REPUBLIC OF TURKEY
BINGOL UNIVERSITY
INSTITUTE OF SCIENCE

RESPONSE OF BROILER CHICKENS TO EITHER WHEAT OR MAIZE BASESD DITES SUPPLEMENTED WITH GRADED LEVEL OF RAW SESAME SEEDS

MASTER THESIS

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BİNGOL-2017

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This thesis has been accepted on the date of 19.10.2017 by a unanimous vote by the below jury.

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ACKNOWLEDGEMENT

First and foremost I am grateful to (Allali) for providing health and strength to conduct the present study. I would like to express my special appreciation and thanks to my supervisors; Prof. Kagan Kokten and Dr. Sleman Beski for the opportunity to pursue my MSc degree. Your continual support and motivation have been invaluable to me. You have been tremendous mentors for me. I would like to thank you for encouraging my research and for allowing me to grow as a research scientist. The support, guidance, advice and education provided by you on both research as well as on my career has been priceless. I highly appreciate the University of Bingol for providing me this opportunity. I would like to extend my appreciation to the staff of Field crop department for their precious assistance and suggestions during my candidature. I am using this opportunity to express my gratitude to the University of Duhok, College of Agriculture and Forestry, particularly Animal Production Department for providing me the facilities to undertake this study project. I express my warm thanks to Assist. Prof. Dr. Kamal N. Doski (The dean of the college of agriculture), Dr. Khalil Oray (The head of the animal production department) and the staff of animal production department for their friendly advice and aspiring guidance during the project work. Also many thanks to dear friend Nechirvan H. Artoshi to his help during my study. Also many thanks to the dean of collage of Veterinary/Duhok University Assist. Prof. Dr. Loqman T.Barwary for his unconditional support. I would also like to thank all of my friends back home who supported me and encouraged me to strive towards my goal. Finally, my higher study was greatly encouraged by my family members. Words cannot express how grateful I am to my parents, brothers, wife, kids (Shadan, Shihyan, Golshan) and sisters. Your prayer for me was what sustained me thus far. Thank you for your tolerance and patience. Your unconditional love and support have been precious.

Ziyad Obaid Saeed PASSI

Bingöl 2017

CONTENTS

LIST OF ABBREVIATIONS

AOAC	: Association of Official Analytical Chemists
AME	: Apparent metabolisable energy
ANFs	: Anti-nutritional factors
BW	: Body weight
^{O}C	: Celsius
CHOL	: Cholesterol
CP	: Crude protein
DCP	: Di-calcium phosphate
EAA	: Essential amino acids
FAO	: Food and Agricultural Organization of the United Nations
FCR	: Feed conversion ratio
FI	: Feed intake
Gizz	: Gizzard
g	: Gram
GLM	: General Linear Models
HDL	: High density lipoprotein
kg	: kilogram
LW	: Live weight
TP	: Total protein
TRG	: Triglycerides
Smal.int	: Small intestine
SBM	: Soybean meal
SEM	: Standard error of mean
SSM	: Sesame seed meal
NSP	: Non-starch polysaccharide

WG : Weight gain

RSS : Raw sesame seed

RSSM : Raw sesame seed meal

LIST OF FIGURES

LIST OF TABLES

DEĞİŞİK SEVİYELERDEKİ SUSAM TOHUMLARININ BUĞDAY VEYA MISIR BAZLI RASYONA EKLENMESİNİN ETLİK PİLİÇLERDEKİ ETKİSİ

ÖZET

Bu çalışma çiğ susam tohumlarının broylerlerin performans, serum biyokimyası, karkas özellikleri ve sindirim fizyolojisi üzerindeki etkisini araştırmak amacıyla yapılmıştır.

Susam tohumları, farklı tane esaslarına göre düzenlenerek broyler civcivlerin başlama, büyütme ve bitirme yemlerine katıldı. Denemede günlük yaştan 35 günlük yaşa kadar Ross 308 etlik civciv kullanılmıştır. Yemler civcivlere toz ve pelet formda verilmiştir. Çiğ susam içeren başlama yemi civcivlere ilk 10 gün süreyle verilmiş ve ilk 10 günlük dönemde susam tohumlarının yem tüketimini ve büyüme performansını iyileştirdiği, fakat üretim döngüsünün son dönemlerinde bu etkinin kaybolduğu görülmüştür.

Etlik piliç rasyonlarına çiğ susam tohumun eklenmesi kan kolesterol düzeyinin azalmasına sebep olmuş ve bu durumun özellikle tüketici tercihlerini etkileyen önemli bir faktör olmuştur. Ayrıca performans üzerinde herhangi bir etkiye neden olmadan özellikle protein ve azotun besin elementlerinin sindirilebilirliğini azaltmada etkili olmuştur.

Sonuç olarak etlik piliç civcivlerinin rasyonlarına özellikle büyüme döneminde susam tohumlarının eklenmesinin etlik piliçlerin büyüme ve gelişme performanslarını artırılmasında, kan kolesterol düzeyinin azaltılmasında için umut verici bir uygulama olduğu, daha net ifadeler kullanılabilmesi için, çeşitli işleme tetkiklerinin geliştirilmesi ve bu konuyla ilgili daha fazla çalışma yapılmasına ihtiyaç olduğu söylenebilir.

Anahtar Kelimeler: Broyler, performans, susam, kan kolesterolü, yem tüketimi.

RESPONSE OF BROILER CHICKENS TO EITHER WHEAT OR MAIZE BASESD DITES SUPPLEMENTED WITH GRADED LEVEL OF RAW SESAME SEEDS

ABSTRACT

An experiment was conducted to assess the influence of raw sesame seeds on the performance, serum biochemistry, carcass characteristics and digestive physiology of broiler chickens. Sesame seeds were included in the starter, grower and finisher diets of broiler chicks and their effects were investigated in different grain based diets. Feeding trials was conducted on Ross 308 broiler chicks from d-old to 35 d of age. All feed was provided as whole mash. This summary provides an over view of the key findings of the research.

Providing newly hatched chicks with starter diets containing raw sesame seeds enhanced feed intake and growth performance at d 10 of age. The effects of supplemental dietary sesame seeds in the starter diets appears to have long-term benefits on the feed intake of broiler chickens and their effects were sustained during subsequent grower stage, however disappeared in the finisher stage of broiler production cycle. Birds on wheat based diets expressed higher feed intake than those on maize based diets throughout the experimental period. However better FCR was recorded for birds on maize based diets. The inclusion of raw sesame seeds appears to have benefits on the serum cholesterol level of the broiler chickens, limiting the high risk of lipid related disease of the costumer. Inclusion of raw sesame seeds was effective at decreasing the digestibility of nutrients particularly protein and nitrogen, with no impacts on the performance of broilers.

The results of this study provide evidence that inclusion of raw sesame seeds to diets of broiler chicks is a promising tool to enhance the performance of broiler chickens especially at an early age. Beyond providing nutrients for growth, sesame seeds can maintain feed intake and regulate the cholesterol level. There is a need for further investigation into use of raw sesame seeds in layer chickens diets. A wider range of exploring various feed staff should be considered, taking advantages and exploiting the most available processing techniques.

Keywords: Broiler, performance, sesame, blood cholesterol, feed intake.

1. INTRODUCTION

The poultry industry has made advances in many areas including nutrition, genetics, and management to maximize the efficiency of growth performance and meat yield. The production cycle of broilers continues to shorten and modern broilers are reaching market age sooner each year (Kleyn and Chrystal 2008). This trend of broiler chicken selection for early maturation and marketing age means that the nutrition of chickens during the post hatch period needs consideration (Takahashi et al. 2011).

The usefulness of a protein feedstuff for poultry depends upon its ability to supply a sufficient amount of the essential amino acids (EAA) that the bird requires, as well as the protein digestibility and the level of toxic substances associated with it. The majority of an animal's dietary protein and energy requirement is supplied by plant sources. Worldwide, in animal nutrition, maize and soybean are the predominant energy and protein sources respectively.

Cereals, like wheat and sorghum, and some plant protein meals are used all over the world as well. Soybean meal (SBM) is the preferred protein source used in poultry feed manufacturing, due to its high CP content and well balanced amino acids, enabling it to balance most cereal-based diets (Ravindran 2013). However Agriculture is continuously faced with the problem of diminishing resources and increased population growth. The increasing cost of feed resources in livestock production has been identified as a serious impediment to meeting the demand for animal protein particularly in developing countries (Adejinmi et al. 2000).

Poultry production relies mainly on maize as the main energy source but it suffers intense competition as food for humans resulting in higher demand than supply, higher cost and thus lower profit margin for poultry producers. On the other hand, the increased global requirement for animal protein, and therefore high quality livestock feeds, has led to high demand and high prices for soybeans and soybean meal. This scenario of ever-increasing cost of poultry feed with concomitant increase in cost of poultry products (meat and eggs), is worsened among poultry producers and makes it necessary to explore the use of alternative feed ingredients that are cheaper and locally available (Agbede et al. 2002; Tuleun et al. 2009). Non-conventional feedstuffs offer cheaper and less competitive alternatives to producers especially during periods of scarcity of specific ingredients. Such work will be of potential benefits, offers recommendations to manufacturers and helps to formulate accurate diets to animals.

Sesame seed meal (SSM) may also, constitute to be good vegetable protein sources for use in poultry diets in regions where they are readily available and relatively inexpensive. Feeding the high methionine content sesame seed meal together with the high lysine containing soybean meal, will make a balanced diet with respect to lysine and methionine (Olomu 1978). The SSM could partially replace soybean meal in the diet as a source of plant protein for chicks (Bell et al. 1990; Pan et al. 1992; Kang et al. 1999) and ducklings (Dey et al. 1982; El-Husseiny et al. 2001). Sesame meal could be a potential alternative to soybean meal in boiler diets when used at a level of not more than 15% (Kang et al. 1999).

The broad aim of the work reported within this thesis was to test the effect of dietary inclusion of raw sesame seed meal in the nutrition of broiler chicks. The main objectives of the present study were to test the addition of different levels of raw sesame seed as a complementary ingredient on either maize-soy or wheat-soy broiler diets on the broiler performance and its subsequent physiology. The study examined nutrient digestibility, carcass characteristics and blood parameters together with performance of broilers in response to dietary raw sesame seeds..

