PERFORMANCE OF BROILER CHICKENS FED SUN-DRIED PINEAPPLE (*Ananas comosus*) AND ORANGE (*Citrus sinensis*) PEELS WASTE BASED DIETS UNDER SINGLE PHASE FEEDING

BY

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ABSTRACT

A study which lasted 70 days was conducted to determine the effect of orange(OP) and pineapple(PP) peel wastes as replacement for maize in poultry diets. One hundred and sixty (160) day old broiler chicks were sorted for weight and were then randomly allotted into four different treatments with four replicates and ten birds (10) per replicate, using a completely randomized design model. Four diets containing pineapple and orange peels wastes were formulated to replace maize at 0 % (control), 5 % pineapple peel (PP), 5 % orange peel (OP) and 2.5 % mixture each of pineapple and orange peels (MPO), respectively. Data on growth performance (weight gain, feed intake and feed conversion ratio), apparent nutrient digestibility, carcass characteristics and sensory evaluation were collected. Data collected were subjected to one-way Analysis of Variance (ANOVA); significant means were separated by using Duncan's Multiple Range Test at ($p< 0.05$). The growth performance results showed that final weight, daily weight gain and the feed conversion ratio (FCR) were influenced by the peels-based diets. Birds on the control diet had better feed conversion ratio (3.21). The dry matter, crude protein, ash, nitrogen free extract, ether extract and total digestible nutrient(TDN) digestibility were significantly affected ($p<0.05$) by the peel-based diets. Result revealed that MPO (mixture of orange and pineapple) recorded the highest dry matter, ash and nitrogen free extra (83.55 %, 64.01 % and 95.89 %) respectively. Birds on 5 % orange peel perform better in term of TDN value of 92.38%. Birds on the MPO diet compared favourably with the control in all digestibility parameters measured. The carcass characteristics were evaluated at the end of the feeding trial with one bird per replicate. The live weight, slaughtered weight, dressing percentage, drumstick, back, liver and lungs were influenced ($p< 0.05$) by the peels-based diets. Also birds on the peels based diets compared favourably with the control in all the parameters measured. The breast meat from the cut part was use for the sensory evaluation. The result showed that the aroma and tenderness were significantly influenced ($p<0.05$) by the peel based diets. Birds on the MPO peels based diets competed favourably with the control diet. It was concluded that broiler birds could tolerate up to 5 % dietary levels of OP (orange peel), PP (pineapple peel) meal and the mixture of pineapple and orange peel (MPO) without adverse effect as indicated by nutrient digestibility, carcass characteristics and sensory evaluation.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

In the recent years, poultry nutritionists have aimed their researches towards the use of non- convectional feed ingredients in partial or total replacement of the conventional costly ingredients. Crop residue and agro-industrial by products are being evaluated to access their nutritive potential to support poultry productivity (Oluremi *et al*., 2007). A number of agro-industrial by-products are generated from fresh Citrus after the main products of interest have been removed or extracted during processing or peeled for direct human consumption as it occurs in the developing countries (Oluremi *et al*., 2007).

Utilization of agro industrial wastes is a matter of great concern. Citrus and Pineapple waste disposal is a problem for agro-industrial manufacturing companies. Some of the wastes from fruits and vegetables processing may be good sources of essential nutrients and, therefore, could be utilized as part of the feed ingredients. If these wastes are properly processed and incorporated in poultry animal rations, these agro-wastes can serve useful purposes by imparting nutrients as well as flavour to the ration and hence increase its palatability and utilization, besides lowering the cost of feed.

Nutrition and diseases are the two major limiting factors in poultry production, the cost of feed alone accounts for about 70-75 % of the total cost of broiler production (Jurgens *et al*., 2009). Availability of quality feed at a reasonable cost is therefore the key to successful poultry production. Poultry birds are excellent feed converters and do not suffer social infringement on consumer acceptability like other livestock species such as pig. The foregoing has triggered the rising demand for poultry products like eggs and meat, given their palatability and high nutritional values. These attributes amongst others, make the poultry industry stand tall amidst rival livestock producing ventures. According to Dipeolu (2004), the development of the poultry industry has been described as the fastest way of ameliorating the animal protein deficiency in third world countries, due to the high turn-over rate associated with poultry production and consequent economic efficiency. Despite the aforementioned benefits derived from poultry, the high cost of its production owing to usage of convectional feed ingredients makes it imperative to explore the use of alternative feed ingredients that are cheaper, locally available and of low human preference in poultry ration formulation. Such alternatives are the sweet orange (*Citrus sinensis*) and pineapple (*Ananas comosus*) peels among others. In Nigeria, all the varieties of orange and pineapple are consumed on a high scale, and the peels are usually considered as wastes and are seen littering the streets and roadsides. As such, orange and pineapple peels have become an environmental problem. It can be inferred that one of the present day core foci of science is to come up with modalities on how to recycle waste materials that are hazardous to the environment into useful products that can be of benefit to humans. It is on this premise that Ipinloju (2000) suggested that rather than discarding these peels, they can be sun-dried and then milled to obtain fine-particles of orange and pineapple peel meals which can be included in poultry diets.

Some studies were conducted to develop a procedure for converting pineapple waste into animal feed (Sruamsiri, *et al*., 2007; Makinde, *et al*., 2011). Problems related to the fresh form were overcome by the sun drying technique of pineapple peels developed by Aboh, *et al*. (2013) which gave dried peels of good quality. However, according to these authors, the dried peels are too compact and hard for its ingestion by animals. Therefore, to overcome this constraint, it is necessary to explore some treatments to be applied to the peels such as crushing, to increase their surface area without degrading the feedstuff nutritional value. Pineapple peel is rich in cellulose, hemicellulose and other carbohydrates. Raw pineapple waste (on DM basis) contains 4 – 8 % crude protein, 60 – 72 % NDF (Neutral detergent fiber), 40 – 75 % soluble sugars (70 % sucrose, 20 % glucose and 10 % fructose) as well as pectin, but it is poor in minerals except Calcium (Muller, 1978; Pereira, *et al*., 2009).

1.2 Statement of the Research Problem

i. Accumulation of wastes from fruit peels constitutes a source of environmental pollution (Pawlowsky, 2000). If fresh pineapple and orange peels waste are not well disposed, it often gets mouldy and sour, and therefore unlikely to be used as an animal feedstuff.

ii. There is urgent need to address the problem of over dependence on convectional feed for poultry diets as this will contribute to increase the cost of poultry production.

iii. Though dried orange and pineapple peels have been successfully fed to broiler birds but there is still paucity of information regarding the combination of dried orange with pineapple peels as alternative energy sources in poultry diet

1.3 Justification of the Study

i. There is a need to evaluate different energy sources so as to make better choices of which to use depending on prevailing circumstances of cost, scarcity and/or abundance. Ani and Adiegwu, (2005).

ii. These agro-wastes can serve useful purposes by imparting nutrients as well as flavour to the ration and hence increase its palatability and utilization, besides lowering the cost of feed.

iii. There are evidences to show that the fruit by - product are high in energy, thus can be used to replace maize partially (Oluremi *et al.*, 2010).

1.4 Aim and Objectives of the Experiment

The aim of this study is to determine;

The effect of orange and pineapple peel wastes as replacement for maize in poultry diets.

