QUALITY OF *DAMBUN NAMA* PREPARED FROM BROILER CHICKENS FED DIETS CONTAINING MORINGA (*Moringa oleifera*) AND SABARA (*Guiera senegalensis*) LEAF MEALS

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A THESIS SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY , IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF DOCTOR OF PHILOSOPHY IN ANIMAL SCIENCE

DEPARTMENT OF ANIMAL SCIENCE,
FACULTY OF AGRICULTURE,
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ZARIA, NIGERIA

DECEMBER, 2021

DECLARATION

I hereby declare that the work in this thesis entitled ‘‘**QUALITY OF *DAMBUN NAMA* PREPARED FROM BROILER CHICKENS FED DIETS CONTAINING MORINGA (*Moringa oleifera*) AND SABARA (*Guiera senegalensis*) LEAF MEALS’’** was carried out by me in the Department of Animal Science under the supervision of Prof. M. Jibir, late Prof S. Duru and Prof. S. B. Abdu.

The information derived from literature has been duly acknowledged in the text and a list of references provided. No part of this thesis was previously presented for another degree or diploma at any university.

………………….. …….. **………………………………..**
Balarabe, Safiya **Date**

CERTIFICATION

This thesis entitled ‘‘**QUALITY OF *DAMBUN NAMA* PREPARED FROM BROILER CHICKENS FED DIETS CONTAINING MORINGA (*Moringa oleifera*) AND SABARA (*Guiera senegalensis*) LEAF MEALS’’** by BALARABE Safiya meets the regulations governing the award of the degree of Doctor of Philosophy of Ahmadu Bello University, Zaria, and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This thesis is dedicated to Almighty Allah (SWT), for sparing my life in good health.

ABSTRACT

Studies were conducted to evaluate quality of *dambun nama* prepared from broiler chickens fed diets containing graded levels of *Moringa oleifera* (MOL) and *Guiera senegalensis* (GSL) leaf meals. The experiments were carried out at the Research Farm, Department of Animal Science and at the Department of Veterinary Microbiology, Ahmadu Bello University, Zaria. A total of two hundred and forty (240) day old broiler chicks of Cobb 500 strain were used for each of the two experiments (MOL and GSL) concurrently. In Experiment 1a, two hundred and forty (240) day old broiler chicks were allotted into four graded levels of MOL at 0, 7, 14 and 21% to serve as treatments MOL1, MOL2, MOL3 and MOL4, respectively. The birds were replicated three (3) times with 20 chicks per replicate in a Completely Randomized Design. In Experiment 1b, MOL was substituted with GSL for GSL1, GSL2, GSL3 and GSL4. The two experiments lasted for 8 weeks. The results revealed that growth performance such as initial weight, final weight gain, feed intake, average daily feed intake and average daily weight gain did not differ significantly among the four treatments from birds in MOL. However, feed conversion ratio was significantly ($P<0.01$) different among the treatments, where MOL1, MOL2 and MOL3 differed significantly ($P<0.01$) with treatment MOL4; values being 2.97, 2.88, 2.83, 2.43. The result on growth parameters such as initial weight, final weight, weight gain, average daily weight gain and feed conversion ratio were not significantly different across the treatment groups (GSL1, GSL2, GSL3 and GSL4). Other growth traits (feed intake, average daily feed intake and mortality) were significantly ($P<0.05$) different among the treatment groups (GSL1; 5332.40g than in GSL2; 4698.20g, GSL3; 4731.50g and GSL4; 4536.70g. Similarly, average daily feed intake was higher ($P<0.05$) in GSL1 (95.22g) than GSL2 (83.89g) and GSL3 (84.47g) and GSL4 (81.01g). However, the results dry matter, lipid, crude protein, ash and carbohydrate) of both fresh meat and *dambun nama* processed from broiler chickens were significantly ($P < 0.05$) differed across the treatments (MOL and GSL). There were significant ($P < 0.05$) differences among sensory attributes of both MOL and GSL *dambun nama* across treatments. However, the storage quality of *dambun nama* from MOL and GSL exhibited variations in their total fungal and bacterial growth over the 12-week storage periods. The growth (cfu/g x 10^5) of microbes measured in *dambun nama* decreased with the increase in concentrations of both MOL and GSL. Among, the packaging media studied; foil paper pack (FPP), wrapped newspaper pack (WNP), plastic container pack (PCP) and disposable container pack (DCP) had low counts of total microbial load in *dambun nama* stored up to 12 weeks. The study concluded that incorporation of MOL and GSL in the diet of broiler chickens up to 21% had no deleterious effects on growth performance, carcass characteristics and chemical composition of both fresh meat and meat floss of broiler chickens. *Dambun nama* was liked very much by the sensory panelists. The packaging media (FPP, WNP, PCP and DCP) had significant effects on microbial load, with PCP and WNP being more effective. It is recommended that MOL and GSL be included in broiler chicken diets up to 21% for improved meat quality. *Dambun nama* from broiler chickens fed diets containing graded levels of MOL and GSL should be stored above the 12- weeks period for further investigation on sensory attributes for its overall acceptance, shelf-life and quality.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Poultry occupies a unique position in the livestock sub-sector of the Nigerian economy because they are good converters of feed, and the best solution to Nigeria's protein intake particularly from animal origin is to increase poultry production (Udedibie *et al.,* 2007). Broiler chicken meat is one of the nutritious meats consumed as component of human diets. It is an excellent source of high quality protein and also contains large amount of minerals and essential vitamins, as well as fats (Ojewola and Onwuka, 2001). Broiler chicken meat is usually an expensive item in the Nigerian diets, however, a small quantity of meat can greatly improve a meal as the protein will supplement the vegetable protein and a balanced meal will be provided (Ojewola and Onwuka, 2001). Consumers are rather conservative and conscious in accepting new ingredients and products, and they prefer to look for new benefits in more or less familiar products (Jongen and Meulenbery, 2005).

Innovations in food technology play a crucial role in translating nutritional information into consumer products to produce new healthy food ingredients and added specific nutrient or functional ingredients (Hsieh and Ofori, 2007). Meat quality is the key criterion of food product evaluation, whereas shelf-life has a direct impact on quality changes. The shelf life of poultry meat is determined by processing, distribution and storage conditions in both retail stores and households. The procedures applied throughout production process, including packaging, should ensure the preservation of quality and safety of food until the best-before date as indicated on each package (EU No 1169/2011). Meat preservation is more difficult than other kinds of food as it may result in oxidative rancidity, discolouration, mouldiness, off-flavour and sliminess (Gandi *et al*., 2014). FAO (1995) reported that meat processing enables the processor to convert low-priced meat cut into high-priced product. It has also been shown that processing of meat to products facilitates the packaging, handling, distribution and marketing of the products (Omojola *et al*., 2004). Plant leaves and extracts as antioxidants have been reported to combat oxidative stress (Tanuj *et al*., 2016). These natural plant leaves (*Moringa oleifera*) extract improved meat quality and its nutritional value. Natural antioxidants have been found in various substances with different chemical characteristics, which are widely present in plants.

Moringa oleifera Lam. belongs to the family *Moringaceae* which is native to the Indian subcontinent and has become naturalized in the tropical and subtropical areas around the world (Iqbal and Bhanger, 2006). *Moringa* is adaptable to a wide range of environmental conditions such as hot, dry and wet conditions (Anwar *et al*., 2007). In India, it is cultivated in large scale in nurseries and orchards. The leaves, seed, flowers, pods (fruits), bark and roots are all seen as a vegetable and consumed by humans throughout the century in diverse culinary ways for their nutritional value, purported medicinal properties and industrial purposes (Iqbal and Bhanger, 2006; Khalafalla *et al.*, 2010). A diet supplemented with *M. oleifera* product could have unique nutrients and a vast array of bioactive constituents of varying polarity for feeding and nourishing the immune system, thereby alleviating most of the nutrition based diseases (Ashfaq *et al.*, 2012).

Another important plant is *Guiera senegalensis* (family: *Combretaceae*) *sabara* (in Hausa Language) is a shrub of the Savannah region of West and Central Africa. *G. senegalensis* is being widely used in traditional medicine for the remedy of many ailments and diseases. The leaf extract is used in the treatment of dysentery, diarrhoea, gastrointestinal pain and disorder, rheumatism and fever (Sule and Mohammed, 2006). This leaf can be used in meat preservation in order to reduce the prevalence of food borne diseases. In addition, partially purified anthocyanin fraction from leaf extract of *G. senegalensis* has been shown to possess antioxidant property against induced oxidative stress in rats (Sule and Mohammed, 2006). However, *G. senegalensis* has also been shown to contain alkaloids, tannins, flavonoids, amino acids, ascorbic acid and anthraquinones and also displays antimicrobial activities (Sule *et al*., 2001).

Processing of meat products aids in the production of value added varieties and conventional meat products to meet the current life style requiremeants, and offers better utilization of different carcasses, cuts and edible by products with different flavours and increases the shelf life of the products (Anjeneyulu *et al*., 2007). Processing of meat facilitates incorporation of non meat ingredients for quality and economy. It also helps in preservation, transportation, distribution and marketing to larger populations (Anjeneyulu *et al*., 2007).

Dambun nama is a dried meat product produced mainly by Hausas and Fulanis in Northern part of Nigeria (Ogunsola and Omojola, 2008; Eke *et al*., 2013). The meat floss is processed by cooking, pounding and then fried with addition of spices (Bube 2003). Due to its low moisture content, meat floss can be kept without refrigeration and will not drastically change at room temperature for long storage period of time (Huda *et al.*, 2012). Most meat floss come from beef, mutton or camel, however, the use of meat from poultry and fish is becoming popular among consumers (Eke *et al*., 2013).

1.2 Problem Statement

The main objection to consumption of locally processed meat products lies with the poor sanitary conditions that are associated with the production and handling processes (Balarabe *et al.*, 2016a). The methods of meat preservation are major challenges among meat consumers, handlers and entrepreneurs. Handling and storage methods are primarily concerned with minimizing microbial contamination and retarding microbial growth (Benjakul *et al*, 1999). However, it is a common practice that after slaughter the animals' meat product is consumed almost immediately without further processing (Steinhauster *et al.*, 1995). In Nigeria, meat processing is still in its technological infancy because the processing methods that have been in use for the past generations are yet to be standardized or modernized to cope with increasing consumer demand (Igene and Mohammed, 1983; Balarabe *et al*., 2016a). The major problem with traditional meat processing industries is lack of standardization required of the finished products (Abubakar *et al*., 2011). Therefore, processing method varies depending on the processor and the quality of the finished products (Farouk *et al*., 1992). In Nigeria, meat is processed traditionally into local products without recourse to quality control, into a variety of products such as *kilishi, balangu, tsire, tukunya, pomo, ganda* and *dambun nama*s. Balarabe *et al*. (2016b, 2016c) reported that standardization of production processes of meat products improved shelf life and keeping quality.

1.3 Justification of the Study

The current tremendous changes of meat supply in Nigeria have made supermarket systems to organize the supply of pre-packed meat cuts in standard qualities especially for the elites in the society which makes the peasants and the have-nots finding ways of solving their own problems (Ojewola and Onwuka, 2001). However, the local meat industry in the country is still traditional and the production processes are usually done in an un-hygienic manner which results in product adulteration and contaminations. Local meat products processed in this manner are prone to microbial contamination resulting in quality deterioration in storage and source of infection to consumers (Bube, 2003). There is the need to standardize the production processes of these local meat products in order to enhance their shelf-life and production of wholesome meat products. It is also important to explore the use of local materials that have the potential of enhancing meat quality in storage quality.

There is currently high consumer health concern in the use of synthetic antioxidants in food industry such as butylated hydroxyanisole (BHA) butylated hydroxyl toluene (B.H.T) and tertiary butyl hydroquinone (B.H.Q) (Oshibanjo *et al.,* 2019) which are used to retard oxidative deterioration in food products. Though, these synthetic antioxidants slow oxidation and increase the shelf life of meat products, consumers have rejected them because of their risk of carcinogenicity (Oshibanjo *et al.*, 2019).

However, natural antioxidants especially of plant source have greater application for consumer acceptability, palatability and increase shelf life of meat products and could improve the nutritional quality of the product too (Oshibanjo *et al*,. 2019). *Moringa oleifera* and *Guiera senegalenses* are among such plants. This, therefore, triggered the current interest for using natural plants as ingredients in the feed of broiler chickens and further processing of the chicken meat into meat floss, to reduce lipid oxidative degradation, which deteriorates the quality of meat and reduces its shelf life. There is limited report on the bioactive constituents of *Moringa oleifera* and *Guiera senegalensis* leaves and their impact on broiler meat antioxidant status (Hassan *et al.* 2016). Previous studies using *Moringa oleifera* and *Guiera senegalensis* leaves were reported to have some positive effects on storage of meat floss (*Dambun nama*) (Balarabe *et al.*, 2016c, 2016d; Salisu, 2017). These earlier studies were mostly on the suppression of microbial (fungal and bacterial) activities. Balarabe *et al.* (2016b, 2016c) used leaf powder at 3.0g/100ml of water in cooking of beef, mutton, chevon, camel and broiler chicken meat to process meat floss (D*ambun nama*) and examined their effects on shelf-life and storage quality over a 5 - week period. Furthermore, Salisu (2017) investigated the inclusion levels of 2.0, 3.0 and 4.0g/100 ml of water in cooking of beef to process meat floss (*Dambun nama*) on the shelf-life and storage quality for up to 12 week period.

However, the limitation of the earlier studies was in the manner of incorporation of these leaf extracts (*Moringa* and *Guiera*), which were only used during cooking processes of meat to process meat floss (*Dambun nama*), but not used as dietary components in feed of broiler chickens, and subsequent evaluation of the raw meat and procesed meat (*Dambun nama*) products. Therefore, there is the need to investigate the effects of dietary utilization of these leaf meals in broiler chickens diet and processing of the raw meat into *dambun nama* for assessment of shelf life and quality.

1.4 Objectives of the Study

The broad objective of this study was to evaluate the effects of dietary levels of *Moringa oliefera* and *Guiera senegalensis* leaf meals on broiler chicken performance and meat quality.

However, the specific objectives were to determine:

a. Growth performance and organ characteristics of broiler chickens fed diets containing graded levels of *Moringa oliefera* and *Guiera senegalensis* leaf meals.
b. Chemical composition of both fresh broiler chicken meat and *dambun nama* processed from broiler chickens fed diets containing graded levels of *Moringa oliefera* and *Guiera senegalensis* leaf meals.
c. Sensory evaluation/organoleptic properties of *dambun nama* processed from broiler chickens fed diets containing graded levels of *Moringa oliefera* and *Guiera senegalensis* leaf meals.
d. The shelf-life and storage media of *dambun nama* processed from broiler chickens fed diets containing graded levels of *Moringa oliefera* and *Guiera senegalensis* leaf meals over a 3 month period.

1.5 Research Hypotheses

Ho: There are no significant differences in growth performance and organ characteristics of broiler chickens fed diets containing graded levels of *Moringa oliefera* and *Guiera senegalensis* leaf meals.

Ho: There are no significant differences in chemical composition of both fresh broiler chicken meat and *dambun nama* processed from broiler chickens fed diets containing graded levels of *Moringa oliefera* and *Guiera senegalensis* leaf meals.

Ho: There are no significant differences in sensory attributes of *dambun nama* processed from broiler chickens fed diets containing graded levels of *Moringa oliefera* and *Guiera senegalensis* leaf meals.

Ho: There are no significant differences in the shelf-life and storage media of *dambun nama* processed from broiler chickens fed diets containing graded of *Moringa oliefera* and *Guiera senegalensis* leaf meals over a 3 - month period.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 *Moringa oleifera (Zogale)*

Moringa oleifera Lam. belongs to the family *Moringaceae* which is native to the Indian subcontinent and has become naturalized in the tropical and subtropical areas around the world, and it belongs to one of the 14 species of the family *Moringaceae* (Iqbal and Bhanger, 2006). *Moringa* is adaptable to a wide range of environmental conditions such as hot, dry and wet conditions (Anwar *et al*., 2007). In India, it is cultivated on a large scale in nurseries and orchards. The leaves, seed, flowers, pods (fruits), bark and roots are all seen as a vegetable and consumed by humans throughout the century in diverse culinary ways for its nutritional value, purported medicinal properties and industrial purposes (Iqbal and Bhanger, 2006; Khalafalla *et al.,* 2010). Hassan *et al* (2016) reported that *Moringa* leaves are said to contain natural antioxidants and phytochemicals (saponins, flavonoids, steroids, alkaloids, vitamins, folic acids, carbohydrates, proteins etc). Natural antioxidants have been found in various substances with different chemical characteristics, which are widely present in plants. Antioxidants are capable of retarding or inhibiting oxidation of other substances by inhibiting the initiation or propagation of oxidizing chain reactions (Velasco and Williams, 2011). The food system balanced with *M. oleifera* could have unique nutrients and a vast array of bioactive constituents of varying polarity for feeding and nourishing the immune system, thereby alleviating most of the nutrition based diseases (Ashfaq *et al.,* 2012).

However, FAO (2014) and Rabiu (2020) reported that *moringa* leaves are also eaten as a salad or dried and ground to make a very nutritious leaf powder. The *Moringa* leaf powder is used to aid the restoration of infants suffering from malnutrition. *Moringa* flowers are used to make tea, added into sauces or made into a paste and fried. The young pods are prepared, and taste like asparagus. Older pods can be added to sauces and curries in which their bitterness is appreciated (Bosch *et al.,* 2004; Orwa *et al.,* 2009). The immature seeds can be cooked in many different ways while the mature seeds are roasted and eaten. Yu *et al.,* (2005) and FAO (2014) have shown that *moringa* seeds contain about 30-40% of an edible oil (ben oil), which is used for salad dressing and cooking, and can replace olive oil. Ben oil is resistant to rancidity and provides substantial amounts of oleic acid, sterols and tocopherols. Medicinally, Rabiu (2020) reviewed that virtually all parts of the tree have been utilized within traditional medical specialty practices and the oil is applied externally for skin diseases (Foidl *et al*., 2001; Rabiu, 2020). *Moringa* species are well documented plant herbs due to their extraordinary nutritional and medicinal properties. They have long been known in folk medicine as having value in treating a wide variety of ailments (Rabiu, 2020). They are known to be anti-helminthic, antibiotic, detoxifiers, immune builders and have been used to treat malaria. *Moringa* seeds contain pterygospermin, a potent antibiotic and fungicide effective against *Staphylococcus aureus* and *Pseudomonas aeruginosa* (Thilza *et al.,* 2010). Moreover, Rabiu (2020) reported that *Moringa* oil has various industrial applications. It is used in the perfume industry, as it readily retains its fragrance and is not prone to rancidity, and in the manufacture of paints and lubricants. Rashida *et al.* (2008) stated that *Moringa* oil has qualities needed for a biodiesel feedstock while *moringa* bark is a source of dye. The cake resulting from seed oil extraction contains about 1% of flocculent proteins that bind mineral particles and organic material in the purification of drinking water. These proteins are also used to assist the sedimentation of fibres in the juice and beer industries (Rabiu, 2020).

Moyo *et al*. (2014) reported that supplementing cross-bred Xhosa breed lop-eared goats with *Moringa oleifera* leaf meal produced chevon with higher meat quality attributes, improved lightness (L*) redness (a*) values. Warner-Bratzler shear force and higher sensory consumer scores compared with the control group. Mukumbo *et al.* (2014) reported that the inclusion of *moringa* leaf meal (2.5, 5.0 and 7.5%) in finisher pig feed, had no detrimental effects on carcass characteristics of physico-chemical meat quality, and it significantly improved the acceptability of pork colour, odour and lipid profile.

2.1.1: Anti-nutrient factors in Moringa leaves

Anti-nutritional factors are compounds mainly organic, which, when present in a diet, may affect the health of the animal or interfere with normal feed utilization. Anti-nutritional factors may occur as natural constituents of plant and animal feeds, as artificial factors added during processing or as contaminants of the ecosystem (Barnes and Amega, 1984). Ingestion of feed containing such substances induce, in some cases, chronic intoxication and in others interferes with the digestion and utilization of dietary protein and carbohydrate and also interferes with the availability of some minerals, thus feed efficiency and growth rate and, consequently, the production of the edible products. Although anti-nutritional factors are present in many conventional feeds, they are more common in most of the non-conventional feeds (Nityanand, 1997).

Anti-nutritional factors are classified as tannins, phytates, trypsin inhibitors, saponins, oxalates and low levels of cyanide. Phytate is an organically bound form of phosphorus in plants. Phytates in foods bind with essential minerals such as calcium, iron, magnesium and zinc in the digestive tract, resulting in mineral deficiencies (Bello *et al*., 2008). They bind minerals to form insoluble salts, thereby decreasing their bioavailability or absorption (Guil and Isasa, 1997; Muhammad *et al.*, 2011). Tannins are plant polyphenols, which have the ability to form complexes with metal ions and with macro-molecules such as proteins and polysaccharides (De-Bruyne *et al*., 1999; Dei *et al*., 2007). Dietary tannins reduce feed efficiency and weight gain in chicks (Dei *et al*., 2007).

Saponins are glycosides, which are steroid saponins and triterpenoid saponins (Dei *et al*., 2007). High levels of saponins in feed adversely affect intake and growth rate in poultry (Potter *et al*., 1993; Dei *et al*., 2007). Saponins, in excess, cause hypocholestrolaemia because they bind with cholesterol, making it unavailable for absorption (Soetan and Oyewole, 2009). Saponin-protein complex formation reduces protein digestibility (Potter *et al*., 1993). Du *et al.* (2007) observed no significant difference in growth performance of 3 weeks old broiler chickens (Arbor Acres) that were fed on diets supplemented with 5, 10, 20 and 30 g/kg levels of *M. oleifera* meal.

Trypsin inhibitor inhibits trypsin and chymotrypsin, which play roles in digestion of protein in broiler chickens. The levels of these anti-nutrients and cyanide detected in the Moringa leaves are low compare to the seeds. Soaking of plant materials or boiling in water is said to reduce toxic effects and improve feed intake and protein digestibility (Okai *et al.,* 1995; Dei *et al.,* 2007).

Nworgu and Fasogbon (2007) observed no mortality when pullet chicks were fed on diets containing different levels of *C. pubescens* leaf meal. A possible explanation for the absence of mortality in chicks might be due to the presence of antioxidants in Moringa leaves, which enhance the immune system of animals (Yang *et al*., 2006; Du *et al.,* 2007). Moreover, Moringa leaf extracts exhibited anti-microbial activity, including inhibition of the growth of *Staphylococcus aureus* strains isolated from feed and animal intestines.

2.2 *Guiera senegalensis (Sabara)*

Guiera senegalensis (family: *Combretaceae*) commonly known as *sabara* in Hausa Language is a shrub of the Savannah region of West and Central Africa. *G. senegalensis* is being widely used in traditional medicine for the remedy of many ailments/diseases. The leaf extract is used against dysentery, diarrhoea, gastrointestinal pain and disorder, rheumatism and fever (Sule and Mohammed, 2006), which when used in meat preservation could probably reduce the prevalence of food borne diseases. In addition, partially purified anthocyanin fraction from leaf extract of *G. senegalensis* has been shown to possess antioxidant property against oxidative stress in rats (Sule and Mohammed, 2006). However, *G. senegalensis* has been shown to positively contain alkaloids, tannins, flavonoids, amino acids, ascorbic acid, and anthraquinones and also displayed antimicrobial activities (Sule *et al*., 2001).

Shafei *et al.* (2016) reviewed the significance of *Guiera senegalensis*; a traditional medicinal plant that grows well in sub-Saharan Africa and Sudan which has been used for research because of its perceived medicinal properties. Shafei *et al.* (2016) reported that evaluation of compounds such as, tannins, alkaloids, flavonoids saponins, terpenoids and phenols have been used as a method of screening of medicinal plants. *Guiera senegalensis* has been used in Western Kourdofan of Sudan and elsewhere in traditional medicine as a cure for infections and wounds (Shafei *et al.*, 2016).

In Sudan, *Guiera senegalensis* is locally known as Ghubaysh of which the leaf extract and the root powder are used for treatments of a variety of wounds and diseases (Shafei *et al.*, 2016). It was also reported that the leaf extract has been used for treating jaundice, representing more than 51.5% of conditions treated; and 48.5% of the other diseases that include diabetes mellitus, hypertension, cough, arthritis, enteritis, diarrhea and malaria (Shafei *et al.*, 2016). These workers reported that majority of people they surveyed used root powder of *Guiera senegalensis* for the treatment of wounds, including wounds resulting from diabetes, and inflammation of skin and injuries. *Guiera senegalensis* extract was also used in folk medicine against leprosy, fever, and was helpful against increased blood pressure and high blood sugar levels (Shafei *et al.*, 2016).

The importance of *Guiera senegalensis* in traditional medicine became more apparent with the recent increase in fungal infections in Africa, and elsewhere (Shafei *et al.*, 2016). Extracts from leaves, shoots and galls of *Guiera senegalensis* are useful against bacteria and fungi infections in Burkinabe folk medicine (Nacoulma, 1996). These antimicrobial properties were credited to the crude methanolic extracts of *Guiera senegalensis* (Shafei *et al*., 2016).

2.2.1: Anti-nutrient factors in *Guiera senegalensis (Sabara)* leaves

Medicinal plants, such as *Guiera senegalensis*, are expected to be a valuable source for a variety of drugs, no wonder that 80% of individuals from developed countries use traditional medicines extracted from plants according to WHO (Amos *et al*., 2001). Traditional medicinal plants were investigated by various researchers to assess their properties, safety, and efficiency of treatment, and the optimum dose (Srinivasan *et al*., 2001; Shafei *et al*,. 2016). Arunkumar and Muthuselvam. (2009) reported that *Guiera senegalensis* leave extract had been found to contain alkaloids, tannins, flavonoids, amino acids, in addition to its antimicrobial activity. Sule *et al.*, (2002) and Shafei *et al*,. (2016) confirmed the presence in *Guiera senegalensis* leave extract of flavonoids, saponins, tannins, terpenes, and carbohydrates, and one of ingredients found in *Guiera senegalensis* leaf and extract are terpenoids, which are found to have a variety of pharmacological activities such anti-bacterial, anti-inflammatory and anti-malarial activities. (Singh and Bhat. 2003) stated that the antimicrobial properties in some traditional medicinal plants can be due to the presence of flavonoids. Furthermore, several biological effects such as antioxidants abilities, and anti-inflammatory effects are attributed to flavonoids and phenolic compounds in medicinal plants (Asha *et al*., 2011).

Alkaloids found in medicinal plants are used as anesthetic agents (Herouart *et al*., 1988). In addition, tannin has been found by Lata and Dubey. (2010) to have a wide range of antimicrobial and anti-inflammatory effects. The anticarcinogenic potentials of tannins could be attributed to their antioxidative properties that protect living cells from oxidative damage (Chung *et al*., 1998). These steroids have antibacterial effects**,** and are important because of its relationship with steroid hormones such as sex hormones estrogen and testosterone

(Racquel 2007; Okwu, 2001 and Shafei *et al*,. 2016). The observed antibacterial effects of the medicinal plant leaves and extracts have been related to the presence of tannins, flavonoids and saponins (Osadebe *et al*., 2004; Lutterodt *et al*., 1999). Lutterodt *et al*. (1999) investigated on the effect of Eucalyptus *Camaldulensis* extract against pathogenic bacteria (*Salmonella typhi* and *Escherichia coli)* and attributed to the effect of the active phytochemical compounds (tannins, flavonoids and saponins) present in the plant leaf extract. *Guiera senegalensis* leaves have high concentration of alkaloids and low concentration of tannins and saponins and have no toxic effect and show no antimicrobial activities in case of fungi (Shafei *et al*,. 2016).

2.3 Composition of Broiler Chickens

Although the composition of meat can be approximated to 75% water, 19% protein, 3.5% soluble non-protein substance (comprising 1.2% carbohydrate, 1.6% nitrogenous substances and 0.5% inorganic substances) and 2.5% fat, an understanding of the nature and behaviour of meat, and of its variability cannot be based on such a simplification (Lawrie, 1998). Olomu (1995) stated that the variability in meat composition depends on factors such as the breed and type of animal as from which part of the animal the meat is obtained. It also depends on the age of the animal as well as type and amount of feeding during rearing of the animal. The same author reported the water content of meat to vary from about 40% for pork to over 70% in chickens. Oguntona and Akinyele (1995) stated that broiler chicken contain 79% moisture, 19.21% protein, 8.0% fat and 2.0% ash. Olomu (1995) reported 6.10% fat 1.9% ash for broiler chicken meat, respectively. Meat protein is of high biological value and contains high amounts of the essential amino acids (Oguntona and Akinyele, 1995). Lawrie (1998) reported that since connective tissue protein has a lower content of amino acids than those of other contractile tissues, muscles containing much connective tissue would provide meat relatively resistant to digestion and absorption.

Table 2.1: Some anti-nutritional factors (mg/100g) in *Moringa oleifera* and *Guiera senegalensis* leaves

Anti-nutritional factor	*Zogale* (*Moringa oleifera*)	*Sabara* (*Guiera senegalensis*)
Tannin	1.45	1.60
Saponin	1.22	1.38
Phytate	2.84	3.10
Alkaloid	9.36	11.58
Flavonoid	0.66	0.84

Balarabe *et al*., 2016b

2.4: Growth Performance of Broiler Chickens

The prominence of poultry production in Nigeria today is primarily due to the short generation interval and relatively quick turn over in investment and high quality protein from poultry products (Makama *et al.*, 2016). It is generally accepted as the fastest way of increasing animal protein consumption in developing countries in the world (Ogundipe, 1999). The rapid growth of broiler chickens demands that they are supplied with high quality diets to sufficiently cater for their nutrient requirements (Makama *et al.*, 2016).