2. LITERATURE REVIEW

2.1. Introduction

Agricultural industries, including animal production, have dramatically changed over the past few decades (Lassen et al. 2006). The change has been driven by the transition from traditional agriculture as a style of life to a business (Fredeen and Harmon 1983). The poultry industry, as an important component of the agricultural sector, has been developed in several areas such as nutrition, genetics and management to maximize the efficiency of growth and meat yield. Agriculture is continuously faced with the problem of diminishing resources and increased population growth. To remain competitive and profitable in the global marketplace, poultry producers have realized that efficiency is the key focus. Genetic selection has improved carcass qualities (yield of meat and composition), and bird productivity (growth rates); while technology has improved labour efficiency, nutrition (least-cost formulation and feed supplements), health (development of new vaccines and medications) and reproduction.

The science of nutrition involves providing a balance of nutrients that best meets the need of an animal for optimal growth, and ensuring effective metabolic activities. For economic reasons, the supply of nutrients should be at least cost therefore only enough must be supplied to meet requirement without any major excess (Ranjhan 2001).

Cereal grains provide the bulk of the energy in poultry feeds; therefore, the utilization and digestion of cereal grains are important. In poultry feed formulation, after the energy-yielding raw materials, protein supplements constitute the biggest component, and attention has been focused on the protein and energy levels of the feed. The banning of the using of animal proteins in animal diets has led to increased interest in vegetable protein sources. Soybean meal is the predominant protein source for animal diets, but the increased prices of soybeans has resulted in an interest in alternative sources of vegetable protein. Some other oil seeds can be used as alternative feed ingredients such as sesame seed meal.

2.2. Cereals for Poultry Feeding

Cereals are crops that are harvested for dry grain (Bareja 2015). Cereals are globally the most important crops. In (Figure 1) the Cereal grains are grown in greater quantities with total grain production of 2 543 million tons (mt) in comparison with less than 350 mt for legume seeds (FAO 2016), Although of its content of all essential nutrients (vitamins, minerals, carbohydrates, fats, oils, and protein) cereals are mainly used as energy sources in both human and animal feeding. More than 50% of the total energy requirements of human are provided by cereals. Therefore cereals have become significant in human society resulting in a large, conspicuous economical business (Pomeranz and Williams1990).

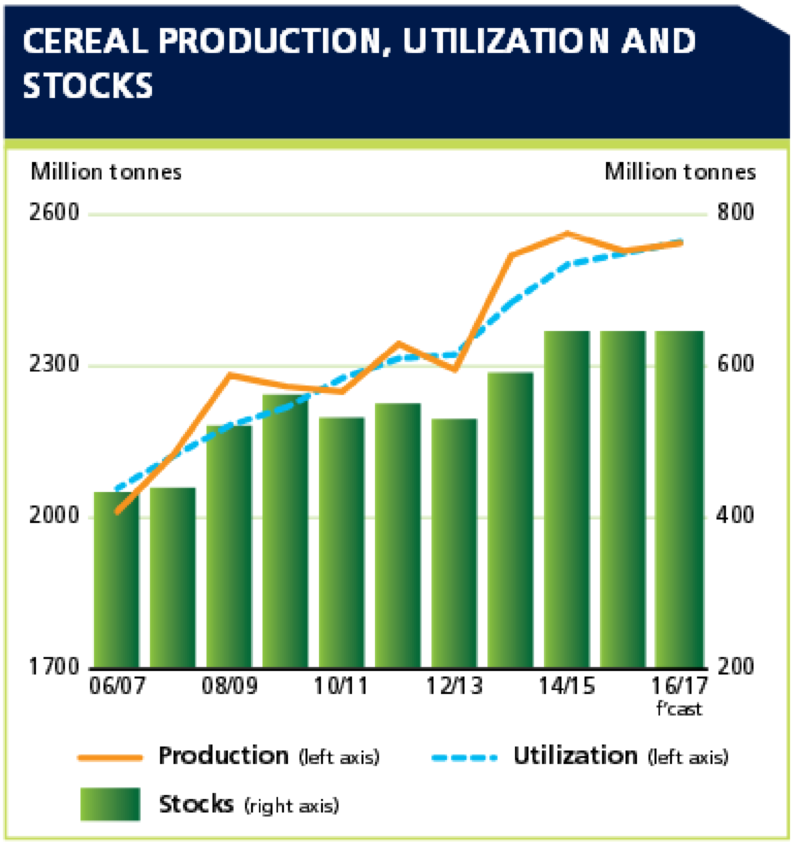

Figure 1. World's cereal production and utilization

Cereals play an important role in animal feed formulation. Cereal grains are primarily used in animal diets as energy sources. Grains and products of grains comprise 80 % or more of most diet formulations for poultry. One third of the total cereal grains produced globally is used as animal feed of which around 60% are used for poultry (Speedy 2003).

The main cereal grain crops that grown in the world are maize, wheat, rice, barley and sorghum. These grains are nutritionally dense and supply carbohydrates, proteins and variety of micronutrients including minerals and vitamins. Among the cereals, maize is the most common energy feedstuff fed to poultry worldwide (Leeson and Summers 1997) followed by wheat. Different categories of poultry have different feed formulations each with a specific composition, depending on the availability of ingredients. Therefore, it is necessary to choose the cheap, easily and locally available energy sources. These crops have significantly helped reduce the cost of poultry production, while simultaneously producing good quality products such as eggs and meat from chickens (Kiarie et al, 2014).

2.2.1. Wheat

Wheat, a species of cereal grasses of the genus Triticum (family Poaceae). Following the corn, wheat is the second most globally produced cereal crop. It is an important stable food crop supplies the dietary energy and protein requirements of almost one third of the planet habitants (Shewry 2009; Abd-El-Haleem et al. 1998; Adams et al. 2002). The poultry producers Europe, Canada, Australia and New Zealand rely on wheat as the main dietary energy source in broiler nutrition.

Wheat is of high nutritive value and contains all the essential nutrients that are necessary for growth (Lincoln 2009). The energy content of wheat is 94% to 96% that of corn, however it is protein, phosphorus, calcium, and amino acids contents are higher than those of corn (National Research Council 1994). The protein content of wheat varies from 11 to 19%, based on kind of wheat, variety, and test weight (Sullivan and Gleaves 1977). The climate situation and the soil may have effects on the chemical composition of the wheat. In general wheat grain is composed of 12% water, 70% carbohydrates, 12% protein, 2% fat, 1.8% minerals, and 2.2% crude fibres and vitamins. The milling process may also alter the chemical composition of wheat (Encyclopedia Britannica Inc. 2017). The AME content of whole wheat grain is about 3.340 to 3.650 kcal/kg and its ME content is about 3,050 to3, 770 kcal/kg (Scott et al. 1998).Wheat stores energy in the form of starch which compromises about 60-75% of the total dry weight of the grain (Šramkováa et al. 2009), while lipids are present only in small amounts. Therefore commercially, wheat provides about 70% of the metabolisable energy and 35% of the protein requirements of broilers. Wheat can be included up to (80-85%) in poultry diets along with soybean meal supplemental vitamins, minerals and amino acids (Carlson and Bonzer 2012).

However, wheat is variable in its physical and chemical composition (Choct et al. 1999). This is mostly attributed to the level of non -starch polysaccharide NSP presents in the structure of the wheat grain (Wiseman 2000). This variation in the quality of the wheat may have a great impact on the performance of chickens (Alamo et al. 2008).

2.2.1. Maize

Corn, *Zea mays* L., is a top ranking cereal in terms of global production. It is second to wheat in total world production and has great significance as human food, animal feed and industrial products. The world production of corn was grown to (968 million metric ton) in 2016, (USDA 2017). One of the cereal of Poaceae family, its cultivation history started from 10.000 BC when it was firstly been cultivated in (Oaxaca Mixico), thereafter spread to America and Caribbean (Ecoport 2010). It is comparatively devoid of viscous non-starch polysaccharides (NSP), which are the main anti-nutritive factors present in most temperate cereal grains (Bedford and Morgan 1996; Smits and Annison 1996; Bach Knudsen 1997). Worldwide, corn is the most widely used energy source in poultry diets (Zanella et al. 1999). The season, variety and post-harvest processing may have effects on the chemical composition of maize (Iji et al. 2003; Cowieson 2005). However, compared to other cereals, maize is considerably less variable in terms of protein content, ranging from 90 to 119 g/kg DM and consistently high in AME values, (Carmencita et al. 2006) founded that the CP of yellow maize, 8.91%, ME 3400 Kcal/Kg ,15.6 ± 0.1 MJ/kg DM (Metayer et al. 1993). Numerous analyses revealed that the corn meal contains 13-14% moisture, 9-10% crude proteins, 3.3% cellulose, 48-50% glucoses, 4.0 sugar and 6-8% fat. In addition, It contains about 2.1% mineral matters, 0.12% calcium, 0.22% phosphorus and

1.28 mg/kg β-carotene, (Filipović et al. 2004; Milošević et al. 2006).Therefore, the chemical composition of maize is favorable for inclusion in poultry diet.

2.3. Sesame in Poultry Feeding

2.3.1. Description of the Sesame Plant

Sesame (*Sesamum indicum* L) is a tropical and subtropical pant with an extremely variable morphology. Sesame is an annual, or occasionally perennial, species which can grow to 50-250 cm in height (Sun Hwang 2005). Sesame is an annual self-pollinating plant with an erect, pubescent, branching stem and 0.60-1.20m tall (Morris 2002). The sesame plant can be branched or un-branched. The leaves vary in shape and size, and may be alternate or opposite (Oplinger et al. 1990). The growing sequence is indeterminate, with leaves, flowers and seeds being produced as long as the weather permits. Having an extensive root system makes the sesame is a drought-tolerant crop that could adapt and grow in various soil types (Ram et al. 1990). The stem of the plant is green, erect, quadrangular, longitudinally furrowed and heavily hairy. The leaves are hairy and variable in shape and size (3-17.5 cm long x 1-7 cm) broad and dull green in colour (Sun Hwang 2005). The leaves are ovate to lanceolate or oblong while the lower leaves are trilobed and sometimes ternate and the upper leaves are undivided, irregularly serrate and pointed. Sesame is rich in flowers, growing along its stem (Ugras Gungur 2004). The flowers are borne on short glandular pedicels (Felter and Lloyd 1898). White to pale pink bell-shaped flowers develops at the leaf axils along the stems. Only flowers borne 30 to 60 cm off the ground develop into fruits. The fruit of sesame is a capsule covering several rows of colored small seeds (Felter and Lloyd 1898; Peace Corps 1990 and McCormick 2001). The seeds are flat with a point at one end and light in weight with 32g for a 1000 seeds. The lighter coloured seeds are considered of higher quality (Hansen 2011; Myers 2002; Sun Hwang 2005; Oplinger et al. 1990). It normally takes 125 to 135 days for unimproved sesame to reach maturity, but commercial varieties only require 90-120 days (Hansen 2011). At maturity, leaves and stems turn yellow to red in colour (Oplinger et al. 1990). The seeds are almost ripe, the pods open signally to the harvesting time. Sesame harvesting is a manual physical practice which mostly doing by hand and the yield is sun dried in the field. Thereafter winnowing and cleaning complete the process (Dudley et al. 2000; Anonymous 2002).