The Objectives of the Study are to;

I. investigate the growth performance of broiler chickens fed sun – dried pineapple orange peels waste based diets.
II. determine the nutrient digestibility of broiler chickens fed sun-dried orange and pineapple peels wastes based diets.
III. evaluate the carcass characteristics of broiler chickens fed sun-dried orange and pineapple peels wastes based diets.
IV. determine the sensory parameters of broiler chickens fed sun-dried orange and pineapple peels wastes based diets.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Origin of Orange and Pineapple

Oranges probably originated from south East Asia, and were cultivated in China by 2500 BC Nicolosi, *et al.,* (2008), where it was referred to as ‘’Chinese’’ apple (Ehler 2011). Today, it is grown almost all over the world as a source of food for humans because of its high nutritional values, source of vitamins and other uses. Economically, Oranges are important fruit crops, with an estimated 60 million metric tonnes produced worldwide as at 2005 for a total value of 9 billion dollars. Of this total, half came from Brazil and the United States of America (Goudeau *et al.*, 2008; Bernardi, *et al.*, 2010). The global citrus acreage according to FAO statistics in 2009 was nine million hectares with production put at 122.3 million tons, ranking sweet oranges first among all the fruit crops (Xu *et al*., 2013**)**. Citrus is widely grown in Nigeria and many other tropical and subtropical regions (Piccinelli *et al.*, 2008). In terms of volume in production, citrus ranks after banana as the world second fruit crop with more than 108 million tons FAO Statistics, (2006).

Brazil is one of the largest fruit producers in the world. According to data from the Brazilian Institute of Geography and Statistics (IBGE 2017), pineapple is the third largest fruit product, being surpassed only by oranges and bananas. The total planted area of pineapple in 2016 was 100,238 hectares, of which 67,254 hectares were harvested. Production in this same year reached 1,734,627 tons, obtaining an average yield of 25,792 kg·ha-1 (IBGE, 2017). Advantages such as geographic location, wide availability of arable land and climatic conditions favour the leading role of pineapple cultivation, ensuring jobs and contributing significantly to the national economy (Morgado, *et al*., 2004; Brito Neto, *et al*., 2008; and Silva, 2016).

Industrial food production causes a high amount of waste, such as bagasse, husks and pulp residues of the fruits. This waste must be taken to a suitable location, which in general adds a costly procedure to the industry. In addition to the cost of treating this material, many of which are of low efficiency, there are still risks for the continuity of environmental pollution (Timofiecsyk & Pawlowsky, 2000). Since the residues produced have great potential for reuse, together with the concern for the environment, numerous studies have been carried out with the intention of taking advantage of them (Borges, *et al*., 2004; Ferrari, *et al*., 2004; and Zhang, *et al*., 2007). Thus, it is possible to reduce environmental pollution, and increase sustainability, along with obtaining new products with higher added value (Pelizer *et al*., 2007).

2.2 Management, Nutrition and Diets of Broiler Chickens

Broiler chickens are mainly bred for fast growth and slaughtered when they weigh about 1.8 to 2.2 kg live mass, usually between 6 and 8 weeks of age (Musa *et al.,* 2006). The overall objective for broiler chicken producers is to produce meat with leaner tissue and acceptable lipid content in order to meet modern consumer demands as per the Hazard Analysis and Critical Control Points (HACCP) approach (Weltzien, 2009). Since feed expenditures frequently comprise 80 % of broiler chicken production cost (Louw *et al.,* 2011), decisions regarding ration composition have a significant impact upon profitability of any broiler production enterprise. However, ration composition is just one of the many interactive components that must be met for efficient and effective poultry production. Therefore, to ensure fast growth rate and efficient feed conversion in broiler chickens, good management practices which involves effective disease prevention and control, flock maintenance under continuous illumination as well as provision of high quality feeds and water (fed *ad libitum*) are all necessary Amakari and Owen, (2011).

2.3 Agro-industrial By-Products

The use of agro-industrial by-products is a possible solution to the high cost of feed ingredients, which results to high cost of production, since some could be gotten relatively free of monetary cost (Orayaga *et al*., 2015a). Agro-industrial by-products such as mango fruit, pineapple peels by-products (Guzmán, *et al* 2012; Orayaga, *et al.*, 2015b) and sweet orange fruit peels (Oluremi, *et al*., 2007; Agu *et al*., 2010) have been identified as feed resources in animal production that can ameliorate the high cost of animal production, especially in monogastric animals. Mc-Donald *et al*., (1995) reported that Agro-industrial by-products have low nutritional value due to low nutrient content, high fibre, low palatability or presence of anti - nutritional factors. However, appropriate treatment of nonconventional feedstuff can improve their utilization and thus better the health, productivity and profitability of farm animals (Tuleun *et al*., 2011).

2.4 Orange Wastes

The dried Citrus sinensis peel can be used up to 5 % in the broiler diet (Chaudry, *et al.,* 2004; Abbasi, *et al.,* 2015) or it can replace maize in broiler diet up to 15 % (Oluremi *et al*., 2010) without any adverse effect on broiler performance (Ebrahimi *et al*., 2014). It also reduced serum cholesterol, low-density lipoprotein and increased high-density lipoprotein concentrations (Chaudry, *et al.,* 2004; Ebrahimi *et al*., 2012; and Ebrahimi *et al*., 2014). However, when dried citrus peel was incorporated at the 10 % level, it increased feed intake and feed conversion ratio, but reduced daily body weight gain and liver and abdominal fat in birds (Oluremi *et al*., 2010; Agu *et al*., 2010).

Sweet oranges (*Citrus sinensis*) are produced in many tropical and subtropical climates. Traditionally, the orange peel has been used for ruminant nutrition, fertilizer, essential oils extraction, pectin extraction, industrial enzyme production, and single cell protein production (López *et al.,* 2010). Sweet orange (*Citrus sinensis*) fruits are produced on a large quantity in Nigeria. Over one hundred and forty (140) countries of the world produce citrus fruits and Brazil is at top the list (FAO, 2013). Nigeria also produces a large quantity of oranges even though it is not listed among ten top producers of the world (Kajo, 2012). Quantitatively, over 100 million metric tons of sweet orange fruits are produced worldwide annually (FAO, 2013). A large percentage of these citrus fruit are either fed to agro-processing industries for processing into various consumable products or consumed fresh locally. Whichever way the citrus fruits are handled, many by-products are generated which consist of 60-65 % peel, 30-35 % pulp (dry matter) and 0-10 % seeds, resulting from processing of citrus fruits (Ipinjolu, 2000). The proximate compositions and energy value of the peels are indicators of its potential as a feed resource capable of replacing maize (Oluremi *et al*., 2007). The chemical composition of sweet orange peel is similar to that of maize in many respects: Whereas, maize has 8.9% crude protein (CP), 2.7 % crude fibre (CF), 4.0 % ether extract (EE), 1.3 ash % Aduku, (2004) and 72 % nitrogen free extract (NFE) (McDonald *et al*., (1995) while, the crude protein of sweet orange fruit peel meal on dry matter basis ranges from 9.30 to 10.96 %, ether extract 2.35 to 2.90 %, nitrogen free extract 65.30 to 67.95 % and ash 5.07 to 5.56 %. Orayaga *et al*. (2010) reported the proximate composition of the peels as 7.22 % CP, 12.32 % CF, 1.96 % EE, 3.67 % ash and 61.49 % NFE and calculated Metabolizable energy of 3167 kcal/kg.