2.4.1 Nutrient requirements of broiler chickens

Nutrient requirement deals with the adequacy of the feed to the need of farm animals (Yahaya, 2014). The nutrients are needed to be present in the diet to support life, growth and production. These nutrients are grouped into carbohydrate, fat, protein, vitamins, minerals and water (Yahaya, 2014). The researcher further reported that any ration lacking in any of these elements may not support life and can have adverse effect on growth and reproduction. Kekeocha (1984) reported that when preparing feed, the nutrient requirement of birds must be met, since proper nutrition is a must for successful poultry farming, and well fed birds are more resistant to diseases and produce better. Babatunde *et al*. (1974) and Kekeocha (1984) reported that the nutrient requirements are mainly for energy and proteins, and through several feeding trials various nutrient requirements have been established for poultry in the tropics.

2.4.2 Energy requirement of broiler chickens

Energy is one of the major factors which plays a vital role in feed intake and consequently in feed formulation in poultry industry (Hunton, 1995). Lopez and Leeson (2007) reported that if diets contain higher energy content, the concentrations of other nutrients should also be increased to compensate for the decline in intake. In essence, the concentration of energy in the diet influences the intake of all other nutrients, so also the utilization of ME and other nutrients. Energy is the most important factor in animal diets, it is needed for maintenance of body temperature, metabolism and locomotion (Yahaya, 2014). In poultry, the energy value of feed is universally expressed as metabolisable energy (Henry *et al*., 1988). According to Shim and Prombora (1984), the amount of intake depends upon metabolisable energy content of the diet, their reproductive status and ambient temperature. The authors further reported that when formulating diet, the level of the constituent is in relation with the energy content of the diet. It was reported by Tewe (1984) that the caloric content of the diet determines how much feed is consumed, consequently, the proportion of other nutrients should be tried around fixed level of energy content in order to ensure optimum growth.

The energy requirement determined by the National Research Council (NRC, 1984) recommended a dietary value of 3200Kcal/ Kg diet for broilers from 0 - 8weeks of age, while Agricultural Research Council (ARC, 1971) recommended a level of 3200 ME/Kg diet. In the tropics, energy requirement as recommended by Olomo and Offiong (1980) for both broiler starter and finisher was 3000Kcal/Kg, while Kekeocha (1984) recommended 2389Kcal ME/Kg for both starter and finisher broiler diets, respectively.

National Research Council (1994) reported that chicks fed low energy of about 2600Kcal ME/Kg diet ate as much as 30% more than similar bird fed diet containing 3200Kcal ME/Kg. Bartov (1992) reported that chicks fed high energy diet consumed significantly more diet during finisher period. Some plant energy sources used in broiler diets are; maize, sorghum, millet, wheat, roots and tubers, molasses, brewer's dry grain, barley etc.

2.4.3 Protein requirement of broiler chickens

Protein required by broilers depends primarily on the amount needed for maintenance, tissue growth and productive purposes (Makama *et al.*, 2016). Although, availability of cheap and good quality protein sources remains the single most important limiting factor in poultry production in Nigeria (Bawa *et al.*, 2003; Abeke *et al.*, 2008). Makama *et al*. (2016) reported that protein is a key nutrient in poultry nutrition and has a significant share in the cost of diet formulation, directly influencing feed conversion, carcass quality and weight gain of animals. Certain levels of protein in the diet must be maintained for each stage of growth for optimum performance. Lower protein in diet cannot lead to poor performance but predispose animals to common diseases (Olomu, 1995). Olomu (1995) recommended three crude protein (CP) regimes for broiler chickens; 24% (0 – 3 weeks), 21% (3 – 6 weeks) and 18% (6 – 8 weeks) all at the same ME level (3000Kcal ME/Kg); NRC (1994) recommended protein levels of 23% and 18 – 20% for broiler starter and finisher, respectively.

The dietary requirement of protein is actually a requirement for the essential amino acid contained in the protein (NRC, 1994). The major limiting amino acid in most plant protein concentrates for broilers are cysteine and methionine, and there is variable but usually low lysine content (McDonald *et al.*, 1989). The limiting amino acids are supplemented with synthetic methionine and lysine. Some amino acids cannot be produced by animals and must therefore be supplied in their diet; these amino acids are referred to as essential amino acids (Makama *et al.*, 2016). In avian species, methionine is one of the essential amino acids needed to improve growth performance and is considered to be the first limiting amino acid because it is limited in plant protein sources and there is strong requirement for it to support feather growth and protein syntheses (Makama *et al.*, 2016). Olomu and Offiong (1980) reported that methionine and lysine plus cysteine requirement were 0.4% and 0.8% for starter, and 0.35% and 0.6% methionine and methionine plus cysteine for finisher diet, respectively. Some commonly used plant protein sources in the diet of broiler chickens are; soya bean, ground nut cake, fish meal, blood meal, cotton seed cake, palm kernel cake, Bambara nut, sesame, bean meal, meat meal, grasshopper meal and sun flower meal.

2.4.4 Water requirement of broiler chickens

Yahaya (2014) reported that water requirement is related to feed consumption and air temperature. Over half of water intake of poultry is obtained from the feed. Water is not often considered as nutrient, but is an important element in poultry nutrition and is known to play a significant role in all body processes (Fetwel and Fox, 1978). It is important for nutrient absorption, toxic and waste material disposal and temperature regulation (Anthony, 2001). The body of broiler chicken is about 60% water, thus, it is important that the nutrient be supplied *ad libitum*. Shapiro (1980) reported that when water is lacking in broiler, sodium imbalance occur which increases the concentration of certain body components that may lead to the manifestation of the syndrome of toxicity. However, generally feed with high protein can lead to increased water intake, also high energy content, calcium and salt levels in the diet can lead to increased water intake (Stahl and Sunde, 1983).

2.4.5 Mineral requirement of broiler chickens

The provision of correct level of the major minerals in the appropriate balance is very important to grow broilers successfully, and the minerals involved are calcium, phosphorus, magnesium, sodium, potassium and chlorine (Yahaya, 2014). Calcium in diets of broiler chickens influences growth, feed efficiency, bone development, leg health, nerve function and the immune system (Yahaya, 2014). The researcher further reported that phosphorus like calcium is required in the correct form and quantity to optimise skeletal structure and growth. Ross Nutrition Supplement (RNS, 2009) recommended phosphorus supplement based on classical availability system, whereby inorganic phosphorus sources are described as being 100% and plant sources as 33% available.

Zinc and manganese are involved in wide variety of physiological processes, making them essential for optimal bird growth and health (Richards *et al.*, 2010). They act as catalysts in many enzymes and immune systems, Suttle (2010) and as a result, they influence growth, bone development, feathering, enzyme structure and appetite (Nollet *et al.*, 2007)

2.4.6. Vitamin requirement of broiler chickens

Requirement of fat soluble vitamin (A, D, E, K) are considered to be proportionate to body weight of older animals (Yahaya, 2014). The researcher further reported that requirement for the B - vitamin (water soluble) which are concerned with metabolism vary with feed or nutrient intake, and may vary according to the extent to which they are synthesized in the alimentary tract. Poultry fed a deficient diet in vitamin A can exhibit symptoms such as retarded growth, weakness, ruffled plumage and staggering gait; deficiency of vitamin D causes bone to break and become soft, retarded growth and weak legs (Atecio *et al*., 2005). Aburto and Britt on (1998) reported that under certain conditions such as climatic stress, the demand for vitamin C becomes greater than can be provided by normal tissue and may have to be supplemented, so also lack of vitamin E results in nutritional encephalomalacia or ‘crazy chick disease’ which makes the chick to be unable to stand or walk, and it is accompanied by haemorrhages and necrosis of the brain cells.

2.4.7 Fat requirement of broiler chickens

Fats and oils of animal origin in poultry diet have been shown to enhance growth, feed conversion, increase appetite and alleviate growth depression effect of heat stress (Olomu, 1995). The recommended maximum fat levels for both starter and finisher diet are 3 – 5% (Olomu, 1995). Lehinger *et al*. (2000) reported that chickens fed rations containing oil showed better performance than birds fed diets without oil inclusion. Zulkifli *et al*. (2003) reported that providing diets containing high levels of palm oil enhanced growth performance and survivability of heat – stressed broiler chickens

However, the addition of high level of fat to broiler rations may result in excessive visceral fat, loss of vitamin A and E by oxidation and changes in the 21lavor of poultry meat (Patrick and Schaible, 1980). Klasing (1997) reported that fat sources with high level of free fatty acids, polyunsaturated fatty acids, and low levels antioxidants are especially susceptible to oxidative rancidity.

2.5 Meat Quality of Broiler Chickens

The composition of meat can be approximated to 75% water, 19% protein, 3.5% soluble non-protein substance (comprising 1.2% carbohydrate, 1.6% nitrogenous substances and 0.5% inorganic substances) and 2.5% fat. The understanding of the nature and behaviour of meat, and of its variability is not easy (Lawrie, 1998). Olomu (1995) stated that the variability in meat composition depends on factors such as the breed and type of animal as from which part of the animal the meat is obtained. It also depends on the age of the animal as well as type and amount of feeding during rearing of the animal. The same author reported the water content of meat to vary from about 40% for pork to over 70% in chickens. Oguntona and Akinyele (1995) stated that broiler chicken contain 79% moisture, 19.21% protein, 8.0% fat and 2.0% ash. Olomu (1995) reported 6.10% fat 1.9% ash for broiler chicken meat, respectively.

Meat protein is of high biological value and contains high amounts of the essential amino acids (Oguntona and Akinyele, 1995). Lawrie (1998) reported that since connective tissue protein has a lower content of amino acids than those of other contractile tissues, muscles containing much connective tissue would provide meat relatively resistant to digestion and absorption.

2.6 Nutritional Quality of Meat

Meat is an excellent source of high quality protein, essential amino acids and vitamins and minerals, especially iron. Appreciable percentages of vitamins A, D, E, and K as well as low, but relatively constant amount of minerals (in bones) have been reported in meat (Rice, 1998).

The eating quality of meat is generally dependent on digestibility, tenderness and flavor (Olomu, 1995). Muscle proteins are more digestible than connective tissue proteins (mostly collagen) and fat. Generally, meat that is easily chewable is considered to be tender (Olomu, 1995).

Fat, particularly fat deposits between muscle cells and muscle bundles is of major importance in assigning meat quality grade, though meat quality does not accurately reflect the texture of meat (Lawrie, 1998). As far as meat quality is concerned, perhaps the most important manifestation of the post mortem denaturation of the muscle protein is their loss of water holding capacity, because in practice, it is a more universal phenomenon than discolorations (Lawrie, 1998).

2.7 Environment Versus Quality Meat Production

Johnson *et al.* (1983) and Bube (2003) reported that microbial contaminations of meat are derived from the air environment of the abattoir, the slaughter slabs and knives, the hides and hooves, the gastrointestinal tract of the animal, the wash water, and the poor hygienic practices. Microorganisms in meat are grouped into psychrophile (-2 to -7 ^{0}C), mesophile (10 to 40 ^{0}C) and thermophile (43 to 66 ^{0}C) according to their optimum growth temperature with minimum (5.5) and maximum (6.8) pH values for growth (Wagner and Moberg, 1989). Bube (2003) reported that lowering the pH of meat either naturally or artificially has been used for centuries to enhance microbiological stability and preserve meat and meat products.

Robert (1989) and Bube (2003) stated that the bacterial flora that develops on red meat in air is largely composed of gram-negative rods (pseudomonas *spp*, *Acineto bacter spp*, and *Maraxella spp*). If meat is of high pH initially, it spoils sooner-because the carbohydrate level is low, *Pseudomonas spp* metabolizes amino acids and peptides, thereby producing metabolites that are judged objectionable.

However, meat products rely on combinations of factors to render them safe to eat and self-stable (Tampkins, 1986; Bube, 2003). These factors include reduction of water, addition of curing salts (e.g sodium nitrate), heat processing and fermentation. Brewer and Wu (1993) stated that microorganisms are primarily responsible for the deleterious effects to meat tissue if the meat product has been temperature abused in any manner. Similarly, Sankara *et al* (1976) stated that the initial bacterial load of meat in the market varied between 1.5×10^5 and 1.6×10^6, but washing reduced the total bacterial load to approximately half while the minced meat had a total of 7.7×10^5.

2.8 Production of Quality White Meat

Nigerian farmers engage in the rearing of species of poultry such as chickens, ducks, turkeys, guinea fowl, quails, pea cock, ostriches and pigeon. The poultry industry in Nigeria comprises of two types of producers; local and modern poultry farmers. Muhammad *et al*. (2010) reported that the local poultry farming is characterized by a small flock size, slow growth rate, hardiness, late attainment to maturity and resistant to most prevailing diseases. The modern poultry on the other hand, is characterized by multitudes of birds managed with modern technologies of feeding, medication, vaccination and restriction in battery cages or deep litter or other improved housing conditions (Muhammad *et al*., 2010).

Poultry production plays vital role in maintaining the protein balance of human population in addition to serving as a source of income and employment to many people. Muhammad *et al*. (2010) reported that Nigeria has an estimated population of over 133.0 million poultry which is one of the major sources of animal protein supply to the citizenry. Nigeria's annual production has risen to 580,000 eggs and 110,900 metric tonnes of poultry meat (CBN, 2005). Poultry constituted 27% of the total animal products during the period (2000 – 2005). Muhammad *et al*. (2010) reported that between 10 and 25 % of total poultry meat and eggs consumed annually in Nigeria are supplied by the modern poultry farms while the rest is supplied by the rural scavenging poultry and imports.

Muhammad *et al*. (2010) stated that the price of poultry meat is high and thus only few farmers are in the business. These workers attributed the reason to high cost of feed ingredients which constitute to about 70% of cost of production. One of the serious constraints to poultry production and distribution is frequent outbreak of diseases. Zahraddeen *et al.* (2010) reported that diseases are one of the militating factors against efficient poultry production in Nigeria. These workers reported that diseases encountered by farmers included incidences of fowl typhoid, fowl pox, fowl cholera, Gumboro disease, New castle disease and coccidiosis.

Poultry contribute to the total requirement of protein among consumers. Meat protein is of high biological value and contains high amount of the essential amino acids (Oguntona and Akinyele, 1995). Meat is the edible portion of animal which is suitable for use as food; it consists of lean and fatty tissues. About 75 % of meat is water, 20% protein and 5% fat, carbohydrate and minerals (Zahraddeen *et al*., 2020). Meat may be fresh, cured, dried or processed in different ways. The quality of meat has been related to the amount of fat which is distributed uniformly throughout the muscle. The quality is also related to the age of the animal (Akpata and Ojo, 2000). Zahraddeen *et al*. (2020) defined white or light meat as the lighter coloured meat of poultry as contrast with dark meat.

2.9 Improvement Techniques for Quality White Meat Production

Zahraddeen *et al*. (2010) reported that poultry offers an avenue for rapid transformation in animal protein production. They have a shorter generation interval than most farm animals. Thus, genetic improvement could be attained at faster rate. The poultry have proved to be a particularly versatile group of domestic animals that are adapted to a wide range climate.

However, with any programme meant to improve the poultry, it is always necessary to include the local stocks since they possess some innate resistance to certain local diseases in addition to a high degree of adaptability to the prevailing climatic condition (Zahraddeen *et al*., 2010). Thus, genetic improvement could be attained at a faster rate if local stocks were involved in selective breeding. The Nigerian indigenous stock are a genomic bank not adequately harnessed and there is great potential for improving and increasing local poultry numbers through small-holders for sustainable animal protein production in the country.

The main goal of breeding is to have an animal which is more productive and efficient in resource utilization. Poultry should be improved. The following are steps to be taken in poultry improvement:-

a. Improving the animal itself through good management practices to enable the animal to fully express its genetic potentials. This includes improving the quality/quantity of feeding, reducing incidences of pests and diseases, good sanitation and prophylactic treatment, provision of good housing, improving the rate at which poultry breed.
b. Improving the poultry genetic potentials. This can also be achieved through: selection within breed (mass/individual, pedigree, family, progeny testing etc.) and introducing new genetic material (inbreeding and cross-breeding) (Osinowo, 1990).

2.10: Factors Affecting Meat Quality

Meat quality variables include wholesomeness, processing yield, convenience, consistency, nutrition, appearance and palatability (Kauffman, 1993). Consumers judge quality of fresh meat by colour, presence of exudates and odour. Fresh meat could have a shelf-life of 3-5 days under refrigerated condition ($\leq$ 4 ^{0}C) due to the growth activities of aerobic psychotrophic spoilage microorganisms. A total number of 10^7 cfu/ml of meat is considered to be the upper limit of microbial acceptability (Lambert *et al*., 1992). Microbial growth in fresh meat is the primary factor associated with meat quality reduction, spoilage and economic loss. Brewers *et al.* (1995) stated that extended shelf-life and meat product safety require maintaining low microbial numbers during handling and storage of meat.

Studies conducted by Kauffman (1993) indicated that frozen colour of beef remained attractive for three months when stored in the dark but for only three days under illumination. The rate of fading was affected by illumination level, storage temperature, packaging methods and muscle types. Arnold *et al.* (1993) reported that discolouration in steaks which have been bloomed for 48 hours prior to freezing was less than they have been derived from vitamin E supplementation as compared with control steers. The authors stated that lipid and pigment oxidation in the meat were interrelated, thus retarding the breakdown of lipids should result in a similar delay in metamyoglobin accumulation.

Increased concern over dietary fat led to studies aimed at evaluating the effect of different feeding regimes on carcass quality and flavour characteristics of meat. Schupp *et al.* (1989) reported that carcasses from cattle finished on forage had less subcutaneous fat and less marbling than those from cattle finished on grains. As far as meat quality is concerned, the important manifestation of post-mortem denaturation of the muscle protein is the loss of water holding capacity (Lawrie, 1998).

In Nigeria, most famers keep livestock in order to dispose or sell them when fully fattened at a high market value. Poultry breeding is solely for commercial purpose. Poultry farmers in the country enjoy all-year round access to markets for their products. These markets exist in various forms. There are daily and weekly live bird markets while others at strategic period over the year, where a large volume of poultry species are required for religious festivals and other festive occasions. Poultry breeding at a small-holder level are mostly a part-time enterprise to argument the family income. Marketing outlets include direct consumers, processors and institutional buyers; hotels, restaurants, cafeterias, supermarkets, hospitals etc.

Poultry marketing system in Nigeria is essentially indigenous with strong cultural control and is characterized by involvement of middlemen along the marketing chain. Middlemen are classified into two major groups – merchants and agent middlemen. Merchants (rural buyers, wholesalers and retailers) take title to goods and therefore own the products they handled while agents act only as representatives of their clients. However, it is difficult to generally talk of a typical marketing channel for the same goods may vary from one location to another, as observed by Muhammad *et al.* (2012). Hence, marketing channels are normally investigated in relation to a particular or specific area. Poultry marketing is very important for production in the sense that they provide mechanisms by which producers exchange their poultry and poultry products for cash and other goods and services.

2.11 Pre- and Post-Slaughter Hygiene and Handling Practices

EU (2015) reported that food can be contaminated at different stages of food chain, these are:- (1) At farm; animal feed can be contaminated with bacteria such as Salmonella which can cause infection in animals and potentially lead to human infection from derived food products, parasites may infect food producing animals, milk can be contaminated by coming into contact with, for example, faeces or environmental dust, animal skin and fur can be contaminated by faeces and environment. Eggs and different vegetables can also be contaminated on the farm. (2) During slaughter; meat can be contaminated by coming into contact with intestinal contents or animal skin. (3) During further processing; microorganisms present in another raw agricultural product or on food contact surfaces may contaminate food, infected humans handling food may also contaminate food. (4) In the kitchen; microbes can be transferred from one food to another by improper use of kitchen utensils or by infected humans handling the food. However, prevention/reduction of the risk imposed by this microorganism on raw meat and other raw food ingredients can be achieved through thorough cooking and good kitchen hygiene (EFSA, 2015).

2.12: Slaughter and Evisceration

AHDB (2009) reported the various stunning options available for farm animals that do not affect their meat quality. These options include captive bolt piston, electric stunning and percussion stunning are mostly used for cattle. Sheep are generally stunned electrically using two electrodes to the head and head to back stunning that normally applies two probes to the head and one to the back.

FAO (1992) reported that one aspect of yield of meat is the age of slaughter in relation to maximum feed conversion efficiency; and this applies to animals reared solely for meat. Care must be taken in slaughter and handling, since improper and insufficient bleeding does not allow the necessary degree of acidity to develop in the meat, and this shortens shelf – life, improper de-hiding of the carcass and leads to heavy contamination, improper evisceration through accidental opening of stomach and tripes spreads contamination, contact with unclean materials during transport adds to contamination, as reported by FAO (1992). This was similarly reported by FAO (1991) that fasting before slaughter reduces the volume of gut contents, and hence, bacteria reduce the risk of contamination of the carcass during dressing.

The work recommended that animals should receive their last feed on the day before slaughter and should have a rest period after arrival at the slaughter house. The objectives of bleeding are to kill the animal with minimal damage to the carcass, and to remove quickly as much blood as possible, as blood is an ideal medium for the growth of bacteria. It is reported that most hygienic systems of bleeding and dressing is to shackle the animal immediately after stunning, then hoist it on to a moving rail. Skinning is done through combined horizontal or vertical methods in order to remove head, legs, neck, chick and shoulder and other components.

Further operations on the carcasses include; hygienic splitting, washing and dressing. Washing of the carcass is done to remove visible soiling and blood stains, and to improve appearance after chilling (FAO, 1991). The carcass is then dressed to remove all damaged or contaminated parts, and to standardize the presentation of carcasses prior to weighing. Veterinary inspections of carcass and offal are carried out by qualified personnel. Signs of diseases or damages are found in the entire carcass, and offal may be condemned and must not enter the food chain (FAO, 1991).

2.13: Carcass Quality and Gross Composition

Production of quality meat has been shown by Gurunathan *et al.* (2015) to be influenced by several environmental factors and management practices. These authors reported that meat animal carcasses vary in composition through genetic species, age and sex of animals, nutritional and environmental effects. These authors, however, observed that carcass composition of various species differs considerably in term of carcass weight, per cent fat, muscle and bone.

Bender (1992) reported that animal carcass consists of muscle, connective tissue, fat and bone, and some 75% water in proportions depending on species, breed, size, age etc. The muscle (lean meat) is relatively constant in composition in a given species. This worker, however, reported that the greatest variable in the carcass is the amount of fat, which can range from 2% in some free living animals to 1,540% in domesticated animals intensively reared.

Gurunathan *et al.* (2015) also reported that as animal becomes older and heavier, the proportion of fat in their carcasses increases and the proportion of muscles and bones decreases. The un-castrated male animals produce carcasses with more muscles than do castrated males. At a particular fat level, the value of a carcass is influenced by the muscle:

bone ratio. A higher ratio is obviously better since it equates to more saleable lean meat as well as better carcass conformation.

Musa (2016) reported proximate composition of different types of white meat. Dry matter contents of local chickens, turkey, guinea fowl, fish and duck as 41.53, 48.94, 44.33, 47.08 and 43.03%, respectively. This worker reported higher percentage of crude protein in fish (52.06%) than in duck (47.56%), local chicken (48.38%), turkey (47.94%) and guinea fowl (48.81%). However, the ash contents were 2.47, 2.54, 2.89, 3.96 and 4.32% for local chicken, turkey, guinea fowl, fish and duck, respectively (Musa, 2016). The per cent fat contents were 6.52, 5.57, 6.13, 6.04 and 5.99% for local chicken, turkey, guinea fowl, fish and duck respectively. Balarabe (2016b) reported per cent proximate composition of broiler chicken meat; moisture (45.04%), crude protein (26.13%), ether extract (5.87%) and ash (3.90%).

Bube (2003) reported chemical composition of fresh local chicken and duck meat ; dry matter (31.5 vs 26.1%), crude protein (19.8 vs 17.3%), ether extract (7.8 vs 5.3%) and ash (2.1 vs 1.7%), respectively.

Harries *et al.* (1968) reported that dietary effect on nutrient composition of lean meat; in which he compared the composition of intensively and extensively reared beef. Analysis of the same muscle from animals on these two systems showed no significant differences in their content of protein, fat, iron, thiamine, riboflavin and niacin. Bender (1992) reported that as animals grow the proportion of total nitrogen and fat, and also the amount of iron increase as the animals approach maturity and more slowly after that. Animals slaughtered after a life time of work provide even tougher meat. Older animals have a high proportion of water soluble extractives in the muscles and animals reared on poor pasture, which are therefore relatively old by the time they reach a size suitable for slaughter, have long been used for the preparation of meat extract.

The protein of typical mammalian muscle after *rigor mortis* but before post mortem degradative changes contain about 19% protein: 11.5% is structural protein (actin and myosin), 5.5% soluble sarcoplasmic protein in the muscle juice, 2% connective tissue (collagen and elastin) encasing the structural protein and about 2.5% fat disperse among the protein fibres (Bender, 1992). Myoglobin is present in relatively large quantities in hard muscles because of heavy oxygen demand (the highest amount of myoglobin in mammals is found in the whale to permit prolonged submersion under water) (Bender, 1992). This researcher also reported that collagen differs from most other protein in containing the amino acids, 31lavor31l-lysine and 31lavor31l-proline and no cysteine and tryptophan. Elastin also present in connective tissue, but with less 31lavor31l-lysine and 31lavor31l-proline. Therefore, cuts of meat that are richer in connective tissue have lower protein quality. Their content of connective tissue makes them tough, and in many regions, these cuts of meat bring a low price. Immediately after *rigor mortis,* there is also 2.5% carbohydrate present; lactic acid, glucose and derivatives (Bender, 1992).

Bender (1992) reported that fats (lipids) are found at three sites in the body; these are fats under skin and around the organs, small streaks of fats are visible between bundles of muscle fibers (inter muscular fat, i.e. in the lean fat of the meat which is also known as marbling and can amount to 4.8% of the weight of lean), and there are small amount of fat within the muscle structures (intra muscular or structural fats which can be 1.3% of the wet weight of muscle and 5 – 7 % of the weight of the liver).

Vitamin content of carcasses is largely independent of diet. Apart from the thiamine effect on pig meat, the exception is vitamin A which is stored in the liver in amount depending on intake with small amount present in the kidney. These are the only tissues to contain significant amount of the vitamin (there are traces, 10 – 60 ug/100g in muscle). Meat and offals contain a wide variety of mineral salts. The content of iron, zinc, and copper vary considerably in different species, liver been the by far the richest source of these minerals compared with muscle tissues (Bender, 1992).

Reid *et al.* (1968) stated that animals of all species vary considerably in composition as a result of their stage of growth, nutritional history and genetic base. This is of concern to livestock producers, the meat industry and consumers, because the economic value of a meat producing animal depends greatly on its composition. Webster (1986) reported that the proportion of muscle in an animal's body varies from less than 35% to nearly 50% of the body weight. In addition to stage of growth, nutrition and genetics, several other factors contribute to variation in body composition, such as contents of the alimentary canal, pregnancy and presence of abnormality (Topel and Kauffman, 1988). These workers reported that these traits collectively complicate the accurate measurement of body composition.

2.14 Parasites and Zoonotic Diseases in Meat

In Nigeria, despite the huge benefits of consuming local meat products in terms of provision of quality nutrients for normal growth and reproduction, less significance is usually attached to the possible effects in transmitting parasites and other zoonotic diseases to humans during the cause of their consumption and handling. Zoonosis is infection or disease that can be transmitted directly or indirectly between animals and humans. For instance, by consuming contaminated foodstuffs or though contact with infected animals. The severity of these diseases in human varies from mild symptoms to life threatening conditions (Wright, 1954). Safe handling of raw meat and other raw food ingredients, thorough cooking and good kitchen hygiene can prevent or minimize the risk posed by these microorganisms implicated in meat and meat product spoilage.

The European Union (EU, 2015) has adopted an integrated approach to food safety in order to protect consumers from this food borne zoonosis from the farm to the fork. The approach consists of both risk assessment (e.g. data collection, analysis, and recommendations) and risk management (e.g. legislative measures, target for reduction), measures involving all key actors; EU Members States, European Commission, European Parliament, the European Centre for Disease Prevention and Control (ECDC), European Food Safety Authority (EFSA) and economic operators.

However, the approach is supported by timely and effective risk communication activities. A coordinated approach by the EU and Member States helped significantly to reduce human Salmonella cases by almost 1 to ½ over a five year period (2004-2009), from 196,000 cases in 2004 to 108,000 cases in 2009 (EU, 2015). Food borne zoonotic diseases are caused by consuming food or drinking water contaminated by pathogenic (disease causing) microorganisms such as bacteria and their toxins, viruses and parasites. These pathogens enter the body through the gastro – intestinal tract where the first symptoms often occur. Many of these pathogens are commonly found in the intestines of healthy food producing animals. The risks of contamination are present from farm to fork and require prevention and control throughout the food chain (Wright, 1954). Common pathogens (microorganisms) associated with food borne diseases are:-

a. Bacteria; Campylobacter (causing Campylobacteriosis), Salmonella (causing Salmonellosis), Listeria (causing Listeriosis), Pathogenic *Escherichia coli*, Yersinia.
b. Bacterial toxins; toxins of *Staphylococcus aurues*, *Clostridium perfringens*, *Clostridium botulinum, Bacillus cereus*.
c. Viruses; Calicivirus (including norovirus); rotarotavirus, hepatitis A virus, hepatitis E virus, infected humans handling goods may contaminate food.
d. Parasites; Trichinella, Toxoplasma, Cryptosporidum, Giardia (Wright, 1954).

The infectious agent which causes Bovine Spongiform Encephalopathy (BSE) also known as mad cow disease in cattle can also be transmitted to humans through consumption of contaminated meat causing variant Creuzfeldt-Jakob disease. Unlike other food borne diseases which are separate by microorganisms, BSE is caused by a prion, which is an abnormal form of a protein known as P_rP^c (Wright, 1954).