Figure 2. The Sesame plant from Amedi Area, Duhok, Iraq.

2.3.2. Historical

Sesame (*Sesamum indicum* L.) is an ancient plant; being cultivated across the globe predominantly for its seeds. Sesame is one of about 35 species belonging to the genus Sesamum in the family of Pedaliaceae (Salunkhe 1992). The cultivation of sesame is thought to have started in central Africa, mainly Ethiopia. However, it had been indicated to be a crop in Babylon and Assyria over 4000 years ago (Oplinger et al. 1990) or India as the country of sesame origin (Weiss 2000).

2.3.3. World Sesame Production

Sesame seeds are the most popular seeds in the world The main reason for their popularity is the fact that they are loaded with health-promoting nutrients and elements, the total annual seed yields about 4.8 m tons compared with less than 1.4 m tones in the early sixties (FAO 2016). Worldwide, Sesame is cultivated in almost 75 countries. Myanmar alone produces about 29% of total sesame production of the world with its annual production of (890,000) m tones. As shown in (Figure 3) Therefore Myanmar is leading the top five sesame producing countries followed by India, China, Sudan and Tanzania (FAO 2016). The white and other lighter-colored sesame seeds are common in Europe, Americas, West Asia, and the Indian subcontinent. The black and darker-colored sesame seeds are mostly produced in China and Southeast Asia (Heuze et al. 2017).

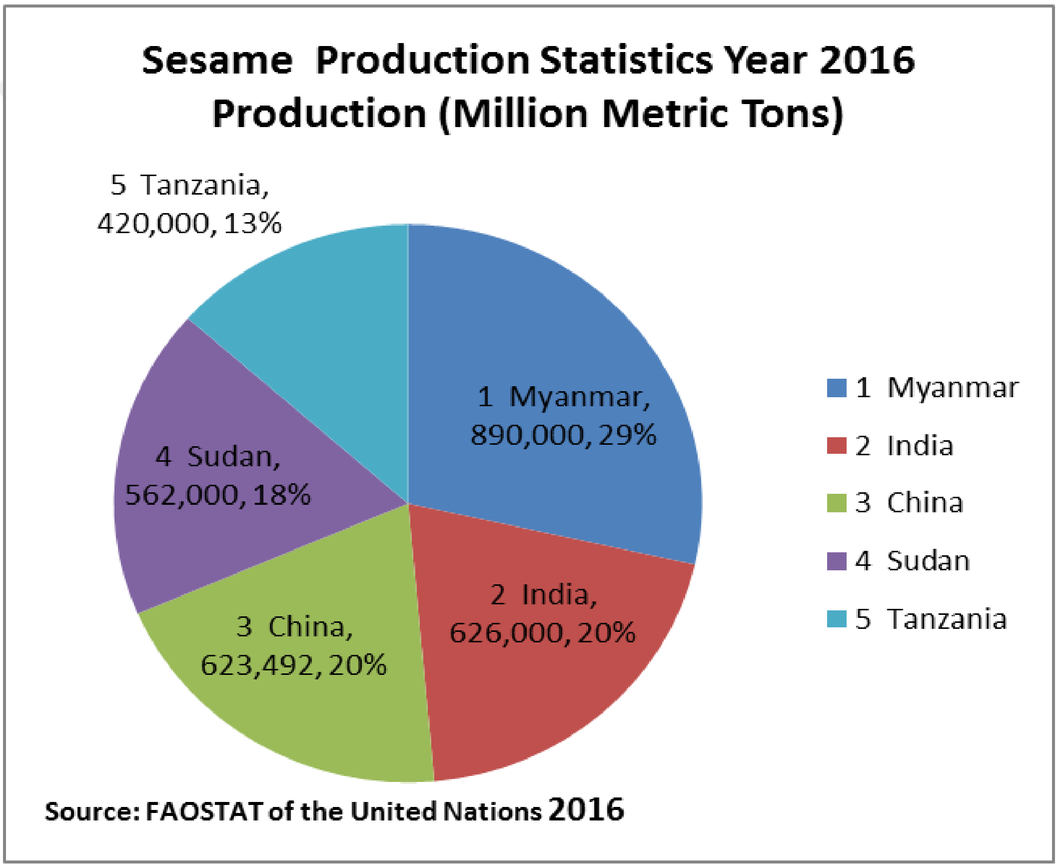

Figure 3. The top five sesame producing countries in 2016 (% of a total world production, and million metric tons per a country), Source: FAOSTAT of the United Nations 2016

2.3.4. Nutritional and Biological Value of Sesame

Sesame is probably the most ancient oilseed used by humans as a food source (Gharbia Abau et al. 2000). Sesame is traditional healthy food ingredient due to its high content of edible oil (Sankar et al. 2006) with excellent stability (Sirato-Yasumoto et al. 2001). It has earned a poetic label “Queen of oilseeds” due to high quality polyunsaturated stable fatty acids in its seeds (Gagan Rani 2014).The seed contains 50-60% oil compared to 20% in soybean (Kato et al. 1998; Ahmed 2005). The oil has excellent stability and resistance against the oxidative deterioration, due to the presence of lignans, pinoresinol, tocopherols, lecithin, myristic acid and linoleate that have been identified as the major antioxidants (Sihyung et al. 2010). The potent antioxidant properties of sesame seed extract could be primarily attributed to the presence of lignans which are phytoestrogens (Ikeda et al. 2003).in addition sesamolin, sesamin and sesamol that are present in the composition of sesame are excellent natural antioxidants (Brar and Ahuja 1979; Kato et al. 1998). Sesamin also has anti-bacterial activities (Home Cooking 1998). Sesame seed also contains a reasonable amount of carbohydrates 10 to 15% carbohydrate (Lee et al. 2005). Its high content of oil together with its content of carbohydrates makes sesame seeds to be valuable source of metabolizable energy which was ranged in between 4963 to 5832 Kcal/Kg as recorded by some researches (Aduku 1992; Olomu 1995; Diarra et al. 2007).

Sesame seed is rich in protein and minerals. The protein content of sesame varies among different researchers. Full fat seeds have been reported to have 18-25% (Borchani et al. 2010), 20% (Nzkouv et al. 2009), 22.30% (Olomu 2011) and 22-25% (Tunde-Akintunde et al. 2012). The meal after oil extraction contains 44% crude protein (Peace Corps 1990; Mamputu and Buhr 1991), 28.40% CP (El-Housseiny et al. 2001) and 52.9% CP (Kaneko et al. 2002). The amino acid profile of sesame protein is similar to that of soybean meal with the exception of lower lysine (Mamputu and Buhr 1991) and higher methionine in sesame (Dipasa 2003). Sesame protein is rich in leucine and arginine (McDonald et al. 1998; Robbelen et al. 1989). Sesame seeds are also contain a reasonable amount of minerals and vitamins such as manganese, copper, calcium, vitamin B1 and vitamin E (Biswas et al. 2001; Ojiako et al. 2010) in addition to the highly absorbable spectrum of vitamin E, they increase its bioactivity in the body (Cooney et al. 2001).

2.3.5. Anti-nutritional Factors in Sesame

The major portion of animal dietary requirements is of plants origin. Oil seeds are the main sources of dietary protein in animal feeding. However, the presence of some natural anti-nutritional factors (ANFs) in the structure of plant proteins is a common feature of almost all plant protein sources. These ANFs may adversely affect the quality and the nutritional value of plant proteins in animal nutrition. ANFs are metabolic by products produced in natural feedstuffs that reduce its nutritive value as a feed through inhibition or activation of nutrients and reduction in the digestive or metabolic utilization of feed (Akande et al. 2010).

The most commonly found antinutrients that limit the use of sesame as feed ingredient are phytate (Salunkhe et al. 1991) and oxalate (Phillips et al. 2005). These anti-nutritional factors have serious implication on the performance and health status of animals when considerable amounts are ingested in feed. Oxalic and phytic acids are known to interfere with the utilization of nutrients by forming insoluble complexes (Adegunwa et al. 2012). However, the nutritive value of sesame seed would be comparable with that of soybean if the anti-nutritional factors are reduced or eliminated.

2.4. Role of Sesame and Sesame by Products in Poultry Nutrition

Sesame seeds have high levels of essential nutrients such as protein, carbohydrates, fiber and some minerals. Almost the complete dietary protein requirements of most farm animals could be afforded by dietary sesame seeds (Weiss 1971). With excellence amino acid profile (Mamputu et al. 1995).

Sesame seed meal (SSM) as a by-product from the oil industry is an excellent protein source in poultry nutrition. Particularly in areas where sesame seeds are inexpensively obtainable. The SSM could partially replace soybean meal in the diet as a source of plant protein for chicks (Bell et al. 1990; Pan et al. 1992; Kang et al. 1999) and ducklings (Dey et al. 1982; El-Husseiny et al. 2001).

The key factors that triggered the SSM to be the main protein source in simple stomach animal diets are lysine deficiency (Jacob et al. 1996) together with the high level of phytic acid (Mulky et al. 1989). Additional lysine source should be used with feeding sesame protein to pigs and poultry (Mulky et al. 1989). However, sesame seed has been used to supplement synthetic methionine in laying hens (Diarra and Usman 2008) and broilers (Agbulu et al. 2010). Therefore, a well amino acid balanced diets could be obtained when

SSM is feeding combined with soybean meal. This combination could fortify the methionine availability and decrease the negative impact of lysine deficiency of feeding sesame (Olomu 1995).

