QUALITY EVALUATION OF MEAT FLOSS FROM BROILER CHICKENS FED DIETS CONTAINING VARYING ENERGY LEVELS

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DECLARATION

I hereby declare that this work is the product of my research efforts undertaken under the supervision of Professor B.F. Muhammad and has not been presented anywhere for the award of a degree or certificate. All sources have been duly acknowledged.

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CERTIFICATION

This is to certify that the research work for this thesis and the subsequent write-up by Auwalu Mallam-Madori Umar (SPS/11/PAS/00002) were carried out under our supervision.

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ABSTRACT

The research was conducted at the Teaching and Research Farm of the Department of Animal Health and Production, Binyaminu Usman Polytechnic, Hadejia, Jigawa State to investigate the effects of feeding diets containing varying energy levels on performance, blood chemistry, carcass characteristics and nutrient digestibility of broiler chickens. At week eight of the trial, meat floss was prepared, its chemical composition as well as the effect of packaging materials on the microbial quality and sensory parameters were evaluated. Two hundred and seventy Cobb-500 Strain day old chicks were raised intensively for 8 weeks in a Completely Randomized Design. Experimental birds were grouped into three treatments of ninety birds and sub-divided into three replications of thirty birds. Three experimental diets (2,400; 2,600 and 2,800 Kcal/kg designated A, B and C, respectively) were formulated and fed to the broiler chickens. The data were subjected to one way Analysis of Variance using SPSS (17.0) and means were separated using LSD. During the finisher phase, the results showed that feed intake decreased as the energy value of the feed increased. Values of the haematological parameters were significantly ($P<0.05$) higher for the birds fed diet containing 2, 400 Kcal/kg. The wing weight, drumstick and liver expressed in percentage of live weight were significantly ($P<0.05$) higher for broiler chickens fed 2,400 and 2,600 Kcal/kg. The meat floss experiment was laid in a 3x4x6 factorial arrangement in a Completely Randomized Design. The factors were 3 dietary energy levels (2, 400, 2, 600 and 2, 800 Kcal/kg); 4 Packaging Materials (High Density Polyethylene, Low Density Polyethylene, Aluminium Foil and Polyvinyl Chloride) and 6 Storage Period (0, 2, 4, 6, 8, 10 weeks). Data were generated on chemical composition and microbial quality of raw meat and meat floss. Sensory evaluation of the meat floss was conducted to determine the overall acceptability of the product. Data generated on chemical composition were analysed using ANOVA in SPSS version 17.0 and significantly different means were separated using LSD, while that of sensory parameters were analysed using JMP Pro 13.1.0 statistical package. The results showed that meat floss of broiler chickens fed 2, 800 Kcal/Kg had the highest mean values of moisture (7.41%), crude protein (49.00%) and ether extract (22.00%). The minerals composition of meat floss from broiler chickens fed diet containing 2, 800 Kcal/Kg had the highest values of Na (44.69 mg/Kg), K (58.81 mg/kg), Fe (14.25 mg/kg) and Zn (25.74 mg/kg). Microbial quality assessment indicated that the raw meat was contaminated with *Staphylococcus aureus* (1.20-2.00 x 10^4 cfu/g) and *Escherichia coli* (2.70-3.00X10^4 cfu/g). There were decreases in overall acceptability rating with increases in period of storage, irrespective of the energy levels from where the meat floss were produced. It was concluded that meat floss of broiler chickens fed diets containing 2, 800 Kcal/kg had highest values of moisture, ether extract, Na, K and Fe. The use of diet containing 2, 800 Kcal/kg to prepare meat floss is recommended.

CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND INFORMATION

Commercial Poultry production has witnessed series of developments, especially in the field of nutrition (Ayoola, Egbeyale, Ekunseltan, Sogunle & Jimoh, 2012). The advancement from the primitive mode of production to modern ways had given way to intensive feeding without the birds roaming about and searching for feed (Ajuonuma & Awodi, 2012). Modern feeding system is the outcome of several years of research work that have studied the nutritional requirements of birds at different ages and for different purposes thereby leading to the development of differently formulated rations (Oladunjoye, Ologhobe, Eniola & Amao, 2004).

Information on the requirements for energy and protein in broiler chickens is richly available (Olomu, 1976; Coon, Becker & Spencer, 1981; Olomu, 1995; Brickett, Dahiya, Classen & Gomis, 2007; Jegede, Adeyeye & Agbede, 2016). The crude protein levels recommended for broiler chickens during starter and finisher phases are 23 to 24% and 18 to 20% with energy base of 3,200 Kcal /Kg and 2,800 Kcal /Kg, respectively (NRC, 1994).

The energy level of feed is the main factor influencing feed intake, as birds eat to satisfy their energy needs. The other dietary nutrients usually vary in relation to the dietary energy content of the diet (Ogundipe, 2002). Energy is the fuel that keeps many different body functions every time of the day. It is a vital feed, costly and the most wasted of the feed ingredients (Oluyemi & Roberts, 2000), hence everything has to be done to enhance the utilization of the diet for productive body functions.

Haematological tests have been widely used for the diagnosis of various diseases and nutritional status of an animal (Afolabi, Akinsoyinu, Olajide & Akinyele, 2010; Nse-Abasi, Etim & Williams, 2014). Information gained from the blood parameters would substantiate the physical examination and together with the medical history provide excellent basis for medical judgment (Abdulazeez, Adamu, Igwebuike, Gwayo & Muhammad, 2016). In addition, it would help to determine the extent of tissue and organ damage, the response of defense mechanism of the patient and aid in the diagnosis of the ailment (Robert, 2016).

Carcass yield is an important factor for evaluating the ability of an animal to transform feed in to edible products (Raji, Igwebuike & Aliyu, 2007). Many factors including age, sex, breed, birth weight, type of diet etc. influence carcass weight and dressing percentage (Louvandili, McManus, Dallago, Machado & Autunes, 2006). Although heredity dictates the extent of growth and development, nutrition along with other environmental factors governs the actual rate of growth and extent to which development is attained (Irshad *et al*., 2012).

Generally, meat is defined by the *Codex Alimentarius* as all parts of an animal that are intended for use and have been judged as safe and suitable for human consumption (FAO, 2006). The word meat comes from the Greek word *mete*, which referred to food in general (Purchas, Rutherfurd & Pearce, 2005; Lawrie, Ledward & Thakur, 2006). Meat is the term used for the flesh of the animals used for food, especially that of cattle, sheep, goat and swine, as distinct from game, poultry and fish: sometimes it is inclusive of all animal flesh (Williams, Droulez & Levy, 2006; Muhammad, Musa, Ibrahim & Inusa, 2012). Wilcox (2005) defined meat as the flesh (mainly muscle) and organs of animals. Meat can be part of balanced diet contributing valuable nutrients that are beneficial to human health. FAO (2007) reported that meat and meat

products contain significant levels of protein, vitamins and minerals which are essential for human growth and development.

Dambun-Nama (meat floss) is a Nigerian traditionally spiced, cooked, pounded, shredded and dried meat product which is commonly prepared using chicken meat, beef, chevon, mutton or camel meat and is popularly consumed in the Northern parts of Nigeria. The product was developed as a means of preserving meat in the absence of facilities for refrigerated storage by the early Fulani and Hausa herdsmen (Sanwo, Olayiwola, Iposu, & Adegbite, 2011).

The need for packaging can be linked with the progress brought about by civilization to preserve perishable food for longer period of time. Packaging is a scientific method used for preserving food products against physical, chemical and biological damages (Omojola, 2008). The major purpose of meat packaging is to safeguard the quality and safety of meat and meat products from the time of manufacture to the time it is being consumed as well as enhance the marketability of the products (Hurmes, Malin & Ahvenainen, 2002).

1.2 PROBLEM STATEMENT

The ever increasing human population coupled with the diminishing available agricultural lands has made it difficult for small scale farmers to keep ruminant animals (Akpa, Alphonsus, Dalha & Garba, 2010). In Nigeria, there exists a persistent insufficient intake of animal protein. An average Nigerian consumes 7.5 g/head/day of animal protein as against 35 g consumed by an average Briton (FAO, 1996).

Meat is a good culture media, high in moisture and nutrients, usually neutral in pH hence contamination with spoilage organisms is almost unavoidable, thereby making its preservation difficult (Banani, Rabi, Runu & Utpal, 2006). Raw meat favours the growth of hazardous micro-organisms which tend to lower its quality, shortens its shelf life, result in economic loss

and health hazard (Kakalou, Faid & Ahami, 2004). Conventionally, meat is sold directly to the consumers and in most cases in Nigeria under poor sanitary conditions. Under such conditions little processing and packaging are done which subject the meat to spoilage leading to poor shelf life. The handling procedure and places of marketing meat products could pose high risks of contamination from either or both microbial and chemical sources. Meat products for sale in Nigeria are commonly displayed in the open and prone to contamination by pollutants (Umar & Muhammad, 2011).

The meat processing technology in Nigeria is still at an infant stage. The processing technology that has been in use for the past generations are yet to be upgraded and modernized to cope with the increasing consumer demand (Omojola, 2009). One of the major problems associated with traditional meat processing is lack of standardized measurements for the finished products. The application of methods varies widely with individual processors, so does the quality of the finished products (Omojola & Adesehinwa, 2006). Most a times, meats are being preserved using different methods for a considerable length of time with associated changes in the nutrient composition (Brewer, 2003). There is a lot of variation in the nutrient composition of meat, which is due to ways meat is cooked, time lapse between slaughter as well as animal in question and the preservation methods (Wilcox, 2005).

1.3 JUSTIFICATION FOR THE STUDY

The acceptability of poultry muscle as food depends largely upon chemical, physical and structural changes that occur on muscle as it is converted to meat (Ayoola *et al.*, 2012*).* Meat and meat products are very important components of human diets, this is because of their high nutritive value. In Northern Nigeria, *Tsire, Balangu, Dambun-Nama, Kilishi* and *Ragadada* are the commonest meat products (Bube, 2003). These meat products are processed locally which

creates an avenue for the use of low value meat pieces. This enables the processors to convert low price meat cuts into high priced processed products (Ikeme, 1990).

Consumer's attitude to meat involves preference depending on the criteria that was considered more important (Apata *et al.,* 2008). Such criteria may include the species of the animal, age at slaughter and eating qualities such as flavor, tenderness, juiciness, colour, texture and overall acceptability (Joseph, Momoh, Omotosho & Ladde, 1995). Organoleptic qualities are excellent guide to nutrition and cooking has been used to improve these qualities. For meat to be acceptable by consumers after chemical treatment there is the need to ascertain the effect of these chemicals on the sensory attributes of the products (Omojola, Kassim, Olusola, Adeniji, & Aremo, 2014).

Consumers prefer good quality throughout the entire shelf life of any food product (Koch, Chrisenses, Sorenses & Meinert, 2009) thus, meat packaging constitute an important aspect of food processing industry and many meat packaging systems are available with different attributes and applications (Han, 2005). However, these packaging materials are very expensive which led to the use of local packaging materials that are cheaper but could have no adverse effect on packaged meat (Hassan, Ezebor, Ikusedun, Ahmed & Igwe, 2012).

The growing importance of meat floss as an indigenous fast food makes it necessary to obtain information on its composition and to assess their nutritional contributions under various processing methods and packaging conditions. Knowledge gained could help to promote sound nutrition, improve public health and could be used to formulate good policies regarding meat products (Muhammad & Muhammad, 2007).

1.4 AIM AND OBJECTIVES OF THE STUDY

The aim of this study is to investigate the effect of feeding varying energy levels on the performance, blood characteristics, carcass characteristics and nutrients digestibility of broiler chickens, as well as to determine the effect of packaging materials, storage period and energy levels on sensory parameters of meat floss produced from broiler chickens fed varying energy levels.

The specific objectives are to:

i) compare the effect of feeding varying energy levels on the performance, haematology, biochemical, carcass characteristics and nutrient digestibility of broiler chickens.

ii) identify the chemical composition of meat floss from broiler chickens fed diets containing varying energy levels.

iii) assess the effect of packaging materials on the microbial quality of meat floss produced from broiler chickens fed diets containing varying energy levels.

iv) determine the effect of packaging materials, storage period and energy levels on sensory parameters of meat floss produced from broiler chickens fed diets containing varying energy levels.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 ORIGIN, TAXONOMY AND CHARACTERISTICS OF BROILER CHICKEN

Broiler chickens (*Gallus gallus domesticus*) are gallinaceous domesticated fowl, bred and raised specifically for meat production (Oluyemi & Roberts, 2000). They are hybrid of the egg-laying chicken, both being a subspecies of the red jungle fowl (*Gallus gallus*) which include chickens (domestic fowls) turkeys, ducks, ostrich, quails, pigeon, and guinea fowls (Olomu, 2010). Broilers came in to being as a result of genetic selection with research being focused on high growth rate, extensive muscle development and efficient feed utilization. The birds reach a slaughter weight of 2.0 kg in 5 to 6 weeks while they are still juvenile (Akanni, Peter, Adebambo, Fumilayo & Omoleye, 2009). Chickens are one of the most common and widespread domestic animals (FAOSTAT, 2009). Eda, Lu, Kiluchi, Li, Li and Yuan (2016); Pitt, Gillingham, Maltby and Stewart (2016) reported that the domestic fowl is probably developed from four (4) wild species of the genus *Gallus*, the species are *Gallus gallus* (red jungle fowl), *Gallus sonnerati* (grey jungle fowl), *Gallus carious* (the green or Javanese jungle fowl) and *Gallus lafayette* (the lafayette or singalese jungle fowl).

Banerjee (1992) and Kekeocha (2001) classified broiler chicken as belonging to the kingdom animalia, phylum chordate, sub-phylum vertebra, class aves, subs-class neornites. The authors further classified them as belonging to the order galliforms, family phasianidae, genus *gallus* and species *G.gallus*. They identified other birds like turkey, Japanese quail, pheasant fowl and pea fowl as belonging to the family phasiandae. Broiler chickens can also be classified according to origin and production:

2.1.1 Classification According to Origin

According to origin, the chickens are of four types:

- Asiatic: Brahma, Longson, Chrochin, Asil etc
- English: Austrolorp, Cornish, Dorking, Orpington etc
- Mediterranean: Leghorn, Minorca, Ancona, Fayoumi etc
- American: Rhode Island Red, New Hampshire, Plymouth Rock etc (Vaisanen & Jeness, 2004).

2.1.2 Classification According to Production

Layer birds

Layer is for egg production, some popular layer breeds are Leghorn, Minorca, Arcona, Fayoumi, Isa Brown, Baby Cock, Star Cross, Lorman etc

Broiler chickens

Broiler Chickens are only for meat production, common ones include: Plymouth Rock Cornish, Sussex, Dorking Coaching, Brahma, Sail, Starbrow, Hi-line.

Dual purpose

These types of breeds are used for the purpose of both meat and egg production. Red Island Rhode, New Hampshire, Plymouth Rock etc are popular (Roenigk, 1999).

Xiang *et al.*, (2004) characterized broilers as warm blooded tetrapods, their body is covered with epidermal feathers, their neck is flexible and long with hind limps covered with scales and armed with claws, their beak is horny and there are no teeth in the mouth, their heart have four chambers with two atria and two ventricles, they have eyes with sclerotic plates with eyelids and nictitating membrane, the auditory aperture lies behind the eye sunk deep hidden by feathers,

they have eggs with large yolks covered by a hard cell and they have twelve pairs of cranial nerves.

2.2 NUTRIENT REQUIREMENTS OF BROILERS

Poultry diets are composed primarily of a mixture of several feedstuffs such as cereal grains, soybean meal, fats, vitamins and mineral premixes. These feedstuffs, together with water, provide the energy and nutrients that are essential for the bird's growth, reproduction and health. The energy necessary for maintaining the bird's general metabolism and for the production of meat and eggs is provided by the energy-yielding dietary components, primarily carbohydrates and fats (Edward, Markus & Nugara, 1968).

2.2.1 Carbohydrates

Dietary carbohydrates are important sources of energy for the poultry (Edney, Comphell & Classen, 1989). Cereal grains such as corn, sorghum, wheat and barley contribute most of the carbohydrates to poultry diets (Friesen, Guenter, Marquarat & Rotter, 1992). Majority of the carbohydrates of cereal grains occur as starch, which is readily digested by poultry (Moran & Jorgan, 1985). Other carbohydrates occur in varying concentrations in cereal grains and protein supplements; these carbohydrates include Polysaccharides, such as cellulose, Hemicelluloses, pentosans and oligosaccharides such as stachyose and raffinose, all of which are poorly digested by poultry. Thus, these dietary carbohydrates often contribute little to meeting the energy requirement of poultry and some adversely affect the digestive process of poultry when present in sufficient dietary concentrations (Wagner & Thomas, 1978).

Scott (1970) showed that the optimum level of production was lower diet (2,700 Kcal/kg or 11.30MJ/kg) for summer reared birds than 3,000 Kcal/Kg (12.552MJ/Kg) for winter reared

birds. The reason for this observation is apparently obvious. The total metabolizable energy supplied in the diet is used for various purposes including heat losses during metabolism, maintenance, reproduction, growth and for producing eggs. At high temperatures, heat losses and basal metabolic rates are generally lower than those at lower temperatures. This means that at high temperatures, the energy is used more for reproductive and productive purposes and less energy is wasted on non reproductive purposes. It is also not therefore surprising that the energy requirement of poultry reared in tropical environment (with high temperatures) is lower than temperate environment (Blum, Guillame & Leclereq, 2005).

The physiological and physical activities of the birds lead to energy expenditure. Dietary energy is expressed as metabolizable energy (ME) which refers specifically to that portion of dietary energy which is available to animals for utilization during both production, maintenance and other vital functions (Cheeke, 1991). When feed under goes digestion, some of this energy is lost as faecal energy, there is further losses of energy in form of gaseous and urine which reduce the digestible energy. ME is considered as the most appropriate measure of accessing dietary energy (Olomu, 2010). They regulate feed intake in accordance with energy needs, because of this, the gross efficiency of feed conversion was directly related to the energy concentration of the ration.

2.2.2 Proteins and Amino Acids

Proteins are complex organic compounds containing Carbon, Hydrogen, Oxygen, Nitrogen and in some instances, Sulphur and Phosphorus. They are polymers of amino acids. The number, kind and arrangement of amino acids that makes the protein, determine the protein proportions (Moral & Stillborn, 1996). There are 20 known amino acids with 10 as essential amino acids. When formulating the protein diets, they must be able to supply all the amino acids in ample

amount. The essential amino acids are those that cannot be synthesized by the body, while the non essential amino acids are those that are not specifically required in the diet because the body can synthesize them (Eyo, 1995). Proteins can either be of plant or animal source/origin. Animal protein has higher nutritive value than vegetable protein rich food. Protein of animal origin like fish meal, meat meal and blood meal are excellent poultry feed ingredients, in terms of obtaining high carcass yield, and somehow good in assuring better mineral profile after proper processing, but expensive and some time not available (Atteh, 2002). Protein of plant origin includes soya bean meal, cotton seed cake, ground nut seed cake and sesame meal. Proper processing and method of preparation of feed stuff of both origins may have significant effect on its nutritive value, as well as the nutritive value of the meat (Akande, Doma, Agu & Adamu, 2010).

2.2.3 Fat

Mateos, Sell, East and Wood (2012) reported that fat consists of a glycerin molecule with three fatty acids attached. Fatty acids are un-branched hydrocarbon chains, connected by a single bond (saturated fatty acids) or by both double and triple bonds (unsaturated fatty acids). Fats are needed to keep cell membranes functioning properly, insulate body organs against shock, keep body temperature stable and to maintain healthy skin and hair. The body does not manufacture certain fatty acids (essential fatty acids) and the diet must supply them (Coyle, 1995).

Fat is important for increasing the energy density of rations especially those of broiler chicks and layers, this is on account of its high heat of combustion equal to 9.4 Kcal/Kg. Fat is also store in the body and eggs (David, Sadava, Craig, David, Hillis & Berenbaum, 2009). Fat is usually added to the feed for meat type poultry to increase overall energy concentration and in turn improve productivity and feed efficiency (Watkin, 1988). Oxidation of fat is an efficient means to obtain energy for the cell in large quantity, whereas anabolic use involves direct

incorporation into the body as a part of growth (Sell, Davis & Scheidder, 1986; Moral & Stillborn, 1996).

2.2. 4 Minerals

Minerals are the inorganic part of feeds or tissues. They are often divided into two (Macro and Micro) categories based on the amount that is required in the diet (Watkin, 1988). Minerals are involved in the physiological functions of the body (Oluyemi & Roberts, 2000). The macro elements are those needed relatively in large amount and are essential for maintenance of the animals wellbeing. These include calcium, phosphorous, sodium, sulphur, potassium, chlorine and magnesium. The micro elements include manganese, iron, zinc, copper, iodine, molybdenum, and selenium (Farouk, Zhang & Cumming, 2015). The entire essential elements enter into the bone composition and give skeleton the rigidity and strength needed to support the soft tissues (Schumann, 2008). The inclusion in the diet of a number of mineral elements that play an important metabolic role is therefore essential (Mc Donald *et al.*, 1995). The minerals requirement for adult bird depends on their weigh and also in laying bird on egg output. The minerals supplied in poultry feed are calcium and phosphorous in the form of blood meal, sodium and chlorine in the form of common salt (Schönfeldt, Naudé & Boshoff, 2010).

2.2.5 Vitamins

Vitamins are organic compound required by birds in small quantity for the promotion of health status, growth and development of animal life. Deficiency of vitamin leads to deficiency disease specific with a particular vitamin. Vitamins are grouped into fat soluble (A, D, E and K) and water soluble (B_1-thiamin, B_2-Riboflavin, Nicotinomide, Biotin, folic acid, B12 Cyncobalamine and ascorbic acid). Vitamin A is essential and very necessary for normal growth,

development and repair of all epithelial tissue. Its deficiency causes unthrifness, droopiness, rulfled feathers and rickets. Vitamin C is synthesized by poultry and is accordingly not considered a required dietary nutrient. There is some evidence, nevertheless, of a favorable response to Vitamin C by birds under stress (Diaz, Rodriguez, Torres & Cobos, 2010). Deficiency of vitamin E will cause crazy chick disease called Encephalonialocia (Ikeme, 1990).