2.15 Carcass Components

The amount of carcass meat obtained from animals varies with the type of animal, only about one-third of the total weight of cattle and lambs and half of the pig (Bender, 1992). Other parts of the animals include liver, heart, brain, pancrease (gut, sweet bread), thrive, thymus (chest sweet bread), tripe, feet (trotters), tail, testes (fries), intestine (chitter lings), cheek and head meat and fat (tallow, lard, suet etc.) are collectively called offal, variety meat, side meats or organ meat in various countries (Bender, 1992). With regards to poultry, the term giblets means liver (with gall bladder removed), heart and gizzard and any other material considered as edible by the consuming country. Not all parts are eaten, depending on consumer acceptance, religion and tradition, as well as regulations imposed for reasons of hygiene. Intestines are used as containers for sausages of different types, blood may be used in sausages, and pork skin may be eaten or used as a source of gelatin. In addition, some inedible by- products such as bone meal can be used as a mineral supplement in animal feed, and there are other inedible by- products of economic value such as hides and horns as well as hooves (Bender, 1992).

2.16: Traditional methods of meat preservation

Traditionally, foods have been preserved by salting, drying and smoking which are methods that have been improved by modern technology (FAO 1992). The simplest and most commonly used method is drying in the open air under the influence of wind and sun. Under favourable climatic conditions, a product of good quality can be obtained but otherwise losses from spoilage, infestation and communication can be excessive, and meat is susceptible to natural predators (FAO, 1992). Rufina and Dorothy (2017) reported traditional methods of preserving foods from the effects of microbial growth as thermal processing, drying, freezing, refrigeration, irradiation, modified atmospheric packaging, and adding antimicrobial packaging agents or salts. Unfortinately, some of these techniques cannot be applied to some food products, such as fresh meats and ready-to-eat products.

Artificial drying plants which are used in advanced meat processing are energy capital and technology intensive, and require skilled labour. They are therefore, not suitable for the needs of small scale producers in developing countries who manufacture small quantities for short periods throughout the year (FAO 1992). An alternative and most suitable solution may be to improve existing sun drying methods or to introduce solar drying, a method by which sun drying is enhanced. The process is best carried out in an enclosed structure so that the product is protected from rain, dust, insects, and predators, and reduces the risk of deterioration of quality and spoilage both during the drying process and during subsequent storage (FAO 1990c)

2.17: Local Meat Industry in Nigeria

The various meat products indigenous to Nigeria have been reported by various workers. Igene and Mohammed (1983) and Bube (2003) described local meat products as *suya* which is a popular, traditionally processed, ready to eat Nigerian meat product which may be served or sold along streets, in club houses, at picnics, parties, restaurants, and within institutions. Uzeh *et al*. (2006) stated that it is a mass consumer fast food, its preparation and sales along streets are usually not done under strict hygienic condition because they are still done locally. Bube (2003) and Zahraddeen *et al.* (2006) identified the different local *suya* meat products to include *tsire, kilishi*, *balangu*, *dambun nama*, pepper soup, *ganda, pomo, ragadada* among others.

2.17.1 *Dambun Nama* (Meat Floss)

Dambun nama is a dried meat product produced mainly by Hausas and Fulanis in Northern part of Nigeria (Ogunsola and Omojola, 2008; Eke *et al*., 2013). *Dambun nama* is processed by cooking, pounding and then fried with addition of spices. Due to its low moisture content, meat floss can be kept without refrigeration and will not drastically change in room temperature for long storage period of time (Huda *et al.*, 2012). The product appears to have developed as a means of preserving meat in the absence of facilities for refrigerated storage by the early Fulani and Hausa herdsmen (Igene *et al.*, 1990) Most *Dambun nama* come from beef, mutton or camel, however, the use of meat from poultry and fish is becoming popular among consumers (Eke *et al*., 2013). Fresh meat of good grade was cut into pieces of approximately 4 cm by 2.5 cm dimensions and washed with water, mixed with spices and ingredients (seasoning cubes, curry, thyme, garlic, onion, pepper, salt, cloves, ginger), boiled for about 35 minutes at 100^0C and pounded into shreds using a mortar and pestle. This was then shallow fried using groundnut oil in a stainless steel pot to obtain *dambun nama*, which is usually brownish in color (Farouk, 1985; Bube, 2003; Kalla *et al.,* 2005, Balarabe, 2016b.c; Musa, 2016; Salisu, 2017).

2.17.2: Sensory Attributes of *Dambun Nama* from White Meat

Research work on *dambun nama* (meat floss) using white meat have been reported in the literature (Bube, 2003; Balarabe, 2016b; Musa, 2016). These workers used different species (broiler chicken, fish, local chicken, duck and guinea fowl) of poultry in their studies. Bube (2003) reported sensory values of palatability (8.4), acceptability (8.4), flavor (8.5), juiciness (8.7), tenderness (8.6) and color (8.3) using the 9-point hedonic scale for *dambun nama* processed from broiler chicken meat. Similarly, Balarabe (2016b) used a panel (academic staff and postgraduate students) to evaluate *dambun nama* from broiler chicken and obtained non- significant difference in palatability between the two types of panelists. However, other sensory attributes investigated differed significantly between academic staff and post graduate student panelists; juiciness (7.14 vs 6.78), tenderness (7.18 vs 6.71), colour (7.16 vs 6.73), aroma (7.00 vs 6.56) and acceptability (7.15 vs 6.75) ($P < 0.05$), respectively (Balarabe, 2016b).

Furthermore, Musa (2016) compared and evaluated the sensory properties of *dambun nama* processed from different types of white meat (local chicken, turkey, guinea fowl, fish and duck). Taste is the only attribute that did not differ significantly among the different types of white meat studied. The appearance, aroma, 37lavor, acceptability, tenderness and colour were significantly ($P < 0.05$) different.

For instance, Musa (2016) reported that local chicken (7.64), turkey (7.22) and guinea fowl (7.11) were significantly better ($P < 0.05$) than fish (6.83) and duck (6.53) in terms of appearance of their meat. Local chicken, turkey, guinea fowl and fish were more acceptable by the panelists in terms of overall acceptability and colour of meat.

2.17.3: Sensory Attributes of *Dambun Nama* from Red Meat

Various researchers used different species (beef, mutton, chevon, camel meat) in the processing of *dambun nama* from red meat. Bube (2003) worked on beef, chevon and mutton. Balarabe (2016b) also reported sensory attributes of *dambun nama* processed from red meat (beef, chevon, mutton and camel meat). This worker reported that the red meat types differed significantly ($P < 0.05$) in terms of juiciness and palatability, but other sensory parameters (color, tenderness, aroma and acceptability) investigated did not show significant ($P < 0.05$) differences. Similarly, Kalla *et al*. (2005) reported sensory attributes of *dambun nama* processed from beef, chevon, mutton and camel meat using panelists of various socio-cultural background in Bauchi State. These workers reported significant differences in all the sensory parameters (color, flavor, tenderness, palatability and overall acceptability), except juiciness which did not differ significantly in the four red meat types studied.

2.18: Sensory Attributes of Meat Products

The eating quality, which is a combination of tenderness, flavor and juiciness is one of the most important characteristics by which consumers judge meat quality (Grunert *et al*., 2004) and one of the attributes that is most difficult to evaluate before purchase because it is not visible and highly variable (Verbeke *et al.*, 2010). The sensory properties like color or tenderness may have a significant impact on meat quality acceptability. The sensory qualities of meat are one of the primary factors influencing consumers' satisfaction. Rodrigues and Teixeira (2009) have reported that sensory analysis performed by trained panelists is the most appropriate tool to explain differences between the treatments as perceived by humans.

Troy and Kerry (2010) have reported that numerous factors including species, sex of the animal, animal growth rate and maturation, diet, genetic factors, disease status, medication and hormone usage, rearing conditions, temperature, relative humidity and general husbandry practices have direct and indirect impact on meat quality. However, it has been reported that these factors and meat quality are closely related with consumers' behavior as well as with some sensory characteristics such as colour, texture, odour, and acceptability. These workers also reported that correct determination of the relationships between these variables plays an important role in meat marketing and consumption. Bube (2003) gave detailed descriptions of these characteristics, as follows:-

Sensory profile can be developed in many ways. The prime concern of a sensory panel is to assess and quantify the sensory characteristics of different products or product type while acceptability is probably best determined by consumers (Belkens *et al*., 1991). Consumer tests can be carried out in many ways. For example home test, where families test a limited number of products at a time or hall test, where up to 10-12 samples can be presented in conditions similar to those in the laboratory (Ikeme, 1990). Belkens *et al* (1991) reported that it is possible to relate consumer preference to laboratory panel data. A model that allows different preference among consumers can be formulated and this overcomes the possibility of opposing views cancelling each other when simple averages of preference data are calculated. Leora (1994) stated that the eating of food elicits both emotional and physical reaction. The author concluded that physically, all the senses are involved in eating. For example, eyes appreciate color and gloss, ears (crunch), mouth and nose (basic taste, aroma, and texture).

2.18.1: Tenderness

This is one of the main eating quality characteristics that influence consumer overall acceptability. Tenderness as a trait that consist of elements such as ease of shearing or cutting during mastication, and one of the main meat quality attributes important for its acceptability and purchasing intention of consumers (Cooper and Horbariczuk, 2002). Tenderness in meat is one of the important desires of the consumer, considering the amount of time and resources expended in an attempt to improve tenderness (Farouk *et al*., 1992). The continuous practice of aging carcasses for 3-14 days to achieve tenderness has made the meat industry the most power intensive of all food industries. Koohamaraie *et al*. (1990) demonstrated that in ovine carcasses, post-mortem storage for 24hrs to increase tenderness can be eliminated by the level of concentration of calcium chloride in a solution. Wheeler and Koohamaraie (1994) concluded that pre-rigor meat was tenderer than post-rigor meat. May *et al*. (1992) fed high concentrate diets to cattle for 12 weeks and found that taste panel tenderness scores were improved as against those without the concentrate. However, additional feeding from 84-168 days did not improve taste panel tenderness ratings.

2.18.2: Flavour

Leora (1994) defined 39lavor as the combined perception of taste, smell and mouth feel. Flavour and aroma are made up of varieties of different classes of chemicals that are either present in the food ingredients or are formed during processing (Neilgard *et al*., 1991). The perception of 40lavor is a result of the chemical stimulation of receptors in both the oral and nasal cavities. Tastes perceived on the tongue are those of salty, sweet, sour and bitter which are caused by substances that dissolve in the mouth (Oreskovich *et al*., 1992). Flavouring ingredients may be used to enhance, extend, round out or increase the potency of 40lavor (James, 1994a). Flavour therefore, represents a major attribute of food and a deciding factor in the public measurement of the quality of food (John, 1993).

2.18.3: Colour

The appearance of meat, especially colour, has been used by consumers as an important indicator of meat quality. James (1993) stated that colour has a powerful influence on consumer acceptance of food products especially meat products and serves as a visual indication of meat quality. Adam *et al.* (2010) reported that meat colour is considered as an important parameter that attracts consumers to buy meat. The meat colour is mainly affected by the level and state of myoglobin. The consumer seeks leanness above all other attributes of meat quality. Traditionally, meat colour has been the main criterion for evaluating freshness of retail meat, and this is a key component of consumer purchase decision for retail beef (Wheeler *et al*., 1991). However, in most countries, the pale colour of meat is one of the major criteria by which consumers judge veal meat quality (Miltenburg *et al*., 1992). Arnol *et al*. (1993) concluded that supplementation of feedlot steers with diets containing vitamin E effectively extends the colour stability and lipid contents in displayed fresh meat from Holstein or crossbreed beef steer for several days. Technology which extends the colour and shelf-life of meat would improve its economic return (Schaefer *et al*,. 1991).

2.18.4: Palatability

Palatability is the overall impression of palate to tenderness, juiciness, and 40lavor. Aduku and Olukosi (1991) stated that if the overall impression is that of satisfaction, and the need appeals to the palate, there will be consumption of more meat, hence it is palatable. Palatability factors are critical in consumer acceptance of meat products and can be both positively and negatively impacted by several processing methods (Arnol *et al*., 1993). Meat is eaten for both enjoyment and nutrition. The enjoyment is in the aroma and 41lavor of the product. Meat has society value because of its fat, which is digested slowly than other components (Nour *et al*., 1994).

2.18.5: Juiciness

Parrish *et al*. (1991) reported that sensory scores for juiciness desirability followed the same trends as those for overall acceptance in steaks with different grades. Juiciness has substantial effect on acceptability of meat cuts (Chambers *et al*., 1992b). Following tenderness, juiciness is most often discussed as essential in muscle food (Chambers and Bowers, 1993). Juicy and moist were terms often mentioned by consumers in focus groups to describe an ideal piece of meat (Chambers *et al*., 1992a). However, excessive moisture and juiciness that result in greasiness are not desirable (Chambers *et al*., 1992b).

2.19: Some Plant Extracts used in Meat Technology

Uzeh *et al* (2006) described the procedure of extracting extracts from spices. The spices are *Afromomum meledueta*, *Piper quinense* and *Capsicum fructescens* extracted using 95% ethanol Twenty (20g) of each spice was ground into powder form in a clean mortar. This was suspended in 100ml of 95% ethanol, stirred, left to stand with occasional stirring for 2 hours and then filtered through cheese cloth into sterile bottles. Uzeh *et al*. (2006) conducted a sensitivity test with some of these antibiotics; ciprofloxacin, offloxacin, erythromycin, gentamycin and streptomycin. The results showed that each of the isolates was sensitive to some of these antibiotics. Also, sensitivity of the bacteria to some spices was also observed, however, *Pseudomonas aerugionosa* was resistant to all the spices. Other plant materials or sources may also have the potentials for use in research to prolong the shelf life of meat products.

However, information was available on the effects of other plant materials/ extracts on the suppression microbial activities in meat products (Balarabe *et al*., 2016b; Balarabe *et al*., 2016c; Musa, 2016; Salihu, 2017). These workers tested the effects of *'sabara'* (*Guiera senegalensis*) and '*zogale'* (*Moringa oleifera*) in the processing and storage of *dambun nama* using various packaging media for shelf life of the products and varying effects of these plant extracts.

2.20: Development of Meat Packaging Technologies

Food is packaged for storage, preservation and protection traditionally for a long time. These three are the basic functions of food packaging that are still required today for a better maintenance of quality and handling of food (Galic *et al*., 2011). Factors like discoloration, lipid oxidation, dehydration and change in smell are taken into account when it comes to considering processed meat products. Rufina and Dorothy (2017) reported that many packaging systems exist, each with different attributes and applications. These sytems range from overwrap packaging for short term chilled storage or/and retail display to a diversity of specified modified atmospheric packaging (MAP) systems for longer-term chilled storage and/or display to vacuum packaging, and also bulk-gas flushing or MAP systems using 100% carbondioxide for long term chilled storage. Potter (1986) reported that lower storage temperatures slow microbial growth and activity. Hansen *et al.* (1995) reported that the *sous vide* (vacuum) cooked roast beef was microbiologically stable for at least five weeks at a storage temperature of 2^{o}C. Wang *et al.* (2004) also demonstrated that the shelf-life of *sous vide* (vacuum) cooked chicken wings were extended up to seven weeks when stored at 2^{o}C. These workers also indicated that the cooking water and storage temperatures were critical to the growth of anaerobic bacteria for the *sous vide* product. It has also been shown that about 70% of the microorganisms on vacuum packaged pork were *Lactobacilli species* which is a gram-positive rod, and the remaining 30% were the members of *Enterobacteriaceae* which is a gram-negative rod (Asensio *et al*., 1988; Wang *et al.*, 2004).

Research work on the effects of packaging media and storage on the keeping quality of *dambun nama* have been reported in literature (Bube, 2003; Balarabe *et al*., 2016d; Musa, 2016; Salihu, 2017). For instance, Balarabe *et al.* (2016d) investigated the effects of various packaging media; Santana polythene packaging (SPP), foil paper packaging (FPP), wrapped newspaper packaging (WNP), plastic container packaging (PCP) and disposable container packaging (DCP) on the keeping quality of *dambun nama* processed from *sabara*- and *zogale*-treated leaf extracts and stored over a 5-week period. Similarly, Musa (2016) studied the effects of stainless steel and glassware media on the storage quality of *dambun nama* prepared from white meat (fish, turkey, local chicken, duck and guinea fowl meat) processed using *sabara*- and *zogale*-treated leaf extracts.

2.20.1: Effects of Packaging Media and Storage on Total Counts of *Dambun Nama*

Musa (2016) reported that total counts of *dambun nama* processed from white meat (turkey, duck, guinea fowl, local chicken and fish) stored over a 5-week period showed lower counts ($P< 0.05$) in stainless steel medium (24.1×10^4cfu/g) having better storage than *dambun nama* stored in glassware container (26.1×10^4cfu/g).

Balarabe *et al*. (2016d) reported the effect of packaging methods (SPP, FPP, WNP, PCP and DCP) and storage period (from 1st week up to 5th week) on total counts (cfu/g x 10^4) of un-treated beef *dambun nama*. In the 1st week of storage, total microbial load was least (5.0×10^4 cfu/g) in WNP and highest in FPP (12.0×10^4 cfu/g). In the 3rd week, total microbial load was lowest in SPP (4.7×10^4 cfu/g) followed by FPP (7.1×10^4 cfu/g) and highest by PCP (12.0×10^4 cfu/g). However, at 5th week of storage PCP had the lowest total count (2.0×10^4 cfu/g) and highest value was in FPP (7.0 x 10 ^{4} cfu/g) (Balarabe *et al*., 2016c; Balarabe *et al*., 2016d). However, the results on the effect of *sabara*-treated beef *dambun nana* revealed that total microbial count in the 1st week of incubation and storage was least in PCP (3.5 x 10 ^{4} cfu/g) and highest in DCP (12.0 x 10 ^{4} cfu/g). As storage/incubation progresses up to 4th week, total counts was least (2.0 x 10^{4} cfu/g) and this superiority was maintained up to 5th week of incubation (2.0 x 10 ^{4} cfu/g) (Balarabe *et al*., 2016c).

Balarabe *et al*. (2016c) reported the effects of packaging method and storage period on total counts of *zogale*-treated beef *dambun nama*. The results showed that DCP had better microbial load (having lowest value of 3.0 x 10 ^{4} cfu/g). At 4th week, SPP and PCP had the lowest total count (each having 1.0 x 10 ^{4} cfu/g) and this was followed by FPP with total count of 2.0 x10 ^{4} cfu/g. At 5th week, FPP was having the lowest total count of 2.0 x 10 ^{4} cfu/g and followed by WNP (3.0 x 10 ^{4} cfu/g).

Similarly, the effects of treated beef *dambun nama* and storage period on total microbial load. At 1st week of incubation/storage, *zogale*-treated beef *dambun nama* (ZBD) had the lowest count of 34.5 x 10 ^{4} cfu/g followed by *sabara*-treated beef *dambun nama* (SBD) having 38.5 x 10 ^{4} cfu/g. This superiority was maintained up to the 3rd week of storage. At 5th week, SBD was more effective (23.0 x10 ^{4} cfu/g) than NBD (24.0 x 10 ^{4} cfu/g) and ZBD (24.0 x10^{4} cfu/g) (Balarabe *et al*., 2016c; Balarabe *et al*., 2016d).

Balarabe *et al*. (2016c Balarabe *et al*., 2016d) reported interaction effects of packaging methods and un-treated/treated beef *dambun nama* on total counts (bacteria and fungi). The interaction effect with the lowest total counts of 21.0 x 10^{4}cfu/g was recorded in ZBD x FPP. This was followed by SBD x FPP. Conversely, the highest total count of 42.7 x 10^{4} cfu/g was in SBD x WNP. This was followed by NBD x WNP.

Furthermore, Salisu (2017) investigated the inclusion levels (2.0, 3.0 and 4.0g/100ltrs of water) of *sabara*- and *zogale* – treated beef *dambun nama* stored over a 12-week period. The results showed lower total counts in *sabara* – treated beef *dambun nama* (19.97 x 10^3 cfu/g) than in *zogale* – treated beef *dambun nama* (20.30 x 10^3 cfu/g) stored at 12-week period.

2.20.2: Effects of Packaging Media and Storage on Total Bacterial Counts of *Dambun Nama*

In air, aerobic bacteria predominate on meat. If nitrogen-containing compounds (i.e, amino acids) are usedc by these bacteria, the end products of microbial growth will include malodorous amines (ammonia, putrescine and cadaverine) and sulphur compounds, which causes off-odours and flavours that are typically described as putrid (Rufina and Dorothy, 2017). The economic and public health consequence of the presence of microorganisms in food depends on the species and quantity present. And also the number of microorganisms present in the product determines whether the contamination will cause microbial deterioration or disease (Rufina and Dorothy, 2017). Musa (2016) reported that total bacterial counts of *dambun nama* processed from white meat and stored over a 5-week period showed significant ($P< 0.05$) differences between stainless steel medium (13.7 x 10^4cfu/g) having better storage (lower count) than *dambun nama* stored in glassware container (17.2 x 10^4cfu/g).

Balarabe *et al*. (2016d) reported the effects of packaging methods and storage period on total aerobic mesophilic counts of non-treated beef *dambun nama* (NBD). The results showed that in the first week of incubation/storage PCP had the lowest count of 1.7 x 10^4 cfu/g followed by WNP (3.0 x 10^4 cfu/g). However, at 4^{th} and 5^{th} weeks PCP and DCP recorded no mesophilic counts while SPP and FPP having (4.0 vs 1.0 x 10^4 cfu/g) and (4.0 vs 0.0 x 10^4 cfu/g) for 4^{th} and 5^{th} weeks, respectively.

Total aerobic mesophilic counts of *sabara*-treated beef *dambun nama* were reported by Balarabe *et al*. (2016d) to be influenced by packaging methods and storage period. Total bacterial counts of 5.0, 3.0, 3.0, 1.2 and 7.0 x 10^4 cfu/g were recorded for SPP, FPP, WNP, PCP and DCP, respectively, when beef *dambun nama* was treated with *sabara* leaf extracts in the first week of storage. At higher weeks (4^{th} and 5^{th}), FPP, DCP and PCP recorded low mesophilic counts.

Similarly, total aerobic mesophilic counts of *zogale*-treated beef *dambun nama* as affected by packaging methods and storage period (Balarabe *et al*., 2016d). These authors revealed that total aerobic mesophilic counts were lowest at 1^{st} week (2.0 x 10^4 cfu/g), 2^{nd} week (2.0 x 10^4 cfu/g), 3^{rd} week (2.0 x 10^4 cfu/g), 4^{th} week (1.0 x 10^4 cfu/g) and 5^{th} week (0.0 x 10^4 cfu/g) were for packaging methods DCP, PCP, PCP, SPP/ FPP/ PCP and FPP, respectively. The overall effects of un-treated (UBD) and treated *dambun nama* (SBD and ZBD) on total aerobic mesophilic counts showed that at week 1, 2, 3, 4 and 5 of storage, total aerobic mesophiilic counts were lowest for SBD, ZBD, UBD vs ZBD and UBD, respectively.

The interaction effects of packaging method and non-treated/treated beef *dambun nama* on total aerobic mesophilic counts showed that the best (lowest count) interaction (10.2 x 10^4 cfu/g) was in SBD x DCP, which was followed by the interaction of ZBD x FPP; having 10.7 x 10^4 cfu/g. Conversely, the highest total aerobic mesophilic counts was in the interaction of SBD x WNP with a total count of 31.6 x 10^4 cfu/g and this was followed by the interaction of NBD x WNP with 23.3 x 10^4 cfu/g as total mesophilic counts (Balarabe *et al*., 2016d).

However, Salisu (2017) investigated the inclusion levels (2.0, 3.0 and 4.0g/100ml of water) of *zogale* – treated beef *dambun nama* stored over a 12-week period. The results showed lower total counts in *sabara* – treated beef *dambun nama* (19.97 x 10^3 cfu/g) than in *zogale* - treated beef *dambun nama* (20.30 x 10^3 cfu/g) stored at 12-week period. The author reported that the total bacterial count of *sabara*-treated beef *dambun nama* at 12-week storage was lowest at inclusion level 3.0g/100 ml of cooking water (1.0 x 10^3 cfu/g) followed by inclusion level 4.0g/100ml of water (3.0 x 10^3 cfu/g) and highest (5.0 x 10^3 cfu/g) when *sabara* leaf extract was incorporated at 2.0g/100ml of water. Similarly, *moringa*-treated beef *dambun nama* showed that the total bacterial count at 12-week storage was lowest (10.0 x 10^3 cfu/g) at inclusion level 3.0g/100ml of water followed by 2.0g/100ml inclusion level (4.0 x 10^3 cfu/g) and highest (5.0 x 10^3 cfu/g) when *dambun nama* was processed using *moringa* leaf extract was included at 4.0g/100ml of water.

2.20.3: Effects of Packaging Media and Storage on Total Fungal Counts of *Dambun Nama*

Musa (2016) compared the efficacy of two storage media on total fungal multiplications in *dambun nama* processed from different types of white meat. The worker reported that total fungal count was significantly ($P<0.05$) lower at 5th week in glassware (8.7 x 10^4cfu/g) than in stainless steel media (9.0 x 10^4cfu/g).

However, Balarabe *et al*. (2016d) reported the effects of packaging methods and storage period on total fungal counts of un-treated beef *dambun nama*. The results showed that the packaging methods with the lowest fungal counts at first, second, third, fourth and fifth weeks of storage were WNP, PCP, SPP, FPP/DCP and WNP/PCP, respectively. However, the influence of *sabara*-treated beef *dambun nama* on total fungal counts revealed that the lowest values of total fungal counts for 1st week (2.3 x 10^4cfu/g), 2nd week (2.6 x 10^4cfu/g), 3rd week (1.0 x 10^4cfu/g), 4th week (0.0 x 10^4cfu/g) and 5th week (2.0 x 10^4cfu/g) were for packaging methods PCP, SPP, FPP, WNP and FPP/WNP/PCP/DCP, respectively.

The effects of packaging method and storage period on total fungal counts of *zogale*-treated beef *dambun nama* showed lowest counts in WNP, DCP, PCP, PCP and PCP at 1st, 2nd, 3rd, 4th and 5th weeks, respectively. The overall effects of un-treated/treated beef *dambun nama* on total fungal counts showed that at 1st week of incubation/storage ZBD was best followed by SBD. Similarly, at 5th week SBD was best (12.0 x 10^4cfu/g) followed by ZBD (15.0 x 10^4 cfu/g) and worst in UBD (19.0 x 10^4cfu/g). However, the highest total fungal count of 26.6 x 10^4cfu/g was recorded in UBD at 3rd week of storage (Balarabe *et al*., 2016d).

Similarly, the interaction effects of packaging method and un-treated/treated beef *dambun nama* revealed that the best interaction with lowest fungal counts of 10.3 x 10^4 cfu/g when ZBD was packaged in FPP (Balarabe *et al*., 2016d). This was followed by SBD x WNP with total fungal counts of 11.1 x 10^4cfu/g. However, the highest/worst interaction was in SBD x DCP. This was followed by interaction of UBD x PCP and UBD x DCP; values being (21.6 x 10^4 cfu/g) and (20.0 x 10^4 cfu/g), respectively.

Salisu (2017) reported that *sabara*-treated beef *dambun nama* showed that the total fungal count at 12-week storage was better at inclusion level 4.0g/100ml of water at 10th and 12th week of storage (1.0 x 10^3 cfu/g vs 3.0 x 10^3 cfu/g) as compared to other inclusion levels of 2.0g/100ml and 3.0g/100ml; values being 5.0 x 10^3 cfu/g vs 5.0 x 10^3 cfu/g and 3.0 x 10^3 cfu/g vs 4.0 x 10^3 cfu/g, when *dambun nama* was stored at 10th and 12th weeks, respectively.

2.21: Meat Contaminations and Adulterations

Fresh meat is a highly perishable product due to its biological composition. Uzeh *et al* (2006) reported aspect of meat microbiology in a raw meat and *tsire-suya* (a local meat product in Nigeria). Under normal, aerobic packaging conditions, the shelf-life of refrigerated meat is limited by the growth and biochemical activities of aerobic, psychrotropic strains of bacteria. Additional control methods which can be used to extend the shelf-life of fresh meat include modified atmospheric packaging, chemical decontamination prior to packaging and low dose irradiation after packaging (Uzeh *et al*., 2006). The authors reported higher count of bacteria in raw meat than in *tsire-suya*, and they attributed to high content of microbes due to the low heat effect on the bacteria during the preparation of *tsire-suya*.

Solberg *et al.* (1986) reported that bacterial count exceeding 10^5/g or coliform count higher than 10^2/g in delicatessen food products are indicative of dangerous contamination. This was similarly reported by Pace (1975). Uzeh *et al.* (2006) reported bacteria count of 7 x 10^2 to 171 x 10^2cfu/g in *tsire-suya*. These workers also reported coliform count of 1 x 10^2 to 42 x 10^2cfu/g in *tsire-suya*. However, the incidence of *Escherichia coli* obtained in *tsire-suya* is a result of poor hygiene since it is popularly sold along streets (Uzeh *et al.*, 2006). Omoregbe and Igbinovia (1992) reported that *S. aureus* and *B. cereus* have been known to be implicated in food borne illness. *S. aureus* have been reported in the nose and throat of food handlers (Omeregbe and Igbinovia, 1992). This microbe has been shown to be in more than 50% of healthy humans, as reported by Bergdol (1990). Uzeh *et al.* (2006) observed that this organism (*S. aureus*) might have occurred in *tsire-suya* as a post processing contaminant or as a result of poor processing. These workers also reported that *B. cereus* is a spore former, which can be found in the air or even spices. These spores are heat resistant and possibly account for its occurrence in *tsire-suya* (Uzeh *et al.*, 2006). *P. aeruginosa* being widely spread in nature especially in soil, water and on plant can easily contaminate *suya* since it is usually exposed. Sometimes the spices used in *suya* preparation may have introduced these microbes into the *suya*.