Sesame could be used as a source of energy in the diets of animals, due to its high oil and carbohydrate content. The potential energy production from a unit of dietary sesame fat is 2.25 times greater than the energy content of an equal unit of carbohydrate in feed cereals or forages (Choi et al. 2008). Each kilogram of sesame could afford about 5500 Kcal of metabolisable energy as an average (Aduku 1992; Olomu 1995; Diarra et al. 2007). Thus dietary sesame could afford a large portion of energy requirement if it incorporated to animal diets.

2.4.1. Effects of Feeding Sesame Seed Meal on the Feed Intake of Broilers

Feed intake was significantly increased when graded levels (4, 8, and 12%) of roasted sesame hulls were included to the broiler chickens diets (Kamel et al. 2015). Similar results were obtained by Rahimian et al. (2013) when different levels of sesame meal were incorporated to the broiler diet. Daily feed intake and total feed consumption were significantly increased when broilers were fed on diets containing 15% of soaked sesame meal (Olaiya et al. 2015; Ogunbode 2016). However a significant reduction in the feed intake was observed as the level of sesame seed meal increased in the diets of 4 weeks old broiler chickens (Diarra et al. 2007; Yasothai et al. 2010; Agbulu et al. 2010). Same effect on the feed intake was also reported by (Ogunwole et al. 2014) due to increased dietary inclusion of toasted sesame seed meal in boiler diets. However in contrast, earlier reports indicated no significant difference in feed intake of broilers that were fed on diets containing either raw or processed sesame seed meal (Akanji et al. 2003). This was also supported by Ngele et al. (2011) and Hatem et al. (2012) who reported that feed consumption of broiler chickens was not affected by dietary supplementation of sesame seed meal to their diets across the entire production cycle. Same results were also revealed by (Sina et al. 2014) who recorded in their investigation that the effect of incorporation of different levels (0, 50, 100, and 150 g/kg) of sesame meal to the broiler diets was not significant on the feed intake of broiler chickens.

2.4.2. Effect of Feeding Sesame Seed Meal the On Body Weight and Weight Gain of Broilers

The body weight of broiler chickens significantly increased when up to 10 % of toasted sesame meal was supplemented to their diets (Adebiyi et al. 2015). Furthermore, same results have also been obtained by Kamel et al (2015) when graded levels of sesame hulls were incorporated to the diet of broiler chickens. However, a significant reduction in body weight was observed as the level of toasted sesame seed meal increased in the diets of broiler chickens (Ogunwole et al. 2014). Same trend has also been observed by Olaiya et al. (2015) and Ogunbode (2016) when broilers were fed on diets containing 15% of soaked sesame meal. Agbulu et al. (2010) also reported a significant decrease in the body weight and weight of broilers when graded levels (0, 5, 10 and 15%) of sesame meal were added to their diets. Al-Harthi and El-Deak (2009) also reported dietary supplementation of sesame seed meal resulted in a significant decrease in broilers body weight and weight gain. Similar results were also recorded by (Mohamed and Wakwak 2013) when Japanese quails were fed on diets supplemented with up to 4% of sesame seed meal. However in contrast, Ngele et al. (2011) found that the body weight and weight gain of broiler chickens were not affected by dietary inclusion of either raw or toasted sesame seed meal to their diets. This was supported by (Sina et al. 2014) who demonstrated that the effect of incorporation of different levels (0, 50, 100, and 150 g/kg) of sesame meal to the broiler diets was not significant on the body weight and weight gain of broiler chickens.

2.4.3. Effect of Feeding Sesame Seed Meal on Feed Conversion Ratio of Broilers

Feed conversion ratio of broiler chickens was improved when processed sesame seed meal was incorporated to their diets of sesame seed meal improved (Diarra et al. 2007; Agbulu et al. 2010). However, Al-Harthi and El-Deak (2009) reported that the FCR of broiler chickens was significantly increased as a result of dietary supplementation of sesame seed meal to their diets. However in contrast, Yakubu and Alfred (2015) indicated that dietary supplementation of toasted sesame meal at levels of 0, 4, 8, 12 and 16% has no significant impact on the FCR of broiler chickens. Ngele et al. (2011) also found that FCR of broiler chickens not affected by dietary inclusion of either raw or toasted sesame seed meal to their diets. Similar results were also obtained by Yosathai et al. (2008). Rama Rao (2008) also reported that food efficiency of broilers was not affected by including SSM up to 0-67 proportion of SBM in starter and finisher diets of broiler chickens. This is supportive to the earlier finding of Daghir (1995) when 50% of sesame seed meal was incorporated to the broiler diets in lieu of soybean meal 50% of soybean meal in broiler diets.

2.4.4. Effects of Feeding Sesame Meal on the Internal Organs

Dietary inclusion of processed SSM significantly increased the relative weight of small intestine and gizzard (Olaiya et al. 2015; Ogunbode 2016). However they reported that the relative weight of liver, spleen and heart was not affected by the experimental treatments. (Agbulu et al. 2010) reported that graded levels (0%, 3% 6%, 9% and 12%) of sesame seeds were included to the broiler diets, the relative weight of small intestine and pancreas significantly increased and that of spleen was significantly decreased by increasing levels of SSM in the diets. Furthermore, the spleen percentage significantly increased as SSM inclusion level increased up to 15% in the broiler diets, however the relative weight of bursa and thymus was not affected by dietary treatments (Al-Harthi and El-Deak 2009). Obeidat et al. (2009) also reported that the relative weight of liver significantly increased and that of heart and spleen were not affected when Awassi lambs were offered diets containing graded levels (0, 8 and 16) of SSM. The non-significant effect of the dietary inclusion of SSM on the relative weight of heart, liver and spleen of goats was also observed by Obeidat et al. (2011). Similar findings in regards to the relative weight of heart and liver have also been reported by (Njidda and Isidahomen 2011) in rabbits on diets containing different levels (0, 4, 8 and 12%) of SSM. Furthermore, Diarra et al. (2007) also reported non-significant differences in the relative weights of the visceral organs as a result of dietary supplementation of processed SSM to the broilers. Rama Rao (2008) also found that there were no significant differences in the relative weight of small intestine, liver and gizzard when SBM was partially replaced with different proportion (0, 0.33, 0.67, and 1%) of SSM in starter and finisher diets of broilers. Similar results have been obtained by Agbulu et al. (2010) concerning to the relative weight of liver, heart and gizzard due to the incorporation of SSM to the broiler diets irrespective to the inclusion level. The non-significant effect of dietary SSM on the relative weight or boiler’s internal organs was further revealed by Yakubu and Alfred (2014). More recently El-Nomeary et al. (2015) also reported that the relative weight of the digestive tract, liver, heart and spleen were not affected when 3% of SSM was included to the diet of rabbits. Barsalani and Rezaepour (2016) reported that the relative weights of liver and heart were not influenced in Japanese quails on low protein diets supplemented with different levels of sesame seeds.

2.4.5. Effect of Feeding Sesame Seed Meal on the Carcass Characteristics

Njidda and Isidahomen (2011) evaluated the nutritional value of toasted white sesame seeds on carcass characteristics of rabbits and reported a significant increase in dressing percentage of rabbits fed raw sesame seed meal. Carcass characteristics including the dressing percentage and the relative weight of breast, thighs and drumsticks were significantly improved when 15% of processed SSM (roasted, boiled, soaked) SSM were added to the diets of broiler chickens (Olaiya et al. 2015; Ogunbode 2016). Agbulu et al. (2010) also reported a significant increase in the relative weight of breast of broilers on diets containing different levels (0%, 3% 6%, 9% and 12%) of sesame seeds. Similar results were also obtained by Mohamed and Wakwak (2013) in regards to the carcass weight when 4% of sesame meal was included to the diet of Japanese quails. The carcass weight significantly increased in Japanese quails offered diets containing 50g/kg of SSM (Sina et al. 2014). There was an improvement in the carcass characteristics of Japanese quails when they fed on a low protein diets supplemented with up to 24 % of sesame seeds (Barsalani and Rezaepour 2016). However in contrast, Kaneko et al. (2002) reported reductions in relative weights of breast, thighs with by rising levels of SSM in broiler diets. Agbulu et al. (2010) also reported a significant decrease in the relative weight of thighs and drumsticks of broilers that were offered diets contained graded levels (0%, 3% 6%, 9% and 12%) of sesame seeds. Furthermore, Rahimian et al. (2013) reported a significant reduction in the carcass weight when different levels of SSM were included to the broiler diets. El-Husseiny et al. (2001) also reported that the relative weight of breast meat was significantly decreased when ducks were fed on diets that containing 30% of SSM. Whereas Diarra et al. (2007) observed no significant difference in dressed and carcass weight when broilers were fed on diets containing different processed sesame meal. Also Agbulu et al. (2010) reported a non-significant improvement on the dressing % of broilers when SSM was included to their diets. The non-significant effect of dietary inclusion of

SSM on the carcass characteristics of broiler chickens was further confirmed by Yakubu and Alfred (2014).

2.4.6. Effects of Feeding Sesame Meal on the Serum Biochemical Parameters

Hemato-biolchemical (blood constituents) values are extensively used as indicators of the general health status of animals and their physio-pathological adaptations (Shah et al. 2007).

The effect of ingested dietary components on blood components is a confirmation (Animashahun et al. 2006). Although the concentration of the nutrients in the blood and body fluids is not a reflex the functional activities of nutrients at cellular level, its considered to be the proximate measure of long-term nutritional status (Doyle 2006).