2.4.1 Use of citrus wastes in feeds of different farm animal species

2.4.2 Dried citrus pulp

The citrus pulp contains 60–65 % peel, 30–35 % internal tissues and up to 10% seeds (Crawshaw, 2004). Due to the high moisture and sugar contents, and presence of mould and yeast, citrus pulp gets rapidly deteriorated (Ashbell, *et al.*, 1988; Nam, *et al.*, 2009) and may cause environmental pollution. Therefore, it should be sun dried and pelleted to increase density or should be ensiled. While drying, generally lime is added to neutralize the free acids, bind the fruit pectins and release water (Wing 2003). The dried pulp is primarily a carbonaceous feedstuff as it contains 5–10 % CP and 6.2 % EE, 10–40 % soluble fibre (pectins), 54 % water-soluble sugars, 1–2 % calcium due to the addition of lime and 0.1% phosphorus. Carotene content is low (Crawshaw 2004; Bakshi. *et al.*, 2013). Citrus pulp is a rich source of trace elements; however, their concentration is much below the maximum tolerance limit for ruminants. The composition of dried citrus pulp is variable and depends mainly on the relative proportions of skins and seeds, which varies according to the citrus species, variety and the harvesting season. It is much less valuable to pigs and poultry due to high fibre content and presence of limonin in the seeds, which is toxic to monogastric (Gohl, 1982).

Poultry: - Dried sweet orange (*Citrus sinensis*) pulp can be incorporated up to 10 % in layer diet without any adverse effect on feed intake, egg production and egg weight (Yang, 1985). Nazok, *et al.* (2010) found that utilization of dried citrus pulp up to 16 % in diet significantly increased serum glucose and high-density lipoprotein and reduced cholesterol, low-density lipoprotein and triglycerides. Results of this study suggested that use of 12 % dried citrus pulp in laying hen diets has no adverse effect on performance and egg quality of laying hens in early phase of production. The level of citrus pulp in the broiler diet should not exceed 5–10 % because of the presence of non-starch polysaccharides which impair growth, lower feed efficiency and reduce carcass yields (Mourao *et al*., 2008). The use of dried orange pulp at 2 % level in the diet improved feed intake and body weight gain, decreased liver and abdominal fat and also the serum triglyceride level in broiler chicken (Abbasi *et al*., 2015).

Rabbits: - Hon *et al*. (2009) showed that the dried sweet orange pulp could replace maize up to 20–30% level in rabbit ration, without affecting their growth performance.

Ruminants: - Despite the bitter taste, it is readily accepted by beef and dairy cattle and is as palatable as sugarcane molasses. It may be mixed with pressed pulp prior to drying, which increases the TDN (total digestible nutrient) content in the dried product without affecting the keeping quality of the pulp. Cattle can consume up to 3 kg/day when offered ad libitum (Gohl 1978). It could replace 50% of ground maize in the diet of fattening steers without reducing BW gain, quality and carcass yield (Hendrickson *et al.,* 1978).

2.5 Pineapple Wastes

Pineapple (*Ananas comosus*) belongs to Bromeliaceae family and is known as the queen of fruits, because of its excellent flavour and taste (Baruwa, 2013). Pineapple is the third most important tropical fruit in the world after banana and citrus (Bartholomew *et al.,* 2003). Thailand is the largest producer of pineapple, contributing 8.9 % of world production (FAO, 2015). Mature fruit contains a protein digesting enzyme, bromelin and substantial amounts of sugar, citric acid, malic acid, vitamins A and B (Joy, 2010; Debnath, 2012). Green pineapple is also used for making pickles. The post-harvest processing of pineapple fruits yields crowns, peels, cores, fresh trimmings and the pomace as pineapple waste, which account for approximately 30-35 % of the fresh fruit weight, (Hepton; 2003; Sruamisri 2007). The wet bran can be fed fresh to animals, ensiled for longer storage or dried until it contains less than 12% moisture. Pineapple waste contains 4–8 % CP, 60–72 % NDF, 40–75 % soluble sugars (70 % sucrose, 20 % glucose and 10 % fructose) as well as pectin, but it is poor in minerals (Muller, 1978; Pereira, 2009). The total soluble sugars and reducing sugar were higher in pineapple pulp than pineapple waste (Hemalatha, 2013; and Hossain, 2015)

Tropical and subtropical fruits processing have considerably higher ratios of by-products than the temperate fruits (Schieber *et al*., 2001). Pineapple by-products are not exceptions and they consist basically of the residual pulp, peels, stem and leaves. The increasing production of pineapple processed items, results in massive waste generations. This is mainly due to selection and elimination of components unsuitable for human consumption. Besides, rough handling of fruits and exposure to adverse environmental conditions during transportation and storage can cause up to 55% of product waste (Nunes *et al*., 2009).

These wastes are usually prone to microbial spoilage thus limiting further exploitation. Further, the drying, storage and shipment of these wastes is cost effective and hence efficient, inexpensive and eco-friendly utilization is becoming more and more necessary. Except for high quality fruits that are selected for shipment, most pineapples are consumed fresh or as canned products. However, low quality fruits do not fetch market and are left on farms. Besides, during orange and pineapple processing, large amount of unusable wastes material are generated (Tanaka *et al*., 1999). Reports have shown that 40-80 % of pineapple fruit is discarded as waste having high biological oxygen demand (BOD) and chemical oxygen demand (COD) values Ban-koffi and Han, (1990).

2.6 Disposal and Environmental Hazard

Fruit residues may cause serious environmental problems, since it accumulates in agro-industrial yards without having any significant and commercial value. Since disposal of these wastes is expensive due to high costs of transportation and a limited availability of landfills they are unscrupulously disposed causing concern as environmental problems. Furthermore, the problem of disposing by-products is further aggravated by legal restrictions. A high level of BOD and COD in pineapple wastes add to further difficulties in disposal. Researcher have focused on co-digestion of pineapple waste along with several other fruit and vegetable wastes, manure, and slaughter house wastes to reduce volatile solids by 50 to 65 % (Alvarez and Liden, 2007). Recently, composting of pineapple wastes using earthworm is reported (Mainoo *et al*., 2009). They have reported that vermicomposting rapidly decomposed about 99% of pineapple pulp wet mass while peel had a loss in weight by almost 87 %. The pH of the waste changed from acidic to a neutral to alkaline during composting.

2.7 Bromelain

Bromelain is probably the most valuable and the most studied component from the pineapple waste. It has been investigated since 1894 (Devakate *et al*., 2009). It is a crude extract of pineapple that contains, among other components, various closely related proteinases, demonstrating, *in vitro* and *in vivo*, antiedematous, anti-inflammatory, antithrombotic (Bhui *et al*., 2009), fibrinolytic activities and has potential as an anticancer agent (Chobotova *et al*., 2009). It is also used in food industry as meat tenderizer and as a dietary supplement (Maurer, 2001). Bromelain is primarily present in stem, known as stem bromelain (EC 3.4.22.32) and also in fruit (EC 3.4.22.33), however small amount of bromelain is also found in pineapple waste (Hebbar *et al*., 2008).

2.8 Energy and Carbon Source

Pineapple wastes generally comprise of organic substances and hence the disposal problem could be attenuated by anaerobic digestion and composting. Some of these wastes could have industrial applications for gas generations Mbuligwe and Kassenga, (2004). Biomethanation of fruit wastes is the best suited waste treatment as it both adds energy in the form of methane and also results in a highly stabilized effluent with almost neutral pH and odorless property (Bardiya *et al*., 1996). They utilized pineapple waste for the production of methane using semi-continuous anaerobic digestion which could produce up to 1682 ml/day of biogas with methane content of 51 % in maximum. Rani and Nand (2004) reported that different conditions of pineapple peels gave biogas yields ranging from 0.41-0.67 m3/kg volatile solids with methane content of 41-6 %. Solid pineapple waste has been used to produce volatile fatty acids and methane (Babel *et al*., 2004). They reported that at higher alkalinity, up to 53 g volatile fatty acids were produced from one kg of pineapple waste. Acetic, propionic, butyric, i-butyric and valeric acids were produced along with methane. Reports on utilizing pineapple waste as the carbon substrate to produce hydrogen gas from municipal sewage sludge is found (Wang *et al*., 2006). The waste contained carbon and nitrogen source for cell growth and hydrogen production. In other report, pineapple fruit wastes have been suggested as a source of carbon for bacterial production of cellulose by *Acetobacter xylinum* (Kurosumi *et al*., 2009).