Uzeh *et al*, (2006) reported that the efficiency of the extracting solvent in the total extraction of the active ingredients from the spices can be in doubt. However, results obtained from the spices are encouraging when compared to those obtained from the antibiotics. The authors recommended that the continuous use of these spices in *suya* preparation is highly recommended not only for their flavouring attributes, but also for their possible health benefit.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Area

The study was conducted at the Department of Animal Science, Faculty of Agriculture, and at the General Microbiology Laboratory, Department of Microbiology, Faculty of Life Sciences, Ahmadu Bello University, Zaria. Samaru is located in the Northern Guinea Savannah Ecological Zone of Nigeria. It is on latitude 11^o 19ˈ North, longitude 7^o, 37ˈ45 East and at an altitude of 610 meters above sea level (Ovimaps, 2019). The temperature ranges between 26^0 and 40^o, depending on the season while the relative humidity during the dry and wet seasons ranged between 21% and 72%, respectively (IAR, 2019). The wet season in Samaru range between May and October with annual rainfall of about 1500mm.

3.2 Sourcing and Processing of *Moringa oleifera* and *Guiera senegalensis* Leaf Meals

Fresh leaves of *Moringa oleifera* and *Guiera senegalensis* were sourced in Samaru and Sabon Gari markets of Zaria LGA (Kaduna State), and were shade-dried for 3 days (72hrs). The dried leaves were ground into powder form using a hammer mill at Labar feed mill Samaru to produce leaf meal of the plants.

3.3 Analysis for Chemical Composition

The leaf powder of *Moringa* (*Moringa oleifera*) and *Sabara* (*Guiera senegalensis*) used in the study were taken to Department of Animal Science Biochemical Laboratory for analysis of chemical composition using the standard method described by (AOAC 2005). The analyses were done to obtain the nutrient composition (Dry matter, Crude Protein, Crude Fibre, Ash and Nitrogen Free Extract) of the diet. Protein was determined by Kjedahl procedure, Ether extract was determined by subjecting the samples to petroleum ether extraction at 60-80^{o}C using the soxhlet extraction apparatus. Dry matter was determined by oven drying the samples at 100^{o}C over a 12-hour period. Crude fiber was determined by boiling the sample under reflux in a weak sulphuric acid (0.255N H_2SO_4), then in a weak sodium hydroxide (0.312N NaOH) for 1 hour. The residues (fibrous material) were dried and weigh. The ash content was determined by igniting a weighted sample in a muffle furnace at 500^{o}C. The nitrogen free extract (NFE) was obtained by the difference after the percentage of other fractions has been subtracted from 100%.

3.4 Experimental Design and Management of Birds

Two experiments were conducted separately for *Moringa oleifera* and *Guiera senegalensis.* The studies were done con-currently, where two hundred and forty (240) day old broiler chicks of cobb 500 strain for each of the two experiments. In the first experiment, the birds were allotted into four different dietary treatments comprising of a control (MOL1; 0) and different proportions of *Moringa oleifera* (7.0, 14.0 and 21.0% of diet to serve as treatments MOL2, MOL3 and MOL4, respectively (Tables 3.1 and 3.2) and the treatments were replicated three (3) times with 20 chicks per replicate in a completely randomized design. The trial lasted for 8 weeks (0 – 4 weeks starter phase and 5 – 8 weeks finisher phase).

Two hundred and forty (240) day old broiler chicks of cobb 500 strain were also used for the second experiment involving *Guiera senegalensis* and the birds were allotted into four different dietary treatments comprising of a control (GSL1; 0) and different proportions of *Guiera senegalensis* (7.0, 14.0 and 21.0% of diet to serve as treatments GSL2, GSL3 and GSL4 respectively) and the treatments were replicated four (3) times with 20 chicks per replicate in a completely randomized design (CRD) (Tables 3.3 and 3.4). The trial also lasted for 8 weeks (0 – 4 weeks starter phase and 5 – 8 weeks finisher phase).

Feed and clean water were given *ad libitum* to the birds throughout the experimental period. The birds were vaccinated against Newcastle and Gumboro diseases (at 2nd and 3rd weeks) as recommended by the Veterinary Teaching Hospital (VTH) of Ahmadu Bello University, Zaria. Other standard methods such as fumigation, sanitation and prophylactic medications were carried out to ensure healthy birds throughout the experiment.

Table 3.1: Composition (Kg) of broiler starter diet containing graded levels of *Moringa oleifera* Leaf meal (0 – 4 weeks)

Ingredients	**MOL 1**	**MOL 2**	**MOL 3**	**MOL 4**
Maize	50.00	46.00	43.00	41.00
FSBM	15.00	15.00	15.00	15.00
MOL	**0.00**	**7.00**	**14.00**	**21.00**
Maize offal	3.50	3.50	3.50	3.50
GNC	27.00	24.00	20.00	15.00
Bone Meal	3.00	3.00	3.00	3.00
Limestone	0.50	0.50	0.40	0.40
Methionine	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.35	0.35
Common salt	0.25	0.25	0.25	0.25
Vit. Premix*	0.25	0.25	0.25	0.25
Total	**100.00**	**100.00**	**100.00**	**100.00**
Calculated Analysis				
ME (Kcal/kg)	2011	2901	2902	2900
Crude Protein (%)	23.11	23.32	23.28	23.13
Crude Fibre (%)	4.61	4.81	4.91	5.00
Ether Extract (%)	6.45	6.55	6.63	6.62
Calcium (%)	1.34	1.34	1.31	1.31
Phosphorus (%)	0.63	0.63	0.62	0.62
Lysine (%)	1.21	1.18	1.20	1.17
Methionine (%)	0.56	0.54	0.52	0.51

*Bio-mix broiler starter premix per 2.5kg of diet: Vit A, 10,000 I.U; Vit D_3, 2,000 I.U; Vit E, 23,000mg; Vit K_3, 2000mg; Vit B1,(thiamine) 1,800; Vit B_2(riboflavin), 5,500mg; Niacin, 27,500; Panthonenic acid, 7,500; Vit B6(pyridoxine),3000mg; Vit B_{12}, 15.00; Folic acid, 750.00mg; Biotin H_2, 60.00mg; Cholin Chloride, 300,000mg; Cobalt, 200mg; Copper,3000mg; Iodine, 3,000mg; Iron, 1,000mg; Manganese, 40,000.00mg; Selenium, 40,000mg; Zinc, 200mg; Antioxidant,1,250mg . GNC= Groundnut cake, FSBM= Full fat soya bean meal, M.E= Metabolisable energy, MOL= *Moringa oleifera* Leaf Meal

Table 3.2: Composition (Kg) of broiler finisher diet containing graded levels of *Moringa oleifera* leaf meal (5- 8 weeks)

Ingredients	MOL 1	MOL 2	MOL 3	MOL 4
Maize	55.00	51.00	48.00	44.00
FSBM	10.00	10.00	10.00	10.00
MOL	**0.00**	**7.00**	**14.00**	**21.00**
Maize offal	8.50	8.50	8.50	8.50
GNC	22.00	19.00	15.00	12.00
Bone Meal	3.00	3.00	3.00	3.00
Limestone	0.40	0.40	0.40	0.40
Methionine	0.25	0.25	0.25	0.25
Lysine	0.35	0.35	0.35	0.35
Common salt	0.25	0.25	0.25	0.25
Vit. Premix*	0.25	0.25	0.25	0.25
Total	**100.00**	**100.00**	**100.00**	**100.00**
Calculated Analysis				
ME (Kcal/kg)	2972	2963	2963	2954
Crude Protein (%)	20.08	20.29	20.15	20.26
Crude Fibre (%)	4.63	4.83	4.93	5.13
Ether Extract (%)	5.63	5.73	5.81	5.91
Calcium (%)	1.29	1.29	1.29	1.29
Phosphorus (%)	0.60	0.60	0.59	0.59
Lysine (%)	1.13	1.10	1.05	1.01
Methionine (%)	0.53	0.51	0.49	0.48

*Bio-mix broiler starter premix per 2.5kg of diet: Vit A, 10,000 I.U; Vit D_3, 2,000 I.U; Vit E, 23,000mg; Vit K_3, 2000mg; Vit B1,(thiamine) 1,800; Vit B_2(riboflavin), 5,500mg; Niacin, 27,500; Panthonenic acid, 7,500; Vit B6(pyridoxine),3000mg; Vit B_{12}, 15.00; Folic acid, 750.00mg; Biotin H_2, 60.00mg; Cholin Chloride, 00,000mg; Cobalt, 200mg; Copper,3000mg; Iodine, 3,000mg; Iron, 1,000mg; Manganese, 40,000.00mg; Selenium, 40,000mg; Zinc, 200mg; Antioxidant,1,250mg , GNC= Groundnut cake, FSBM= Full fat soya bean meal. M.E= Metabolisable energy, MOL= *Moringa oleifera* Leaf Meal

Table 3.3: Composition (Kg) of broiler starter diet containing graded levels of *Guiera senegalensis* Leaf meal (0 – 4 weeks)

Ingredients	GSL 1	GSL 2	GSL 3	GSL 4
Maize	50.00	46.00	43.00	41.00
FSBM	15.00	15.00	15.00	15.00
GSL	**0.00**	**7.00**	**14.00**	**21.00**
Maize offal	3.50	3.50	3.50	3.50
GNC	27.00	24.00	20.00	15.00
Bone Meal	3.00	3.00	3.00	3.00
Limestone	0.50	0.50	0.40	0.40
Methionine	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.35	0.35
Common salt	0.25	0.25	0.25	0.25
Vit. Premix*	0.25	0.25	0.25	0.25
Total	**100.00**	**100.00**	**100.00**	**100.00**
Calculated Analysis				
ME (Kcal/kg)	2911	2901	2903	2900
Crude Protein (%)	23.11	23.32	23.28	23.13
Crude Fibre (%)	4.61	4.81	4.91	5.00
Ether Extract (%)	6.45	6.55	6.63	6.71
Calcium (%)	1.34	1.34	1.31	1.31
Phosphorus (%)	0.63	0.63	0.62	0.62
Lysine (%)	1.21	1.18	1.20	1.17
Methionine (%)	0.56	0.54	0.52	0.51

*Bio-mix broiler starter premix per 2.5kg of diet: Vit A, 10,000 I.U; Vit D_3, 2,000 I.U; Vit E, 23,000mg; Vit K_3, 2000mg; Vit B1,(thiamine) 1,800; Vit B_2(riboflavin), 5,500mg; Niacin, 27,500; Panthonenic acid, 7,500; Vit B6(pyridoxine),3000mg; Vit B_{12}, 15.00; Folic acid, 750.00mg; Biotin H_2, 60.00mg; Cholin Chloride, 300,000mg; Cobalt, 200mg; Copper,3000mg; Iodine, 3,000mg; Iron, 1,000mg; Manganese, 40,000.00mg; Selenium, 40,000mg; Zinc, 200mg; Antioxidant,1,250mg . GNC= Groundnut cake, FSBM= Full fat soya bean meal, M.E= Metabolisable energy, GSL= *Guiera senegalensis* Leaf Meal

Table 3.4: Composition (Kg) of broiler finisher diet containing graded levels of *Guiera senegalensis* Leaf meal (5- 8 weeks)

Ingredients	GSL 1	GSL 2	GSL 3	GSL 4
Maize	55.00	51.00	48.00	44.00
FSBM	10.00	10.00	10.00	10.00
GSL	**0.00**	**7.00**	**14.00**	**21.00**
Maize offal	8.50	8.50	8.50	8.50
GNC	22.00	19.00	15.00	12.00
Bone Meal	3.00	3.00	3.00	3.00
Limestone	0.40	0.40	0.40	0.40
Methionine	0.25	0.25	0.25	0.25
Lysine	0.35	0.35	0.35	0.35
Common salt	0.25	0.25	0.25	0.25
Vit. Premix*	0.25	0.25	0.25	0.25
Total	**100.00**	**100.00**	**100.00**	**100.00**
Calculated Analysis				
ME (Kcal/kg)	2972	2963	2963	2954
Crude Protein (%)	20.08	20.29	20.15	20.26
Crude Fibre (%)	4.63	4.83	4.93	5.13
Ether Extract (%)	5.63	5.73	5.81	5.91
Calcium (%)	1.29	1.29	1.29	1.29
Phosphorus (%)	0.60	0.60	0.59	0.59
Lysine (%)	1.13	1.10	1.05	1.01
Methionine (%)	0.53	0.51	0.48	0.48

*Bio-mix broiler starter premix per 2.5kg of diet: Vit A, 10,000 I.U; Vit D_3, 2,000 I.U; Vit E, 23,000mg; Vit K_3, 2000mg; Vit B1,(thiamine) 1,800; Vit B_2(riboflavin), 5,500mg; Niacin, 27,500; Panthonenic acid, 7,500; Vit B6(pyridoxine),3000mg; Vit B_{12}, 15.00; Folic acid, 750.00mg; Biotin H_2, 60.00mg; Cholin Chloride, 300,000mg; Cobalt, 200mg; Copper,3000mg; Iodine, 3,000mg; Iron, 1,000mg; Manganese, 40,000.00mg; Selenium, 40,000mg; Zinc, 200mg; Antioxidant,1,250mg , GNC= Groundnut cake, FSBM= Full fat soya bean meal, M.E= Metabolisable energy, GSL= *Guiera senegalensis* Leaf Meal

3.5: Experiment 1: Growth Performance of Broiler Chickens Fed Diets Containing Graded Levels of *Moringa oleifera* and *Guiera senegalensis* Leaf Meals

3.5.1 Performance traits evaluation

The initial body weights of the birds were measured at the beginning of each of the two experiments while final body weights were recorded at the end of each experiment. Feed consumption and body weight of the birds were taken weekly. Body weight was then computed as the difference between the final body weight and the initial body weight. The feed conversion ratio was computed as the ratio between feed intake and body weight gain.

3.5.2: Carcass evaluation traits

At the end of the 8th week of the two trials (1a and 1b), three (3) birds of representative weights were randomly selected from each replicate making 12 birds per treatment. The birds were fasted overnight and provided with water, then weighed, slaughtered, and eviscerated. Carcass indices such as live weight, carcass weight, dressing weight, dressing percentage, organs weight and weight of the prime cuts were taken. Prime cuts and organ weights were expressed as percentages of dressed weight and live weight, respectively.

3.5.3: Proximate analysis of carcass

At the end of the feeding trials (8th week), three birds (one bird per replicate) of the same weights were randomly selected from each treatment groups of the two experiments in *Moringa oleifera* (MOL1, MOL2, MOL3 and MOL4) and *Guiera senegalensis* (GSL1, GSL2, GSL3 and GSL4). The birds were slaughtered, dressed and eviscerated. The breast parts were cut from the carcass of birds and the samples were immediately taken to laboratory for analysis of proximate composition (dry matter, crude protein, crude fibre, lipid, ash and carbohydrate) according to AOAC (2005). The following procedures were made:-

1) **Determination of Moisture Content:** This was done by washing of aluminium/plastic dishes and dried to a constant weight in an oven at 100^{0}C. They

were later removed and cooled in a dessicator and weighed (W1). 2grams og the grounded powder sample was placed in the weighed moisture dish (W2). The dish containing the sample was kept in an oven for about 3hours, the samles were removed and cooled in the dessicator and then weighed (W3).

The moisture was calculated as: W2-W3 x 100/ W2-W1

2) **Determination of Ash Content:** Crucibles were cleansed and dried in the oven, dried and cooled in the dessicator and weighed (W1). 2grams of the ground powder sample was placed in the crucibles and weighed (W2). They were transferred into muffle furnace for about 550^0C, then removed and cooled in the dessicator and weighed (W3). This was calculated as: W3-W1 x 100/ W2-W1

3) **Determination of Fibre:** 2grams of the sample was placed in a beaker containing 1.2ml of H_2SO_4 per 100ml of solution and boiled for about 30mins, the residue was filtered and washed with hot water, then transferred to a beaker containing 1.2gram of NaOH per 100ml of solution and boiled for 30mins, the residue was then washed with hot water and dried in an oven and weighed (C2), the weighed sample was incinerated in a furnace for about 550^0C, removed and allowed to cool and then weighed (C3).

   This was calculated as: C2-C3 x 100/ W

4) **Determination of Lipid (Fat):** 250ml clean boiled flask was dried in an oven, then transferred into dessicator and allowed to cool. Empty filter paper was weighed and labelled W1. 2gram of the sample was weighed into labelled thimbles (filter paper) W2. The boiling flask was filled with petroleum spirit, and soxhlet apparatus was assembled and allowed to reflux for 8hrs. This was then removed and transferred to an oven to dry, and removed from oven to dessicator to cool and weighed as W3.

   The % fat is calculated as: W2-W3 x 100/ W2-W1

5) **Determination of Protein:** For digestion, 0.5-2grams of the sample was weighed in a

Kjeldahl flask, catalyst (copper) and 15ml conc. H_2SO_4 were added. Then heated in fume cupboard till solution assumes a greenish colour. This was then cooled and any black particles showing at the mouth and neck of the flask was washed with distilled water. After cooling, the digest with several washing was transferred into 100ml with distilled water. Distillation was done by steaming through the Markham distillation apparatus for 15mins; 100ml conical flask containing 10ml of Boric indicator was placed under the condenser. 10ml of the digest was pipette in the apparatus through a small funnel aperture, and then washed down with distilled water followed by 10ml of 40% NaOH solution. This was then steamed through for about 5-7 mins to collect ammonium sulphate (30-40ml), and then removed by receiving the flask and wash down the tip of the condenser into the flask.

The % protein was calculated as: Final reading – Initial reading blank (0.2) x standard number of Nitrogen (1.4) divide by Initial weight (0.5) x standard number of protein (6.25).

6) **Determination of Carbohydrate** (Pearson 1976): By difference, the carbohydrate content was obtained by calculations having estimated all other fractions by proximate analysis i.e =100 (% of moisture + % ash + % fat).

3.6: Experiment 2: Sensory Evaluation of *Dambun Nama* from Broiler Chickens Fed Diets Containing Graded Levels of *Moringa oliefera and Guiera senegalensis* Leaf Meals

Birds (three in each replicate) of broiler chickens in the two experiments (MOL1, MOL2, MOL3 and MOL4) and (GSL1, GSL2, GSL3 and GSL4) were selected, slaughtered, dressed and processed into *dambun nama*.This include preparation of meat, cooking, shredding and frying.

3.6.1: Preparation of *Dambun nama*

Fresh broiler chicken meat was cut into pieces of approximately 4 cm by 2.5 cm dimensions and washed with water, mixed with spices (ginger, pepper, onion, cloves, garlic, seasoning cubes, thyme, salt, curry) in the ratio of 6g of spice to 100g of meat. Water was added to the meat samples and cooked for about 35 minutes at 100^0C. Cooking was done in different aluminium pots for each of the treatments to avoid mixed up, and procedures were the same across all the treatment groups. The cooked meat was then pounded into shreds using a mortar and pestle. Pounding was intense and consistent until the meat strands disengaged and were beaten into shreds. This was then shallow-fried using groundnut oil in a stainless steel pot to obtain *dambun nama*, which is usually brownish in colour (Bube 2003). The flow chart for the preparation of *dambun nama* is shown in Figure 1, and mixture of spices used in the preparation is shown in Table 3.5.

3.6.2 Proximate analysis of *Dambun nama*

Freshly processed *dambun nama* from broiler chickens fed diets containing graded levels of *Moringa oleifera* (MOL1, MOL2, MOL3 and MOL4) and *Guiera senegalensis* (GSL1, GSL2, GSL3 and GSL4) leaf meals were immediately taken to the laboratory for analysis of proximate composition (moisture, crude protein, crude fibre, lipid, ash and carbohdrate). Methods of procedures were the same with the analysis of fresh chicken meat described by AOAC (2005).

3.6.3: Sensory evaluation of *Dambun nama*

Dambun nama processed from broiler chickens fed dietary inclusion levels of *Moringa oleifera* and *Guiera senegalensis* leaf meals were subjected to sensory evaluation for their acceptance. Forty (40) semi trained panelists (staff and postgraduate students) of the Department of Animal Science, Faculty of Agriculture, Ahmadu Bello University, Zaria; who are familiar with quality attributes of meat products were constituted for evaluation, using the 5 - point Hedonic scale: 5 - like exteremely, 4 – like very much, 3 - neither like nor dislike, 2 - dislike very much and 1 - dislike extremely.

Fresh raw meat

↓

Cutting into pieces of 4 cm x 2.5 cm x 1.5 cm

↓

Washing with clean water

↓

Mixing with ingredients

↓

Boiling for about 35 minutes

↓

Pounding into shreds

↓

Frying with groundnut oil

↓

Cooling

↓

Dambun nama

Figure 1: Flow chart for the preparation of broiler chicken meat into *Dambun nama*
Source: Bube (2003)

Table 3.5: Composition of spices used in processing of *Damnub nama*

Ingredients	Hausa	Scientific/Botanical	Quantity (g/100g)
Table salt	Gishiri	*Sodium Chloride*	10.00
Seasoning cube	Dunkule		15.00
Thyme	Tyme	*Thymus vulgaris*	8.00
Curry	Curry	*Murraya koenigii* (L) *Spreng*	8.00
Onion	Albasa	*Allium cepa* L. *var. cepa*	30.00
Red pepper	Borkono	*Piper nigrum L.*	20.00
Garlic	Tafarnuwa	*Allium sativum L.*	2.00
Cloves	Kanumfari	*Syzgium aromaticum*	2.00
Ginger	Chitta	*Zangiber officinale Rosc.*	5.00
Total			100

Botanical names according to Rehm and Espig (1991)

Buscuits (crackers) and water were provided for cleansing of the taste buds which is done in between each taste of the samples provided. However, the samples were blind coded with figures. The sensory attributes considered were tenderness, juiciness, texture, colour, aroma and acceptability (Appendix 1).

3.7: Experiment 3: Effects of Storage Period and Packaging Method on Shelf- life of *Dambun Nama* Processed from Broiler Chickens Fed Diets Containing Graded Levels of *Moringa oliefera and Guiera senegalensis* Leaf Meals

Dambun nama (meat floss) processed from broiler chickens fed dietary inclusion levels of *Moringa oleifera* (MOL1, MOL2, MOL3, and MOL4) and *Guiera senegalensis* (GSL1, GSL2, GSL3, and GSL4) leaf meals from Experiment 2 were packaged and stored in four (4) different packaging materials each, previously described by Balarabe *et al*. (2016b). The materials are Foil Paper Packaging (FPP), Wrapped Newspaper Packaging (WNP), Plastic Container Packaging (PCP) and Disposable Container Packaging (DCP) to give a total of eight (8) products. The products were stored and monitored for shelf-life stability at 0, 4, 8 and 12 week intervals. The analysis of total counts (bacterial and fungal counts) was carried out (at 0, 4, 8 and 12 weeks intervals) at the General Microbiology Laboratory, Department of Microbiology, Faculty of Life Sciences, Ahmadu Bello University, Zaria.

3.7.1 Fungal analysis

Total fungal count (yeast/moulds) was determined by the methods of AOAC (2005). This was done by plaiting 0.1ml of the representative sample on potato dextrose agar which was incubated at 25^oC for 5 days. Fungal colonies were then counted and averaged, which was expressed as total number of colonies counted multiplied by the dilution factor and volume of inoculum to give the colony forming unit per gramme (cfu/gm x 10^5).

3.7.2 Bacterial analysis

This analysis was conducted to determine total aerobic mesophilic counts (cfu/g x 10^5) as per the procedures of AOAC (2005) and Beyene and Seifu (2005). Total aerobic mesophilic counts were made by plating dilutions of samples on plate count agar and incubated aerobically at 37°C for 24 hours. After incubation, bacterial colonies were counted and averaged, which was expressed as total number of colonies counted multiplied by dilution factor and volume of inoculum thereby giving the colony forming unit per gramme (cfu/gm x 10^5).

3.8 Data Analysis

Data obtained from the experiments were subjected to the analysis of variance (ANOVA) using the general linear model procedure of Statistical Analysis System (SAS, 2008). Significant means (P<0.05) were separated using Duncan's Multiple Range Test (DMRT) in the SAS version 9.0 package

Statistical Models

Exp. 1: $Y_{ij} = \mu + T_i + e_{ij}$

(Treatments; inclusion levels of *Moringa oleifera* and *Guiera senegalensis)*

Exp. 2: $Y_{ij} = \mu + T_i + e_{ij}$

(Treatments; Meat floss processed from the inclusion levels of *Moringa oleifera* and *Guiera senegalensis)*

Exp. 3**:** $Y_{ijkl} = \mu + T_i + P_j + S_k + (T \times P)_{ij} + (T \times S)_{ik} + (P \times S)_{jk} + (T \times P \times S)_{ijk} + e_{ijkl}$

Where;

Y_{ij} = Record of observations for dependent variable

μ = Overall mean

T_i = Effect of treatments in diets (i= 1, 2, 3, 4)

e_{ij} **=** Random error

Y_{ijkl} = Interaction between observed variables

P_j = Packaging media

S_k = Storage period

$(T \times P)_{ij}$ = Interaction between treatments on packaging

$(T \times S)_{ik}$ = Interaction between treatments on storage period

$(T \times P \times S)_{ijk}$ = Interaction between treatments on packaging and storage period

e_{ijkl} = Random error between observable variables

CHAPTER FOUR

4.0 RESULTS

4.1. Chemical composition of *Moringa oleifera* and *Guiera senegalensis* Leaf Powder

The result of chemical composition of *Moringa oleifera* and *Guiera senegalensis* leaves is presented in Table 4.1. The dry matter (DM) content for *Moringa oleifera* leaf is numerically higher (88.51%) than that of *Guiera senegalensis* leaf which is 87.04%. Crude protein value of 19.25 and 19.52% were obtained for *Moringa oleifera* and *Guiera senegalensis* leaves. However, per cent crude fibre for *Moringa oleifera* leaf (8.71%) was numerically lower than that of *Guiera senegalensis* leaf (9.15%). *Moringa oleifera* leaf had crude fibre content of 3.11% and *Guiera senegalensis* had 2.97%. The per cent nitrogen free extract (NFE) content was 60.07% in *Guiera senegalensis* leaves and 60.93% in *Moringa oleifera* leaves. *Guiera senegalensis* leaves had 5.16% ash content and 8.00% was obtained for *Moringa oleifera* leaves. Calcuim was numerically higher in *Guiera senegalensis* leaves (0.23%) than the value obtained for *Moringa oleifera* leaves (0.11%). However, Magnesuim (Mg), Potassuim (K), Soduim (Na) and Phosphorus (P) were numerically higher in *Moringa oleifera* leaves; values being: 0.97, 1.45, 0.99 and 0.33%) than the values obtained in *Guiera senegalensis* leaves as; 0.87, 0.55, 0.52 and 0.09%, respectively. Similarly, 1867.75, 108.08 amd 111.08mg/kg for Fe, Mn and Zn were obtained in *Moringa oleifera* leaves, compared to values of 1254.08, 98.17 and 132.74mg/kg (Fe, Mn and Zn) in *Guiera senegalensis* leaves. *Moringa oleifera* leaves had 244.08mg/kg and *Guiera senegalensis* leaves had 577.67mg/kg of Copper (Cu), respectively.

Table 4.1: Chemical Composition of *Moringa Oleifera* and *Guiera Senegalensis* Leaf meals

Parameters	**Moringa (*Moringa Oleifera*)**	**Sabara (*Guiera Senegalensis*)**
Dry Matter (%)	88.51	87.04
Crude Protein (%)	19.25	19.52
Crude Fibre (%)	8.71	9.15
Fat (%)	3.11	2.97
Nitrogen Free Extract (%)	60.93	60.07
Ash (%)	8.00	5.18
Ca (%)	0.11	0.23
Mg(%)	0.97	0.87
K (%)	1.45	0.55
Na (%)	0.99	0.52
P (%)	0.33	0.09
Fe (mg/kg)	1867.75	1254.08
Mn (mg/kg)	244.08	577.67
Cu (mg/kg)	108.08	98.17
Zn (mg/kg)	111.08	132.74

Table 4.2: Growth performance of broiler chickens fed diets containing graded levels of *Moringa oleifera* leaf meal (0-8weeks)

	Treatments					
Parameters	**MOL1 (0%)**	**MOL2 (7%)**	**MOL3 (14%)**	**MOL4 (21%)**	**SEM**	**LOS**
Initial weight (g/bird)	250.00	250.00	251.67	251.67	4.17	NS
Final weight (g/bird)	2115.50	2124.40	2111.10	2383.30	18790	NS
Weight gain (g/bird)	1865.50	1874.40	1859.40	2131.70	18683.06	NS
Feed intake (g/bird)	4864.00	4761.50	4633.90	4571.70	67155.86	NS
Average daily feed intake (g/bird)	86.86	85.03	82.75	81.64	21.42	NS
Average daily weight gain (g/bird)	33.31	33.47	33.20	38.07	5.96	NS
Feed conversion ratio	2.97^{b}	2.88^{b}	2.83^{b}	2.43^{a}	0.011	**
Mortality (%)	10.00^{a}	6.67^{ab}	3.33^{ab}	0.00^{b}	22.92	*

^{abc}Means having different superscripts across row are significantly different at *P<0.05, **P<0.01, MOL- *Moringa oleifera* leaf meal, SEM- Standard Error Mean, NS- Not significant at P<0.05, LOS = Level of Significance

Table 4.3: Carcass and organ characteristics of broiler chickens fed diets containing graded levels of *Moringa oleifera* Leaf meal

Parameters	Treatments MOL1 (0%)	MOL2 (7%)	MOL3 (14%)	MOL4 (21%)	SEM	LOS
Live Weight(g)	1850.00^{b}	2191.70^{a}	2033.30^{ab}	2191.70^{a}	15000	*
Dressed Weight(g)	1695.00^{b}	1900.00^{a}	1816.67^{ab}	1963.33^{a}	8985.41	*
Dressing Percentage(%)	66.31^{ab}	64.08^{ab}	62.92^{b}	67.71^{a}	3.56	*
Oragans Weight (expressed as percentages of live weight)						
Heart	0.53^{a}	0.45^{b}	0.44^{b}	0.47^{b}	0.01	**
Gizzard	2.51	2.25	2.60	2.31	0.03	NS
Liver	2.50^{a}	2.06^{b}	2.69^{a}	2.05^{b}	0.02	**
Abdominal Fat	1.71	2.12	2.43	1.68	0.27	NS
Prime Cuts Weight(expressed as percentages of dressed weight)						
Drumstick	15.79	16.11	15.94	16.12	0.15	NS
Breast	27.47	23.91	26.58	26.33	6.49	NS
Thigh	17.89	17.56	17.91	16.91	0.87	NS
Back	18.21	18.45	18.27	18.25	0.30	NS

^{abc}Means having different superscripts across row are significantly different at *P<0.05, **P<0.01, MOL- *Moringa oleifera* leaf meal, SEM- Standard Error Mean, NS- Not significant at P<0.05, LOS = Level of Significance

4.2 Effects of Dietary *Moringa oleifera* Leaf Meal on Performance and Meat Quality of Broiler Chickens

4.2.1: Growth and carcass characteristics of broiler chickens fed diets containing graded levels of *Moringa oleifera* leaf meal

Table 4.2 shows the growth performance of broiler chickens fed diets containing graded levels of *Moringa oleifera* leaf meal. The results revealed that growth performance such as initial weight, final weight gain, feed intake, average daily feed intake and average daily weight gain did not differ significantly among the four treatments (MOL1, MOL2, MOL3, and MOL4) ($P > 0.05$).