2.4.6.1. Effect of Feeding Sesame on the Serum Lipid Profile

Serum cholesterol, triglycerides and LDL were significantly increased in broiler fed on diets containing graded levels (0, 25, 50, 75, and 100%) of toasted sesame meal in lieu of soybean meal (Ogunwole et al. 2014). Serum HDL was not affected by dietary treatments. Idowu et al. (2003) demonstrated that serum triglycerides values increased with higher inclusion of TSSM in the broiler diets. On the other hand, cholesterol level reduced with rising levels of SSM in broiler diets (Al-Harthi and El-Deak 2009). Njidda and Isidahomen (2011) indicated that serum cholesterol was significantly affected when different levels (0, 4, 8 and 12%) of sesame were included to the diet of rabbits with the lower cholesterol content for the groups that were obtained the highest SSM level. This was further supported by the finding of AL-Fadhli et al. (2015) who reported the hypolipidemic effect of sesame oil on the lipid profile (including cholesterol, triglycerides and LDL) of layer chickens. They also indicated that the level of HDL significantly increased when sesame oil was added to the diets of layer chickens. There was significant reduction in the serum of Japanese quails that were fed on a low protein diets supplemented with different levels of sesame seeds, whereas the level of serum triglycerides, HDL and LDL were not influenced by dietary treatments (Barsalani and Rezaepour 2016). However, Yakubu and Alfred (2014) reported that serum cholesterol was not affected by SSM supplementation to the broiler diets. Similar results have been obtained by (Agbulu et al. 2010) in broilers that were offered diets contained graded levels (0%, 3% 6%, 9% and 12%) of sesame seeds. Hatem et al. (2012) also reported that the serum biochemical parameters including lipid profile did not affected by dietary inclusion of SSM to the broiler diets.

2.4.6.2. Effect of Feeding Sesame on Serum Biochemistry

Serum total protein significantly increased in broiler that were fed on diets containing graded levels (0, 25, 50, 75, and 100%) of toasted sesame meal in lieu of soybean meal (Ogunwole et al. 2014). Serum albumin was not affected by dietary treatments. Furthermore, Njidda and Isidahomen (2011) indicated that serum globulin significantly increased in rabbits on diets contained different levels (0, 4, 8 and 12%) of sesame seeds. Whereas Rama Rao (2008) reported that there was a linear decrease in the concentration of serum total protein when SBM was partially replaced with different proportion (0, 0.33, 0.67, and 1%) of SSM in starter and finisher diets of broilers. Agbulu et al. (2010) also reported a significant decrease in the serum total protein and albumin of broilers that were offered diets contained graded levels (0%, 3% 6%, 9% and 12%) of sesame seeds. However globulin was not affected. Yakubu and Alfred (2014) reported that the serum protein significantly decreased and serum glucose significantly increased as a result of dietary supplementation of toasted SSM to the broiler diets. However serum albumin was not affected by SSM supplementation to the broiler diets. However, Hatem et al. (2012) reported that the serum biochemical parameters did not affected by dietary inclusion of SSM to the broiler diets. Barsalani and Rezaepour (2016) reported that the concentration of serum glucose was not influenced in Japanese quails on low protein diets supplemented with different levels of sesame seeds. Njidda et al. (2011) indicated that serum total protein and albumin were not affected when different levels (0, 4, 8 and 12%) of sesame were included to the diet of rabbits.

2.4.7. Nutrient Digestibility in Response to Dietary Sesame Meal

The effect of dietary SSM on the nutrient digestibility has been estimated by some researchers. El-Nomeary et al. (2015) stated that there was a significantly improvement in protein digestibility of rabbits that were offered diets that contained 3% of SSM. However they also reported that the dietary treatments had no significant effects on the digestibility of dry matter and ether extracts. Obeidat et al. (2011) evaluated the effect of dietary supplementation of SSM in goats. They concluded that the digestibility ether extract was significantly improved however that of protein and dry matter was not affected when different levels (0, 10, 20%) of sesame hulls were added to the diet of goat kids. Furthermore, in another feeding trial conducted by Obeidat et al. (2009) the digestibility of protein, dry matter and ether extract was not affected in Awassi lambs that were fed on diets containing graded levels (0, 8 and 16) of SSM.

3. MATERIAL AND METHOD

3.1. Experimental Design, Diets, and Bird Husbandry

The study was carried out at the poultry houses of Dept. of Animal Production, College of Agriculture, University of Duhok, Duhok city-Iraq. It's above altitude 471 m, 36.8582°N, 42.86861° E, from February 13, 2017 to March 19, 2017.

This experiment was designed to investigate the effect of dietary supplementation of raw sesame seeds (RSS) on broiler performance and physiology up to 35 d of age. Three inclusion levels of RSS (0, 5, 10 g/kg) diet were used in either maize or wheat based diets which were fed from hatch to 35 days of age. Three phases of feeding were adopted, a starter diet from 1 to 10 d, grower diets from 11 to 24 d, and finisher diets from 25 to 35 d. All diets were formulated to meet the requirements for Ross 308 broiler chickens. (Tables 1, 2 and 3) (Ross 308 manual 2015). In a 3 × 2 factorial arrangement, a total of 240 Ross 308-d-old broiler chicks (initial weight, 41.0 ± 0.92 g) were randomly assigned to 6 treatments, each with 4 replicates, 10 chickens per replicate (Figure 4). Chickens were reared in floor pens bedded with softwood shavings. Feed and water were provided ad libitum. The room temperature was gradually decreased from 33 °C on d 1 to 24 °C ± 1 °C at 35 d (Table 6). Eighteen hours of lighting were provided per d throughout the duration of the experiment, apart from days 1 to 7 when 23 hours of lighting were provided (Table 5). On day 35, the birds and feed were weighed to measure the body weight, weight gain, feed intake and feed conversion ratio. Mortalities were recorded as they occurred, and feed per gain values were corrected for mortality. All birds were vaccinated against Newcastle and Gumboro diseases (Table 7).

On day 35, two birds from each cage were randomly selected and killed by cervical dislocation. The abdominal cavity was opened and visceral organs were weighed. The relative organ weight was calculated as mass per unit of body weight.

Figure 4. The experiment room

Figure 5. Formulations and mixing of the experimental diets by the researcher

3.2. Selection of Crops

Wheat, Corn & Sesame were obtained from local market in Duhok City, Kurdistan Region/ Iraq (Figure 6).

Figure 6. Samples of the crops used in the study

Table 1. Ingredient and nutrient composition of the starter diets

Ingredients	1	2	3	4	5	6
Corn	50.00	0.00	50.00	0.00	50.00	0.00
Wheat	0.00	59.70	0.00	59.70	0.00	59.40
Protein conc.[1]	8.00	5.80	7.50	5.00	7.00	4.80
SBM[2]	35.52	28.00	35.52	28.30	35.52	28.30
Oil	2.40	2.70	2.40	2.70	2.40	2.70
Limestone	1.50	1.22	1.50	1.22	1.50	1.22
DCP[3]	1.00	0.90	1.00	0.90	1.00	0.90
DL. Methionine	0.15	0.15	0.15	0.15	0.15	0.15
L lysine	0.15	0.15	0.15	0.15	0.15	0.15
Enzyme	0.10	0.20	0.10	0.20	0.10	0.20
Salt	0.30	0.30	0.30	0.30	0.30	0.30
Vit .premix	0.80	0.80	0.80	0.80	0.80	0.80
Anti-fungal	0.08	0.08	0.08	0.08	0.08	0.08
Sesame	0.00	0.00	0.50	0.50	1.00	1.00
Nutrient composition						
Crude Protein	23.80	23.37	23.69	23.27	23.58	23.24
ME (kcal/kg)	3021.26	3021.10	3022.21	3021.75	3023.16	3021.05
Methionine	0.85	0.73	0.83	0.71	0.81	0.70
Lysine	1.71	1.58	1.70	1.56	1.68	1.55
Tryptophan	0.34	0.32	0.34	0.33	0.34	0.33
Meth+cyst	1.11	0.96	1.08	0.93	1.06	0.92
Threonine	0.90	0.80	0.90	0.81	0.90	0.80
Arginine	1.47	1.44	1.47	1.45	1.47	1.45
Ca	1.35	1.15	1.33	1.12	1.31	1.11
Available p	0.67	0.62	0.66	0.60	0.65	0.60
Sodium	0.39	0.36	0.38	0.34	0.37	0.34
Chloride	0.22	0.24	0.22	0.24	0.22	0.24

[1]protein conc = protein concentrate (see the composition in Table 4); [2]SBM= soybean meal; 3DCP= Di-calcium phosphate.

Table 2. Ingredient and nutrient composition of the grower diets

Ingredients	1	2	3	4	5	6
Corn	57.25	0.00	56.15	0.00	56.60	0.00
Wheat	0.00	65.50	0.00	65.00	0.00	64.50
Protein conc.[1]	5.00	4.00	5.50	4.00	4.00	4.00
SBM[2]	31.00	22.97	31.00	22.97	31.55	22.97
Oil	3.20	4.00	3.30	4.00	3.30	4.00
Limestone	1.20	1.20	1.20	1.20	1.20	1.20
DCP[3]	1.00	0.90	1.00	0.90	1.00	0.90
DL. Methionine	0.15	0.15	0.15	0.15	0.15	0.15
L lysine	0.15	0.15	0.15	0.15	0.15	0.15
Enzyme	0.10	0.20	0.10	0.20	0.10	0.20
Salt	0.25	0.25	0.25	0.25	0.25	0.25
Vit.premix	0.60	0.60	0.60	0.60	0.60	0.60
Anti-fungal	0.10	0.08	0.10	0.08	0.10	0.08
Sesame	0.00	0.00	0.50	0.50	1.00	1.00
Nutrient composition						
Crude Protein	21.20	21.18	21.39	21.20	21.17	21.22
ME (kcal/kg)	3143.19	3147.74	3142.51	3145.94	3146.18	3144.14
Methionine	0.71	0.63	0.73	0.63	0.67	0.63
Lysine	1.46	1.37	1.48	1.37	1.44	1.37
Tryptophan	0.32	0.30	0.32	0.30	0.33	0.30
Meth+cyst	0.92	0.82	0.94	0.82	0.89	0.82
Threonine	0.84	0.73	0.84	0.72	0.85	0.72
Arginine	1.34	1.30	1.33	1.29	1.36	1.29
Ca	1.07	1.02	1.08	1.02	1.03	1.02
Available p	0.57	0.55	0.58	0.55	0.55	0.55
Sodium	0.29	0.29	0.30	0.29	0.27	0.29
Chloride	0.19	0.21	0.19	0.21	0.19	0.21

