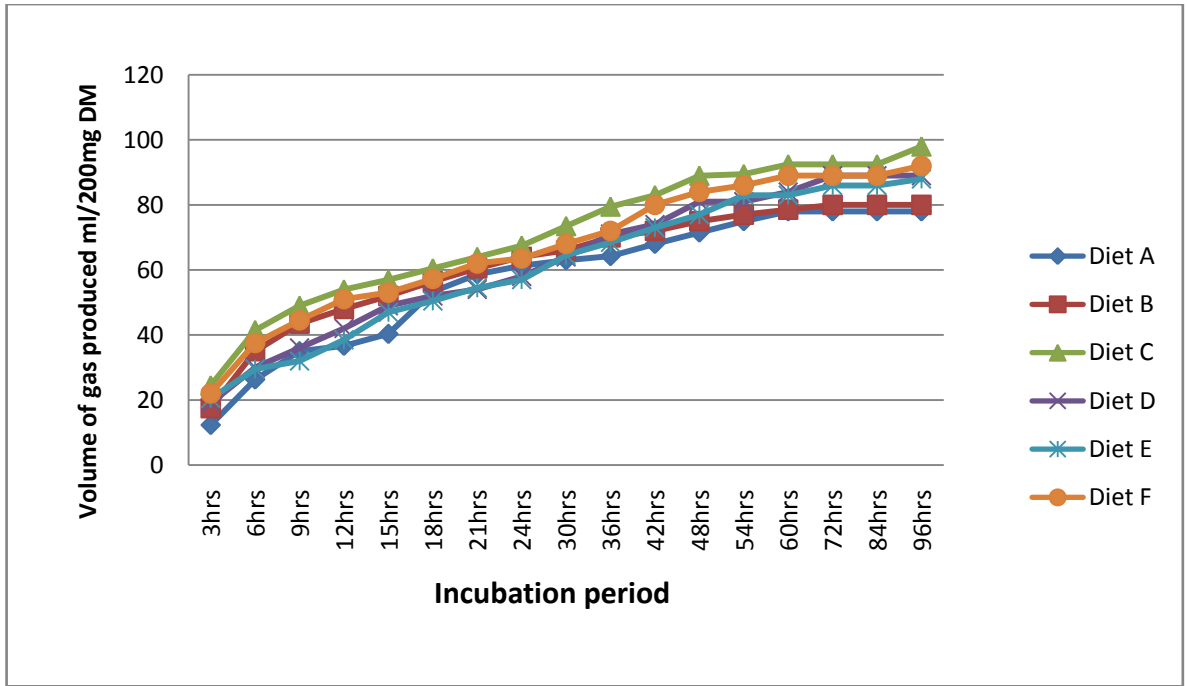
Fig 3: *In vitro* gas parameters of fermented graded mixtures of OPS and CaP at 24, 60 and 96 hrs incubation period

4.4.2. *In vitro* fermentation parameters of fermented graded mixtures of oil palm slurry and cassava peel at 24 hours incubation period

The results of *in vitro* fermentation characteristics at 24 hours are presented in Table 4. The values obtained for the insoluble but degradable fraction (b), significantly varied (p<0.05) for all diets, with the highest value (48.00 ml) for Diet C and the least value (39.33 ml) for diet A. The value obtained for the potential degradability (a+b) was not significant (p>0.05) for all diets. Rate of degradation (c) increased with increasing level of Cassava peel (CaP); from Diets A-C, the least value of (0.0553 h^{-1}) recorded for diet A while the highest value (0.0796 h^{-1}) was record for diet C. However, variations in diets E and F was not significant (p>0.05). Time of degradation (t) and effective degradability (y) showed no significant variations (p>0.05) in all the diets.

TABLE: 4   *In vitro* gas production parameters of fermented graded mixtures of oil palm slurry and Cassava peel at 24hrs incubation period.

Fermentation Characteristics	Diet A	Diet B	Diet C	Diet D	Diet E	Diet F	SEM
B	39.33^{ab}	46.00^{c}	48.00^{a}	43.50^{d}	41.00^{e}	47.21^{b}	1.17
a+b	60.33	57.50	62.50	62.00	56.00	64.24	1.50
C	0.0553^{e}	0.0633^{d}	0.0796^{a}	0.0683^{ab}	0.0671^{c}	0.0770^{b}	0.03
T	6.00	6.00	6.00	6.00	6.00	6.00	0.01
Y	37.33	35.00	37.60	35.00	36.00	36.12	1.16

a, b, c, d, e Means along the same row with different superscripts are significant $(p<0.05)$.

Insoluble degradable fraction (b), potential degradability (a+b), rate of degradation (c), time (t) and effective degradability (y)

Diet A- 1 litre Oil palm slurry + 1kg cassava peel

Diet B - 1 litre Oil palm slurry + 2kg Cassava peel

Diet C - 1 litre Oil palm slurry + 3kg Cassava peel

Diet D - 1 litre Oil palm slurry + 4kg Cassava peel

Diet E -1 litre Oil palm slurry + 5kg Cassava peel

Diet F - 6kg Cassava peel

SEM=Standard Error of Mean

4.4.3 *In vitro* fermentation parameters of fermented graded mixtures of oil palm slurry and cassava peel at 60 hours incubation period

The in vitro fermentation parameters of fermented graded mixtures of Oil palm slurry and Cassava peel at 60 hours of incubation is presented in Table 5. In this study, the value of (b) was significant ($p<0.05$) in all the diets, from 64.50 ml (diet A) to the highest 78.50 ml (diet C) although no particular trend was observed. The (a+b) also followed the same pattern within diets and the highest (98.50 ml) value was record for diet C, while the least value (73.50 ml) was obtained for diet A. The observed value of (c) was significantly higher ($p<0.05$) for Diet C ($0.049h^{-1}$). There were no significant differences ($p<0.05$) in values within diets, A, E and F. The values were (0.039 h^{-1}, 0.039 h^{-1} and 0.041 h^{-1}) respectively

TABLE : 5 *In vitro* gas production parameters of fermented graded mixtures of Oil palm slurry and Cassava peel at 60hrs incubation period.

Fermentation Characteristics	Diet A	Diet B	Diet C	Diet D	Diet E	Diet F	SEM
B	64.50^e	70.41^c	78.50^a	74.00^b	67.00^d	69.21^{bc}	0.650
a+b	73.50^e	96.27^b	98.50^a	93.50^c	86.00^d	90.42^{bc}	1.840
C	0.039^d	0.043^c	0.049^a	0.045^b	0.039^d	0.041^d	0.001
T	6.00	6.00	6.00	6.00	6.00	6.00	0.000
Y	32.00	34.00	33.00	32.00	34.50	34.00	0.006

a,b,c,d,e Means along the same row with different superscripts are significant ($p<0.05$)

Insoluble degradable fraction (b), potential degradability (a+b), rate of degradation (c), time (t) and effective degradability (y)

Diet A - 1 litre Oil palm slurry + 1kg cassava peel

Diet B - 1 litre Oil palm slurry + 2kg Cassava peel

Diet C - 1 litre Oil palm slurry + 3kg Cassava peel

Diet D - 1 litre Oil palm slurry + 4kg Cassava peel

Diet E - 1 litre Oil palm slurry + 5kg Cassava peel

Diet F - 6kg Cassava peel

SEM=Standard Error of Means

4.4.4 *In vitro* **fermentation parameters of fermented graded mixtures of Oil palm slurry and Cassava peel at 96 hours incubation period**

The *in vitro* fermentation parameters of fermented graded mixtures of Oil palm slurry and Cassava peel at 96 hours incubation period is shown in Table 6. At 96 hrs, values obtained for (b) were not significant in all diets. The values of (a+b) were significantly lower (p<0.05) in diet E with the value of 83.60 ml compared to higher value of 94.67 ml for diet C. No significant differences were observed for (c) among diets A, B, E and F, but diets C and D varied significantly (p<0.05) with the values of 0.036 h^{-1}and 0.026 h^{-1} respectively. The variation in the value for time (t) was not significant in all diets. The value of (y) of the diets varied significantly (p<0.05) with highest value of 57.00 recorded for diet C, while the lowest value of 26.34 was obtained in diet F.

TABLE 6 : *In vitro* gas production parameters of graded fermented mixtures of Oil palm slurry and Cassava peel at 96hrs incubation period.

Fermentation Characteristics	Diet A	Diet B	Diet C	Diet D	Diet E	Diet F	SEM
B	71.00	69.50	72.67	74.00	74.63	74.01	2.38
a+b	85.50^e	92.26^b	94.67^a	90.00^{ab}	83.60^c	89.24^d	3.56
C	0.038^a	0.043^a	0.036^b	0.026^c	0.042^a	0.041^a	0.002
T	6.00	18.00	9.00	6.00	14.00	12.00	2.36
Y	35.00^c	38.15^{ab}	57.00^a	30.00^d	48.33^b	26.34^e	2.26

a ,b ,c ,d ,e Means on the same row with different superscripts are significant ($p < 0.05$)

Insoluble degradable fraction (b), potential degradability (a+b), rate of degradation (c) time (t), effective degradability (y)

Diet A - 1 litre Oil palm slurry + 1kg cassava peel

Diet B - 1 litre Oil palm slurry + 2kg Cassava peel

Diet C - 1 litre Oil palm slurry + 3kg Cassava peel

Diet D - 1 litre Oil palm slurry + 4kg Cassava peel

Diet E - 1 litre Oil palm slurry + 5kg Cassava peel

Diet F - 6kg Cassava peel

SEM=Standard Error of Means

4.5.   Graded mixtures of Oil palm slurry and Cassava peel at 24, 60 and 96 hrs incubation period on pH using *in vitro* technique

The pH of the fermented graded mixtures of Oil palm slurry and Cassava peel at 24, 60 and 96 hours of incubation represented in Table 7. The pH values varied significantly (P<0.05) only at 60 hours and increased with increasing level of CaP. The highest value of 6.66 was recorded for diet E, while diet C recorded the least value of 6.21. There were no significant variations in values obtained in all the diets at both 24 and 96 hours of incubation.

TABLE 7: The pH of fermented graded mixtures of Oil palm slurry and Cassava peel fermented at 24, 60 and 96hrs.

Incubation Periods	Diet A	Diet B	Diet C	Diet D	Diet E	Diet F	SEM
24	6.45	6.37	6.37	6.34	6.37	6.34	0.03
60	6.50^c	6.50^c	6.21^d	6.81^b	6.91^a	6.60^{ab}	0.07
96	6.70	6.62	6.61	6.59	6.75	6.50	0.04

a,b,c,d Means along the same row with different superscripts are significant $p < 0.05$

Diet A -1 litre Oil palm slurry + 1kg Cassava peel

Diet B -1 litre Oil palm slurry + 2kg Cassava peel

Diet C -1 litre Oil palm slurry + 3kg Cassava peel

Diet D -1 litre Oil palm slurry + 4kg Cassava peel

Diet E - 1 litre Oil palm slurry + 5kg Cassava peel

Diet F - 6kg Cassava peel

SEM=Standard Error of Means

4.6. ***In vitro gas*** **characteristics of fermented graded mixtures of Oil palm slurry and Cassava peel at 24, 60 and 96 hrs of incubation**

The in vitro characteristics of fermented graded mixtures of Oil palm slurry and Cassava peel at 24, 60 and 96 hours are represented in Table 8. In this study, significant differences ($p < 0.05$) were observed in the gas volume (GV) at 24 hours and the highest value was in diet C (67.67), least value (52.14) was recorded for diet D. A similar trend was observed for Metabolisable Energy (ME), Organic Matter Digestibility (OMD %) and Short Chain Fatty Acids (SCFA,µmol) with highest values of 11.42, 82.98 and 1.56 respectively in diet C, while least values of 8.83, 72.17 and 1.27 respectively were obtained for diet A.

TABLE 8: *In vitro* gas characteristics of fermented graded mixtures of Oil palm slurry and Cassava peel at 24 hours incubation period

Parameter	Diet A	Diet B	Diet C	Diet D	Diet E	Diet F	SEM
GVmol/200mgDM	52.14^e	55.71^{ab}	67.67^a	53.18^d	54.38^c	63.71^b	0.09
ME MJ/kg DM	8.83^e	9.04^d	11.42^a	9.47^c	9.76a^b	10.94^b	0.08
OMD %	72.17^d	73.85^c	82.98^a	69.82^e	71.57^{bc}	79.85^b	0.03
SCFA mmol	1.27^e	1.30^d	1.56^a	1.33^c	1.37^{ab}	1.46^b	0.01

a,b,c,d,e Means along the same row with different superscripts are significant ($p<0.05$)

GV= Gas Volume (ml/200mgDM)

ME=Metabolisable energy(MJ/Kg DM)

OMD=Organic Matter Digestibility (%)

SCFA=Short Chain Fatty Acids SCFA(mmol)

Diet A -1 litre Oil palm slurry + 1kg Cassava peel

Diet B -1 litre Oil palm slurry + 2kg Cassava peel

Diet C -1 litre Oil palm slurry + 3kg Cassava peel

Diet D -1 litre Oil palm slurry + 4kg Cassava peel

Diet E -1 litre Oil palm slurry + 5kg Cassava peel

Diet F - 6kg Cassava peel

SEM=Standard Error of Means

4.7. Ammonia nitrogen concentration of fermented graded mixtures of OPS and CaP at 24, 60 and 96 hours incubation period

The ammonia nitrogen concentration of graded fermented mixtures of Oil palm slurry and Cassava peel at 24, 60 and 96 hours of incubation are shown in Table 9. The results revealed that at 24 60 and 96 hours, significant differences ($p < 0.05$) were obtained for all the diets at all observed hours with diet C recording the highest values of 10.50, 12.10 and 13.60 respectively while the least recorded values were 4.0, 6.5 and 6.9 at 24, 60 and 96 hours.

TABLE 9: *In vitro* Ammonia nitrogen concentration of fermented graded mixtures of Oil palm slurry and Cassava peel at 24, 60 and 96hrs incubation period.

Incubation Periods	Diet A	Diet B	Diet C	Diet D	Diet E	Diet F	SEM
24	4.0^e	6.2^d	10.5^a	7.8^c	$7.1b^c$	8.4b	0.02
60	6.5^e	7.2^d	12.1^a	8.5^c	9.0^b	9.2b	0.01
96	6.9^e	8.1^d	13.6^a	9.7^c	9.9^c	10.0b	0.03

a, b, c, d, e Means along the same row with different superscripts are significantly different $p < 0.05$

Diet A -1 litre Oil palm slurry + 1kg Cassava peel

Diet B -1 litre Oil palm slurry + 2kg Cassava peel

Diet C -1litre Oil palm slurry + 3kg Cassava peel

Diet D -1litre Oil palm slurry + 4kg Cassava peel

Diet E -1litre Oil palm slurry + 5kg Cassava peel

Diet F- 6kg Cassava peel

OPS - Oil palm slurry

CaP -   Cassava peel

SEM=Standard Error of Means

4.8   **DISCUSSION**

4.8.1   *In vitro* **gas production parameters of fermented graded mixtures of OPS**
             and CaP at 24, 60 and 96 hours

Proximate composition is usually the basic and the most common form of feed
evaluation by animal nutritionists. A more reliable technique of estimating livestock
feed is *in vitro* gas fermentation (Menke and Steingas, 1988). Although the two
methods are independent of each other, however, they are interrelated. Gas production
is an indication of microbial degradability of samples (Babayemi *et al.,* 2004b, Fievez
et al., 2005)

 At 24 hours, the insoluble but degradable fraction (b), in diet C with OPS and CaP in
the ratio 1:3, could be attributed to the high amount of Crude Protein in the mixture.
This facilitated high rate of microbial activity by supplying the required nitrogen for
their cellular protein synthesis as established by Roger *et al.,* (1977). The highest value
of 48.00 ml obtained for this diet, could also be connected with the adequate ratio of
oil to cassava peel in the diet compared to other diets. This is in agreement with the
findings of Jones and Porter (1998) who reported that adequate combination of oil and
carbohydrate would improve fermentation. The high concentration of oil to cassava
peel in diet A inhibited the activities of microorganisms, hence the slow rate of gas
production. This assertion was corroborated by the work of Palizdar *et al*., (2011) in
which it was reported that saturated fatty acids had more inhibitory effect on rumen
microbial ecosystem.