2.2.6 Water

Water must be regarded as an essential nutrient, although it is not possible to state its precise requirement (Medway & Kare, 1959). The amount needed depends on environmental temperature and relative humidity, the composition of diet, rate of growth or egg production, microbes, nitrate level, hardness etc. and efficiency of kidney re-absorption (Friesen *et al*., 1992). It has been generally assumed that birds drink approximately twice as much water as the amount of feed consumed on a weight basis, but water intake actually varies greatly.

Several dietary factors influence water intake and water: feed ratios. Increasing crude protein increases water intake and water: feed ratios. Crumbling or pelleting of diets increases both water and feed intake relative to mash diets, but water: feed ratios stay relatively the same. Increasing dietary salt increases the water intake (Olomu, 2010).

2.3 FACTORS AFFECTING NUTRIENT REQUIREMENTS IN BROILERS

Dietary requirements for meat-type chickens vary according to whether the birds are broiler breeder pullets and hens, or broiler breeder males. Broilers are usually allowed to feed on an *ad libitum* basis to ensure rapid development to market size, although some interest has been expressed in controlling feed intake in an attempt to minimize the development of excessive carcass fat. Broilers are marketed at a wide range of ages and body weights. Females may be

grown 900 to 1,000g body weight in Cornish hens, mixed sexes may be reared to 1.8 to 2 Kg for use as whole birds and specialty parts, and males may be grown from 2.8 to 3 Kg for deboned meat. Thus, it is difficult to establish a single set of requirements that is appropriate to all types of broiler production. Furthermore, nutrients requirement may vary according to the criterion of adequacy. Hence, any expression of nutrient requirements can be only a guideline representing a consensus of research reports. These guidelines must be adjusted as necessary to fit the wide variety of ages, sexes, and strains of broiler chickens (NRC, 1994). The following are some of the factors affecting nutrient requirements of broilers: Environmental temperature, energy content of the feed, productive stage of the animal, physical activity, size of the animal, age, stress, diseases, genetic background of the stock, balance between nutrients, availability of nutrients from various feedstuffs, presence of peroxidizing fats in diet and destruction or loss of nutrients in feedstuff or in the gastrointestinal tract.

2.3.1 Environmental Temperature

Environmental temperature has marked effect upon energy requirement and hence on feed intake. Broilers tend to eat less in warm than in cold environments. Research shows that optimum temperature recommended for brooding is 32.5 - 35, 29.7-32.2 and 26.6-29.7 ^{o}C for first, second and third weeks, respectively (Abeke, 2002). Once kept under a comfortable temperature zone, chicks move freely and feed intake is observed across the pen.

2.3.2 Energy Content of the Feed

The requirement for energy cannot be stated as precisely as the requirements for protein, minerals and vitamins. This is because good growth can be achieved with a wide range of energy levels. Most broiler chickens have the ability to adjust feed intake in order to obtain the

necessary energy required for optimum performance. Chicks aged day-old to 4-6 weeks are however not so much able to adjust feed intake to dietary energy variation and thus tend to consume slightly more energy. The energy levels recommended for broiler chickens were averagely estimated as 3,000 Kcal/Kg or 12.552MJ/Kg (Bamgbose, Ogunbenro, Obasohan, Aruna & Oteku, 2004).

2.3.3 Productive Stage of the Animal

This refers to rate of growth, for example, broiler chickens and turkey have high requirement for amino acids to meet the needs for rapid growth; the mature cockerels has a very low requirement than the laying hen, even though body size is actually greater and feed consumption is similar; high egg producing hen would require more nutrient than low egg producing hen (Lillie & Denton, 2017).

2.3.4 Physical Activity

Feed consumption increases with increase in the activity of the animal. Active chickens require more nutrients than inactive ones (Plavnik & Hurwitz, 2015). Some voluntary activity must be allowed in poultry. However any reduction in unnecessary physical activity will make more energy available for more productive purposes (Oluyemi & Roberts, 2000). An animal that is growing require more nutrient than the one that is not growing (Olomu, 2010).

2.3.5 Size of the Animal

Large animals need more food and hence nutrients than smaller ones. However, smaller size animals have higher energy and protein requirement per unit weight than do large animals of the same species (Okorie, 2002), this is because the ratio of surface area to weight increases as

size diminishes and consequently more energy is needed to meet heat losses from relatively large surface (Olomu, 2010).

2.3.6 Age

As animal increases in size they consume more nutrients. Mathew (2000) reported that cockerels require more energy than pullets, and nutrients requirement changes as the age of the animal changes.

2.3.7 Stress

Stresses that occur in everyday life may affect nutrient requirements. Any kind of stress will change the energy requirement of the animals. Stress can result from overcrowding, handling, external disturbances, poor quality feed, water pollution, diseases etc (Atteh, 2002).

2.3.8 Diseases

Diseases and the presence or absence of internal parasites (capillaria, ascaridia, coccidian), bacteria and external parasites (lice, tick etc) may affect feed intake and the requirements for certain nutrients. Infection reduce feed intake. Animals recovering from illness need more energy and nutrients than healthy animals (Williamson & Geigor, 1999).

2.3.9 Genetic Background of the Stock

Nutrient requirements differ among breeds and strains-due perhaps different in body size, growth rate, egg production, efficiency of digestion, nutrient absorption and metabolism (Ahuja & Sen, 2007). The performance of chicks especially in terms of nutrient requirements depends on its genetical background.

2.3.10 Balance between Nutrients

Balance between amino acids; dietary protein level versus individual amino acids; vitamin D, calcium and phosphorus relationship may affect the metabolic utilization of individual nutrients and hence their requirements (Oluyemi & Roberts, 2000).

2.3.11 Availability of Nutrients from Various Feedstuffs

Availability may be affected by certain substances, e.g. phytate, oxalate and certain organic chelating agents may render ions such us zinc, manganese and even calcium completely unavailable to the animal. Availability of niacin, biotin and other vitamins are variable in nature. Practically, phytin phosphorus is not completely available (about 30-50% available). Availabilities of amino acid in feedstuff vary depending on a number of factors (Olomu, 2010).

2.3.12 Presence of Peroxidizing Fats in Diet

Payne (1990) reported that, in the presence of some minerals, e.g. manganese and iron; and in absence of suitable stabilization an oxidant, for example, oxidative rancidity of the polysaturated fats in the diet results in the destruction of vitamins A, D, E, K and biotin. Examples of anti oxidant in use are ethoxyquin (6-ethoxyl-1, 2, dihydro-2-2-4-trimethyl quinoline) and Butylated Hydroxyl Toluene (BTH).

2.3.13 Destruction or loss of Nutrients in Feedstuff or in the Gastrointestinal Tract

The breakdown products of fatty acids rancidity may react with the episilon amino groups of lysine and thereby decrease the protein and energy values of the diet. Improper processing, e.g. over heating of a food item, may produce similar effect. Other factors affecting nutrient requirements includes destruction of some nutrients by some chemicals, interference in absorption, presence of specific anti-metabolites in feed, presence of toxic factors in feedstuff,

unfavourable intestinal bacteria, internal protein synthesis, effect of enzymes, effect of hormones and system of management (Olomu, 2010).

2.4 COMPOSITION OF MEAT

Meat can be defined as a flesh of an animal needed for food. The animal carcass consists of muscles connective tissue, fat, bone and about 75% water in proportion depending on species, breed, size, age of the animal. The composition of meat is not constant and depends on the age of the animal analyzed (Amanda *et al.,* 2007). In meat composition fat is the most variable which ranges from 2% in some free living animals to 15-40% in domesticated animal intensively reared. An average cut of a beef had the following composition; 69% water, 21% fat, 18% protein, and 1.1% ash (Ogunsola & Omojola, 2007). Olomu (2010) presented the composition of various meat types (beef, chicken, turkey, pork, rabbit and lamb) at Table 1, while Wattanachant, Benjakul and Ledward (2004) presented the chemical composition of meat from broiler and spent layer (Table 2).

Table 1: Nutrient Composition of Various Meat Types

Nutrient	Beef	Chicken	Turkey	Pork	Rabbit	Lamb
Macro Nutrient						
Dry matter (%)	37.30	26.20	32.60	46.70	28.50	47.70
Crude Protein (%)	18.20	19.20	22.20	15.10	21.00	17.80
Crude Fat (%)	19.00	6.10	9.30	31.00	6.50	36.60
Ash (%)	0.10	0.90	1.10	0.60	1.00	1.30
N-Free Extract (%)	0.00	0.00	0.00	0.00	0.00	0.00
Energy (Kcal/kg)	2438	1320	1725	3400	1560	3186
Amino Acids						
Arginine	1.16	1.29	1.49	0.94	1.00	1.23
Cystine	0.24	0.34	0.40	0.12	N/A	N/A
Methionine	0.47	0.34	0.40	0.38	0.55	0.41
Histidine	0.60	0.38	0.45	0.41	0.50	0.48
Isoleucine	0.95	0.79	0.91	0.74	0.84	0.85
Leucine	1.47	1.27	1.47	1.15	1.81	1.32
Lysine	1.57	1.44	1.67	1.20	1.83	1.35
Phenylalanine	0.72	0.77	0.89	0.62	0.67	0.69
Threonine	0.80	0.77	0.89	0.74	1.07	0.87
Tryptophan	0.20	0.15	0.18	0.20	0.15	0.34
Tyrosine	0.57	0.48	0.55	0.54	0.97	0.92
Valine	0.96	1.29	1.49	0.72	N/A	N/A
Minerals and Vitamins						
Calcium (mg/100g)	0.01	0.02	0.02	0.01	0.02	0.01
Total Phosphorus (mg/100g)	0.16	0.20	0.32	0.13	0.35	0.14
Iron (mg/100g)	2.70	1.20	3.80	1.70	1.30	1.50
Vitamin A (iu)	40.00	110.00	150.00	150.00	0.00	0.00
Thiamine (mg)	0.09	0.08	0.07	0.44	0.08	0.13
Riboflavin (mg)	0.16	0.14	0.17	0.14	0.06	0.10
Niacin (mg)	4.40	8.00	10.40	2.40	12.80	4.30
Vitamin B_{12} (mg)	2.00	trace	trace	trace	trace	trace

Source: Olomu, 2010
N/A:Not Available

Table: 2 Chemical Compositions of Meat from Broiler and Spent Layer

Type of Bird	Moisture	Protein	Fat	Ash
		Component (%)		
Broiler	74.87±0.46	20.59±0.26	0.68±0.06	1.10±0.01
Spent Layer	67.46±3.13	24.36±2.81	7.15±0.09	1.04±0.09

Source: Wattanachant *et al*. (2004)

2.5 NUTRITIONAL QUALITY OF MEAT

Meat plays an important role in the diet of human beings. It supplies essential amino acid in form of protein, it also contain vitamin B complex (especially Niacin and riboflavin), iron, phosphorous and calcium. Certain meats cut especially liver contain vitamins A and D. Meat is a major source of high quality protein, fat, carbohydrate, vitamins and minerals and is delicious, palatable and easily digestible (Singh, Udit, Yadav & Basanti, 2014: Nwakanma, Unachukwu & Momoh, 2015). Nutritional requirement can be met easily and efficiently if reasonable amount of meat is included in the diet (Singh *et al.*, 2014). Hassan *et al*. (2014) described meat as major source of protein and important source of vitamins for most people in many parts of the world. Meat is essential for the growth, repair and maintenance of body cells which are necessary for everyday activities. Meat is held in high esteem in most communities. It has prestige value, it is often regarded as the central food round which meals are planned. Various types of meat made the basis of festive and celebratory occasions, and from the popular as well as the scientific point of view, it is regarded as a food of high nutritive value (McMillin, 2008).

Meat quality can be influence by a number of factors such as the age of the animal, sex, and the environment in which the animal has been raised talking particular account of feed, exercise and the species. The other factors are to a certain extent reflected in the appearance of meat especially in such qualities as relative proportion of bone, fat, muscle, colour and texture. These qualities are the basis for grading meat (Kordlylas, 1995).

2.6 PROCESSED MEAT PRODUCTS

Meat product is defined as any meat which has been modified in order either to improve its taste or to extend its life shelf. These products are meat mixes composed of comminuted muscle with varying quantities of animal fat, non-meat ingredients are added in

smaller quantities for improvement of flavor. Popular varieties of meat products include ham, pork, bacon, salami, sausages, steak, roast beef, corned beef, beef jerky, pepperoni and pastrami others are Meat Floss (*Dambun-Nama)*, *Balangu*, Kilishi and *Tsire* (Akinleye, Omojola, Kassim, & Adenekan, 2017).

2.6.1 Bacon

Bacon is a type of salt-cured pork prepared from several different cuts of meat, typically from the pork belly or from back cuts, which have less fat than the belly. It is eaten on its own, as a side dish (particularly during breakfasts), or used as a minor ingredient to flavour dishes. It can also be served with eggs and sausages as part of full breakfast (Hog, 2014). Hiskey (2010) reported that the word bacon is derived from the Old High German *bacho*, meaning "buttock". Meat from other animals, such as beef, lamb, chicken, goat or turkey, may also be cut, cured, or otherwise prepared to resemble bacon (WHO, 2015).

Bacon is cured through either a process of injecting with or soaking in brine, known as wet curing, or using plain crystal salt, known as dry curing. Bacon brine has added curing ingredients, most notably sodium nitrite (or less often, potassium nitrate), which speed the curing and stabilize color. Fresh bacon may then be dried for weeks or months in cold air, or it may be smoked or boiled. Fresh and dried bacon are typically cooked before eating, often by pan frying. Boiled bacon is ready to eat, as is some smoked bacon, but they may be cooked further before eating (Cloake, 2012). Differing flavours can be achieved by using various types of wood, or less common fuels such as corn cobs or peat (Hog, 2014). Bacon is distinguished from other salt-cured pork by differences in the cuts of meat used and in the brine or dry packing (Lin, Wang, Lai, Lee & Cheng, 1999).

Bacon is similar to salt pork, which in modern times is often prepared from similar cuts, but salt pork is never smoked, and has a much higher salt content. Sodium polyphosphates, such as sodium triphosphate may also be added to make the product easier to slice and to reduce spattering when the bacon is pan-fried (Rohrmann & Linseisen, 2016). Varieties differ depending on the primal cut from which they are prepared. Different cuts of pork are used for making bacon depending on local preferences (USDA, 2019).

Side bacon or streaky bacon, comes from the pork belly. It has long alternating layers of fat and muscle running parallel to the rind. This is the most common form of bacon in the United States. Pancetta is an Italian form of side bacon, sold smoked or unsmoked (*aqua*). It is generally rolled up into cylinders after curing, and is known for having a strong flavour.

Back bacon contains meat from the loin in the middle of the back of the pig. It is a leaner cut, with less fat compared to side bacon. Most bacon consumed in the United Kingdom and Ireland is back bacon.

Collar bacon is taken from the back of a pig near the head.

Cottage bacon is made from the lean meat from a boneless pork shoulder that is typically tied into an oval shape.

Jowl bacon is cured and smoked cheeks of pork.

Guanciale is Italian jowl bacon that is seasoned and dry cured but not smoked.

The inclusion of skin with a cut of bacon, known as the 'bacon rind' varies, though is less common in the English-speaking world.

2.6.2 Ham

Ham is pork from a leg cut that has been preserved by wet or dry curing, with or without smoking. As a processed meat, the term "ham" includes both whole cuts of meat and ones that have been mechanically formed. The modern word "ham" is derived from the Old

English *ham* or *hom* meaning the hollow or bend of the knee. Because of the preservation process, ham is a compound foodstuff or ingredient, being made up of the original meat, as well as the remnants of the preserving agent(s), such as salt, but it is still recognised as a food in its own right (Wierbicki & Howker, 2016). Ham is produced by curing raw pork by salting, also known as dry curing, or brining, also known as wet curing. Additionally, smoking may be employed. Besides salt, several ingredients may be used to obtain flavoring and preservation (Zhou & Zhao, 2007).

Dry-cured

Traditional dry cure hams may use only salt as the curative agent, such as with San Daniele or Parma hams, although this is comparatively rare. This process involves cleaning the raw meat, covering it in salt while it is gradually pressed draining all the blood (Vestergaard, Erbou, Thauland & Adler-Nissen, 2015). Specific herbs and spices may be used to add flavour during this step. The hams are then washed and hung in a dark, temperature-regulated place until dry. It is then hung to air for another period of time. The duration of the curing process varies by the type of ham, with, for example, Serrano ham curing in 9–12 months, Parma hams taking more than 12 months, and Iberian ham taking up to 2 years to reach the desired flavour characteristics. Some dry cured hams, such as the Jinhua ham, take approximately 8 to 10 months to complete (Sentandreu & Toldrá, 2018).

Most modern dry cure hams also use nitrites (either sodium nitrite or potassium nitrate), which are added along with the salt. Nitrates are used because they prevent bacterial growth and, in a reaction with the meat's myoglobin, give the product a desirable dark red color. The amount and mixture of salt and nitrites used have an effect on the shrinkage of the meat (Vestergaard *et* al., 2015). Because of the toxicity of nitrite (the lethal dose of nitrite for humans is about 22 mg

per kg body weight), some areas specify a maximum allowable content of nitrite in the final product. Under certain conditions, especially during cooking, nitrites in meat can react with degradation products of amino acids, forming nitrosamines, which are known carcinogens (Zhou & Zhao, 2007).

The dry curing of ham involves a number of enzymatic reactions. The enzymes involved are proteinases and exopeptidases (peptidase and aminopeptidase). These enzymes cause proteolysis of muscle tissue, which creates large numbers of small peptides and free amino acids, while the adipose tissue undergoes lipolysis to create free fatty acids. Salt and phosphates act as strong inhibitors of proteolytic activity (Toldrá & Flores, 2018).

Wet-cured

Wet-cured hams are brined, which involves the immersion of the meat in brine, sometimes with other ingredients such as sugar also added for flavour. Meat is typically kept in the brine for around 3 to 14 days. Wet curing also has the effect of increasing volume and weight of the finished product, by about 4%. The wet curing process can also be achieved by pumping the curing solution into the meat. This can be quicker, increase the weight of the finished product by more than immersion, and ensure a more even distribution of salt through the meat. This process is quicker than traditional brining, normally being completed in a few days (Larsson & Wolk, 2012).

Smoking

Ham can also be additionally preserved through smoking, in which the meat is placed in a smokehouse (or equivalent) to be cured by the action of smoke. The main flavor compounds of smoked ham are guaiacol, and its 4, 5, and 6-methyl derivatives as well as 2, 6-dimethylphenol.

These compounds are produced by combustion of lignin, a major constituent of wood used in the smokehouse (Rohrmann, 2013).

Typical analysis of canned ham per 100g consists of 65-72 g water, 18 g protein, 5-12 g fat, 0.5-0.8 MJ, 1100-1250 mg sodium, 1.2-2.7 mg iron, 0.2 mg copper, 2 mg zinc, 0.5 mg thiamin, 0.2-0.25 mg riboflavin, 4 mg niacin, 0.2 mg vitamin B6, and may have residual ascorbic acid 10-60 mg (Sárraga, Gil & García-Regueiro, 2013).

2.6.3 Sausage

Sausage is a highly season minced meat prepared from the intestine of pork usually stuffed in casings. There are many types of sausage made of comminuted or chopped meat of various kinds, seasoned with salt and spices, often mixed with cereal and packed into natural casings (consisting of the connective and muscle tissue of animal intestines) or made of cellulose, collagen or synthetic materials. There are six main types of sausage - fresh, smoked, cooked, smoked and cooked, semi-dry and dry (Sanwo *et al.*, 2011). Frankfurters, Bologna, Polish and Berliner sausages are generally made from beef, pork and pork fat comminuted with the addition of curing salts and are smoked and cooked. Thuringer, soft salami, mortadella, and soft cervelat are cooked and semi-dry; pepperoni, chorizos, dry salami and dry cervelat are slowly dried to a hard texture without cooking. Liver sausage contains 10-20% liver and in many cases other edible offals. Blood sausage contains 10-20% whole blood with nitrite salt (not precooked). Other components are precooked meat, edible offals, fatty tissue (cooked sufficiently to separate fat with a low melting point) and pigskin, this type of sausage has a firm consistency due to swollen connective tissue and gelatinized collagen.

Fermented sausages are dry sausages including salami, dry pork, beef sausages and summer sausages that have been subjected to bacterial fermentation. Meat from a variety of

animals may be used, including camel, donkey and horse but rarely mutton and goat. Only well-chilled or frozen meat is used and a temperature of -2 to +5°C maintained during chopping to facilitate comminuting of lean and fatty tissues to the particle size desired and to avoid deposition of fat drops. Added salt prevents the growth of unwanted micro-organisms and extracts salt-soluble proteins to form a protein gel which binds the pieces of meat together. The bacteria originate from the natural flora of the meat and the environment although starter cultures of *Micrococcus, Pediococcus cerevisiae*, etc., are sometimes used. During the slow, prolonged fermentation, the pH falls to from 4.8 to 5.4 then the product is dried and may be smoked. Fermented sausage is not cooked and preservation depends on the high acidity and high salt content together with the low water content (Mielnik, Aaby, Rolfsen, Ellekjær & Nilsson, 2002).

2.6.4 Meat Floss

This is a traditional processed meat product prepared from beef, mutton, chevon or chicken. The method of preparation involved cutting the raw meat (boneless) in to pieces approximately 4 cm by 2.5 cm dimension and washing with clean water, mixing with ingredients, boiling for about 90 minutes and pounding into shreds using a mortar and pestle. This is deep fried using ground nut oil in a stainless steel pot resulting in a produce, which is brown in colour (Farouk,1985), known as *Dambun-Nama*. *Danbun-Nama* is rich in iron and is a good source of protein. In many Hausa homes, *Danbun-Nama* is served as a snack.

Meat Floss also known as shredded meat, serunding meat or meat fibre is one of the traditional meat based product popular among Malaysians and the Asian community (Abubakar, Bube, Adegbola & Oyawoye, 2014). It is known by different names such as *Abon*in Indonesia, *moo yong* in Thailand, *mahu* in Philippines, rousing in China and *thitheokhotieu* in Vietnam. In Nigeria, it is known as *Dambun-Nama* (Ogunsola & Omojola, 2008). Due to its low moisture

content, meat floss can be kept without refrigeration and will not drastically change in room temperature storage (Ockerman & Li, 1999).

2.6.5 *Balangu*

This is a boneless meat of a sizeable cut roasted by placing it on a brown paper on a wire mesh. The pieces of meat were sliced into thin sheets not less than 1 cm in thickness. Groundnut oil, spices and salt were sprinkled during roasting. The meat was continuously turned over until it was well roasted as described by Abubakar, Bube, Adegbola and Oyawoye (2011).