2.9 Use of Pineapple Waste as a Feed

Feed production has become a new industry. The utilization of agro-industrial wastes as animal feed seems to mitigate the difficulties of forage shortage during critical seasons. Several studies have focused on exploiting pineapple wastes as feed for ruminants. The outer peel or skin and core from the pineapple canning industries, called bran, and the leaves are being utilized as feed for ruminants (Tran, 2006). The nutritive value of pineapple peel has been reported (Negesse *et al*., 2009). Sruamisri, (2007), that in China, pineapple waste from the field or from the cannery are being used as dairy feed. Cattle preferred fermented pineapple waste with higher acidity to fresh waste. Sruamisri, (2007) reported that dried and ensiled pineapple waste can be used as supplemental roughage and could replace 50 % roughage in the total mixed ration for dairy cattle. Besides, researchers have also focused on the performance and the apparent digestibility of pineapple by-product when used as feed. On feeding twenty-four cross bred local goats for 80 days, it was found that dehydrated pineapple by-products would increase the digestibility with increase in weight of the animals (Costa *et al*., 2007).

A survey reports that in Nigeria, pineapple and orange peels are also used for feeding small ruminants and that they could be used after proper processing (Onwuka *et al*., 1997). Another report on suitability of pineapple waste as animal feed and pulp for human consumption is also found (Cabrera *et al*., 2000). However, some researchers have reported that by-product of pineapple processing industry is not considered attractive as an animal feed because of high fiber content and soluble carbohydrates with low protein content (Correia *et al*., 2004).

2.9.1 Use of pineapple waste in non-ruminants

Pigs did not relish dried pineapple bran offered ad libitum. The high Crude fibre content (20%) limits its use in pigs of < 27 kg body weight gain. However, incorporation up to 50 % in the ration of older pigs (57 kg BW) improved BW gain and feed conversion efficiency. Beyond 50 % in the ration, these parameters were depressed (Arthington, 2001). Inclusion of 15 % pineapple bran in chick diets reduced the FCR and 20 % inclusion decreased weight (Hutagalung, 1973).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Experimental Site

This research was carried out at the Poultry Unit of Department of Animal Production Teaching and Research Farm of School of Agriculture and Agricultural Technology, Gidan kwano Campus Minna, Niger state. Minna is located between latitude 4° 30 and 9° 37 North and longitude 6°33 and 6°45 East. Niger State experiences distinct dry and wet seasons with annual rainfall of 1100 and 1600 mm in the northern part. The rainy seasons last for about 120 days in the Northern part, to about 150 days in the Southern part of the State. The temperature is between 21° c minimum and 36.5°c maximum; the humidity is about 53.5 % while the altitude is about 299 m above sea level. Presently, the state covers a total land area of 76,363.0 square kilometre or about 8 % of Nigeria total land area (Afolayan *et al.,* 2012).

3.2 The Experimental Diets and Design

The experimental birds were randomly allocated into four treatment diets namely, T1(control), T2(PP) (5 % pineapple peels waste), T3(OP) (5 % orange peels waste), and T4(MPO) (2.5 % each of orange and pineapple peels wastes) at the rate of 40 birds per treatment in a completely randomly design. Each dietary treatment was replicated four times with a total of 10 birds per replicate. The experimental diets were formulated using pineapple peels, orange peels and their mixture. The pineapple and orange peels waste were sun-dried on a clean concrete floor with constant turning and was oven dried until a 10 % moisture content was attained. Part of the dried peels was grounded to fine powder and pass through a 2 mm sieve and mixed with the other ingredients as presented on Table 3.1

Table 3.1. Composition of Experimental Diets for Broiler Birds Under a Single Phase Feeding Regime

Ingredients	T1(Control)(kg)	T2(PP)(kg)	T3(OP)(kg)	T4(MPO)(kg)
Maize	51.00	46.00	46.00	46.00
Maize offal	9.00	9.00	9.00	9.00
Ground nut cake	17.00	17.00	17.00	17.00
Full fat soya	14.00	14.00	14.00	14.00
Fishmeal(imported)	3.00	3.00	3.00	3.00
Orange peel	0.00	0.00	5.00	2.50
Pineapple peel	0.00	5.00	0.00	2.50
Limestone	2.00	2.00	2.00	2.00
Bone meal	2.00	2.00	2.00	2.00
Palm oil	1.00	1.00	1.00	1.00
Salt	0.25	0.25	0.25	0.25
*Vit/min Premix	0.25	0.25	0.25	0.25
L-Lysine	0.25	0.25	0.25	0.25
Dl-Methionine	0.25	0.25	0.25	0.25
Total	**100**	**100**	**100**	**100**
Calculated analysis				
%Crude protein	20.52	20.07	20.07	20.07
ME/Kcal/kg	3089.37	2917.02	2917.02	2917.02
%Ether extract	7.00	6.81	6.81	6.81
% Crude fibre	4.05	3.94	3.94	3.94
%Calcium	1.45	1.45	1.45	1.45
%Phosphorus	0.45	0.45	0.45	0.45
%Lysine	1.12	1.12	1.12	1.12
%Meth + Cys	0.61	0.59	0.59	0.59

Vitamin – Mineral Premix. Vitamin A 1500 IU, Vitamin D 300 IU, Vitamin E 3.00, Vitamin K 0.25 g, Thiamine 0.2 mg, Riboflavin 0.6mg, Pantothenic acid 1.00 mg, Pyridoxine 0.4999 mg, Niacin 4.00 mg, Vitamin B12 0.002 mg, Folic acid 0.10 mg, Biotin 0.008 mg, Choline chloride 0.05g, Antioxidant 0.012 g, Manganese 0.0096 g, Zinc 0.0060 g, Copper 0.0006g, Iodine 0.006 g, Iodine 0.00014 g, Selenium 0.024, Cobalt 0.004 mg.

Keys: T1(control), T2(PP) = Pineapple peels waste, T3(OP) = Orange peels waste, and T4(MPO) = Mixtures of orange and pineapple peels waste.
ME: Metabolizable energy, meth = methionine and cys = cystein

3.3 Source of the Experimental Birds and Ingredients

One hundred and sixty (160) day old (Ross 308) broiler chicks were purchased from a reputable hatchery (Agrited) in Ibadan which was used for the experiment. Fresh composite pineapple and orange peels were collected from the retailer sell points in Kure Ultra-Modern Market in Minna Metropolis where the retailers peeled the fruits for consumers and discard the peels. The feed ingredients, soya bean, fishmeal, bone meal, limestone, maize offals, groundnut cake were purchased from Sammy agro venture, Nigeria limited, located at U.K Bello way Minna, Niger State. Maize, palm oil and salt were purchased from Central Market Minna, Niger State.

3.4 Managements of the Experimental Birds

Before the commencement of the feeding trial, the Poultry Unit was washed thoroughly with disinfectant (Vinkokill 150ml/25 litres of water) and allowed to dry to prevent the spread of diseases from the previous research. Feeders and drinkers were washed regularly to prevent faecal and microbial contamination. The experimental birds were subjected to brooding with kerosene lamp and charcoal as sources of illumination and heat respectively. Birds were vaccinated following the vaccine routine guide for the locality, infectious bursal disease (Gumboro) vaccine was given at week one and week three while Newcastle vaccine (lasota) was given at week two and week four through drinking water at the rate of 0.005ml/bird and in order to reduce stress caused by the vaccination to the birds, anti-stress (Vitalyte 1g to 2 litres of water) was administered before and after vaccination. The birds were raised on a deep litter system. Feeds and water was given *ad-libitum* throughout the period of the experiment.