Since gas production is dependent on the relative proportion of soluble, insoluble but
degradable and undegradable particles of diets, mathematical description of gas
production profiles allows evaluation of substrate and fermentability of soluble and
slowly fermentable components of feeds (Getachew *et al.,* 1998). The values of a+b, c,
and y in the diet C were similar to diet F, but significantly higher ($p<0.05$) than other
diets. The implication of this is that, diet C, which had ratio 1:3 (OPS: CaP) would
enhance optimal degradability *in vivo*. The values of 'b' obtained in this study (68.67
– 75.25) were higher than those reported for dry matter (DM) degradation of some
tropical legumes and grasses (Ajayi *et al.,* 2007) and the values of 9.5-32.0 ml/200 mg
DM reported for some crop residues (Babayemi *et al.,* 2009).

The potential degradability (a+b) of a diet depicts the level at which the diet could be degraded if it were in the actual rumen of the animal (*in vivo*). This largely depends on how much of the fibre fractions (ADF and NDF) have been broken down for easy access of the microbes to the nutrients available in the diet. At 24 hrs, there were no significant variations among the diets, which suggest that early hours of incubation and oil inclusion could not be effective for the different diets including the control (diet F). A corroborative result was obtained elsewhere (Jones and Porter. 1988) which established that the time of oil inclusion was a determinant in facilitating degradability in the rumen.

The potential degradability (c) increased down the treatments except diets D&E, which could be attributed to the different levels of oil inclusion.

At 60 hrs, the fermentable fractions of the substrate in each of the diets increased along with the cellular activity of the rumen microbes due to prolonged period of incubation. This could have suppressed the binding capacity of the oil to the diet. It agrees with the earlier report of Devendra and Lewis, (1974).

The values obtained for potential degradability were significantly (76.50-86.00 ml/200mg DM) higher than those reported for dry matter of some legumes and grasses (kimambo *et al*., 1994; Ajayi *et al.,* 2009; Babayemi *et al*., 2009).This result buttressed other findings (Yang *et al*., 2000; Peacock *et al*., Park *et al*., 2003 and 1994) that oil serves as a supplemental nutrient source for growth and maintenance of microbial cells. The higher values of CaP have also been reported to have high degradability during fermentation (Ofuya and Nwajiuba, 1990; Arowora, 2002). Therefore, the combination of these two might be responsible for the high degradability recorded. .

At 96 hrs, the significant variations in the values of a+b, c and y across the diets were due to different levels of oil inclusion. Diet C, however had the highest values for a+b and y (94.67 and 57.0) which gave it an outstanding performance.

4.9. *IN VITRO* GAS CHARACTERISTICS OF FERMENTED GRADED MIXTURES OF OPS AND CAP AT 24, 60 AND 96 HOURS INCUBATION PERIOD

4.9.1 Short Chain Fatty Acids of fermented graded mixtures of Oil palm slurry and Cassava peel

When feedstuffs are incubated with buffered rumen fluid (inoculum) *in vitro*, gas production is basically the result of microbial degradation of carbohydrates under anaerobic condition to acetic, propionic and butyric acids (Wolin, 1960; Steingass and Menke, 1986). Gas production from protein fermentation is relatively small compared to carbohydrate fermentation. The contribution of fat to gas production is negligible (Wolin, 1960). The result obtained for diet C (1.56 µmol) was highest in all the diets and it conformed with other finding (Yang *et al*., 2000) that oil has the ability to increase microbial growth in fermentation, This was as a result of the unique trend observed in the earlier discussion. It could be attributed to higher preference of the microbes for this diet due to the favorable ratio of oil to cassava peel (1:3). Futhermore, oil is considered a component of many fermentation media because of its supplemental nutrient source for microbial activity depending on its level of inclusion in the substrate. (Peacock *et al*., 1994). Oil also acts as an adjunct to fermentation (Jones and Porter, 1998).

4.9.2. Organic Matter Digestibility of fermented graded mixtures of Oil palm slurry and Cassava peel

The OMD value is a good measure of the amount of feed which was accessible to the microbes in the rumen. Diet C recorded highest value of OMD (82.98 %) indicating that nutrient uptake was best at this ratio. Higher levels of oil inclusion (diets A and B) might have reduced the capacity of the microbes in breaking down the lignin content due to its inhibitory effect. The findings of Phengvilaysouk and Wanapat, (2008) also supported the supplementation of cassava hay with oil. At higher levels than Diet C, the oil ratio to the cassava peel might not have been sufficient for microbial attack on the lignocellulose cell components of the mixture. This statement however is at variance with the findings of Wanapat *et al*., (2007) that OMD fermentation was best at oil supplementation level of 4% for cassava hay. Again, the detoxifying effect of the oil may be hindered due to uneven mixture that reduces microbial activity.

4.9.3. Metabolisable Energy (ME) of fermented graded mixtures of Oil palm slurry and Cassava peel

A correlation between ME values measured *in vivo* and predicted from 24hr *in vitro* gas production and chemical composition of feed was reported (Menke and Steingass. 1988). The *in vitro* gas production method has been widely used to evaluate the energy value of several classes of feed (Getachew *et al*., 1998;2002). A direct correlation between metabolisable energy was recorded from *in vitro* gas production together with CP and fat content. This compared with metabolisable energy value of conventional feeds measured *in vivo* (Menke and Steingass, 1988). The results obtained in this study is in order with that reported elsewhere (Mako *et al.,* 2009). This could be due to the varying levels of oil present in each diet. This however, was not in line with other reports (Babayemi, 2007; Hriston *et al*., 2009).

4.10. The pH of graded fermented mixtures of Oil palm slurry and Cassava peel

The pH is a strong determinant of the microbial activity in the rumen. Documented pH level for optimum rumen microbial performance is between 6.5-6.9 (Grants and Mentes, 1992). All the pH values obtained in this experiment were within the recommended range for normal rumen performance. Hriston *et al*., (2009) noticed that oil inclusion to diets increased pH of the rumen slightly. The trend is at variance with the finding at 60 hrs. The pH increased as CaP inclusion rate increased as reported by Phengvilaysouk and Wanapat (2008). At 24 and 96 hrs for buffallow when fed cassava hay supplemented with different levels of coconut oil. Kamel *et al*.,(2009) described pH as dependent on administrated dosage of the substrate composition and microbial population in the inoculum. This explains the variations in the response observed at different levels of oil supplementation. At 60 hrs of fermentation, a peculiar drop in pH was observed for diet C. This observation connotes the tendency of microbes in using carbon from oil as carbon source for cellular protein synthesis (Roger *et al.,* 1977). This produced VFAs (propionate, acetate and butyrate) which are acidic, hence, a drop in the pH (6.21).The protein fermentation produced branched chain fatty acids (valeric, iso-valeric and iso-butyric acids) which increased the pH (6.61) at 96 hrs. This suggests that the oil to cassava peel ratio was favourable for microbial actions and nutrient release as in line with the report of Yang *et al.*, (2000).

4.11. Ammonia Nitrogen Concentration (NH_3^-N) of fermented graded mixtures of Oil palm slurry and Cassava peel

The pH and ammonia nitrogen concentration has a direct relationship. The pH is directly proportional to the ammonia nitrogen concentration. The concentration of ammonia in Diet A (4.0) was the least obtained at 24 hrs, among all the diets. At 60 and 96hrs, slight increase in the concentration was observed. This suggested that ratio of oil to cassava was not too favourable and could have inhibited activities of the microbes. Another important factor might be the low crude protein content (8.10 %) observed compared with other diets, since the ammonia concentration is a function of the crude protein content in the feed. The value observed was lower than the values stated by other authors (Preston and Leng. (1987); Wanapat and Pimpa, (1999). The trend of ammonia nitrogen produced as Diet C was steady from 24 to 96 hrs, and was within the range of value cited elsewhere (Boniface *et al.*, 1986; Preston and Leng. 1989) as the optimal level for microbial activities. All the other diets including the control, also recorded values within the reported range for optimal microbial performance. This might probably be due to the favourable range in pH values, for optimal performance (Grants and Mentes. 1992).

CHAPTER FIVE

5.1   PERFORMANCE CHARACTERISTICS AND TOTAL RUMEN MICROBIAL COUNT OF WEST AFRICAN DWARF SHEEP FED FERMENTED GRADED MIXTURES OF OIL PALM SLURRY AND CASSAVA PEELS

5.2. INTRODUCTION

The ultimate focus of livestock industry is the conversion of feeds into prime animal products, which are either edible to man or surplus for his basic requirement (Payne and Wilson, 1999). The frequent increase in price of conventional feedstuff such as maize, millet, sorghum and soybean and also the competition between human and livestock for feed ingredients as a source of feed, has made most ingredients unaffordable for livestock feeding especially ruminants. Another limiting factor to the use of conventional feedstuff is the unavailability at the time they are required for feeding.

The search for such alternative feedstuff has brought agro industrial by products in focus. These unconventional feedstuffs are readily available, economical and are abundant at various processing sites thereby, making them very acceptable particularly, to ruminant husbandmen. A very important reason for the wide acceptability of these agro-industrial by products by ruminants, is their innate ability to synthesise high quality protein from non-protein nitrogenous (NPN) compounds, through the action of microorganisms present in their digestive tract (Cott, 2009). Protein available for digestion in the small intestine thus consists of microbial protein and feed protein that has escaped microbial breakdown in the rumen (Preston, 1995).

Cassava peels (CaP) and Oil palm slurry (OPS) are agro-industrial by-products that possess same attributes earlier ascribed to these wastes. A unique characteristic, which they both bear, is that both are by products of cash cropping, and are harvest both frequently within a year, thereby making their wastes abundantly available throughout the year. However, while research have been conducted on the use of cassava peels as feed for ruminants, there is dearth of information on the use of oil palm slurry as feed

for ruminants. In addition, the use of a combination of Oil palm slurry and Cassava peel as fed for ruminants requires investigation.

The quality of a feed is considerably determined by its physical characteristics, which may be relatively independent of its chemical composition. Feeds and foods are not equal in their capacity to support the rational functions of animals such as maintenance, growth, reproduction and lactation. Feeds supply energy and the essential nutrients in the form of proteins, vitamins and minerals. Energy and protein are limiting nutrients in ruminant ration and have so far received the most attention in evaluation systems (Preston, 1995; Arowora, 2002).

Acceptability or free choice intake attributes of a feed connotes the actual response of an animal to a particular feed and the possible visual effects of the feed to the animal. This conversely depicts the efficiency of the feed in the rumen (Van Soest, 1995).

Digestibility trial shows a fast mimic of the extent of nutrient breakdown of the proximate constituents and the fibre fractions of a feed in the rumen of an animal. It is a valid measure of how nutritious the feed is. It could also be defined as the proportion of a feed that is available to the animal for absorption from the gastro-intestinal tract. (Awah, 1981)

Rumen microorganisms are responsible for the degradability of feedstuff prior to its digestibility by the host animal (Idahor, 2006). Therefore, it is important to examine the effect of the collective microorganisms in the rumen of an animal. This will complement the *in vitro* determination in the laboratory thereby categorically estimating how much the feed would meet the requirements of the animal for growth and other metabolic activities.

This study was undertaken to evaluate the accceptability, digestibility and estimation of the total ruminal microbial count of WAD sheep fed fermented graded mixtures of Oil Palm slurry (OPS) and Cassava peel (CaP).

5.3 ACCEPTABILITY STUDY

5.3.1 Free choice intake of fermented graded mixtures of OPS and CaP

5.3.2   Material and method

Sample of OPS were collected from four different oil palm processing locations in the South Western Nigeria namely: Oyo state-Badeku, Osun state-Ikoyi, Ogun state-Mamu, Edo state- Nifor

Cassava peels was also collected from a cassava-processing unit at Eleyele in Ibadan. Both (OPS) and (CaP) were combined as follows:

Diet A - 1litre OPS +1kg CaP

Diet B - 1litre OPS +2kg CaP

Diet C - 1litre OPS +3kg CaP

Diet D- 1litre OPS +4kg CaP

Diet E - 1litre OPS +5kg CaP

Diet F - (Control)-CaP 6kg only

The diets were tied and fermented for five days in airtight cellophane bags and then sun dried.

5.3.3 Experimental site

The experiment was conducted at the sheep and goat unit of the Teaching and Research Farm, University of Ibadan, Ibadan, Nigeria, situated in the derived savannah vegetation belt. The location is $70^O 27^1$ N and $30^O 45^1$E at an altitude of between 200 and 300m above sea level. Mean temperature of 15-29°C with an average annual rainfall of about 1250mm. The soils are much drained and belong to the altisol (Babayemi *et al*., 2003).The surrounding of the house was sprayed with herbicides while the inside of the house was fumigated at 3 days interval with germicide and insecticide simultaneously for 18 days and left to rest for 3 days before the animals were brought in. The feed and water troughs were washed and disinfected to get rid of

any pathogens present in the vicinity. Analyses were carried out at the ruminant nutrition laboratory of the Department of Animal Science, University of Ibadan, Ibadan.

5.3.4   Experimental sheep

Six WAD sheep weighing between 20.00-25.00kg aged between 5-6 months previously certified free of endo and ectoparasites by the University Veterinary department, were subjected to free choice feeding to evaluate acceptability of the combination of graded OPS and CaP levels (Diets A, B, C, D, E and F) in a cafeteria feed preference study (Babayemi *et al*., 2006). They were housed together in the sheep pens, which were constructed to achieve good ventilation. The floor of the house was made of concrete and covered with wood shavings for easy cleaning.

5.3.5   Feeding of animals

The previously fermented diets were placed strategically in six different troughs and then offered to the sheep as outlined (Babayemi *et al*., 2006). The wooden feeder (150cm x 60cm) was used to, enable the six sheep feed simultaneously in a convenient situation. Each animal had access to each of the diets. The position of the feeders was changed every day before serving the diets to prevent adaptation of the animals to a particular diet. The feeding was allowed from 0800 to 1600 hours daily. Feed consumed was determined by deducting the feed refusal from the quantity offered. The experiment lasted fourteen (14) days in which the first (7days was for adjustment of the animal micro flora to the diets and the latter days was for data collection).The treatment preferred was accessed from the coefficient of preference (COP) value as follows using the formula.

Co-efficient of preference (COP)   =   Average Intake / Individual daily Intake

If COP is <1, the material will be rejected and when >1, the material will be accepted. (Bamikole *et al*., 2004)

Plate 4: Fermented graded mixtures of OPS and CaP during sun curing

Plate 5: Some sheep feeding on a diet during acceptability study

5.4 RESULTS

5.4.1 ACCEPTABILITY OF FERMENTED GRADED MIXTURES OF OPS AND CaP BY WAD SHEEP

The coefficient of preference of graded mixtures of OPS and CaP fed to WAD sheep is shown in table 10. In this study, Diet C, recorded the highest COP value of (1.41) compared to other diets followed by Diet B, with a value of (1.11) while diets D and E recorded the lowest COP values of 1.00 and 1.07 respectively. Diets A and F recorded values of 0.82 and 0.75, which were, less than unity.