2.6.6 *Kilishi*

This is a lean meat cut and sliced into pieces of about 0.2 - 0.4 cm thick and 15 cm long using a sharp sterile knife. The sliced meat is spread on a clean mat for 2 to 3 hours under the sun. The dried meat is immersed into a 7 litre bowl containing about 3 litres of slurry of spices made up of groundnut cake, onion, seasoning, ginger and other aromatic condiments. The seasoned meat is sun dried again for 4 to 6 hours and roasted on a wire mesh placed on a red hot charcoal for 5 to 10 minutes at a temperature of about 100^0C (Abubakar *et al.*, 2011). The product becomes ready for consumption after cooling.

2.6.7 *Tsire*

Tsire is a boneless lean meat stacked on sticks, coated with red pepper, ground ginger, ground nut paste, garlic, salt and vegetable oil and then roasted over wood using a fire from charcoal (Samuel, Ifeanyi, Frederick & Michael, 2015: Ngozi, Akwasiam & Iheanyi, 2017). It is a mass consumer fast food which is processed and sold along streets (Uzeh, Ohenhen & Adeniji, 2006). Lean meat is cut into pieces and sliced with a sharp knife, staked on a wooden stick and heavily dusted with a mixture of spices made up of groundnut cake, seasoning, salt, ginger and

other aromatic spices. The staked meat is roasted around a glowing charcoal fire as described by Abubakar, Bube, Adegbola and Oyawoye (2014).

2.7 MEAT SPOILAGE

Meat spoilage is the process where a meat becomes unsuitable to ingest by the consumer. The cause of such a process is due to many outside factors as a side-effect of the type of product, as well as how the product is packaged and stored (Garcha, 2018). Bacteria, various fungi, oxidation and enzymes are the major causes of spoilage and can create serious consequences for the consumers (Ngozi *et al.*, 2017).

Spoilage of meat occurs, if the meat is untreated, in a matter of hours, it becomes unappetizing, poisonous or infectious. The major cause of spoilage is by due to the presence of bacteria and fungi, which are borne by the animal itself, by the people handling the meat and by their implements. Meat can be kept edible for a much longer time though not indefinitely if proper hygiene is observed during production and processing, and if appropriate food safety, food preservation and food storage procedures are applied (Anderson, 1978). Signs of meat spoilage may include an appearance different from the meat in its fresh form, such as a change in color, a change in texture, an unpleasant odour, or an undesirable taste. The meat may become softer than normal. If mold occurs, it is often visible externally on the meat.

2.7.1 Factors Affecting Meat Spoilage

The Micro-organisms ability to grow in food is closely related to many factors, some of which are intrinsic, while others are extrinsic (Cenci-Goga, 2012). The main factors which affect the shelf life of meat products and favour some bacterial strain rather than others are packaging, storage temperature, the composition of the products and other factors such as antibacterial

substances or biopreservatives (Nychas, Skandamis & Tassau, 2008; Remenant, Jaffres, Dousset, Pillet & Zogorec, 2015).

Intrinsic factors

Composition and antimicrobial hurdles

Meat is rich in protein, lipid, minerals and vitamins, but poor in carbohydrates, this composition provides an opportunity for some species instead of others with different nutrient requirements. After microbial death, intracellular enzymes can catalyse some food nutrients to simpler forms which can be exploited by other species. The presence of growth factors and natural or chemical inhibitors (additives such as nitrites) further select specific strains (Ray & Bhunia, 2013). All food substances which do not occur naturally or are environmental contaminants are generally regarded as added. Among the first category of additives are antimicrobial agents added to prevent bacterial contamination of food, thus avoiding spoilage and poisoning process caused by pathogens or other toxins (Cenci-Goga, Bystricky, Nagy & Papova, 1996).

pH

Meat pH also affects the selection of bacteria; each species has an optimum and a range of pH for growth. During post-slaughter, muscle pH decreases to 5.4-5.8, as in stressed animals (dark, firm and dry meat) and in cooked meat products such as sliced ham (Aymrich, Garringa, Costa, Manfort & Hugas, 2002). The presence of high pH in meat determines a more rapid spoilage process due to a more rapid bacterial growth and consumption of nutrients (Ray & Bhunia, 2013).

Redox potential

Oxidation-reduction potential is the function of the pH, gaseous atmosphere and presence of reductants. It measures the potential differences in a system generated by coupled reactions, in which one substance is oxidized and a second substance is reduced simultaneously, in electric unit of milvolts (mv). The redox potential of a food is related to its chemical composition, processing treatments and storage. Raw meat has Eh (redox potential) of -200 mv, ground raw meat has an Eh of +225 mv and cooked meat arrange of +90 to -50 mv (Cenci-Goga, 2012).

Water activity

Water Activity (aw) is the measure of the amount of water in a food which is available for the growth of micro-organisms. It identifies the water available for carrying out enzymatic reactions, synthesizes cellular materials and takes part in other biochemical reactions. Raw meat has aw values of 0.98-0.99 and cooked meat has approximately 0.94; these values allow the growth of most micro-organisms (Aymerich *et al.*, 2002).

Dried products are usually considered shelf stable and are therefore often stored and distributed unrefrigerated. The characteristic of dried food which makes them shelf stable is their lower water activity. A water activity of 0.85 or below will prevent the growth and toxin production of pathogens including *Staphylococcus aureus* and *Clostridium botulinum*. *S. aureus* grows at a lower water activity than other pathogens and should therefore be considered the target pathogens for drying (Leonard, 2011).

Extrinsic factors

Packaging and gaseous atmosphere

Packaging condition and gaseous composition of the atmosphere surrounding the meat greatly influence the composition of spoilage flora (Borch, Kant-Muermans & Blixty, 1996;

Sechi, Lulietto, Mattei, Novell & Cenci-Goga, 2014; Rossaint, Klausmann & Kreyenschmidt, 2015). Aerobic storage condition promotes above all the growth of *Pseudomonas* (Rossaint *et al*., 2015). *Psuedomonas spp*., *Acinetobacter spp*. and *Moraxella spp*. are considered the major sources of meat deterioration in aerobically stored meat products at different temperatures from -1 to 25^0C. Members of the *P. fluorescens* group together with the Psychotrophic *P. fragi*, *P. ludensis* and *P. putida* are the most commonly isolates in aerobically packed spoiled meat (Ercoloni, Russo, Torrieri, Masi & Villani, 2006; Ercolini *et al.*, 2010).

Packaging of meat under vacuum or carbon dioxide modified atmosphere has resulted in extended shelf life compared to traditional packaging condition (Yost & Nattress, 2002a).The use of carbon dioxide and nitrogen extend the lag phase of aerobic micro-organisms and promote the growth of facultative and strict anaerobic species. This change in packaging condition determines a shift from aerobic bacteria such as *pseudomonas spp*. to facultative anaerobic spp such as *Brochotrix thermosphacta* (Nychas *et al*., 2008) and lactic acid bacteria (Maria, Lulietto, Elena & Cenci-Goga, 2015). Lactic acid bacteria are the predominant microflora of vacuum or carbon dioxide modified atmosphere packed products, representing dominant spoilage causing bacteria (Yost & Nattress, 2002b; Arvanitoyannis & Stratakes, 2012). In fact, the combination of micro-aerophiilic conditions and a reduced water action inhibits gram negative spoilage flora and favours the proliferation of lactic acid bacteria (Borch *et al*., 1996; Korkeala & Bjorkroth, 1997; Samelis, Kakari. & Rementzis, 2000; Audenaert *et al.*, 2010).

Storage temperature

Storage temperature affects the duration of lag phase, the maximum specific growth rate and the final cell number (Maria *et al.*, 2015). Lower refrigerated temperatures decreases bacterial growth and modifies the composition of microflora present in meat; psychotrophic bacteria could

grow and either gram positive such as lactic acid bacteria or gram negative such as *Pseudomonas spp*. (Maria *et al.,* 2015), at chill temperature. In modified atmosphere packaging and vacuum packed meat products the dominance of lactic acid bacteria is also maintained under refrigerated condition.

2.8 MEAT CONTAMINATION

Poultry and poultry meat are often found contaminated with potentially pathogenic microorganisms such as *Salmonella spp, Campylobacter spp, Staphylococcus aureus, Escherichia coli* and *Listeria spp*. In some occasions also *Yersinia enterocolitica*, *Aeromonas* and *Clostridium perfringens* have the potential to be important pathogens in poultry product. However, *Salmonella spp, Campylobacter spp* and to a lesser extent *Listeria spp* are considered to be the major food-borne pathogens in poultry industry (Simmons, Fletcher, Cason & Berrang, 2003). It is believed that, the source of bacterial contamination of poultry meat is essentially the intestines or gut content which may come in contact with carcasses already in the broiler house and during transport and slaughter, either directly or indirectly, through a vehicle such as transport and processing equipment. Highly levels of bacterial cross-contamination may occur especially during defeathering and water chilling with intestinal contamination apparently being the only source. However, these levels may also increase during evisceration of the carcasses, washing and processing due to contamination by personnel (Oostero, Notermans, Karman & Engels, 1983; Wempe, Genigeorgis, farver & Yusufu, 1989). Some pathogenic organisms are as follows:

2.8.1 Salmonella species

Salmonella is a genus of gram negative motile, aerobic, non-spore forming bacilli that are found in the intestinal tract of animals and human. The infection they cause is called Salmonellosis. Infection in human occurs when products from animals such as chicken, swine (reservoir lost) is cooked improperly and are left at room temperature. The symptoms of this infection usually begin from 8-48 hours with sudden onset of nausea, vomiting, abdominal pain and diarrhea often accompanied by fever and chills (Corry & Atabay, 2001). Most *Salmonella spp* found on poultry meat are non-host specific and are considered capable of causing human food poisoning. Salmonellosis (gastro enteritis) is the most common disease in human. Incubation period is generally 6 to 72 hours (Behravesh, 2008) and can be longer than 10 days symptoms include nausea, vomiting, diarrhea, abdominal cramps and fever (Pickering, 2006).

2.8.2 Escherichia coli

The envelope of *E. coli* contains three layers: the cytoplasmic membrane, the peptidoglycan or murein layer, and the outer membrane. The peptidoglycan layer resides between the cytoplasmic membrane and the outer membrane. There it is embedded in a hydrated, largely proteinaceous substance, the periplasm (Begg, 2018). All the layers participate in shaping *E. coli*. However, early experiments showed that upon isolation, the covalently linked peptidoglycan layer retains the shape of the cell (Rothfield, 2018).

The shape of *Escherichia coli* is strikingly simple compared to those of higher eukaryotes. *E. coli* morphogenesis is a cylindrical tube with hemispherical caps. Verocytotoxin-producing strains of E. coli (VTEC), cause diarrhea and haemorrhagic colitis in humans and can lead to potentially life-threatening such as haemolyticuraemic syndrome and thrombotic thrombo-cytopaenicpurpura. Although VTEC strains occur in a wide range of O sero groups, the

most important in human disease is 0157, which accounts for almost all major food borne outbreaks. The first case involving this organism occurred in 1982 in livestock and various foods of animals' origin (Kessel *et al.*, 2001).

2.8.3 Campylobacter jejuni

Campylobacter jejuni is one of the most common causes of human bacterial diarrheal diseases worldwide (Black, Levine, Clements, Hughes & Blaser, 2018). It is a Gram-negative microaerophilic organism requiring rich media for growth *in vitro*. Despite its metabolic limitations, it can successfully compete with the human intestinal microflora with ingestion of as few as 500 bacteria resulting in human disease (Cooper, Cooper, Zuccolo & Joens, 2018). *Campylobacter jejuni* is caused by contaminated raw foods. It is the most prevalent pathogen of poultry and in most cases can result in arthritis, septicemia, meningitis, inflammation of the heart and other organs and in severe cases Guillain-barre syndrome paralysis (Ray, 2001).

2.8.4 Staphylococcus aureus

Staphylococcus aureus is a major bacterial human pathogen that causes a wide variety of clinical manifestations. Infections are common both in community-acquired as well as hospital-acquired settings and treatment remains challenging to manage due to the emergence of multi-drug resistant strains such as Methicillin-Resistant *Staphylococcus aureus* (MRSA). *S. aureus* is found in the environment and is also found in normal human flora, located on the skin and mucous membranes (most often the nasal area) of most healthy individuals (Totura, Sherwood, Willey & Woolverton, 2004). *S. aureus* does not normally cause infection on healthy skin; however, if it is allowed to enter the bloodstream or internal tissues, these bacteria may cause a variety of potentially serious infections. Transmission is typically from direct contact. However,

some infections involve other transmission methods (Tong, Davis, Eichenberger, Holland & Fowler, 2015).

Staphylococcus aureus is Gram-positive bacteria (stain purple by Gram stain) that are cocci-shaped and tend to be arranged in clusters that are described as "grape-like." On media, these organisms can grow in up to 10% salt, and colonies are often golden or yellow (aureus means golden or yellow). These organisms can grow aerobically or anaerobically (facultative) and at temperatures between 18 to 40 ^{0}C (CDCP, 2018). Typical biochemical identification tests include catalase positive (all pathogenic *Staphylococcus* species), coagulase positive (to distinguish *Staphylococcus aureus* from other *Staphylococcus* species), novobiocin sensitive (to distinguish from *Staphylococcus saprophyticus*), and mannitol fermentation positive (to distinguish from *Staphylococcus epidermidis*).

Staphylococcus aureus (including drug-resistant strains such as MRSA) are found on the skin and mucous membranes, and humans are the major reservoir for these organisms (DeLeo, Diep & Otto, 2017). *S. aureus* are one the most common bacterial infections in humans and are the causative agents of multiple human infections (Anderson, Nester, Robert, Pearsal & Nester, 1998), including bacteremia, infective endocarditis, skin and soft tissue infections (e.g., impetigo, folliculitis, furuncles, carbuncles, cellulitis, scalded skin syndrome, and others), osteomyelitis, septic arthritis, prosthetic device infections, pulmonary infections (e.g., pneumonia and empyema), gastroenteritis, meningitis, toxic shock syndrome, and urinary tract infections. Depending on the strains involved and the site of infection, these bacteria can cause invasive infections and/or toxin-mediated diseases. The pathophysiology varies greatly depending on the type of *S. aureus* infection (Le & Otto, 2017).

2.9 MEAT PACKAGING MATERIALS

Marketers and consumers alike prefer good quality throughout the entire shelf life of any food product (Koch *et al.*, 2009), thus meat packaging constitutes an important aspect of food processing industry and many meat packaging systems are available with different attributes and applications (Han, 2005). These include:

2.9.1 Aluminium Foil

Aluminium foil often referred to as misnomer tin, it is prepared in thin metals leaves with a thickness of less than 0.2mm (Berger & Kenneth, 2002). Standard household foil is typically 0.016mm (0.94 mils). The foil is pliable and can be readily bent or wrapped around objects. Thin foils are fragile and are sometimes laminated to other materials such as plastics or paper to make them useful (Mary, 2012). Foil is 98.5% aluminum with the balance primarily from iron and silicon to give strength and puncture resistance. The molten alloy is rolled thin and solidified between large, water-cooled chill rollers. During the final rolling, two layers of foil are passed through the mill at the same time (Ogbonna, Sunday, Oyekemi & Odu, 2012). The foil is fragile and is sometimes laminated to food and non food products as packaging materials.

2.9.2 Polyethylene (PE)

Polyethylene is a thermoplastic polymer with variable crystalline structure and an extremely large range of applications depending on the particular type. It is one of the most widely produced plastics in the world (tens of millions of tons are produced worldwide each year). The commercial process (the Ziegler-Natta catalyst) that made PE such a success was developed in the 1950s by German and Italian scientists Karl Zeigler and Giulio Natta (Hurmes *et al.*, 2002). There are vast array of applications for polyethylene in which certain types are more or less well suited. Generally speaking, High Density Polyethylene (HDPE) is much more

crystalline, has a much higher density, and is often used in completely different circumstances than low density polyethylene (Hadad, Geresh & Sivan, 2005).

Low density polyethylene (LDPE)

Low density polyethylene is a softer and flexible material with unique flow properties that makes it particularly suitable to plastic film applications like shopping bags. LDPE has high ductility but low tensile strength which is evident in the real world by its propensity to stretch strained (Baechler, Devouno & Pearce, 2013). It has both high short chain branching and long chain branching content with good resistance to chemicals, vapour barrier and stress crack. LDPE has low density (0.910 g/cm^3) with material co-efficient of expansion and melting point of 20X10^5 K-I and 110 ^{0}C, respectively. LDPE has opaque, milky white colour. It is tough with more branching than HDPE. The intermolecular forces are weaker with higher resilience (Soroka, 2009).

Linear low density polyethylene (LLDPE)

Linear low density polyethylene is very similar to LDPE with the added advantage that the properties of LLDPE can be altered by adjusting the formula constituents and that the overall production process for LLDPE is typically less energy intensive than LDPE (Kreiger, Anzalone, Mulder, Glover & Pearce, 2013).

High density polyethylene (HDPE)

High density polyethylene (HDPE) is a strong, high density, moderately stiff plastic with a highly crystalline structure. It is frequently used as a plastic for milk cartons, laundry detergent, garbage bins, and cutting boards (Kreiger, Mulder, Glover & Pearce, 2014). HDPE has a large strength to density ration (0.941 to 0.959 g/cm^3) with material co-efficient of expansion and melting point of 20X10^5 K-I and 130 ^{0}C, respectively. HDPE has opaque, milky white colour, it

is flexible and has translucent material, with higher tensile strength (Kreiger *et al.*, 2014). It has excellent chemical resistant properties making it suitable for a wide range of foods and other products. HDPE has a linear polymer chain with a short chain branching which are packed close together resulting in greater intermolecular forces and a more crystalline structure.

Polyethylene terephthalate

This is abbreviated as PET or PETE. It is a clear, strong, and lightweight plastic that is widely used for packaging foods and beverages, especially convenience-sized soft drinks, juices, water, personal care products and many other consumer products. It is readily available, relatively inexpensive, has high strength to weight ratio, very resistant to moisture, has excellent chemical resistance to organic materials and water, virtually shatterproof, easily recycled and is highly transparent. PET has good gas barrier properties and good chemical resistance its crystallinity varies from amorphous to fairly high crystalline. It is the most common thermoplastic polymer resin of the polyester family (Baechler *et al.*, 2013).

2.9.3 Polyvinyl Chloride (PVC)

This is a synthetic resin made from the polymerization of vinyl chloride, second only to polyethylene among the plastics in production and consumption. PVC is used in an enormous range of domestic and industrial products, from rain coats and shower curtains to window frames and indoor plumbing. A lightweight rigid plastic in its pure form, it is also manufactured in a flexible plasticized form.. It is made softer and more flexible by the addition of plasticizers. If no plasticizers are added, it is known as uPVC (unplasticized polyvinyl chloride) or rigid PVC (Berger & Kenneth, 2002).

2.9.4 Brown Paper

This is a type of paper made from unbleached wood pulp, use especially to make paper bags and envelops or as wrapping parcels. Wood pulp for sack paper is made from softwood by the kraft process. The long fibers provide the paper its strength and wet strength chemicals are added to even further improve the strength. Both white and brown grades are made (Paulapuro & Hannu, 2000). Kraft paper or kraft is a paper or paper board (cardboard) produced from chemical. Sack kraft paper is porous with high elasticity and high tear resistance, designed for packaging products with high demands for strength and durability (Hurmes *et al.*, 2002).

2.9.5 Plastic Wrap

This is a thin plastic film typically used for sealing food items in containers to keep them fresh over a longer period of time. Plastic wrap, typically sold on rolls and boxes with a cutting edge, clings can thus remain tight without adhesive or other devices (Apata, Eniolorunda, Ahmad & Okubanjo, 2014).

2.9.6 Over Wrap

An overwrap or wrap is applied over another form of packaging. It is often made of plastic film, sometime called poly wrapping. The features of over wrap include combining two or more smaller wrappers, keeping a package or item clean, help to prevent premature opening of the package, help to provide a tamper indicating seal and help to keep insects out of a package (Dallyn & Shorten, 1998).

2.9.7 Parchment Paper

Parchment paper is grease and moisture resistant paper specially designed for oven use. It is very versatile, it is used in cake molds and baking sheets, to wrap fish and other dishes that are cooked en papillote, and to cover countertops during messy tasks to make cleanup easy.

Parchment paper can be purchased in rolls, sheets, or a precut round to fit cake pans; Parchment paper is treated with silicone, so it is nonstick; it is also heatproof and grease-resistant. It's available as bleached (white) or unbleached (brown). It protects pans, aids cleanup, and prevents food from sticking. It also makes a handy funnel for transferring dry ingredients. It is used to bake fish or chicken in it for a low-fat cooking method. Rolls of parchment paper are available in the baking section of most supermarkets. Precut sheets and rounds can be found in baking-supply stores (Kreiger *et al.,* 2014).

2.9.8 Wax Paper

Wax paper has a thin coating of wax on each side, making it nonstick and moisture-resistant; it is a good, less-expensive substitute for parchment paper for tasks such as covering countertops, and is available at any supermarket. Unlike parchment paper, however, it is not heat-resistant and therefore should not be used in the oven, as the wax could melt, or even ignite. Wax paper (also called paraffin paper) is a paper that has been made moisture-proof through the application of wax. It is also commonly used to attach pattern pieces to fabric while cutting it for sewing. One can press an iron over the wax paper briefly and attaches it to the cloth, making it easier to trace while cutting (Ogbonna *et al.*, 2012).

2.10 CONSUMER PREFERENCE OF MEAT

Meat and meat products currently represent an important source of protein in the human diet and their quality varies according to intrinsic and extrinsic parameters that can sometimes be shaped to make a product more desirable. Because consumers are the final step in the production chain, it is useful to identify which factors affect their behavioral patterns. This would allow the meat sector to better satisfy consumer expectations, demands and needs (Omojola *et al.*, 2004). Consumer preference explains how a consumer ranks a collection of goods or services or prefers

one collection over another. This definition assumes that consumers rank goods or services by the amount of satisfaction or utility afforded (Omojola, Isah, Adewumi, Ogunsola & Attah, 2003). Preferential consumption exists in spite of the importance of meat as a source of protein with high biological value. Burton and Young (1992) and Koppert and Hladik (1990) reported that factors that affect the consumption of meat can be classified as economic, social and cultural while Ojewola and Onwuka (2001) specifically highlighted religion, age, sex, socio–economic factors, individual variation and income as major factors in Nigeria. Reasons for preferences have been found to include nutritional value, taste, freshness or tenderness, availability, affordability, ease to preparation or cooking, fat content and several others. The household income and price of meat greatly affect the quantity and types of meat consumed.