However, feed conversion ratio was significantly ($P<0.01$) different among the treatments. Treatments MOL1, MOL2 and MOL3 were similar, but significantly ($P<0.01$) poorer compared to treatment MOL4; values being 2.97, 2.88, 2.83, 2.43, respectively. There was significant ($P<0.05$) difference in mortality rate among the treatments; with MOL1, MOL2 and MOL3 did not differ significantly while there was no mortality in MOL4 throughout the feeding trial, as shown in Table 4.2.

Result on carcass and organ characteristics of broiler chickens fed diets containing graded levels of MOL is presented in Table 4.3. The results showed significant ($P<0.05$) differences in live weight, dressed weight, dressing percentage, heart weight and liver weight. Live weight was better ($P<0.05$) in MOL2, MOL3 and MOL4 compared to MOL1. Dressed weight was also significantly ($P<0.05$) better in MOL2, MOL3 and MOL4 compared to MOL1. The dressing percentage was better in MOL1, MOL2 and MOL4 compared to MOL3. Other carcass parameters traits such as gizzard weight, abdominal fat, drumstick, breast, thigh and back weights were not significantly different across the treatment groups.

4.2.2: Chemical composition of fresh meat from broiler chickens fed diets containing graded levels of *Moringa oleifera* leaf meal (MOL)

Table 4.4 shows data on per cent chemical composition of fresh meat from broiler chickens meat fed diets containing graded levels of MOL. The results shows that dry matter, lipid, crude protein, fibre, ash and carbohydrate contents were significantly (P<0.05) different across the treatment groups. The perentage dry matter content was significantly (P<0.05) highest in MOL1 (23.67%), also in MOL2 (23.05%), MOL3 (23.02%) and the lowest value was recorded in MOL4 (22.10%). The percentage lipid was highest in MOL4 (9.59%) compared to the lowest in MOL1 (7.10%). However, the crude protein content among the treatment groups was highest (P<0.05) in MOL4 (26.03%) followed by MOL3 (25.39%) and lowest in MOL1 (21.49%). The percentage ash content was highest (P<0.05) in MOL3 (3.70%) followed by MOL1 (3.45%) and MOL2 (2.80%) and lowest in MOL4 (2.65%). The per cent carbohydrate content of fresh meat from broiler chickens was highest in MOL1 (43.95%) and lowest in MOL4 (39.50%).

4.2.3: Chemical composition of *dambun nama* from meat of broiler chickens fed diets containing graded levels of *Moringa oleifera* leaf meal

The chemical composition of *dambun nama* processed from meat of broiler chickens fed diets containing graded levels of *Moringa oleifera* leaf meal (MOL) as presented in Table 4.5. The results showed that all the parameters measured were significantly (P<0.05) different across the treatments. The per cent moisture content of meat floss was significantly (P<0.05) highest in MOL4 (4.32%) and MOL1 (4.17%) followed by MOL2 (3.61%) and lowest in MOL3 (2.88%). The per cent lipid content differed (P<0.05) significantly among the treatments; with the highest value of 21.92% in MOL2, others are 19.40, 20.80 and 21.02% for MOL1, MOL3 and MOL4, respectively.

Table 4.4: Chemical composition of fresh meat from meat of broiler chickens fed diets containing graded levels of *Moringa oleifera* leaf meal

	MOL LEVELS (%)					
Parameters (%)	**(0)**	**(7)**	**(14)**	**(21)**	**SEM**	**LOS**
Dry Matter	23.67[a]	23.05[b]	23.02[b]	22.10[c]	0.067	*
Lipid	7.10[d]	8.75[b]	7.55[c]	9.59[a]	0.01	*
Crude Protein	21.49[d]	24.64[c]	25.39[b]	26.03[a]	0.008	*
Crude Fibre	0.54[c]	0.56[b]	0.57[ab]	0.58[a]	0.01	*
Ash	3.45[b]	2.80[c]	3.70[a]	2.65[c]	0.007	*
Carbohydrate	43.95[a]	40.75[b]	40.32[c]	39.50[d]	0.007	*

[abc]Means having different superscripts across row are significantly different at *P<0.05, MOL- *Moringa oleifera* leaf meal, SEM- Standard Error Mean, LOS = Level of Significance

However, the per cent crude protein content of *dambun nama* processed from meat of broiler chickens fed diets containing graded levels of MOL revealed that MOL3 (49.85%) was highest (P<0.05) followed by MOL4 (47.85%) and lowest in MOL1 (36.40%). The per cent carbohydrate contents was significantly (P<0.05) higher in MOL1 (37.34) with other values of 25.36, 24.40 and 28.86 for MOL2, MOL3 and MOL4, respectively.

4.2.4: Sensory attributes of *dambun nama* from meat of broiler chickens fed diets containing graded levels of *Moringa oleifera* leaf meal

The results on sensory attributes of *dambun nama* (meat floss) from broiler chickens fed dietary inclusion levels of MOL is presented in Table 4.6. The sensory attributes considered were colour, texture, aroma, tenderness, juiciness and acceptability. The results showed that colour, texture, aroma, tenderness and acceptability did not differ significantly across the treatment groups. However, score for juiciness was significantly (P<0.05) higher in meat floss from MOL2 (4.59) and MOL4 (4.44) compared to other treatments but similar to the score for MOL1 (4.41). However, MOL1, MOL2 and MOL4 were most preferred as compared to MOL3.

4.2.5: Effects of storage period on shelf life of *dambun nama* from meat of broiler chickens fed diets containing graded levels of *Moringa oleifera* leaf meal

Table 4.7 presents data on the effects of storage period on shelf life stability of *dambun nama* (meat floss) processed from broiler chickens fed dietary inclusion levels of MOL. The results showed significant differences (P<0.05) between bacterial and fungal growth in MOL1 (0%) and MOL3 (14%) at first day (week 0) of storage. Total fungal counts were lowest (2.0 x 10^5cfu/g) in MOL4 followed by MOL2 and MOL3, each having 5.0 x 10^5cfu/g. MOL1 had the highest fungal count of 8.0 x 10^5cfu/g among the treatment groups. Similarly, the total bacterial count were lowest in MOL4 (2.0 x 10^5cfu/g) and MOL2 (6.0 x 10^5cfu/g) followed by MOL3 (11.0 x 10^5cfu/g) and highest in MOL1 (17.0 x 10^5cfu/g).

Table 4.5: Chemical composition of *dambun nama* from meat of broiler chickens fed diets containing graded levels of *Moringa oleifera* leaf meal

Treatments (%)	MOL LEVELS (%)				SEM	LOS
	0	**7**	**14**	**21**		
Moisture	4.17^{a}	3.61^{b}	2.88^{c}	4.32^{a}	0.009	*
Lipid	19.40^{d}	21.92^{a}	20.80^{c}	21.02^{b}	0.007	*
Crude Protein	36.40^{d}	46.43^{c}	49.85^{a}	47.85^{b}	0.01	*
Crude Fibre	2.79^{b}	2.99^{a}	2.04^{c}	2.06^{c}	0.005	*
Ash	2.65^{a}	2.60^{a}	2.20^{b}	2.13^{b}	0.01	*
Carbohydrate	37.34^{a}	25.36^{b}	24.40^{b}	28.86^{b}	13.59	*

^{abc}Means having different superscripts across row are significantly different at *P<0.05, MOL- *Moringa oleifera* leaf meal, SEM- Standard Error Mean, LOS = Level of Significance

Table 4.6: Sensory attributes of *dambun nama* from meat of broiler chickens fed diets containing graded levels of *Moringa oleifera* leaf meal

	MOL LEVELS (%)					
Sensory attributes	**(0)**	**(7)**	**(14)**	**(21)**	**SEM**	**LOS**
Colour	4.63	4.52	4.44	4.67	0.478	NS
Texture	4.11	4.37	4.11	4.04	0.640	NS
Aroma	4.37	4.33	4.11	4.07	0.681	NS
Tenderness	4.26	4.11	3.76	4.15	0.656	NS
Juiciness	4.41^{ab}	4.59^{a}	3.96^{b}	4.44^{a}	0.718	*
Acceptability	4.41	4.44	3.96	4.18	0.771	NS

^{a,b,}: Means across row having different superscript are significantly different at P< 0.05*, NS= Not significant, Like extremely = 5, Like very much = 4, Neither like nor dislike = 3, Dislike very much = 2, Dislike extremely = 1, LOS = Level of Significance

At 4th week of storage, significant ($P<0.05$) differences were observed in all the treatment groups investigated. The total fungal counts of meat floss were lowest in MOL4 and MOL3 (each having 8.0 x 10^5cfu/g and 11.0 x 10^5cfu/g), while MOL1 and MOL2 each have 15.0 x 10^5cfu/g. The total bacterial count was lowest in MOL3 (25.0 x 10^5cfu/g) followed by MOL4 (28.0 x 10^5cfu/g) and highest count was observed in MOL2 (37.0 x 10^5cfu/g) (Table 4.7). There were no significant difference in MOL1 and MOL4 at 8th week storage period as compared to MOL2 and MOL3. Storage quality of *dambun nama* showed that MOL2 had the lowest total fungal counts of 11.0 x 10^5cfu/g compared to the other treatment groups. This increased to 12.0 x 10^5, 18.0 x 10^5 and 12.0 x 10^5cfu/g in MOL1, MOL3 and MOL4, respectively.

Similarly, the lowest total bacterial count was in MOL4 (13.0 x 10^5cfu/g) and increased to 27.0 x 10^5cfu/g in MOL2. However, at 12th week storage of meat floss all the treatment groups were not significantly affected except for MOL2. Fungal counts were decreased to 8.0, 1.0, 2.0 and 1.0 x 10^5cfu/g for treatments MOL1, MOL2, MOL3 and MOL4. The total bacterial count was lowest (1.0 x 10^5cfu/g) in MOL4. This was followed by MOL3 (3.0 x 10^5cfu/g) and highest count was in MOL2 with a total bacterial count of 17.0 x 10^5cfu/g, as shown in Table 4.7.

4.2.6: Total microbial load (cfu/g x 10^5) of *dambun nama* from meat of broiler chickens fed diets containing graded levels of *Moringa oleifera leaf* meal

Result of the overall effects on types of meat floss on total microbial load (bacterial and fungal) is presented in Table 4.8. The overall effects showed that the total microbial load of meat floss decreases as the concentration (level of inclusions of MOL) was increased; MOL1 (76 x 10^5cfu/g), MOL2 (71 x 10^5cfu/g), MOL3 (65 x 10^5cfu/g) and MOL4 (44 x 10^5cfu/g) for tatal bacterial counts. Similarly fungal counts were; 43 x 10^5cfu/g, 32 x 10^5cfu/g, 36 x 10^5cfu/g and 23 x 10^5cfu/g for MOL1, MOL2, MOL3 and MOL4, respectively.

Table 4.7: Effects of week of storage and type of microbes (cfu/g x 10^5) on shelf life of *dambun nama* from meat of broiler chickens fed diets containing graded levels of *Moringa oleifera* leaf meal

	MOL Levels(%)			
SP/TM	**0**	**7**	**14**	**21**
0				
Fungi	8.0	5.0	5.0	2.0
Bacteria	17.0	6.0	11.0	2.0
Total	25.0	11.0	16.0	4.0
LOS	*	NS	*	NS
4				
Fungi	15.0	15.0	11.0	8.0
Bacteria	34.0	37.0	25.0	28.0
Total	49.0	52.0	36.0	36.0
LOS	*	*	*	*
8				
Fungi	12.0	11.0	18.0	12.0
Bacteria	15.0	27.0	26.0	13.0
Total	27.0	38.0	44.0	25.0
LOS	NS	*	*	NS
12				
Fungi	8.0	1.0	2.0	1.0
Bacteria	10.0	17.0	3.0	1.0
Total	18.0	18.0	5.0	2.0
LOS	NS	*	NS	NS

NS = Not Significant at 5%; LOS = Level of Significance * P<0.05; MOL= *Moringa oleifera* Leaf Meal, SP = Storage Periods, TM = Types of Microbes (bacteria and fungi)

4.2.7: Effects of packaging media and storage period on total bacterial loads of *dambun nama* from meat of broiler chickens fed diets containing graded levels of *Moringa oleifera* leaf meal

The effect of packaging media and storage period on total bacterial loads is presented in Table 4.9. The packaging media studied were: Foil paper pack (FPP), Wrapped newspaper pack (WNP), Plastic container pack (PCP) and Disposable container pack (DCP). While the storage periods were 0, 4, 8 and 12 weeks. The results showed that at first day (0 week) of storage, significant (P<0.05) differences were observed among the packaging media at MOL3 (14%).

PCP had the lowest bacterial count (7.0 x 10^5cfu/g) across the treatment groups and packaging media, followed by FPP (9.0 x 10^5cfu/g). DCP had the highest bacterial counts (12.0 x 10^5cfu/g). There were no detectable bacterial spp in WNP, PCP and DCP (0.0 x 10^5cfu/g) at higher inclusion level (21%) of MOL. However, at 4^{th} and 8^{th} week of storage, all the packaging media were statistically (P<0.05) affected across the treatment groups. At 4^{th} week of storage, total bacterial load increased across the treatment groups and packaging media investigated.

At 8^{th} week of storage period, the total bacterial count were reduced with PCP having the lowest total bacterial count (25.0 x 10^5cfu/g), and DCP has higher bacterial counts (41.0 x 10^5cfu/g). At 12^{th} week of storage, only MOL2 (7%) was significantly (P<0.05) affected among the treatment groups. Total bacterial counts were suppressed, with PCP having the lowest count (7.0 x 10^5cfu/g) across the treatment groups, and at higher inclusion level of MOL (21%) PCP had no detectable bacterial spp across the packaging media studied.

Table 4.8: Total microbial load (cfu/g x 10^5) of *dambun nama* from meat of broiler chickens fed diets containing graded levels of *Moringa oleifera* leaf meal

Treatments	Fungi	Bacteria	Description
MOL1 (0%)	43.0 x 10^5	76.0 x10^5	Satisfactory
MOL2 (7%)	32.0 x 10^5	71.0 x10^5	Satisfactory
MOL3 (14%)	36.0 x 10^5	65.0 x10^5	Satisfactory
MOL4 (21%)	23.0 x 10^5	44.0 x10^5	Satisfactory

MOL= *Moringa oleifera* leaf meal, Satisfactory = Passable and safe limits (10^7cfu/g) specified by the International Commission of Microbiological Standard of Foods (ICMSF), 2014.

Table 4.9: Effects of storage period and packaging media on total bacterial loads (cfu/g x 10^5) of *dambun nama* from meat of broiler chickens fed diets containing graded levels of *Moringa oleifera* leaf meal

SPXPM	MOL LEVELS(%)			
	MOL1(0)	MOL2(7)	MOL3(14)	MOL4(21)
0				
FPP	0.0	6.0^b	1.0^a	2.0
WNP	1.0	4.0^a	6.0^b	0.0
PCP	0.0	7.0^b	0.0^a	0.0
DCP	0.0	0.0^a	12.0^c	0.0
LOS	NS	*	*	NS
4				
FPP	12.0^b	17.0^b	5.0^a	20.0^b
WNP	8.0^a	13.0^b	12.0^b	3.0^a
PCP	15.0^b	3.0^a	12.0^b	12.0^b
DCP	14.0^b	4.0^a	8.0^a	12.0^b
LOS	*	*	*	*
8				
FPP	0.0^a	19.0^c	16.0^b	0.0^a
WNP	10.0^b	8.0^b	17.0^b	10.0^b
PCP	13.0^b	0.0^a	0.0^a	12.0^b
DCP	16.0^b	0.0^a	15.0^b	12.0^b
LOS	*	*	*	*
12				
FPP	3.0	1.0^a	1.0	3.0
WNP	2.0	1.0^a	1.0	1.0
PCP	4.0	0.0^a	3.0	0.0
DCP	2.0	7.0^b	0.0	1.0
LOS	NS	*	NS	NS

^{abc}Means with superscripts across column within a subset are significantly different * $P<0.05$; NS = Not Significant at 5%; LOS = Level of Significance, MOL = *Moringa oleifera* Leaf Meal, SP = Storage Periods, PM = Packaging Media, FPP = Foil Paper Packaging, WNP = Wrapped Newspaper Packaging, PCP = Plastic Container Packaging, DCP = Disposable Container Packaging

4.2.8: Effects of packaging media and storage period on total fungal loads of *dambun nama* from meat of broiler chickens fed diets containing graded levels of *Moringa oleifera leaf* meal

Table 4.10 shows the data on the effects of storage and packaging media on total fungal counts of *dambun nama* (meat floss) processed from broiler chickens fed dietary inclusion levels of MOL. The results revealed that there were no significant differences observed in MOL1 and MOL4 as compared to MOL2 and MOL3, between the packaging media investigated. There were no fungal counts in the control (0.0 x 10^5 cfu/g) (MOL1) among the treatment groups and the various packaging media at first day (0 week) of storage period. WNP and DCP had the lowest fungal counts (3.0 x 10^5cfu/g) across the treatment groups and packaging media, respectively. There were no fungal counts in WNP, PCP and DCP at higher inclusion of MOL4 (21%). At 4^{th} and 8^{th} week of storage, all the treatment groups and packaging media were statistically ($P<0.05$) affected. WNP maintained its superiority (9.0 x 10^5cfu/g) at 4^{th} week of storage, and DCP was having no fungal count at 21% inclusion level of MOL across the treatment groups and packaging media, respectively.

At 8^{th} week of storage period, there were reduced total fungal counts across the treatments; FPP had the lowest value (7.0 x 10^5cfu/g) of total fungal counts across the packaging media, and DCP had no detectable fungal counts at 21% level of MOL. At 12^{th} week of storage period, significant ($P<0.05$) difference was only observed in MOL3. Total fungal counts were decreased across the treatment groups and packaging media. There were no detectable total fungal counts in PCP (0.0 x 10^5cfu/g). Similarly, at 21% inclusion level of MOL (MOL4), WNP and PCP had no fungal counts (0.0 x 10^5cfu/g) (Table 4.10).

Table 4.10: Effects of storage period and packaging media on total fungal loads (cfu/g x 10^5) of *dambun nama* from meat of broiler chickens fed diets containing graded levels of *Moringa oleifera* leaf meal

SPXPM	MOL LEVELS(%)			
	MOL1(0)	MOL2(7)	MOL3(14)	MOL4(21)
0				
FPP	0.0	2.0^a	0.0	2.0
WNP	0.0	1.0^a	2.0	0.0
PCP	0.0	5.0^b	0.0	0.0
DCP	0.0	0.0^a	3.0	0.0
LOS	NS	*	NS	NS
4				
FPP	3.0^a	0.0^a	0.0^a	8.0^b
WNP	1.0^a	2.0^a	5.0^b	1.0^a
PCP	0.0^a	9.0^b	6.0^b	1.0^a
DCP	6.0^b	4.0^{ab}	0.0^a	0.0^a
LOS	*	*	*	*
8				
FPP	0.0^a	0.0^a	0.0^a	7.0^b
WNP	16.0^b	0.0^a	9.0^b	1.0^a
PCP	0.0^a	11.0^b	0.0^a	0.0^a
DCP	0.0^a	0.0^a	9.0^b	0.0^a
LOS	*	*	*	*
12				
FPP	1.0	0.0	0.0	1.0
WNP	1.0	1.0	2.0	0.0
PCP	0.0	0.0	0.0	0.0
DCP	2.0	2.0	3.0	1.0
LOS	NS	NS	NS	NS

[ab]Means with superscripts across column within a subset are significantly different * $P<0.05$; NS = Not Significant at 5%; LOS = Level of Significance, MOL = *Moringa oleifera* Leaf Meal, SP = Storage Periods, PM = Packaging Media, FPP = Foil Paper Packaging, WNP = Wrapped Newspaper Packaging, PCP = Plastic Container Packaging, DCP = Disposable Container Packaging

4.2.9: Effects of packaging media and treatment groups of storage period on total microbial load of *dambun nama* from meat of broiler chickens fed diets containing graded levels of *Moringa oleifera* leaf meal

Figure 2 presents data on the packaging media and treatment groups on total microbial counts for 12 weeks storage period (bacteria and fungi) of *dambun nama* prepared from broiler chickens fed diets containing graded levels of MOL. The result showed that FPP had the least (19 x 10^5cfu/g) microbial counts among the packaging media in the control group (MOL1), followed by PCP (32 x 10^5cfu/g), WNP (39 x 10^5cfu/g) and DCP (40 x 10^5cfu/g) having the highest total counts. DCP had the least total counts (17 x 10^5cfu/g) and FPP had the highest total counts (45 x 10^5cfu/g) in MOL2 (14%).

At 14% inclusion level (MOL3), WNP had the highest total microbial counts of 54 x 10^5cfu/g, and PCP had having the least total microbial counts of 21 x 10^5cfu/g. WNP had the lowest total microbial counts (16 x 10^5cfu/g) in *dambun nama* (meat floss) from MOL4 (21%), followed by PCP (25 x 10^5cfu/g), DCP (26 x 10^5cfu/g) and FPP (43 x 10^5cfu/g) throughout the 12 weeks storage period of *dambun nama*.

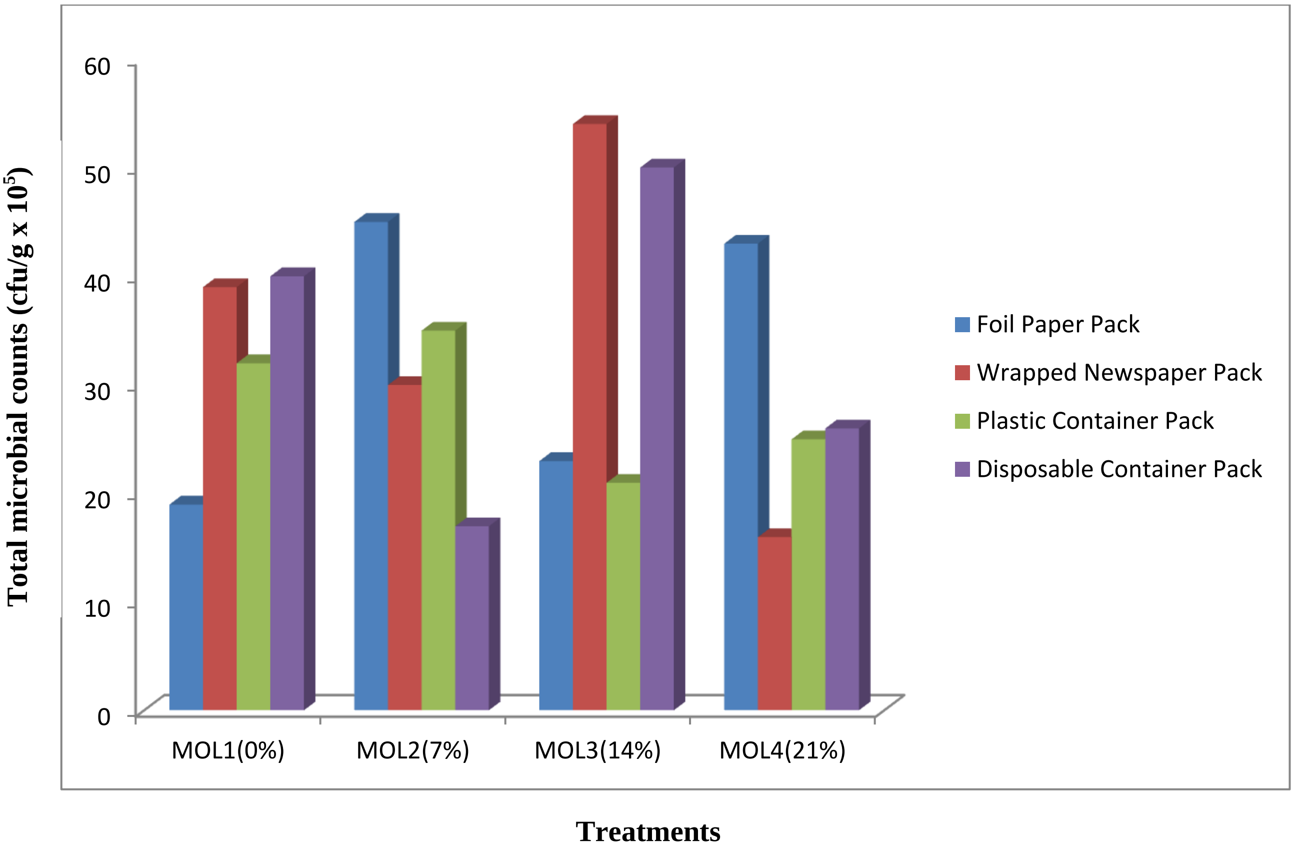

Figure 2: Overall Effects of packaging media and treatments on total microbial counts (cfu/g x 10^5) of *dambun nama* from broiler chickens fed diets containing graded levels of *Moringa oleifera* leaf meal (MOL)

4.3: Effects of Diets Containing Graded Levels of *Guiera senegalensis* Leaf Meal on Performance and Meat Quality of Broiler Chickens

4.3.1: Growth and carcass characteristics of broiler chickens fed diets containing graded levels of *Guiera senegalensis* leaf meal (GSL)

Table 4.11 presents data on growth performance of broiler chickens fed dietary inclusion levels of GSL. The result showed that growth parameters such as initial weight, final weight, weight gain, average daily weight gain and feed conversion ratio were not significantly different across the treatment groups (GSL1, GSL2, GSL3 and GSL4). Other growth parameters like feed intake, average daily feed intake and mortality were significantly (P<0.05) different across the treatment groups. Feed intake was significantly (P<0.05) higher in GSL1 (5332.40g) than in GSL2 (4698.20g), GSL3 (4731.50g) and GSL4 (4536.70g). Similarly, average daily feed intake was higher (P<0.05) in GSL1 (95.22g) compared to GSL2 (83.89g) and GSL3 (84.47g) and GSL4 (81.01g). The mortality rate was significantly (P<0.05) higher in the control (GSL1) (18.33%) than in other treatments; GSL2 (5.00%), GSL3 (5.00%) and GSL4 (0.00%). The carcass characteristics of the broiler chickens in presented in Table 4.12. The result showed that carcass traits (live weight and breast weight) were the only parameters that showed significant (P<0.05) differences among the treatments. For instance, the live weight were 1916.7, 1766.7, 1900.0 and 2100.0g for GSL1, GSL2, GSL3 and GSL4 (P<0.05), respectively. The breast weight also differed (P<0.05) significantly among the treatment groups; with GSL3 (26.59g) and GSL4 (27.46g) being heavier than GSL1 (22.76g) and GSL2 (21.41g). All the other carcass traits were not significantly different among the treatment groups.