Table 10: Coefficient of Preference of fermented graded mixtures of Oil Palm Slurry and Cassava Peel fed to WAD Sheep

Parameters	Mean daily intake (kg DM)	Coefficient of preference (COP)
Diet A	2.46	0.82
Diet B	3.45	1.11
Diet C	4.51	1.41
Diet D	3.02	1.00
Diet E	3.23	1.07
Diet F	2.28	0.75

Diet A-1 litre Oil palm slurry + 1kg cassava peel

Diet B -1 litre Oil palm slurry + 2kg Cassava peel

Diet C- 1litre Oil palm slurry + 3kg Cassava peel

Diet D- 1litre Oil palm slurry + 4kg Cassava peel

Diet E-1litre Oil palm slurry + 5kg Cassava peel

Diet F- 6kg Cassava peel

5.5   **DISCUSSION**

Free choice intake or acceptability study of a feed is a quick accessement of the physical quality of the feed by the animal. It is one of the *in vivo* trials that reveals the actual reaction of animals to a feed. Coefficient of Preference (COP) is a direct measure of acceptability and nutritional capabilities of a feedstuff.

In this study, some physical changes were observed after fermentation. Diet A had coffee brown colour and very oily, Diet B also had a coffee brown colour but contained lesser oil than A although they both had sweet aroma, diet C was slightly brown, crispy with a sweet aroma while diets D and E were of creamy white colour as the control diet F but without any particular odour. Diet C was the most relished with COP of 1.41. This might be attributed to its favourable physical attributes compared to other diets. The too oily appearance of diet A probably slowed down microbial activities in the rumen, which consequentially perhaps led to low digestibility therefore resulting in low intake. This might be the reason for its low acceptability by the sheep. Diet F was the least relished of all the diets.This might be due to the repulsive physical attributes. This conformed with the observations of Campel and Laherrere (1998) that fermentation of food in animal or plant tissue subjected to the action of microorganisms gives desirable biochemical changes and significant modification of food quality.

The inclusion rate and time of supply of oil to a diet, could also affect microbial activity (Adebiyi, 2004). However, report (Krueger *et al*., 1974) that small ruminants prefer sweet and generally reject bitter plants, might be the reason why sheep accepted more of diet C due to the favourable OPS to CaP ratio which aided in reducing the antinutritional factor in the diet. This probably gave the microbes added advantages of breaking down the fibrous content resulting in the attributes exhibited over diet F (Adebowale, 1981).

Oldham and Alderman (1980) also reported that *ad libitum* intake by animals was increased by higher crude protein content of diets. These findings also buttressed the reason for the highest value of COP for Diet C compared to other diets. This diet had the highest crude protein content of 14.15% while diets B, C, D and E were all consumed beyond the recommended body weight of 3-5% dry matter DM requirement

for ruminants (ARC, 1980; Devendra, 1978). Diets A and F were eaten below the recommended average body value.

5.6 DIGESTIBILITY OF FERMENTED GRADED MIXTURES OF OIL PALM SLURRY AND CASSAVA PEEL BY WAD SHEEP

5.6.1 Material and methods

5.6.2 Experimental site

The experiment was carried out at the sheep and goat unit of the Teaching and Research Farm of the University of Ibadan, Ibadan Nigeria, between the months of December 2009 to March 2010.

The animal pen was made of low walls of 1m by 1.5m in size and each pen was about 0.22 m long 0.12 m wide. The floor of the pen was made of concrete and the roof was made of the sheep unit which housed the pens was made of corrugated iron sheets. The pens were dusted and washed thoroughly with detergent and were further disinfected with broad-spectrum insecticide, acaricides and larvicides (diasuntol). The feeding and drinking troughs were washed and disinfected and the whole house was left to rest for two weeks before usage. Wood shavings were spread on the floor of the pen as bedding materials and there after replaced fortnightly.

5.6.3 Experimental animals

Eighteen (18) post weaned female West African dwarf sheep aged 5-6 months weighing 20.0-25.0kg were used for the experiment. They were purchased from Oyo town in Oyo state. On arrival, the sheep were given prophylactic intramuscular treatment of oxytetracycline and vitamin B complex, at the dosage of 1m/10kg body weight of the animal. They were also drenched with albendazole to control endoparasites and treated for mange and other ectoparasites using Livermectin.

5.6.4 Collection of oil palm slurry (OPS) and cassava peels (CaP)

Oil Palm slurry (OPS) was collected fresh from Mamu in Ogun State of Nigeria while fresh Cassava peel (CaP) was collected from a garri processing plant at Eleyele in Ibadan Oyo state. The samples were then mixed in various grades as follows:

(Diet A):1 litre OPS + 1kg CaP

(Diet B): 1 litre OPS + 2kg CaP

(DietC): 1 litre OPS + 3kg CaP

(Diet D): 1 litre OPS + 4kg CaP

(Diet E): 1 litre OPS + 5kg CaP

(Diet F): 6kg CaP only

Each of these mixture was tied in cellophane bags in an airtight condition to encourage microbial activities. Fermentation was carried out for five days and afterwards sun-cured.

Each sun-cured sample was then oven dried at 105^OC (AOAC. 1990) and kept for dry matter determination

5.6.5   Experimental design

The animals were allowed 2 weeks of adjustment to their new environment (acclimatisation) and the effect of the administered drugs to wear out. Three sheep of similar average body weight were randomly allotted into separate metabolic cages with fitted facilities for separate collection of feaces and urine (Akinsoyinu, 1974). The design of the experiment was a completely randomized design (CRD). Rumen fluid was also collected through suction tubes and analysis was carried out in 4 by 6 latin square arrangement.

5.6.6   Sheep feeding

The experiment lasted 14 days, in which the first seven days was to adjust the sheep and their ruminal micro-flora to the new test diets and the latter was for data collection. The animals were fed at 0900 hours in the morning and at 0300 hours in the afternoon daily. Feed was served at 3% of the body weight of the animals. Water and salt lick were accessible to the animals throughout the metabolic period. Feed refused was weighed at 0800 hours every morning and deducted from the total offered for intake determination prior to serving new feed daily. Fresh water was also served *ad libtum*. During seven days of collection, total faeces and urine were collected, weighed and

10% aliquot was taken and stored in the freezer at -4^OC. After 7-day collection period, the total faeces from daily collection were bulked, mixed and dried in the oven and kept till required for chemical analysis. Urine samples was collected and measured daily for each animal in the morning using measuring cylinder and kept into separately labeled containers. Two drops of concentrated sulpuric acid was added to each container daily after collection of each sample to prevent microbial growth and loss of nitrogen measured. Approximately 10% of total urine was sampled daily and stored at -4^OC till required for nitrogen analysis. Three days to the end of data collection, rumen fluid was collected from each animal *prepandia* (before feeding), and at three hours interval after feeding over a period of twelve hours. Samples were immediately squeezed out through a four layer cheese cloth after each collection into labeled 5ml plastic specimen bottles. The pH of each sample was immediately taken with the aid of a portable digital pH meter. The samples were then taken to the laboratory in a thermos flask for total microbial count. Each sample was diluted at the rate of 10^{-1}-10^{-6} with sterile distilled water using pour plate technique for 48 hours at a temperature of 39^OC. The plates were taken out and total microbial count was done with the aid of a colony counter. The remaining samples were then used to determine the ammonia nitrogen concentration by distillation with 0.01N HCL as described (Preston, 1995).The design of the experiment was a 4x6 factorial arrangement.

5.7   RESULTS

5.7.1 The proximate composition of experimental diet fed to WAD sheep.

The proximate composition of experimental diet fed to West African Dwarf Sheep is represented in Table 11. The dry matter composition of all the diets revealed significant differences only among diets A (52.27) and C (71.04) while statistical similar variations in values were obtained for diets B (68.47) and F (68.42). Diets D and E obtained similar variation in values. The highest CP value (1.15) was obtained for diet C while the least value (5.50) was recorded for diet F. Ash values of 3.20 and 5.01 were significant for diets C and D only while diets A and B were statistically similar. Diets E and F were also not statistically varied. Significant ($p<0.05$) values were observed for the CF and EE. The least CF value (14.25) was obtained for diet C and the highest (20.36) was recorded for diet F. EE values 36.00 were highest for diet C while diet A obtained the least value of 21.20.

Table 11:   Dry matter and Proximate composition (g/kgDM) of experimental diet fed to WAD Sheep

Parameter	Diet A	Diet B	Diet C	Diet D	Diet E	Diet F	SEM
Dry matter%	52.27^d	68.47^b	71.04^a	63.29^c	63.00^c	68.42^b	0.05
Crude protein	8.10^d	9.05^c	14.15^a	11.25^b	11.21^b	6.50^e	0.08
Crude fibre	18.96^c	19.20^b	14.25^e	17.00^d	18.04^{ab}	20.36^a	0.03
Ash	6.58^d	4.29^b	3.20^e	4.98^b	5.01^c	6.90^d	0.01
Ether extract	21.20^e	30.21^c	36.00^a	33.40^b	31.75^{ab}	28.00^d	0.05

a ,b, c, d, e means on the same row with different superscripts are significant ($p < 0.05$)

Diet A-1 litre Oil palm slurry + 1kg cassava peel

Diet B -1 litre Oil palm slurry + 2kg Cassava peel

Diet C- 1litre Oil palm slurry + 3kg Cassava peel

Diet D- 1litre Oil palm slurry + 4kg Cassava peel

Diet E-1litre Oil palm slurry + 5kg Cassava peel

Diet F- 6kg Cassava peel

WAD – West African Dwarf

SEM-Standard Error of Means

5.7.2. Apparent nutrient digestibility and nitrogen utilisation by WAD sheep fed fermented graded mixtures of OPS and CaP

The apparent nutrient digestibility and nitrogen utilization by West African dwarf sheep fed graded mixtures of OPS and CaP is shown in Table 12. The results revealed that the variations in DM digestibility were significant ($p < 0.05$) only on animals placed on diets A and C recording 58.41 and 89.43. Animals on diet C had the highest CP digestibility value of 92.70 and the least 80.I6 for sheep on diet A. The CF digestibility was significantly $p < 0.05$ high for Diet C with a value of (87.39) followed by Diet B (86.88) while the least value $p < 0.05$ (56.02) was observed for Diet A. The values obtained for EE, ADF, NDF and hemicellulose contents were statistically similar $p > 0.05$

TABLE 12: Apparent nutrient digestibility (%) by WAD sheep fed fermented graded mixtures of Oil palm slurry and Cassava peel.

Parameters	Diet A	Diet B	Diet C	Diet D	Diet E	Diet F	SEM
Dry matter	58.41[e]	76.08[b]	89.43[a]	70.21[d]	70.64[c]	74.52[ab]	2.05
Crude protein	88.16[d]	89.48[c]	92.70[a]	90.00[b]	80.26[e]	90.32[b]	1.02
Crude fibre	56.02[e]	78.48[c]	87.39[a]	85.88[b]	80.00[ab]	64.05[d]	2.23
Ether extract	90.90	95.00	91.35	83.17	93.24	92.04	3.12
Neutral detergent Fibre	83.42	88.45	90.05	84.96	88.55	85.66	1.07
Acid detergent fibre	54.29	72.86	76.84	64.25	73.51	66.76	2.88
Cellulose	17.59	28.74	36.63	23.29	17.08	15.60	2.05
Hemicellulose	13.82	15.59	17.93	20.71	15.04	18.90	1.45

Diet A-1 litre Oil palm slurry + 1kg cassava peel

Diet B -1 litre Oil palm slurry + 2kg Cassava peel

Diet C- 1litre Oil palm slurry + 3kg Cassava peel

Diet D- 1litre Oil palm slurry + 4kg Cassava peel

Diet E-1litre Oil palm slurry + 5kg Cassava peel

Diet F- 6kg Cassava peel

WAD – West African Dwarf

SEM-Standard Error of Means

5.7.3 Nitrogen utilization by WAD sheep fed fermented graded mixtures of Oil palm slurry and Cassava peel

The nitrogen utilization of sheep fed graded mixtures of Oil palm slurry and Cassava peel is shown in table: 13. The N-utilisation of sheep, N-intake, fecal-N, Urinary-N, N-balance and N-retention, ranged from 10.00-16.01g/d, 1.45-4.24, 0.60-1.20, 2.01-5.45, 45.60-75.05 % respectively. Significant variations ($p < 0.05$) were observed in the fecal-N and N- retention of the sheep fed graded mixtures, with sheep on Diet C (4.24,75.05) recording the highest values for both parameters while least values (1.45,45.60) were obtained for sheep on Diet A.

N-Intake varied significantly ($p < 0.05$) for sheep fed Diets, A, B, C and F. The highest values was obtained for sheep on Diet C (16.01g/dm) and lowest for sheep on Diet A (10.00g/dm). Statistical similar variations in values were obtained for sheep on diet D and E. Same trend was observed for the Urinary-N and N-balance for animals on Diets A,B,C and F. The value of (1.20g/d) was least for animals on Diet C for Urinary-N, while the highest value of (1.20g/d) was recorded for animals on Diet A. Treatment effect was not significant ($p > 0.05$) for animals on diets D and E. The value of 5.45 was significantly ($p < 0.05$) higher for animals on Diet C followed by 4.89 for animals on Diet F while those on diet A was least with the value of 2.01. Treatment effect was also not significant ($p > 0.05$) for sheep on diets D and E.

In the total digestible nutrients, the CP, CF, EE, NFE and TDN were all significantly ($p < 0.05$) highest for sheep on diet C with the values of 11.51, 20.22, 15.09, 34.18, 73.04% respectively. Sheep on diet F followed with variations of 13.05, 18.79, 13.10, 32.06 and 69.24% values respectively. The least significant variations for all the parameters were recorded for sheep on diet A.

Table 13: Nitrogen utilization by West African dwarf sheep fed fermented graded mixtures (%) of Oil palm slurry and Cassava peels

Parameters	Diet						
	A	B	C	D	E	F	SEM
N-Intake (g/d)	10.00^e	14.21^c	16.01^a	13.45^d	13.89^d	15.00^b	0.02
Feacal-N (g/d)	4.24^a	2.51^b	1.45^e	1.70^c	1.82^{ab}	1.63^d	0.04
Urinary-N (g/d)	1.20^a	1.00^b	0.60^e	0.84^c	0.80^c	0.75^d	0.04
Total-N excreted (g/d)	5.40	3.51	2.01	2.54	2.62	2.38	0.02
N-Balance (g/d)	4.56_e	10.7^d	14.0^a	10.91^{bc}	11.27^c	12.62^b	0.02
N-Retention(%)	45.60^e	56.00^d	75.05^a	60.01^c	65.35^{ab}	70.25^b	0.01

Table 14: **D**igestible Nutrients intake (%) by West African Dwarf sheep fed fermented graded mixtures of Oil palm slurry and Cassava peel

Parameters	Diet composition						
	A	B	C	D	E	F	SEM
Crude Protein	5.27^d	7.75^c	11.51^a	9.45^b	8.90^{ab}	4.05^e	1.21
Crude Fibre	9.03^e	13.45^d	20.22^a	17.67^c	17.32^c	18.79^b	0.89
Ether Extract	12.00^e	13.78^c	15.09^a	13.23^c	12.40^d	13.10^b	0.21
Nitrogen Free Extract	23.70^e	30.11^d	34.18^a	32.65^b	31.88^{dc}	32.06^c	1.10
Total Digestible Nutrients	53.90^e	58.06^d	73.04^a	60.57^c	62.00^{ab}	69.24^b	0.09

a, b, c, d, e means on the same row with different superscripts are significantly different($p<0.05$)   Diet A - 1 litre Oil palm slurry+ 1kg cassava peel

Diet B - 1 litre Oil palm slurry+ 2kg cassava peel

Diet C - 1 litre Oil palm slurry+ 3kg cassava peel

Diet D - 1 litre Oil palm slurry+ 4kg cassava peel

Diet E - 1 litre Oil palm slurry+ 5kg cassava peel

Diet F (control) 6kg cassava peel only

SEM=Standard Error of Means

5.8   **DISCUSSION**

High protein, feeds have been found usually acceptable, stimulate appetite and digestive activity (Cott, 2009). In this experiment, animals on diet C had the highest DM (Dry matter) and CP (Crude Protein), compared to animals on other Diets and the control. This indicated that maximum microbial activity at this ratio of OPS to CaP was probably attained. This may be linked to its high CP of 14.15% obtained from the proximate composition.