2.11 SENSORY EVALUATION OF MEAT

Sensory evaluation of meat is a scientific discipline that analyses and measures human responses to the composition of food and drink, e.g; Appearance, touch, odour, texture, tenderness and taste (Wattanachant, Benjakul & Ledward, 2004). It is a common and very useful tool in quality assessment of processed meat products. It makes use of the senses to evaluate the general acceptability and quality attributes of the products (Robert & Nwaiwu, 2012). The testing involves tenderness, flavour, colour, juiciness and palatability (Ogunsola & Omojola, 2007).

2.11.1 Tenderness

Tenderness is a relative term which refers to toughness or easy to chew meat. Tenderness is an important characteristic that determine meat acceptability or rejection. Meat that is tough is unacceptable. Tenderness of meat may be influence by various factors such as age of the animal, part of the animals cut, nature of cooking etc. One important way to tenderize meat is by aging.

Meat is age by holding it at refrigeration temperature for 2-4 weeks which allows enzymes within the meat to break down the muscle and connective tissue which make meat more tender (Joseph *et al.,* 1995).

2.11.2 Flavour

Flavour and aroma create the sensation the consumer has during eating (Apata *et al.,* 2008). Flavour is a distinct taste of quality characteristics (Shahidi, 1989). Salt is probably the most important flavour enhancer. It brings out the natural flavour (Larson, Holm, Marchelle & Slander, 1992). Consumption of meat and meat products can be ensured through a tasty, nutrition and safety meat supply to the consumer. Appearance, taste, aroma and texture of meat can generally persuade a consumer decision to purchase meat. Flavour relies on the smell through nose and on the sensations of salt, sweet, sour and bitter on the tongue (Shahidi, 1989).

2.11.3 Colour

Colour refers to sensation produced in the eye which is the physical appearance of meat. It has been used by consumers to assess the quality attribute of meat. Meat colour has greater influence on consumer acceptance; it serves as a visual criterion for justifying quality of meat (Joseph *et al.,* 1995). The bright red colour of good quality beef, sockeye salmon and young lamb are naturally appealing, whereas the paler colours of veal and other fish species are less appealing to many although more sought after by some ethnic groups (Meilgaard, Civille & Carr, 1991).

2.11.4 Juiciness

Juiciness in cooked meat has two organoleptic components. The first is the impression of wetness during the first few chews and is produced by the rapid release of meat fluid; the second is one of sustained juiciness, largely due to the stimulatory effect of fat on salivation. This

function of the latter explains why, for example, the meat of young animals gives an initial impression of juiciness but, due to the relative absence of fat, ultimately a dry sensation. Good quality meat is juicier than that of poor quality, the difference being at least partly attributable to the higher content of intramuscular fat in the former (Malik, Jiya, Ayanwale & Kasimi, 2018).

Consumers consider tenderness and juiciness to be the most important quality attributes of fresh meat and meat products. Sensory analyses measure the two components of juiciness, the initial impression of fluid, primarily moisture, exuded on the meat surface and sustained juiciness upon chewing, which is dependent upon both water and fat (Melgaard, Carr & Civelli, 2006). Meat juiciness is an important contributor to eating quality and also plays a key role in meat texture contributing between 10% and 40% to its variability. Unlike other key aspects of texture, juiciness remains a uniquely subjective property. The relationship between 'subjective' juiciness of meat and any objective measurement remains elusive and poorly understood. The degree of shrinkage on cooking is directly correlated with loss of juiciness to the palate (Eke, Ariahu & Okonkwo, 2012).

2.11.5 Palatability

Palatability is defined as the pleasing or satisfying aspect of a food. It may also refer to as free chance of consumption of food. Hence palatability factors are critical in consumer acceptance of meat product and can be positive or negative depending on processing method (Omojola *et al.*, 2004). Palatability include how tough (tenderness), how much liquid (juiciness) and how texture and tasty a food can be (Larson *et al.*, 1992).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 DESCRIPTION OF THE STUDY AREA

The experimental research was conducted at the Poultry Demonstration Farm of the Department of Animal Health and Production, Binyaminu Usman Polytechnic, Hadejia, Jigawa State. Hadejia is one of the oldest Local Government Area created since 1975 from the then Kano State (now Jigawa State) of Northern Nigeria with a projected population of 139, 490 (NPC, 2016). Hadejia emirate comprises of Hadejia, Mallam-Modori, Kafin-Hausa, Birniwa, Guri, KiriKasamma, kaugama and Auyo Local Government Areas. The area is located in the sudan savannah zone of Nigeria.

Hadejia town is the capital of Hadejia Emirate and is located at the central part of the emirate which lies between 10^0 02'28· 14" E Longitude and 12^0 27'12.49" N Latitude. The town is served by Federal trunk linking it to Nguru in the east, Kano in the northwest, Katagum in the south and Dutse (capital of the state) in the southwest. The old town has been extended beyond the traditional walls.

Hadejia Local Government Area possesses palatable grasses (*Andropogan gayanus*, *Cyanodon dactylum* and *Pennisetum pedicelatum*) and legumes (*Centrosema pubescens* and *Stylosanthes hamata*) with crops residues such as sorghum stover, millet stalks, rice straws, cowpea haulms, ground nut hay and agro-byproducts which include wheat offal, cotton seed cake, ground nut cake and cereal bran. Major livestock slaughtered include cattle, sheep, goat and camel. Table 3 presented the monthly break down of livestock slaughtered at Hadejia Abattoir. Information from PPA (2019) showed that on daily basis, average of 400 chickens (improved and indigenous), 70 guinea fowls. 40 pigeons, 10 ducks and 1 turkey are slaughtered.

Table 3: Break Down of Livestock Slaughtered at Hadejia Abattoir

Month	Livestock			
	Cattle	Sheep	Goat	Camel
January	220	120	382	191
February	261	131	566	161
March	118	110	486	184

Source: Meat Inspector, Hadejia Abattoir: 2019

The study area has an annual rainfall ranging from 700-800mm accompanied by strong wind. The temperature of the area ranged from 31 to 40^0C. Olofin (1987) stated that the combination of rain fall and temperature is controlled by the movement of the Inter Tropical Discontinuity (ITD) which results in four seasons in the year, viz: Dry and Cool Season from December to January (*Bazara*), Dry and Hot Season from March to May (*Rani*), Wet and Warm Season from June to November (*Damina*) and a season of decreasing rain fall and fallen temperature from October to November (*Kaka*).

3.2 EXPERIMENTAL DIETS

Three experimental diets containing different energy levels of 2 400, 2 600 and 2 800 Kcal/Kg designated as A, B and C, respectively were formulated and fed to the broiler chickens. The crude protein of the Starter and Finisher diets were fixed at 24 and 20%, respectively. The ingredients and nutrient composition of the experimental starter and finisher diets were presented in Tables 4 and 5, respectively.

Table 4: Ingredient and Nutrient Composition of Experimental Starter Diet

Ingredient	Dietary Energy Levels (Kcal/Kg)		
	A	B	C
Maize	22.00	33.00	44.00
Soybean Meal	24.00	26.00	29.00
Ground nut cake	15.00	16.00	16.00
Wheat Offal	33.00	19.00	5.00
Bone Meal	3.00	3.00	3.00
Limestone	2.00	2.00	2.00
Common Salt	0.30	0.30	0.30
*Premix	0.25	0.25	0.25
Methionine	0.25	0.25	0.25
Lysine	0.20	0.20	0.20
Total	**100.00**	**100.00**	**100.00**
Composition Calculated			
ME(Kcal/kg)	2417	2613	2810
Crude Protein (%)	24.00	24.00	24.10
Lysine (%)	1.40	1.40	1.40
Methionine (%)	0.60	0.60	0.60
Calcium (%)	1.60	1.60	1.60
Phosphorus (%)	0.70	0.70	0.70
Crude Fibre (%)	5.60	4.80	4.00
Ether Extract (%)	3.80	3.90	3.90
Proximate (%)			
Moisture	5.59	4.55	4.04
Ash	11.94	10.45	12.67
Crude Fat	3.77	3.94	3.83
Crude Protein	24.97	25.66	24.60
Crude Fibre	5.93	5.68	5.01
Carbohydrate	47.81	49.73	49.81

*Starter Premix provided per kg diet: Vitamin A 10,000mg, Vitamin D3, 20,000mg, Vitamin E 23,000mg, Vitamin K3 2,000mg, Vitamin B1 1,800mg, Vitamin B2 5,500mg, Niacin 27,500mg Pantothenic acid 7,500mg, Vitamin B6 3000mg, Vitamin B12 1500mg, Folic acid 750mg, Biotin H2 600mg, choline Chloride 500,000mg, Cobalt 200,000mg, Copper 3,000mg, Iodine 1000mg, Iron 20,000mg, Manganese 40,000mg, Selenium 200mg, Zinc 30,000mg, Antioxidant 1,250mg
.

Table 5: Ingredient and Nutrient Composition of Experimental Finisher Diet

Ingredient	Dietary Energy Levels (Kcal/Kg)		
	A	B	C
Maize	33.00	40.00	50.50
Soybean Meal	18.00	17.00	20.00
Groundnut Cake	7.00	10.00	11.80
Wheat Offal	39.00	27.00	11.70
Bone Meal	3.00	3.00	3.00
Limestone	2.00	2.00	2.00
Common Salt	0.30	0.30	0.30
*Premix	0.25	0.25	0.25
Methionine	0.25	0.25	0.25
Lysine	0.20	0.20	0.20
Total	**100.00**	**100.00**	**100.00**
Composition Calculated			
ME(Kcal/kg)	2430	2602	2816
Crude Protein (%)	19.80	19.70	20.20
Lysine (%)	1.20	1.10	1.20
Methionine (%)	0.50	0.50	0.50
Calcium (%)	1.60	1.60	1.60
Phosphorus (%)	0.70	0.60	0.60
Crude Fibre (%)	5.40	4.70	3.90
Ether Extract (%)	3.60	3.70	3.70
Proximate (%)			
Moisture	5.58	5.27	4.35
Ash	11.06	10.38	11.92
Crude Fat	4.05	4.30	4.55
Crude Protein	22.87	22.09	20.46
Crude Fibre	5.82	5.63	5.38
Carbohydrate	50.62	52.32	53.34

*Finisher Premix provided per Kg diet: Vitamin A 8,500iu, Vitamin D3 1,500iu, Vitamin E 10,000mg, Vitamin K3 1,500mg, Vitamin B1 1,600mg, Vitamin B2 4,000mg, Niocin 20,000mg, Pantothenic Acid 5000mg, Vitamin B6 1,500mg, Vitamin B12 1000mg, Folic Acid 500mg, Biotin H2 750mg, Choline Cloride 175,000mg, Cobalt 200mg, Copper 3000mg, Iodine 1000mg, Iron 20,000mg, Manganese 40,000mg, Selenium 200mg, Zinc 30,000mg, Antioxidant 1,250mg.

3.3 EXPERIMENTAL ANIMALS AND THEIR MANAGEMENT

A total of two hundred and seventy (270) day old broiler chicks of Cobb 500 strain were purchased from a reputable distributor. The chicks on arrival were weighed and randomly allotted to the treatments containing ninety birds per treatment; each treatment had three replications of thirty birds. The birds were managed under deep litter system with wood shavings as litter materials. The chickens were vaccinated against Newcastle Disease and Gumboro. The pen was cleaned and disinfected using recommended disinfectant (7% Tar Acid Phenol and 2% Cresylic Creosote) to avoid microbial contamination. Routine management was carried out as described by Oluyemi and Roberts (2000). Experimental feed and fresh clean water were provided *ad-libitum*. The feeding trial lasted from February to April, 2016.

At the end of the production, 27 birds (three birds per replication) were slaughtered for the preparation of meat floss. Four packaging materials were used; i.e High Density Polyethylene, Low Density Polyethylene, Polyvinyl chloride and Aluminium Foil to package the meat floss for ten weeks (April to June, 2016).

3.4 DATA COLLECTION

The birds' initial weights were determined and the following parameters were also calculated:

3.4.1 Daily Feed Intake (DFI)

A known quantity of feed offered in the morning and the left over measured the next morning, the differences were determined to compute daily feed intake.

$$\text{DFI} = \frac{\text{Quantity of Feed Supplied (g)} - \text{Quantity of feed left over (g)}}{\text{Number of Birds}}$$

3.4.2 Body Weight Gain (BWG)

The actual body weight was subtracted from the weight of the previous week.

BWG = actual body weight (g) – Previous weight (week)

3.4.3 Feed Conversion Ratio (FCR)

This is defined as the quantity of feed consumed to affect a unit weight gain

FCR = Feed Intake ÷ Body Weight Gain

3.4.4 Blood Collection and Analyses

At 8th week of the trial, three birds per replication were randomly selected, 6 ml of blood was collected from each bird via the wing vein using sterilized syringes and needles; 2 ml was transferred into an Ethelyne Diamine Tetra Acetic Acid (EDTA) container which was immediately transported to the laboratory. The blood was analysed for haematological parameters using Automated Haematology Analyser (SYSMEX XP300). Parameters examined included white blood cell (WBC), red blood cell (RBC), haemoglobin (HgB), packed cell volume (PCV), mean cell volume (MCV), mean cell haemoglobin (MCH), mean cell haemoglobin concentration (MCHC) and platelet (PLT). The remaining 4 ml of blood was transferred into Lithium Heparin containers. The blood samples were arranged in sample trays at right angle and allowed to sediment for 2 hours. Automated pipettes and tips were used to collect the already separated sera and transferred into a micro-tube for chemical analysis using Automated Chemistry Analyser (Selectra Junior Pro-S). Parameters determined included urea, creatinine, albumin, globulin and total protein.

3.4.5 Carcass Characteristics

At the end of the 8th week of the feeding trial, 3 birds were randomly selected from each of the replicate for carcass and organ analyses. The birds for carcass analyses were starved overnight and slaughtered at 06:00 hours. The birds were then dressed and dressing percentages were calculated.

$$\text{Dressing Percentage} = \frac{\text{Carcass Weight}}{\text{Live-weight}} \times 100$$

The primal joints (head, shank, thigh, wings, neck, breast and drumstick) were weighed and expressed as percentage of live weight. The visceral organs (crop, gizzard, liver, spleen, abdominal part, caeca, heart, intestine and kidney) of each bird were similarly determined. The carcass analyses were conducted at the Anatomy Laboratory, Department of Animal Health and Production, School of Agriculture, Binyaminu Usman Ploytechnic, Hadejia, Jigawa State.

3.4.6 Nutrient Digestibility

Three (3) birds per treatment (one bird per replication) were randomly picked and housed in individual cages; the birds were acclimatized for two (2) days, after which faecal collection was conducted for four (4) days. Known quantity of each diet (A, B and C) were weighed and fed to the birds *ad libitum*. Faeces voided were collected by placing a clean polythene sheet on the floor of the cages. The faeces were cleaned of wasted feed, feathers and other foreign materials to avoid contamination. The faeces collected from each treatment were labeled accordingly and oven dried at 70^0C for 24 hours. The dried faecal samples were allowed to equilibrate with atmosphere and then weighed. Samples were analysed for proximate composition at the Department of Animal Science Laboratory, Bayero University Kano. The percentage digestibility was calculated using the formula:

$$\text{Nutrient Digestibility (\%)} = \frac{\text{Nutrient in Diet} - \text{Nutrients in faeces}}{\text{Nutrient in Diet}} \times 100$$

3.5 PREPARATION OF SPICE MIXTURES FOR MEAT FLOSS PRODUCTION

Two spice mixtures were formulated as shown in Tables 6 and 7. The ingredients used for the formulations were purchased from a local spice market within the study area. Each spice was dried and ground separately using a table top grinder (Model BLSTMG. PN133093-002) and the coarse particles removed using a sieve of 1.0 mm mesh diameter. The cooking and

shredding recipes were separately stored in airtight polyvinyl chloride containers for subsequent use.

Table 6: Composition of Spice Mixture used for Broiler Chicken Meat Floss Production (g/100g)

Ingredient	Quantity
Common Salt (Sodium Chloride)	10.00
Thyme (Thymus vulgaris L.)	12.50
Curry Powder®	12.50
Onions (Allium cepa L. var. cepa)	50.00
Stalk Cube	15.00
Total	**100.00**

Source: Omojola *et al*., 2014
® Trade name

Table 7: Composition of Shredding Recipe before Frying used for Broiler Chicken Meat Floss Production (g/100g)

Ingredients	Quantity
Pepper (*Piper nigrum* L.)	35.00
African Nut Meg (*Monodora myristica* (Gaertn.) Dunal)	2.50
Ginger (*Zingiber officinale* Rosc.)	4.00
Garlic (*Allium sativum* L.)	3.00
Cloves (*Syzygium aromaticum* (L.) Merr. et L.M. Perry)	2.50
Curry Powder®	3.50
Thyme Leaves (*Thymus vulgaris* L.)	2.50
Common Salt (Sodium Chloride)	5.00
Onions (Allium cepa L. var. cepa)	12.00
Stalk Cube	30.00
Total	**100.00**

Source: Omojola *et al.*, 2014
® Trade name

3.6 COOKING OF MEAT

After slaughtering and dressing of the birds, the bones and the muscles were separated; lean meat was cut into pieces of approximately 4 cm by 2.5 cm dimension, washed with clean

water and mixed with spices. Each meat type was cooked on an adjustable Pifco Japan Electric Hot Plate (Model Number ECP 2002). The cooking recipe was added in the ratio of 1 g of spice to 100 g of meat. Four (4) medium-sized (500 g) onions (approximately 50 g of onions on Dry Matter basis) were thinly sliced and added. Water was added at the ratio of 1.5 liters to 1.0 kg of meat. The meat samples were cooked to an internal temperature of 72 ºC and the broth was allowed to dry with the meat. The meat samples were removed and allowed to equilibrate to room temperature and weighed.

3.7 MEAT SHREDDING

The cooked meat samples were pounded into shreds using a mortar and pestle. The shredding recipe was added in the ratio of 1:20 (50 g of spice to 1000 g of meat), while 120 g onion on dry matter basis was added to every 100 g of spice used. These were weighed and added a little at a time as pounding progressed for uniform mixing of the recipe.

3.8 FRYING OF MEAT TO FLOSS

The shredded meat from each meat type was separately shallow fried using stainless steel pot in Soy bean oil (Grand®) which was pre-heated to 70 ºC. The ratio of oil to meat was 1 liter to 500 g of meat. The meat samples were fried at 70 strokes per minute (Farouk, 1995) until a golden brown colour was obtained (20 minutes). Figure 1 demonstrates chicken meat floss production.

3.9 DRAINING OF OIL

The products were poured into a colander after frying and pressure applied to remove excess oil and prevent the final product from sticking. The dry spongy product from each meat type was poured into separately marked flat containers, allowed to cool and separated into strands.

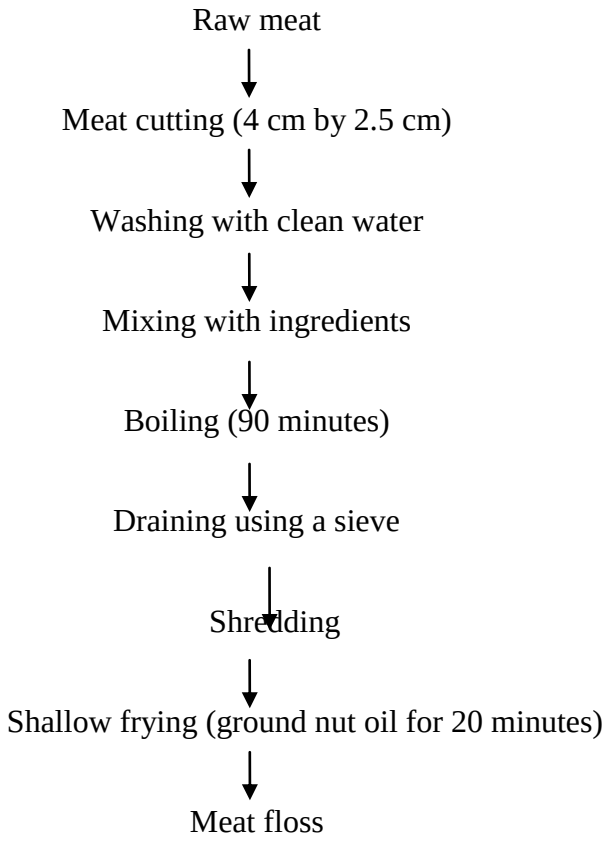

Figure 1: Procedure for broiler chicken meat floss preparation: Farouk (1985)

3.10 CHEMICAL ANALYSIS OF RAW AND BROILER CHICKEN MEAT FLOSS

The meat floss samples produced from broiler chickens fed different energy levels were assessed for chemical constituents (moisture, crude protein, ash and ether extract) according to the procedure of AOAC (2007). Moisture content was determined gravimetrically (Corthinas *et al.*, 2004; Oluwatosin, Olawoyin, Agiang, De Neji, & Iso, 2007) by drying 6 g of meat at 105°C accordingly. Crude protein was determined by Kjeldahl method according to the NF V 04-407

norm and using a Kjeltec Auto Sampler System 1035 Analyzer (Foss, Benelux), each analysis was repeated twice. The total ash content was determined according to the NF V 04-404 French standard method, about 6 g of samples were ashed in an oven maintained at 550°C to determine ash content and was repeated twice. The fat content was determined by Soxhlet method according to the NF V 04-402 standard ISO 1443: 1973, each analysis was repeated twice using petroleum ether at 40-60 °C.

3.11 MINERAL ANALYSIS OF BROILER CHICKEN MEAT FLOSS

One (1g) gram from both raw and broiler chicken meat floss samples were collected in triplicate from the three different treatments and inoculated in vacuum polyvinyl chlorides which were immediately transported to the Soil Science laboratory of Bayero University, Kano for minerals analyses. After wet digestion, the minerals determined were Calcium (Ca), Magnesium (Mg), Copper, (Cu), Iron (Fe) and Zinc (Zn) using Atomic Absorption Spectrophotometer (Buck Scientific Model 210 VGP), and Sodium (Na) and Potassium (K) using Flame Photometer.