3.6 Data Collection

The following parameters was measured and recorded: initial body weight of the birds at the commencement of the experiment and weekly thereafter, feed intake and body weight. These parameters were used to calculate weight gain, feed conversion ratio, apparent nutrient digestibility and carcass evaluation was also determined. The sensory attributes were also evaluated.

3.6.1 Initial weight- The birds was weighed with Salter digital weighing scale (SF 400) on arrival and the result was recorded accordingly (Malik *et al.,* 2010).

3.6.2 Feed intake

Feed was weighed for the birds in each replicates, the amount consumed for the day was obtained by differences of feed given and feed refused (Malik *et al.*, 2010).

$$\text{Average daily feed intake} = \frac{\text{weight of feed given} - \text{weight of the refused feed}}{\text{Number of birds in the replicate}}$$

3.6.3 Body weight

The birds were weighed at the beginning of the experiment and subsequently on weekly interval throughout the eight weeks of the experiment (Malik *et al.,* 2010).

3.6.4 Mean weight gain

The mean body weight gain was obtained by difference between the body weight for the proceeding week and current week.

Mean weight gain (g) = Present week eight (g) - Previous week weight (g)

3.6.5 Feed conversion ratio

It was calculated as the ratio of feed intake to weight gain.

Feed Conversion Ratio (FCR) = $\frac{\text{Average weekly feed intake (g)}}{\text{Avearage weekly weight gain(g)}}$ (Egbewande, 2009)

3.6.5 Nutrient digestibility

In the last week of feeding trial, a nutrient digestibility trial was conducted using the total collection method. This was done in specially designed metabolism cages having separate watering and feeding troughs. One bird per replicate was selected and placed in a metabolism cage. The birds were allowed to adjust to the conditions in the cages for three (3) days after which total faecal collection was carried out for five days. Dietary feed was weighed and water was served *ad-libitum* daily for four days. Total droppings were collected for four days and oven dried daily at 80^{o} C for 24hours using hot air oven (Gallenkamp 300-inch series) and the replicates from each treatment was bulked and used for proximate analysis at the Department of Animal Production Laboratory.

Apparent Digestibility = $\frac{\text{Nutrients in feed consumed} - \text{nutrients voided in droppings}}{\text{Nutrients in feed consumed}} \text{ x } 100$

(Aduku and Olukosi, 1990)

3.6.6 Carcass evaluation

At the end of the feeding trial of eight (8) weeks, carcass evaluation was done. Four birds per treatments were fasted for 12 hours as recommended by Aduku and Olukosi (2000) and final weights of all the birds were taken using a sensitive weighing scale. The fasted birds were weighed before slaughter and immediately after the slaughter, they were dressed and re-weighed. The weights of the carcass cuts: drumstick, thigh, back, wing, shoulder, breast and neck and visceral organs: lungs, liver, spleen, heart, gall bladder, gizzard, intestine and proventriculus were also taken as the percentage of the dressing weight. All other weights were expressed as percentage of live weight.

3.6.7 Sensory evaluation of birds

The sensory evaluation was performed according to the methodology of Dutcosky (2007). The cut sample of the breast was cooked for twenty minutes in 500 mls of water with a pinch of common salt in an aluminum pot without any spices added. The meats were served to 20 semi-trained Panelists, comprising of Staff and Students which were randomly selected from School of Agriculture and Agricultural Technology, Federal University of Technology, Minna, Nigeria. A 9- point hedonic rating scale from 1 to 9 (1: disliked extremely; 2: dislike very much; 3: dislike moderately; 4: dislike slightly; 5: neither like nor dislike; 6: like slightly; 7: like moderately; 8: like very much; 9: like extremely) was used to evaluate the following characteristics of the chicken meat: aroma, juiciness, appearance, flavour, colour, texture and over all acceptability.

3.7 Chemical Analysis

The proximate composition of the experimental diets and faecal droppings were carried out at the Department of Animal Production Laboratory according to the procedures of AOAC (2000). The result was used to calculate apparent nutrient digestibility.

3.8 Data Analysis

All data generated were analysed using one-way analysis of variance (ANOVA) and where significant differences occurred, the means was separated using Duncan Multiple Range Test as contained in the SAS package (2015) version 15.0.

CHAPTER FOUR

4.0 RESULTS

4.1. Proximate Composition of Sun-dried Orange and Pineapple Peels

The proximate results (Table 4.1) showed that moisture content values were 9.20 % (Orange peel), 8.20 (Pineapple peel) and 8.50% (Mixture of pineapple and orange peels) respectively. The crude protein values ranges between 5.60 % and 7.00 %. The crude fibre results ranges between 1.50% (mixture of pineapple and orange peels) and 3.50% (pineapple peel). The proximate result showed that ether extract values ranges 3.00 and 5.00 %. The ash content result ranges between 6.00 and 6.10. The NFE was higher in (pineapple peel) 74.60 and lower in 70.69 (orange peel). The energy value was 3138.15 (orange peel) 3061.20 (pineapple peel) and 3180.80 (mixture of pineapple and orange peels) kcal/kg respectively.

4.2 Proximate Composition and Energy Value of the Experimental Diets

The proximate composition and energy (Kcal/kgME) of the experimental diets are presented in Table 4.2. Dry matter values ranges from 89.20 % in (Pineapple peel) to 92.60 % in (mixture of pineapple and orange peels) were quite high and showed tendency to be stored for considerable period of time without spoilage and microbial growth. The crude protein of diets T1 (control), T2 (pineapple peel), T3 (orange peel) and T4 (mixture of pineapple and orange peels) are 23.80, 23.45, 24.50, and 22.40 respectively., The crude fibre ranges between 4.00-5.00 % throughout the treatment groups. The value for ether extract ranges between 14.50 to 17.50 %. The nitrogen free extract of the diets was T1 (control) 36.00 %, T2 (pineapple peel) 36.75 %, T3 (orange peel) 34.00 % and T4 (mixture of pineapple and orange peels) 41 .00 % respectively.

4.3 Growth Performance of Broiler Chicken Fed Sun-dried Orange and Pineapple Peels Based Diets Under Single Phase Feeding

The results of growth performance of broiler chickens fed sun-dried orange and pineapple peels based diets under a single phase feeding are presented in Table 4.3.

Table 4.1 Proximate Composition and Energy Value of Orange(OP) and Pineapple(PP) Peels

Parameters	SDOP	SDPP	MPO
Dry matter	90.80	91.80	91.5
Moisture content	9.20	8.20	8.50
Crude Protein	7.00	5.60	6.90
Crude Fibre	2.10	3.50	1.50
Ether Extract	5.00	3.00	5.00
Ash Content	6.01	6.10	6.00
NFE	70.69	74.60	72.10
Energy(Kcal/kg)	3138.15	3061.20	3183.80

SDOP (Sun-dried orange peel), SDPP (sun-dried pineapple peel) MPO (Mixture of pineapple and orange peels) and NFE (nitrogen free extract)

Table 4.2. The Proximate Composition and Energy (Kcal/kgME) of the Experimental Diets

Treatment (%) Parameters	T1(control)	T2(PP)	T3(OP)	T4(MPO)
Dry matter	90.80	89.20	90.00	92.60
Crude protein	23.80	23.45	24.50	22.40
Crude fibre	4.00	5.00	4.50	4.50
Ether extract	17.00	16.50	17.50	14.50
Ash content	10.00	8.50	9.00	10.00
NFE	36.00	36.75	34.00	41.20
Energy (kcal/kgME)	3488.00	3455.40	3531.40	3445.30