[1,2,3] as shown in Table 1

Table 3. Ingredient and nutrient composition of the finisher diets

Ingredients	**1**	**2**	**3**	**4**	**5**	**6**
Corn	64.25	0.00	64.25	0.00	63.55	0.00
Wheat	0.00	73.65	0.00	73.55	0.00	73.35
Protein conc.[1]	4.00	2.90	3.50	2.50	3.60	2.20
SBM[2]	25.00	16.00	25.00	16.00	25.00	16.00
Oil	3.00	3.80	3.00	3.80	3.10	3.80
Limestone	1.50	1.32	1.50	1.32	1.50	1.32
DCP[3]	1.10	1.10	1.10	1.10	1.10	1.10
DL. Methionine	0.15	0.15	0.15	0.15	0.15	0.15
L lysine	0.15	0.15	0.15	0.15	0.15	0.15
Enzyme	0.10	0.20	0.10	0.20	0.10	0.20
Salt	0.25	0.25	0.25	0.25	0.25	0.25
Vit.premix	0.40	0.40	0.40	0.40	0.40	0.40
Anti-fungal	0.10	0.08	0.10	0.08	0.10	0.08
Sesame	0.00	0.00	0.50	0.50	1.00	1.00
Nutrient composition						
Crude Protein	18.71	18.72	18.60	18.63	18.66	18.57
ME (kcal/kg)	3181.94	3183.65	3182.89	3184.05	3185.11	3183.90
Methionine	0.61	0.52	0.59	0.51	0.59	0.49
Lysine	1.24	1.14	1.22	1.12	1.22	1.11
Tryptophan	0.31	0.28	0.31	0.28	0.31	0.28
Meth+cyst	0.78	0.67	0.76	0.65	0.76	0.64
Threonine	0.81	0.66	0.80	0.66	0.80	0.65
Arginine	1.15	1.11	1.15	1.11	1.15	1.10
Ca	1.01	0.91	0.99	0.90	1.00	0.89
Available p	0.50	0.50	0.48	0.49	0.49	0.48
Sodium	0.24	0.24	0.23	0.23	0.23	0.22
Chloride	0.36	0.34	0.34	0.32	0.34	0.31

[1,2,3] as shown in Table 1

Table 4. Nutrient composition of the protein concentrate used in this study

Nutrients g/kg	
Moisture	80
Crude protein	400
ME Poultry	2239 Kchal/Kg
Fat	50
Ash	244
Amino acids g/kg	
Lysine	38.5
Methionine	37
Meth+cyst	41.4
Arginine	25.5
Tryptophan	4.3
Threonine	17.0
Valine	17.3
Minerals g/kg	
Ca	38.3
P Available	53.4
Sodium	25.0
Chloride	38.3
Choline	6.073,00 mg/Kg
Mn	1.600,00 mg/Kg
Zn	1.200,00 mg/kg
Fe	1.000.00 mg/kg
I	20.00 mg/kg
Se	5.00 mg/kg
Salinomycine	1.200,00 mg/kg
Vitamins	
Vit A	200.000,00 I.U
Vit D3	60.000,00 I.U
Vit B1	600.00 mg/kg
Vit B2	140,00 mg/kg
Vit B6	80,00 mg/kg
Vit B12	700,00 mcg
Biotin	2,00 mg/kg
Niacin	800,00 mg/kg
Vit K3	50,00 mg/kg
Folic acid	20,00 mg/kg

Table 5. Temperature schedule applied in this feeding trial

Age	Temperature. ^{0}C
Day 1	33
Day 3	32
Day 5	31
Day 10	30
Day 12	28
Day 14	27
Day 16	26
Day 17	25
Day 19 to end	24

Table 6. The Lightening program applied in this feeding trial

Age (days)	Day length (Hours)
At arrival	24 lightness
1-7	23 lightness, 1 darkness
8-32	18 lightness, 6 darkness
32-35	23 lightness, 1 darkness

Table 7. Vaccination and medical program for broiler flock throughout 35 days experimental Period

Age (days)	Vaccine and method of Vaccination
2-5	Multi-vitamins (CHOLIVIT)****
7	Coccidiosis through drinking water
14	Gumboro through drinking water
21	Newcastle (B1 strain) through drinking water + Vitamin C and Multi-vitamins

(Naji, 2006)

3.3. Measurements and Analyses

3.3.1. Growth Performance

Feed intake (FI) and live weight (LW) were recorded at d 10, 24 and 35 for determination of average FI, weight gain (WG) and LW. Mortality was recorded when it occurred and feed conversion ratio (FCR; feed intake/weight gain) was corrected for mortality.

3.3.2. Visceral organ weight

Body weight and the weight of the small intestine, gizzard, liver, heart, spleen, pancreas and bursa of Fabricius of sampled birds were recorded at day 35. The relative organ weight was calculated as mass per unit of live body weight (g/100g of live body weight).

3.3.3. Carcass parts yield

Carcass weight and the weight of breast, thighs and drumsticks were recorded at d 35. The relative part weight was calculated as an indication of mass per unit of live body weight (g/100g live body weight).

3.3.4. Blood collection

Blood samples (approximately 5 ml) from the jugular vein were collected in non-heparinized tubes. Blood samples were then allowed to clot at room temperature for 2 h and centrifuged at 3,000 rpm for 15 minutes to separate the serum from the cells. Subsequently, serum was harvested and collected into Eppendorf tubes and immediately frozen until biochemical assays were performed.

Serum biochemical parameters including total protein, albumin, cholesterol, triglycerides and high density lipoprotein were determined by colorimetric enzymatic methods following the procedures provided in the used corresponding commercial kits purchased by BIOLABO, Maizy, France.

3.3.5. Nutrient digestibility

On days 33, 34 and 35 of bird's age, feces samples of each pen were collected into plastic container and immediately freeze stored until analyses. All samples were analysed in duplicate. The protein content of feed samples was directly determined by Agri check method using NIR as described by AOAC for undigested samples. Nitrogen content was determined by the Kjeldahl method (AOAC 2005). About 0.5 g of feces sample was dried for 24-72 hours at 121 °C. After that 10 ml of H_2SO_4 were added to the samples and left to get mixed for 24 hours. Then about 5-10 ml of H_2O_2 was added to the mixture. Then the nitrogen content was measured by Kjeldahl nitrogen analyser and converted to equivalent CP by a numerical factor of 6.25.

Apparent digestibility coefficients of nutrients (protein, nitrogen and energy) were calculated for each pen using routine procedures (Noblet et al. 1985). The nutrients apparent digestibility values corresponded to the difference between their values in diets and their loss in feces. The digestibility percentage of nutrients was estimated according to the following formula.

$$\text{Digestibility \%} = \frac{\text{Nutrient in feed - Nutrient in feces}}{\text{Nutrient in feed}} \times 100$$

3.4. Statistical analysis of data

All data collected were analysed using the General Linear Models (GLM) procedure of Minitab version 17 for the main effect of SSM level, grain, along with their interactions. Differences between mean values were determined using Duncan's multiple range tests.

4. RESULTS

4.1. Gross Response

The effects of experimental factors on broiler performance at day 10 are presented in Table (8). No interaction was observed between experimental factors in terms of FI, BW, WG and FCR. Regardless to the grain type used, the sesame level tended to have a significant (P < 0.06) effect on feed intake. In general, feed intake was higher in birds fed on diets that containing sesame than those on control diets. Grain type has no significant effects on the performance of birds at this particular age

Table 8. Feed intake (FI, g/bird), Body Weight (BW, g), weight gain (WG, g) and FCR (g feed/g weight gain) of birds between hatch and 10 d after placement on diets supplementing with different levels of sesame seeds fed with different grains

Grain	**Sesame Level g/kg**	**Response**			
		FI	**BW**	**WG**	**FCR**
Wheat	**0**	267.0	239.8	195.9	1.37
	5	278.4	235.9	192.6	1.44
	10	268.3	240.1	196.4	1.37
Corn	**0**	256.3	232.6	189.3	1.36
	5	273.8	237.7	194.2	1.41
	10	267.5	241.5	197.7	1.36
SEM		1.01	1.19	1.19	0.093
Level	**0**	261.6	236.2	192.6	1.36
	5	276.1	236.8	193.4	1.42
	10	267.9	240.7	196.9	1.36
Grain	**Wheat**	271.2	238.6	195.0	1.39
	Corn	265.8	236.9	193.3	1.37
Source of variation					
Grain		0.26	0.84	0.85	0.65
Level		0.06	0.83	0.85	0.33
Grain× Level		0.68	0.81	0.84	0.96

Each value represents the mean of 4 replicates. SEM = Standard error of mean.

Up to 24 days of bird's age. Feed intake significantly increased (P < 0.02) in birds on wheat based diets. The experimental factors and their interaction had no significant effect on the performance parameters presented in Table (9). In a general view, supplementation of sesame seeds expressed some positive effects on the broiler performance up to the grower phase.

Table 9. Feed intake (FI, g/bird), Body Weight (BW, g) weight gain (WG, g) and FCR (g feed/g weight gain) of birds between hatch and 24 day after placement on diets supplementing with different levels of sesame seeds fed with different grains

Grain	**Sesame Level g/kg**	**Response**			
		FI	**BW**	**WG**	**FCR**
Wheat	**0**	1403.4	1128.8	1084.9	1.29
	5	1426.5	1121.4	1078.1	1.32
	10	1416.5	1149.2	1105.4	1.28
Corn	**0**	1288.4	1070.7	1027.3	1.26
	5	1367.2	1080.1	1036.6	1.32
	10	1342.8	1093.5	1049.7	1.28
SEM		2.71	2.75	2.75	0.069
Level	**0**	1345.9	1084.3	1056.1	1.28
	5	1396.8	1120.8	1057.3	1.32
	10	1379.6	1111.7	1077.6	1.28
Grain	**Wheat**	1415.4[a]	1133.1	1089.5	1.30
	Corn	1332.8[b]	1081.4	1037.9	1.29
Source of variation					
Grain		0.02	0.15	0.15	0.50
Level		0.46	0.85	0.85	0.21
Grain × Level		0.78	0.98	0.98	0.78

Each value represents the mean of 4 replicates. [a,b,c] Mean values in the same column not sharing a superscript letter are significantly different at the P-level shown for the main effect. SEM = Standard error of mean.