3.12 PACKAGING OF BROILER CHICKEN MEAT FLOSS

Four (4) different packaging materials: Low Density Polyethylene (LDPE), High Density Polyethylene (HDPE), Aluminium Foil (AF) and Polyvinyl Chloride (PVC) were used to store broiler chicken meat floss at 30 ^{o}C±10 ^{o}C (Eke *et al.,* 2012) for ten weeks. The effect of packaging materials on sensory parameters and microbial load of broiler chicken meat floss were determined fortnightly as described by Ogunsola and Omojola (2007).

3.13 MICROBIAL ANALYSIS OF BROILER CHICKEN MEAT FLOSS

3.13.1 Meat Sample Preparation

Samples of meat floss produced from broiler chicken chickens fed diets containing 2 400, 2 6000 and 2 800 Kcal/Kg were stored at room temperature in HDPE, LDPE, AF and PVC for

ten weeks. One gram (1.0 g) of each meat floss sample was weighed and aseptically taken into a sterile jar containing 9 mL sterile peptone water, which was homogenized with sterile blender (Retsch, GM 200, Australia) at 3, 000 rpm for 10 minutes. A 1 mL aliquot of homogenate was transferred to a test tube containing 9 mL sterile distilled water to make 10^{-2} dilution and centrifuged with vortex mixer (Digosystem, VM-1000, Taiwan) at 2, 000 rpm for 5 minutes. Serial dilutions up to 10^{-5} were prepared for the microbiological analysis. Test tubes were labeled with respect to their dilution.

3.13.2 Culturing of Meat Floss Samples

The microbial quality and safety of meat floss were assessed on the basis of Total Viable Count (TVC), Total *Staphylococcus aureus* Count (TSAC), Total *Escherichia coli* Count (TECC) and Total Fungal Count (TFC) using Nutrient Agar, Mannitol Salt Agar, Mac Conkey Agar and Potato Dextrose Agar, respectively. All culture media were prepared in accordance with the manufacturer's specification. Aliquots (0.1 mL) of each dilution were transferred in replicate into corresponding differential and selective media (in duplicates), and were spread uniformly using a hockey stick. Diluted meat floss samples were spread on to those plates and incubated at 37 ^{0}C for 24 hours except detection of fungi, which were incubated at 25 ^{0}C for 5 days. Discrete colonies were sub-cultured into fresh agar plates aseptically to obtain pure cultures of the isolates. Pure isolates of resulting growth were then stored for further identification.

3.13.3 Enumeration and Isolation

From the 10-fold dilutions of the homogenates; 0.1ml of 10^{-2}, 10^{-3} and 10^{-4} dilutions of the homogenates were plated on different media, using pour plate method. The plates were then incubated at 37^0C for 24 hours. Mac Conkey Agar was used for *E. coli* enumeration while

Mannitol Salt Agar was used for *S. aureus*, Total Viable Count was performed on Nutrient Agar. At the end of the incubation period, colonies (30-300) that appeared on each plate for the different dilution were counted and recorded using the illuminated colony counter (Gallenkamp, England). The counts for each plate were expressed as colony forming unit (cfu/g) of the suspension ie

$$\text{Colony forming unit/g} = \frac{\text{Number of colony counted x Reciprocal of dilution factor}}{\text{Volume of sample inoculated}}$$

3.13.4 Identification and Characterization of the Isolates

Colonies identifiable as discrete on the nutrient agar were carefully examined microscopically for cultural characterization such as shape, colour, size and consistency. Bacterial isolates were characterized based on microscopic appearance, colonial morphology and gram staining reaction as well as appropriate biochemical test, for examples, Fructose, Citrate Test, Urease Test, Catalase and Coagulate Test were carried out as described by Cheesbrough (2003) and Oyeleke and Manga (2008). The isolates were identified by comparing their characteristics with those of known texa as described by Bergey's Manual for Determinative Bacteriology (Buchanan & Gribbson, 1974), as well as based on their biochemical reaction according to Buchanan and Gribbson, (1974).

To differentiate gram positive from gram-negative organisms, a gram reaction test was carried out. *Staphylococcus aureus* and *Escherichia coli* were used as control organisms, a wire loop was sterilized in bunsen burner and allowed to cool then a loopful of growth was collected from the agar plate and applied on a clean grease-free slide, then a drop of normal saline was added, emulsified and heat fixed by passing over a flame three times. The smear was flooded with crystal violet for 30-60 seconds and then covered with iodine for 30-60 seconds and then washed off; it was decolorized with acetone until no colour runs off the slide and rinsed

immediately. The slide was covered with safranin for 1minute and then washed off with clean water. The slide was kept in a rack to air dry after wiping the back with cotton wool. The stained smear was then examined microscopically under oil immersion at 100x objective lens. Gram – positive bacteria appeared dark purple while gram-negative bacteria appeared red.

The carbohydrate fermentation test was used to determine the ability of bacteria to utilize different sugars. Examples are mannitol, glucose, fructose, lactose and sucrose. The method include, the sugar solutions were prepared and poured into test tubes well stopped with Durham tube for gas collection. The sugar was autoclaved after which a loopful of test organisms was introduced into the sugar solution (Buchanan & Gribbson, 1974). A change in color from pink to yellow shows fermentation and collection of gas bubbles in the Durham tube shows gas production which is a positive test. A control was set up without the organism inoculated.

Citrate test was based on the ability of an organism to use citrate as its source of carbon. It was used to identify the *Enterobacteria*. The method involved Simon's citrate agar medium was prepared in a slant bijou bottle, and then using a sterile wire loop was used to inoculate the test organism onto the slant medium and incubated at 35 ^{0}C for 48 hours after which it was examined for color formation. A bright blue color in the medium gave a positive citrate test. *Staphylococccus aureus* and *Escherichia coli* were employed as positive and negative controls respectively.

For Urease test, the test was aimed at identifying *Enterobacteria* that produce urease enzyme, which hydrolyze urea to give ammonia and carbon dioxide. Both *S.aureus and E. coli* responded negatively. The procedure was that the test organism was heavily inoculated into Christensen's urea broth in a bijou bottle using a sterile wire loop and incubated at 35 ^{0}C for 18-24 hours and examined, thereafter a pink color in the medium showed positive test.

To differentiate those bacteria that produce enzyme catalase such as *Staphylococcus aureus* and *Escherichia coli* were used as positive and negative controls respectively. a catalase test was carried out as follows; Three milliliters (3 ml) of hydrogen peroxide solution was poured into a sterile test tube. Then a sterile glass rod was used to collect several colonies of the test organisms and inoculate into the hydrogen peroxide solution. It was observed for immediate active bubbling for positive test.

Coagulase test was used to identify *Staphylococcus aureus* which produces the coagulase enzyme which cause plasma to clot by converting fibrinogen to fibrin. The slide method was used. The method used was a drop of sterile distilled water was placed on each end of a sterile slide. Then a colony of the test organism was emulsified on each spot to make two thick suspensions. A loopful of plasma was added to one of the suspensions and mixed gently. The slide was examined for clumping or clotting of the organism within10 seconds. Plasma was not added to the second suspension which serves as control.

3.14 SENSORY EVALUATION OF BROILER CHICKEN MEAT FLOSS

Sensory evaluation was carried out using a 9 point hedonic scale of 1= dislike extremely, 2= Dislike very much, 3= Dislike moderately, 4= Dislike slightly 5= Intermediate, 6= Like slightly, 7 = Like moderately, 8= like very much and 9= Like extremely (Iwe, 2002; Onwuka & Nwosuagwu, 2005; Ogunsola & Omojola, 2008; Omojola, 2008 and Eke, Ariahu & Abu, 2013). The data on sensory parameters were collected using structured questionnaires. A total of one hundred and eighty (180) copies of questionnaires were administered to the taste panelists using empirical procedure of "taste and tell". Each respondent was served with four (4) copies of score cards. After every two weeks, triplicate of the samples were given to fifteen (15) member semi-trained panelists comprising of ten males and 5 females with age ranged between 17 to 25 years

to assessed the meat floss. Assessment was performed under bright light (Olusola, Okubanjo & Omojola, 2013). The products were stored at room temperature (37 ^{0}C) for ten weeks. Sample preparation was done using the method described by Omojola (2009).

The broiler chicken meat floss (15 g each) from different meat types (triplicate) were presented sequentially to the panelists on a clean saucer and their preference recorded (Watts, Ylimaki, Jeffery & Elias, 1989: Meilgaard, Civille & Carr, 1991). Meat floss were coded as 432 (Treatment A-HDPE), 448 (Treatment A-LDPE), 388 (Treatment A-AF), 477 (Treatment A-PC), 666 (Treatment B-HDPE), 789 (Treatment B-LDPE), 454 (Treatment B-AF), 765 (Treatment B-PC), 459 (Treatment C-HDPE), 471 (Treatment C-LDPE), 634 (Treatment C-AF) and 703 (Treatment C- PC). Meat floss from each treatment was evaluated independent of the other. The panelists were provided with clean water for use in-between treatment meat samples. Each panelist was presented the blind coded samples and asked to score each sample for colour, juiciness, flavour, texture, tenderness and overall acceptability (Abubakar *et al.*, 2011; Bashir, Bello & Doma, 2017).

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 RESULTS

4.1.1 Growth Performance of Broiler Chickens Fed Diets containing Varying Energy Levels

The growth performance and economics of producing broiler chickens (at starter phase) fed diets containing varying energy levels are presented in Table 8. Feed intake showed significant (P<0.05) difference across the treatments. Highest final live weight, total feed intake and body weight gain were recorded for birds fed diet containing 2 400 Kcal/Kg, while birds fed diet containing 2 800 Kcal/Kg recorded the least. Thus, as the energy density increases, the total live weight, total feed intake and body weight gain decreases. There is progressive increase in feed cost as the energy density of the diet increase. Lowest cost/gain ratio was reported in diet C.

Table 8: Growth Performance and Economics of Producing Broiler Chickens (at Starter Phase) fed Diets Containing Varying Energy Levels

Parameter	Energy Levels (Kcal/Kg)			S.E (±)
	A	B	C	
Initial Live Weight (g/b)	40.42	40.60	40.50	2.30
Final Live Weight (g/b)	738.64	724.28	686.38	48.74
Total Feed Intake (g/b)	1551.24[a]	1454.76[b]	1305.61[c]	75.68
Body Weight Gain (g/b)	689.22	683.68	645.88	21.30
Feed Conversion Ratio	2.22	2.13	2.02	0.43
Feed cost (₦/kg)	84.08	85.68	88.16	0.20
Cost/Gain	250.56	290.46	220.40	1.20

g/b = gram per bird;
Means along the same row having different superscripts (P<0.05) differ

Table 9 shows the growth performance and economics of producing broiler chickens (at finisher phase) fed diets containing varying energy levels. Feed intake decreased as the energy value of the feed increased. There was significance (P<0.05) difference in total feed intake and

body weight gain between birds fed diets A, B and C. The weight gain values of birds fed diets A and C were statistically similar which differs with birds fed diet B. Highest values for final live weight and total feed intake were recorded for birds fed diet containing 2, 400 Kcal/Kg, whereas lowest values for initial live weight, total feed intake and feed conversion ratio were recorded for birds fed diet containing 2, 800 Kcal/Kg. Feed cost showed progressive increase as the energy level of the diet increases. Diet B has the lowest cost/gain ratio.

Table 9: Growth Performance and Economics of Producing Broiler Chickens (at Finisher Phase) fed Diets Containing Varying Energy Levels

Parameters	Energy Levels Kcal/Kg)			S.E (±)
	A	B	C	
Initial Live Weight (g/b)	738.64	724.28	686.38	57.14
Final Live Weight (g/b)	2493.67	2416.70	2480.50	53.63
Total Feed Intake (g/b)	3600.68[a]	3095.77[b]	2819.88[c]	56.00
Body Weight Gain (g/b)	1755.03[a]	1692.42[b]	1794.12[a]	10.98
Feed Conversion Ratio	2.05	1.83	1.40	0.52
Feed Cost (₦/kg)	72.42	73.36	78.08	0.03
Cost/Gain	165.84	151.12	153.82	1.08

g/b = gram per bird;
Means along the same row having different superscripts (P<0.05) differ

4.1.2 Blood Parameters of Broiler Chickens (At Week 8) Fed Diets Containing Varying Energy Levels

The values of haematological indices monitored are shown in Table 10. There was significant difference (P<0.05) between the treatments in WBC, RBC, HgB, PCV and PLT. The WBC, RBC, HgB, PCV, MCV, MCH, and MCHC values were consistently higher (P<0.05) for the birds on 2,400 Kcal/Kg, when compared with birds fed diet containing 2,800 Kcal/Kg which has the least.

Table 10: Haematological Parameters of Broiler Chickens (at week 8) fed Diets Containing Varying Energy Levels

Parameter	Energy Regimes (Kcal/kg)			
	A	B	C	SE(±)
WBC (10^3mm^3)	250.78[a]	244.00[b]	238.79[b]	1.79
RBC (10^6mm^3)	2.78[a]	2.33a[b]	2.11[b]	0.20
HgB(g/100ml)	11.89[a]	10.78a[b]	10.33[b]	0.48
PCV (%)	38.89[a]	33.78[b]	33.00[b]	0.98
MCV (μm^3)	139.69	135.89	138.56	2.74
MCH (pg)	44.56	42.33	41.89	1.10
MCHC (%)	31.78	31.56	30.89	0.46
PLT (10^9/l)	21.56[b]	21.44[b]	35.11[a]	3.44

WBC= White Blood Cell, RBC= Red Blood Cell, HgB= Haemoglobin, PCV= Packed Cell Volume, MCV= Mean Cell Volume, MCH = Mean Cell Haemoglobin, MCHC= Mean Cell Haemoglobin Concentration and PLT= Platelet.
Means along the same row having different superscripts ($P<0.05$) differ

Table 11 shows the biochemical parameters of broiler chickens (at week 8) fed diets containing varying energy levels. The values of biochemical parameters did not differ between the treatments, hence, they were not affected by feeding different energy levels. The creatinine, albumin, globulin and total protein were consistently higher for birds fed diet containing 2,400 Kcal/Kg.

Table 11: Biochemical Parameters of Broiler Chickens (at week 8) Fed Diets Containing Varying Energy Levels

Parameter	Energy Levels (Kcal/Kg)			
	A	B	C	SE(±)
Urea (mg/dl)	2.79	3.89	3.93	0.54
Creatinine (mg/dl)	41.89	41.44	40.22	1.11
Albumin (g/dl)	1.84	1.46	1.60	0.30
Globulin (g/dl)	1.16	1.08	1.11	0.76
Total Protein (g/dl)	2.90	2.54	2.71	0.74

4.1.3 Carcass and Organ Weight of Broiler Chickens (At Week 8) Fed Diets Containing Varying Energy Levels

The results of the analysis of carcass and organs weight of broiler chickens fed diets containing varying energy levels are presented in Table 12. Live weight, Slaughtered weight, Plucked weight, Carcass weight and Dressing percentages of treatments A, B and C were statistically ($P>0.05$) similar, even though the carcass weight and dressing percentage of treatment A was higher compared to those recorded for B and C. The values obtained for live weight and dressing percentage ranged from 2.42 to 2.49 Kg and 66.94 to 69.88 %, respectively. The wing was significantly higher ($P<0.05$) for broiler chickens on treatments A and B. Drumstick and liver followed similar trend.

The carcass weight and dressing percentage for treatment A was the highest while the Live and Slaughter weights of treatment B was the least. The Crop and Proventriculus of

treatment A were the highest, while that from B had the least. The dietary treatments did not influence the relative weight of breast, gizzard and abdominal fat.

Table 12: Carcass and Organ Weight (expressed as % Live weight) of Broiler Chickens (at week 8) fed Diets Containing Varying Energy Levels

Parameter	Energy Levels (Kcal/Kg)			
	A)	B	C	SE(±)
Primal Joint				
Live weight (kg)	2.49	2.42	2.48	0.11
Slaughtered weight (kg)	2.41	2.35	2.41	0.10
Plucked weight (kg)	2.33	2.26	2.30	0.10
Carcass weight (kg)	1.74	1.62	1.70	0.08
Dressing percentage (%)	69.88	66.94	68.55	5.41
Cut up parts (%)				
Head	2.65[b]	2.87[b]	3.52[a]	0.04
Legs	4.23	4.60	4.23	0.01
Thigh Muscle	9.52[a]	7.00[b]	7.41[b]	0.02
Wing	8.01[a]	7.59[ab]	6.67[b]	0.10
Back	6.88	9.36	7.76	0.06
Neck	4.23	4.60	4.76	0.01
Breast	11.11	10.92	6.88	0.08
Drumstick	11.11[a]	10.34[ab]	8.47[b]	0.02
Shank	0.53	0.57	0.53	0.01
Organ Weights (%)				
Crop	0.03[a]	0.02[b]	0.02[b]	0.01
Gizzard	3.70	4.02	3.17	0.00
Liver	2.22[a]	2.13[ab]	1.70[b]	0.01
Abdominal Fat	0.53	0.55	0.53	0.01
Caeca	1.56	1.15	1.56	0.01
Heart	0.53	0.57	1.06	0.01
Kidney	0.53	0.57	1.06	0.01
Proventriculus	1.18	1.15	1.16	0.02

Means along the same row having different superscripts ($P<0.05$) differ

4.1.4 Nutrient Digestibility of Broiler Chickens Fed Diets Containing Varying Energy Levels

The results of the nutrient digestibility of broiler chickens fed diets containing varying energy levels are presented in Table 13. There were significant ($P<0.05$) differences in all the

parameters measured. Higher values of ether extract and crude fibre were reported from the group fed 2,600 Kcal/Kg. The ash content of the group fed 2,400 and 2,800 Kcal/Kg is statistically similar which differ significantly (P<0.05) with the group fed 2, 600 Kcal/Kg.

Table 13: Nutrients Digestibility of Broiler Chickens fed Diets Containing Varying Energy Levels

Parameter (%)	Metabolizable Energy (Kcal/Kg) Levels			
	A	B	C	SE(±)
Ash	87.45[a]	85.01[b]	86.68[a]	0.78
Ether Extract	86.20[b]	88.37[a]	84.30[c]	0.68
Crude Protein	78.57[b]	76.51[c]	80.24[a]	0.67
Crude Fibre	72.29[c]	79.50[a]	77.29[b]	0.43

Means along the same row having different superscripts (P<0.05) differ

4.1.5 Chemical Composition of Raw Broiler Chicken and Meat Floss

The chemical composition of raw meat prepared from broiler chickens fed diets containing varying energy levels is presented in Table 14. Results showed that the raw meat of broiler chickens fed diet containing 2, 800 Kcal/Kg has the highest values of ash, moisture and crude protein. The raw meat of broiler chickens fed diet containing 2, 400 Kcal/Kg has the highest ether extract value. There is significant (P<0.05) differences in all the parameters (ash, moisture, crude protein and ether extract) measured across the three treatments.

Table 14: Chemical Composition (%) of Raw Broiler chicken Meat Fed Diets Containing Varying Energy Levels (Kcal/kg)

Parameters (%)	Energy Levels (Kcal/kg)			
	A	B	C	SE (±)
Ash	3.05[c]	3.53[b]	4.30[a]	0.02
Moisture	69.02 [b]	68.82 [b]	68.90 [a]	0.05
Crude Protein	11.29[c]	12.07[b]	12.97[a]	0.01
Ether Extract	16.47[a]	15.58[b]	13.79[c]	0.01

Means along the same row having different superscripts (P<0.05) differ

Table 15 shows the chemical composition of meat floss prepared from broiler chicken fed diets containing varying energy levels. Results showed that there were statistical (P< 0.05) differences across treatments. Chicken meat floss of birds fed diet containing 2, 800 Kcal/Kg has the highest mean values of moisture, crude protein and ether extract.

Table 15: Chemical Composition (%) of Meat Floss Prepared from Broiler Chickens Fed Diets Containing Varying Energy Levels

Parameters (%)	Energy Levels (Kcal/Kg)			
	A	B	C	SE (±)
Ash	7.47[a]	7.75[a]	6.00[b]	0.00
Moisture	9.03[b]	8.75[c]	8.88[a]	0.05
Crude Protein	58.57[b]	59.40[b]	58.75[a]	0.00
Ether Extract	24.92[b]	24.10[c]	26.37[a]	0.00

Means along the same row having different superscripts (P<0.05) differ

4.1.6 Mineral Composition of Raw Broiler Chicken Meat and Meat Floss

The result of the mineral composition of raw broiler chicken meat fed diets containing varying energy levels is presented in Table 16. The sodium content ranged from 30.16 mg/kg in birds fed diet containing 2, 400 Kcal/kg to 48.02 mg/kg in birds fed diet containing 2, 800 Kcal/kg. The amount of potassium ranged from 47.22 mg/kg obtained in birds fed diet containing 2, 400 Kcal/Kg to 53.96mg/kg in birds fed diet containing 2, 800 Kcal/Kg. The raw meat of poultry broiler chicken fed diet containing 2 800 Kcal/kg has the highest values of Ca, Na, K and Fe. The values of Na, K and Fe were lowest in birds fed 2 400 Kcal/Kg. Ca, Mg, K and Fe recorded significant differences (P<0.05) between treatments.

Table 16: Mineral Composition of Raw Broiler Chicken Meat Fed Diets Containing Varying Energy Levels

Mineral (mg/kg)	Energy Levels (Kcal/kg) A	B	C	SE (±)
Ca	35.43[b]	33.67[c]	37.72[a]	1.27
Mg	22.00[a]	18.32[b]	16.72[c]	1.34
Na	30.16[b]	30.60[b]	48.02[a]	1.17
K	47.22[c]	50.82[b]	53.96[a]	1.18
Cu	3.81[a]	4.70[a]	1.51[b]	0.58
Fe	5.61[c]	7.00[b]	7.82[a]	1.15
Zn	20.76[a]	20.59[a]	17.55[b]	1.21

Means along the same row having different superscripts ($P<0.05$) differ

The result of the mineral composition of meat floss produced from broiler chickens fed diets containing varying energy levels is presented in Table 17. The calcium content ranged from 35.76 mg/kg in birds fed diet containing 2, 600 Kcal/Kg to 40.92 mg/kg in birds fed diet containing 2, 400 Kcal/Kg. The amount of magnesium ranged from 24.58 mg/kg obtained in birds fed diet containing 2, 800 Kcal/Kg to 33.73 mg/kg in birds fed diet containing 2, 600 Kcal/Kg. Meat floss produced from broiler chickens fed diet containing 2, 800 Kcal/Kg had the highest values of Na, Fe and Zn. Ca, Mg, Na, Cu, Fe and Zn recorded significant differences ($P<0.05$) between treatments. The values of Ca, Na, Fe and Zn were lowest in birds fed diet containing 2, 600 Kcal/Kg.