NFE (Nitrogen free extract)

T1=control

T2 (PP) =Pineapple peel

T3 (OP) =Orange peel

T4 (MPO) =Mixture of orange and pineapple peels

The results show that final weight, daily weight and the feed conversion ratio (FCR) were significantly influenced ($p<0.05$) by the peel based diets. However, the initial weight and feed intake were not affected statistically. The result show that there were significant differences ($p<0.05$) in the final weight of birds fed sun dried peels based diets. The final weight results ranges between 1200-1410g. The birds fed control diet was significantly ($p<0.05$) higher than the other treatment groups. However, the group fed 5 % orange peel recorded the least value ($p<0.05$). The result show that there was significant ($p<0.05$) in the daily weight of birds fed sun dried peels based diets. The daily weight results ranges between 14.52 – 17.15g. The birds fed control diet was significantly ($p<0.05$) higher than the other treatment groups. However, the group fed 5 % orange peel recorded the least value ($p<0.05$). The feed conversion ratio was influenced ($p<0.05$) by the peel based diets. The feed conversion ratio results ranges between 3.21-3.60. The feed conversion ratio result shows that birds fed the control diet (T1) were significantly better than the other groups. However, the control and the other dietary treatments were significantly ($p<0.05$) different.

4.4 Apparent Nutrient Digestibility of Broiler Chicken fed sun-dried Orange and Pineapple Peels Based Diets Under Single Phase Feeding

The results of the apparent nutrient digestibility of broiler chickens fed diets containing sun-dried orange and pineapple peels based diets are presented in Table 4.4. The results showed that dry matter, ash, NFE (Nitrogen free extract) and TDN (Total digestibility nutrient) digestibility were influenced positively by the peels bases diets. However, the crude fibre digestibility was not influenced ($p>0.05$) by the dietary treatments. The dry matter digestibility results showed that birds on T2 (pineapple peel) and T3 (orange peel) diets had similar values which were significant ($p<0.05$). Birds on T4 (mixture of pineapple and orange peels) treatment had highest dry matter digestibility 83.55 % than all the other

Table 4.3 Growth Performance of Broiler Chicken Fed Sun-dried Orange and Pineapple Peels Based Diets Under Single Phase Feeding regime

	Treatment						
Parameters	T1	T2	T3	T4	SEM	P/Value	L/S
Initial Weight (g)	37.83	38.30	38.03	37.95	0.052	0.059	NS
Final Weight (g)	1410.25[a]	1340.58[b]	1200.22[d]	1320.49[c]	22.790	0.001	*
Daily Weight (g)	17.15[a]	16.27[b]	14.525[d]	16.04[c]	0.285	0.001	*
Daily Feed Intake (g)	55.05	54.21	52.41	55.04	0.481	0.163	NS
FCR	3.21[a]	3.33[b]	3.60[d]	3.43[c]	0.031	0.001	*

[abcd] Means on the same row having different superscripts are significantly different ($P<0.05$)

SEM: = Standard Error of Mean, LS=level of significant, FCR = (Feed conversion ration).

T1=control

T2 (PP) = Pineapple peel

T3 (OP) = Orange peel

T4 (MPO) = Mixture of orange and pineapple peels treatments, the least was recorded by birds on T3 (orange peel) diet 78.78 %. The crude protein digestibility values ranged between 69.39 % and 76.22 %. The birds on T1 (control), T3 (orange peel) and T4 (mixture of pineapple and orange peels) had similar ($p>0.05$) values. Similarly, birds on T2 (pineapple peel), T3 (orange peel) and T4 (mixture of pineapple and orange peels) also had similar ($p>0.05$) values. However, birds on T1 (control) diet had significantly higher ($p<0.05$) CP digestibility than those of T2 (pineapple peel) diet. The ash content digestibility ranges from 44.52 % to 64.01 %. The ash content digestibility results showed that birds on T1 (control) and T4 (mixture of pineapple and orange peels) diets had similar ($p>0.05$) values; birds on T2 (pineapple peel) and T3 (orange peel) diets also had similar. However, birds on T1 (control) and T4 (mixture of pineapple and orange peels) are significantly ($p<0.05$) higher in terms of ash digestibility value than birds on T2 (pineapple peel) and T3 (orange peel) diets. The ether extract digestibility result ranges between 87.57% and 89.51%. Birds on T1 (control), T3 (orange peel) and T4 (mixture of pineapple and orange peel) diets had similar ($p>0.05$) values, birds on T2 (pineapple peel), T3 (orange peel) and T4 (mixture of pineapple and orange peels) diets also had similar ($p>0.05$) values. However, birds on T1 (control) diet had the highest EE while the least was recorded by birds on T2 (pineapple peel) diet. The NFE digestibility results showed that birds on diet T4 (mixture of pineapple and orange peels) had the higher ($p<0.05$) value than those of birds in the other treatments. Birds on T1 (control) and T2 (pineapple peel) had similar ($p>0.05$) values, however, they had higher value than birds on T3 (orange peel) diets. The total digestibility nutrient (TDN) result showed that birds on T1, T2 and T4 had similar values which were significant ($p<0.05$). However, bird on T3 had the highest total digestibility nutrient of 92.38% than the other group. The dietary treatments did not influence ($p<0.05$) the crude fibre digestibility.

Table 4.4 Apparent Nutrient Digestibility of Broiler Chicken fed Sun-dried Orange and Pineapple Peels Based Diets Under Single Phase Feeding

	Treatments						
Parameters	T1	T2	T3	T4	SEM	P/Values	L/S
Dry Matter	83.03^{b}	78.96^{c}	78.78^{c}	83.55^{a}	0.839	0.005	*
Crude Protein	76.22^{a}	69.39^{b}	74.10^{ab}	71.53^{ab}	1.087	0.067	*
Ash	59.12^{a}	44.52^{b}	47.91^{b}	64.01^{a}	3.119	0.009	*
Crude Fibre	63.30	54.86	62.12	56.28	1.623	0.137	NS
Ether Extract	89.51^{a}	87.57^{ab}	89.04^{ab}	88.78^{b}	0.312	0.103	*
NFE	93.26^{b}	92.83^{b}	88.26^{c}	95.89^{a}	1.063	0.004	*
TDN	88.76^{b}	88.23^{b}	92.38^{a}	89.37^{b}	3.729	0042	*

^{abc} Means on the same row having different superscripts are significantly different ($P<0.05$)

SEM: = Standard Error of Mean,

NFE: = (Nitrogen free extract), TDN=Total digestibility nutrient

T1 = Control

T2 (PP) =Pineapple peel

T3 (OP) =Orange peel

T4 (MPO) =Mixture of orange and pineapple peels

4.5 Carcass Characteristics of Broiler Chicken fed Sun-dried Orange and Pineapple Peels Based Diets Under Single Phase Feeding

The results of carcass characteristics of broiler chickens fed sun-dried pineapple and orange peels based diets is presented in Table 4.5. The results showed that live weight, slaughtered weight, dressing percentage, were all significant ($p<0.05$). The values for the live weight ranges between 1200-1410g. Birds on T1 (control), T2 (pineapple peel) and T4 (mixture of pineapple and orange peels) had similar ($p>0.05$) values, while birds on T2 (pineapple peel), T3 (orange peel) and T4 (mixture of pineapple and orange peels) also had similar ($P>0.05$) values. However, birds fed diets T1 (control) had the highest live weight while the lowest was recorded by diet T3 (orange peel). The slaughtered weight results ranges between 1120-1360g. Birds on T1 (control), T2(pineapple peel) and T4 (mixture of pineapple and orange peel) had similar ($p>0.05$) values, while birds on T2 (pineapple peel), T3 (orange peel) and T4 (mixture of pineapple and orange peel) also had similar ($p>0.05$) values. However, birds fed diets T1 (control) had the highest live weight while the lowest was recorded by diet T3 (orange peel). The values for the dressing percentage ranges between 169.00g -73.73 %. Birds on T3 (orange peel) and T4(mixture of pineapple and orange peel) had similar ($p>0.05$) values, while birds on T1(control) and T2(pineapple peel) also had similar ($p>0.05$) values. However, birds fed diets T4(mixture of pineapple and orange peels) had the highest dressing % while the lowest was recorded by birds on diet T2(pineapple peel).