Table 4.11: Growth performance of broiler chickens fed diets containing graded levels of *Guiera senegalensis* leaf meal (0-8weeks)

	Treatments					
Parameters	**GSL1 (0%)**	**GSL2 (7%)**	**GSL3 (14%)**	**GSL4 (21%)**	**SEM**	**LOS**
Initial weight (g/ bird)	251.67	250.00	253.33	250.00	4.167	NS
Final weight (g/bird)	2166.70	2207.00	2196.90	2216.70	29069.90	NS
Weight gain (g/bird)	1915.00	1957.00	1943.50	1966.70	29019.96	NS
Feed intake (g/bird)	5332.40^{a}	4698.20^{b}	4731.50^{b}	4536.70^{b}	47868.08	*
Average daily feed intake (g/bird)	95.22^{a}	83.89^{b}	84.47^{b}	81.01^{b}	15.26	*
Average daily weight gain (g/bird)	34.19	34.95	34.71	35.12	9.25	NS
Feed conversion ratio	3.19^{b}	2.73^{b}	2.77^{b}	2.63^{a}	0.08	*
Mortality (%)	18.33^{a}	5.00^{b}	5.00^{b}	0.00^{b}	14.58	*

^{a,b}: Means having different superscripts across row are significantly different at *P<0.05, GSL- *Guiera senegalensis* leaf meal, SEM- Standard Error Mean, NS- Not significant at P<0.05, LOS = Level of Significance

Table 4.12: Carcass and organ characteristics of broiler chickens fed diets containing graded levels of *Guiera senegalensis* leaf meal

Parameters	GSL1 (0)	GSL inclusion levels (%) GSL2 (7)	GSL3 (14)	GSL4 (21)	SEM	LOS
Live Weight(g)	1916.70[ab]	1766.70[b]	1900.00[ab]	2100.00[a]	26041.67	*
Dressed Weight(g)	1750.00	1433.30	1541.70	1866.70	47500.00	NS
Dressing Percentage(%)	67.56	59.54	59.26	66.99	43.45	NS
Oragans Weight (expressed as percentages of live weight)						
Heart	0.47	0.43	0.49	0.51	0.004	NS
Gizzard	2.38	2.46	2.35	2.46	0.09	NS
Liver	2.32	1.99	1.88	1.96	0.25	NS
Abdominal Fat	2.35	1.53	2.05	2.20	0.81	NS
Prime Cuts Weight(expressed as percentages of dressed weight)						
Drumstick	13.95	14.86	14.32	13.94	0.29	NS
Breast	22.76[ab]	21.41[b]	26.59[a]	27.46[a]	5.91	*
Thigh	16.59	17.05	16.42	18.88	8.04	NS
Back	17.27	17.42	17.47	16.97	0.76	NS

[a,b]: Means having different superscripts across row are significantly different at *P<0.05, GSL- *Guiera senegalensis* leaf meal, SEM- Standard Error Mean, NS- Not significant at P<0.05, LOS = Level of Significance

Table 4.13: Proximate composition of fresh meat of broiler chickens fed diets containing graded levels of *Guiera senegalensis* leaf meal (GSL)

Parameters (%)	**GSL LEVELS (%)**					
	GSL1(0)	**GSL2(7)**	**GSL3(14)**	**GSL4(21)**	**SEM**	**LOS**
Dry Matter	24.92^{b}	24.49^{c}	25.28^{a}	25.06^{b}	0.008	*
Lipid	8.70^{a}	8.18^{b}	7.69^{c}	6.70^{d}	0.01	*
Protein	20.51^{d}	25.25^{b}	25.46^{a}	24.41^{c}	0.008	*
Fibre	0.43	0.44	0.43	0.44	0.079	NS
Ash	2.96^{a}	2.81^{a}	2.14^{b}	2.90^{a}	0.01	*
Carbohydrate	42.98^{a}	39.26^{b}	39.09^{b}	41.56^{a}	0.599	*

^{a,b,c}: Means across row having different superscripts are significantly different at *P< 0.05, NS= Not significant ,GSL= *Guiera senegalensis* leaf meal**,** SEM= Standard error mean. LOS = Level of Significance

4.3.2 Chemical composition of fresh meat of broiler chickens fed diets containing graded levels of *Guiera senegalensis* leaf meal

Table 4.13 depicts the result of the chemical composition of fresh meat from broiler chickens fed dietary inclusion levels of GSL. The results showed that percentages of fibre contents were not significantly influenced by dietary feeding of GSL in broiler chicken diets. The results also showed that other chemical compositional parameters such as percentages of dry matter, lipid, crude protein, ash and carbohydrate contents were significantly ($P<0.05$) affected by dietary inclusion of GSL in the diets of broiler chickens. However, the per cent moisture content was highest ($P<0.05$) in GSL3 (25.27%), and lowest in GSL2 (24.49%). Per cent lipid was highest ($P<0.05$) in GSL1 (8.70%), followed by GSL2 (8.18%) and lowest in GSL4 (6.70%). The per cent crude protein was highest in GSL3 (25.46%) followed by GSL2 (25.25%) and lowest in GSL1 (20.51%). The per cent ash content was significantly ($P<0.05$) different among the treatments; values being 2.96, 2.81, 2.14 and 2.90% for GSL1, GSL2, GSL3 and GSL4, respectively. The results also revealed that the per cent carbohydrate contents in the broiler chicken meat were 42.98, 39.26, 39.09 and 41.56% for GSL1, GSL2, GSL3 and GSL4, respectively.

4.3.3: Chemical composition of *dambun nama* from meat of broiler chickens fed diets containing graded levels of *Guiera senegalensis* leaf meal (GSL)

Data on chemical composition of *dambun nama* (meat floss) processed from broiler chicken fed dietary inclusion levels of GSL are shown in Table 4.14. The results showed that all the proximate parameters differed ($P<0.05$) significantly across the treatment groups (moisture, lipid, crude protein, fibre, ash and carbohydrate). The per cent moisture contents were 3.56, 3.60, 2.45 and 4.85% ($P<0.05$) for GSL1, GSL2, GSL3 and GSL4, respectively. The lipid contents were 22.25, 22.00, 21.89 and 22.07% ($P<0.05$) for GSL1, GSL2, GSL3 and GSL4, respectively.

Table 4.14: Proximate composition of meat floss from meat of broiler chickens fed diets containing graded levels of *Guiera senegalensis* leaf meal (GSL)

Parameters	**GSL LEVELS (%)**					
(%)	**(0)**	**(7)**	**(14)**	**(21)**	**SEM**	**LOS**
Moisture	3.57^{b}	3.61^{b}	2.46^{b}	4.86^{a}	0.095	*
Lipid	22.25^{a}	22.00^{b}	21.89^{c}	22.07^{b}	0.003	*
Protein	41.77^{c}	44.81^{b}	50.53^{a}	46.89^{b}	1.243	*
Fibre	2.12^{b}	2.90^{a}	2.93^{a}	2.14^{b}	0.01	*
Ash	2.90^{a}	2.83^{ab}	2.18^{c}	2.65^{b}	0.01	*
Carbohydrate	30.48^{a}	26.74^{b}	23.25^{d}	25.54^{c}	0.01	*

^{a,b,c}: Means across row having different superscripts are significantly different at *P< 0.05, NS= Not significant ,GSL= *Guiera senegalensisI* leaf meal**,** SEM= Standard error mean, LOS = Level of Significance

The per cent crude fibre and carbohydrate contents for GSL1, GSL2, GSL3 and GSL4 were 2.12 vs 30.48%, 2.90 vs 26.74%, 2.93 vs 23.25% and 2.13 vs 25.54%, respectively.

4.3.4: Sensory attributes of *dambun nama* from meat of broiler chickens fed diets containing graded levels of *Guiera senegalensis* leaf meal (GSL)

Results of the sensory attributes of *dambun nama* (meat floss) prepared from meat of broiler chickens fed dietary inclusion levels of GSL are shown in Table 4.15. The attributes investigated were colour, texture, aroma, tenderness, juiciness and acceptability. Scores for aroma, tenderness and juiciness were significantly ($P<0.05$) different among the treatment groups. In terms of aroma, GSL4 (4.29), GSL1 (4.14) were liked very much ($P<0.05$) compared to GSL2 (3.66) and GSL3 (3.96) which were neither liked nor disliked. GSL1 had the highest value for likeness (4.29) in terms of tenderness, and GSL2 (3.74) had the least value. GSL1, GSL3 and GSL4 were statistically similar in terms of juiciness across the treatment groups. However, there were no significant ($P>0.05$) differences with respect to colour, texture and acceptability among the various treatment groups.

4.3.5: Effects of storage period on shelf life of *dambun nama* from meat of broiler chickens fed diets containing graded levels of *Guiera senegalensis* leaf meal (GSL)

Data on storage period on shelf life of *dambun nama* (meat floss) prepared from meat of broiler chickens fed diets containing graded levels of GSL are shown in Table 4.16. The results showed significant differences ($P<0.05$) between bacterial and fungal growth in GSL1 (0%) and GSL4 (21%) at first day (week 0) of storage. There were no fungal counts in GSL3 and GSL4 had the least count of 2.0 x 10^5cfu/g, followed by GSL2 (3.0 x 10^5cfu/g) and highest in GSL1 (4.0 x 10^5cfu/g). Similarly, the total bacterial counts were lowest in GSL2 (2.0 x 10^5cfu/g) and was followed by GSL3 (3.0 x 10^5cfu/g). The control (GSL1) had the highest total bacterial count of 24.0 x 10^5cfu/g.

Table 4.15: Sensory attributes of meat floss from meat of broiler chickens fed diets containing graded levels of *Guiera senegalensis* leaf meal (GSL)

Sensory attributes	GSL LEVELS (%) (0)	(7)	(14)	(21)	SEM	LOS
Colour	4.48[a]	4.37[a]	4.59[a]	4.33[a]	0.592	NS
Texture	4.33	3.93	4.11	4.14	0.749	NS
Aroma	4.14[ab]	3.66[b]	3.96[ab]	4.29[a]	0.826	*
Tenderness	4.29[a]	3.74[b]	3.88[ab]	3.96[ab]	0.811	*
Juiciness	4.22[a]	3.70[b]	4.25[a]	4.22[a]	0.751	*
Acceptability	4.51	4.14	4.33	4.29	0.613	NS

[a,b,]: Means across row having different superscripts are significantly different at *P< 0.05*, NS= Not significant ,Like extremely = 5, Like very much = 4, neither like nor dislike = 3, Dislike very much = 2, Dislike extremely = 1, LOS = Level of Significance

Table 4.16: Effects of week of storage and type of microbes (cfu/g x 10^5) on the quality of *dambun nama* from meat of broiler chickens fed diets containing graded levels of *Guiera senegalensis* leaf meal (GSL)

	GSL Levels(%)			
SP/TM	**GSL1(0)**	**GSL2(7)**	**GSL3(14)**	**GSL4(21)**
0				
Fungi	4.0	3.0	0.0	2.0
Bacteria	24.0	2.0	3.0	8.0
Total	28.0	5.0	3.0	10.0
LOS	*	NS	NS	*
4				
Fungi	2.0	1.0	1.0	1.0
Bacteria	20.0	24.0	23.0	20.0
Total	22.0	25.0	24.0	21.0
LOS	*	*	*	*
8				
Fungi	2.0	1.0	0.0	0.0
Bacteria	18.0	8.0	8.0	7.0
Total	20.0	9.0	8.0	7.0
LOS	*	*	*	*
12				
Fungi	2.0	0.0	0.0	0.0
Bacteria	27.0	15.0	6.0	5.0
Total	29.0	15.0	6.0	5.0
LOS	*	*	*	*

LOS = Level of Significance, * $P<0.05$; NS = Not Significant at 5%; GSL= *Guiera senegalensis* Leaf Meal, SP = Storage Periods, TM = Type of Microbes (bacteria and fungi)

However, at 4^{th}, 8^{th} and 12^{th} week of storage, significant ($P<0.05$) differences were observed in all the treatment groups investigated. At 4^{th} week storage of *dambun nama*, the results shows that GSL2, GSL3 and GSL4 had the lowest total fungal counts (each having 1.0 x 10^5cfu/g). This was followed by GSL1 (2.0 x 10^5cfu/g). Similarly, the lowest total bacterial count was in GSL1 and GSL4 (each had 20.0 x 10^5cfu/g) followed by GSL3 (23.0 x10^5cfu/g). Treatment 2 (GSL2) had a total bacterial count of 24.0 x10^5cfu/g.

Furthermore, at 8^{th} week storage of meat floss, total fungal count was highest in GSL1 (2.0 x 10^5cfu/g) with GSL3 and GSL4 each had 0.0 x 10^5cfu/g. Also results on total bacterial count shows that the control (GSL1) had the highest counts of 18.0 x 10^5 cfu/g, whereas GSL2 and GSL3 had total bacterial counts of 8.0 x 10^5cfu/g each. At 12^{th} week of storage period, total fungal counts were 0.00 x 10^5cfu/g, 0.00 x 10^5cfu/g, 0.00 x 10^5cfu/g each for GSL2, GSL2, GSL3 and GSL4, and 2.0 x 10^5cfu/g for GSL1, respectively. Similarly, the total bacterial counts showed that GSL1 had the highest (17.0 x 10^5cfu/g) followed by GSL2 (15.0 x 10^5cfu/g), GSL3 (6.0 x 10^5cfu/g) and GSL4 (5.0 x 10^5cfu/g).

4.3.6: Total microbial load (cfu/g x 10^5) of *dambun nama* from meat of broiler chickens fed diets containing graded levels of *Guiera senegalensis* leaf meal (GSL)

The total fungal and bacterial counts decreased as the inclusion levels of GSL increased (Table 4.17). The overall effects showed that the total microbial load of *dambun nama* (meat floss) decreases as the concentration (level of inclusions) of GSLwere increased; GSL1 (89 x 10^5cfu/g), GSL2 (49 x 10^5cfu/g), GSL3 (40 x 10^5cfu/g) and GSL4 (40 x 10^5cfu/g) for tatal bacterial counts. Similarly fungal counts were; 10 x 10^5cfu/g, 5 x 10^5cfu/g, 1 x 10^5cfu/g and 3 x 10^5cfu/g for GSL1, GSL2, GSL3 and GSL4, respectively for GSL1, GSL2, GSL3 and GSL4.

Table 4.17: Total microbial load (cfu/g x 10^5) of *dambun nama* from meat of broiler chickens fed diets containing graded levels of *Guiera senegalensis* leaf meal (GSL)

Levels	Fungi	Bacterial	Description
GSL1 (0%)	10.0×10^5	89.0×10^5	Satisfactory
GSL2 (7%)	5.0×10^5	49.0×10^5	Satisfactory
GSL3 (14%)	1.0×10^5	40.0×10^5	Satisfactory
GSL4 (21%)	3.0×10^5	40.0×10^5	Satisfactory

GSL= *Guiera senegalensis* Leafmeal, Satisfactory = Passable and safe limits (10^7cfu/g) specified by the International Commission of Microbiological Standard of Foods (ICMSF), 2014.

Table 4.18: Effects of storage period and packaging media on total bacterial loads (cfu/g x 10^5) of *dambun nama* from meat of broiler chickens fed diets containing graded levels of *Guiera senegalensis* leaf meal (GSL)

SPXPM	GSL LEVELS (%)			
	GSL1(0)	GSL2(7)	GSL3(14)	GSL4(21)
0				
FPP	2.0^a	0.0	3.0	0.0^a
WNP	0.0^a	1.0	0.0	0.0^a
PCP	4.0^a	0.0	0.0	5.0^b
DCP	18.0^b	1.0	0.0	3.0^a
LOS	*	NS	NS	*
4				
FPP	10.0^b	1.0^a	8.0	0.0^a
WNP	15.0^c	2.0^a	8.0	2.0^a
PCP	10.0^b	8.0^b	10.0	10.0^b
DCP	2.0^a	4.0^a	10.0	11.0^b
LOS	*	*	NS	*
8				
FPP	17.0^a	0.0^a	16.0^c	9.0^b
WNP	27.0^b	8.0^b	10.0^b	0.0^a
PCP	15.0^a	0.0^a	17.0^c	7.0^b
DCP	18.0^a	0.0^a	0.0^a	12.0^b
LOS	*	*	*	*
12				
FPP	5.0^b	7.0^b	0.0^a	8.0^b
WNP	0.0^a	0.0^a	0.0^a	10.0^b
PCP	10.0^c	0.0^a	8.0^b	0.0^a
DCP	5.0^b	8.0^b	10.0^b	8.0^b
LOS	*	*	*	*

[abc]Means with superscripts across column within a subset are significantly different * P<0.05; NS = Not Significant at 5%; LOS = Level of Significance, GSL = *Guiera senegalensis* Leaf Meal, SP = Storage Periods, PM = Packaging Media, FPP = Foil Paper Packaging, WNP = Wrapped Newspaper Packaging, PCP = Plastic Container Packaging, DCP = Disposable Container Packaging

4.3.7: Effects of packaging media and storage period on total bacterial loads of *dambun nama* from meat of broiler chickens fed diets containing graded levels of *Guiera senegalensis* leaf meal (GSL)

Table 4.18 depicts data on the effects of packaging media and storage period on total bacterial counts of *dambun nama* processed from meat of broiler chickens fed diets containing graded inclusion levels of GSL.

The results showed that at first day (0 week) of storage, significant ($P<0.05$) differences were observed among the packaging media at GSL1 (0%) and GSL4 (21%). GSL2 (2.0 x 10^5cfu/g) and GSL3 (3.0 x 10^5cfu/g) had lower total bacterial counts than GSL1 (24.0 x 10^5cfu/g) and GSL4 (8.0 x 10^5cfu/g) across the packaging media observed. Also WNP had the least bacterial counts (1.0 x 10^5cfu/g), followed by FPP (5.0 x 10^5cfu/g). Conversely, DCP had the highest counts (21.0 x 10^5cfu/g) across the treatment groups and packaging media. At 4th, 8th and 12th week of storage periods, all the packaging media were statistically ($P<0.05$) affected across the treatment groups. At 4th week storage, GSL2 and GSL4 were better (total bacterial counts) than GSL1 and GSL3. FPP (19.0 x 10^5cfu/g) maintained the superiority of having lower bacterial counts across the treatment groups at week 4, as compared to other packaging media. However, there were variations of bacterial growth at 8th week of storage, bacterial counts were increased, with GSL2 (8.0 x 10^5cfu/g) having lower counts than GSL1, GSL3 and GSL4; (770.0 x 10^5cfu/g, 43.0 x 10^5cfu/g and 28.0 x 10^5cfu/g) in terms of total bacterial counts. DCP (30.0 x 10^5cfu/g) had lower total bacterial counts than FPP (42.0 x 10^5cfu/g), WNP (45.0 x 10^5cfu/g) and PCP (39.0 x 10^5cfu/g) across the treatment groups. At higher week of storage (12th week), GSL2 (15.0 x 10^5cfu/g) and GSL3 (18.0 x 10^5cfu/g) were lower than GSL1 (20.0 x 10^5cfu/g) and GSL4 (26.0 x 10^5cfu/g) with regards to their bacterial counts. *Dambun nama* packaged in WNP (10.0 x 10^5cfu/g) had the least counts, and DCP (31.0 x 10^5cfu/g) had the highest counts across the treatment groups, as presented in Table 4.18.

4.3.8: Effects of packaging media and storage period on total fungal loads of *dambun nama* meat of broiler chickens fed diets containing graded levels of *Guiera senegalensis* leaf meal (GSL)

Data on the effects of storage period and packaging on total fungal counts of *dambun nama* processed from meat of broiler chickens fed diets containing graded levels of GSL is shown in Table 4.19. The results showed that at first week of storage (0 week) all the packaging media were not statistically affected across the treatment groups. GSL2, and GSL4 had lower fungal counts (2.0 x 10^5cfu/g) as compared to GSL3 (3.0 x 10^5cfu/g) and GSL1 (12.0 x 10^5cfu/g) which the packaging media were significantly similar. All the packaging media had suppressive effects on fungal growth and multiplications; with lower counts across the treatments. At 4th and 8th week of storage periods, all the treatment groups and packaging media were statistically ($P<0.05$) affected, except in treatment 4 (21%) which was not significantly affected across the packaging media. At 4th week of storage, there were variations in total fungal growths in all the four treatments where FPP (2.0 x 10^5cfu/g) had the least count followed by DCP (3.0 x 10^5cfu/g) and PCP (4.0 x 10^5cfu/g) than WNP (25.0 x 10^5cfu/g) across the treatments. Result at 8th week of storage period shows that fungal growth were reduced in most of the packaging media across the treatment groups investigated, especially in GSL3 and GSL4 (14% and 21%) as they recorded low total fungal counts with PCP (2.0 x 10^5cfu/g) having the least counts. At 12th week of storage period, significant ($P<0.05$) differences were observed in GSL1 (0%), GSL3 (14%) and GSL4 (21%). GSL2 (7%) was not statistically affected, and WNP (15.0 x 10^5cfu/g) had the highest counts at 12th week of storage period across the treatment groups and packaging media investigated.

Table 4.19: Effects of storage period and packaging media on total fungal loads (cfu/g x 10^5) of *dambun nama* from meat of broiler chickens fed diets containing graded levels of *Guiera senegalensis* leaf meal (GSL)

		GSL LEVELS(%)		
SPXPM	**GSL1(0)**	**GSL2(7)**	**GSL3(14)**	**GSL4(21)**
0				
FPP	3.0	1.0	1.0	0.0
WNP	3.0	0.0	0.0	0.0
PCP	4.0	1.0	2.0	2.0
DCP	2.0	0.0	0.0	0.0
LOS	NS	NS	NS	NS
4				
FPP	2.0^a	0.0^a	0.0^a	0.0
WNP	7.0^b	7.0^b	10.0^b	1.0
PCP	2.0^a	2.0^a	0.0^a	0.0
DCP	3.0^a	0.0^a	0.0^a	0.0
LOS	*	*	*	NS
8				
FPP	3.0^a	1.0^a	0.0a	1.0
WNP	1.0^a	0.0^a	0.0^a	0.0
PCP	1.0^a	0.0^a	0.0^a	0.0
DCP	13.0^b	10.0^b	7.0^b	4.0
LOS	*	*	*	NS
12				
FPP	2.0^a	3.0	0.0^a	0.0^a
WNP	0.0^a	0.0	10.0^b	5.0^b
PCP	1.0^a	1.0	0.0^a	0.0^a
DCP	8.0^b	0.0	0.0^a	0.0^a
LOS	*	NS	*	*

[ab]Means with superscripts across column within a subset are significantly different * P<0.05; NS = Not Significant at 5%; LOS = Level of Significance, GSL = *Guiera senegalensis* Leaf Meal, SP = Storage Periods, PM = Packaging Media, FPP = Foil Paper Packaging, WNP = Wrapped Newspaper Packaging, PCP = Plastic Container Packaging, DCP = Disposable Container Packaging

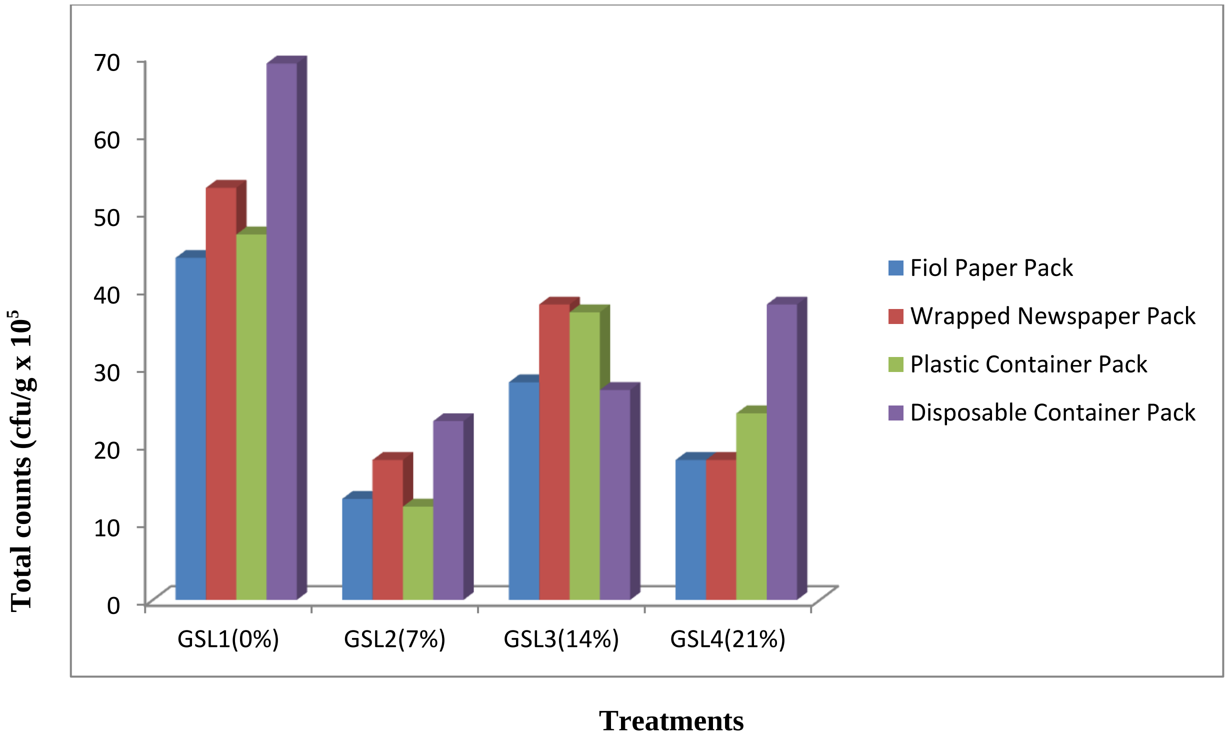

Figure 3: Overall effects of packaging media and treatment groups on total counts (cfu/g x 10^5) of *dambun nama* from meat of broiler chickens fed diets containing graded levels of *Guiera senegalensis* leaf meal (GSL)

4.3.9: Effects of packaging media and treatment groups of storage period on total microbial load of *dambun nama* from meat of broiler chickens fed diets containing graded levels of *Guiera senegalensis* leaf meal (GSL)

Figure 3 shows data on the effects of packaging media and storage period on total microbial load (fungal and bacterial) of *dambun nama* processed from meat of broiler chickens fed diets containing graded levels of GSL. The results showed that FPP (44 x 10^5) had the least total microbial counts, followed by PCP (47 x 10^5), WNP (53 x 10^5) and DCP (69.0 x 10^5) which had the highest total microbial counts across the four packaging media in GSL1 (0%). In GSL2 (7%), PCP (12.0 x 10^5cfu/g) and FPP (13.0 x 10^5cfu/g) had the least counts than WNP (18.0 x 10^5cfu/g) and DCP (23.0 x 10^5cfu/g). FPP had the highest counts (32.0 x 10^5cfu/g) in GSL3, and WNP had the least counts of 20.0 x 10^5cfu/g. GSL4 recorded lower values of total counts in FPP and WNP (18.0 x 10^5cfu/g), where DCP (38.0 x 10^5cfu/g) recorded the highest counts among the packaging media.

4.4: Effect of Types of D*ambun Nama* from Meat of Broiler Chickens Fed Diets Containing Graded Levels of *Moringa oleifera* and *Guiera senegalensis* Leaf Meals and Packaging Media on Total Microbial Load

The interaction between packaging media and types of *dambun nama* (Treatments) from chickens fed diets containing graded levels of *Moringa oleifera* and *Guiera senegalensis* leaf meals on total microbial load (bacteria and fungi) as presented in Figure 4. The results revealed that there were both low and high interaction effects among many of the parameters studied. There were high interactions between FPP x MOL2, FPP x MOL4, WNP x MOL3 and DCP x MOL3, values being; 45.0, 43.0, 54.0 and 50.0 x 10^5cfu/g, respectively. There were also low interactions among the treatments. These were FPP x MOL1, WNP x MOL4, PCP x MOL3 and DCP x MOL2, values being; 19.0, 16.0, 21.0, and 17.0 x 10^5cfu/g, respectively.