Table 17: Mineral Composition of Meat Floss Produced from Broiler chickens Fed Diets Containing Varying Energy Levels

Minerals (mg/kg)	Energy Levels (Kcal/Kg) A	B	C	SE (±)
Ca	40.92[a]	35.76[c]	38.05[b]	1.70
Mg	28.84[b]	33.73[a]	24.58[c]	1.50
Na	38.42[b]	36.63[c]	44.69[a]	1.24
K	53.24[b]	53.67[b]	58.81[a]	1.36
Cu	7.51[b]	7.91[a]	3.74[c]	1.01
Fe	11.33[b]	9.26[c]	14.25[a]	1.57
Zn	24.62[b]	22.69[c]	25.74[a]	1.19

Means along the same row having different superscripts ($P<0.05$) differ

4.1.7 Microbial Quality of Raw Broiler Chicken Meat and Meat Floss

The Bacteriological quality of raw broiler chicken meat fed diets with varying energy levels is presented in Table 18. The results indicated that all the samples were contaminated by indicator microbes that can pose threat to public health. *Staphylococcus aureus* and *Escherichia coli* species were detected. The total viable count ranged from 1.20 to 3.00 $x10^{-4}$ cfu/g.

Table 18: Bacteriological Quality of Raw Broiler Chicken Meat fed Diets Containing Varying Energy Levels (Kcal/Kg)

Energy Level (Kcal/kg)	TVC(cfu/g) $x10^4$	Isloate
2, 400	1.20	*Staphylococcus aureus*
	1.70	*Escheriria coli*
2, 600	1.40	*Staphylococcus aureus*
	3.00	*Escheriria coli*
2,800	2.00	*Staphylococcus aureus*
	1.30	*Escheriria coli*

TVC = Total Viable Count; cfu/g= Colony Forming Unit Per Gram

Effect of packaging and storage duration (2 Weeks) on bacterial mesophilic count (cfu/g) of broiler chicken meat floss

The experimental broiler chicken meat floss was examined to ascertain the bacterial mesophilic count (cfu/g) after two weeks storage in different packaging materials and the result presented (in Table 19) showed that chicken meat floss packaged in LDPE recorded high contamination of TVC while AF recorded the least. Similarly higher concentration of *S.aureus* and *E.coli* were recorded in LDPE.

Table 19: Effect of Packaging and Storage Duration (2 weeks) on Bacterial Mesophilic Count (cfu/g) of Chicken Meat Floss

Packaging Materials	TVC (cfu/g) $X10^4$	*S.aureus* (cfu/g) $X10^4$	*E.coli* (cfu/g) $X10^4$
HDPE	6.70	3.40	3.60
LDPE	7.00	3.70	4.20
AF	5.50	2.80	3.10
PVC	6.10	3.00	3.30

HDPE = High Density Polyethylene; LDPE = Low Density Polyethylene; AF = Aluminium Foil PVC = Polyvinyl chloride; TVC = Total Viable Count; cfu/g= Colony Forming Unit Per Gram

Characterization and identification of isolates

The characterization and identification results were presented on Tables 20 and 21. The isolates identified were *Staphylococcus aureus* and *Escherichia coli*.

Table 20: Microscopic, Culture Media Identification and Characterization of the Isolates

Microscopic Morphology	Mac Conkey	Mannitol Salt	Isolate
Rod	Red coloration On the surface	-	*E. coli*
Cocci	-	Yellow zone Surrounding growth	*S. aureus*

Table 21: Biochemical Identification and Characterization of the Isolates

Gram Reaction	Fructose	Citrate	Urease	Catalase	Coagulase	Isolate
-	+	-	-	-	-	*E. coli*
+	-	+	-	+	+	*S. aureus*

+= Positive, - = negative

Impact of packaging materials (10 weeks) on bacterial mesophilic count (cfu/g) of broiler chicken meat floss

Table 22 presents the impact of packaging materials (10 weeks) on bacterial mesophilic count (cfu/g) of broiler chicken meat floss. The results showed no growth of *S.aureus* was recorded on chicken meat floss packaged in HDPE and LDPE while no growth of *E. coli* was recorded on chicken meat floss Packaged in Polyvinyl chloride.

Table 22: Impact of Packaging Materials (10 weeks) on Bacterial Mesophilic Count (cfu/g) of chicken Meat Floss

Packaging Materials	TVC (cfu/g) $X10^4$	*S. aureus* (cfu/g) $X10^4$	*E. coli* (cfu/g) $X10^4$
HDPE	2.40	0.00	1.30
LDPE	2.90	0.00	1.20
AF	1.70	1.00	1.00
PVC	2.20	1.10	0.00

HDPE = High Density Polyethylene; LDPE = Low Density Polyethylene; AF = Aluminium Foil
PVC = Polyvinyl chloride; TVC = Total Viable Count; cfu/g= Colony Forming Unit Per Gram

Effect of fungal count on meat floss prepared from broiler chicken fed diets containing varying energy levels

The effect of fungal count on meat floss prepared from broiler chickens fed varying energy levels is presented on Table 23. The results showed that the Fungal Count from treatments A and B were statistically ($P>0.05$) similar, so also Treatments B and C, but there was significant difference ($P<0.05$) of fungal load between treatments A and C. The result also showed that Treatment A has the highest Fungal Count while treatment B has the least.

Table 23: Effect of Energy Level on Fungal Count of Meat Floss Prepared from Broiler Chicken

Energy Levels (Kcal/kg)	Fungal Count (cfu) x 10^4	S.E
A	6.96^{a}	0.05
B	5.54^{ab}	0.05
C	5.55^{b}	0.05

Means along the same row having different superscripts (P<0.05) differ

Effect of fungal count of broiler chicken meat floss stored in different packaging materials

Table 24 presents the effect of fungal count of broiler chicken meat floss stored in different Packaging Materials. Results showed that the fungal load of chicken meat floss stored in HDPE and LDPE were statistically (P>0.05) similar. Chicken meat floss stored in HDPE has the highest Fungal Count while that stored in AF has the lowest fungal count.

Table 24: Effect of Packaging Materials on Fungal Count of Broiler Chicken Meat Floss

Packaging materials	Fungal Count (cfu) x 10^4	S.E
HDPE	6.36^{a}	0.06
LDPE	6.32^{a}	0.06
AF	5.13^{c}	0.06
PVC	6.26^{b}	0.06

HDPE= High Density Polyethylene, LDPE= Low Density Polyethylene, AF= Aluminium Foil' PVC= polyvinyl chloride.
Means along the same row having different superscripts (P<0.05) differ

4.1.8 Effect of Period, Energy Level and Packaging Material on Sensory Parameters of Meat Floss

The effect of period, energy level and packaging material on panelist colour preference is presented in figure 2. Results showed that highest scores (6.70 to 8.10) were obtained in the early

period of storage across the four (4) packaging materials and less scores (4.5 to 5.0) were recorded at the tail end of the trial irrespective of the packaging materials. The mean panels rating for colour in all the meat floss showed generally higher scores which indicated that all the meat floss have meat of good quality in terms of colour.

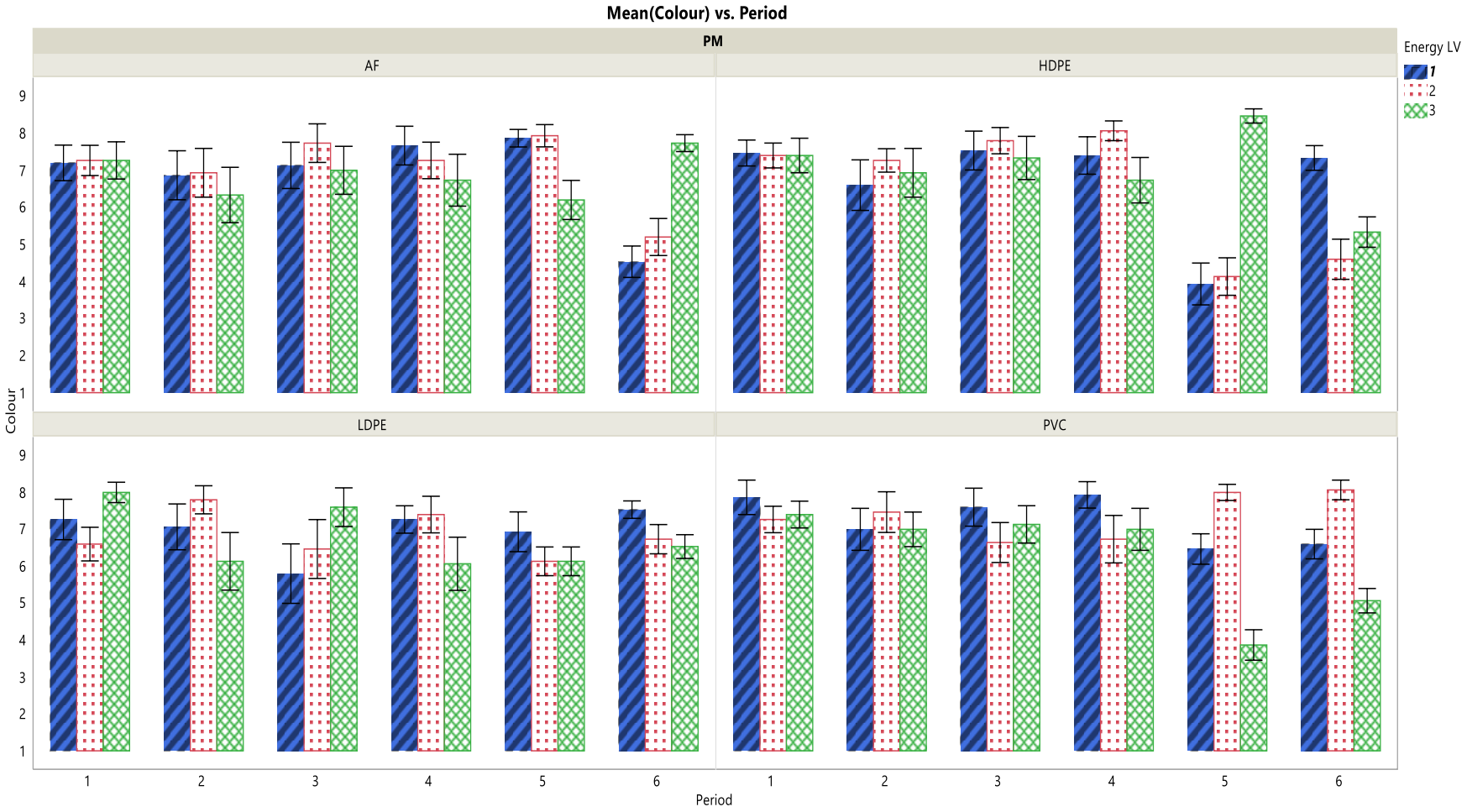

Figure 2: Effect of Period, Energy Level and Packaging Material on Panelists' Meat Floss Colour Preferences

Figure 3 presented the effect of Period, energy level and packaging material on panelist juiceness preference. Meat floss packaged in Aluminium foil produced from birds fed 2, 600 and 2, 800 Kcal/Kg received higher scores of 8.20 and 8.10, respectively while that stored in Polyvinyl Chloride and produced from 2, 400 and 2, 600 Kcal/Kg were rated 7.10 and 8.30, respectively.

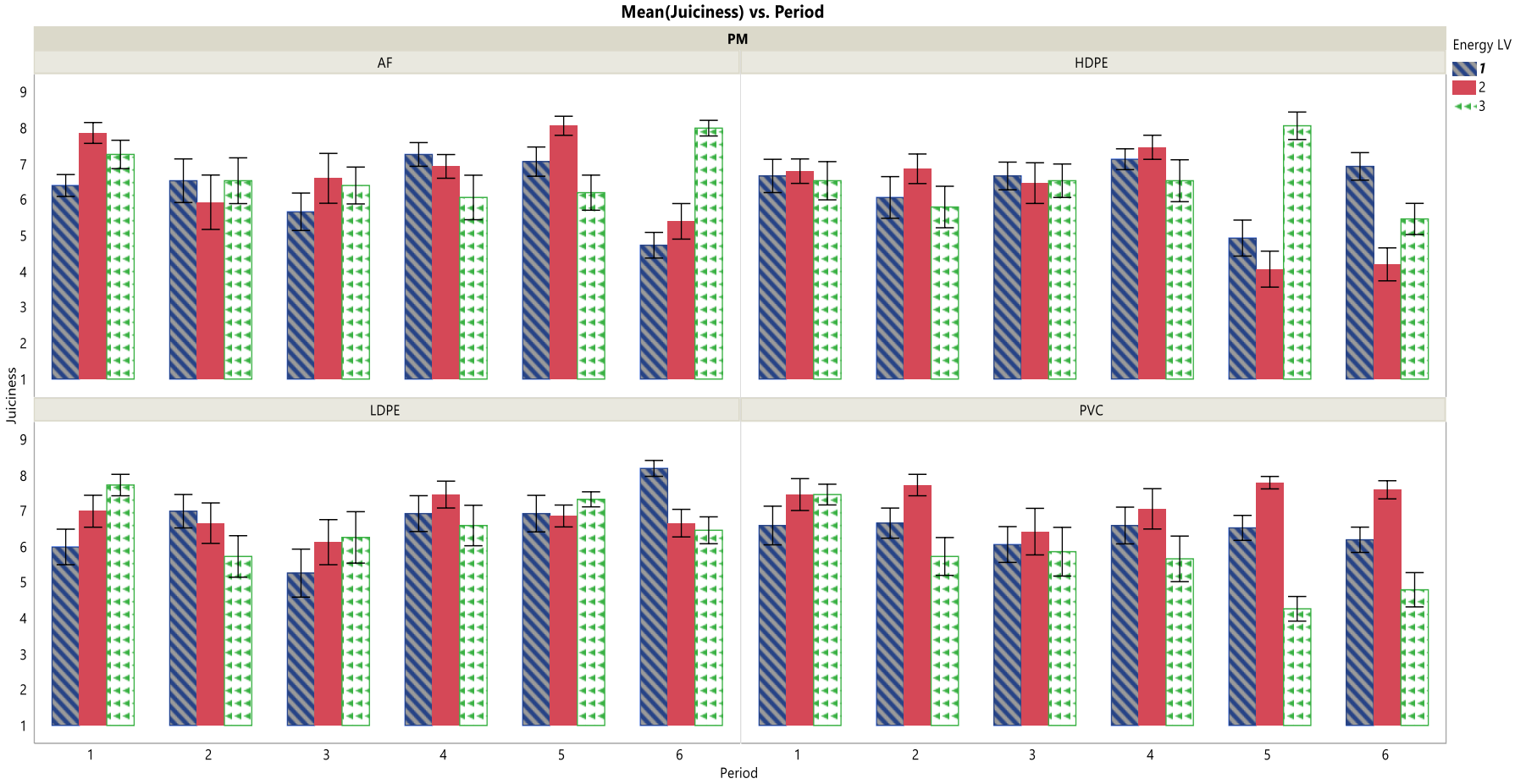

Figure 3: Effect of Period, Energy Level and Packaging Material on Panelists' Meat Floss Juiceness Preferences

The taste panel evaluation results on the effect of period, energy level and packaging material on panelist flavour preference is shown in Figure 4. Meat floss produced from birds fed diet containig 2, 800 Kcal/Kg and packaged in Aluminium foil, High Density Polyethylene and Low Density Polyethylene had the highest rating of 8.50, 8.10 and 8.00, respectively.

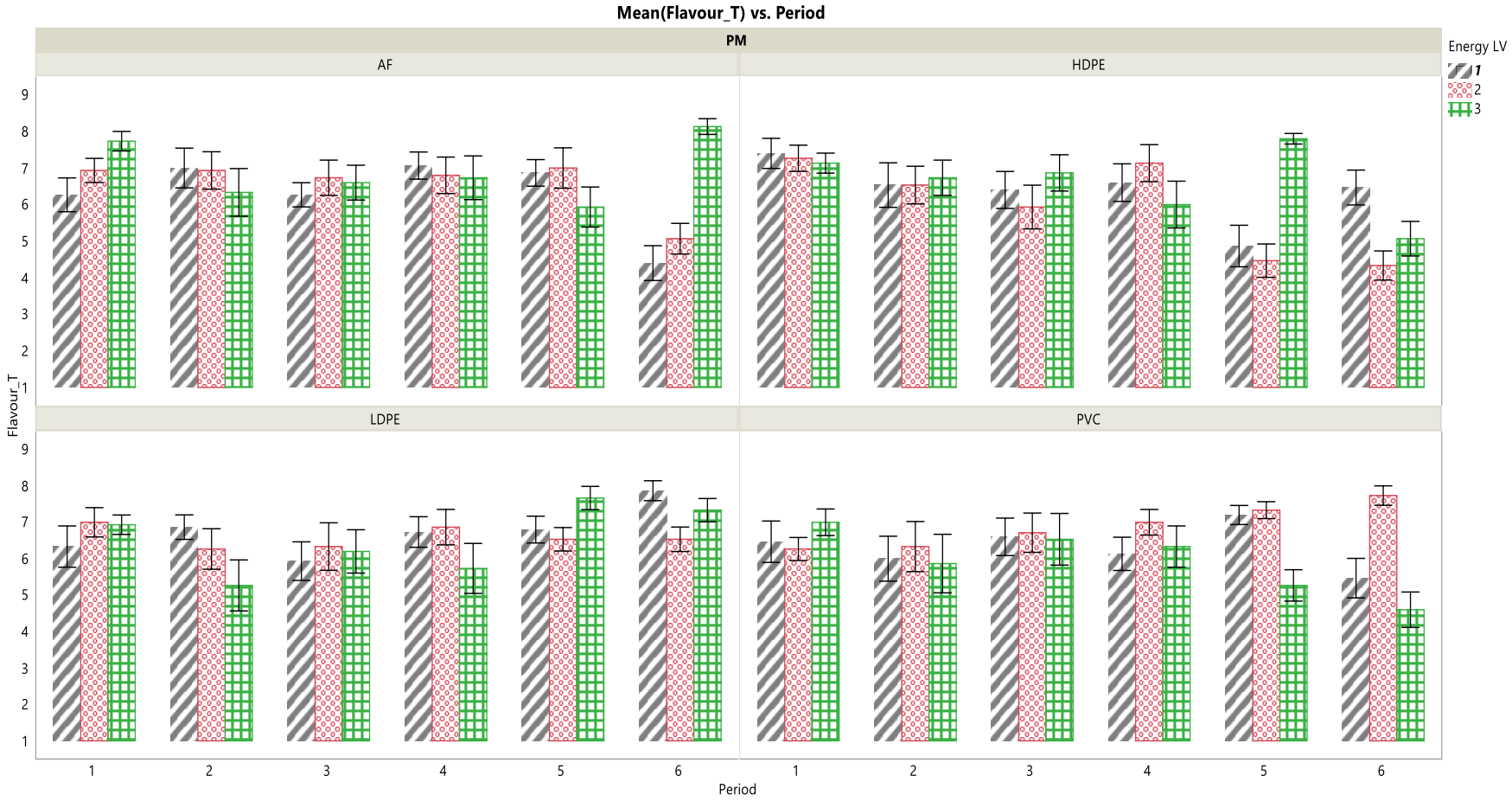

Figure 4: Effect of Period, Energy Level and Packaging Material on Panelists' Meat Floss Flavour Preferences

The effect of period, energy level and packaging material on panelist texture preference is shown in Figure 5. Higher scores of 8.30, 7.80 and 8.20 were recorded from meat floss obtained from birds fed diet containing 2, 800 Kcal/Kg and packaged in Aluminium foil, High Density Polyethylene and Low Density Polyethylene, respectively

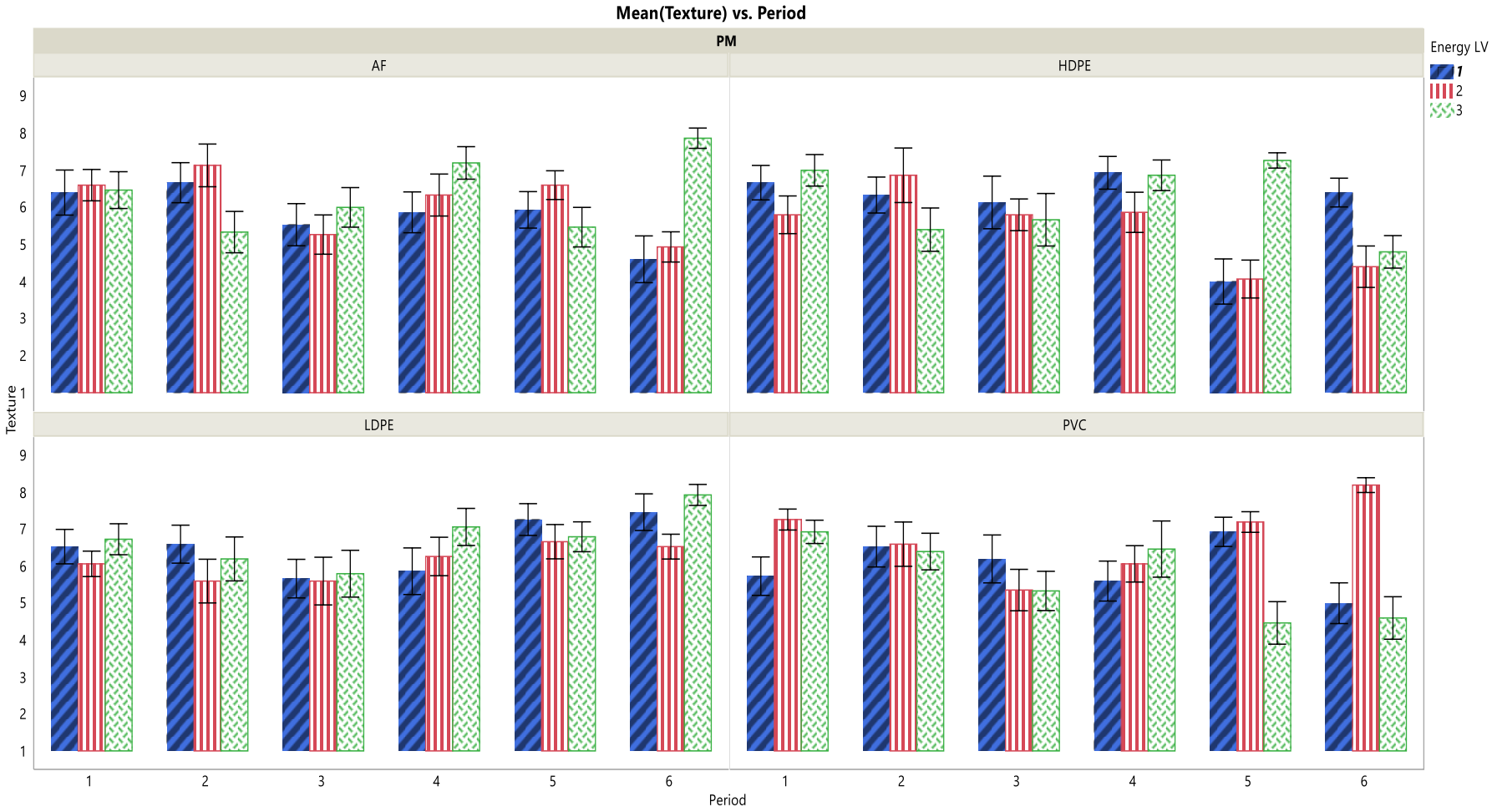

Figure 5: Effect of Period, Energy Level and Packaging Material on Panelists' Meat Floss Textural Preferences

The effect of period, energy level and packaging material on panelist tenderness preference is shown in Figure 6. Result showed that there was progressive decrease in tenderness with increase in storage period across the packaging materials. Scores of meat meat floss produced from birds fed diet containing 2, 600 Kcal/Kg and packaged in Aluminium foil decreases from 8.00 to 2.90 while that produced from birds fed diet containing 2, 800 Kcal/Kg and packaged in High Density Polyethylene decreases from 8.00 to 2.50, similarly meat meat floss produced from birds fed diet containing 2, 400 Kcal/Kg and packaged in Low Density Polyethylene decreases from 7.20 to 3.20 and that produced from birds fed diet containing 2, 400 Kcal/Kg and packaged in Polyvinyl Chloride decreases from 8.20 to 2.00.