The result of the cut parts such as drumstick and back were influenced ($p< 0.05$). The result of drumstick % ranges between 8.99 % and 10.01 %. Birds on T1 (control), T2 (pineapple peel) and T3 (orange peel) diets had similar value ($p>0.05$). The result of back % ranges between 12.10 % and 10.01 %. Birds on diets T1 (control), T3 (orange peel) and T4 (mixture of pineapple and orange peels) had similar ($p>0.05$) values. Birds on diets T1 (control) T2 (pineapple peel) and T4 (mixture of pineapple and orange peels) also had similar values (p>0.05).

The results also showed that internal organs such as liver and lungs were also influenced (p<0.05) by the peels based diets. The result of liver % ranges between 2.07 % and 2.94 %. Birds on diets T1 (control), T2 (pineapple peel) and T3 (orange peel) had similar (p>0.05) values. The result of lung % ranges between 0.54 % and 0.73 %. Birds on diets T2 (PP), T3 (orange peel) and T4 (mixture of pineapple and orange peel) had similar (p>0.05) values. Birds on diets T1 (control), T3 (orange peel) and T4 (mixture of pineapple and orange peel) also had similar (p>0.05) values. However, birds on T2 (pineapple peel) diet recorded the highest value, while birds on diet T1 (control) treatment recorded the least value. The carcass weight, cut parts such as breast %, thigh %, wing %, and internal organ such as gizzard heart and spleen were not influenced (p>0.05) by the peels based diets.

4.6 Sensory Properties of Broiler Chicken fed Sun-dried Orange and Pineapple Peels Based Diets Under Single Phase Feeding

The results of the sensory properties of broiler birds fed sun-dried pineapple and orange peels based diets are presented in Table 4.5. The results showed that aroma and tenderness were influenced (p<0.05). The result of aroma ranges between 6.20 to 7.33. Birds on diets T1 (control), T2 (pineapple peel) and T4 (mixture of pineapple and orange peel) had similar (p>0.05) values. Birds on diets T2 (pineapple peel), T3 (orange peel) and T4 (mixture of pineapple and orange peel) also had similar values (p>0.05).

However, birds on T1 (control) diet was significantly (p<0.05) higher than the other treatments. The result of tenderness ranges between 6.33 and 7.73. Birds on diets T1 (control), T2 (pineapple peel) and T4 (mixture of pineapple and orange peel) had similar (p>0.05) values. Birds on diets T2 (pineapple peel), T3 (orange peel) and T4

Table 4.5 Carcass Characteristics of Broiler Chicken fed Sun-dried Orange and Pineapple Peels Based Diets Under Single Phase Feeding

			Treatments				
Parameters	T1	T2	T3	T4	SEM	P/Value.	L/S
Live weight(g)	1410^{a}	1340^{ab}	1200^{b}	1320^{ab}	33.959	0.151	*
Slaughter weight (g)	1360^{a}	1250^{ab}	1120^{b}	1270^{ab}	34.098	0.066	*
Carcass weight(g)	972.50	935.00	855.00	975.00	24.186	0.274	NS
Dressing %	69.00^{b}	69.85^{b}	71.52^{ab}	73.73^{a}	0.612	0.013	*
Cut part [percentage of slaughtered weight (%)]							
Breast	15.48	15.47	15.43	17.26	0.341	0.148	NS
Thigh	12.43	12.58	12.53	12.43	0.173	0.990	NS
Drumstick	8.99^{b}	9.48^{ab}	9.31^{b}	10.01^{a}	0.135	0.035	*
Wings	8.97	9.23	9.74	9.78	0.175	0.308	NS
Back	12.67^{ab}	12.16^{b}	13.61^{a}	12.69^{ab}	0.231	0.157	*
Internal organs [percentage of live weight (%)]							
Gizzard	2.16	1.97	2.08	2.01	0.696	0.814	NS
Heart	0.60	0.58	0.53	0.51	0.190	0.263	NS
Liver	2.94^{a}	2.84^{a}	2.90^{a}	2.07^{b}	0.133	0.038	*
Lungs	0.54^{b}	0.73^{a}	0.61^{ab}	0.61^{ab}	0.302	0.161	*
Spleen	0.23	0.17	0.19	0.12	0.202	0.448	NS

^{ab} Means on the same row having different superscripts are significantly different ($P<0.05$)

SEM: Standard Error of Mean.

T1 = (control), T2(PP) = pineapple peel, T3(OP)=orange peel, T4(MPO) = mixture of orange and pineapple peels (mixture of pineapple and orange peel) also had similar values ($p>0.05$). However, birds on T1 (control) was significantly ($p<0.05$) higher than the other treatments. Other parameters such as colour, appearance, juiciness, flavour and overall acceptability were not significantly influenced ($p>0.05$) by the peels based diets.

Table 4.6 Sensory Evaluation of Broiler Chicken fed Sun-dried Orange and Pineapple Peels Based Diets Under Single Phase Feeding

	Treatments						
Parameters	T1	T2	T3	T4	SEM	P/Values	L/S
Colour	6.80	6.20	5.87	6.87	0.174	0.260	NS
Juiciness	6.60	6.67	6.47	7.13	0.206	0.696	NS
Appearance	7.00	647	6.33	7.00	0.179	0.424	NS
Flavour	7.07	7.27	6.47	7.46	0.196	0.307	NS
Aroma	7.33^{b}	6.80^{ab}	6.20^{b}	7.20^{ab}	0.176	0.097	*
Tenderness	7.73^{a}	6.53^{ab}	6.33^{ab}	6.93^{ab}	0.226	0.128	*
Over all Acceptability	7.60	7.60	7.13	7.89	0.169	0.495	NS

^{ab} Means in the same row having different superscripts are significantly different (P<0.05) SEM=standard error of mean

T1=(control), T2(PP)=pineapple peel, T3(OP)=orange peel, T4(MPO)=mixture of orange and pineapple peels.

CHAPTER FIVE

5.0 DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 Discussion

The proximate composition of the peels based diets used in this study met the nutrient requirements of the broiler chickens in the tropics as stated by (Olomu, 1995). Sweet orange peels, pineapple peels and their mixtures has a crude fibre (CF) range of 4.0 - 5.0 % as against 2.70 % in maize and metabolizable energy (ME) content of 3445.3 – 3531.4kcal/kg as against 3432.00 kcal/kg in maize by (Aduku, 2000). Dry matter (DM) values also ranged from 89.20 % in (pineapple peel) to 92.60 % in (mixture of pineapple and orange peels).