Sheep on control (Diet F) recorded lower values of DM and CP compared to those on Diet C. This may be attributed to the residual anti nutritional factor (glucocyanide) present even after fermentation. Adebowale (1981) observed that about 80% of the anti nutritional factors only could be removed in cassava peel after fermentation. Treatment effect of OPS to CaP ratio was least observed on the DM and CP digestibility parameters in sheep placed on Diet A, which might be due to a higher concentration of oil to cassava ratio that could have hindered the effect of rumen microbes (Jones and Porter, 1998). However, there is the dearth of information on any particular level of oil palm slurry to cassava peel inclusion in the DM and CP digestibility of nutrients in sheep or small ruminants. The residual oil present in the slurry represents a percentage of palm oil in feed.

Conversely, Gonzalez *et al.* (1999) reported no treatment effect on DMI digestibility in the use of 0.5 and 10% palm oil with diets based on cassava foliage meal for growing pigs. The DMI values of animals on diets B, D, E and F, in this study, compared with the range of values obtained by Mako (2009), when Water hyacinth, Guinea grass and concentrates were fed to goats. The lower values observed for animals on diet A could be adduced be attributed to low activity of the micro flora in the rumen, hence low by-pass protein from the rumen, subsequent low digestion as well as absorption in the omasun abomasum (Mako, 2009) due to high concentration of oil in the diet. However, reduced feed intake has been established to have a direct relationship with feed retention time in the rumen. (Van Soest, 1995).

Nguyen *et al.* (2005) where a linear increase in DM was observed as the level of oil ingestion increased. As the strength of OPS decreased due to increased inclusion of cassava peels, DM digestibility in this study increased Nguyen and Thom. (2004) reported similar results that groundnut oil at 5mI/kg live-weight could improve feed

intake, growth rate and profitability. The highest DM value(89.43) recorded, for sheep on diet C in this work was higher than 71.2; 83.3% reported by Chhay *et al*. (2003) for diets in which levels of palm oil were added to basal diet of ensiled cassava leaves. These values were similar to 76.08 and 74.52g/DM obtained for Diets B and F (control).The reported (Oldham and Alderman, 1980) high DM digestibility value for animals on diet C compared to those on diets B and F might be traced to the higher CP value recorded.

The high CP digestibility in animals fed diet C compared with other diets in this study might be related to the high CP as earlier stated and the favourable mixture of the diet which aided microbial breakdown. However, this CP value of the diet is higher than the 8-12% (ARC) recommended ammonia levels required for optimal rumen functioning of small ruminants. The excess ammonia produced could be a useful source of protein build up by the rumen micro flora for microbial activities.

An inference drawn from the reports of Shahid *et al.,* (2000) was that excess ammonia not utilised by the microbes was absorbed in the blood circulation and converted to urea in the liver, with a consequence of metabolic burden on liver of the animal.

The CP digestibility (90.26g/DM) obtained for animals on diet F (control), was higher than those of animals on other diets except diet C. This could be connected to the residual anti nutritional factor present after fermentation that aided in protecting the protein from fermentation in the rumen. F Foulkes and Preston (1978); Wanapat *et al*. (1997), indicated that cassava hay was a good source of rumen by-pass protein due to the condensed tannins acting to protect the protein from fermentation in the rumen, which may increase the supply of amino acids to the small intestine.

Animals on diet D recorded the least CP digestibility value; this was not expected because the animals on diet A recorded the least values in other parameters, hence the lowest microbial activity than animals on diet D and other diets. Therefore, reason for the low CP digestibility in animals on diet D could not be ascertained. The CP digestibility values of 88.16-92.70% obtained in this study were higher than those reported for Water hyacinth 80.13-67.89% (Mako. 2009) probably due to fermentation which influenced high microbial activity in the rumen of the animals. It has been reported (0kpako *et al.,* 2008) that fermentation brings about high microbial activity hence high protein synthesis.

Digestibility value of crude fibre (CF) 87.39 obtained for animals on diet C, was the highest. This could be due to the favourable OPS to CaP ratios, which facilitated the high microbial breakdown of the cellulose cell wall in the diet. It could then be traced to the residual CP available to the microbes in the rumen of the animals as discussed earlier, which aided the diet in staying longer in the rumen. This caused a gang up of microbes in the breakdown of the CF contents in this diet for single cell formation (Mako, 2009). Oil has also been discovered an adjunct to fermentation (Jones and Porter, 1998). In the study of (Perry and Stewart, 1979), it was pointed out that the influence of oil at 3% inclusion level, in sheep diet significantly $p<0.05$ increased fibre digestibility. Sheep on diet A had the least value of CF compared to the animals on other diets and the control. The reduction in the build up of rumen microorganisms responsible for the breakdown of CF (Kane *et al.*, 1965) might be the reason for this observation. This connotes that the ratio 1:1 of OPS to CaP mixture was unfavourable to the ruminal microflora of the animals for this diet thereby suppressing CF digestibility. Palmquist and Conrad (1980) reported no effect of fat on CF digestibility. Prak kea *et al,* (2003) also noted that, CF digestibility was not significantly different at all the levels of oil to broken rice inclusions, that has been established to have a direct relationship with feed retention time in the rumen (Van Soest, 1995).

Observations from the present study, showed that ether extract (EE), nitrogen detergent fibre (NDF), acid detergent fibre (ADF), cellulose and hemicelluloses contents were not significantly influenced ($p>0.05$) by dietary treatments. However, Gonzalez *et al.* (1999) indicated for diets based on cassava foliage meal for growing pigs that NDF digestibility decreased while ether extract digestibility was enhanced with increasing levels of dietary palm oil. Further reports Phengvilaysouk and Wanapat (2008) revealed that supplementation of cassava hay with coconut oil significantly ($p<0.05$) improved digestion of NDF and ADF.

Results of the N-balance showed that animals on diet C had the highest N-balance, which might be because of the relatively higher nitrogen intake and the high micro floral gang up towards the feed ingested. It could be deduced that the ratio of the feed mixture, i.e. OPS to CaP was favorable to the microbes in the rumen of the animals on this diet. The reduction in the microbial utilization by the animals fed diet A, may be connected to the low intake of the feed, due high CF and low CP composition of the mixture. Mako (2009) deduced that dry matter intake (DMI) was a limiting factor in

feed utilization since it will affect the overall performance of the animal which may result in a low microbial utilization of the feed. Cheng *et al*. (1984) reported that microbial colonisation of highly lignified particles was limited. Though the crude protein content of animals fed diet F was low compared to other diets, the value of N-retention obtained (70.25) was higher than that of sheep on the other diets except for animals on diet C. This observation could be due to the residual anti nutrient which might be present in the feed that aided in trapping down the bypass protein, hence a high N-retention as reported (Wanapat *et al*., 1997).

The high total digestible nutrients (TDN) and apparent digestibility of dry matter, crude protein, positive N-balance and N-retention of animals on diet C may be indicative of proper utilisation of the feed by the animals placed on this diet as compared to other diets.

Plate 6: Culture showing some colonies formed after 48 hours incubation period

5.9 TOTAL RUMINAL MICROBIAL COUNT, pH AND AMMONIA NITROGEN CONCENTRATION OF WAD SHEEP FED FERMENTED GRADED MIXTURES OF OPS AND CaP

5.9.1 RESULTS

The trend in the total microbial count in the rumen of sheep fed graded mixtures of Oil palm slurry and Cassava peel is presented in Figure 3. The trend in the graph revealed that at 0 hour (*pre-prandia)*, animals on diets C, D and E had the least count of microorganisms in the rumen; with colony forming units (cfu) of 5.0, 5.0 and 5.0 respectively. Values for animals on diet B was (cfu) of 5.1 while Sheep fed diets A and F had cfu 5.2 and 5.3 respectively.

At the third hour of collection, animals on diet F recorded a sharp decline in total microbial count with the value of 4.9 cfu. Sheep on diets B and E also had a slight increase in microbial population with values of 5.2 and 5.1 respectively. Animals on diet C, had a steady increase in total count (5.3). Diet A had a stationary microbial growth at this hour while Diet D showed a slight increase in total count (5.1)

At the sixth hour, animals on Diets B and C followed yet a steady trend of increase in total cfu of 5.3 and 5.6 respectively. While sheep on Diet F showed a sharp increase to 5.3. The same growth rate was observed for animals on diet E which recorded an increase of 5.2. Sheep on diet D had a slight increase to 5.2 while diet A maintained a constant microbial growth of 5.2 cfu.

At the ninth hour, the total ruminal microbial count for all the animals decreased with values of 4.9, 4.6, 4.9, 4.7 and 5.1 respectively for sheep on diets A, B, C, D, E and F.
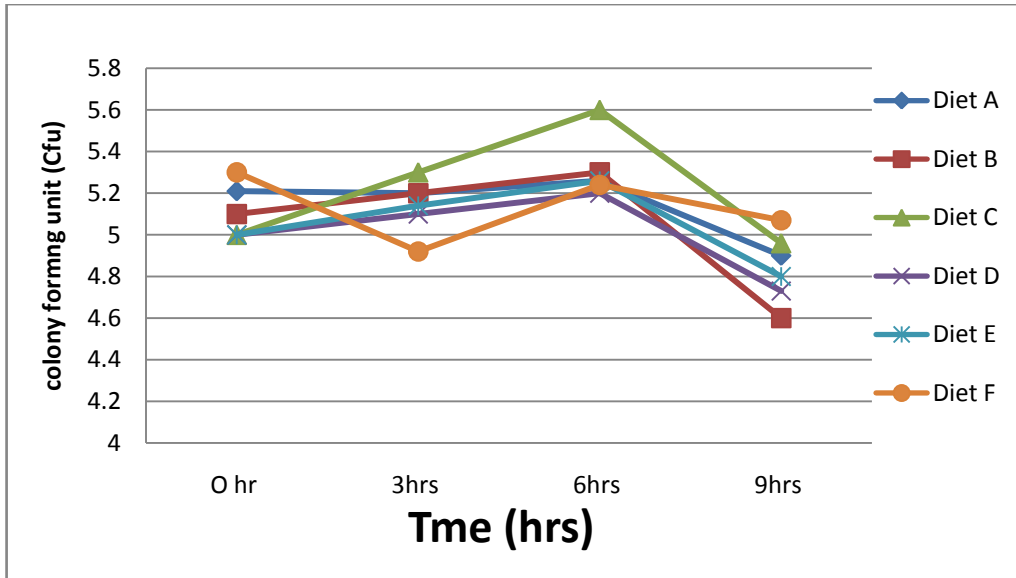
Figure 3: Ruminal microbial growth curve of WAD sheep fed fermented graded mixtures of OPS and CaP

5.9.2   Effect of time on ruminal pH and NH$_3$-N concentration of WAD sheep fed fermented graded mixtures of OPS and CaP

The effect of time on ruminal pH and NH$_3^-$N concentration of WAD sheep fed fermented graded mixtures of OPS and CaP was shown on Table: 15. The results revealed that values obtained for pH did not vary significantly at all the hours of rumen liquor collection (0 to 9) hour. There were variations in ammonia nitrogen (NH$_3$-N) concentration recorded at all the observed hours of rumen liquor collection with the highest values recorded at the third (17.9), sixth (16.2), ninth (9.5) and least value was recorded at 0 hour (4.3).

TABLE 15: Effect of time on ruminal pH and Ammonia Nitrogen concentration of WAD Sheep fed fermented graded mixtures of OPS and CaP

Parameters	Time (hrs)				
	0	3	6	9	SEM
pH	6.3	6.3	6.28	6.25	1.25
NH_3-N conc	4.38	17.94	16.23	9.57	2.45

OPS - Oil palm slurry

CaP - Cassava peel

Conc -concentration

SEM= Standard Error of Means

5.9.3 Treatment effect on ruminal pH and NH$_3$-H concentration of West African Dwarf Sheep fed fermented graded mixtures OPS and CaP

Treatment effect on ruminal pH and ammonia nitrogen concentration of sheep fed fermented graded mixtures of OPS and CaP mixtures are represented on Table 16. It was revealed from the results that treatments had a varied effect on the pH of the rumen fluid. The least observed value of 6.35 was for animals on diet A while those on diets C, D and E were not significantly (p>0.05) varied. Sheep on diet F recorded the highest value of 7.12. The NH$_3$-N concentration was also significant different in all the sheep on all the diets with the highest value of 13.19 for diet C while the least recorded value of 10.46 was for animals on diet A.

TABLE 16: Treatment effect on ruminal pH and ammonia nitrogen (NH_3-N) concentration of W A D Sheep fed fermented graded mixtures of OPS and CaP.

Parameters	Diets						
	A	B	C	D	E	F	SEM
pH	7.12	6.52	6.60	6.58	6.20	6.64	0.08
NH_3-N concentrations	10.46e	10.79d	13.19a	12.89b	12.04b	11.48c	0.01

a, b, c, d, e Means on the same row with different superscripts are significant ($p < 0.05$)

Diet A- 1 litre Oil palm slurry+ 1kg cassava peel

Diet B- 1 litre Oil palm slurry+ 2kg cassava peel

Diet C - 1 litre Oil palm slurry+ 3kg cassava peel

Diet D - 1 litre Oil palm slurry+ 4kg cassava peel

Diet E - 1 litre Oil palm slurry+ 5kg cassava peel

Diet F (control) 6kg cassava peel only

OPS – Oil Palm Slurry

CaP – Cassava Peel

SEM= Standard Error of Means

5.9.4 Interaction of time and treatment on ruminal pH and NH₃⁻N concentration of WAD sheep fed fermented graded mixtures of OPS and CaP

The interaction between time and treatment on ruminal pH and NH_3^-N concentration of WAD sheep fed fermented graded mixtures of OPS and CaP is presented in Table 17. The interaction between time and treatment was not significant on pH at 0 hour. However, it was significant for NH_3-N concentration. The least value (3.4) was recorded for sheep on control diet and the highest value of (5.5) for animals on diet A although no significant variation ($p<0.05$) was obtained for animals on diets C, D and E.

At the 3rd hour, a significant variation was recorded for pH values among animals on all diets. The highest values (6.7) recorded was for the control and the least value was obtained for sheep on diet E (6.0). A significant variation was also obtained for the NH_3-N concentration with the least value recorded for sheep on diet F (16.7) while the highest value was obtained for animals on diet A (19.5).

The 6th hour observation revealed a significant variation ($p<0.05$) in diets. The least value of pH was obtained for animals on diet D (6.2) and the highest was reported in the control (6.6). There was no significant difference ($p>0.05$) between the animals on diets B 6.3 and C 6.5 variations also followed the same trend as observed for sheep on the control diet. Animals on control diet recorded the least value of 13.4 while sheep on diet B recorded the highest value of 18.8.

Significant variations ($p<0.05$) were observed on the pH of animals on all the diets at the 9th hour. The highest value was obtained for sheep on the control (5.9). No significant differences were observed for the pH values among sheep on diets A, B and C while significant variations were also observed in the NH_3-N concentrations.