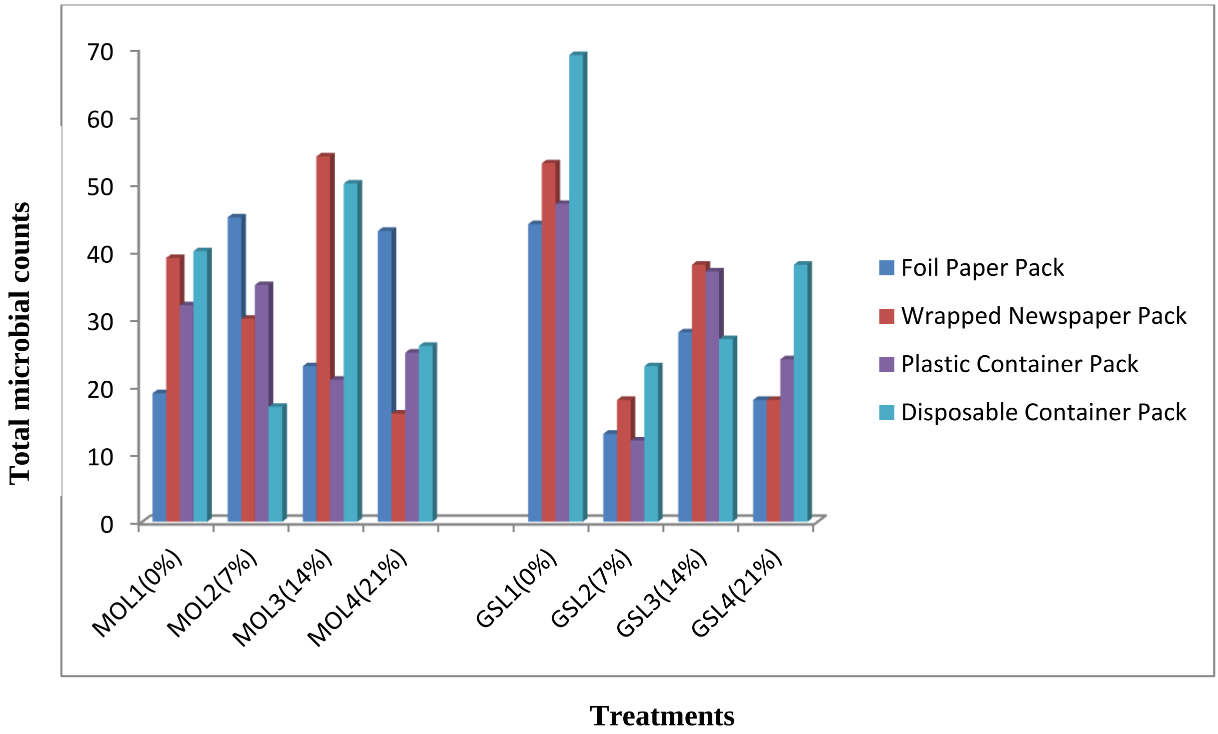

Figure 4: Effects of Types of D*ambun Nama* from *Moringa oleifera* (MOL) and *Guiera senegalensis* (GSL) Leaf Meals and Packaging Media on Total Microbial Load (cfu/g x 10^5)

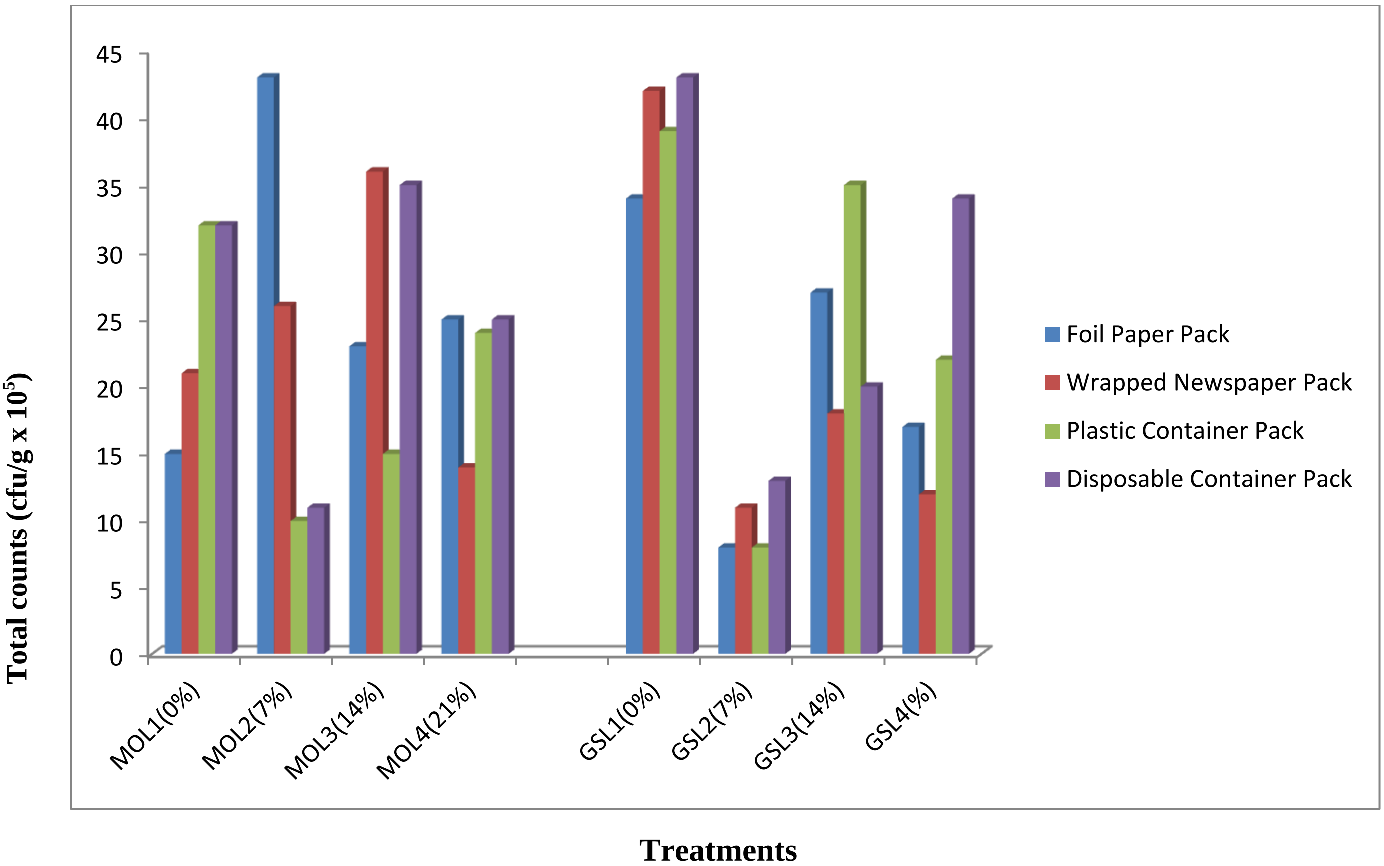

Figure 5: Effects of Types of D*ambun Nama* from Chickens Fed Diets Containing *Moringa oleifera* (MOL) and *Guiera senegalensis* (GSL) Leaf Meals and Packaging Media on Total Bacterial Load (cfu/g x 10^5)

However, the results also showed that there were high interactions between FPPx GSL1, WNP x GSL1, PCP x GSL1 and DCP x GSL1 (44.0, 53.0, 47.0 and 69.0 x 10^5cfu/g), respectively. Other interactions with low values were between FPP x GSL2, WNP x GSL2/GSL4, PCP x GSL2 and DCP x GSL2; values being 13.0, 18.0, 12.0 and 23.0 x 10^5cfu/g, respectively.

4.4.1: Effects of Types of D*ambun Nama* from Broiler Chickens Fed Diets Containing Graded Levels of *Moringa oleifera* and *Guiera senegalensis* Leaf Meals and Packaging Media on Total Bacterial Load

Data on interaction effects of packaging media and types of *dambun nama* (Treatments) on total bacterial counts are presented in Figure 5. The results showed that interactions of *dambun nama* (meat floss) processed from chickens fed diets containing MOL levels and packaging media were high in terms of total bacterial counts between FPP x MOL2, WNP x MOL3, PCP x MOL1 and DCP x MOL3; values being 43.0, 36.0, 32.0 and 35.0 x 10^5cfu/g, respectively. Similarly, there were low interactions between FPP x MOL1, WNP x MOL4, PCP x MOL2 and DCP x MOL2, values being 15.0, 14.0, 10.0 and 11.0 x 10^5cfu/g.

However, the interactions of meat floss processed from GSL and packaging media on total bacterial counts showed both high and low interactions. For instance, the low interaction is between FPP x GSL2, WNP x GSL2, PCP x GSL2 and DCP x GSL2 with values of 8.0, 11.0, 8.0 and 13.0 x 10^5cfu/g, respectively. Similarly, the high interactions were between FPP x GSL1, WNP x GSL1, PCP x GSL1 and DCP x GSL1; values being 34.0, 42.0, 39.0 and 43.0 x 10^5cfu/g, respectively.

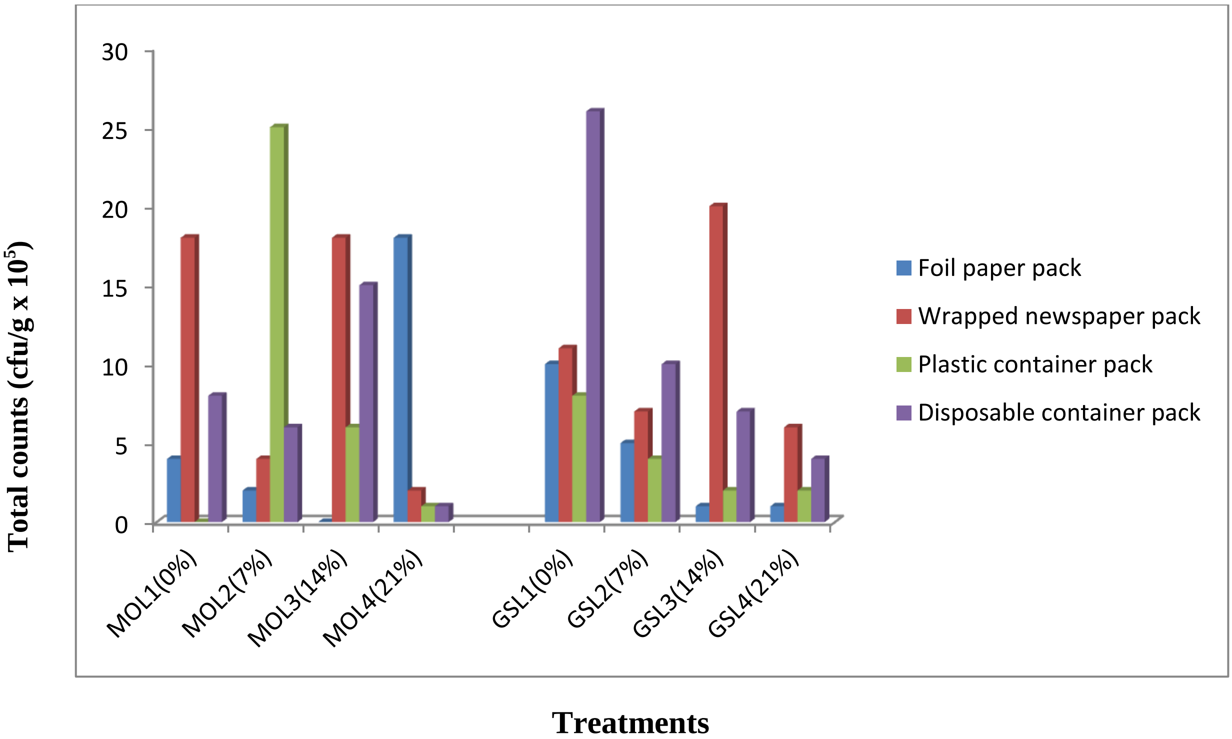

Figure 6: Effects of Types of D*ambun Nama* from Chickens Fed Diets Containing *Moringa oleifera* and *Guiera senegalensis* Leaf Meals and Packaging Media on Total Fungal Load (cfu/g x 10^5)

4.4.2: Effects of Types of D*ambun Nama* from Broiler Chickens Fed Diets Containing *Moringa oleifera* and *Guiera senegalensis* Leaf Meals and Packaging Media on Total Fungal Load

Figure 6 shows data on interactions between packaging media and types of *dambun nama* (meat floss) on total fungal counts. The results showed that there were high interactions among MOL treatments and packaging media were FPP x MOL4, WNP x MOL1/MOL3, PCP x MOL2 and DCP x MOL3; values being 18.0, 18.0, 25.0 and 15.0 x 10^5cfu/g. Conversely, there were low interactions were between FPP x MOL3, WNP x MOL4, PCP x MOL1 and DCP x MOL4, values being 0.0, 2.0, 0.0 and 1.0 x 10^5cfu/g, respectively.

Furthermore, the results also showed that there were high values among the interactions between GSL and packaging media studied. For instance, the interaction between FPP x GSL1, WNP x GSL3, PCP x GSL1 and DCP x GSL1; values being 10.0, 20.0, 8.0 and 26.0 x 10^5cfu/g, respectively. Similarly, there were low interactions among the treatments. For example, interaction between FPP x GSL3/GSL4, WNP x GSL4, PCP x GSL3/GSL4 and DCP x GSL4; values being 1.0/1.0, 6.0, 2.0/2.0 and 4.0 x 10^5cfu/g, respectively.

CHAPTER FIVE

5.0 DISCUSSION

5.1: Proximate composition of *Moringa oleifera* and *Guiera senegalensis* Leaf Powder

Proximate and nutrient analysis of edible parts of plants plays a crucial role in assessing their nutritional significance. As various medicinal plant species are also used as feed along with their medicinal benefits, evaluating their nutritional significance can help to understand the worth of these plants species for providing nutritional supplements (Pandey *et al*., 2006). The dry matter content obtained in this study for *Moringa oleifera* and *Guiera senegalensis* leaf powder are similar to the reports of Nouala *et al*. (2006) and Kakengi *et al*. (2007) as 89.29 and 86.00%. The per cent CP of both *Moringa oleifera* and *Guiera senegalensis* leaf powder were lower than the values (23.27%) reported by Nouala *et al*. (2006) for *Moringa oleifera* leaf, and higher than the values (13.93%) reported by Nabaa *et al*. (2016) for *Guiera senegalensis* leaf. However, it was also lower than the range of 25.10 to 29.60% reported by some investigators (Gupta *et al*., 1989; Makkar and Becker, 1999; Foidl *et al*., 2001; Sarwatt *et al*., 2002; Price, 2007). Proteins are essential nutrients for growth and building of the body. Protein content in *Guiera senegalensis* leaves is relatively high and could support the biological functions of the animal cells (Nabaa *et al*., 2016).

The crude fibre content observed for *Moringa oleifera* and *Guiera senegalensis* leaves in this study are below the range of 18.7 to 22.5% reported by Foidl *et al*., (2001), Price (2007) and Kakengi *et al*., (2007) for *Moringa oleifera* leaves and 60.50% reported by Nabaa *et al*. (2016) for *Guiera senegalensis* leaf powder. Values ranging between 8.86 to 14.77% for per cent ash in *Moringa oleifera* leaves were reported by Foidl *et al*., (2001), Price (2007) and Kakengi *et al*., (2007), while Nabaa *et al*. (2016) reported 2.15% in *Guiera senegalensis* leaves. However, Nabaa *et al*. (2016) reported that no comparable data is available for crude protein, crude fibre and fat content of *Guiera senegalensis* leaves. The per cent NFE values in

Moringa oleifera and *Guiera senegalensis* leaves obtained in this study were higher than the value of 10.60% reported by Kakengi *et al*., (2007). The result observed in this study shows that *Moringa oleifera* leaves is higher in per cent DM, Fat, NFE, Ash, Mg, Na and P than *Guiera senegalensis* leaves. Other compositional parameters such as; Fe, Mn and Zn were lower in *Moringa oleifera* leaves than in *Guiera senegalensis* leaves. This might be due to the high anti-nutritional factors in *Guiera senegalensis* leaves than *Moringa oleifera* leaves, this is similarly reported by Balarabe *et al*., (2016b).

However, the differences in the values observed in this study as compared to reports by previous researchers could be due to environmental condition, soil fertility and harvesting stage of the plant leaves. The low concentration of minerals that is usually present in plants may be due to several factors including climate, temperature, soil type, soil pH and erosion which affect largely the minerals content (Chaves *et al*., 2013). Minerals have important properties in the body; they participate in the structural component of the body organs and tissues. Also, they activate the action of enzymes process, hormones system and regulate the balance between water and osmotic pressure, acid base balance, and cerebrospinal fluids. (Underwood and Suttle 1999). The macro mineral elements (Ca, K and P) in *Moringa oleifera* and *Guiera senegalensis* leaves were similar and in contrast to previous reports, for example Busani *et al*. (2011) reported 3.65%, 1.5% and 0.30%, respectively while values of 3.5%, 0.164% and 0.3% were reported by Nabaa *et al*. (2016). The values obtained for Mg, Cu, Zn and Mn in this study were higher than the values reported by Busani *et al*. (2011), who reported 0.5%, 8.2mg/kg, 13.03mg/kg and 86.80mg/kg for Mg, Cu, Zn and Mn. Busani *et al*. (2011) and Nabaa *et al*. (2016) reported that the nutrient characterization of *Moringa* and *Guirea* leaves are clear indication that the plant leaves are rich in nutrients and have potential to be used as a feed additive with multiple purposes like serving as a protein, fatty acid, mineral and vitamin resource for animals and humans. The nutrient contents found in the dried leaves are important nutritional indicators of the usefulness of the plant as a likely feed resource. The authors however, indicated that drying of the leaves assists to concentrate the nutrients, facilitates conservation and consumption.

5.2: Effects of Diets Containing Graded Levels of *Moringa oleifera* Leaf Meal on Performance and Meat Quality of Broiler Chickens

5.2.1: Growth and Carcass Characteristics of Broiler Chickens Fed diets containing graded levels of *Moringa oleifera*

Growth performance parameters such as initial weight, final weight, weight gain, feed intake, average daily feed intake, average daily weight gain did not differ significantly among the four treatments of *Moringa oleifera* leaf meals (MOL1, MOL2, MOL3 and MOL4) respectively. Treatment four (MOL4) had the highest body weight gain (2131.70g), followed by MOL2 (1874.40g). This shows that *Moringa oleifera* leaf meal does not have any deleterious effect in the diet of broiler chickens; this might have been due to low content of tannins and alkaloids which were efficiently metabolised by the chickens. This is in line with the reports of Cariaso (1988) and Olugbemi *et al* (2010), that growth rate, body weight gain, feed consumption, final body weight gain and feed cost were not adversely affected when broiler chickens were fed diets containing 5% level of *Moringa oleifera* leaf. Nihad *et al*. (2016) repoted that *Moringa oleifera* leaf incorporated in broiler chicken diet at 15 to 20% led to better growth performance of the birds compared to maize meal feed alone. Body weights obtained were 2318- 2391g/bird for birds fed diets containing 15 and 20% *Moringa oleifera* leaf. The authors reported that effect of supplementation of *Moringa oleifera* leaf at 15 and 20% in diet of poultry chickens increased body weight and blood biochemical parameters of broiler chickens. Hassan *et al*. (2016) reported that the effect of different levels of *Moringa oleifera* leaf meal on body weight of broiler chickens, were 1307, 1408, 1488 and 1543g, of treatment MOLM (0, 0.1, 0.2 and 0.3%),after 35days, respectively.

Feed conversion ratio was significantly different among the treatment groups, with treatment four (MOL4) having the best value of 2.43. This is in contrast with the report of Akhouri *et al* (2013) and Abou Sekken (2015) that *Moringa oleifera* significantly increased feed conversion ratio in broiler chickens.

Carcass and organ characteristics of broiler chickens fed dietary inclusion levels of *Moringa oleifera* leaf meal showed significant differences in live weight, dressed weight, dressing percentage, heart weight and liver weight with MOL2, MOL3 and MOL4 having better values than MOL1. Dressing percentage was better in MOL1, MOL2 and MOL4 than in MOL3 respectively. This result showed that broiler chickens fed diets containing *Moringa oleifera* leaf meal at 21% had the highest values in live weight, dressed weight and dressing percentage (2191.7g, 1963.33g and 67.71%) respectively as compared to the other treatment groups. This might be due to the presence of phytochemicals in *Moringa oleifera* leaf which improves physical and chemical properties of meat. Mukumbo *et al.* (2014) reported that inclusion of *Moringa oleifera* leaf (2.5%, 5.0% and 7.5%) in finisher pig diet had no detrimental effect on carcass characteristics of physico-chemical meat quality and it significantly improved the acceptability of the meat colour, odour, and lipid profile.

5.2.2: Chemical Composition of fresh meat of broiler chickens fed diets containing graded levels of *Moringa oleifera* leaf meal

Chemical composition of meat is influenced by different factors such as species, breed, age, sex, anatomical location of muscle and nutrition (Lawrie, 1998). The results revealed that all the compositional parameters (dry matter, lipid, crude protein, fibre, ash and carbohydrate contents) were significantly different among the treatment groups investigated. The dry matter content (22.10-23.67%) of fresh broiler meat obtained in this study is less than the value observed by Bube (2003) who reported dry matter content of raw local chicken and duck meat as 31.5% and 26.0%, respectively. This was also in contrast with the reports of Balarabe *et al.*

(2016b) who showed the dry matter content of fresh meat of broiler chicken as 54.96%, respectively. The dry matter content observed in this study might be due to the different inclusion of *Moringa oleifera* Leaf meal in the diets of the broiler chickens. Plane of nutrition, breed and age of an animal can influence its compositional status, and dry matter content is a reflection of the amount of moisture content present in the raw meat samples, as the moisture content increases, the amount of dry matter decreases (Balarabe *et al*, 2016b).

However, the per cent crude protein content among the treatment groups was similar and in contrast to the reports of Bube (2003) and Balarabe *et al.* (2016b) who showed the protein content of fresh broiler and local chicken meat as 26.13% and 19.8% respectively The per cent ash content was highest in MOL3 (3.70%) and lower in MOL4 (2.65%), the values are similar to the report of Balarabe *et al.* (2016b). The per cent carbohydrate content of fresh broiler chicken meat was highest in MOL1 (43.95%) and lowest in MOL4 (39.50%).

The significant differences observed in the composition of fresh meat of the experimental birds as compared to other reports might be due to the inclusion of the plant leaf meal in the diets of broiler chickens which has the ability to improve/increase the crude protein, reduce fat content and nutritional value of meat (Kakengi *et al*, 2007). Qwele *et al* (2013) reported that with higher crude protein level in *moringa* enriched products, a small quantity will be required by consumers to meet their nutrient requirement, and hence reduce expenditure on meat and meat products.

5.2.3: Chemical composition of *dambun nama* from meat of broiler chickens fed diets containing graded levels *Moringa oleifera* leaf meal

The results showed that all the parameters were significantly different across the treatments. The per cent moisture content of *dambun nama* was significantly highest in MOL4 (4.32%) and lowest in MOL3 (2.88%). This is in contrast to the report of Balarabe *et al.* (2016b) who reported the moisture content of *dambun nama* processed from broiler chicken meat using

Moringa oleifera leaf extract in cooking of the meat as 10.6%, Ogunsola and Omojola (2008) obtained 6.5- 7.3% for *dambun nama*. Eke *et al*. (2013) reported 5.50-7.60% moisture for *dambun nama*. Bube (2003) reported the moisture content of *dambun nama* from meat of broiler chicken as 6.2%. The moisture content of *dambun nama* is influenced by processing methods, temperature and time taken to cook the meat. The lesser the moisture content of meat products, the higher the shelf life of the meat products. This shows that *Moringa oleifera* leaf has the potential of increasing and improving the quality of meat and meat products. The per cent lipid content differed significantly among the treatments; values being 19.40, 21.92, 20.80 and 21.02% for MOL1, MOL2, MOL3 and MOL4, respectively. The variation in the fat content of meat floss can be as a result of the fat content of the chicken meat from which the *dambun nama* were processed. Birds fed diets containing graded levels of MOL had higher level of fat content; this could be as a result of the influence of MOL on the meat.

However, the per cent crude protein content of *dambun nama* processed from meat of broiler chickens fed diets with inclusion levels of MOL is in contrast and similar to the observations of Bube (2003), Balarabe *et al.* (2016b), and Salisu (2017) with values of; 52.9, 51.9 and 45.56% respectively. Abubakar *et al*. (2011) reported 51.0 and 59.2% crude protein content for broiler chickens and spent layers' *dambun nama* respectively. The per cent ash contents in this study (2.66%-2.14%) were lower than the reports of previous researchers (Bube, 2003; Balarabe *et al.,* 2016b), respectively. The differences observed in the composition of *dambun nama* in this study with respect to previous researches could be attributed to the procedures used in preparing the *dambun nama*, amount and different spices used and the time taken in constant turning and frying of the meat. However, *Moringa oleifera* leaf meal included in the diet of the broiler chickens and further processing into *dambun nama* (meat floss) improved the quality characteristics of the meat. This might be as a result of the antioxidant, phytochemical and bioactive properties of the plant leaf (Hassan *et al*, 2016).

5.2.4: Sensory attributes of *dambun nama* from meat of broiler chickens fed diets containing graded levels of *Moringa oleifera* leaf meal

Sensory attributes such as palatability, juiciness, tenderness, colour, aroma and acceptability are important components of consumer preferences and consumption which may vary from product to product and also the locality of the meat product (Balarabe *et al*,. 2016b). The results showed that colour, texture, aroma, tenderness and acceptability did not differ significantly across the treatment groups. However, juiciness was the only attribute that differed significantly among the treatment groups. However, MOL1 (4.41), MOL2 (4.59) and MOL4 (4.44) were most preferred than MOL3 (3.96). The high colour scoring in this study is similar to the high colour scoring of broiler chicken *dambun nama* (meat floss) from the reports of Bube (2003) and Balarabe *et al.* (2016b). Appearance of meat influences the acceptance of meat since colour is the first criterion consumers' use to judge meat quality and acceptability (Comfort, 1994). The appearance of meat, especially colour, has been used by consumers as an important indicator of meat quality (Balarabe *et al*, 2016b).

The mean panel score for tenderness, texture, aroma and acceptability did not show any difference across the treatment groups, this could be due to familiarity of the meat product and also the tender nature of the *dambun nama* which makes it easier to chew. It has been reported that tenderness is one of the primary factors influencing consumer satisfaction, for instance, the tenderness of fat in meat is considered one of the decisive factors influencing the sensory quality of meat, particularly where there are significant differences between samples evaluated (Hocquette *et al*,. 2010). Bube (2003) reported high sensory scores of *dambun nama* among ruminant and non-ruminant species in terms of tenderness, juiciness, acceptability and flavour. Balarabe *et al.* (2016b) reported high score of tenderness of *dambun* *nama* in broiler chicken and indicated that it might be due to marbling effect of muscle fat which agrees with the report of Miller *et al.* (1995) that mode of marbling had a significant effect on meat tenderness. However, the sensory properties of meat like tenderness, texture and aroma may have significant impact on meat quality acceptability. Leora (1994) reported that aroma is made up of varieties of different classes of chemicals that are either present in the food ingredients or are formed during processing. The author also stated that flavour which is linked to aroma is defined as the combined perception of taste; smell and mouth feel. Therefore, aroma of meat is considered as a major factor that improves meat palatability and consumption. The acceptability of all the *dambun nama* (meat floss) across the treatment groups in this study could be due to familiarity of broiler chicken meat among the panelists. This was similarly reported by Kalla *et al.* (2005) that familiarity of a product has positive influence on its acceptability. Bube (2003) reported highest acceptability scores among panelists assessing varieties of *dambun nama* processed from both red and white meat. However, the slight difference observed in juiciness among the treatments in the present study might be due to the impact of the *moringa* leaf meal in the meat. Therefore, the results obtained on sensory attributes in this study showed that *dambun nama* from meat broiler chickens fed diets containing *Moringa oleifera* leaf meal among the treatment groups had meat of good characteristics in terms of colour, texture, aroma, tenderness and acceptability.

5.2.5: Effects of storage period on shelf life of *dambun nama* from meat of broiler chickens fed diets containing graded levels of *Moringa oleifera* leaf meal

Stability of meat product is influenced by several chemical factors, and the major concern is the control of microbial growth. Moisture content of meat product influences shelf life and stability which give micro-organisms enabling environment for growth and multiplications (Fakolade and Omojola, 2008).

From the results obtained in this study, at first day of storage, there were few fungal counts in MOL1 (8.0 x 10^5cfu/g), and least in MOL4 (2.0 x 10^5cfu/g). Total bacterial count was lowest in MOL4 (2.0 x 10^5cfu/g), and highest in MOL1 (17.0 x 10^5cfu/g) respectively. In week 4 and week 8, both total fungal and bacterial counts reduced with increase in the level of MOL across the treatment groups observed.

At the 12th week of storage, both fungal and bacterial counts were reduced across the treatment groups. Total fungal and bacterial counts were least in MOL4 (1.0 x 10^5cfu/g) and bacterial counts were high in MOL2 (17 x 10^5cfu/g) across the treatment groups. It can be observed that both bacterial and fungal counts decreases as the concentration of MOL is increased, this could be attributed to the effect of concentrations of *Moringa oleifera* leaves and several factors like weather condition and temperature changes. This is in line with the reports of Balarabe *et al.* (2016c,d) and Salisu (2017) who investigated microbial counts on both red and white meat *dambun nama* processed using *moringa* leaf extract at different inclusion levels. This is similar to the report of Zahraddeen *et al.* (2016) who investigated total microbial counts of *dambun nama* of different white meat (fish, local chicken, duck and turkey).

5.2.6: Effects of packaging media and storage period on total bacterial loads of *dambun nama* from meat of broiler chickens fed diets containing graded levels of *Moringa oleifera* leaf meal

Several chemical factors have been reported to be involved in the stability of meat products. But the chief concern for product stability is the control of microbial growth, where the moisture content influences the shelf life stability of the meat products as higher moisture gives the micro-organisms a condusive environment for growth (Fakolade and Omojola, 2008). Traditional methods of preserving products from the effect of microbial growth include thermal processing, drying, freezing, refrigeration, irradiation, modified atmospheric packaging and adding antimicrobial agents or salts which unfortunately some of these techniques cannot be applied to some food products such as fresh meats and ready- to- eat products (Rufina and Dorothy, 2017).

The results showed that at first day (0 week) of storage, *dambun nama* packaged in MOL1 and MOL4 had lower total bacterial counts in all the packaging media. FPP, PCP and DCP were having no bacterial count in the control. Also no bacterial count was observed at higher inclusion level of MOL4 for WNP, PCP and DCP. At 4th week of storage, total bacterial load deteriorate progressively across the treatment groups and packaging media. This could be attributed to temperature changes in the environment. At 8th week of storage period, total bacterial count was least in MOL2, and FPP had no bacterial count in the control and at 21% (MOL4) among the packaging media investigated. At 12th week of storage, total bacterial counts were suppressed, with MOL2 and WNP having the least value among the treatment groups and across the packaging media. PCP had the lowest bacterial counts at MOL4. This showed that the packaging media used in this study have the potential of suppressing total bacterial counts in meat floss and most probably due to the anti- microbial effect of the plant leaf meal (MOL) in broiler meat, also the low moisture content of *dambun nama*. Zahraddeen *et al.* (2016) reported that as the shelf life of meat floss (*dambun nama*) increases, the action of micro-organisms decreases. Balarabe *et al.* (2016d) reported low total bacterial counts in some packaging media investigated (plastic, disposable and foil paper packs) at higher weeks of storage, and attributed this to the effectiveness of these packaging media in suppressing total bacterial load in *dambun nama*. Mead (1990) indicated that the shelf life of poultry products depends on several factors such as initial bacterial load, storage temperature and the gaseous environment around the product. This agrees with the report of Wang *et al.* (2004) that any technique that could control these factors may be the key for the extension of shelf life of poultry product. Also, lipid oxidation is another concern for processed poultry products as it causes deterioration in quality and results in the development of rancid off-flavours and odours (Wang *et al*., 2004).

5.2.7: Effects of packaging media and storage period on total fungal loads of *dambun nama* from meat of broiler chickens fed diets containing graded levels of *Moringa oleifera* leaf meal

Results on effect of storage periods and packaging media on quality of *dambun nama* processed from broiler chickens fed dietary inclusion levels of *Moringa oleifera* leaves on total fungal counts showed varied results and efficacies during packaging and storage periods for up to 12 weeks. The results revealed that the control had no fungal counts in all the packaging media as compared to the other treatment groups. At 21% (MOL4), all the packaging media had no fungal count except FPP (2.00 x 10^5cfu/g) at first day (0 week) of storage period. At 4th week of storage, fungal counts were increased. Wrapped newspaper and disposable paper packs had the lowest counts as compared to the other packaging media.