The growth performance of broiler chickens fed sun-dried orange and pineapple peels based diets indicated that treatments had effect on final weight, daily weight and feed conversion ratio (FCR), though there were no similarities among the results of birds on orange, pineapple peels and the control diets. This could be associated with the peels effects on enhancing the gastro intestinal enzyme thereby improving digestion and assimilation of nutrients. The birds fed the control (0 %) diet utilized the feed better than those on the orange and pineapple peels mixture. This is an indication that the control diet contains more essential nutrients as compared to the other treatments. The report of this research study is in accordance with the work of Ani *et al*., (2015) who stated that the effect of treatment on final weight and daily weight gain on broiler birds were significant ($p<0.05$) when pineapple peel waste. Birds on control diet (0% OP&PP) orange peel and pineapple peels had significantly ($p<0.05$) higher weight than those fed other diets. Aboh, *et al*. (2013) reported that final average live weight gains and feed conversion rate of growing rabbits were significantly influenced as inclusion level of pineapple peels increased. Moreover, Adeyemi, *et al*. (2010) and Fapohunda, *et al*. (2008) observed the same trend when using pineapple peels in the rabbits feed. This report is in agreement with the observation of Ngiki *et al*., (2014) who included cassava root-leaf meal mixture in broiler diets and Eruvbetine *et al*. (2003) who included cassava leaf meal and cassava root meal (50:50) in the diets of broiler chickens. It had been reported that sweet orange and pineapple peels have higher crude fibre content than maize (Oluremi *et al*., 2007). In addition, Nicolakakis *et al*. (1999), Ahaotu and Ekenyem (2009) observed that higher dietary fibre depresses weight gain in broiler chickens, thus, confirming the results of this experiment. The utilization of the sun dried peels based diets as replacement for maize depressed the performance of the birds and this negative effect became more severe at 5 % orange peel inclusion level. The biological performance of broiler chicks measured in terms of final weight (FW), daily weight gain, (DWG) was comparable to the control diet. Bibi *et al*. (2001) have reported significant weight gain in broiler chicken with diet containing citrus peel waste 5 %.

The nutrient digestibility of broilers fed orange, pineapple peels and their mixture indicated an improvement in dry matter, crude protein, ash, ether extract, nitrogen free extract (NFE) and total digestible nutrient (TDN) digestibility. This report agrees with the findings of Fafiolu *et al*. (2015) who observed that palm kernel extraction residue (PKER) had a significantly higher apparent digestibility on dry matter, crude protein, ether extract, ash, nitrogen free extract and metabolizable energy in Marshall broiler chickens. The significant difference observed in the dry matter digestibility with diet of 5.0 % orange peel having the lowest (78.78%) is in agreement with the report of Iyeghe-Erakpotobor *et al*. (2006), where dry matter digestibility obtained was lower than that recorded for the control diet (76%) but similar to that recorded with 50 % soybean cheese waste meal by the same author. The broiler chickens fed the control diet exhibited superiority in terms of crude protein, crude fibre and ether extract digestibility compared to the groups fed the sun dried peel meals. This could be due to the effect of residual anti nutritional factors present in the sun dried peel meals. The presence of anti-nutritive factors and dietary fiber are some factors that can influence digestibility of feed Leeson and Summers, (2002).

The differences in carcass characteristics could be attributed to differences observed in the growth performance parameters in the present study. The low live weight of birds on orange peel could be as a result of fibre content of the peel based diets. This report is in agreement with Adeyemo and Longe (2007) who reported significant differences for live weight, plucked weight and dressed weight when broiler chickens were fed graded levels of pineapple waste based diets. The higher dressing percentage (T4 mixture of orange and pineapple peels) recorded in this study might be attributed to better utilization of the feed particularly the orange and pineapple mixtures. The values of dressing percentage (69.00-73.73 %) were comparable to the findings of Adeyemo and Longe (2007) who reported 65.63 - 73.33% for dressed weight when broiler chickens were fed graded levels of pineapple waste based diets. Also, the values were within the values (67.6 - 82.07 %) of dressing percentage reported by Zanu *et al*. (2017). Disproportionate growth, which favoured the growth of some parts at the expense of other parts, could be caused by diet (Hubbard, 2006) and a situation where there was no significant difference means that the diets were similar in value with respect to supporting carcass yield. Agu *et al*. (2010) observed a similarity in growth performance of finisher broiler chickens when even 20 % of maize was replaced by SOPM (sweet orange peels meal) in their diets. The author did not however shed light on effect of SOPM (sweet orange peels meal) on internal organs, but similarity among treatment groups suggests that 20 % SOPM (sweet orange peels meal) in diets of broiler chickens was a safe level.

The cut part and the internal organs such as drumsticks, back, liver and lungs were significantly influenced. Similar observation agrees was reported by Jiménez-Moreno *et al*. (2009) that inclusion of fibre increased the relative weight of the different segments of the gastro-intestinal tract in birds. This observation did not agree with the reports of (Fafiolu *et al*., 2015).

The authors reported no significant differences in the weight of the cut-up parts, and harvested organs, and length of the GIT when palm kernel extraction residue (PKER) and palm kernel sludge (PKS) were fed to Marshall Broiler chickens. Also, this was contrary to the finding of Muhammad *et al*. (2015) who reported no significant differences in the values for cut–up parts expressed as percentage of slaughter weight. There was difference between groups for organ weight such as liver and lungs (%). This observation was contrary to the report of Noman *et al*. (2015) who observed no differences between groups in weight of liver, gizzard, heart, spleen or pancreas. This report was also not in agreement with Agu *et al*. (2010) who conducted a study to evaluate the effect of sweet orange peel meal (SOPM) as feed resource in broiler production. The authors found that the dietary SOPM (sweet orange peel meal) had no effect on the kidney, liver, heart, spleen, gall bladder and lung but had a significant effect on proventriculus and gizzard as the SOPM (sweet orange peels meal) level increased.

The dietary treatments influenced the aroma and tenderness of the meat, though there were similarities among the results of birds on orange, pineapple and mixture of orange and pineapple peels. The report is in accordance with the report of Omojola and Adesehinwa, (2007) who stated that aroma and tenderness are the two important parameters consumers consider when buying meat. (Haščík *et al*. 2011; 2013) found comparable results of sensory evaluation carried on chicken breast meat and thigh muscles. Fat acts as a carrier and reservoir of aroma compounds, stimulates the senses during eating and acts as a precursor for flavour ventanas *et al*., (2010). This report is in accordance with (Desmond, 2006) and Saint-eve *et al*. (2009) who stated that salt is included to enhance the tenderness and aroma of meat. This report in not in agreement with the observation of Ponte *et al*. (2008) who stated that subterranean clover pasture had no impact on tenderness, juiciness flavour of broiler meat.

5.2 Conclusion

Based on the results obtained from this study it can be concluded that:

I. The utilization of the sun dried peels based diets as replacement for maize depressed the growth performance of the birds and this negative effect became more severe at 5 % orange peel inclusion level.

II. The apparent nutrient digestibility revealed that orange, pineapple peel and their mixture had significant effect on the digestibility of the broiler chickens. Birds on 5 % sun dried orange peels was statistically better.

III. Carcass characteristics indicated that birds fed the control diets had the highest live weight, and slaughter weight. However, the broiler chicken in the control group did not show any superiority statistically in term of drumstick, back, liver and lung with other treatment groups

IV. Sensory properties showed that aroma and tenderness were influenced by the peels based diets. Breast meat from (T1) Control had the better aroma 7.33 and tenderness 7.73 which is statistically similar with the other treatment groups

5.3 Recommendations

Mixture of orange and pineapple peels should be encouraged so as to reduce the pressure on maize as indicated by nutrient digestibility, carcass characteristic and sensory evaluation.

The sun drying of orange and pineapple peels would improve the palatability and aroma of the feed.

Finally, further research should be carried out to establish an appropriate method of processing to apply to both orange and pineapple peels and the inclusion levels under which better results can be achieved.

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