TABLE 17: Effect of interaction between time and treatment on ruminal pH and ammonia nitrogen (NH_3^-N) concentration of WADsheep fed fermented graded mixtures of OPS and CaP

PARAMETERS TIME	DIETS	pH	NH_3-N
0 HR (*pre pandia*)	CONTROL	6.45	3.45[a]
	A	6.50	5.50[a]
	B	6.50	4.10[c]
	C	6.20	4.56[b]
	D	6.40	4.35[b]
	E	6.10	4.35[b]
	AVERAGE	6.36	4.39
3HRS	CONTROL	6.70	16.67[e]
	A	6.20	19.45[a]
	B	6.15	18.56[ab]
	C	6.50	17.75[bc]
	D	6.50	17.00[bc]
	E	6.00	18.23[ab]
	AVERAGE	6.34	17.94
6HRS	CONTROL	6.60	13.40[e]
	A	6.20	17.65[b]
	B	6.25	18.83[a]
	C	6.55	15.49[d]
	D	6.15	16.54[d]
	E	6.20	16.45[c]
	AVERAGE	6.34	16.39
9HRS	CONTROL	6.58	8.30[c]
	A	6.24	10.20[a]
	B	6.30	10.05[a]
	C	6.20	10.34[a]
	D	6.00	9.03[b]
	E	6.00	9.48[b]
	AVERAGE	6.22	9.57

a,b,c,d means on the same row with different superscripts are significantly different (p<0.05)

NH_3^-N- Ammonia nitrogen

SEM- Standard Error of Means

5.10   **DISSCUSION**

A progressive increase in the microbial load signified a successful microbial degradation of a large proportion of the diets utilized for the synthesis of cellular protein needed for optimal metabolic activities.

In this work, at the 0 hour (*pre-pandia*), varied ruminal microbial populations were obtained for animals on diets A, B and F while the same microbial counts were recorded for sheep on diets C, D and E. This observation is an indication of normal flora (McSwency *et al*., 2006), which is a function of the graded levels of diet previously fed to each group of animals prior to overnight starvation, thereby influencing the microbial level of the rumen before feeding. The graded levels of diet also had different carbon concentrations that could be the effect of the feed ingested the previous day on the microbial population before collection of rumen liquor the following morning.

Also at this hour (*pre-feeding*), the reduction in the microbial population might be due to extinction of some microbes that could not survive after a series of microbial synthesis through glycogenetic pathway (utilisation of stored up glycogen). The survivors in a resting stage (no cellular division or multiplication), might be waiting for the diet of the day to be reactivated for metabolic activities. Hence, a low NH_3^-N recorded for all the diets was expected. NH_3^-N concentration for all the animals were within the standard range in literature *pre pandia* which is between 4-10 mg/ml (Hemston and Moir, 1979). Values lower than the recommended range recorded for animals on Diet F might be due to a high concentration of anti-nutritional factors such as (glycocyanide) which led to acidity.

A high microbial activity is directly proportional to the efficient utilisation of nutrients in the diet. This could explain why there was a spontaneous reaction amongst all the sheep micro floral activity after feeding as observed in the NH_3-N concentrations from 0 to 3rd hour. This finding conforms to those of Shahid e*t al.* (2010) in the rumen metabolism of sheep fed poultry litter. A continous increase was obtained in the NH_3-N concentration at 3hrs post feeding. In the control et, there was a gradual reduction in the microbial load which probably may have been an indication of the presence of residual anti-nutritional factor (Adebowale 1981) which corroborated the work of Pham Ho Hai *et al*.(2009).

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An increasing trend in the microbial load was obtained at the 3rd and 6th hours for all diets probably because the microbes still had sufficient nutrients available in the feed. This observation was contrary to that of Shahid *et al*. (2010) who obtained a decreased NH_3^-N concentration at 6th hour *post-prandia* was observed.

At the 6th and 9th hours, a decline in microbial load was observed in the rumen and this connotes the exhaustion of the nutrients in the diet by the microbes. Furthermore, there could have been an over crowdedness of microbes over a long period of cell divisions and multiplication, which could have caused a buildup of metabolites that were eventually toxic against them, leading to lag phase.

5.10.1   DIET A

At 0 (*pre pandia)* to 3rd hour, stationary phase assumed by the microbes might have been as a result of the inhibitory effect of the oil concentration in OPS to CaP ratio of 1:1, which probably was capable of inactivating the microbial activities. Although, Wanapat *et al,* (2005); Phengvilaysouk and Wanapat. (2008) established that coconut oil supplementation reduced protozoa population in the rumen of buffalo. A slight resistance to the oil inhibitory effect by the microbes, was observed at the 3rd to 6th hours but at 6th to 9th hours, a reduced growth in the microbial load was noticed probably because the anaerobic microbes were in a stationary phase while the aerobic microbes were either inactivated or dead. This implied that very little of the nutrients was available to the animal for active microbial activity. This could be noticed in the low dry matter intake (DMI) of sheep placed on this diet.

5.10.2   **DIET B**

From 0 to 6th hours, there was a gradual but slow rate of increase in the microbial growth with the sixth hour corresponding to the optimum growth, this trend is an indication of the unfavorable strength of oil to cassava peel ratio (1:2) which had a negative effect on microbial interactions. Though the impact was less observed yet, nutrient was released to the animals but the microbes were not at the best of their performance.

5.10.3   **DIET C**

The consistent increase of the microbial load that continued in a progressive manner from 0 to the 6th hours where optimal growth was recorded could be due to a favourable ratio of OPS to CaP (1:3). In this diet; highest microbial load was observed. It can then be deduced from the animals on this diet that the microbes were at their best active performance and nutrient was released to the sheep steadily. Shahid *et al*. (2010) explained that increased DMI reduced the cellulose cell wall or structural carbohydrates, with a corresponding increase in cell contents as well as increased rate of digestion due to microbial stimulation with corresponding increases in microbial population and protein synthesis. Therefore, high DMI obtained from sheep on this diet might be an added advantage for its gradual and steady increase in microbial load. Between the 6th and the 9th hour, a remarkable decline in cellular synthesis was observed which might be an indication of the efficient utilisation of nutrients in the diet by the microbes. Although this work did not focus on classification, a decrease in protozoan population will positively affect bacteria population, which favours fibre degradation.

5.10.4   **DIET D**

Between 0 to 3rd hours, a slight increase in microbial population was observed at which optimal microbial growth was attained at the 3rd hour, due to the availability of nutrients. A continuous growth could not be maintained at 3rd to 9th hours because of possible cidal effect of the potentially toxic ingredient in the diet. The slight increase observed in the microbial growth might have resulted from the utilisation of the

nutrients to build up their resistance against the toxic level of the diet which the inclusion ratio (oil to cassava ratio; 1:4) could not breakdown totally.

5.10.5   DIET E

Though the microbial growth was progressive, yet it was not at an optimal increase from the 0 to the 6th hour due to an unfavourable ratio of oil to cassava peel (1:5).

5.10.6   DIET F

The negative growth of the microbes from the 0 to the 3rd hour which was different from all the other diets cannot be defined, but might possibly be as a result of the toxic threshold of the glycocyanic content of the diet which influenced the extinction of some microbes. An exponential increase (from a point of exponential decrease) might have been due to the slow but gradual self-replication of the survivors until a resistance was built against the toxic level up to the 6th hour. In other words, nutrient supplied by diet F might be inadequate for the animal.

5.11   EFFECT OF TREATMENT ON RUMINAL AMMONIA NITROGEN (NH_3^-N) AND   pH OF WEST AFRICAN DWARF SHEEP FED FERMENTED GRADED MIXTURES OPS AND CaP

The most suitable rumen NH_3^-N levels for microbial activities were 5 to 20mg/100ml in ruminants fed on low quality roughages (Boniface *et al.*, 1986). Preston and Leng, (1987) also reported that the optimum level of NH_3^-N in rumen fluid for microbial growth ranged from 5 to 25mg/ml and a range of 8.5 to over 30mg/ml was considered optimum by (Mc Donald *et al.,* 1996). The results from all the diets in this experiment ranged within all the findings of the above authors irrespective of the level of oil supplementation. This result is also similar to the findings of Wanapat *et al.* (2005), observed that the NH_3-H concentration in the rumen fluid was not significantly affected by increasing level of oil in the diet.

The pH of 7.12 that was recorded for Diet A must have been associated with the unfavorable OPS to CaP mixture, which reduced the microbial activity although the effect of the oil and fermentation might be a reason for the alkalinity. Jones and Porter (1998) described oil as an excellent adjunct for improving fermentation productivity and in the reduction of anti-nutritional factors. The pH values of other diets fed, including the control in this study was within the recommended range (6.5-7.0) indicated for optimal rumen microbial activity. Therefore, the NH_3^-N might be a better determinant of the best-preferred diet. This might perhaps be Diet C because it recorded the highest stipulated value within stipulated values within the range in literature.

5.12 EFFECT OF TIME ON RUMINAL pH AND AMMONIA NITROGEN (NH_3^-N) CONCENTRATION OF WAD SHEEP FED FERMENTED GRADED MIXTURES OF OPS AND CAP

Maximum production of NH_3^-N at 6 hours of collection indicated that active degradation by the microbes had just commenced. At the 9th hour, there was a drop in the production of NH_3^-N which may be an indication of a negative time of collection due to the total utilization of nutrients in the rumen by the microbes.

5.13 EFFECT OF INTERACTION BETWEEN TIME AND TREATMENT ON RUMINAL pH AND AMMONIA NITROGEN (NH_3^-N) CONCENTRATION OF WAD SHEEP FED FERMENTED GRADED MIXTURES OF OPS AND CaP

The highest average pH (6.36) value and the least ammonia nitrogen (NH_3^-N) 4.39 concentration were both observed at 0 hour. This could be due to low nutrient availability, which implies low microbial activity. At 3 hours *post prandia,* a sudden increase in NH_3^-N (17.94) was recorded with no numerical variation obtained for pH (6.34). This increased value might have resulted from the efficient feed utilization which was in accordance with the report of Shahid *et al*. (2010) that NH_3^-N increased significantly at 3 hours post feeding. At 6 hours after feeding, pH was constant but a slight reduction in NH_3^-N concentration was observed, probably

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due to the utilization of the nutrients by the microbes in building up of their cellular protein (Shahid *et al.,* 2010). A drastic decline in value was observed in both pH (6.22) and NH_3^-N (9.57) concentration at the 9th hour and this could be due to nutrient deficiency and reduced microbial population. If the degradation were allowed to continue beyond the 9th hour, a further reduction in pH and NH_3^-N could have been recorded, this would have probably led to the proliferation of lactic acid bacteria with an eventual production of excess lactic acid resulting in lacticacidaemia.

CHAPTER SIX

6.1 SUMMARY, CONCLUSION AND RECOMMENDATION

6.2   Summary

The inadequate supply of forage all year round, land acquisition by the government for non- agricultural purposes and the incessant increase in prices of conventional feedstuffs are some of the factors hindering the adequate production of ruminant livestock in Nigeria. Recent efforts are therefore, focused towards the use of alternative sources, which are, less expensive, not in competition with man as feedstuff and are readily available to each locality.

In Nigeria, cassava peel has been widely acceptable as a source of feed for ruminants. Nigeria is the 5th largest palm oil producing country but there is dearth of information on the use of its effluent (Slurry) as alternative feed resource for ruminants. Therefore, this study involved three different experiments meant to evaluate the nutrient potential of fermented combination of both ingredients for ruminant (sheep) feeding.

6.3   Conclusion

The chemical composition of oil palm slurry collected from different locations in this study, indicated a higher Crude Protein value than Cassava peel which had a positive influence on the Crude Protein fortification of the fermented combination of Oil palm slurry and Cassava peel.

Fermentation also improved the quality of the mixture by breaking down the fibre contents in each graded combination through microbial metabolic activities. The best result was obtained at the ratio 1:3 Oil palm slurry to Cassava peel. However, this dilution ratio of oil palm slurry to cassava peel is an important factor to be considered.

The *in vitro* fermentation results revealed that the effective degradability was most efficient at the ratio of 1:3, Oil palm slurry to Cassava peel. Mixtures at higher or lower ratios were not as effective.

Acceptability results revealed that fermentation improved the physical and chemical stability of the diets depending on the dilution ratio. The Total Digestible Nutrients, N-Balance and N-Retention and total microbial count of the rumen microbes indicated

that optimum performance in West African Dwarf sheep was best at 3% CaP to 1litre Oil palm slurry.

At the ratio of 1:3 (OPS to CaP), minimum cassava peel with little quantity of oil palm slurry will be required thereby controlling the economy of alternative feed resources.

Ordinarily, diet F was expected to perform best but oil inclusion has enhanced best performance in diet C. This confirms that oil was as an antidote to anti nutritional factors contained in unprocessed cassava peel before fermenting diet F.

6.4 Recommendation

Collection of oil palm slurry from several palm oil processing sites within a location for the assessement of variations in their chemical composition will reveal the effect of different sites within a location.

Consideration of different processing techniques could be a determinant factor in the correlation between the physical parameters and the nutrient value of the effluent (Slurry).

Reduction of anti nutritional factors by subjecting cassava peel to prior sun drying before mixing with oil palm slurry might have a positive influence on biodegradation of the mixture.

Finally, it is suggested that in further studies on Oil palm slurry and Cassava peel microbial characterization should be conducted so as to ascertain the specific micro flora of the rumen.

REFRENCES

Abu, A.A., Okai, D.B. and Tuah, A.K. (1984). Oil palm slurry (OPS) as a partial replacement for maize in the diets of growing-finishing pigs. Nutrition Reports International 30 (1): 121–127

Achinewhu, S.C., Barber, L.I. and Ijeoma, I.O.(1998). Physiological properties and garification (gari yeild) of selected cassava cultivars in Rivers State, Nigeria. *Plant Foods For Human Nutrition,* June 1998, vol.52, no. 2, p. 133-140.

Adebiyi O.A. (2006). Fungal Degradation of cowpea Seedhull for Utilisation by meat-type (BROILER) Chicken. Ph.D thesis University of Ibadan, Nigeria.

Adebowale, E. A. (1981). The maize replacement value of fermented Cassava peels (MANIHOT UTILISSMA POHL) in ration of sheep. Tropical Animal Production 1981 6:1.

Adebowale, E.A. (1983). The performance of West African dwarf goats and sheep fed silage plus concentrate *Review of Animal* 4: 15-20.

Adeleye I.O.A. (1991), Dried poultry droppings as a source of dietary nitrogen for sheep fed corn- cobs based diets.

Aderiye, J.A. (1996). Maize or sundried Oil Palm Slurry as energy source in calf concentrate diets. Effect on feed intake and weight gain of White Fulani Calves. An M.Sc dissertation in the Department of Animal Science, University of Ibadan.

Aderolu, A. Z. (2000). Physico-chemical properties of biodegraded fibrous feedstuffs as energy sources using Trichoderma spp. M. Phil. Project. Department of Animal science, University of Ibadan.

Agosin, D., Jarpa, S., Rojas, E. and Espejo, E. (1989). Solid state fermentation of pine saw dust by brown-rot fungi. *Enzyme and Microbial Technology.* 11: 511-517.

Ajayi, D.A., Babayemi O.J. and Taiwo A.A. (2007). Effect of *Stylosanthes guianensis* and *Aeschynomene histrix* on the yield, proximate composition and in sites dry matter and crude protein degradation of panicum maximum (Ntchisis). Livestock Research for Rural development 19 (3).

Akinsoyinu, **A.O. (1974).** Studies on Protein and energy utilization by West African dwarf goats.PhD, Thesis University of Ibadan, Nigeria.

Allen S. and Miller, E. L. (1976). British Journal of Nutrition 36, 353-368.

1.1.1   Andrews, R. J. and Lewis D. (1970). The utilization of dietary fats by ruminants:II.   The effect of fatty acid chain length and unsaturation on digestibility. University of Nottingham School of Agriculture, Sutton Bonington, Loughborough.The Journal of Agricultural Science.

A.O.A.C (1990). The official methods of Analysis. Association of Official Analytical Chemist, 15th Edn., Washington DC. Pg. 69-88.

A.O.A.C (1995). The official methods of Analysis. Association of Official Analytical Chemist, 16th Edn., Washington DC. Pg. 69-88.

Apori. S.O. (1984). Oil Palm Slurry supplementation in diet for White Fulani Calves. MS. C. project submitted at the Department of Animal Science University of Ibadan.