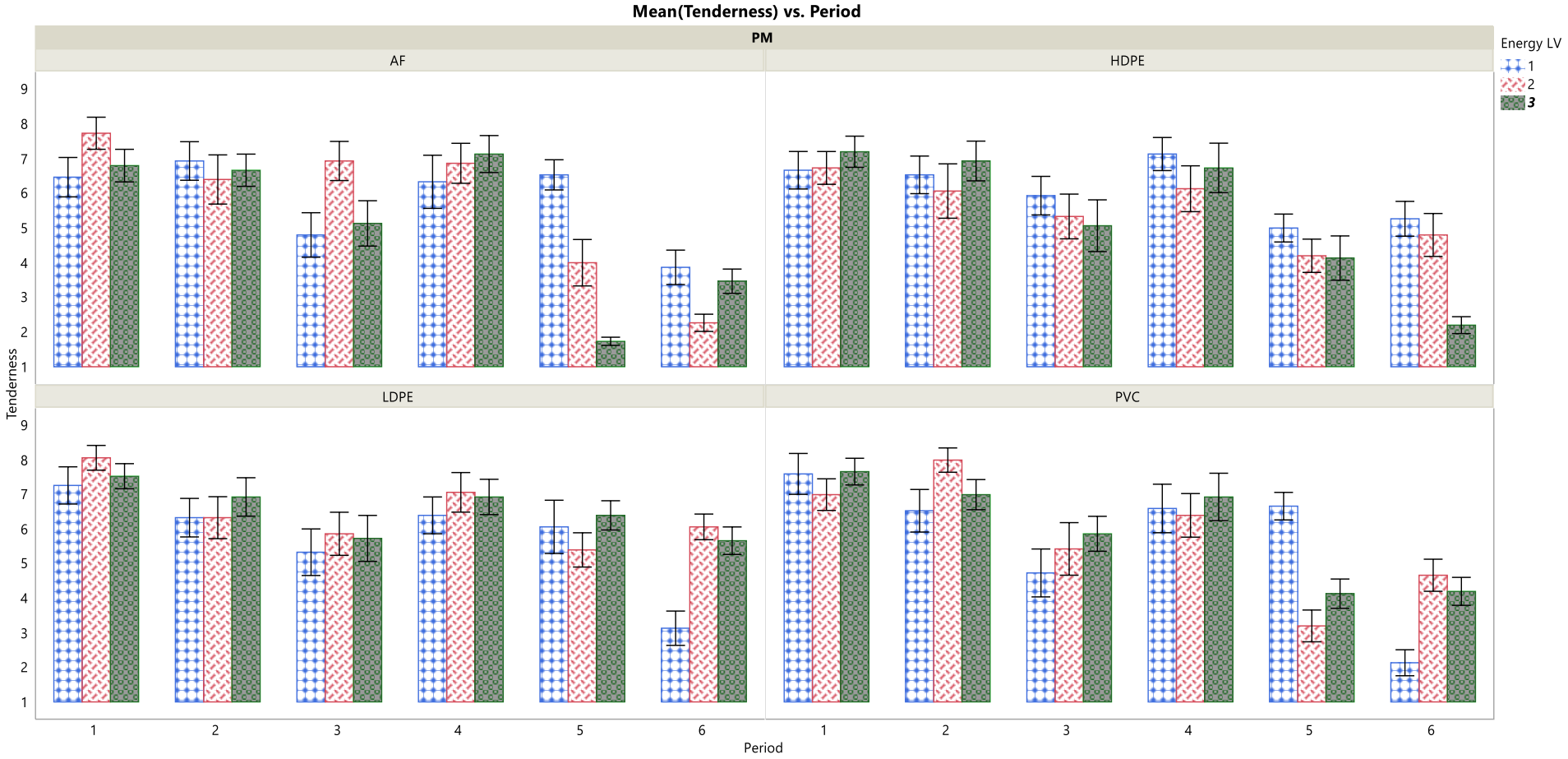

Figure 6: Effect of Period, Energy Level and Packaging Material on Panelists' Meat Floss Tenderness Preferences

Figure 7 presents the effect of period, energy level and packaging material on panelist overall acceptability preference. There were progressive decrease in penalist rating of meat floss across the packaging materials as the period of storage increases, irrespective of the energy level from where the meat floss were produced. Scores of meat floss produced from birds fed diet containing 2, 600 Kcal/Kg and packaged in Aluminium foil and High Density Polyethylene decreases from 8.50 to 4.20 and 8.80 to 5.00, respectively, while that produced from birds fed diet containing 2, 800 Kcal/Kg and packaged in Polyvinyl Chloride decreases from 8.70 to 5.10. Meat floss packaged in polyvinyl chloride had higher overall acceptability values.

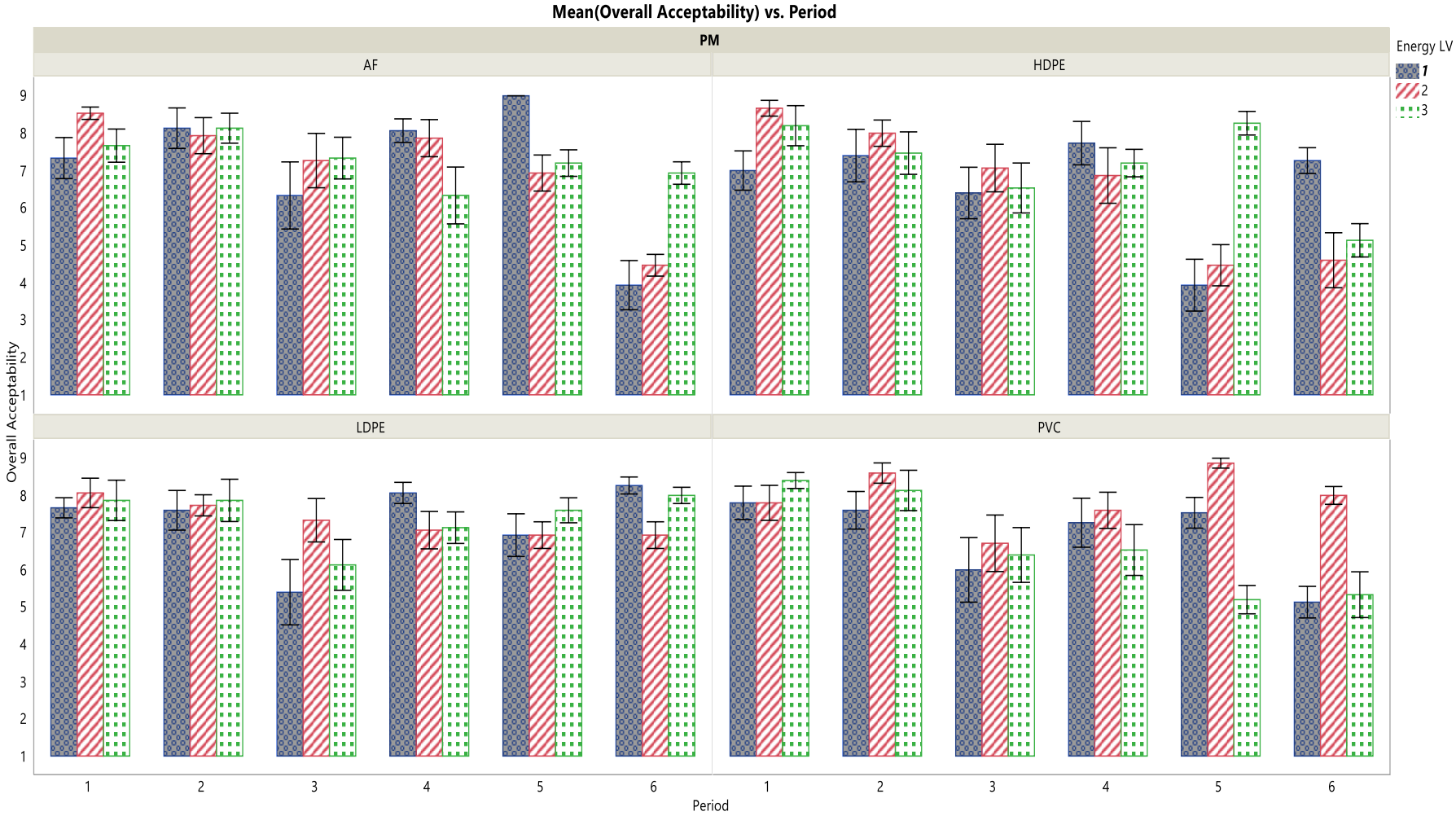

Figure 7: Effect of Period, Energy Level and Packaging Material on Panelists' Meat Floss Overall Acceptabilty Preferences

4.2 DISCUSSION

4.2.1 Growth Performance of Broiler Chickens Fed Diets Containing Varying Energy Levels

At the starter phase, as the energy level increases, there was decrease in feed intake. This is in agreement with the report of Smith (2001) who stated that broiler chickens eat more to satisfy their energy need. Sundu, Kumar and Dinge (2005) and Fatufe, Akanbi, Saba, Olowofeso and Tewe (2007) reported that the voluntary feed intake of birds have been established to be a function of dietary fibre characteristics. Birds fed least energy level showed highest final live weight and body weight gain.

The higher values in final live weight and body weight gain of the birds fed on diet A indicated that the diet was better utilized. The range for final live weight recorded in this study is in conformity with that reported (630. 56g/b to 872.50g/b) by Nworgu and Egbunike (2013), the same authors recorded body weight gain of 590.96 to 830.59g/b which is within the range with that reported in this work. The range for feed conversion ratio in this study is similar with that published by Dairo *et al*. (2010); Nworgu *et al.* (2014); Olaiya *et al.*, (2014); Teniola *et al.* (2014) and Teniola *et al.* (2016) as 2.11 to 2.56, 2.03 to 2.89, 2.15 to 3.25, 2.10 to 2.80 and 2.08 to 2.10 respectively.

The feed intake at the finisher phase was significantly higher from the birds fed the least energy diet (A), this could be attributed to the fact that birds under normal circumstances eat to satisfy their energy needs, thus confirming the report of Akinola and Sese (2011) who stated that feed intake in birds fed diet containing low energy concentration was higher. This is also in agreement with the findings of Mc Donald *et al*. (2002) who reported that most animals consumed the quantity of feed needed to satisfy their energy requirement.

The range for feed intake values in this study agrees with that reported (2 800 g/b to 3 800 g/b) by Jegede *et al.* (2016), the same authors reported final live weight range of 1 800 g/b to 2 500 g/b which is similar to that found in this research. The finding of Oloruntola, Ayodele, Agbede and Omoniyi (2016) that the final live weight range of broiler chickens was between 2 081.38 g/b to 2 476.28 g/b is similar to what is obtained in this research.

4.2.2 Blood Parameters of Broiler Chickens (At Week 8) Fed Diets Containing Varying Energy Levels

The results obtained for RBC and MCHC were in agreement with that reported by Dairo *et al*. (2010) who fed High and Low Dietary Energy and Protein Levels to Broiler Chickens. High PCV values had been reported to be an adapted mechanism that provides optimum water for evaporative cooling process. High level of white blood cell indicates high level of immunity (Garba & Abubakkar, 2013). The life span of WBC varies considerably from few hours for granulocytes to potentially month for monocytes and years for lymphocytes (Amao, Adejumo & Togun, 2012). Khan and Zafar (2005) reported that increase in RBC values of farm animals is an indicator of the disease-free status of the animals. Maxwell, Robertson, Spence and Mecorquodade (1990) reported that nutritional change can influence blood parameters.

The biochemical indices were not affected by feeding different energy levels. Similar results were reported by Nweze and Ekwe (2012). The serum biochemical indices observed were all within normal range as reported by Dukes (1975). Creatinine content has been shown to depend upon quantity and quality of feed and environmental temperature (Ewuola *et al.*, 2004). Insignificant differences among treatments in the values of urea suggest the normal functioning of the kidney (Mc Donald *et al.*, 1995). The lower values of urea obtained support the quality of the feed. According to Iyayi and Tewe (1998) blood urea level depend on both the quality and

quantity of the protein supplied in the diet and higher level of urea in the blood could be attributed to the presence of some anti-nutritional factors which might have lowered the quantity of the protein indicating imbalance of amino acid in the diet and caused elevated blood urea concentration.

Globulin and albumin are component of blood plasma (Guache *et al.,* 1991). The values of Albumin, Globulin and Total Protein in this research agree with the findings of Al-Homidan (2005), Ademola, Farinu and Babatunde (2009) and Wafaa, Khadiga, Bakheit and Ahmed (2012). Total Protein, Albumin and Globulin have been reported to be directly responsible to protein intake and quality (Onifade, Odunsi, Babatunde, Olorede & Muma, 1999).

4.2.3 Carcass and Organ Weight of Broiler Chickens (At Week 8) Fed Diets Containing Varying Energy Levels

Dressing percentage gives the best practical expression of the slaughter value of livestock, making it possible at the same time to carry out various comparisons (Madziga, Voh, Barje & Goska, 2016). The knowledge of dressing percentage is important to farmers as it enable them to accurately estimate carcass weight from on-farm live weight and target the carcass weight ranges which will maximizes returns (Muir & Thomson, 2008; Goska *et al.*, 2017). There are large differences in growth rate between breeds which lead to substantial differences in the weight of the carcass at a given age (Allen & Kilkenny, 1980).

The result in this study agrees with that of Dairo *et al*. (2010) who reported statistical similarities in live and dressed weight of broiler chickens fed high and low dietary energy levels slaughtered at weeks 4 and 8. Similarly, Magala, Kugonza, Kwizera and Kyarisiima (2012) reported Dressing percentage and relative organ weights to be similar across all dietary treatments (2, 800; 2, 900 and 3, 000 Kcal/Kg). These findings were also in agreement with the

result of Nguyen and Bunchasak (2005) who reported that the carcass yield of Chinese Betong native chickens were not affected by varying dietary energy and protein levels from 3, 000 to 3, 200 Kcal/Kg and 17 to 23% CP, respectively. Karman *et al*. (2008) similarly reported that the carcass yield did not differ when broilers were fed diets varying from 2,717 to 3,146 Kcal/Kg and 19 to 22% CP during the finishing phase.

On the contrary, Zhuge *et al*. (2009) observed increasing viscera fat deposition when dietary energy was increased from 2,900 to 3,100 Kcal/Kg in the diets of growing broiler chickens. Young, Northcutt, Buhr, Lyon and Ware (2001); Havenstein, Ferket and Qureshi (2001) and Brickett *et al.,* (2007) reported that carcass yield is affected by a number of factors including genetic, feed quality and quantity, slaughtering conditions, live weight and sex. The values obtained for Dressing Percentage in this work were within the range with that obtained by Ravindran and Savakanenssan (1996); Salami, Longe and Oluyemi (2004); Kwari, Igwebuike, Shuaibu, Titima, and Raji, (2014); Diarra, Sandakabatu, Perere, Tabuaciri and Mohammed (2015) who reported 65.84 to 70.77%, 65-70%, 67.19-73.11% and 67-68%, respectively as the ideal Dressing Percentages for well finished broilers. Leeson *et al.,* (1996); Nahashon, Adefope, Amenyenu and Wright (2006); Alabi, Ng'ambi and Norris, (2013) reported that drumstick, thigh and wing differed significantly ($P<0.05$) by increasing dietary energy levels. This might be attributed to the storage of energy in adipose tissues once the requirements for basal metabolic rate and thermogenesis had been met (Nahashon, Adefope, Amenyenu and Wright, 2005, Karman *et al*., 2008 and Hosseini *et al*., 2010).

4.2.4 Nutrient Digestibility of Broiler Chickens Fed Diets Containing Varying Energy Levels

FAO (1995) classified digestibility of feed as high (>60%), medium (40-60%) and low (<40%). Several researches such as Okorie *et al.*, (2005), Ojewola and Nwochi (2012), Rafi'u, Okunlola, Shittu, Okonola and Faladun (2012); Abu, Amusa, Atoyebi, Kehinde and Nworgu, (2013); Idowu *et al*., (2013), Tamburawa, Wali and Hassan (2013); Tamburawa and Rano (2014), Adebowale *et al*., (2015), Fafiolu, *et al*., (2015), Jiya, Aremu, Abe and Azeez (2016a) and Oke, Oluwatosin, Adeyemi and Adeoye, (2016) reported significant ($P<0.05$) differences in all the parameters measured. The values of crude protein range from 74.04 ± 2.57 to 78.85% ± 0.88 reported by Ayanwale, Kudu, Shuaibu and Tsodo (2010), 74.50 to 81.48% by Ojewola and Nwochi (2012), 79.99 to 84.45% by Sabo, Duru and Afolayan (2015) and 77.86 to 80.39% by Oke *et al*. (2016) are similar to that reported in this research.

The values of ether extract range from 82.75 ± 1.44 to 91.54% ± 1.70 as reported by Ayanwale *et al.*, (2010) are similar to that reported in this research. The values of crude fibre range from 75.87 to 76.88% reported by Ojebiyi, Aboderin, Shittu and Ogunyeye (2016), 70.07 to 78.17 % by Jiya *et al.*, (2016a) and 74.84 to 76.54 % by Oke *et al*. (2016) are similar to that reported in this research. Palander, Nasi and Jaivinen (2005) explained that apparent crude fibre digestibility increases with age of birds. The values of ash range from 83.32 to 88.90% reported by Oke *et al*. (2016) are similar to that reported in this research.

4.2.5 Chemical Composition of Raw Broiler Chicken Meat and Meat Floss

The ash values of the raw meat ranged from 3.24 to 4.80% and is in conformity with that reported (2.98±0.09%) by Folorunso, Onibi and Bakre, (2014). Abubakar *et al*. (2016) reported crude protein value of raw meat as 15.68 ±0.01 which agrees with the findings (12.01 to 14.37%) of this work. Huss (1988) observed that the chemical composition of animals varies from species

to species as well as from individual animals depending on age, sex, environment and season. Ash in food determines largely the extent to which the dietary minerals would be available in a particular food sample. It also determines the rate at which food substances would make available the amount of energy locked in it (Nwosu, 1979). This implies that birds fed diet containing 2, 800 Kcal/Kg could furnish man with more energy and some viable minerals than the remaining meat sources.

Souza, Faria and Bressan (2011) reported moisture range from 76.15 to 77.23% for chickens type as a function of genetics strains and sex, which was relatively higher than the finding of this study, possible due to difference in the location, where the experiments were sited. Out of the three treatments examined, moisture content was 76.34% in birds fed diet containing 2, 800 Kcal/Kg, 74.27% in birds fed 2, 600 Kcal/Kg and 73.58% in birds fed 2, 400 Kcal/Kg. This result showed that birds fed diet containing 2, 800 Kcal/Kg was the highest in moisture content. Moisture in food determines the keeping qualities of food. It also enhance the rate at which absorption takes place within the digestive system and influences the rate at which enzyme activities take place on the food. The result showed that the meat obtained from birds fed diets containing 2, 800 Kcal/kg will be easily absorbed by the body.

Prasanna and Sahitya (2014) reported fat values from 13.74 ± 18 to 22.39 ± 91, which is similar to that reported in this work. Valsta, Tapanainen and Mannisto (2005) documented that appropriate manipulation with broiler chicken chicken diet could modify fatty acid profile in meat and increase its nutritional value, which is in agreement with the work of Castellini, Mugnai and Dal Bosco (2012), who stated that chemical composition of meat depended on type of the diet. The crude fat determined was 17.25% for birds fed diet containing 2, 400 Kcal/Kg, 16.81% for birds fed 2, 600 Kcal/Kg and 15.28% for birds fed diet containing 2, 800 Kcal/Kg,

which were within the range (3.70 to 18.06%) reported by Ogunmola, Taiwo and Ayankoso (2013). Birds fed diet containing 2, 800 Kcal/Kg has the highest crude fat percentage followed by those fed diet containing 2, 6000 Kcal/Kg and the least value was determined in birds fed diets containing 2, 400 Kcal/Kg, thus, there was progressive decrease in fat content as the energy level increase. Possible reason for the high fat content from broiler chickens fed diet containing 2, 400 Kcal/Kg may be as a result of high feed intake at both starter and finisher stages. Fats play an important role in building the membranes that surround our cells, in helping blood to clot. Also, presence of fat in the right proportion in the body helps the body to absorb certain vitamins and also to prevent the body from extreme cold and heat.