At 8th week of storage period, MOL4 had the lowest value of total fungal counts across the packaging media followed by MOL2. Similarly, FPP had the lowest total fungal counts among the packaging media and treatment groups. Fungal counts were reduced at 12th week of storage period, and PCP had no counts across the treatment groups and packaging media. This is mainly attributed to the anti-microbial effect of *Moringa oleifera* leaves on fungal and bacterial growth, and efficacy of the packaging media which further prevented contamination from the environment. This is in line with the reports of Balarabe *et al.* (2016c) and similar to the findings of Attwood (2007) that about 70% of the micro-organisms on vacuum-packed pork were *Lacto bacillus* species, which is a gram positive rod, and the remaining 30% were members of *Enterobacteriacae*, which is a gram negative rod.

The results on combined effects of storage period and packaging media on both total fungal and bacterial counts were observed in the present study. Both fungal and bacterial counts were decreased as the inclusion level of MOL is increased at storage period for up to 12 weeks, respectively. This was due to the suppressive effect of the plant leaf (MOL) on microbial growth and improved quality shelf life of meat floss. Siddhuraju and Becker (2003) reported that *moringa* leaves has good source of natural antioxidant and thus, enhance shelf life of fat containing foods due to the presence of various types of antioxidants like ascorbic acids, flavonoids, phenolic and carotenoids.

5.3: Effects of Diets Containing Graded Levels of *Guiera senegalensis* Leaf Meal on Performance and Meat Quality of Broiler Chickens

5.3.1: Growth and Carcass Characteristics of Broiler Chickens Fed diets containing graded levels of *Guiera senegalensis* leaf meal

Growth parameters like initial weight, final weight, weight gain, average daily weight gain were not significantly different across the treatment groups of broiler chickens fed dietary inclusion levels of *Guiera senegalensis* leaf meals. This is similar to the result obtained from broiler chickens fed *Moringa oleifera* leaf meal with the exception of feed conversion ratio. Conversely, other growth parameters like feed intake, average daily feed intake, feed conversion ratio and mortality were significantly different among the treatments with GSL1 having the highest values. This might be attributed to the effect of anti- nutritional factors present in *Guiera senegalensis* leaf which is most likely to reduce feed intake and nutrient digestion or absorption.

Furthermore, carcass traits (live weight and breast weight) of birds fed dietary inclusion levels of *Guiera senegalensis* leaf meals were significantly different with GSL4 having the highest value on live weight (2100.0g) followed by GSL1 (1916.7g), GSL3 (1900.0g) and GSL2 (1766.7g) respectively. Other carcass traits such as dressed weight, dressing percentage, heart, gizzard, liver, abdominal fat, drumstick, thigh and back were not significantly affected among the treatment groups. This study shows that *Guiera senegalensis* leaf like other herbal drugs enhances digestion and encourages the growth of good bacteria and decreases unlikely microorganisms which will affect growth performance and gut micro flora of poultry (Nabaa *et al*., 2016). Also, phytochemicals in *Guiera senegalensis* leaves like in *Moringa oleifera* leaves improves physical and chemical properties of meat.

5.3.2: Chemical Composition of fresh meat of broiler chickens fed diets containing graded levels of *Guiera senegalensis* leaf meal

The result showed that percentages of fibre contents were not significantly influenced by dietary feeding of GSL in broiler chicken diets. The results also showed that other chemical compositional parameters such as percentages of moisture, lipid, crude protein, ash and carbohydrate contents were significantly affected by dietary inclusion of GSL in broiler chicken diet.

However, the per cent dry matter was high in GSL3 (25.27%) and lowest in GSL2 (24.49%). The values obtained in the dry matter content among the treatment groups were slightly higher than that obtained in birds fed *Moringa oleifera* leaf meal (22.11%-23.97%) from this same study, and slightly lower than the reports of Bube (2003) on local chicken and duck meat (31.5% and 26.0%). Oguntona and Akinyele (1995) reported moisture content of broiler chicken meat as 79%, Balarabe *et al.* (2016b) reported the dry matter content of fresh meat of broiler chicken as 54.96%. The per cent lipid was highest in GSL1 (8.70%), and lowest in GSL4 (6.70%), this is similar to the report of Oguntona and Akinyele (1995) who reported 8.0%. The per cent crude protein obtained in this study was higher than the report of Oguntona and Akinyele (1995) who reported 19% CP. The per cent ash content was significantly different among the treatments; values being 2.96, 2.81, 2.14 and 2.90% for GSL1, GSL2, GSL3 and GSL4, and was similar to the report of Oguntona and Akinyele (1995) as 2.0% ash content in fresh broiler chicken meat, respectively. The results also revealed that the per cent carbohydrate contents in the broiler chicken meat were 42.98, 39.26, 39.09 and 41.56% for GSL1, GSL2, GSL3 and GSL4, respectively.

However, the per cent values of all the compositional parameters of fresh broiler chicken meat fed dietary inclusion levels of *Guiera senegalensis* leaf meal observed in this study were similar and in contrast to the reports of other researchers (Bube., 2003; Balarabe *et al*., 2016b; Salisu., 2017), and this might be due to the presence of phytochemicals and bioactive components (trace metal ions, carotenoids, protein, polyphenols, vitamins etc) present in the plant leaf of *Guiera senegalensis* which interfered with biological utilization of protein, lipids and carbohydrates (Shafei *et al*., 2016). Sravanti and Rao (2014) reported that these phytochemicals and bioactive components in the plant enhance long term health benefits. Also the difference could be due to variation of intra muscular fats (marbling) of the animals (Balarabe *et al*., 2016b).

5.3.3: Chemical composition of *dambun nama* from meat of broiler chickens fed diets containing graded levels *Guiera senegalensis* leaf meal

All the compositional parameters were significantly different among the treatment groups. Per cent moisture was highest in the control (GSL1) having 3.56%, and GSL3 had the least value of 2.45%. This is in contrast with the reports of Bube, (2003) with a value of 6.1%, Ogunsola and Omojola (2008); 6.5-7.3% and Eke *et al.* (2013); 5.50-7.60% .The difference might be due to constant pounding, shredding and frying of the meat floss during processing. The lower the moisture contents of a meat product, the higher the shelf life. Lipid content in this study was similar to the reports of Bube (2003), Balarabe *et al.* (2016b). The per cent ash content was lower than previous reports of Balarabe *et al.* (2016b, c) on the ash content of *dambun nama* processed using plant leaf extract. *Guiera senegalensis* leaf meals included in the diet of broiler feed and further processing into meat floss improved the quality characteristics, and reduces lipid oxidation of the meat product. This might be as a result of the antioxidant, phytochemical and bioactive properties of the plant leaves, and an indication that the activity of the microorganisms would be reduced and thereby increases the shelf life of the *dambun nama*.

These two leaf meals (*Moringa oleifera* and *Guiera senegalensis* leaf meals) included in the diet of broiler feed and further processing into meat floss did not show any deleterious effect to the birds and improved the quality characteristics of the meat. This might be as a result of the antioxidant, phytochemical and bioactive properties of the plant leaves (Shafei *et al.*, 2016; Hassan *et al.*, 2016).

5.3.4: Sensory attributes of *dambun nama* from meat of broiler chickens fed diets containing graded levels of *Guiera senegalensis* leaf meal

The sensory attributes were affected by inclusion levels of GSL in the diets of broiler chickens. The mean panel score for colour, texture, and acceptability in this study did not show any significant difference among the treatment groups. However, the sensory properties of the *dambun nama* (meat floss) like aroma, tenderness, and juiciness were significantly different across the treatment groups; GSL4 (4.29) was rated best in terms of aroma as compared to the other treatment groups. It was also revealed that *dambun nama* (meat floss) from the control (GSLI) is more tender, and in terms of juiciness, GSL1 (4.22), GSL3 (4.25) and GSL4 (4.22) were similar and rated better as compared to GSL2, based on the 5-point hedonic scale used in the sensory rating. The sensory attributes of meat is a strong indicator of consumer patronage and acceptability (Wahidu *et al.,* 2013). However, the slight difference observed in aroma, tenderness and juiciness among the treatments in the present study might be due to the presence of the *Guiera senegalensis* in the meat, and most likely the level of pounding, shredding and frying of *dambun nama*. This result is in line with the reports of Balarabe *et al.* (2016b,c) that broiler chicken meat processed into *dambun nama* using *Guiera senegalensis* extract was well cherished and rated high in terms of acceptability. Also this is similar with the report of Bube (2003). The acceptability of all the *dambun nama* across the treatment groups in this study could be due to familiarity of broiler chicken meat among the panelists. This was similarly reported by Kalla *et al.* (2005) that familiarity of a product has positive influence on its acceptability.

5.3.5: Effects of storage period on shelf life of *dambun nama* from meat of broiler chickens fed diets containing graded levels of *Guiera senegalensis* leaf meal

At the first day of storage (0 week), there were low total fungal counts in GSL3 and GSL4 (2.0 x 10^5 cfu/g) had the least among the treatment groups. Total bacterial count was highest in GSL1 (24.0 x 10^5 cfu/g), and lower in GSL2 (2.0 x 10^5 cfu/g), respectively. However, there were variations of total bacterial and fungal counts across the treatment groups at 4^{th} week of storage with GSL1 having high fungal counts and GSL2 with high bacterial counts among the treatment groups observed. At 8^{th} week of storage, meat floss from 14% (GSL3) and 21% (GSL4) had no fungal growth, and GSL2 and GSL3 had the highest bacterial counts among the treatment groups which are at par. The variation could be due to the effect of concentration of the leaf meal and temperature changes, as similarly reported by Balarabe *et al.* (2016c, d), Salisu (2017). There were no total fungal counts in GSL2 (7%), GSL3 (14%) and GSL4 (21%) at the 12^{th} week of storage period, with GSL1 (0%) having a value of 2.0 x 10^5 cfu/g. Total bacterial count was high in GSL1 as compared to the other treatment groups. This shows that *Guiera senegalensis* leaf has more effect in suppressing fungal counts than bacterial counts. This is in contrast to the report of Salisu (2017) that *Guiera senegalensis* extract had more potential in suppressing bacterial growth. Haruna (2014) reported positive effects (low total fungal counts) when a range of spice extracts were tested on chicken nuggets storage quality. This author attributed the low total fungal counts to the inhibitory action of these spice extracts on fungal activities.

The results on combined effects of storage period and packaging media on both total fungal and bacterial counts for GSL were observed in the present study. Both fungal and bacterial counts were decreased as the inclusion level of GSL is increased at storage period for up to 12 weeks, respectively. This was due to the suppressive effect of the plant leaf (GSL) on microbial growth and improved shelf life of *dambun nama*.

5.3.6: Effects of packaging media and storage period on total bacterial loads of *dambun nama* from meat of broiler chickens fed diets containing graded levels of *Guiera senegalensis* leaf meal

The results revealed that GSL2 and GSL3 had lower bacterial counts across the treatment groups with WNP and FPP having the least counts among the packaging media at first day of storage (0 week). At 4th and 8th week, GSL2 had the least bacterial counts with DCP having the least value. These variations could be due to the presence of moisture and effect of packaging of processed meat during the storage period, which are usually the main factors that influence growth of micro-organisms in meat and meat products, also opening and closing of the package in the process of microbial count could lead to the exposure of the products to contamination. Total bacterial counts were reduced at 12th week of storage with GSL2 and GSL3 having the lowest total bacterial counts. WNP had no counts in all the treatments except for treatment 4 (GSL4) and the least counts among the packaging media investigated. The low bacterial counts observed in this study could be as a result of the effective phytochemicals (steroids, flavonoids, saponins and tannins) present in GSL which are anti-bacterial in nature. This is in line with the reports of Lutterodt *et al.* (1999), Okwu (2001), Sule *et al*. (2001), Osadebe *et al.* (2004), Raquel (2007), and Shafei *et al* (2016). These authors reported that *Guiera sensgalensis* contains phytochemicals such as flavonoids, saponins, carotenoids, tannins and steroids which were found to be anti-bacterial, anti-microbial and anti-oxidant in nature.

5.3.7: Effects of packaging media and storage period on total fungal loads of *dambun nama* from meat of broiler chickens fed diets containing graded levels of *Guiera senegalensis* leaf meal

The result shows that there were no fungal growth in WNP and DCP in GSL2, 3 and 4 as compared to the other packaging media. At higher inclusion level of GSL (21%), FPP and WNP had no fungal counts at 1st week of storage period (0). At 4th week, FPP, PCP and DCP had the least counts. WNP and PCP had the lowest total fungal counts at 8th week as compared to the other treatment groups observed. At 12th week of storage period, PCP had the least counts as compared to all the packaging media investigated. Balarabe *et al.* (2016c) observed low values of fungal counts in *dambun nama,* packaged and stored in similar packaging media used for this study for 5 weeks and stated that the low values were probably due to the enclosed nature of the packaging materials which prevented further contamination from the environment. From this study, GSL has high effectiveness in suppressing fungal counts than bacterial counts, respectively.

However, the bacterial and fungal counts observed in this study were within the acceptable and safe limits (10^7 cfu/g) specified by the International Commission of Microbiological Standard of Foods (ICMSF) (2014), and safe limit reported by Pearson (1968) $2.5 \times 10^5 - 1.0 \times 10^8$cfu/g.

5.4: Effects of Types of D*ambun Nama* from Meat of Broiler Chickens Fed Diets Containing *Moringa oleifera* and *Guiera senegalensis* Leaf Meals and Packaging Media on Total Microbial Load (cfu/g x 10^5)

The results showed that total fungal and bacterial counts increases and decreases as the level of *Moringa oleifera* leaf meal increases across the treatment groups. Conversely, the total fungal and bacterial counts decrease as the level of *Guiera senegalensis* leaf meal increases. This showed that the combined effects of total microbial load of meat floss decreases as the concentration of the plant leaves was increased.

There were very high and low interaction effects of total microbial counts among the treatment groups and packaging media for *Moringa oleifera* leaf meal (MOL) and *Guiera senegalensis* leaf meal (GSL). However, the high interaction was observed between FPP x MOL2, DCP x MOL1, WNP x MOL3, and PCP x MOL2 for MOL and DCP x GSL1, WNP x GSL1, PCP x GSL1 and FPP x GSL1 for GSL, respectively. Lower interactions on total counts were observed between FPP x MOL1, WNP x MOL4, PCP x MOL3 and DCP x MOL2 for MOL and FPP x GSL2, WNP x GSL2/GSL4, PCP x GSL2 and DCP x GSL2 for GSL, respectively. Some of these interaction effects gave an excellent results; having lower total counts in packaging media investigated. Balarabe *et al*. (2016d) reported positive interaction effects on treated beefs *dambun nama* processed from *Moringa oliefera* and *Guiera senegalensis* leaf extracts and packaging media on reduction of total microbial counts. These autors reported that the positive interaction effect was probably as a result of treated beef *dambun nama* with the two leaf exracts. Higher values were obtained when un-treated *dambun nama* was packaged in the various packaging media studied. These authors further stated that the difference in the total counts may be attributed to treatment of *dambun nama* with *Moringa oleifera* (MOE) and *Guiera senegalensis* (GSE) leaf extracts.

From this study, it can be observed that total microbial counts in *dambun nama* of *Moringa oleifera* leaf meal (MOL) and GSL (*Guiera senegalensis* leaf meal) decreases as the inclusion level is increased across the treatment groups and packaging media, respectively. *Guiera senegalensis* leaf meal (GSL) had high level of effect in suppressing microbial counts than *Moringa oleifera* leaf meal (MOL), but the two plant leaves have promising effect in inhibiting microbial load, especially total fungal counts, prolong shelf life of *dambun nama* and keeping quality of *dambun nama*. Salisu (2017) reported that *Guiera senegalensis* leaf extracts had more potential in suppressing bacterial counts than *Moringa oleifera* leaf extract in beef *dambun nama* Similarly, the different packaging media used in this study (FPP, PCP, WNP and DCP) had the capacity of storing meat floss for up to 12 weeks of storage period without any deleterious effect of microbial counts which did not exceed the borderline specified by International Commission of Microbiological Standards for Foods (ICMSF, 2014). Solberg *et al.* (1986) reported that bacterial count exceeding 10^5/g or coliform count higher than 10^2/g in delicatessen food products are indicative of dangerous contamination.

Similarly in this study, the low interaction values observed in the different packaging media investigated in storage period of *dambun nama* (meat floss) processed from broiler chickens fed diets containing graded levels of *Moringa oleifera* leaf meal (MOL) and *Guiera senegalensis* leaf meal (GSL) might probably due to the active antioxidant nature of the two plant leaves and the enclosed nature of the packaging materials which prevented further contamination from the environment. This agrees with the report of Wang *et al.* (2004) who indicated that the shelf life of poultry products depends on several factors particularly initial bacterial loads, storage temperature and the gaseous environment around the product.

5.4.1: Effect of types of *dambun nama* from Meat of Broiler Chickens Fed Diets Containing *Moringa oleifera* and *Guiera senegalensis* leaf meals and packaging media on total bacterial load

There were positive high and low interractions between treatment groups of MOL and packaging media on total bacterial counts for a storage period of 12 weeks. The result shows that low interaction was observed in FPP x MOL1 (15.0 x 10^5cfu/g), DCP x MOL2 (11.0 x 10^5cfu/g), PCP x MOL2 (10.0 x 10^5cfu/g), WNP x MOL4 (14.0 x 10^5cfu/g). High interactions were observed between FPP x MOL2, WNP x MOL3, PCP x MOL1, and DCP x MOL3. It can be observed that MOL4 (21%) and MOL2 (7%) had better interactive value among the four treatment groups in terms of low total bacterial counts, across the packaging media. Similarly, WNP had low positive interaction value among the packaging media and across the treatment groups studied. However, the interactions of *dambun nama* processed from GSL and packaging media on total bacterial counts showed both high and low interactions. Low interactions were observed between FPP x GSL2, WNP x GSL2/GSL4, PCP x GSL2 and DCP x GSL2, and high interactions were between FPP x GSL1, WNP x GSL1, PCP x GSL1 and DCP x GSL1, respectively. This shows that GSL2 (7%) and GSL4 (21%) interacted best among the treatments and between the packaging media on storage period of *dambun nama* for up to 12 weeks, as observed in MOL. At higher inclusion (GSL), WNP had the least interactive value among the packaging media. It can be observed that GSL is more effective than MOL, especially at 7% inclusion level in terms of bacterial growth. And bacterial load decreases as the inclusion of both MOL and GSL is increased. The high and low values of bacterial counts observed from the packaging media across the treatment groups could be as a result of temperature changes, moisture and the different types of packaging materials used, and also opening and closing of the packaging media in the process of microbial count during storage period in the lab can lead to the exposure of the product to gaseous air in the environment. Brewer and Wu (1993) reported that micro-organisms are primarily responsible for deleterious effects to meat tissue if the meat product has been temperature abused in any manner. Microbial contaminants of meat are derived from the air environment of the abattoir, the slaughter slabs and knives, the hides and hooves, the gastro intestinal tract of the animal, the wash water and from poor hygienic practices (Johnson *et al*, 1983).

5.4.2: Effects of types of *dambun nama* from meat of broiler chickens fed diets containing *Moringa oleifera* and *Guiera senegalensis* leaf meals and packaging media on total fungal load (cfu/g x 10^5)

Interaction between FPP x MOL4, WNP x MOL1/MOL3, PCP x MOL2, and DCP x MOL3 was high, while FPP x MOL3, WNP x MOL4, PCP x MOL4 and DCP x MOL4 had low interaction effect on total fungal counts for *Moringa oleifera* leaf meal, respectively. However, for *Guiera senegalensis* leaf meal (GSL) meat floss, there were high interactions between FPP x GSL1, WNP x GSL4, PCP x GSL1 and DCP GSL1 than interactions between

FPP x GSL2/GSL3, WNP x GSL4, PCP x GSL3/GSL4 and DCP x GSL4 which had lower values of interaction effect.

However, it can be observed that all the plant leaf meals investigated (*Moringa oleifera* and *Guiera senegalensis*) interacted positively between packaging media and storage period of 12 weeks, this indicates the ability of the two leaf meals to improve the quality and high chance of increasing the shelf life of meat products, especially *dambun nama*. All the packaging media are very good in preventing further contamination in the *dambun nama*. This is line with the reports of Balarabe *et al.* (2016d) and Haruna (2014). Salisu (2017) reported that *Guiera senegalensis* leaf extract had more potential in suppressing bacterial growth than *Moringa oleifera* leaf extract as opposed to the observation in this present study. Siddhuraju and Becker (2003) reported that *moringa* leaves are good sources of natural antioxidant and thus, enhance shelf life of fat containing foods due to the presence of various types of antioxidants like ascorbic acids, flavonoids, phenolic and carotenoids.

Similarly, the different packaging media used in this study (FPP, PCP, WNP and DCP) had the capacity of storing meat floss for up to 12 weeks of storage period without any deleterious effect of microbial counts which did not exceed the borderline specified by International Commission of Microbiological Standards for Foods (ICMSF, 2014). Solberg *et al.* (1986) reported that bacterial count exceeding 10^5/g or coliform count higher than 10^2/g in delicatessen food products are indicative of dangerous contamination.

CHAPTER SIX

6.0 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 Summary

1. Based on the findings of this study on *Moringa oleifera* leaf meal (MOL), the results are summarized as follows:-

a. Carcass and organ characteristics of broiler chickens fed diets containing graded levels of *Moringa oleifera* leaf meal (MOL) revealed that live weight, dressed weight, dressing percentage, heart and liver weights differed ($P<0.05$) significantly across the four treatment groups. All other parameters were similar among the treatment groups investigated.

   Growth traits of broiler chickens fed diets containing graded levels of MOL revealed that only feed conversion ratio and mortality rate were significantly ($P < 0.05$) different across the treatment groups. Other growth rates such as final weight, weight gain, feed intake, average daily feed intake and average daily weight did not differ significantly among the treatment groups.

b. Chemical composition parameters on fresh meat of broiler chickens fed diets containing graded levels of MOL revealed that per cent dry matter, lipid, crude protein, crude fibre, ash and carbohydrate were significantly ($P < 0.05$) different across the treatment groups.

c. Chemical composition of processed *dambun nama* (meat floss) from meat of broiler chickens fed diets containing graded levels of MOL showed that all the compositional parameters investigated (moisture, lipid, crude protein, crude fibre, ash and carbohydrate) differed significantly ($P < 0.05$) across the treatments.

d. Sensory attributes of *dambun nama* (meat floss) processed from meat of broiler chickens fed diets containing graded levels of MOL showed only juiciness differed significantly across the treatments. Other sensory attributes like colour, texture, aroma, tenderness and acceptability were not significantly different among the four types of *dambun nama* studied.

e. The storage quality of *dambun nama* (meat floss) processed from meat of broiler chickens fed diets containing graded levels of MOL showed that microbial multiplications (both fungal and bacterial growth) decreased as the concentration of MOL was increased in the diet, especially at 12th week storage period.

f. All the packaging methods (FPP, WNP, PCP and DCP), especially PCP and WNP were effective in storing *dambun nama* for 12 weeks period with lower total microbial counts especially at concentration level of MOL2 (7%) and MOL4 (21%).

2. Based on the findings of this study on *Guiera senegalensis* (GSL), the results were summarized as follows:-

    a. Carcass and organ characteristics of broiler chickens fed diets containing graded levels of *Guiera senegalensis* (GSL) showed that live weight, and breast weight were the only parameters that differed significantly ($P < 0.05$) among the treatment groups. Other parameters such as dressed weight, dressing percentage, weights of organ (heart, gizzard, liver and abdominal fat) and prime cuts (drumstick, thigh and back) did not differ significantly among the treatment groups investigated.

    Growth performance of broiler chickens fed diets containing graded levels of GSL showed that feed intake, average daily feed intake, feed conversion ratio and mortality rates were significantly ($P < 0.05$) different among the four treatment groups. However, other growth traits such as final weight, weight gain and average daily weight did not show significant differences across the treatment groups investigated.

b. The compositional parameters on fresh meat of broiler chickens fed diets containing graded levels of GSL showed that per cent moisture, lipid, crude protein, ash and carbohydrate contents were significantly ($P < 0.05$) different across the four treatment groups. There were no significant differences with respect to per cent crude fibre among the four treatment groups.

c. Chemical composition of *dambun nama* (meat floss) from meat of broiler chickens fed diets containing graded levels of GSL revealed that parameters such as moisture, lipid, crude protein, crude fibre, ash and carbohydrate differed ($P < 0.05$) significantly among the treatment groups.

d. Sensory attributes of *dambun nama* (meat floss) from meat of broiler chickens fed diets containing graded levels of GSL showed that color, texture and acceptability were not significantly affected across the treatment groups studied. Other sensory attributes like aroma, tenderness and juiciness were significantly ($P>0.05$) different across the treatment groups, respectively.

e. The storage quality of *dambun nama* (meat floss) fed diets containing graded levels of GSL revealed that total fungal and bacterial counts decreased, especially fungal counts, as GSL was increased from 0% to 21% in the diet.

f. All packaging methods investigated, especially FPP had lower total bacterial and fungal counts in *dambun nama* from meat of broiler chickens fed diets containing graded levels of GSL at higher week of storage periods (12 weeks) and there were low total microbial counts in meat floss across the treatments and packaging media investigated.

6.2 Conclusions

This study concludes as follows:-

a. Incorporation of MOL in the diet of broiler chickens at the inclusion levels (0, 7, 14 and 21%) had no deleterious effects on growth performance and carcass characteristics of the birds. And also improved chemical composition of both fresh meat and processed *dambun nama* (meat floss) from meat of broiler chickens. The processed *dambun nama* was well - cherished by the sensory panelists and rated the product high for quality. Storage of *dambun nama* over 12 week period showed reduced total microbial load (fungal and bacterial) in all the treatments studied. The packaging methods investigated (FPP, WNP, PCP and DCP) had suppressive effects, especially PCP and WNP against microbial growth and multiplications at 12 weeks of storage periods.

b. Inclusion of GSL in the diet of broiler chickens did not affect the growth performance, chemical composition of the fresh meat and processed *dambun nama*. *Dambun nama* evaluated by panelists was rated high in terms of their sensory attributes; with the control being similar to the other treatment groups in the overall acceptability. Total counts in *dambun nama* decreased as the concentration of GSL was increased up to 21% and 12weeks storage period. All the packaging methods investigated had positive effects on lowering bacterial and fungal growth and multiplications of the packaged *dambun nama* at 12 weeks of storage period, especially WNP and PCP being the best.

6.3 Recommendations

This study on dietary inclusions of both *Moringa oleifera* (MOL) and *Guiera senegalensis* (GSL) leaf meals in broiler chicken production recommends as follows:-

- Broiler chickens can be fed MOL and GSL in their diets for up to 21% inclusion for enhanced quality and storage of both fresh meat and processed meat.

- *Dambun nama* (meat floss) processed from broiler chicken fed diets containing graded levels of MOL and GSL for up to 21% can be stored for up to 12 weeks without any deleterious effect.
- *Dambun nama* processed from broiler chickens fed diets containing graded levels of MOL and GSL should be evaluated for sensory and stored above the 12-week period and investigated further for its overall acceptance, quality and shelf-life.
- Plastic container packs can be used in storing processed meat for up to 12 weeks storage period.
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CONTRIBUTION TO KNOWLEDGE

- Incorporation of GSL and MOL in diet of broiler chickens at inclusion levels of 7, 14 and 21% had no negative effect on growth and chemical composition of both fresh meat and meat floss. For example, the crude protein content of broiler fresh meat and meat floss were between 24.41to 25.46% vs 46.89 to 50.53% and 24.65 to 26.03% vs 46.43 to 49.85%, respectively.

- Meat floss processed from broiler chickens fed MOL and GSL were well-cherished by the constituted sensory panelists and rated the product high (4.44 score) for quality.

- Microbial loads (10^5 cfu/g) observed in meat floss stored for up to 12weeks were within the safe and acceptable limits (10^7 cfu/g) specified by the International Commission of Microbiological Standard for Foods (ICMSF, 2014).

- All the packaging methods (FPP, WNP, PCP and DCP) had suppressive effect (0.0 to3.0 x 10^5 cfu/g), especially PCP and WNP against microbial (bacterial and fungi) growth at higher week (12weeks) of storage for both MOL and GSL.

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APPENDICES

Appendix 1: Sensory evaluation score sheet for meat floss processed from broiler chickens fed dietary inclusion levels of MOL and GSL

DEPARTMENT OF ANIMAL SCIENCE
AHMADU BELLO UNIVERSITY ZARIA
SENSORY EVALUATION SCORE SHEET

Date:…………………

SECTION A: Please tick the most appropriate

Sex: Male ( ) Female ( )

Average age: 20-30 ( ) 31-40 ( ) 41- 50 ( ) 51-60 ( )

Marital status: Single ( ) Married ( )

Occupation: Civil Servant ( ) Student ( ) Other ( )

Level of Education: Non- formal ( ) Primary ( ) Secondary ( ) Tertiary ( )

Do you like chicken meat? Yes ( ) N0 ( )

How do you prefer chicken meat? Fried ( ) Roasted meat ( ) Meat floss ( ) Pepper soup ( ) Others ( )

SECTION B: Consumer's Perception

Please choose your level of perception of the samples given to you by writing the appropriate number under the product code. Ensure you rinse your mouth after each tasting

5 Hedonic scale:

1- Disike extremely
2- Dislike very much

3- Neither no dislike

4- Like very much

5- Like extremely

Kindly score the following samples based on the five (5) point scale below

Parameter	**Product**				
	A	**B**	**C**	**D**	**E**
Colour					
Texture					
Aroma					
Tenderness					
Juiciness					
Acceptability					

Thank you very much for your cooperation