Aregheore, E.M. (2000). Chemical composition and Nutritive value of some tropical by-product feedstuff for small ruminants- In vitro and in vivo digestibility. Animal Feed Science Technol. 85: 99-109.

ARC. (1980). The nutrient requirements of farm livestock. Farnham Royal: Agricultureal Research Council, Commonwealth Agricultural Bureaux.

Arowora, k.A. **(2002).** Biochemical characterization and enzymic degradation of cassava peel and its utilization in pig feeding. A thesis submitted at the department of animal science, University of Ibadan, Ibadan Nigeria.

Awah, A . A. (1982). Effect of milk and concentrate feeding on nutrient utilization and tissue development of West African Dwarf (FOUTA DJALLON)

kids under humid tropical environment. A thesis submitted in the Department of Animal Science University of Ibadan. Nigeria**.**

Ayoade J.A. , Ayoola, G.B., and D.V Uza (1991). Fattening beef cattle on local crop residues and agro-indusrial by product. A feasible post harvest enterprise for smallholder farmers in Benue state. A proceedings of third all animal Faming Systems Research and Extension workshop (Middle Belt Zone) Badeggi, Nigeria pp 113-118.

Ayoade, J. A., Adeleye, I. A. O. and Ogebe, O. F. (1993). A survey of rural goat production in the middle belt region of Nigeria. A case study of Ado Local Government Area of Benue State. Small Ruminant Network Newsletter. 26:5-11.

Ayoola G. B. and J. A. Ayoade (1993). Socio-economic and policy aspects of utilizing crop residues and agro-industrial by products as alternative livestock feed resources in Nigeria. Proceedings of joint feed resource networks workshop on 'complimetary of feed resources for animal production in Africa' (Stares J. E.S, Said, A. N. and J. A. Kategileeds) Pp. 377-383.

Babayemi, 0.J., Bamikole, M.A., Daniel, I.O., Ogungbesan, A and Oduguwa, B.O. (2003). Growth, nutritive value and dry matter degradability of three Tephrosia species. Nigerian Journal Animal Production 30: 62-70.

Babayemi, O. J., Demeyer, D. and Fievez, V. (2004). Nutritive value and qualitative assessment of secondary compounds in seeds of eight tropical browse, shrub and pulse legumes. *Comm. Appl. Biol. Sci. Ghent University.* 69(1):103-110.

Babayemi, O.J., Bamikole, M.A. and Omojola, A.B. (2006). Evaluation of the nutritive value and free choice intake of two aquatic weeds (*Neophrolepis biserrata and Spirodela polyrhiza*) by West African Dwarf goats. *Trop. and subtrop. Agro ecosystem* 6 (1): 15-22.

Babayemi, O.J. and Bamikole, M.A. (2006) Effect of Tephrosia Candida DC leaf and its mixtures with Guinea grass on the *in vitro* fermentation changes in feed for ruminants in Nigeria. Pakistan Journal of Nutrition. 5: (1) 14-18.

Babayemi O.J.; Otukoya F.A.; Familade. F.O. and Daodu, M.O. **(2009).** Assessment of the nutritive value of bovine liquor and urea treated corn straw and corn- cobs as feed for the West African dwarf Sheep and goats. Nigerian Journal of Animal Production. 36. (2): 313- 324.

Babayemi, O. J., Ifut, O. J., Inyang, U. A. and Isaac I. J., (2010) Quality and chemical composition of Cassava waste ensiled with *Albasia Saman* Pods. Agricultural Journal volume 6 [issue 3] Pp 225-228.

Bamikole, M. A., Akinsoyinu, A. O., Ezenwa I, Babayemi, O. J., Akinlade, J. and Adewumi, M. K. (2004). Effect of six - weekly harvests on yield, chemical composition and dry matter degradability of Panicum maximum and Stylosanthes hamata in Nigeria. Grass and Forage Science, 59, 357-363.

Balagopalan, C. (1996) Nutritional Improvement Cassava Products Using Microbial Techniques for Animal Feeding. Monograph of the Central Tuber Crops Research Institute, Kerala, India. 44p.

Barrios-González, J. A., Tomasini, G., Viniegra-González and López, L. (1994) Penicillin production by solid state fermentation.*Journal of Biotechnology*. 10(11): 793-798.

Bergman, E. N. (1990). Energy contributions of volatile fatty acids from gastro intestinal tract in various species. *Physiol Rev.* 70: 567-590.

Belewu, M. A. and Banjo, N. O. (**1999).** Biodegradation of rice husk and sorghum stover by edible mushroom (*Pleurotus sajo caju*). *Tropical J. Anim. Sci.* 2: 137-142.

Blummel, B., Makkar, H. P. S. and Becker, K. (1997). *In vitro* gas production: a technique revisited. *Journal of Animal Physiology and Animal Nutrition.* 77: 24-34.

Blummel, M. and Orskov, E. R. (1993). Comparison of gas production and nylon bag degradability of roughages in predicting feed intake in cattle. *Animal Feed Sci. Technol*. (40): 109.

Blummel, M., Orskov, E. R., Becker, K. and Soller, H. (1990). Anwedung des Hoheheimer Gastests zur Schatzung kinetischer Parameter der Pansenfermentation. *J. Animl.Physiol. Anim. Nutr.* 64, 56.

Bohman, O. R., Wade, M. A. and Hunter, J. E. (1957). Effect of Chlortetracycline, stilbesterol and animal fat on fattening steers. *Journ. Of Anim. Sci*. 15:833-839.

Bolaños, M. A. (1986). La palma aceitera en Costa Rica. En: IV Mesa Redonda Latinoamericana sobre Palma Aceitera, Valledupar, Colombia 8–12 de junio de 1986, ORLAC/FAO p 23-25.

Boniface, A. N., Murray, R. M. and Horgan, J. P. (1986). Optimum level of ammonia in the rumen liquor of cattle fed tropical pasture hay. In: Proceedings of Australian society of Animal Production 16:151-154.

Boopathy, R. (1994). Transformation of nitroaromatic compunds by a methanogenic bacterium, Methanococcus sp. (strain B). Archives of Microbiology 162:167-172.

Borquin, L. D., Garleb, K. A., Merchan, N.R., Jr. and Fahey G.C. (1990). Effects of intake and forage level on site and extent of digestion of plant cell nunumeric components by sheep. *J. Anim Sci.* 68: 2479-2495.

Bauchop T. (1981). The anaerobic fungi in fibre digestion. Agric. Environ. 6:339-348.

Bruneton. J. (1999). Toxic Plants Dangerous to Human and Animals, Lavoisier Pub. France.Pp 545.

Bryant, M. P. (1993). Microbiology of the Rumen and Intestine. Inc. The Ruminant Animal Digestive Physiology and Nutrition. Church, D.C. (ed). Waveland Press. Inc. III Pp 126.

Busquet. M., Calsamigila S., Ferret, A., Carro, M. D. and Kamel. (2005). Effect of garlic oil and four of its compounds on rumen microbial fermentation. Journal of Dairy Science 88:4393-4404.

Butler, W. H. and Barnes, J. M. (**1963**) Brit. J. Cancer, 17, 699.

Campbell, C. J. and Laherrere, J. M. (1998). The end of cheap oil. Sci. Am. 3:78-83.

Cannel, E. and Moo-Young. M. (**1980).** Solid state fermentation systems. *Process Biochem*. 15:2428.

Carro, M. D., Lopez, S., Gonzalez, J. S. and Ovejero, F. J. (1994). Comparison of laboratory methods for predicting digestibility of hay in sheep. *Small Rumin. Res.* 14: 9.

Chahal, D. S. (1985). Solid state fermentation with *Trichoderma reesi* for *cellulose* production. *Appl. Environ. Microbial.* 49:205.

Chahal, P. S., Chahal DS, Le GBB (1996). Production of cellulose in solid– state fermentation with Trichoderma reesei MCG 80 on wheat straw. Appl. Biochem. Biotechnol. 57: 433-442.

Chhay, T. Y., Preston, T. R. and Ly J. (2003). The use of ensiled cassava leaves in the diet of growing pigs. 2. The influence of type of palm oil and cassava leaf maturity on digestibility and N- balance fo growing pigs. Livestock Research for Rural Development (15) 8 retrieved,from http://www.cipav.org.co/Irrd/Irrd15/8/ chha 158. Htm.

Chantalakhana C. (2001). Urgent Need in Buffalo Development for Food Security and Self- Sufficiency. Workshop on Swamp buffalo in Vietnam. Proceedings Buffaloes workshop December 2001, from http://www. Mekarn. Org/procbuf/chan.htm.

Choct, M. (**1998**). Feed non-starch polysaccharides: Chemical structure and nutritional significance. *Brt. Poult. Sci.* 306: 62-98.

Cheng, K.J., Stewart, C.S., Dinsdale, D., and Costeron, J.W. (1984). Electron microscopy of bacteria involved in the digestion of plant cell walls. Animal Feed Science Technology. 10:93-120.

Christopher S. McSweency, Brain Palmer, Rowan Bunch and Denis O. Kranse (1999). Isolation and characterization of Proteolytic ruminal bacteria from sheep and goats fed the Tannin-containing shrub legumes.

Clapperton, J. L. (1974). The effect of Trichloroacetamide, Chloroform and Linseed oil giving into the rumen of sheep on some end products of rumen digestion. Br. J. Nutr. 32: 155-161.

Coelho, M., Hembry, F.G., Barton, F.E and Saxton, A. M. (1988) A comparison of microbial, enzymatic, chemical and near -infrared reflectance spectroscopy method in forage evaluation. Anim. *Feed Sci. Technol.* 93, 205.

Cone, J. W. (1991). Degradation of starch in feed concentrates by enzymes, rumen fluid and rumen enzymes. J. Sci. Food Agric. 54: 23-34.

Cott. R. (2009). Montana Farm Flock Sheep production handbook, Nutrition Part 2- section 6 of 7.

Cowan, W. D., Korsbak, A. Hastrup, T. and Rasmussen, P. B. (1996). Influence of added microbial enzymes on energy and protein availability of selected feed ingredients *Anim. Feed Sci. Techn.* (60). 311-319.

Czerkawski, J. W. (1986). An introduction to rumen studies. Pergamon Press, Oxford, Pp 236.

Davis, F. and Briggs, G. M. (1998). Saw Dust Purified Chick Rations Poultry Sci; 27:11-118.

Dawson A. and Kemp A., (1970). Physiology of Digestion and metabolism in the ruminant. Ed. A.T. Philllipson. Oriol Press, New Castle, P. 504.

Dazel, R. (1978). A case study on the utilization of effluent and by-products of oil palm by cattle and buffaloes on oil palm estate. In feeding stuffs for livestock in South East Asia (Ed. Devendra C and Hutagalung,B.I.)Pg.132-141, Kuala Lumpur. Malaysian Society of Animal Production.

Deinum, B. and **Van Soest, P. J**. **(1969).** Prediction of forage digestibility from some laboratory procedure. Neth. J. Agric. Sci., 119.

DeLange, F., Ermans, A. M., Van der Velden, M., and Kinthaert, J. **(1973**). Mechanism of goitrogenic action of cassava. In *Chronic Cassava Toxicity. International Development Research Centre Monograph* no. OIOe, pp.153-157.

DeRamus, H. A., Clement, T. C., Giampola, D. D. and Dickison (2003).. 32: 269- Methane emission of beef cattle on for ages: efficiency of grazing management system. J. Environ. Quality 277.

Deshpande, S.S., Cheryan,M. and Salunke,D.K. (1986). Tannin Analysis of Food Products. CRC. *Critical Reviews in Food Science and Nutrition*, 24: 401.

Devendra, C. and Lewis. D. (1974). Animal Production. 19:67.

Devendra, C. (1977). Utilization of Feedingstffs from the Oil Palm. In: Proc. Symp. Feedingstuffs for Livestock in South East Asia p 116–131.

Dierick, N. A. (**1989**). Biotechnology of acid to improve feed and feed digestion, enzymes and fermentation. *Arich. Anim. Nutr. Ber.* 39 (3): 241-261.

Dixon, R. M. and Egan, R. M. (**1987**). Strategies for utilizing fibrous crop residues as animal feeds. Paper presented to the 7th AAFARR Workshop. 2-6 July, Chiang Mai, Thailand

Doelle, H.W., Mitchell, D. A. and Rolz, C. E. (**1992**). Solid Substrate Cultivation. Elsiever Sci. Publ. Ltd; London & New York; pp 466

Dohme, F., Machmueller, A., Wasserfallen, A., and Kreuzer, M . (**2001**). Ruminant Metanogenesis as Influenced by Individual Fatty Acids Supplemented to Complete Ruminant Diets. Lett Appl. Micro. Biol. 32,47-51.

Dougherty, R. W., Mullenok, C. H. and Allison, M. J. (**1964**). Physiological phenomena associated with eructation in ruminants. In: Physiology of Digestion on the Ruminant (R.W. Dougherty, Ed.) Butterworth's, London.

Dutton, J. (**1987**). Silage enzymes are starting to win friends. Farmers weekly, Feb. 13 pp. 40

Dyer, I. A., Ensminger, M. E. and Blue, R. C. (**1957**). Effect of Fat, oxytetracycline and stilbesterol on performance and hepatic stores of carotene and vitamin A in steers. Journ. Anim. Sci. 16: 828-832.

1.2.1.1   ***Egan R. Adrian.** (**1987**). Technological Constraints and Opportunities in Relation to Class of Livestock and Production Objectives.* Department of Agriculture and Resource Management, University of Melbourne, Parkville, Victoria 3052, Australia.

Ermans, A. M, DeLange, F. and Thilly, C. H. (**1980**). Endemic goitre in Kiku, Africa: focus on cassava. In *Role of Cassava in the Aetiology of Endemic Goitre and Cretinism. International Development Research Centre.*

Feeny, P. (1970). Seasonal changes in Oak Leaf Tannins and Nutrients as a cause of Spring Feeding by Winter Moth Caterpillars. *Journal of Ecology*. 51:565.

Fievez, V., Dohme, F., Danneels, M., Raes, K, and Demeyer, D. I. (**2003**). Fish oil as poten rumen methane inhibitor and associated effects on rumen fermentation *In vitro* and *in vivo*. *Anim. Feed Sci. Technol.* 104: 41-58.

Firkins, J. L., Berger, L. L. Merchen and Farhez, (Jr). G. C. (**1986**). Effects of forages particle size, level of feed intake and supplemented protein degradability on microbial protein synthesis and site nutrient digestion in steers. *J. Anim Sci.* 62: 1081-1094.

Ffoulkes, D. and Preston, T. R. (**1978**). Cassava or sweet potatoe forage as combined sources of protein and roughage in molasses based diets. Effect of supplementation with syabean meal. Tropical Animal Production (3):

186-192.   Hppt://www.fao.org/ag/aga/agap/frg/tap33/: http://www.utafoundation.org/TAP/TAP33/3 3 1.pdf.

Georing, H. K. and Van Soest, P. J. (**1970**). Forage fibre analysis, apparatus reagents, procedures Geori and some applications. Agriculture handbook No. 379 USDAARS, Washington, D.C. P. 20402.

Getachew, G., **Makkar, H. P. S., Becker, K.** (**1997**). The in vitro gas with ammonia measurement for evaluation nitrogen of nitrogen degradability in low quality roughages using incubation medium of low buffering capacity. J.Sci. Food. Agric.

Getachew, G., Blummel, M., Makkar, H. P. S. and Becker, K. (**1998**). *In vitro* gas measuring techniques for assessment of nutritional quality of feeds: a review: *Anim. Feed Sci. Technol.* 72, 261.

Getachew, G., H. P. S. Makkar and Becker, K. (**1999**). Stoichiometric relationship between short chain fatty acid and *in vitro* gas production in presence and absence of polyethylene glycol for tannin contaning browses, EAAP Satelite Symposium, Gas production: Fermentation kinetics for feed evaluation and to assess microbial activity, 18-19 August, Wageningen, The Netherlands.