When assessed over the 35 days experimental period. Considering the main effects, the grain type used trended to increase (P < 0.07) the feed intake arising from the relatively higher feed intake in birds on the wheat based diets (Table 3). The same trend (P < 0.07) has been fond for the FCR, when it was relatively better in birds on maize based diets. However, no significant impact of the experimental factors and their interaction was observed in terms of FI, BW, WG and FCR across the 35 days period of in this experiment.

Table 10. Feed intake (FI, g/bird), weight gain (WG, g) and FCR (g feed/g weight gain) of birds between hatch and 35 day after placement on diets supplementing with different levels of sesame seeds fed with different grains

Grain	**Sesame Level g/kg**	**Response**			
		FI	**BW**	**WG**	**FCR**
Wheat	**0**	2840.5	1865.0	1821.0	1.51
	5	2632.8	1813.5	1770.3	1.49
	10	2800.0	1845.5	1801.8	1.55
Corn	**0**	2558.9	1817.3	1773.9	1.44
	5	2702.1	1845.8	1822.3	1.48
	10	2576.1	1809.0	1765.2	1.44
SEM		4.12	3.01	3.01	0.088
Level	**0**	2699.7	1833.2	1789.7	1.46
	5	2688.3	1839.6	1796.3	1.49
	10	2667.4	1829.9	1786.1	1.50
Grain	**Wheat**	2757.9	1836.6	1793.1	1.51
	Corn	2612.4	1832.6	1789.1	1.47
Source of variation					
Grain		0.07	0.82	0.82	0.07
Level		0.94	0.96	0.96	0.85
Grain × Level		0.16	0.60	0.60	0.36

Each value represents the mean of 4 replicates. SEM = Standard error of mean.

4.2. Visceral Organ Weight

Overall, there was no significant effect of sesame level, grain type used and their interaction on the relative weight of visceral organs at day 35 of broiler age. However, there was a tendency for the relative weight bursa to get significantly ($P < 0.07$) higher in the birds on wheat based diets than those on maize based diets (Table 11).

Table 11. Relative weights of visceral organs of broiler chickens at day 35 fed different sesame seed levels supplemented to either maize- or wheat-based diet.

Grain	Sesame level g/kg	Gizz[1]	Smal.int[2]	Liver	Spleen	Bursa
Wheat	**0**	2.21	4.94	2.77	0.13	0.17
	5	2.59	5.29	2.64	0.12	0.15
	10	1.82	5.96	3.62	0.17	0.22
Corn	**0**	2.50	5.67	2.95	0.14	0.15
	5	2.24	5.74	2.74	0.13	0.14
	10	2.40	5.73	2.96	0.12	0.13
SEM		*0.200*	*0.348*	*0.269*	*0.051*	*0.068*
Level	**0**	2.35	5.30	2.86	0.13	0.16
	5	2.41	5.52	2.69	0.13	0.14
	10	2.11	5.84	3.29	0.14	0.18
Grain	**Wheat**	2.20	5.40	3.01	0.14	0.18
	Corn	2.38	5.71	2.88	0.13	0.14
Source of variation						
Grain		0.35	0.57	0.69	0.40	0.07
Level		0.38	0.72	0.32	0.48	0.42
Grain × Level		0.13	0.76	0.52	0.11	0.27

Each value represents the mean of 4 replicates.1Gizz=Gizzard; 2smallint=small intestine. SEM = Standard error of mean.

4.3. Lipid Profile of Serum

The sesame seeds level and the grain type used significantly ($P < 0.02$) interacted, depressing the serum cholesterol content in diets supplemented with sesame seeds (Table 12). Across the 35-d trial, the interaction between sesame seeds supplementation and the grain type used showed a tendency ($P = 0.056$) arising from the relatively higher TRG in birds fed on wheat based diets supplemented with medium level of sesame. The lower TRG content was recorded for the birds offered the corn based diet supplemented with the higher level of sesame seeds. Considering the single main effects neither the sesame level nor the grain type used, influenced the lipid profile of serum.

Table 12. Effect of dietary supplementation of sesame seeds in maize- and wheat-based diets on the serum lipid profile of broiler chickens at 35 days of age

Grain	Sesame Level g/kg	Response		
		TRG[1]	CHOL[2]	HDL[3]
Wheat	**0**	42.2	122.0[ab]	65.7
	5	37.6	100.1[c]	69.0
	10	48.4	104.3[abc]	78.0
Corn	**0**	42.3	115.2[abc]	70.7
	5	50.5	124.5[a]	67.7
	10	31.2	104.9[bc]	65.0
SEM		0.933	0.96	1.22
Level	**0**	42.2	118.6	68.2
	5	44.1	112.3	68.3
	10	39.8	104.7	70.6
Grain	**Wheat**	42.7	109.3	70.9
	Corn	41.4	114.9	67.5
Source of variation				
Grain		0.77	0.25	0.67
Level		0.75	0.13	0.92
Grain × Level		0.056	0.05	0.62

Each value represents the mean of 4 replicates. [a,b,c] Mean values in the same column not sharing a superscript letter are significantly different at the P-level shown for the main effect. [1]TRG= Triglycerides; [2]CHOL= Cholesterol; [3]HDL= High density lipoprotein. SEM = Standard error of mean.

4.4. Serum Biochemistry

No interaction has been detected between the experimental factors for the serum biochemistry (Table 13). However, the albumin content significantly ($P < 0.03$) increased in birds fed corn based diets. Furthermore, birds on corn based diets tended ($P < 0.09$) to have significantly higher total protein content than the wheat based diet groups. The albumin content was higher Glucose, globulin and A/G ratio were not affected by the experimental factors and their interaction. However, in general, the measured biochemical parameters were higher in sesame supplemented birds than control.

Table 13. Serum biochemistry of broiler chickens on either maize or wheat based diets supplemented with graded level of sesame seeds and fed for 35 days.

Grain	Sesame Level g/kg	Response				
		Glucose	TP[1]	Albumin	Globulin	A/G[2]
Wheat	**0**	223.3	2.27	0.92	1.35	0.68
	5	238.1	2.41	0.99	1.42	0.69
	10	258.1	2.41	1.01	1.40	0.73
Corn	**0**	232.1	2.51	1.04	1.47	0.71
	5	250.6	2.86	1.20	1.66	0.72
	10	245.1	2.47	1.10	1.40	0.77
SEM		1.49	0.176	0.113	0.139	0.068
Level	**0**	227.1	2.39	0.98	1.41	0.70
	5	244..4	2.63	1.09	1.52	0.71
	10	251.6	2.44	1.04	1.40	0.75
Grain	**Wheat**	2.38.2	2.36	0.97[b]	1.39	0.70
	Corn	242.6	2.61	1.10[a]	1.51	0.73
Source of variation						
Grain		0.81	0.09	0.03	0.19	0.13
Level		0.24	0.35	0.30	0.37	0.12
Grain × Level		0.63	0.53	0.58	0.54	0.99

Each value represents the mean of 4 replicates. a,b,c Mean values in the same column not sharing a superscript letter are significantly different at the P-level shown for the main effect. [1]TP= Total protein; [2]A/G= Albumin/Globulin ratio. SEM = Standard error of mean.

4.5. Nutrient Digestibility

The effects of sesame seeds supplementation and the grain type used on the apparent digestibility of protein, nitrogen and metabolized energy are presented in Table (14). No interactions were observed between experimental factors in terms of protein digestibility. Dietary supplementation of sesame seeds resulted in a lower protein digestibility than those on control diets. However it was only significant ($P < 0.01$) in birds that had received diets supplemented with the highest level of sesame seeds independent to the grain type used. Protein digestibility was significantly ($P < 0.01$) higher in maize based diet birds than those on wheat based diets.

A significant ($P < 0.01$) interaction was noticed between sesame supplementation and grain type when energy digestibility was assessed across the 35-d study. Energy digestibility decreased in birds that had received the maize based diets supplemented with the highest level of sesame.

Over all, energy digestibility numerically decreased as the sesame supplementation level increased. Furthermore, energy digestibility was relatively higher in maize based diet birds than those on wheat based diets.

Table 14. Apparent protein, nitrogen and energy digestibility of 35 days broiler chickens given sesame seeds at different supplementation levels (0, 5 or 10 g/kg) in either maize or wheat based diets

Grain	Sesame level g/kg	Response		
		Protein	**Nitrogen**	**Energy**
Wheat	**0**	0.57	0.57	0.43[abc]
	5	0.54	0.59	0.42[bc]
	10	0.52	0.53	0.46[ab]
Corn	**0**	0.67	0.67	0.48[ab]
	5	0.63	0.65	0.49[a]
	10	0.55	0.55	0.41[c]
SEM		0.064	0.064	0.058
Level	**0**	0.63[a]	0.62[a]	0.46
	5	0.58[ab]	0.62[a]	0.45
	10	0.54[b]	0.54[b]	0.44
Grain	**Wheat**	0.54[b]	0.56[b]	0.44
	Corn	0.61[a]	0.62[a]	0.46
Source of variation				
Grain		0.01	0.01	0.27
Level		0.01	0.01	0.56
Grain × Level		0.29	0.33	0.01

Each value represents the mean of 4 replicates. [a,b,c] Mean values in the same column not sharing a superscript letter are significantly different at the P-level shown for the main effect. SEM = Standard error of mean.

4.6. Carcass Yield and Its Parts Weight

There were no significant effects or interactions from sesame level or the gain type on the dressing percentage and the relative weight of carcass parts of broiler chickens at 35 d of age (Table 15). Overall, the dressing percentage and the relative weight of carcass parts were numerically higher in broiler chickens fed on diets contained sesame seeds than those in control groups.

Table 15. Dressing percentage and the weight of breast, thigh and drumsticks of broiler chickens at 35 day at various sesame seeds supplementation levels on either maize- or wheat-based diets

Grain	Sesame Level g/kg	% of body weight			
		Carcass yield	Breast	Thighs	Drumsticks
Wheat	**0**	69.8	23.6	10.9	8.4
	5	75.3	25.8	11.5	9.4
	10	71.2	29.6	13.3	11.0
Corn	**0**	73.9	28.1	11.0	8.7
	5	71.6	26.6	9.8	9.0
	10	73.2	25.8	10.9	8.7
SEM		0.57	0.70	0.44	0.41
Level	**0**	71.9	25.8	11.0	8.5
	5	73.4	26.1	10.6	9.2
	10	72.3	27.6	12.1	9.9
Grain	**Wheat**	72.2	26.2	11.9	9.6
	Corn	72.9	26.8	10.6	8.8
Source of variation					
Grain		0.62	0.78	0.15	0.29
Level		0.66	0.79	0.37	0.37
Grain × Level		0.10	0.36	0.53	0.32

Each value represents the mean of 4 replicates. SEM = Standard error of mean.