Ash value ranged (5.00 to 6.00%) for chicken meat floss of this study is in conformity with the work of Abubakar, Bube, Adegbola and Oyawoye (2014) who reported 6.2, 6.3 and 7.1% for shredded meat prepared from beef, mutton and chevon, respectively. Similar results (4.87±0.11 to 5.60±0.14) were reported by Bulus and Ibe (2016). Eke *et al.* (2012) reported ash values of 5.76 ± 0.02 (Laboratory *Dambun- Nama*) and 4.90 ± 0.04 (Traditional *Dambun-Nama*) which were within the range (5.00 to 6.00%) obtained in this study. The same authors reported crude protein values of 46.51 ±0.03 (Laboratory *Dambun-Nama*) and 39.19 ± 0.03 (Traditional *Dambun-Nama*) which were similar with the result of this findings. The moisture content of the chicken meat floss obtained in this study was within the range values of intermediate moisture products reported by Ogunsola and Omojola (2008). Differences in moisture content may be related to water holding capacity and lipid content of the samples.

The crude protein range of 46.00 to 49.00% was in agreement with the work of Abubakar *et al*. (2014) who reported 47.1, 51.9 and 58.0% for shredded meat prepared from chevon, beef and mutton, respectively. The same authors reported ether extract values of 24.9, 26.2 and 26.9%

for shredded meat prepared from beef, chevon and mutton, respectively, which was relatively lower (18.67 to 22.00%) with the report of this work and this may be explain due to differences in the species of animals (Huss, 1988). In a separate experiment Abubakar *et al*., (2011) reported that broiler chicken *Dambun-Nama* has 51.0% crude protein, 20.8% ether extract and 6.0% ash which were all similar to the findings of this work.

Proteins are powerful compounds that build and repair tissues; it also helps to maintain the body's structure. Protein speeds up chemical reaction in the body, serves as chemical messenger, fight infection and transport oxygen from the lungs to the body tissue. Poultry broiler chickens have recently been shown to fall into a group of high-protein foods that can help keep post-meal insulin levels within a desirable range (Nwosu *et al.,* 1980). There was noticeable increase in the nutrient profile of the chicken meat floss over their raw counterparts (Tables 14 and 15). The ash increased by 45.83%, 36.50%, 4.00% and the crude protein content by 74.44%, 71.63%, 80.67% while the ether extract increased by 13.75%, 9,97%, 30.55% for the meat floss from birds fed 2 400, 2 600 and 2 800 Kcal/Kg, respectively over their respective raw meat. These indicated that chicken meat floss is a nutrient dense product. The crude protein, ash and ether extract contents of the products were probably a reflection of what was in their corresponding raw meat.

4.2.6 Mineral Composition of Raw Broiler Chicken and Meat Floss

Ogunwole, Obo and Majekodunmi (2014) reported Ca range in raw chicken meat between 29.12 to 33.08 mg/kg which was within the range (23.67 to 50.72 mg/kg) found in this research. The same authors reported significant differences in Ca and K between treatments in the raw meat of broiler chicken chickens. Similar Ca values (30.00 to 39.00 mg/kg) were reported by Asibey (1974). The work of Eniola, Babatunde and Oyelami, (2017) who reported

significant differences in Ca and Fe between treatments in the raw meat of domesticated and Wild Grass-cutter agrees with this finding. The iron content as reported by Asibey (1974) in the raw meat of Wild Grass-cutter (4.36 mg/kg), Domesticated Grass-cutter (3.75 mg/kg), Mutton (3.10 mg/kg) and pork (3.10 mg/kg) were similar to the values obtained in this work.

The Ca, Mg and Na values of raw meat obtained from each treatment in this research is in line with the finding of Yasmine (2009), in her research conducted on Nutrients Composition of Chicken Meat. The Cu value of raw meat obtained from birds fed 2, 400 and 2, 600 Kcal/Kg were similar to the finding of Jokanovic *et al.* (2014) in their research conducted on the Proximate and Minerals Composition of Chickens Giblets from Vojvodina (Northern Serbia). The significant differences ($P<0.05$) between treatments in Ca and Mg values as reported by Ogunwole, Majekodunmi, Olowe and Olumide (2013) was similar to what was reported in this study. The same authors reported Ca values (33.00 to 35.58 mg/kg) which agrees with the findings of this work. Jiya, Ijaiya, Ayanwale, and Olorunsanya, (2016b) reported significant differences ($P<0.05$) in the raw meat of rabbit between treatments in Ca, Mg, Na, K, Cu, Fe and Zn. The same authors reported K values (49.30 to 53.52 mg/kg), which were in conformity with the finding of this work.

Calcium is responsible for strong bones and teeth. It also helps in the transmission of nerves impulses, contractions of muscle, blood clothing, activation of enzyme reactions and secretion of hormone. The Recommended Daily Allowance (RDA) value for Calcium is 50 mg, this indicates that the poultry broiler chickens are very rich in calcium and should be consumed by both young and old people. Calcium in birds fed diet containing 2, 800 Kcal/kg can provide about 81.84% of the daily recommended value.

Similar to other meat species as reported by Jokanovic *et al.* (2014), K was quantitatively the most abundant mineral in poultry meat and the least was copper, which agrees with the findings of this work. Umar and Muhammad (2011) reported K with the highest value (71.75 for raw meat, 60.44 for *Tsire* and 78.06mg/kg for *Balangu*), and Cu having the least value (3.5 for raw meat, 4.3*Tsire* and 5.8 mg/kg *Balangu*). Katarzyna, (2013) reported K with the highest value of 40.00 mg/kg, 39.5 and 42.4 mg/kg at the ages of 35, 38 and 42 days, respectively for poultry breast muscle. The Ca value of meat floss obtained from birds fed 2, 400 Kcal/kg was relatively similar to what was reported by Jokanovic *et al.* (2014).

K is a major intracellular cation and is involved in the osmotic regulation of tissue fluids and in acid-base balance. RDA for K is 65mg, which means broiler chicken chickens fed diet containing 2, 800 Kcal/kg can provide 83.02% of the daily recommended value. An ionic balance exists amongst K, Na, Ca and Mg. K and Na work together in muscle contraction and nerve transmission. Na^+ is the main regulators of extra cellular fluid and volume. Mg is a structural part of bone and is closely associated with Ca, P and vitamin D in bone formation. Mg is one of the activators in phosphorus metabolism. It is also involved in carbohydrate metabolism and plays a major role in the neuromuscular functions of the muscles. Mg helps in supporting the functioning of immune system; assists in preventing dental decay by retaining the calcium in tooth enamel; it has an important role in the synthesis of proteins, fat, nucleic acid, glucose metabolism as well as membrane transport system of cells. The RDA value of magnesium is 42mg; the Magnesium in birds fed diet containing 2, 400 Kcal/Kg can provide 52.38% of the daily recommended value.

Fe, Zn and Cu are trace minerals and exist in similar concentration among the meat products. They play part in digestion and acts as activator to other enzymes. Fe is the central

metal in the haemoglobin molecule for oxygen transport in the blood and is present in myoglobin located in muscles. Other food materials rich in iron include liver, leaf vegetables, beans, egg etc. Fe is an important mineral that is inadequate in the diet of many consumers. The daily requirement of Iron for adults is 8 mg for men and 18 mg for menstruating women to compensate for the losses of iron with the monthly menstrual cycle. The Fe in birds fed diet containing 2, 800 Kcal/Kg has higher value compared to those fed diets containing 2, 400 and 2, 600 Kcal/Kg.

Zn is a structural component of various metabolic enzymes. Most of the Zn in animal's body is contained in the skin, hair and wool. It is vital for wound healing and to keep the immune system strong. The daily requirement for zinc for adults is 41 mg for men and 38 mg for women. Cu, apart from being a catalyst necessary for the absorption of iron, participates in the process of pigmentation and keratinization of hair. It is a structural component of certain proteins and an activator of various metabolic enzymes (Wan Zabri & Wahid, 1985). Copper assists in the formation of haemoglobin, prevention of anemia and involved in several enzymatic actions. The values of all the micro minerals observed for chicken meat floss were significantly ($P<0.05$) higher than in raw meat except Zn in meat floss obtained from birds fed 2, 400 Kcal/kg, were the raw meat has significantly higher Zn value (40.76 mg/kg) compared to 27.62 mg/kg in meat floss. The Fe and Zn values of meat floss obtained from birds fed 2, 400 and 2, 800 Kcal/Kg was similar to the finding of Jokanovic *et al*, (2014).

4.2.7 Microbial Quality of Raw Broiler Chicken Meat and Meat Floss

Microorganisms grow on meat causing visual, textural and organoleptic changes when they release metabolite (Walter & Kundin, 2002). A lot of factors affect the growth of microorganisms on meat. These factors include temperature, pH, water availability, presence of

nutrients, gaseous requirement and atmosphere of storage (Nester, Aderson, Roberts, Pearsall & Nester, 2001). The possible sources of contamination are through slaughtering of sick animals, washing the meat with contaminated water, handling by butchers, contamination by flies, processing close to sewage or refuse dumps environment, addition of contaminated spices, transportation and use of contaminated equipment such as knives and other utensils (Enem & Onyekwodiri, 2015; Igyor & Uma, 2005*)*. Processing operations such as heating, boiling, filtration, freezing, irradiation of finished products, addition of condiment and condition of storage affect both bacterial and fungal loads (Igene, Farouk, & Akanbi, 1990). The slaughtering process affords extensive contamination of sterile tissue with gram-negative enteric bacteria from animal intestine including *Salmonella spp* and *Escherichia coli* as well as contaminant such as gram-positive *cocci* associated with humans, animals and the environment (Nwakanma *et al.*, 2015).

Gilbert and Harrison (2001) reported that the presence of *Staphylococcus spp* on meat samples is as the result of cross contamination from meat handlers during processing, since it is a normal flora of the skin. *Staphylococcus spp* and *Bacillis spp* are abundant in the nose and throat as well as the skin of humans. They can be found in the air and even in the spices and the spores are heat resistant (Samuel *et al.,* 2015), in a related work Dineen, Emori and Harley (1999) showed that coliforms are introduced from the water used for washing the meat, this is also in agreement with the report of Umoh (2004) that the presence of *Escherichia coli* arises from the use of non portable water during washing of raw meat.

The microbial load obtained in the current study (1.10-7.00 x 10^4 cfu/g) could be compared to what had been reported locally: 2.88 x 10^2 – 9.49 x 10^3 (cfu/g) by Abubakar *et al*., (2014) for *Dambun-Nama*, 7.00 x 10^2 – 1.71 x 10^4 cfu /g by Uzeh *et al.*, (2006) for *tsire suya*,

3.30 x 10^4 cfu /g for processed ready to eat beef by Ologhobo, Omojola, Ofongo, Moiforay and Jibir (2010), 7.00 x 10^3- 2.22 x10^5 cfu/g for ready to eat *suya* by Edema, Osho and Diala, (2008), 3.70 x 10^5 – 2.40 x 10^6 cfu/g by Inyang, Igyor and Uma, (2005), 7.40 x 10^4 cfu/g by Chukwu and Imodiboh, (2009) and 8.00 x 10^5 cfu/g by Shamsuddeen and Oyeyi, (2008), all these fell within the safe limits of 10^7 cfu/ g specified for meat products by the ICMSF (1978). On the contrary Salihu *et al*. (2010) obtained total mesophilic aerobic bacteria count of 4.50 x 10^9 cfu/ g on traditionally prepared *Dambun -Nama* sold in Sokoto and concluded that the product (*Dambun-Nama)* was unsafe and constitutes a food safety risk to the numerous ever-increasing consumers.

Manyi, Idu and Ogbonna, (2014) isolated *Escherichia coli*, *Staphylococcus aureus*, *Klebsiella spp*, *Streptococcus spp*, *Bacillus spp* and *Pseudomonas* spp from Suya (roasted beef) sold in Makurdi, Benue State, Nigeria. High prevalence of *E. coli* in retail meat market had also been reported by Kumar, Ottu and Karunasagar, (2001). Isolation of *Bacillus*, *Streptococcus*, *Staphylococcus*, *Proteus*, *Aureus* and Yeast were reported from beef and pork *kilishi* subjected to different packaging media (Ogunsola & Omojola, 2008). Similarly Abubakar *et al*., (2011) isolated four fungal species (*Aspergillus niger, Aspergillus fumigatus, Rhizophus nigricans* and *Hansenula anomala)* after seven days storage of meat products at ambient temperature. Other workers such as Ologhobo *et al*., (2010) and Salihu *et al*., (2010) have also reported that meat products sold in Nigeria were contaminated with various species of bacteria and fungi.

The microbial load obtained in the current study (4.53–8.30 x 10^4 cfu/g) fell within the safe limits of 10^7cfu/ g specified for meat products by the ICMSF, (1978). Inyang *et al*. (2005) advocated that appropriate packaging of meat products to eliminate air and subsequently lengthen the shelf life is indispensable. Care should be taken to avoid raw meat from being

contaminated by harmful microbes before, during and after processing, because their spores are known to endure heat treatment, so as to ensure delivery of safety meat products to consumers.

4.2.8 Effect of Period, Energy Level and Packaging Material on Sensory Parameters of Meat Floss

James (1993) stated that colour has a powerful influence on consumer acceptance for food products especially meat product and serves as a visual indication of meat quality. In addition, the colour of meat floss is always enhanced by the use of red pepper. Consumers often based their meat purchasing decisions on colour but usually make repeat purchase based on product flavor and texture (Schilling, Behrends, Williams & Jackson 2009). In a fresh muscle, the colour of meat is related to the level of pigmentation (myoglobin) present in the muscle, when meat is processed however, it changes the characteristics of fresh meat. In meat floss production, a colour change is a result of the frying process and the use of plant ingredients, giving it a final golden brown colour.

Apata *et al*. (2014) reported that chicken meat packaged in Polyvinyl Chloride had the highest sensory scores followed by those packaged in polythene bags and A4 paper wrappers while those packaged with cartons had the least. In a related experiment Bashir *et al*., (2017) reported juiciness sensory scores of 7.70, 6.90, 6.75, 7.35 and 7.20 for broiler chicken, spent layers, duck, guinea fowl and local chicken respetively, which were within the values obtained in this study. Juiciness is made up of two effects viz the impression of moisture released during chewing and the salivation produced by flavour factor (Omojola, Isah, Adewumi, Ogunsola & Attah, 2003).

According to Moloney (1999), meat juiciness is an important component of meat tenderness and palatability and it has two major components; the first is the impression of

wetness produced by the release of fluid from the meat during the first few chews, while the second is the more sustained juiciness that apparently results from the stimulating effect of fat on the production of saliva and the coating of fat that builds up in the tongue, teeth and other parts of the mouth. Juiciness is an important factor in sensory evaluation as it facilitates the chewing process as well as brings the flavour component in contact with the taste buds (Miller, Hower, Cook, Guerra & Huffman, 1995), it depends on the raw meat quality and the cooking procedure (Miller *et al*., 1995). The two sensory descriptive words for juiciness, in cooked meat, are initial and sustained juiciness (Lyon & Lyon, 1989); Initial juiciness is the amount of fluid released by the cut surface of meat, during compression between the forefingers and thumbs (AMSA, 1995) and is positively correlated with the water holding capacity of meat (Offer & Trinick, 1983). Sustained juiciness is described as the perceived juiciness after a few seconds of mastication, due to the presence of intramuscular fat stimulating saliva secretion (Lawrie, 1998).

Bashir *et al*. (2017) reported the sensory scores for flavour of meat floss from local chicken (8.05) and poultry broiler chicken (7.55) which were similar to the finding of this study. Similar results were reported by Abubakar *et al.* (2014) on the flavour of *dambu* from different types of livestock as 7.8, 7.7 and 7.7 for beef meat floss, mutton meat floss and chevon meat floss, respectively. According to Ihekoronye and Ngoddy (1985) flavour, texture and appearance (colour) are the most important characteristics of food because they are the attributes the consumer can readily assess. They reported that flavour determines the acceptance or rejection of food by consumers even though appearance evokes the initial response. They define flavour as a complex sensation that is derived from food including particularly the sensation of taste and smell.

Safari, Fogarty, Ferrier, Hopkins and Gilmour (2001) stated that flavour characteristics are difficult to measure with consumer because their vocabulary is insufficient to describe the complex flavor found in most meat products. Physiologically, the perception of flavour involves the detection of four basic sensations including saltiness, sweetness, sourness and bitterness by the nerve endings on the surface of tongue (Forrest *et al*., 1975). The several spices used in meat floss production also added to the flavour of the product (Moloney, 1999).

Omojola (2008) conducted an experiment on yield and organoleptic characteristics of *Suya* prepared from three different muscles of a matured bull and reported the textural test panelists scores of 6.75± 0.57, 4.88 ± 0.69 and 4.50 ± 0.46 for semimembranosus, bicep femoris and psoas major muscles, respectively.The results of the taste panelists contradict the present study probably because of the effect of spices on meat texture or due to differences in the type of animal used. McMillin (2005) reported that age, breed and diet influence textural, tenderness, juiciness and flavour of meat. In a related experiment, Sogunle *et al.* (2010) reported tenderness scores between 6.47±0.43 to 7.23±0.42 from meat of two different strains of broiler chicken chickens, which agrees with the finding of this result.

Moloney (1999) defined tenderness of meat as the sensory manifestation of the structure of meat and the manner in which this structure reacts to the force applied during biting and the specific senses involved in eating. The most important contributing sensory attributes to eating quality are tenderness, flavor and juiciness (Safari *et al*., 2001). Tenderness is defined as the ease of mastication, which involves initial penetration by the teeth, the breakdown of meat into fragments and the amount of residue remaining after chewing (Lawrie, 1998). It is an integrated textural property composed of mechanical and chemical components. The mechanical characteristics include hardness, cohesiveness, elasticity, grittiness and fibrousness while the

chemical characteristics include juiciness and oiliness (Brewer & Novakofski, 2008). Tenderness has also been shown to depend positively upon intramuscular fat (Aaslyng & Støier 2004).

The ranged for overall acceptability in this study (5.50 to 8.80) was relatively higher with that reported by Muhammad and Muhammad (2007) who documented panelist score ranged between 6.10 to 7.40, this may possibly be due to differences in the type of meat product. The result obtained for the overall acceptability indicated that the consumers prefer freshly prepared meat floss as against those that were stored for a longer period.

Generally all the products were acceptable as panelists score them very high, this is similar with the findings of Muhammad and Muhammad (2007) and Abubakar *et al*. (2011). The values reported in this study were higher than those (2.33 to 4.47) reported by Ogunsola and Omojola (2008), they were also higher than values obtained by Omojola (2008) which ranged from 1.90 to 6.00. Consumers often based their meat purchasing decisions on appearance but usually make repeat purchase based on product flavor and texture (Schilling *et al*., 2009). The ranged for overall acceptability in this study (6.77 to 7.56) was similar with that of Muhammad and Muhammad (2007) who reported an overall acceptability range from 6.10 to 7.40. Similar result was reported by Abubakar *et al.* (2011) on the flavour of *dambu* from the different species of poultry. Apata *et al*. (2014) reported that chicken meat packaged in polyvinyl chloride had the highest sensory scores followed by those packaged with polythene bags and A4 paper wrappers while those packaged with cartons had the least.

CHAPTER FIVE

5.0 SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 SUMMARY

The experimental research was sited at the poultry demonstration farm of the Department of Animal Health and Production, Binyaminu Usman Polytechnic Hadejia to evaluate the Quality of meat floss (*Dambun-Nama*) prepared from broiler chickens fed diets with varying energy levels and to assess the effect of packaging materials on the microbial quality and sensory evaluation of the meat floss. Three experimental diets (A, B and C) containing three energy levels of 2, 400 (A), 2, 600 (B) and 2, 800 Kcal/Kg (C) were formulated and fed to the chickens which were allotted into three treatments of ninety birds each with three replications.. The crude protein of the Starter and Finisher diets were fixed at 24 and 20%, respectively. Nutrient digestibility, performance, blood chemistry and carcass characteristics of the birds were determined at the end of the feeding trial. In the 8^{th} week, the birds were slaughtered and the meat was prepared into floss. The chemical composition, effect of packaging materials, microbial quality and sensory parameters of the floss were evaluated in a 3x4x6 factorial experiment. The data collected was analysed in a one way analysis of variance.

The results showed that feed intake decreased as the energy value of the feed increased. The values for haematological parameters were significantly ($P<0.05$) higher for birds fed diet of 2,400 Kcal/kg. The wing weight, drumstick and liver expressed as a percentage of live-weight were significantly ($P<0.05$) higher for broiler chickens fed 2,400 and 2,600 Kcal/Kg. Meat floss of broiler chickens fed 2,800 Kcal/kg had the highest mean values of moisture (7.41%), crude protein (49.00%) and ether extract (22.00%). The minerals composition of meat floss of birds fed diet containing 2,800 Kcal/kg had the highest values of Na (44.69 mg/kg), K (58.81 mg/kg), Fe

(14.25 mg/kg) and Zn (25.74 mg/kg). Microbial quality assessment indicated the presence of *Staphylococcus aureus* (1.20-2.00 $X10^4$ cfu/g) and *Escherichia coli* (2.70-3.00 x 10^4 cfu/g) in the meat. Meat floss packaged in polyvinyl chloride had higher overall acceptability values. There was decrease in overall acceptability rating with increase period of storage for the energy levels.

5.2 CONCLUSION

It was concluded that feed intake decreased as the energy value of the feed increased, raw meat and meat floss of broiler chickens fed diets containing 2, 800 Kcal/Kg had highest values of moisture, ether extract, Na, K and Fe.

5.3 RECOMMENDATIONS

The study recommended the followings:

- Low energy diets should be formulated for broiler chickens at both starter and finisher stages with no detrimental effects on the physiological and metabolic functions of the birds.
- The use of diet containing 2, 800 Kcal/kg should be used to prepare meat floss.
- The use of Aluminium foil to package meat floss as it has the least bacterial and fungal load.
- Meat floss should be consumed immediately after production as its scores for sensory parameters decreases with increase in storage period.

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