Getachew, G., DePeters, E. J., Robinson, P. H., Taylor, S. J. (**2000**). *In vitro* rumen fermentation and gas production: Influence of yellow grease, tallow, corn oil and their potassium soaps. *Anim. Feed Sci. Technol.* 93: 1-15.

Getachew, G., DePeters, E.J., Robinson, P. H. and Taylor, S. J. (**2001**). *In vitro* rumen fermentation and gas production: Influence of yellow grease, tallow, corn oil and their potassium soaps. *Animal Feed Sci. Technol.* 93:1-15.

Getachew, G., Makkar, H. P. S. and Becker, K. (**2002**). Tropical browses: content of phenolic compounds, *in vitro* gas production and stoichiometric relationship between short chain fatty acids and *in vitro* gas production. *J. Agric. Sci.,* 139-341.

Getachew, G., Robinson, P. H., DePeters, E. J., Taylor, S. J., Gisi, D. D., Higginbotham, G. E. and Riordan, T. J. (**2005**). Methane production from commercial dairy rations estimated using an *in vitro* gas technique. *Animal Feed Science and Technology*. 123-124: 391-402.

Gonzalez, D. A, Gonzalez C, Diaz I, Ly J. and Vecchionacce, H. (**1999**). Determinacion en credos de la digestibilidad de nutrients de dietas de follaje de yucca amarga (Manihot esculenta Crantz) y aceite de palma (Elaeis guineensis Jacq.) Revista Computagonzada de Produccion Porcina 6(1)22-30.

Grainger, R. B. White, T. W. Baker F. H. and Stroud J. W. (**1957**). The inter-relationship between calaium and fat in ruminant digestion. Jour. Anim. Sci. 16: 1086-1087.

Grants, R. J. and Mentes, D. R. (**1992**). Influence intake, NDF source and ruminal pH on in situ fibre disappearance. Journal of Dairy Science, 75: 2762-2768.

Haaland, G. A., Matsushima J. K., Johnson., D. E. and Ward, G. M. (**1981**). Nutritive value of protected tallow product fed with hay to beef Cattle as assessed by respiratory calorimetry.

Haltrich, D., Nidetzky B., and Kulbe, K. D. (**1996**). Production of fungal xylanases. *Biores. Technol.* 58:137-161.

Hamlyn, P. F. (**1998**). Extracellular enzymes of *penicillium*: In Biotechynology, Handbooks Vol. I . *Penicillium* and *Acremonium* (Pebeddy J.F.Eds). Plenum Publishing corporation. New York. Pp245-286.

Hawke, J. C. (**1973**). Lipids in chemistry and biochemistry of herbage, pp. 213-263.

Hriston, A. N. (**2009**). Journal of Dairy Sci. Nov, 92 (11) pp 61-82. Department of Animal and Vet Sci. University of Idaho, Moscow ID 83844. anh 13 @ psu. edu.

Hume, I. D. (**1970**). Synthesis of microbial protein in the rumen III: The effect of dietary protein. *Australian. Journ. of Dietary Reaserch* 21:305-214.

Hutagalung, R. I. (1978). Non -traditional feeding stuff for livestock. In feeding stuffs for livestock in South- East Asia . Malaysian Society of Animal Production. Kuala Lumpar : Pg 259-288.

Hutagalung, R.I. and Mahyudin, M. (**1981**). Feeds for animals from the oil palm. Proc. Inter. Conf. on Oil Palm in Agriculture in the Eighties. p 609–622

Hungate, R. E. (**1966**). The Rumen and its Microbes. Academic Press, New York.

Idahor, O. K. (**2006**). Evaluation of Nutritional Potentials of Differently Processed Foliages and *Elaeis guineensis, Tithonia diversifolia, Spondias mombin* and *Terminalia catappa* for ruminant nutrition. MS.C dissertation submitted at the Dept. of Anim. Sci. University of Ibadan.

Iyayi, E. A. and Aderolu, Z. A. (**2004**). Enhancement of the feeding value of some agro-industrial by products for laying hen after their solid state fermentation with Iyayi *Trichoderma viride. African J. of Biotech.*3 (3) : 182-185

Iyayi, E.A., and Losel, D.M. (**2001**). Changes in the nutritional status of cassava products following solids state fermentation by fungi. A technical report submitted to the Royal Society of the UK.

Jamal, I. D. and Md. Zahangir. A. (**2010**). Statistical optimization of fermentation conditions for Cellulase Production from Palm Oil Mill Effluent. American Journal of Environmental Science 6(1) 66-70.

Jecu, L. (2000**). Solid-state fermentation of agricultural wastes for endoglucanase production. *Industrial Crops and Products.* 11:1-5.

Johnson, K.A. and Johnson, D.E. (**1995**). Methane emission in cattle. *Journal of Anim. Sci.* 73: 2483-2492.

Jones, A. M. and Porter, M. A., (**1998**).Vegetable oils in fermentation:beneficial effects of low-level supplementation. Journ. of Industrial Microbiology and Biotechnology, vol 21, no 4-5.

Kamel. C., Greathead H. M. R., Ranilla M. J., Tejido, M. L., Ramos, S. and Carro, M. D.(**2009**).

Kane, E., Baker, J. P. and L. S. Bull. (**1979**). Utilisation of corn oil supplemented diet by the pony. *J. Anim*. Sci. 48: 1379.

Kenneth, M. Olsen and Barbara A. Schaal (**1999**). Evidence on the origin of cassava: Phylogeography of *Manihot esculenta.* Department of Biology, Washington University, St. Louis, MO 63130 *Communicated by Peter H. Raven, Missouri Botanical Garden, St. Louis, MO.*

Kharat, S. T. (**1974**). Factors affecting the nutritive value of wheat straw verities. M.Sc. Thesis. G.B. Plant Univ. Pantnagar Effect of garlic oil on invitro fermentation and methane production Pony. J. Anim. Sci. 48(6): 1379-1384.

Kimambo, A. E., Weisbjerg, M. R., Hvelplund, T. and Madsen, J. (**1994**). Feeding values of some tropical feeds evaluated by the nylon bag technique. In symposium on integrated livestock/ Crop Production Systems in Small Scale and Communal Farming Sector. University of Harar,. Harare.

Kirchgessner, M.H. Freisecke and Koch G. (**1976**). Nutrition and Composition of milk. Coesby Lookwood and Scn. Ltd., London, Pp. 1-38 and 130-133.

Kowalczyk, J., Orskov, E. R., Robinson, J. J. and Stewart, C. S. (**1977**). Effect of fat supplementation on voluntary food intake and rumen metabolism in Sheep. Br. Journ. Nutri. 37: 251-258.

Kronfeld, D. S. and Donoghue S. (**1980**). Digestibility and associative effects of protected tallow. J . Dairy Sci. 63:642.

Krueger, W. C., Laycock, W. A. and Price, D. A. (**1974**).Relationships of taste, smell, sight and touch to forage selection .J. Range Manage. 27:258-262.

Lee, H. J., Lee, S. C., Kim, C. W., and Kim, K. J. (**2003**). Methane Production potential of feed ingredients as measured by In vitro gas test. Asian-Austra. J. Anim. Sci. 16. 1143-1150.

Longe, O. G. and Adetola, J. A. (**1983**). Metabolisable values of some Agricultural wastes and Industrial by-products for layers and effect of these ingredients on gut dimension.Journal of Animal Research 1(3):1.

Longe, O. G. (**1988**). Meeting the energy needs of non-ruminants from non-conventional feed resources in Nigeria. Paper presented at Rural Management Training Institute (ARMTI) Ilorin, Nov. 21-25, 1988.

MaCaskey, T. A. and Anthony, W. B. (**1979**). Human and animal health aspect of feeding livestock excreta. J. Anim. Sci. 48(1): 163-177.

Macleod, G. K. and Buchanan-Smith, J. G. (**1972).** Digestibility of hydrogenated tallow, Saturated fatty acids and soybean oil supplemented diets by sheep. J. of Anim. Sci. 35: 890-895.

Macleod, G. K. A., Wood, A. S. and Yao, Y. T. (**1972**). Influence of dietary fat on rumen fatty acids, plasma lipids and milk fat composition in the cow. J. Dairy Sci. 55:446.

Makkar, H. P. S. (**1994**). Application of the *in vitro* gas method in the evaluation of feed resources and enhancement of nutritional value of Tannin rich tree browse leaves and agro-industrial by products.

Mako, A. A. (**2009**). Water Hyacinth (*Eichornia crassipess Mart Solms-lau bach*) As a potential feed for the West African Dwarf Goats. Ph.D. Thesis. University of Ibadan, Ibadan.

Malherbe, S. and Cloete.T. E.(**2003**).Lingnocellulose biodegradation:fundamentals and applications: A review. Environ.Sci. Biotechnol.1:105-114.

McDonald, P**., Edwards, R. A. and Greenhalgh, J. F. D.** (**1988**). Animal Nutrition (4th ed). Longman Publisher. Pp 200-250.

McDonald, M. W., Maslin, B. R. and Harwood, C. E. (**1996**). Taxonomic studies of tropical dry zone *Acacia* species facilitate their domestication, *in* M.J.Deiters, A.C.Matheson, D.G.Nikles, C.E.Harwood & S.M.Walker (eds), *Tree Improvement for Sustainable Tropical Forestry*. Proceedings

of QFRI-IUFRO Conference. 27 October–1 November 1996, Caloundra, Queensland, Australia, pp. 96–98. Queensland Forestry Research Institute, Gympie, Queensland.

Mehrez, A. Z. and Orskov, E. R. (**1977**). A study of artificial fibre bag technique for determining the digestibility of feeds in rumen. *J. Agric. Sci.,* 88, 645.

Menke, K. H., Raab, L., Salewski, A., Steingass, H., Fritz, D. and Schneider, W. (**1979**). The estimation of the digestibility and metabolisable energy content of ruminant feedstuffs from the gas production when they are incubated with rumen liquor. *J. Agric. Sci.* 93, 217.

Menke, K. H. and Steingass, H. (**1988**). Estimation of the energetic feed value obtained from chemical analyses and gas production using rumen fluid. *Anim. Res. Develop.* 28, 7.

Mijares, N. R. (**1985**). Aspectos ecológicos de la palma africna de aceite. En: Potential Productivo de la Palma Africana en Venezuela, Facultad Agropecuaria, Maracay, Venezuela p 17.

Minson, D. J. (**1990**). Forage in Ruminant Nutrition. Academic Press. San Diego.C.A. Pp 482.

Mudgett, R. E. (**1986**). Solid-state fermentations. In: Demain A. L, Solomon N. A. (eds) Manual of Industrial Microbiology and Biotechnology. American Society of Microbiology, Washington DC, USA, pp 66-83.

Muetzel, S. and Becker, K. (**2003**). Supplementation of Barley straw with sesbania parachycarpa leaves *in vitro*: Effects of fermentation variables and rume microbial population structure quantified by ribosomal RNA – target probes. *British Journal of Nutrition.* 89:53, DOI:10. 1079/BJN2002813.

Nartey, F. (1966). A flatoxins of *Aspergillus flavus* grown on cassava. Physiologica Plantarum 19(3):818–822. [Provides evidence that *Aspergillus flavus* thrives on cassava meal substrate and produces relatively high levels of aflatoxins.]

Nithya K. S. and **Ramachandramurty** B. (**1994**). Screening of Some Selected Spices

withMedicinal Value for Cu (II)-Ninhydrin Positive Compounds.

NRC (**1988**). Nutrient Requirement of Domestic Animals. Nutrient Requirement of Swine. 8th ed. National Academy Press, Washington, D. C.

Nguyen Thi Hong Nhan, Nguyen Trong Ngu, Nguyen Thiet, Preston T.R. and Leng R.A. (**2005**). Determination of the optimal level of soyabean oil drench with respect to the rumen ecosystem, feed intake and digestibility in cattle. Workshop- seminar, MEKARN-CTU hppt://www.mekarn.org/proctu/nhan09a.htm.

Nguyen Xuan Trach and Mai Thi Thom (**2004**). Responses of the growing beef cattle to the feeding regime combining road side grazing and rice straw feeding supplemented with urea and brewers dried grains following an oil drench. Livestock Research for Development. http://www.cipav.org.co/Irrd16/7/trac 16053.htm.

Njidda, A. A and Ikhimioya, I. (**2010**). Correlation Between Chemical Composition and *In Vitro* Dry Matter Degradability of Leaves of Semi-Arid Browses of North-eastern Nigeria. American-Eurasian J. Agric. and Envron. Sc. 9(2): 169-175

Oboh, G. and Akindahunsi, A.A. (**2003**). Nutrient enrichment of cassava peels using a mixed culture of Saccharomyces cerevisae and Lactobacillus spp solid media fermentation techniques. Electronic Journal of Biotechnology. Vol. 9 No. 1, Issue of January 15 2006.

Ocampo, A., Lozano, E. and Reyes, E. (**1990a**). Utilización de la cachaza de palma africana como fuente de energía en el levante, desarrollo y ceba de cerdos. Livest. Res. Rur. Dev. 2(1): 43–50.

Ocampo, A., Castro, C. and Alfonso, L. (**1990b**). Determination del nivel óptimo de proteína al utilizar cachaza de palma africana como fuente de energía en raciones para cerdos de engorde. Livest. Res. Rur. Dev. 2(2):67–76.

Ocampo, A. (**1992**). Oil-rich Fibrous Residue from African Oil Palm as Basal Diet of Pigs; Effects of Supplementation with Methionine. Livest. Res. Rur. Dev. 4(2):55–59.

Ocampo, A. (**1994a**). Utilizacion del fruto de palma Africana como fuente de energia con niveles restringidos de proteina en la alimentacion de cerdos de engorde. Livest. Res. Rur. Dev. 6(1): 1–7.

Ocampo, A. (**1994b**). Raw palm oil as the energy source in pig fattening diets and *Azolla filiculoides* as a subtute for soya bean meal. Livest. Res. Rur. Dev. 6 (1):8–17.

Ocampo, A. (**1994c**). Efecto del nivel de pulidura de arroz en una dieta basada en el fruto entero de palma africana para el engorde de cerdos. Livest. Res. Rur. Dev. Livest. Res. Rur. Dev. 6 Dev.6 (2): (18kb).

Ofuya, C.O. and Nwanjiuba, C. J. (**1990**). Microbial degradation and utilization of cassava peels. *World J. Microbial Biotechno*. 6: 144-146.

Ogimoto, K. and **Imai, S. (1981**). Atlas of Rumen Microbiology. Japan Science Society Press, Tokyo.

Okpako, C.E., Nkoi, V. O., Osuwagu, A. N. and Obasi, F. I. (**2008**). Proximate composition and cyanide content of cassava peels fermented with *Aspergillus niger* and *Lactobacillus rhamnosus* . Journal of food, Agriculture and Enivronment. Vol 6(2):251-255.

Oldham, J. D. and Alderman G. (**1980**). Recent advances in understanding protein-energy interrelationship in intermediary metabolism in ruminants. In: Protein and energy supply of high production of milk and meat, Pergamon Press, Oxford, pp: 33

Olie, J. J and Teng, T. D. (**1972**). Traitement et evacuation des eaux residuaries d''une huilerie de palme (treatment and disposal of oil palm mill effluent) Oleagineux 27:215-228,273-275.

Oriol, E., Schettino, B., Viniegra-Gonzalez, G. and Raimbault, M. (**1988**). Solid state culture of *Aspergillus niger* on support. *Journal of Fermentation Technolog.* 66: 57-62.

Orpin, C. G. (**1977**). Invasion of Plant Tissue in the Rumen by the Flagellate *Neocullimastix frontalis. Journal of General Microbiology,* 98: 427-430.