5. DISCUSSION

5.1. Gross Response

This study shows the possibility of feeding raw sesame seeds without detrimental effect on growth performance of broilers. Although not significant, supplementation of sesame seeds in the starter and grower periods showed some positive effects. The inclusion of sesame seeds led to some increase in feed intake and an improvement in body weight in an early age and continued to the subsequent grower age. This could be attributed to the role of methionine present in sesame seeds promoting growth and yielding good feed efficiency. However this effect disappeared in the finisher phase particularly in wheat based diets. This was in line with Ngele et al. (2011) when up to 10% of raw sesame seed meal was fed to broiler chickens. However, in contrast (Mahmoud et al. 2015) stated that the weight gain was significantly increased when roasted sesame hull was fed to broiler chickens. Rahimian et al. (2013) reported that body weight and weight gain of broiler chickens were improved when sesame seed meal was incorporated to their diet. Feed conversion ratio, body weight and weight gain were significantly improved in rabbits that were offered diets containing sesame seed meal (El-Nomeary et al. 2015). Al-Harthi and EI-Deek (2009) obtained a significant decrease in live body weight and weight gain when sesame seed meal was replaced soybean meal in broiler diets.

Although of having Anti-nutrient factors mainly phatic acid in its composition. The incorporation of such additions of raw sesame seeds had no adverse effect on the performance broiler chickens throughout the experimental period. Sesame seed meal may not be suitable as a main source of protein but could be used up 30% of total dietary protein for broilers and 23.6% for laying hens to achieve optimal performance (Reddy et al. 1999). This study demonstrated that supplementation of young broilers diets with small amount of raw sesame seeds could be beneficial, especially with the presence of phytase which could eliminate the negative effects of phystic acid. In addition birds are consuming little amount of feed in this particular age compared to the finisher phase.

The absence of any ill effects when using higher levels of raw sesame seeds in broiler diet may have been due to better availability of amino acids particularly methionine and lysine from the sesame seed meal used in this study. The sesame seed used was not subjected to heat treatment, therefore, the lysine in it might have been made available.

5.2. Visceral Organ Weight

In the present study the relative weight of visceral organs was not affected by the experimental factors. The inclusion of sesame seeds tested in this study did not appear to have an impact on the weight of organs, although there was an impact from the type of the grain on the relative weight of visceral organs. In particular, there was an increase in the relative weight of the bursa for birds fed the corn based diets. This could be partly attributed to the influence of grain texture and composition, resulting in stimulation of the development of such organ. The results were in accordance to those of (Yakubu and Alfred 2014) who reported that there was no significant effect of dietary supplementation of sesame meal on the weight of internal organs of broiler chickens. Similar finding were obtained by Obeidat and Gharaybeh (2011) when they fed sesame hull to goats. Agbulu et al. (2010) found that the relative weight of most of internal organs were significantly affected by graded level of sesame seeds in the broiler diets except the weight of liver, heart and gizzard which were not affected.

5.3. Meat Yield

The results of the current study showed that supplementation of sesame to the diets had no significant effect on the meat yield in terms of weight of breast, thighs and drumsticks of broilers on either grain-based diet. Dressing percentage was improved to some extent due to sesame feeding. Inclusion of sesame seeds in the diets of broiler chickens on either maize- or wheat-based diets marginally improved the carcass parts weight, especially breast and drumsticks. This may have been due to the complementary effects of amino acids of SSM and SBM in this combination. The results are supported by Yakubu and Alfred (2014) who stated that dressing percentage of broiler chicken was not affected by dietary sesame meal. Agbulu et al. (2010) also demonstrated that the inclusion of sesame hull in broiler diet marginally improved carcass yield and the breast weight. Mahmoud et al. (2015) reported a significant increase in breast weight by rising levels of roasted sesame hulls in broiler diets. In terms of thighs and drumsticks weight, the results of the present study were in contract with those of Agbulu et al. (2010) who reported a significant decrease in the thigs and drumsticks weight in broiler chickens fed on diets containing sesame hull in comparison with the control. The weight of thighs and drumsticks were decreased with increasing level of sesame seed meal in broiler diets (Kaneko et al. 2002). Obeidat et al. (2009) reported a significant decrease in the dressing percentage of Awassi lambs as a result of dietary supplementation of sesame meal. A medium level of sesame seeds in wheat-based diet produced the best outcomes. This improvement may be due to the better protein absorption of sesame supplemented groups, which may result in better protein deposition in muscle tissue than other groups. Total protein and albumin were higher in the serum of the sesame supplemented birds than the other experimental groups as shown in Table 9. Bamgbose et al. (2003) reported that total protein and albumin are indicators of the total protein reserve in an animal body.

5.4. Lipid Profile of Serum

The results of the current study showed that the inclusion of medium level of sesame seed meal in the wheat based diets had a hypocholesterolemic effects on broiler chickens. However, triglycerides were higher in the birds that were offered the corn based diets supplemented with medium level of sesame seed meal. Sesame seed inhibit the intestinal absorption of cholesterol and its synthesis in the liver (Yamauchi et al. 2006). This could be due to the presence of biological active compound such as sesamin and sesamolin in sesame seeds are known to have a hypocholesterolemic action. Sesame oil is also known to maintain the level of high density lipoprotein and low density lipoprotein (Anilakumar et al. 2010). Furthermore, the hypo-cholesterolemia effects of the lignans and lignin glycosides isolated from sesame seeds and oil have also been reported by Kapadia et al. (2002). Such cholesterol inhibitory actions of sesame may decrease the deposition of cholesterol in poultry products which in turn may decrease the health problems in human following the consumption of these products (Bamgbose et al. 2011). The results were in line with those of Yakubu and Alfred (2014) who found a linear decreasing of serum cholesterol when broiler were fed on diets containing different levels of toasted sesame meal. A reduction in the serum cholesterol was also reported by Al-Harthi and El-Deek (2009) when sesame seed meal was included to the broiler diets. Similarly, Al-Fadhli ea al. (2015) reported a significant reduction in the serum cholesterol when sesame oil was added to the diet of layer chicken. The reduction in the lipid profile was further confirmed in the milk composition when sesame meal was fed to Awassi sheep (Suliman, et al. 2014). However in contrast to the results of the current study, they found a significant reduction in the serum triglycerides and a significant increase in the serum HDL contents of the layers. Agbulu et al. (2010) reported that the serum cholesterol was not affected by feeding of sesame seeds to the broiler chickens.

5.5. Serum Chemistry

In general, serum biochemistry was not affected by the experimental factors except for the albumin and total protein that were affected by the grain type used. Serum albumin and total protein were higher in birds on corn based diets than those in wheat based diets The results were in contrast to the finding of Yakubu and Alfred (2014) who reported a significant increase in serum glucose and a significant decrease in serum total protein when broiler were offered diets supplemented with various levels of toasted sesame meal. They also found a linear decreasing in albumin content in the serum of sesame meals supplemented birds. Agbulu et al. (2010) found a significant decrease in serum protein and albumin content of broiler that was fed on diets containing sesame seed meal. In general, the measured biochemical parameters were higher in sesame seed supplemented birds than control.

5.6. Nutrient Digestibility

The results of the present study demonstrate that the digestibility of nutrients was affected by the experimental factors. The most important observation was the interaction between the sesame seed level and grain type on the digestibility coefficient of energy and protein, whereby the lowest values were seen in the chicken groups that consumed the highest sesame seeds level (10 g/kg) on maize-based diets compared to the control and other experimental groups. There was a dose-dependent decrease in the protein digestibility with increasing levels of sesame seed. This may be due to the low net protein utilization of SSM as well as low lysine and high phatic acid content (Ravindran and Blair 1992). Rama Rao (2008) also reported that the non-linear decrease in food efficiency in broilers fed diets containing higher levels of SSM may have been due to the reduction in the utilization of nutrients at higher levels of SSM in diet. The results were in contrast with those of Obeidat et al. (2009) who reported a non-significant effect of dietary supplementation of sesame meal on the nutrient digestibility of Awassi lambs. Furthermore, the digestibility of crude protein significantly increased in rabbits that were fed on diets containing sesame seed meal (El-Nomeary et al. 2015).

Protein digestibility was higher in the birds on maize-based diets than those on wheat-based diets. The activity of digestive enzymes can be influenced by the form (Gabriel et al. 2003) and type of cereal grains (Almirall et al. 1995) used in diets for poultry. Therefore, variation in the digestibility of certain nutrients between the two grain-based diets could be due to the differences in the chemical composition of the grains, including the nature of Anti-nutritional factors such as NSP in wheat.

6. CONCLUSION AND RECOMMANDATION

Understanding the response of chickens to dietary inclusion of raw sesame seeds is essential to maximizing its use in diets for young birds'. The present study highlights the benefits of using raw sesame seed.

The results reported in this thesis show that feeding of raw sesame seeds meal (RSS) can influence the growth performance, digestive physiology and serum lipid profile at an early age and throughout the broiler production cycle. Early feeding of RSS has important nutritional roles in young developing chicks. Dietary RSS improved the feed consumption of broiler in the starter and subsequent grower phase. In addition the cholesterol content obviously reduced throughout the broiler production cycle. Feeding RSS negatively influenced the digestibility of nutrient without any negative impacts on the productive performance of broilers.

Future research should consider combining RSS with some specific microbial enzymes to exploit both the nutritional and non-nutritional effects of sesame seeds. This may provide further benefits to the chicks at high risk of nutritional disorders and enhance the digestive development of the chicks.

There is also a need to determine the optimal inclusion levels of raw sesame in diets of starter and subsequent grower and finisher phases of broiler production.

More investigation into gut micro flora and gastrointestinal immunity of broiler chickens on similar diets to those used in this study would be worthwhile. It would also be worthwhile to investigate the use of RSS in layer diets to ascertain whether it has any effect on egg production.

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PERSONAL BACKGROUND

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