Orskor, E. R. and McDonald, I. (**1979**). The estimation of protein degradability in the incubation measurements weighted according to rate of passage. *J. Agri. Sci.* (Camb).92: 499-504.]

Orskor, E.R. and Ryle, M. (**1990**). Energy Nutrition in Ruminants. *Elsevier, London*. 149Pp.

Osakwe, I. I. and Nwose, R. N. (2008). Feed intake and nutrient digestibility of weaner rabbits fed Cassava peel as replacement for maize. Animal Research international 5(1): 770-773.

Park, Y. S., Momose, Y., Tsunoda, K. and Okabe, M. (**1994**). Enhancement of cephamycin C production using soybean oil as the sole carbon source. Applied Microbiology and Biotechnology, No. 40, 773-779.

Parlizdar, M. H., Sadeghipanah, H., Amanlou, H., Nazer andMirhadi. **A.** (**2011).** In vitro organic matter digestibility and gas production of fish-meal coated with fat. African *Journal of Biotechnology* Vol. 10 (13), pp. 2548-2555. Academic Journal.

Palmquist, D. L. (**1977**). Associative effect of high fat diets on nutrient digestibility in lactating Cows. *Journ. Of Anim. Sci.*60: Supplementary paper 143: Pp. 127.

Palmquist, D. L. and H. R. Conrad, (**1980**). Tallow and Hydrolysed Blended Fats at Two Intakes. Jour. Dai. Sci. 63: 391-395.

Palmquist, D. L. and Jenkins, T.C. (1980). Fat in lactation rations : review. *Journal of Dairy Science* 63: 1-14 http://jds. Fass.org/cgi/reprint/63/1/1.

Payne and Wilson (**1999**). Winter Avian community and sparrow response to field border width. http://onlinelibrary.wiley.com/doi/10.2193/2006-119/pdf.

Perry, T. W., and T. S. Stewart (**1979**). Effect of fat and Lecitin and of moisture levels of corn and corn silage on nutrient digestibility by ruminants. *Journ. Anim. Sci.* 48(4):900-905.

Peacock, L., Ward, J., Ratledge, C., Dickinson, F. M.(**2003).** How *Streptomyces lividans* uses oils and sugars as mixedsubstrates. *Enzyme Microbiol*. Tech. 32: 157-166.

Pham, Ho Hai and T. **R. Preston**. (**2009**). Effect of dried Cassava peelings on the rumen environment of Cattle fed natural grasses.Department of Animal Physiology Research,Inst. Of Agric.Sc.for Southern Vietnam (LAS) phhai@iasva. Org. "Tosoly, AA48 Socorro, Colombia.Livestock Research for Rural Development 21(9).

Phengvilaysouk, A. and Wanapat, M. (**2008**). Effect of coconut oil and cassava hay supplementation on   rumen ecology, digestibility and feed intake in swamp buffaloes. Livestock Research for Rural Development.

Pillai, K. R. and Tan, H. T. (**1976**): Possible Livestock production on estates using factory effluent.Proc.Symp.on smallholder livestock prod. and development.Bull. No. 144, Ministry of Agriculture. Pg. 133-146**.**

Prak Kea, Preston and Ly J. (**2003**).Feed intake, digestibility and N retention of a diet of water spinach supplemented with palm oil / and or with broken rice and dried fish for growing pigs. Livestock Research for Rural Development (15) 8 Retrieved, from http;//www.cipav.org.co/Irrd/Irrd15/8/kea158.htm.

Preston, T. R. and Leng, R. A. (**1987**). Matching ruminant production system with available resources in N+ the tropics and sub-tropics. Panarbul Books. Artnidale, Austria.

Priest, F. G. (**1984**). Extracellular enzymes. Aspect of Microbiology Vol 9 Van Nostrand Reinhold, England Procedures and some applications. Agriculture handbook No. 379, USDAARS.

Putnam, R. R., Oltjen and Bond J. (**1969**). Effect of Soybean oil,urea,roughage and of progestigin on the utilization of corn based finishing ration by beef Cattle. *Journ. Of Anim. Sci*. 28(2): 256-262.

Quin, J. I. (**1943**). Studies on the Alimentary Tract of Merino Sheep in South Africa.VII. Fermentation in the forestomach of sheep, *Onderstepoort. J. Vet. Sci. Anim. Industry.* 2: 91-117.

Radostits, O. M., Blood. D.C., and Gary, C.C. (1997). A Testbook of the Disease of Cattle, Sheep,Pig,Goat and Horses (8th edition). W.B. Sauders Co. Ltd. London. Pp 1223-1280; 1532-1612.

Raimbault, M. (**1998).** General and microbiological aspects of solid substrate fermentation. *Journal of Biotechnology.* 63: 395-399.

Ram, P. C., Lodha, M. L., Srivastava, K. N., Iyagi J. and Mehta, S. L. (**1979**). Improving nutritive value of maize (*Zea mays* L.) by germination. *J. Food Sci. Technol. India.* 16 (6) 258-260.

Rashid, S. S., Alam, M. Z., Karim, M. I. A. and Salleh, H. M., (**2009**). Management of palm oil mill effluent through production of cellulases by filamentous fungi. *World J. Microbiol.* Biotechnol., 25: 2219-2226.DOI: 10.1007/s11274-009-0129-9.

Robinson, P. H., Tamminga, S., and Van Vuuren, A. M. (**1986**). Influence of declining level of feed intake and varying the proportion of starch in the concentrate on rumen fermentation in dairy cows. *Livestock Prod. Sci.* 15: 173-189.

Roger, Y., Stainier Edward, Adelberg, A. and John, L. Ingraham. (**1977**) General Microbiology. Published by The Macmillan Press Ltd.

Roussos, S. (**1985**). Croissance de *T. harzianum* par FMS: physiologie, sporulation et production de cellulases. Thèse de Doctorat, Université Provence, Marseille Fr., Orstom Ed.

Russell, J. B., O'Connor, J. D, Fox, D. J., Van Soest, P. J. and and Sniffen, C. J. (**1992**). A net carbohydrate and protein system for evaluating cattle diets. I. Ruminal fermentation. *J. Anim. Sci.* 70: 3551-3561.

Saleem, and M. G. Jackson (**1975**). Improving utilization of agricultural waste materials and industrial by-products as livestock feed. Research progress report. 1969-1974; G.B. Pant Univ.

SAS (**1999**). Statistical Analytical System. SAS/STAT. User's guide. Version 6,3rd edition. Carry, North Carolina, USA, 943pp.

Satter, L. D. and Slyter, L. L. (**1974**). Effect of ammonia concentration on rumen microbial protein production *in vitro. British Journal of Nutrition* 32: 194-208.

Saucedo-Castañeda, G., Lonsane, B. K., Navarro, J. M., Roussos, S. and Raimbault, M. (1992b). Potential of using a simple fermenter for biomass built up, starch hydrolysis and ethanol production: Solid state fermentation system involving *Schwanniomyces castellii*, *Applied Biochemistry and Biotechnology*. 36: 47-61.

Sauer, F. D., Fellne. V., Kinsman. R., Kramer, J. K. G., Jackson, H. A., Lee, A. J. and Cahen, S. (**1998**). Methane output and lactation response in Holstein cattle with monensin or unsaturated fat added to the diet. *Journal of Animal Science.* 76,:909-914.

Schaefer, D.M., Davis, C. L and Bryant, M. P. (**1980**). Ammonia saturation constants for predominant species of rumen bacteria. *J. Dairy Sci.* 63: 1248-1263.

Senez, J. C., Raimbault. M. and Deschamps, F. (**1980**). Protein enrichment of starchy substrates for animal feeds by solid state fermentation. World Animal Review 35: 36-40.

Shahid R. Raza, S. H. and Tanveer. A. (**2010**). Rumen metabolism of sheep fed silage containing poultry litter. Dept. of Animal Nutrition. University of Agriculture Faisalabad, Pakistan.

Sharma, H. R., Ingalls J. R. and McKirdy J. A. (**1978**). Replacing Barley with Protected Tallow in Ration of Lactating Holstein Cows. *Jour.   Sci*. 61:574-583.

Smith, T., Chakanyuka , C., Sibanda, S. and Manyuchi, B. (**1989**). Maize stover as a feed for ruminants: (eds. A.N. Said and B. Dzowela). Overcoming constraints to the efficient utilization of agricultural by- products as animal feed. ILAC, Addis Ababa. pp 218-231.

Sniffen C. J., Robinson P. H. (**1987**). Microbial growth and flow as influenced by dietary manipulations. J. Dairy Sci. **70**:425–441.

Solano, R. (**1986**). Principales subproductos de las plantas extractoras de aceite. En IV Mesa Redonda Latinoamericana sobre Palma Aceitera, Valledupar, Colombia 8–12 de junio de 1986, ORLAC/FAO p 161–167.

Steingass, H. and Menke, K. H. (**1986**). Schatzung des energestischen Futterwertes aus der in vitro mit Pasnensaft bestimmten Gasbildung und der chemischen Analyse. Tierernahrung, 14, 251.

Steinkraus K. H. (**1995**). Production of Vit B$_{12}$ in tempeh. Proc. Asian. Symposium on Non-salted soyabean fermented Tuskuba Science city; National Food Research Institute. Tsukuba, Japan pp 205-208.

Storry J. E., Hall. A. J. and Johnson V. W. (**1972**). The effect of increasing amounts of dietary tallow on milk fat secretion in the Cow. *J.Dairy Res*. 40: 293-299.

Stur W, Gray D, and Bastin G, (**2002**). Review of the Livestock Sector in the Lao People's Democratic Republic , International livestock Research Institute, DAPO 7777, Metro Manila, Phillipines. http://www.ilri.org/.

Sun, Y., and Cheng, J. (**2002**). Hydrolysis of lignocellulosic material from ethanol production: A review. *Biores. Technol.*. 83: 1-11.

Sundstol, F., and Owen, E. (**1984**). Straw and other fibrous wastes as by-products. *ElsevieAmsterdam*.pp604.

Sundstol. F. (**1974**). Hydrogenated marine fat as feed supplement. IV. Hydrogenated marine fat in concentrate mixtures for dairy cows. Agricultural University of Norway. Dept. of Anim. Nutri. Report. No 162 2-43.

Swatson, H. (**1979**). The effect of different levels of oil palm slurry on the performance of carcass characteristics of broiler chicks. Unpublished B.Sc (Hons). Dissertation, University of Science and Technology, Dept. of Animal Sc, Kumasi, Ghana.

Tamminga, S. (**1981**). Effect of the roughage/concentrate ratio on nitrogen entering the small intestine of dairy cows. *Neth. J. Agric. Sci.* 29: 273-283.

Tengerdy, R. P. (**1985**). Solid substrate fermentation. *Trends in Biotechnology* 3: 96-99.

Tewe, O. O., Steinbatch, J and Smidt, D. (1981). Investigation on blood of European pigs raised under tropical conditions. Animal Res.Dev. 14:101.

Tilley, J. M. A. and Terry, R. A. (**1963**). A two stage technique for the digestion of forage crops. *J. Br. Grassl. Soc.* 18: 104-111.

Trejo-Hernandez, M.R., Lonsane, B.K., Raimbault, M. and Roussos, S. (**1993**). Spectra of ergot alkaloids produced by *Claviceps purpurea* 1029c in solid state fermentation system: Influence of the composition of liquid medium used for impregnating sugar cane pith bagasse. *Process Biochemistry.* 28: 23-27.

Trejo-Hernandez, M. R., Raimbault, M., Roussos, S. and Lonsane, B. K. (**1992**). Potential of solid state fermentation for production of ergot alkaloids. *Letters in Applied Microbiology* 15: 156-159.

1.2.2   **Underkoffler, L.A**. (**1972**). **Enzymes: Handbook of food additives. 2nd edition. T.O.Furai (eds). CRC press, Cleveland.** Better utilization of crop residues and by-products in animal.

Van Soest, P.J and R.W. Mc Queen (**1973**). The chemistry and estimation of fibre. Proc. *Nutr. Soc.* 32: 123-130.

Van Soest, P.J. (**1982**). Nutritional ecology of the ruminant. O and B books. *Corvallis Oregen* p.52-175.

Van Soest, Peter J. (**1994**) Nutritional Ecology of the Ruminant by, Hardcover, Subsequent   Edition) Cornell University Press, Ithaca, NY.

Van Soest, P.J.   (**1995**).   Nutritional Ecology of Ruminants, 2nd edn. Cornell University Press, 476pp.

Vroon, S. J. (**1978**). The effect of different levels of oil palm slurry on the growth rate and performance of weaner pigs. Unpublished B.Sc. (Hons.) Dissertation, University of Science and Technology, Department of Animal Science, Kumasi, Ghana.

Wallace, R.J. (**1979**). Effect of ammonia concentration on the composition, hydrolytic activity and nitrogen metabolism of the microbial flora of the rumen. *J. Appl. Bact* 47: 443-445.

Wambeck, N. (**1990**). La experiencia Malasiana en el desarrollo de la industria de la palma aceitera con la tecnologia avanzada de Estechnik. In: VI Mesa Redonda Latinoamerica sobre Palma Aceitera San José, Costa Rica 12–16 marzo 1990 ORLAC/FAO p 255–267.

Wanapat M, Pimpa O, Petlum A and Boontao U (**1997**). Cassava hay: A new strategic fed for ruminants during the dry season. Livestock Research for rural development, 9(2): http://www.cipav.org.co/LRRD/lrrd9/2/methan92.htm.

Wanapat, M and Pimpa, O., (**1999**). Effect of ruminant NH3-N levels on ruminant fermentation, purine derivatives, digestibility and rice straw intake in swamp buffaloes. *Asian/ Australasian Journal of Animal Science* 12 (6) 904-907.

Wanapat M., G. Granum, P. Pakdee, C. Wachirapakorn and W. Toburan (**2007**). A Comparative Study on the Effect of Cassava Hay Supplementation in Swamp Buffaloes (*Bubalus bubalis*) and Cattle (*Bos indicus*). Tropical Feed Resources Research and Development Center (TROFREC), Faculty of Agriculture. Khon Kaen University, 40002, Thailand.

Wayne Carl Figroid (**1971**). Effect of energy intake level on the digestibility of high energy rations by Cattle. Ph.D. Thesis (University of Arizona) Dissertation ABstr. Int. 32(1): 7B.

Webb,B. H, Hutagalung,R. I and Chean,S. T (**1977**): Palm oil mill and waste as animal feed processing and utilization. International Developments in palm oil (Ed.Earp.D.A and Nawal)pg. 125-145. Kuala Lumpur. Incoporated society of planters.

Wolin, M. J. (**1960**) *Ecology*. A theoretical rumen fermentation balance. *J. Dairy Sci.*, 43, 1452.

Wolin, M. J. (**1979**). The rumen fermentation: a model for microbial interactions in anaerobic ecosystems. *Advances in Microbial*.

Yang, H. H., Effland, M. J., and Kirk, T. K. (**1980**). Factors influencing fungal degradation of lignin in a representative lignocellulosic, thermo-mechanical pulp. *Biotechnology and Bioengineering.* 22(1):65-77.

Yang, W.-C., and Sundaresan, V. (2000). Genetics of gametophyte biogenesis in *Arabidopsis*. Curr. Opin. Plant Biol. **3,** 53–57.[CrossRef][Web of Science][Medline].

Yokoyama, M. I. and Johnson, K. A. (**1993**). Microbiology of the Rumen and the Intestine In: Church, D.C. (ed). The Ruminant Animal Digestive Physiology and Nutrition. Waveland Press, Inc. III. Pp 269-297.

Zadrazil, F., Diedrichs, M, Janssen, H, Schuchardt, F., and Park, J. S. (**1990**). Large scale solid state fermentation of cereals straw with *Pleurotus spp.* In advances in biological treatment of lignocellulose materials (eds M.P. Coughlan and M.T. Amaral Collaco), *Elservier Applied sci*. pp 43-58.